UNDERSTANDING SOCIAL VULNERABILITY IN AGING POPULATIONS:

INSIGHTS ACROSS DIFFERENT HEALTHCARE SETTINGS

By

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I dedicate this thesis

to my family and friends

for their advice, support, patience, faith and love.

To my father who is my rock.

To my mother who is my heart.

To my brother who is my best friend.

To my husband who is my dearest confidant.

To my grandparents and great grandparents who were my first teachers.

Loving you all is the greatest adventure of my life.

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Abstract

Social vulnerability is the degree to which a person's overall social circumstances leave them susceptible to adverse events, driven by the relative disadvantages from the conditions in which they were born, live, work and age. This thesis explores the complex nature of social vulnerability, conceptualizes its measurement through social vulnerability indices (SVIs), and examines its associations with health outcomes for older adults. Across eleven chapters, social vulnerability is explored using systematic and scoping reviews, qualitative interviews and quantitative data analyses in different populations of community dwelling and hospitalized older adults, primarily in Nova Scotia. This thesis begins with an exploration of the potential value of intervening to reduce social vulnerability by demonstrating complex interventions with a predominant social component were associated with improved function, better subjective health and lower hospital use. The next chapters describe the theory, method, and strengths of constructing a multiple level and multiple domain SVI and demonstrate feasibility in both a smaller clinical study and a larger population-based dataset. Using the SVI to understand how social vulnerability influences hospital outcomes among older adults in the emergency department showed that while frailty drove admission and mortality, social vulnerability prolonged hospitalization and increased risk of long-term care home entry. Within the hospital setting, qualitative interviews revealed healthcare providers' perceptions of "socially admitted" patients including individual, institutional, and system challenges to providing patient centred care for this population. In later chapters, dynamic relationships are found between social vulnerability and mortality, home care hours, and long-term care home entry even after accounting for frailty and cognition. The findings presented in this thesis support the importance of considering social vulnerability for older adult health and use of healthcare and home care resources. The findings also suggested healthcare systems appear less responsive to older adults with high social vulnerability and potentially, unintentionally, facilitate care pathways towards institutionalization. Lastly, this thesis presents a model of caring for older adults at risk of frailty and social vulnerability across healthcare settings to guide future research, emphasizing the need for systems level thinking, comprehensive redesign, and proportional funding reform to effectively support the goal of aging-in-place in Canada.

List of Abbreviations Used

ADL – Activities of daily living

aHR – adjusted Hazard ratio

AIC – Akaike information criterion

ALC – Alternate level of care

aOR – adjusted Odds ratio

ATSDR – Agency for Toxic Substances and Disease Registry

BIC – Bayesian information criterion

CCI – Charlson Comorbidity Index

CDC – Centers for Disease Control and Prevention

CGA – Comprehensive Geriatric Assessment

CI – Confidence interval

CLSA – Canadian Longitudinal Study on Aging

ED – Emergency department

EPPI – Evidence for Policy and Practice Information [and Co-ordination Centre]

FI – Frailty index

FTC – Failure to cope

GP – General practitioner

GPID – Geriatric Patient Information Database

IADL – Instrumental activities of daily living

ICC – Intraclass correlation coefficient

LTC – Long-term care

LTCH – Long-term care home

LOS – Length of stay

MMAT – Mixed Methods Appraisal Tool

NS – Nova Scotia

NSH – Nova Scotia Health (previously NSHA – Nova Scotia Health Authority)

OT – Occupational therapist

PCCF+ – Postal Code Conversion File Plus

PICOT – Population, intervention, comparison, outcome, type of study

PRESS – Peer Review Electronic Search Strategies

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

QoL – Quality of life

RAI-HC – Resident Assessment Instrument-Home Care

RCT – Randomized controlled trial

REB – Research ethics board

SARS-COV 2 – Severe acute respiratory syndrome coronavirus 2

SD – Standard deviation

SDOH – Social determinants of health

SEAscape – Single Entry Access Simultaneous Client Assessment Placement Evaluation

SOS – Serious Outcomes Surveillance [Network]

SV – Social vulnerability

SVI – Social vulnerability index

TRoPHI – Trials Registrar of Promoting Health Interventions

USA – United States of America

WHO – World Health Organization

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Chapter 1. Introduction

"And then a new question arises: If independence is what we live for, what do we do when it can no longer be sustained?"

— Atul Gawande

Being Mortal: Medicine and What Matters in the End (1)

Imagine an older adult, determined to remain in the comfort of their home as they age, surrounded by familiar faces and memories with intact autonomy and independence. This vision, known as "aging-in-place," is a key goal of successful aging in the community.

The benefits of aging-in-place are numerous. First, 91% of Canadians, and almost 100% of older Canadians 65 years and above, plan on living independently in their own home and supporting themselves as long as possible (2). Aging-in-place is desirable because it provides security and familiarity, creates attachment and connection to a community, and is associated with an individual's sense of identity through independence and autonomy (3). For policymakers, there is a financial benefit to caring for older adults in the community compared to long-term care homes (LTCHs). In one estimate, the costs for home care were less than half the costs for an older adult living in a LTCH (4). Globally, aging-in-place is one proposed solution to mitigating the societal, economic and health consequences of an aging demographic. The search for solutions to respond to older adults' needs with resources that promote health, provide a life of meaning, and foster aging with dignity has worldwide attention; hence the United Nations declared 2021 to 2030 the Decade of Healthy Aging and the World Health Organization promotes Age-friendly Communities (5,6).

The desire to age-in-place also shapes the landscape of health and community care in Canada. Care closer to home is one pillar of the National Seniors Strategy (7). Defining the services and type of care encompassed under 'care closer to home' is a challenge. The Government of Canada defines home and community care services as "services [that] help people to receive

care at home, rather than in a hospital or long-term care facility, and to live as independently as possible in the community. Home and community care is delivered by regulated health care professionals (e.g., nurses), non-regulated workers, volunteers, friends and family caregivers." (8). Another synonym umbrella term is long-term care (LTC). The National Institute on Ageing from Toronto Metropolitan University defines LTC as a "range of preventive and responsive care and supports, primarily for older adults, that may include assistance with Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs) provided by either not-for-profit and for-profit providers, or unpaid caregivers in settings that are not location specific and thus include designated buildings, or in home and community-based settings." (7) These ambiguous definitions result in inconsistencies in the services, its providers, and funding structures for care closer to home; the same observations were made by the Romanov Report in 2002 which called for home and community care services to be included in the Canadian Health Act to establish national standards (9). Canada did not established national standard following this report, meaning access to services to support aging in homes and communities remains a challenge. In the 2015/2016 Canadian Community Health Survey, 1.6% of Canadians reported an unmet home care need and only 65% of people receiving home care reported the services adequately addressed their needs (10). In a care system that relies heavily on informal caregivers, it is also concerning that 63% of Canadians surveyed felt their families would not be able to provide care for older family members if they needed long-term care for financial or other reasons (7).

From a physician's perspective, there are many opportunities to help older adults age-in-place such as a general practitioner engaging in preventative health (e.g. immunization counselling to prevent influenza and pneumococcus), an internist managing chronic diseases (e.g. heart failure medication management to reduce shortness of breath), or a surgeon fixing obstacles to mobility (e.g., management of prolapse to reduce incontinence or elective knee surgery for osteoarthritis). However, after medical interventions, older adults are often left with greater levels of frailty – the accumulation of health deficits that increase risk of subsequent adverse health outcomes and diminish capacity to engage in higher-order functioning and IADLs (11). As the marvels of modern medicine continue to save lives, the trade-off comes at the cost of a

growing incidence and prevalence of older adults living with increasing states of frailty (12) – but why are some older adults able to live at home in spite of their frailty, while others are not?

While most older adults can manage their health and frailty and remain in the community, there are many who cannot. Alternate level of care (ALC) is one example, also known as people who have their "hospital stay extended until home care services or supports [are] ready" (13). At any moment, people designated as ALC occupy 10% to 30% of all hospital beds across Canada depending on region (14–16). Another group of older adults who struggle to remain is the community have been designated "social admissions", a non-diagnostic label referring to people admitted to hospital for whom no medical or health conditions are deemed amenable to reversibility or rehabilitation; rather, social circumstances are felt to be the sole cause of hospitalization (17). These labels of ALC and "social admissions" are often misleading and are associated with potentially fatal misdiagnoses (18). Another group of people who are not living in the community are residents of LTCHs, yet between one in five to one in nine may not require an institutionalized setting and their medical needs may be manageable in the community if appropriate supports were in place (19,20). Absolute numbers may be small, but there is a large impact of older adults who are ALC, "social admissions" or prematurely sent to LTCHs, in part due to longer stays in institutions translating to thousands of beds potentially unavailable for acute care, hundreds of thousands of potentially avoidable bed days and billions of dollars potentially saved annually (4,15,21,22).

The broad research question underpinning my thesis is to better understand the drivers of, and how to best address, the needs of a socially vulnerable older patient population. People who seek healthcare with high social vulnerability often have a distinct medical profile. For example, ALC patients often have higher levels of cognitive impairment, frailty, functional deficits and disease burden (23). This alone still does not explain why some people with the same health deficits can live in the community and others cannot. From clinical experience, a shared characteristic of this latter group is that they lack social supports that are sufficient and conducive enough to returning home in the community. Several examples come to mind: an

older man with visual impairment whose health had not changed but his wife had lost their finances, a middle-aged man with morbid obesity who lost his spot in a group home after a short episode of cellulitis brought him to the emergency department, or a recently widowed woman with worsening dementia whose children lived out of province with nighttime wandering behaviours. All these specific social circumstances are different yet can be all attributed to non-medical determinants of health. Non-medical factors can be considered the conditions in which people are born, live, work, and age – also known as the social determinants of health (24). In addition to health outcomes, social determinants exhibit bidirectional effects on health care; they not only contribute to the need for health resources, they can also have great practical relevance when frontline health care teams attempt to help older adults return home (25). Centered through the lens and experiences of a physician, here I explore why and how two older adults who have the same medical conditions and the same degree of frailty can experience vastly different living situations whereby one returns to independent living in the community with or without supports and the other requires an alternate level of care stay in hospital or admission to a long-term care home. My thesis primarily explores this question through a social vulnerability lens, although it also accounts for the observation that older adults do not experience social vulnerability or frailty in isolation. A visual roadmap of the manuscripts in this publication-based thesis is shown in Figure 1.

Chapter 1: Introduction	RATIONALE	METHODS	HOSPITAL	HOME CARE	Chapter 11: Discussion and Conclusion
	Chapter 2: Do interventions reducing social vulnerability improve health in community dwelling older adults? A systematic review	Chapter 3: Social vulnerability indices: a scoping review	Chapter 5: Social vulnerability and frailty in hospitalized older adults	Chapter 8: Changes in frailty predict social vulnerability among home care clients living in the community followed for ten years	
		Chapter 4: A standard procedure for constructing a multi-level social vulnerability index using CLSA and SOS data as worked examples	Chapter 6: Admissions for presumed social reasons: epidemiology, risk factors, and hospital outcomes	Chapter 9: Social vulnerability and home care hours among older adults in Nova Scotia	
			Chapter 7: Managing "socially admitted" patients in hospital: a qualitative study of health care providers' perceptions	Chapter 10: The association between social vulnerability and survival and long-term care entry using routinely collected home care data	

Figure 1. Overview of chapters in my publication style thesis

Chapter 2: Do interventions reducing social vulnerability improve health in community dwelling older adults: A systematic review provides the rationale and recognition that non-medical interventions have the potential to positively impact health outcomes. While there is existing evidence that demonstrates the health impacts of social determinants, it is important to establish proof of concept regarding the efficacy of intervening on these determinants to improve health outcomes. From the onset, this explains the "so what" question of later work in my thesis. This chapter also introduces a key construct for this thesis, *social vulnerability*, and the conceptual model linking the social determinants of health to social vulnerability and health outcomes. Chapter 2 is the published version of my comprehensive examination.

Chapter 3: Social vulnerability indices: a scoping review and Chapter 4: A standard procedure for constructing a multi-level social vulnerability index using CLSA and SOS data as worked examples expand on social vulnerability, its underlying theory, and how to measure it using a social vulnerability index (SVI). Although Chapter 4 summarizes the underlying theory, more details are provided here because understanding the social circumstances that contribute to the health of individuals and groups are complex and do not fit well within traditional medical models of disease (26).

An understanding of social capital is helpful before operationalizing social vulnerability. In 1983, Pierre Bourdieu described three types of capital: economic, cultural, and social. Like economic capital, he hypothesized that social capital could be harnessed to bring advantages for the wealthy or powerful through their entrenched networks and institutionalized relationships (27). James Coleman, accounting for many definitions, distilled social capital down to two common elements consisting "of some aspect of social structures, and they facilitate certain actions of actors – whether persons or corporate actors – within the structure" (28)(page S98). The social scientist Robert Putamen went on to define social capital as the characteristics of communities that make people more productive, framing social capital as a way of fostering civic engagement, good neighbourliness and democracy (29). Social capital is now understood as grounded in community norms of reciprocity and trust through bonds (within group capital) and bridges (horizontal relationships between heterogenous populations) (30). Social capital can be broken down into social support, social engagement and access to resources (31). Adequate social capital is productive; in its absence, achievement of certain ends would not be possible (28). To illustrate, following a hip fracture, economic capital to purchase a wheelchair or renovate a home with a ramp improves function, but so will social capital in the form of free exchanges of food, time or company provided by friends, family and community members. Collectively, the works by Coleman, Putamen and Bourdieu suggest social capital is a tangible asset that can be accessed in times of need; low social capital may be a commonality shared by

people unable to live independently when others with the same degree of frailty are able to do so.

Does social capital exist at the level of the individual or the collective? It is certainly true that one's social status is related to characteristics of the individual (i.e. race, gender, or education). However, the contributions of the relationships among different actors (individuals and state) within a specific context (i.e. culture) cannot be ignored when discussing social circumstances. Therefore, social capital and social circumstances should be conceptualized on a continuum (31). Brofenbrenner's ecological perspective offers a useful way to think about how multiple social determinants may influence the aging of populations and individuals by visualizing person-context interrelatedness through the dynamic micro, meso, exo and macro systems (32). As it pertains to an example of an older adult seeking healthcare, the micro system involves their own health behaviours and their closest links with family and caregivers. The meso system includes the education of the older adults' children and their familiarity with health resources. The exo system refers to the community supports available such as day hospitals or access to rehabilitation programs, and the macro system encompasses the attitude towards older adults in broader policy reflected in pension plans or universal long-term care insurance. The chrono system is a fifth level of influence developed by Brofenbrenner in later years and explains how populations vary over time periods and can be influenced by specific historical events (33).

While social determinants have a robust evidence base, there is a need to incorporate more complexity than allowed by a "one at a time" approach, appreciating that multiple health deficits and social deficits occur simultaneously (26). On average, older adults experience more health problems and functional limitations due to decreased mobility and increased frailty. They would benefit greatly from increased social supports, yet are faced with shrinking social circles due to infirmity and death of their friends and families (34). Divergence theory suggests that with time, socioeconomic disparities and resultant health inequities increase with age due to progressive accumulation of disadvantages at social and biological levels (35). In many high-income countries, some disadvantages are [fortunately] mitigated by old age security and

similar social policies. As a result, teasing out the social risks for health between a socially estranged wealthy older man compared to an older woman supported by the state but who has a welcoming family and church group is challenging. Using this example, a reliance on a lone social determinant of health (e.g., wealth) cannot reflect the informal supports of family and friends. Reliance on a single marker or even a few variables of social circumstance in many cases is inadequate, hence multiple social determinants are needed to capture a complete understanding of someone's social situation.

To summarize, forms of social capital can be harnessed towards a tangible goal, social circumstances are embedded in layers of complexity and levels of influence, and more than one marker of social conditions are required to understand the collective impact of the social determinants of health. Collectively, these theories help explain the deficit accumulation approach to construct a multiple item, multiple domain index of social vulnerability.

Chapters 5, 6 and 7 explore social vulnerability in an acute care (i.e., hospital) setting. Chapter 5: Social vulnerability and frailty in hospitalized older adults uses the SVI to examine how social vulnerability contributes to hospital outcomes and hospital resources (i.e., admission to hospital, length of stay (LOS), ALC status, in hospital mortality and incident discharge to a LTCH) for older adults presenting to the Emergency Department (ED). Chapter 6: Admissions for presumed social reasons: epidemiology, risk factors, and hospital outcomes and Chapter 7: Managing "socially admitted" patients in hospital: a qualitative study of health care providers' perceptions delves into the often commented upon, but rarely empirically studied, population of patients admitted to hospital with labels of "social admission". Chapter 6 scopes the literature trying to find more information on this population who often have complex underlying medical problems, some which may be acute, and who are at high risk of poor outcomes. Then, Chapter 7 gives insights into how "socially admitted" are perceived when acute care beds are occupied through interviews with healthcare providers, and includes the challenges healthcare providers face when trying to arrange health and home care for this population. Examining older adults in acute care may clarify how underlying frailty and social vulnerability contribute

not only to a greater risk of presenting the ED, but also prevent recovery after an adverse health (e.g.., hip fracture) or social event (e.g., death of a spouse).

The last three chapters in my thesis return to quantitative methods to assess social vulnerability in the home care setting. Chapter 8: Changes in frailty predict social vulnerability among home care clients living in the community followed for ten years considers the dynamic relationship between accumulation of health deficits and accumulation of social deficits. Chapter 9: Social vulnerability and home care hours among older adults in Nova Scotia examines the extent to which trajectories of home care usage are patterned by between-person and within-person factors. Chapter 10: The association between social vulnerability and survival and long-term care home entry using routinely collected home care data looks into the ultimate endpoints in the care trajectory for most older adults and how social vulnerability and frailty are associated with these outcomes.

Studying social vulnerability in the home and community care setting is vital to the broad research question of this thesis because home care is one of the only tools to achieve the goal of aging-in-place that serves as a bridging step between full independence and institutionalization, and all Canadians should be able to access this. As mentioned above, attention to home care reflects an emergent widespread preference of older adults who require assistance to remain in familiar settings rather than receiving care for chronic health conditions in an institutionalized setting (3,36–38). Home and community care benefits individuals through decreased mortality, reduced hospitalizations, delayed institutionalisation and improved quality of life (39–42). The appeal of home care services is that it can produce health outcomes comparable to those achieved in institutionalised settings, respond to the call for personalised care and improve cost-efficiency in a cash-strapped healthcare system (43,44). Moreover, it is one of the few services triaged through healthcare that provides social support. As Evelyn Shapiro, the "mother" of universal home care in Manitoba, pointed out home care services "really doesn't only consist of medical services, it consists primarily of social supports" (45). A health service with social focus is especially important because only 10-20% of health outcomes

can be prevented or attributed to clinical care – and because the most modifiable determinants of health are social and economic rather than medical (46,47).

Aging-in-place presents substantial challenges for some older adults, hindering their ability to achieve optimal health and well-being. The manuscripts and published articles in my thesis will further investigate the characteristics, perceptions, and care trajectories of individuals whose social circumstances, in conjunction with frailty, impede their ability to reside at home. As medical advances prolong life expectancy – resulting in more people with greater frailty – and national demographics age, the seemingly simple desire to age in place is complicated by multifaceted social factors that influence the use of services (e.g. home care) that allow people to live at home. My thesis aims to bring to light considerations of how different healthcare settings currently deal with social vulnerability and what can be done going forward. My thesis concludes with a discussion of potential ways to view this information in the wider healthcare system and suggests ways to support socially vulnerable older adults.

Chapter 2: Do Interventions Reducing Social Vulnerability Improve Health in Community Dwelling Older Adults? A Systematic Review

[published]

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Do Interventions Reducing Social Vulnerability Improve Health in Community Dwelling Older Adults? A Systematic Review

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Background: Social vulnerability occurs when individuals have been relatively disadvantaged by the social determinants of health. Complex interventions that reduce social vulnerability have the potential to improve health in older adults but robust evidence is lacking.

Objective: To identify, appraise and synthesize evidence on the effectiveness of complex interventions targeting reduction in social vulnerability for improving health related outcomes (mortality, function, cognition, subjective health and healthcare use) in older adults living in the community.

Methods: A mixed methods systematic review was conducted. Five databases and targeted grey literature were searched for primary studies of all study types according to predetermined criteria. Data were extracted from each distinct intervention and quality was assessed using the Mixed Methods Appraisal Tool. Effectiveness data were synthesized using vote counting by direction of effect, combining p values and Albatross plots.

Results: Across 38 included studies, there were 34 distinct interventions categorized as strengthening social supports and communities, helping older adults and their caregivers navigate health and social services, enhancing neighbourhood and built environments, promoting education and providing economic stability. There was evidence to support positive influences on function, cognition, subjective health, and reduced hospital utilization. The evidence was mixed for non-hospital healthcare utilization and insufficient to determine effect on mortality.

Conclusion: Despite high heterogeneity and varying quality of studies, attention to reducing an older adult's social vulnerability assists in improving older adults' health.

Keywords: social determinants, older adults, complex interventions, social frailty

Background
What is Social Vulnerability

When two older adults have the same medical conditions and the same degree of frailty, the difference between living independently in the community with supports and requiring admission to a hospital or long-term care facility can be explained by social circumstances. Social vulnerability (SV) is defined as the degree to which a person's overall social circumstances leave them susceptible to further insults (ie health or socially related adverse events).[1]

Social vulnerability occurs when individuals have been relatively disadvantaged by the broader conditions in which they were born, lived, worked and aged; also known as the social determinants of health.[2] Socially vulnerable individuals have variable presentations. For example, an older woman living below the poverty line in a racialized neighbourhood may be vulnerable due to economic and housing reasons but has a robust social network of friends and family. Another example of social vulnerability is the reclusive and wealthy older man who has no one to call in the event of a natural disaster. The commonality is the inability to respond in times of crises due to a social reason (ie poverty or isolation) rather than a health-related reason. Unequal determinants directly impact individuals, but arise from complex political,

social and economic structures. For this reason, the social determinants of health (SDOH) and social vulnerability are often conceptualized through ecological models.[3–5]

How SV Influences Health & How Reducing SV Might Work

The link between SDOH and health is well documented, accounting for 30–55% of adverse health outcomes globally, such as mortality from chronic diseases.[6] The construct of social vulnerability as the manifestation of poor social determinants in an individual is less prominent; nonetheless, being socially vulnerable has been associated with greater mortality,[5,7–10] risk of cognitive decline[11] and disability,[9] and likelihood of long-term care admission.[12] Social divergence theory suggests socioeconomic disparities accumulate with time, resulting in worse health inequities in older age, which are compounded by shrinking social circles due to infirmity and death of friends and family members.[13] Figure 1 shows the associations between SDOH, SV and health outcomes and helps to explain how interventions reducing social vulnerability through the SDOH might work.

Why It is Important to Do This Review

Studying social vulnerability is challenging as complex interrelated pathways by which upstream social factors influence health to do not allow for hypothesis testing through traditional research methods. Moreover, since multicomponent intervention studies rarely distinguish the social components of the intervention, there is little evidence suggesting what can be done to reduce health inequities through the addition of social programs in real life situations. As social determinants research "for the most part exists outside the literature concerned with effectiveness of interventions",[14] especially in non-hospitalized populations,[15,16] this is one gap this review will try to address. To our knowledge, no previous systematic review has attempted to collate and evaluate complex interventions based on a strong social intervention component in older adults. Additionally, for older adults with multiple medical conditions, it is nearly impossible to separate out those who are purely frail from those who are purely socially vulnerable. By accepting that multiple things can go wrong simultaneously in an individual, interventions aimed at social vulnerability cannot ignore medical frailty and vice versa; to do so would continue to fractionate research areas, moving away from treating individuals holistically. Instead, the lens used here to study social interventions within complex interventions accounts for the broader context where older adults would presumably receive both medical and social supports. Combined with a systematic mixed-methods literature review methodology, the authors attempt to answer the broad research question: is there evidence to support the notion that complex interventions targeting reduction in social vulnerability improve health outcomes for older adults living in the community?
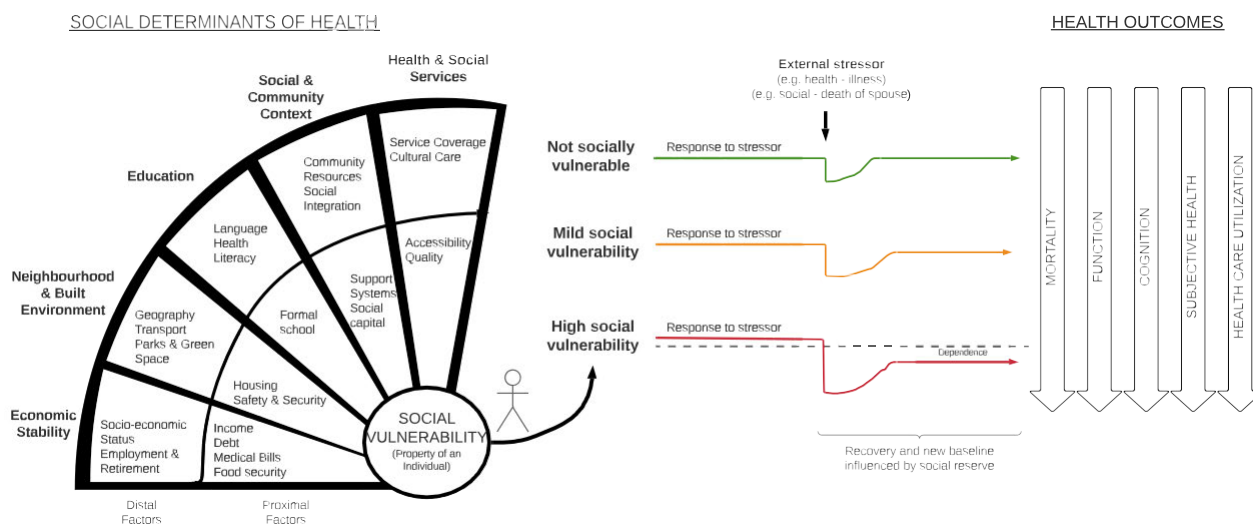
Figure 1 Conceptual model linking the social determinants of health to social vulnerability and health outcomes.

Methods

Review Objectives

To identify, appraise and synthesize evidence on the effectiveness of complex interventions where a main component of the intervention targets reduction in social vulnerability for improving health related outcomes (mortality, function, cognition, subjective health and healthcare use) in older adults living in the community.

Study Design, Search Strategy & Selection Criteria

This systematic review employs a mixed methods approach to synthesizing complex interventions following PRISMA-CI guidelines.[17,18] Five databases were searched for primary studies: Medline, Cochrane Library (CENTRAL), EPPI-Centre's Trials Registrar of Promoting Health Interventions, Campbell Collaboration, and Social Sciences Citation Index. The search strategy in Medline was approved by a medical librarian using the Peer Review Electronic Search Strategies (PRESS) checklist,[19] then translated to the remaining databases (Supplement A provides the complete search strategy). The last search was conducted on May 18, 2021. Reference lists of included studies were also searched. Due to the nature of the interventions of interest, there was a concurrent search of grey literature to find interventions conducted by governments, non-profit or volunteer organizations.[20] This included a targeted website search of known national and international organizations who fund, implement or evaluate social interventions (Administration for Community Living, The Care Policy and Evaluation Centre, Government of Canada, HelpAge International, The International Federation on Ageing and the World Health Organization).

Inclusion criteria is fully described in Table 1 using the PICOT approach. Quantitative, qualitative or mixed studies were included if they investigated complex interventions targeting reductions in social vulnerabilities through the SDOH in a community-dwelling older adult population, and evaluated a priori outcomes of mortality, function, cognition, self-assessed health, hospital use or other healthcare use (primary care visits to doctors or nurses). A common pitfall in complex intervention reviews is the ambiguity of included studies; hence Supplement A3 provides a full list of exclusion criteria with examples. Although closely related, this is not a review of interventions targeting only social isolation, physical fitness or falls prevention, which already have considerable literature bases and excellent systematic reviews.[21–27] The search was limited to English studies from the last ten years, enabling the assessment of practices and challenges relevant in the current political and healthcare climate. This review looked exclusively at active interventions, hereby called social vulnerability interventions, rather than broad governmental policies influencing social vulnerability.

Data Collection & Extraction

Citations were imported into EndNote[31] for de-duplication and title and abstract screening. Then full texts were assessed for relevance to inclusion criteria and reasons for exclusions were recorded. Screening and extraction was conducted by the primary author (JM). Relevant data was collected using a piloted data extraction form (Supplement B) to collect information on: (1) general information, (2) study design (3) population (4) intervention details (5) results and outcomes (6) key author conclusions. Methodological quality was assessed using the Mixed Methods Appraisal Tool (MMAT).[32]

Data Synthesis

Evidence was synthesized using an integrated and aggregated synthesis approach following the Joanna Briggs Institute recommendations.[33] Due to the heterogeneity of the studies' interventions, populations and outcomes/measures, a meta-analysis was not possible as few studies reported sufficient data to calculate standardized effect sizes; nonetheless, three methods of quantitative synthesis were used to answer the primary objective: (1) all studies were synthesized using vote counting based on direction of effect,[34,35] (2) for studies including a control group, p values were combined using Fisher's method to answer the question: "is there evidence of a positive effect on outcome in at least one study" to demonstrate the intervention is beneficial compared to the control,[34] and (3) Albatross plots were constructed for studies with a control group and calculable mean differences, which uses 2 sided p values plotted against sample sizes to estimate a magnitude of intervention effect.[36] Full details and calculations are described in Table 2. Data extraction and synthesis was conducted by one author (JM). A second reviewer also extracted, assessed risk of bias and performed the

Table 1 Search Strategy: Inclusion Criteria, PICOT Format

	Criteria	Details
Inclusion Criteria		
Population (P)	Older adults 60 years of age or older.	Targeted or actual population mean or median age ≥ 60 years old. An established geriatric filter was used in the search strategy.[28]
Intervention (I)	Community-based complex interventions where a main component of the intervention targets at least one social determinant of health, reducing social vulnerability, in the following categories: ● Economic stability ● Education ● Neighbourhood and Built Environment ● Social and Community Context ● Health & Social Services	Guided by left side of the conceptual model in Figure 1. The SDOH categorization comes from the US Department of Health and Human Services.[29] The individual determinants in Figure 1 were chosen by the authors based on expertise of the SDOH in older adults, compiled from SDOH lists by the World Health Organization, Centers of Disease Control and Prevention and the Government of Canada.[6,29,30] The definition of complex intervention follows the Medical Research Council guidance.[17]
Comparison (C)	No comparison, passive comparison (standard of care) or active comparison (variation of intervention) accepted.	Terms comparison and control group used interchangeably in this review.

Outcome (O)	1) Measurable health outcomes:
	  a. Mortality
	  b. Function
	  c. Cognition
	  d. Subjective health or health related quality of life
	2) Utilization of healthcare services
	  a. Hospital or Emergency Department (ED) use
	  b. Other healthcare use –primary care provider visits (physicians or nurses)
		These outcomes were chosen a priori for their relevance to the health of older adults. No limits were placed on type of outcome measurement.

Type of Study (T)	Any interventional study or evaluative study. Qualitative, quantitative or mixed methods.	Expert opinions, reviews, and commentaries were excluded. Protocol papers were excluded, but corresponding authors were contacted for results if the intervention fit the remaining criteria.

quantitative data synthesis on a randomly sampled 25% of the included papers to check that the data extraction and synthesis was consistent (audit results also shown in Supplement D3 and E3). All analyses were conducted with RStudio and Excel.

Results
Results of Search

Of the 5918 citations retrieved, 567 were duplicates, 4457 were excluded after title and abstract screening, and 174 full text articles were obtained (see Figure 2). This review included a total of 38 studies, representing 34 distinct interventions. 52.9% of studies were conducted in the United States.

Description of Interventions

Table 3 (with full details in Supplement C) summarizes the characteristics of each complex intervention and target population, grouped into five categories of reducing social vulnerability. On average, participants were 74.9 years old, 69.6% female and 50.2% lived alone. Social workers and nurses were the most prevalent trained professionals.

Lasting between 10 weeks to 3 years, there were 12 weekly or biweekly programs aimed at strengthening the social supports and communities where older adults live. Eight involved group activities in senior centers, community or public

Table 2 Methods of Quantitative Data Synthesis, organized by descending amount of information provided by synthesis method

Question	Method	Calculation
What is the estimated magnitude of the intervention effect on outcome?	Albatross plot	1. Gather two-tailed p value and direction of effect 2. Plot p value (x-axis) by sample size (y-axis) 3. Estimate effect size contours for mean difference (most common measure in this review). Equation and effect sizes from Harrison et al (2017): $N \frac{1}{4} \frac{4SD^2}{MD^2} Z_p^2$ N=sample size, SD = standard deviation, MD = mean difference, Z = Z-statistic, p = p-value N.b. Only studies with a control or comparison group where mean differences could be calculated were included in Albatross plots.
Is there evidence of a positive effect on outcome in at least one study/intervention?	Combining p values	1. Covert two-tailed p value to one-tailed p value in direction of effect: $p1 \frac{1}{4} \frac{p2}{2}$ or $p1 \frac{1}{4} 1 - \frac{p2}{2}$ 2. Combine using Fisher's method: $X_{2k}^2 \approx 2 \sum_{i \frac{1}{4} 1}^{k} \ln(p_i)$ where p_i is the p-value for the ith hypothesis test 3. Interpret one sided p value against H_0 (no effect in any study)
Is there any evidence of effect?	Vote counting and sign test	1. Count studies with findings in one direction and compare to studies with findings in opposite direction a. To count direction of effect when there are multiple measures within same outcome domain: report direction (positive or negative) when combined outcomes >70% in same direction, report mixed effects when combined outcomes <70% consistency in one direction following the method by Thomson et al (2013)[37] 2. Calculate sign test as a simple binomial experiment (mixed votes excluded from total in sign test) 3. Interpret p value against H_0 (there is an equal number of "signs" or studies) N.b. Vote counting by direction of effect, not by statistical significance. Nonetheless, statistical significance, set at p<0.05, was recorded.

spaces[21,38–45] and 4 involved matched volunteers facilitating social activities.[46–49] The interventions varied from organized group activities[38,39,41–43,45] to sessions promoting health literacy or knowledge of community assets.[21,39,43]

Ranging from 4 to 52 weeks, some interventions helped older adults and their caregivers navigate health and social services. Navigators were community health workers or volunteers,[50–52] social workers[53–56] or consisted of multi-disciplinary teams.[57–63] All took place at home, but 4 were initiated during or shortly after a hospital admission.[50,51,54–56] The Community Aging in Place: Advancing Better Living for Elders (CAPABLE) intervention (and its variations) is noteworthy as it is one of the few that has been implemented in multiple states and cities and has a large evidence base (five studies in 6 citations included for this review).[57–62]

Six interventions worked to enhance the neighbourhood or home built environment. Half provided social services, personalized care coordination, and environmental hazard reduction to affordable housing buildings.[64–66] Two offered private home modifications for safety[67,68] and 1 provided accommodations for an adult in need by placing them in a home of an approved Shared Lives carer.[69]
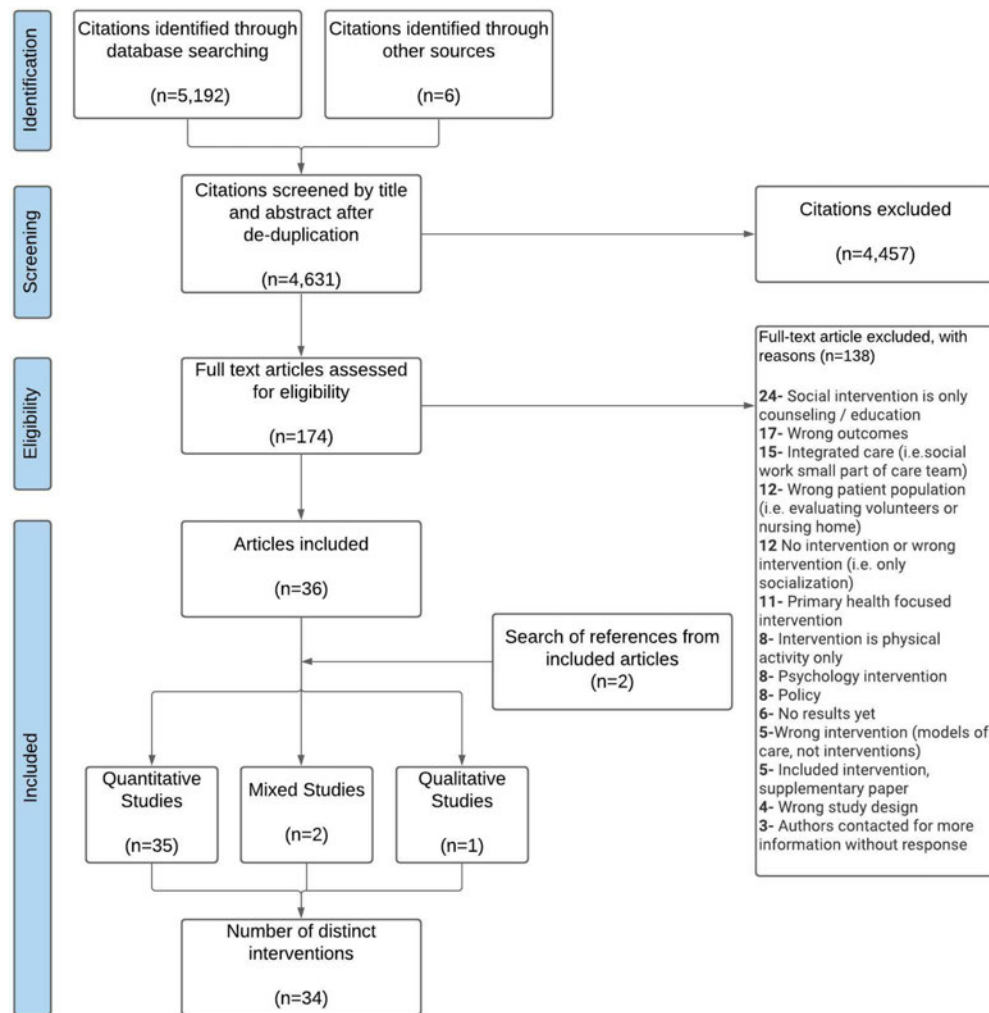
Figure 2 Flowchart of study selection.

Two interventions provided financial assistance to older adults in the form of supplemental income[70,71] or medication co-payment assistance,[72] both followed for 18 months. Three interventions mainly focused on education: 2 as college programs designed for seniors[73,74] and 1 for nutrition.[75]

Description of Study Designs and Quality Assessment

Across all studies, 35 reported only quantitative outcomes, 2 studies used a mixed methodology and one study reported qualitative outcomes. Of the quantitative studies, 9 were randomized controlled trials (RCTs),[38–40,51,58,59,61,70,75] 7 were quasi-experimental studies or longitudinal cohort studies with a control group (hereafter called controlled before after (CBA)),[41,43,47,62,64,67,68] 3 were retrospective cohort studies (RCS),[46,54,65] and 1 study conducted a cross-sectional survey (XCS).[69] The remaining quantitative studies did not have a control group. The mean and median sample sizes of all quantitative studies were 6908 and 242 participants, respectively, ranging from 12 to 172,965 participants. The largest studies were CBA or RCS in study design. Interviews were conducted with 6, 11 and 17 participants in the mixed methods or qualitative studies.

A summary of the individual MMAT scores per question and summary scores per study design are available in Supplement D. No patterns emerged when cross tabulating intervention category with study design. Overall, the quality of the included studies were poor or moderate, with only four studies matching all criteria and deemed high quality.[47,54,59,69] Poor quality studies were not excluded from synthesis.

Table 3 Characteristics and Population of Interventions Included in Review, by Five Categories of Reducing Social Vulnerability

Authors, Reference, Year (Location)	Intervention	Target Population
Intervention Category = [Strengthening] Social and Community Context		
Bae et al, 2019[38] (Takahama City, Japan)	Kenkojiseichi combines group based physical, cognitive, and social activities (16 times each) in 90-minute sessions twice per week for 24 weeks. Supervised sessions consisted of condition checks, stretching, and main activities, followed by report writing and discussion.	Older adults 60 years+ with mild cognitive impairment and without a certification of needing care from Japan's long term care insurance.
Blancafort et al, 2021[39] (Barcelona, Spain)	Sentire-nos Be (Feeling Well) sessions are held weekly for two hours and facilitated in groups of 15 people for 12 weeks. Sessions were delivered in primary care centers or were held in public spaces for social and physical activities.	Community dwelling adults 60 years+ in disadvantaged urban areas who perceived their health as fair or poor.
Boen et al, 2012[40] (Oslo, Norway)	Weekly 3 hour group meeting 35–38 times per year with 7–10 participants. Program included (1) transportation to and from senior center, (2) a warm meal at low cost, and (3) a physical training program developed by physical therapists, run by trained volunteers.	65 years+ living at home in the community, not regular users of the senior center.
Jacobs et al, 2020[47] (California, Florida and New York, USA)	Peer-to-peer (P2P) is a minimum 1-year program matching an older adult with a trained volunteer in the same community. Volunteers provide transportation assistance, check-in calls, social activities, help with shopping, organizing services and trips to medical appointments.	65 years+, living independently in the community, at or below the poverty line, socially isolated, and who have chronic illnesses requiring frequent community resource use.
Hikichi et al, 2015[42] Hikichi et al, 2017[41] (Taketoyo, Japan)	Salons are a community project where seniors congregate and participate in social activities. Popular activities included dance classes, chatting with other participants, arts and crafts, music quizzes and games, and interactive activities with children. Seniors visited 1–3 times per month for 90–120 minutes per session. Fee of 100 yen per visit ($1USD).	All community-dwelling adults 65 years+ adults who were physically and cognitively independent in the town of Taketoyo or the participants in the Aichi Gerontological Evaluation Study.
Harada et al, 2020[43] (Kobe City, Japan)	Tsurukabuto Active Aging Project is an events-based community program organized by Kobe University staff to create opportunities to meet and talk with neighbors and improve neighborhood social networks. Community events once per month include music, lectures about sleep and health promotion, moon viewing, academic festivals, gardening, and group walking.	60 years+, residents of the Tsurukabuto community from the electoral register in Nada Ward.
Liotta et al, 2018[46] (Rome, Italy)	The Long Live the Elderly (LLE) program includes a multi-dimensional evaluation of care needs, an individual care plan including provision of services, periodical phone calls and increased support when needed. The program intensifies when a heat wave occurs, prompting tracing by phone with staff or volunteers bringing food or medicine during home visits.	Population 75 years+ living in three urban areas in Rome.
Chapin et al, 2013[48] (Kansas, USA)	Reclaiming Joy uses dyadic relationships between volunteers and participants to guide participants through goal setting activities and to foster connections to community resources. Meetings once a week for 10 weeks.	64 years+, receiving Medicaid in three regions served by area agencies on aging, with at least one symptom of depression or anxiety.
Daban et al, 2021[44] (Barcelona, Spain)	Weekly outings in disadvantaged neighborhoods facilitated by volunteers using a portable climbing wheelchair to promote social support, group activities and participation activities such as visiting friends, walks, going to the market or attending church.	59 years+, living in isolation in their homes for two or more months due to mobility limitations and/or lack of an elevator in their buildings.
Coll-Planas et al, 2017[21] (Catalonia, Spain)	A coordinated and group-based program aimed at building and strengthening the network between primary healthcare centers, senior centers and other community assets in the neighborhood. Meetings are 1.5 hours a week for 15 weeks and includes (1) social isolation and participation discussions, (2) community assets introductions, (3) visits to community assets including primary care, and (4) arts based activities.	60 years+, community dwelling, who feel lonely "sometimes, often or always", can walk to the center independently, without cognitive decline, able to participate in group dynamic, and does not usually participate in social activities.

(*Continued*)

Table 3 (Continued).

Authors, Reference, Year (Location)	Intervention	Target Population
Chiang and Hsu, 2018[49] (Taichung, Taiwan)	Community Care Centers (CCC) provide health promotion, food services, home visits and telephone greetings. Home visit and telephone greetings are intended to increase social participation and linkages. CCCs are required to be set up in every neighborhood. Programs included physical activities, health knowledge courses, and leisure activities (ie arts).	All older adults living in the community.
Taylor et al, 2017[45] (Queensland, Australia)	Men's sheds provide a variety of activities including woodwork, metalwork, group social events, mentorship, and restoration projects. It is open five days a week and overseen by a management committee.	Men 65 years+, from regional or remote areas, from low socioeconomic areas.
Intervention =[Enhance] Neighborhood and Build Environment		
Park et al, 2021[67] (PyeongChang, South Korea)	Aging Study of PyeongChang Rural Area Intervention Study (ASPRA-IS) is a 24-week multi-component intervention program including home nutritional supplementation, depression management, discontinuation of high-risk medication, home hazard reduction and group exercise training.	65 years+, living in the region, living alone or receiving medical aid (government public assistance program) designated for low-income status.
Castle & Resnick, 2016[64] (Pittsburg, USA)	Staying at Home (SAH) program involves on site (1) Care Coordination, (2) Advanced Planning, (3) Medication Management, (4) Health Care Diary/ Outreach, and (5) All services paid by local health provider.	Older adults living in publicly subsidized elderly high-rise buildings.
Tohn et al, 2020[68] (Connecticut, USA)	An injury prevention intervention was added to the standard weatherization packages. An occupational therapist assessed home injury risk factors and identifies priority modifications to reduce the risk of falls over 5 visits in a year. An energy auditor accompanied the occupational therapist (OT) to improve weatherization.	70 years+ who had a slip or fall in the prior six months, from low-income households with income and eligibility for weatherization services or home energy upgrades.
Gusmano, et al, 2018[65] (New York, USA)	Self-help Active Services for Aging Model (SHASAM) provides social services provided as part of affordable housing. On-site social workers (1) assess residents for existing government programs and entitlements, (2) provide personalized functional and psychological assessments, counseling and advocacy, (3) provide health education and wellness programs, (4) lead physical activity and socialization programs, and (5) provide evaluations for a referral out to additional public services (ie chronic disease programs or in-home safety technology).	65 years+, who live in affordable housing buildings, and who are Medicare beneficiaries.
Callaghan et al, 2017[69] (England, UK)	Shared Lives (SL) is a service where an adult who needs support or accommodation moves into (or regularly visits) the home of an approved SL carer.	65 years+ people with learning disabilities, using any form of SL support with capacity for consent.
Turcotte et al, 2019[66] (Massachusetts, USA)	Community health worker assessment followed by an individualized intervention plan. Home visits consisting of (1) environment mediations such as pest management, mattress encasements, cleaning supplies, and structural interventions like repairing ventilation or plumbing, and (2) culturally and literacy appropriate education.	62 years+ adults with, low-income, diagnosed with asthma by a physician, residing in public and private subsidized housing.
Intervention = [Improving] Navigation of Health and Social Services		
Galbraith et al, 2017[50] Balaban et al, 2015[51] (Massachusetts, USA)	Patient navigators (PNs) conduct introductory visit(s) with the patient and caregivers, then weekly telephone meetings. PNs (1) organize appointments and rescheduling, (2) address barriers to obtaining or taking medications, (3) identify concerning symptoms and facilitate communication with MD offices, (4) assist with transportation, (5) reassess patients' home care needs and make connections to community services, (6) assist with health insurance issues, and support patient self-management, and (7) help patients navigate the health care system.	General medicine inpatients having at least one of the following readmission risk factors: (1) age ≥60 years, (2) any inpatient admission within the past 6 months, (3) length of stay ≥3 days, (4) admission diagnosis of heart failure, or (5) chronic obstructive pulmonary disease.

(*Continued*)

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Table 3 (Continued).

Authors, Reference, Year (Location)	Intervention	Target Population
Evans et al, 2021[54] (Chicago, USA)	The Chicago Southland Coalition for Transition Care program (CSCTC) is a social worker driven care transition program to coordinate post hospital care. Following the Coleman Care Transition Intervention (CTI) model, it (1) manages health care, meds, and nutrition, (2) communicates more effectively with physicians, and (3) connects to community resources such as meal delivery, payment assistance for meds and transportation. CSCTC supplies patients with pharmacy free support services and home-delivered meals.	Four hospitals that serviced 70 low-income zip codes in Chicago Southland area.
Prior et al, 2012[63] (Midwestern, USA)	A faith based, grant funded, community senior outreach program focused on assisting clients towards stabilization of crisis situations and the development of a plan for ongoing social interventions. Clients receive weekly in-home visits for the first 2 to 3 months and biweekly to monthly visits thereafter depending on need. Emphasis placed on utilization of community resources, development of self-management skills, resolution or reduction of in financial concerns and connection with social and family supports. Program monies are utilized to assist with prescription costs, housing, and transportation needs when no other resources are available.	55 years+, with histories of repeated emergency department or hospital visits, who are part of the senior outreach program (usually seniors with< $1000 per month, 1/3 live in subsidized housing).
Scharlach et al, 2015[52] (San Diego, USA)	ElderHelp Concierge Club is a volunteer run membership program. Members receive an assessment for services eligibility which includes: (1) driving, (2) grocery shopping, (3) housekeeping, (4) home maintenance and repair, (5) financial advocacy, (6) friendly visits, (7) and pet care. Dues follow a capitated model and are dependent on income and home ownership.	60 years+, who do not have a condition that would prevent them from participating fully in their own care.
Stevens et al, 2015[55] (Texas, USA)	The community living program (CLP) includes (1) plan of care based on formal assessment, (2) health coaching, (3) money for purchasing formal care ($750/month), and (4) home visits and telephone calls. 6 home visits and 3 telephone calls over 10 months.	60 years+, a resident of central Texas Agency in Aging service area, functionally impaired, memory or health problems that make it difficult to live alone, and availability of informal support system.
Watkins et al, 2012[56] (Southeastern USA)	Hospital to Home Program involves a elder navigator who identifies eligible participants during hospital admission, arranges social supports to begin immediately after discharge, and home visits within 72 hours of discharge. The navigator reviews orders and medications, confirms services and helps the patient and family identify other needs. Services including transportation, light housekeeping, laundry, meal preparation, prescription pick up and grocery shopping were provided at no cost to the patient up to 4 months.	65+, eligible for Medicare ± Medicaid, with chronic conditions, physical disability or functional decline requiring assistance with function, falls, polypharmacy, cognitive decline or depression, nutritional impairment, hip fracture, and limited social support.
Szanton et al, 2011, 2015, 2016, and 2019[57–60] Crews et al, 2019[61] (Maryland, USA) Spoelstra et al, 2019[62] (Michigan, USA)	Community Aging in Place: Advancing Better Living for Elders (CAPABLE) CAPABLE involves ~ 10 in-home sessions, each 60 minutes long, over a 6-month period (depends on paper). It draws upon best practices to enhance uptake and adoption of intervention strategies such as patient-centered care and motivational interviewing. All participants in the intervention received each component of the intervention (assessment, education, interactive identification of barriers to function with joint discussion of possible retraining and solutions), but interventionists customized components to each participant's risk profile and goals. Includes up to $1300 USD for repairs.	65 years+, cognitively intact, difficulty with at least 1 Activity of Daily Living (ADL) or 2 instrumental ADLs, income <200% of federal poverty line.
	Intervention = [Promoting] Education	
Suominen et al, 2015[75] (Helsinki, Finland)	One year intervention with tailored nutritional guidance with home visits, and discussions with the participants and their caregivers every three months with 1–2 group sessions The nutritionist visited each couple between four and eight times according to the participants' individual needs.	A 65 years+ person with dementia living with spouse, able to reach the study place by taxi and stand on a scale, living in the Helsinki metropolitan area, without terminal disease.

(*Continued*)

Table 3 (Continued).

Authors, Reference, Year (Location)	Intervention	Target Population
Jo et al, 2018[73] (Ontario, Canada)	Canada Enoch Senior's College (CESC) runs weekly sessions for a duration of 8–11 weeks biannually. Each day is divided into four time slots. The morning is an organized assembly with short lectures on Korean-relevant topics. Lunch is a traditional Korean style congregate meal. Afternoons are elective classes and small groups (arts, music, technology, medicine, etc.).	Korean immigrant older adults in the Greater Toronto Area.
Molina-Luque et al, 2018[74] (Catalonia, Spain)	Senior Programme of the University of Lieda is a four year program. Senior students choose a field of study that puts into practice their previous knowledge. These students also participate in extra-curricular programs on social innovation for ageing and "together old and young" (TOY) program.	>55 years
Intervention = [Help with] Economic Stability		
Aguila & Smith, 2020[70] Aguila et al, 2015[71] (Yucatan, Mexico)	Reconocer Urbano is a supplementary income program providing a monthly supplement of MXN$550 for 18 months.	All 70 years+ residents who are eligible for supplemental income programs.
Herity et al, 2018 (North Carolina, USA)	Senior PharmAssist optimizes medication management while addressing social determinants. Scheduled meetings occur every 6 months. Meetings with pharmacists for (1) medication therapy management, (2) education, (3) medication copayment assistance, (4) Medicare insurance counseling, and (5) referral to other services. Program flexible (open 40h/week) or provides home visits.	60 years+, Medicare-eligible, have an income of 200% of the federal poverty level or less.

Effects of Interventions

Following quality appraisal, data was synthesized according to intervention category and outcome type (individual results in Supplement E). A visual summary of effect direction by vote counting of all included studies has been tabulated in Table 4. Across all studies, there was a positive direction of effect for function, cognition (borderline), subjective health and decreased hospital use. The sign test for the effect on non-hospital physician or nurse visits was 1, signalling interventions were equally likely to result in increased or decreased healthcare use.

Mortality

Only one study examined mortality as an outcome in relation to a social intervention. The Long Live the Elderly (LLE) study demonstrated a 13% reduction in mortality ($p<0.001$) during the summer of 2015 in urban areas with LLE compared to areas without the program, with indirect evidence to also suggest LLE attenuated the pre-existing association of higher mortality and lower socioeconomic status.[46]

Function

Of the 10 studies, 9 used a measure for ADLs or IADLs;[42,43,52,57–59,61,62,67,70] all but two had a positive direction of effect.[52,59] Across 8 studies with a comparison group, the combined one-sided p value was <0.001, suggesting a positive effect on function favouring the intervention in at least one study. The studies reporting outcomes with calculable mean differences are visualized in Figure 3A with small estimated effect sizes (less than a 0.2 point difference in any measure used). The study of highest quality and design in this review examined the CAPABLE intervention. At its primary endpoint of 5 months, there was a medium improvement in the CAPABLE group's ADL (aOR: 0.70, CI: 0.54–0.93, p=0.01) and IADL scores (aOR: 0.83, CI: 0.65–1.06, p=0.13) but not at 12 months (secondary endpoint).[59]

Table 4 Summary of Direction of Health Impacts from Included Studies Using Vote Counting

Author, Year	Study Design	MMAT Score	Sample (I/C)	Follow Up Time	Mortality	Function	Cognition	Subjective Health	Hospital Use	Other Healthcare Use
Intervention = Social and Community Context										
Bae et al, 2019	RCT	80%	41/83	6 months[a]			◁▷			
Blancafort et al, 2021	RCT	60%	195/195	12 weeks – 9 months[b]				◁▷	Δ	◁▷
Boen et al, 2012	RCT	0%	77/61	12 months[a]				▽		
Jacobs et al, 2020	CBA	100%	222/234	3–12 months					◁▷	
Hikichi et al, 2015 and 2017	CBA	80%	1067/ 13,195(cognition) 246/2175 (function)	5–7 years[a]		▲	▲			
Harada et al, 2020	CBA	60%	173/489	3 years[a]		Δ		Δ		
Liotta et al, 2018	RCS	80%	6483/5724	~1.5 years	▲					
Chapin et al, 2013	UBA	80%	40	90days[b]				Δ		
Daban et al, 2021	UBA	80%	147	6 months[a]				▲		
Coll-Planas et al, 2017	UBA	60%	36	15 weeks				Δ	□	▽
Chiang et al, 2018	XUS	60%	417	n.a			Δ	Δ		
Taylor et al, 2017	MM/ XUS	40%	143	n.a				▽		
Navigation of Health and Social Services										
Galbraith et al, 2017 and Balaban et al, 2015	RCT	40%	747/1190	180 days[a]					Δ	◁▷
Evans et al, 2021	RCS	100%	45,522/ 127,443	7–90 days[a]					▲	
Prior et al, 2012	UBA	80%	193	24 months[b]					▲	
Scharlach et al, 2015	UBA	80%	26	6 months[a]		▽		Δ	Δ	
Stevens et al, 2015	UBA	40%	149	12 months[a]			Δ	Δ	▲	▲
Watkins et al, 2012	UBA	40%	292	30 days - 4 months[b]				▲	Δ	
Intervention = CAPABLE or variation (Navigation of Health and Social Services)										
Szanton et al, 2019	RCT	100%	152/148	5–12 months[b]		Δ ◁▷				
Szanton et al, 2011	RCT	60%	24/16	6 months[b]		Δ		Δ		
Crews et al, 2019	RCT	60%	6/6	5 months[b]		Δ				
Spoelstra et al, 2018	CBA	60%	270/1350	32 weeks[a]		Δ			◁▷	
Szanton et al, 2015 and 2016	UBA	80%	281	5 months[a]		Δ				

(*Continued*)

Table 4 (Continued).

Author, Year	Study Design	MMAT Score	Sample (I/C)	Follow Up Time	Mortality	Function	Cognition	Subjective Health	Hospital Use	Other Healthcare Use
Intervention = Neighbourhood and Built Environment										
Park et al, 2021	CBA	80%	187/196	3–30 months[a]		Δ				
Castle et al, 2016	CBA	40%	736/399	6months – 3 years[a]				▲	▲	▼
Tohn et al, 2020	CBA	40%	49/35	6 months[b]					Δ	
Gusmano et al, 2018	RCS	60%	1248/15,947	1 year[a]					▲	
Callaghan et al, 2017	XCS	100%	121/121	n.d				▲		
Turcotte et al, 2019	UBA	60%	93	12 months[a]				▲	Δ	▲
Intervention = Education										
Suominen et al, 2015	RCT	60%	50/49	12 months[a]				▲		
Jo et al, 2018	MM/ UBA	80%	79	8–11 weeks				Δ		
Molina-Luque et al, 2018	Q	20%	6	4 years			Δ			
Intervention = Economic Stability										
Agulia et al, 2015, 2020	RCT	80%	1146/510	6–18 months[a]		▲	▲			▽
Herity et al, 2018	RU	60%	191	6–24 months[a]				▲	Δ	
Vote Counting using Sign Test										
Votes showing benefit/Votes showing harm/Votes with mixed results					1/0/0	8/1/1	5/0/1	15/2/1	12/0/3	2/3/2
Two sided sign test					n.a.	**0.039**	0.06	**0.002**	**<0.001**	1.00

Notes: Effect direction: upward arrow (Δ▲) = positive health impact or reduction in health service use, downward arrow (▽▼) = negative health impact or increase in health service use, sideways arrow (◁► or ◄▷) =mixed effects/conflicting findings as multiple outcome measures, square (□) = results not displayed and text states no difference in effect. Synthesis of multiple outcomes within same outcome domain: report direction (positive or negative) when combined outcomes >70% in same direction, report mixed effects when combined outcomes <70% consistency in one direction. Statistical significance: filled arrow = met statistical significance, empty arrow = did not met statistical significance at p<0.05. Synthesis of statistical significance of multiple outcomes within same outcome domain: report as statistically significant >60% of outcomes statistically significant, report as not met statistical significance if <60% of outcomes statistically significant. Statistical tests reported according to following hierarchy depending on availability: Controlled studies: differences between control and intervention group at follow up > changes within intervention group only at follow up. Uncontrolled studies: change since baseline
Follow up: [a]Time from start of intervention, [b]Time from end of intervention.
Abbreviations: n.a., not applicable; n.d., not described; Study design: RCT, randomized controlled trial (includes cluster, parallel and waitlist); CBA, controlled before and after study; RCS, retrospective controlled study; XCS, cross-sectional controlled study; UBA, uncontrolled before and after study; RU, retrospective uncontrolled study; XUS, cross-sectional uncontrolled study; MM, mixed methods; Q, primary qualitative study; MMAT, Mixed Methods Appraisal Tool.
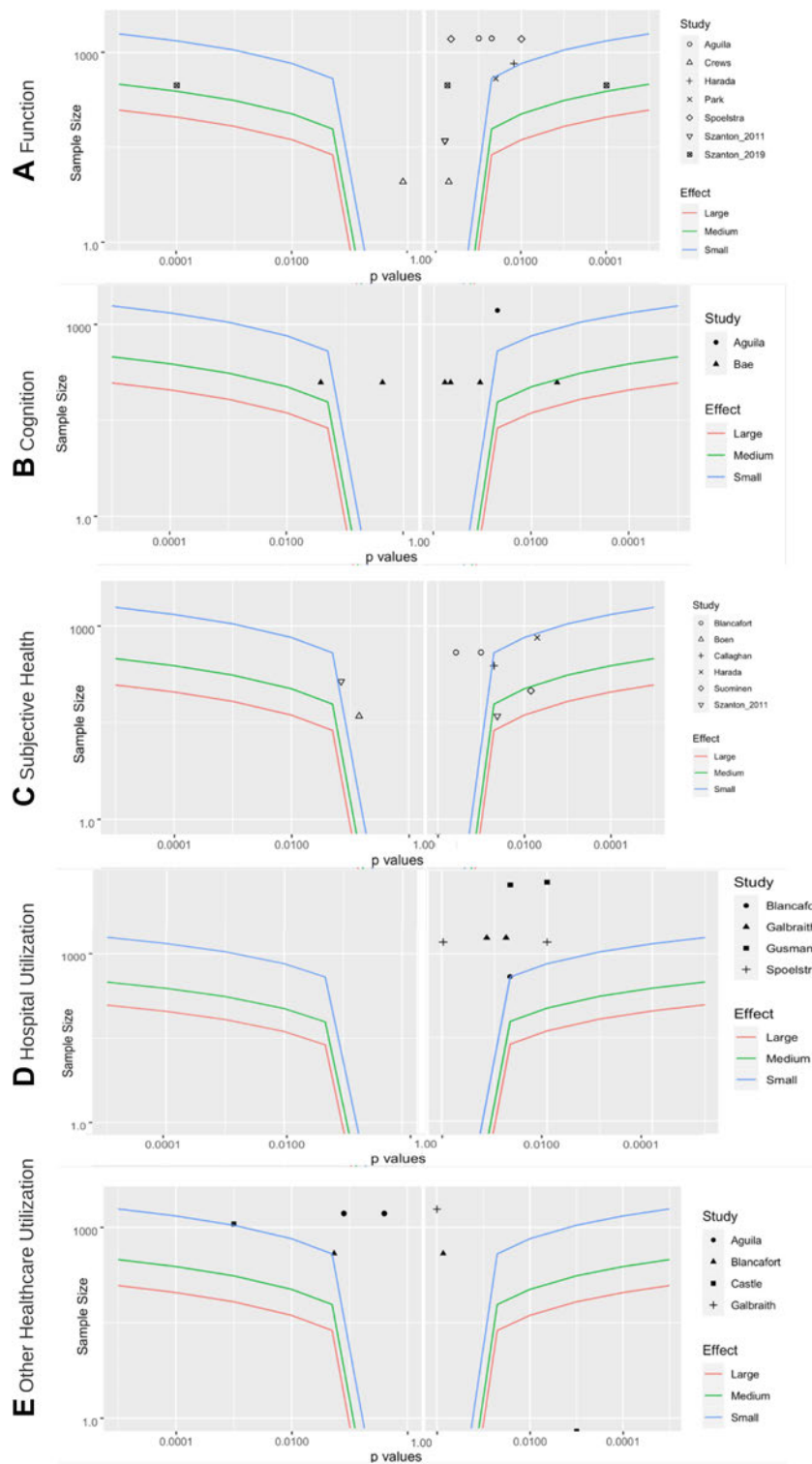
Figure 3 Albatross plots depicting the association between interventions and five health outcomes (**A** – function, **B** – cognition, **C** – subjective health, **D** – hospital utilization, **E** – other healthcare utilization). Effect size contours represent mean differences of 0.2 (small), 0.5 (medium) and 0.8 (large). The left wings represent a negative association, the right wings represent a positive association and a p value of 1.00 represents a null effect.

Cognition

Five out of 6 studies demonstrated benefit on cognition as an outcome of interest.[41,49,55,70,74] Three of the interventions focused on strengthening social and community participation.[38,41,49] Of the studies with a control group, there was strong evidence of cognitive benefit in at least one study using eight distinct measures of cognition (p<0.001, 3 studies). One RCT reported mixed results with statistically significant benefits on spatial memory only out of 6 cognitive measures.[38] Another demonstrated improved verbal recall in the intervention group at 6 and 12 months.[70] The estimated effect sizes from the two RCTs are presented in Figure 3B.

Subjective Health

Subjective health (self-perceived or self-reported) or health related quality of life was the most commonly evaluated outcome in 18 studies;[21,39,40,43–45,48,49,52,55,56,60,64,66,69,72,73,75] but was also the outcome with the highest proportion of uncontrolled studies. Notably, at least half of all studies in each intervention category measured subjective health. Combining the p values from the controlled studies suggest we reject the null hypothesis of no benefit in any study (p<0.001, 7 studies). The Albatross plot is depicted in Figure 3C and the estimated average effect size ranges from a small to medium improvement in subjective health.

Hospital Utilization

ED visits or hospitalizations were assessed in 15 studies; 80% reported reduced hospital use.[39,50,52,54–56,63–66,68,72] Combining p values implies strong evidence (p<0.001, 8 studies) of positive effect on reducing hospital use but Figure 3D suggests any size of effect would be small.

Other Healthcare Utilization

Three studies reported increased primary care provider visits[21,64,70] and two studies reported decreased visits[55,66] although the latter were both uncontrolled before after (UBA) studies of low quality. Within studies, this outcome varied as well; for example, in one study the intervention decreased physician visits but increased nursing visits.[39] The calculated combined p value of 4 controlled studies was 0.98 (accepting the null of no benefit of social interventions collectively on primary care provider visits), reflected in Figure 3E.

Discussion
Summary of Results

By counting direction of effect in all studies, the authors show there is a signal for effectiveness on function, subjective health and hospital utilization outcomes greater than chance alone for complex interventions with a main component of the intervention targeting social vulnerability. Then, combining p values of studies with a control group provided strong evidence (p<0.001) that at least one of the interventions improved function, cognition, subjective health and hospital utilization in a positive direction, although the effect sizes estimated with the Albatross plots were small (possible exception of a medium effect size for subjective health). There was an inadequate number of studies evaluating death as an outcome, but the sole study showed a statistically significant reduction in mortality. There is no evidence to suggest the interventions in this review had a consistent impact on primary care utilization. Although a positive effect was coded as a reduction in healthcare utilization, increasing physician and nursing visits can be seen as a good outcome in certain circumstances (ie for older adults in need but with reduced access) and should be considered in the interpretation of results. The complex interventions also demonstrated substantial variations in the program components, settings within the community and targeted older adult population. This review aligns with a recent systematic review and meta-analysis also addressing the gap between social interventions and measuring objective health outcomes, which concluded governmental social policies are an overall promising way to improve population health but noted that studies are often underpowered to detect a health effect, which offers an explanation for the small or null associations found by this review.[76]

Strengths & Limitations

This review is novel in that it has attempted to describe, and synthesize, complex interventions where the common thread is a strong focus on social interventions. This review looks at effectiveness on objective health outcomes, as opposed to the more common health outcomes of self-perceived improvements, lifestyle changes or surrogate markers (ie increased physical activity);[15] albeit, the measured outcomes may not reflect those that are most valued by older adults. By including all types of studies, we are able to determine, in principle, that complex interventions focusing on reducing social vulnerability as a key intervention component does improve health outcomes. However, the choice to lump interventions instead of splitting the complex interventions means that the question of which type of intervention, for which populations, or which components of the intervention are most effective remains unanswerable. For example, Cappelli et al's recent review on social vulnerability suggested the quality of social relationship was a key factor in protecting older adults from functional decline.[77] Future research could answer this latter question using component network meta-analytic methods as recommended by the Cochrane Collaboration.

The biggest challenge of this review was managing the heterogeneity of the targeted populations, the SDOH addressed, and the measurement of health outcomes; hence synthesis via a meta-analysis was not feasible nor was answering questions of effect size and relative weights of each study according to quality. Generalizing across studies is also problematic given that 12 different countries and 34 distinct complex interventions, each with multiple components, are included in the findings. How much an intervention can impact is influenced by national or regional health and social policies. For example, the North American navigator interventions may not be as effective in Japan where older adults are automatically assessed for community resources under the national long-term care insurance scheme. Since the same intervention will have varied effects in different populations when the distributions of SDOH supports differ, there is a practical benefit of including all study types in this review, not only the ones with the best evidence or the most funding for a robust study design. Even if only RCTs were examined, the gold standard's emphasis on "average effects" would not solve the problem of generalizability, nor would it help policymakers implement an intervention in their specific context. Said another way, the authors recognize that complexities create less definitive causal inferences which is a limitation of the review, but continue to search for methods to answer these types of questions without artificially fragmenting the duality of medical and social frailty.

The authors also recognize that this is a synthesis of social interventions that targeted reductions in social vulnerabilities through the social determinants. However, this is not the same as assuming the participants of the included studies were at the same level of baseline social vulnerability, which is another study limitation. A review of this nature, looking at interventions for a defined population with known social disadvantages would be a worthy endeavor.

While this review followed rigorous PRISMA-CI methodology, a single reviewer conducted the screening, data extraction and analysis as part of her doctoral studies. Ideally, a double screening and extraction approach would have been carried out to increase internal validity and reliability, and reduce the chance of random error or personal bias. However, since there was significant consultation between the authors to ensure adherence to the pre-established review protocol and to ensure consensus for any difficult screening questions, it is unlikely that double screening would change the overall findings of this paper.

Clinical, Research and Policy Relevance

Investing in social interventions to improve health has strong intuitive appeal, fundamentally based on the assumption that better population health requires interventions for socially vulnerable older adults. The question of how effective SV interventions may be remains difficult to answer with this review providing a small, but certain positive signal of effect among 34 complex interventions with a strong social focus. Furthermore, the findings of this review challenge researchers in this area to develop or revitalise research methodologies that can make cohesive sense of the heterogeneity of these studies, of the pragmatic nature of social interventions and of the wide variety populations. By providing evidence for the collective effectiveness and practicability of such interventions, there are implications for clinicians, policymakers and older adults themselves to implement and advocate for social interventions that will benefit their communities with objective health improvements as a motivator.

Conclusion

Attention to reducing an older adult's social vulnerability may be helpful in accomplishing improvements to health. Complex interventions with a main component of the intervention targeting social vulnerability showed evidence of positive effects on function, cognition, subjective health and reduced hospital utilization. Moreover, this review demonstrates heterogeneity in intervention type and quality of studies and supports the need for more research in this area.

Abbreviations

aOR, adjusted odds ratio; CBA, controlled before & after study; CDC, Centers for Disease Control and Prevention; CI, confidence interval EPPI, Evidence for Policy and Practice Information and Co-ordination Centre; MMAT, Mixed Methods Appraisal Tool; OT, occupational therapist; PICOT population, intervention, comparison, outcome, type of study; PRESS, Peer Review Electronic Search Strategies; Q, qualitative; QoL, quality of life; RCS, retrospective controlled study; RCT, randomized controlled trial; RU, retrospective uncontrolled study; SDOH, social determinants of health; SV, social vulnerability; TRoPHI, Trials Registrar of Promoting Health Interventions; UBA, uncontrolled before after study; USA, United States of America; WHO, World Health Organization; XCS, cross-sectional controlled study; XUS, cross sectional uncontrolled study.

Author's Information

This work is a modified and shortened version of the primary author's comprehensive exams written as part of her doctoral program.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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KR is President and Chief Science Officer of DGI Clinical, which in the last five years has contracts with pharma and device manufacturers on individualized outcome measurement. In 2017 he attended an advisory board meeting with Lundbeck. Otherwise any personal fees are for invited guest lectures and academic symposia, received directly from event organizers, chiefly for presentations on frailty. He is Associate Director of the Canadian Consortium on Neurodegeneration in Aging, which is funded by the Canadian Institutes of Health Research, and with additional funding from the Alzheimer Society of Canada and several other charities, as well as, in its first phase (2013–2018), from Pfizer Canada and Sanofi Canada. He receives career support from the Dalhousie Medical Research Foundation as the Kathryn

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Chapter 3: Social Vulnerability Indices: A Scoping Review

[published]

Mah JC, Penwarden JL, Pott H, Theou O, Andrew MK. Social vulnerability indices: a scoping review. BMC Public Health. 2023 Jun 28;23(1):1253.

Social vulnerability indices: a scoping review

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Melissa Kathryn Andrew[5]

Abstract

Background Social vulnerability occurs when the disadvantage conveyed by poor social conditions determines the degree to which one's life and livelihood are at risk from a particular and identifiable event in health, nature, or society. A common way to estimate social vulnerability is through an index aggregating social factors. This scoping review broadly aimed to map the literature on social vulnerability indices. Our main objectives were to characterize social vulnerability indices, understand the composition of social vulnerability indices, and describe how these indices are utilized in the literature.

Methods A scoping review was conducted in six electronic databases to identify original research, published in English, French, Dutch, Spanish or Portuguese, and which addressed the development or use of a social vulnerability index (SVI). Titles, abstracts, and full texts were screened and assessed for eligibility. Data were extracted on the indices and simple descriptive statistics and counts were used to produce a narrative summary.

Results In total, 292 studies were included, of which 126 studies came from environmental, climate change or disaster planning fields of study and 156 studies were from the fields of health or medicine. The mean number of items per index was 19 (SD 10.5) and the most common source of data was from censuses. There were 122 distinct items in the composition of these indices, categorized into 29 domains. The top three domains included in the SVIs were: at risk populations (e.g., % older adults, children or dependents), education, and socioeconomic status. SVIs were used to predict outcomes in 47.9% of studies, and rate of Covid-19 infection or mortality was the most common outcome measured.

Conclusions We provide an overview of SVIs in the literature up to December 2021, providing a novel summary of commonly used variables for social vulnerability indices. We also demonstrate that SVIs are commonly used in several fields of research, especially since 2010. Whether in the field of disaster planning, environmental science or health sciences, the SVIs are composed of similar items and domains. SVIs can be used to predict diverse outcomes, with implications for future use as tools in interdisciplinary collaborations.

Keywords Social vulnerability, Social vulnerability index, Indices, Disaster planning, Environment, Climate, Tools

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Background

There has been increased interest in understanding social vulnerability within medical sciences and medical practice. Social vulnerability in medicine is bi-directional; it contributes to the factors which increase risk of adverse health conditions and has practical implications for arranging supports after an adverse health event. Social vulnerability provides a way to understand how the broader conditions in which people are born, live, work and age can worsen an unfortunate event (e.g., a health crisis) into a veritable disaster [1, 2]. Reducing social vulnerability through modification of social conditions opens intervention opportunities to prevent or reduce suffering after a health event.

A better understanding of social vulnerability can be elucidated by examining interdisciplinary social vulnerability research. Social vulnerability has roots in a rich and evolving literature base involving various natural, health and social disciplines. For example, a review of social vulnerability in climate change helps make sense of the complexity of this concept [3]. Assessing social vulnerability enables the separation of the biophysical dimension from the human and social dimension of susceptibility to climate events [3]. Moreover, social vulnerability as a concept reflects both the capacity of a system to respond from an impact as well as an intrinsic lack of capability of individuals to cope with external stressors [3]. Another common working definition in disaster planning refers to the "characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" [4], often compounded by the inability of the external system to respond. Similarly, adverse events, whether disaster or health-related, tend to expose, and make it possible to capture, the pre-existing social inadequacies that make individuals or communities disproportionately vulnerable. When we apply this to social vulnerability within medicine, it can be viewed as describing the non-health dimensions that keeps individuals incapacitated longer than expected (e.g., in hospital unable to return home) because of social circumstances close to the individual (e.g., marital status) but also because of social support systems that fail to respond or perpetuate vulnerability (e.g., lack of affordable housing for people with disabilities).

Regardless of field, social vulnerability research strives to understand the social environment not just as a descriptor but as a predictor of vulnerability relative to changes in the environment, social circumstances, disasters, or health status [1, 5–7]. To this end, estimating and quantifying social vulnerability is necessary. A common way to estimate social vulnerability is through an index aggregating social indicators. This approach has several benefits, including the opportunity to include variables from different categories of social factors (e.g., socioeconomic status, social engagement, social capital) instead of a one-at-a-time approach [1]. An index does not arbitrarily separate related factors into distinct categories for separate analysis. Moreover, it allows for gradations in social vulnerability (instead of binary or ordinal social variables) and for scaling to account for different units of analysis [1, 8]. In practical terms, an index overcomes the following dilemma. Two households with an average income below the poverty line may be classified as vulnerable in a study examining household income. Suppose one household comprises a recently graduated, working-age, married couple well integrated into the community with strong social ties, and the other is an older adult living off government assistance with no friends or family who could help in a time of need. Thus, there are two distinct tiers of social vulnerability not captured by examining household income alone.

One problem with an index approach is deciding which social factors to include in a social vulnerability index. Items to be included can be limitless or highly context dependent. Cutter and colleagues [9] have previously noted that there are no accepted sets of variables for vulnerability to climate change, but there is general consensus on using age, gender, race and socio-economic status; while necessary, these four factors are insufficient to give the full picture of social vulnerability. Furthermore, a worthwhile endeavour may be to create a social vulnerability index relevant to medical and health contexts, yet there have been only a few social vulnerability indices published specific to medicine [10–12]. Looking at the social factors composing these few indices relevant to medicine does not provide breath of social conditions if we understand social vulnerability to be an interdisciplinary concept encompassing both the individual's and system's inability to cope. Expanding this pool of commonly used variables to include in a social vulnerability index would provide additional benefit for future indices, and for indices relevant to medicine.

This scoping review broadly maps the literature on social vulnerability indices. Our three main objectives were: (1) to characterize social vulnerability indices, (2) to understand the composition of social vulnerability indices, and (3) to describe how these indices are utilized in the literature.

Methods

This scoping review uses the Arksey and O'Malley framework refined by Levac, Colquohoun, and O'Brien [13, 14]. We also followed the PRISMA checklist for scoping reviews (see Additional file 1).

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Information sources

An electronic search was carried out to locate publications in the following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE), Embase, Social Science Citation Index (SSCI), Cumulative Index to Nursing & Allied Health (CINAHL), Public Affairs Index, and Environment Complete from inception to December 1, 2021. No other search terms were included given the specificity of the term "social vulnerability index.mp" or "social vulnerability indic*.mp". We used the web-based platform Covidence® as the primary screening tool.

Eligibility criteria

The following inclusion criteria were adopted: (i) original research; (ii) published in English, French, Dutch, Spanish or Portuguese (languages spoken or read by the research team or affiliates); (iii) and which addressed the development or use of a social vulnerability index (hereafter called 'SVI'). We excluded studies: (i) where a larger index incorporated an SVI and that larger index no longer focused on social vulnerability; (ii) analyzing social factors individually and not the index itself; and (iii) including non-human participants.

Screening process

Titles and abstracts of search records were screened by two team members independently. We also worked independently to review the full texts of records deemed potentially eligible after the title and abstract screening phase, excluding publications that did not meet the inclusion criteria. Any disagreements were decided by consensus or judication by a third author.

Data charting process

We extracted data using a piloted data collection form including general study information (reference, year, location), study objective, population, the field of study (we decided a priori to categorize this by: (1) environment, climate or disaster, (2) health or medicine, or (3) other), and composition of the social vulnerability index (items, calculations, scale of measurement, underlying theory). Here, SVI items were the individual questions or statistics (e.g., proportion of institutionalized individuals in a region) comprised in an index. Each SVI constituted one observation in the charting of the index composition and multiple studies using the same constructed SVI were linked. We hand searched reference lists and reported on the earliest publication of the original SVI. Complete information was extracted for studies describing an original SVI (defined by the review authors as the first published study that describes an SVI with

least five different items/domains from a previous SVI and a 25% change in a previous SVI's items). To answer objective 2 regarding the composition of the indices, we established this criterion to avoid overrepresentation of items/domains from frequently replicated SVIs (which may have been reproduced in other datasets with only a few items or domains added or dropped). For studies using a previously described index (hereafter called 'replications'), we extracted only general information, population unit, field of study, study objectives and outcomes when the SVI was included in predictive modelling. We also emailed authors to get additional information when necessary.

Synthesis methods

Simple descriptive statistics and counts synthesized the extracted data. We also documented when the SVI was used in an environmental, disaster management, or climate change-related field and when the SVI was used in a health or medicine-related field. To better understand the composition of the SVIs, we tallied each item and re-aggregated the items into domains. The domains were derived from a thematic aggregation of the items in an iterative and consensus-based approach. Finally, we report on a subset of studies that used an SVI to predict outcomes. If the purpose of the SVI was predictive, we recorded and counted the outcomes.

Results

Summary of search

The search retrieved 1,126 records of which 515 were duplicates. After screening of titles and abstracts, 187 records were excluded, and 424 full text articles were obtained (see Fig. 1). There are 292 studies included, of which 118 studies examined original SVIs and 174 studies examined replicated SVIs. Of the 118 studies which examined original SVIs, three of the studies examined two SVIs each, therefore the number of original SVIs is 121 (Additional file 2 provides complete references divided into original and replicated SVI studies).

Study characteristics

The study characteristics are summarized in Table 1 with full details of each SVI available in Additional files 3 and 4. Overall, 53.4% of studies (156/292) reported on the SVI in relation to the fields of health or medicine. Among original SVIs, most were developed for an environmental or disaster planning field (90/118). Of the 292 included studies, 42.8% were conducted in the United States of America (USA) followed by Brazil (18.8%), and 49.7% of studies were conducted after 2019.

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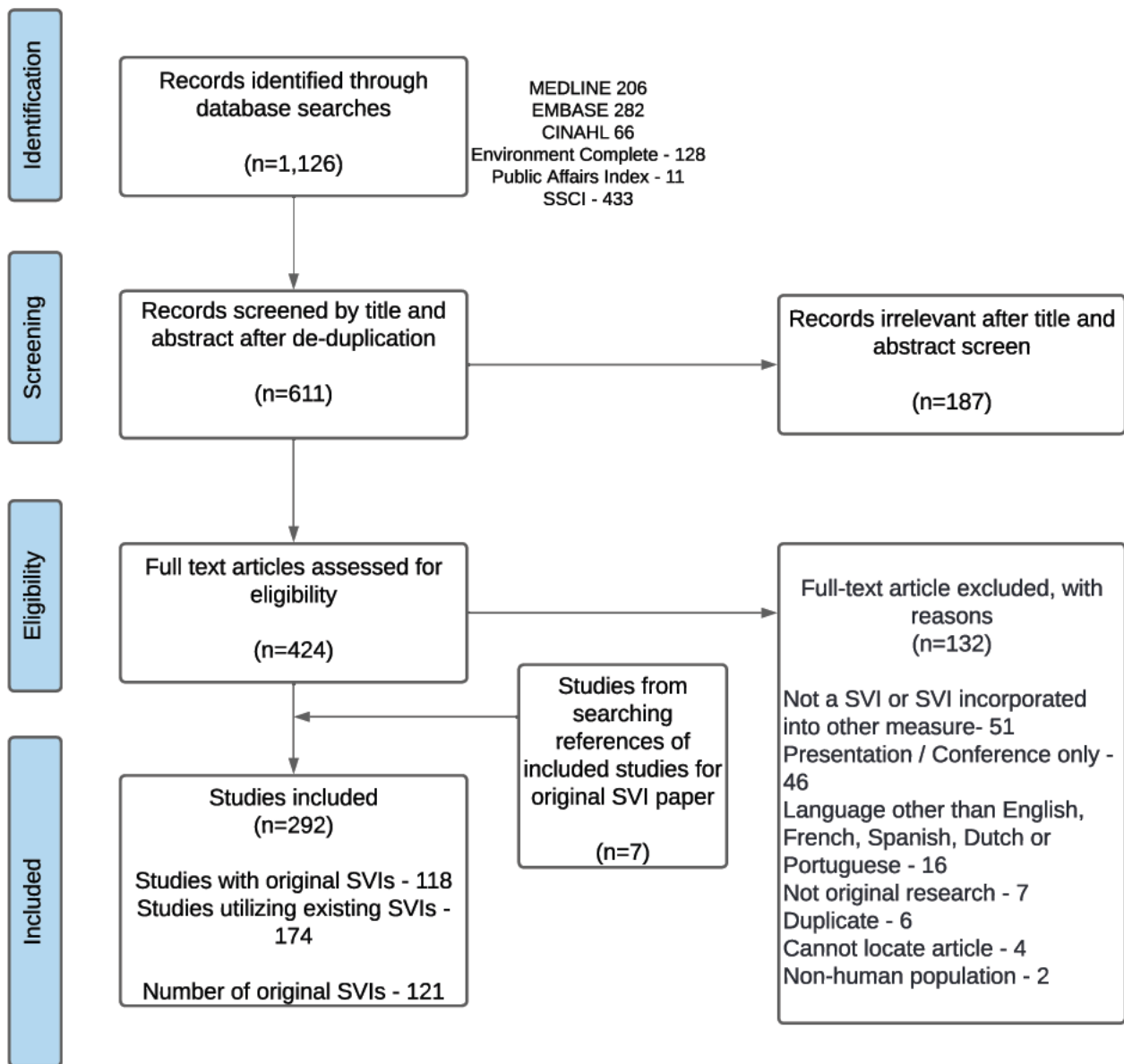
Fig. 1 Study selection

Replications

There were 174 studies that used existing SVIs in their research (replications). The most commonly used original SVIs were: the Centers for Disease Control and prevention / Agency for Toxic Substances and Disease Registry's (CDC/ATSDR) SVI [15], the Social Vulnerability Index (SoVI) by Cutter et al. [9], the SVI by Nahas et al. [16], the Brazilian Social Vulnerability Atlas [17] and the Índice Paulista de Vulnerabilidade Social [18]. The CDC/ATSDR SVI was cited in 51.7% of studies. Most replications (83.3%) were used in papers related

to health or medicine. Additional file 4 provides the frequency of replications for each original SVI.

SVI composition

The mean and median number of items per SVI was 19.3 (SD 10.5) and 18, (IQR 16) ranging from indices with four items [19, 20] to 60 items [21]. SVIs primarily in environment, climate or disaster studies had a mean of 18.8 (SD 10.0) items compared to 21.0 (SD 12.5) items in SVIs in the health or medicine studies. Items were weighted in

Table 1 Study characteristics

Articles	All		Environment, Climate or Disaster		Health or Medicine		Other[a]	
	292		126		156		10	
	n	%	n	%	n	%	n	%
Year								
Before 2000	1	0.3	0	0.0	1	0.6	0	0.0
2000–2004	4	1.4	2	1.6	2	1.3	0	0.0
2005–2009	8	2.7	4	3.2	3	1.9	1	10.0
2010–2014	39	13.4	22	17.5	17	10.9	0	0.0
2015–2019	95	32.5	59	46.8	33	21.2	3	30.0
After 2019	145	49.7	39	31.0	100	64.1	6	60.0
SVI								
Original	118	40.4	90	71.4	26	16.7	2	20.0
Replicate	174	59.6	36	28.6	130	83.3	8	80.0
Country								
USA	125	42.8	33	26.2	86	55.1	6	60.0
Brazil	55	18.8	5	4.0	47	30.1	3	30.0
China	22	7.5	22	17.5	0	0.0	0	0.0
Canada	8	2.7	1	0.8	7	4.5	0	0.0
Italy	5	1.7	4	3.2	1	0.6	0	0.0
Romania	5	1.7	5	4.0	0	0.0	0	0.0
India	4	1.4	3	2.4	1	0.6	0	0.0
South Africa	4	1.4	3	2.4	1	0.6	0	0.0
Australia	3	1.0	3	2.4	0	0.0	0	0.0
Indonesia	3	1.0	3	2.4	0	0.0	0	0.0
Multiple in Africa	3	1.0	2	1.6	1	0.6	0	0.0
Netherlands	3	1.0	2	1.6	1	0.6	0	0.0
Spain	3	1.0	3	2.4	0	0.0	0	0.0
Taiwan	3	1.0	2	1.6	1	0.6	0	0.0
Zimbabwe	3	1.0	3	2.4	0	0.0	0	0.0
Other[b]	38	13.0	30	23.8	7	4.2	1	10.0
Multiple countries	5	1.7	2	1.6	3	1.9	0	0.0

[a] Other means mix of fields or another field altogether (e.g., social work, urban design)

[b] Other countries (*n* < 3) included: Algeria, Argentina, Austria, Bangladesh, Barbados, Benin, Botswana, Chile, Colombia, Dominican Republic, France, Egypt, Ghana, Greece, Honduras, Hong Kong, China, Iran, Israel, Japan, Kenya, Lesotho, Liberia, Mexico, Nepal, Nigeria, Pakistan, Palestine, Peru, Philippines, Portugal, Samoa, South Korea, Sri Lanka, Vietnam, Zambia

43.8% of all SVIs. Almost all SVIs were numeric scales (98.3%).

As shown in Fig. 2, among all SVIs, 55.4% of the items came from census data, 13.2% had items from population surveys, 5.0% from administrative data, 4.1% from clinical datasets and 2.5% from other sources (e.g., data collected specifically for the SVI). Notably, 19.8% of SVIs were composed of items from at least two of the data types listed previously. Items from SVIs in fields of environment, climate or disaster were collected primarily from census repositories (62.0%) such as the United States Census of Population and Housing, Israeli National Census [20], Barbados' national decennial census [22], etc., or national geographic data such as Taiwan's National Geographic Information System [23]. In comparison, studies that included SVIs in health or medicine collected their items 29.6% of the time from census data and 33.3% of the time from population surveys such as the Survey of Health, Ageing and Retirement in Europe [11], Climate Change in the American Mind survey [24], Canadian National Population Health Survey [12], among many others. There were several unique ways to determine the items in an SVI. For example, in one study, items were initially identified through a round of qualitative interviews and a Delphi survey of local professionals and decision makers resulting in a household survey comprised of

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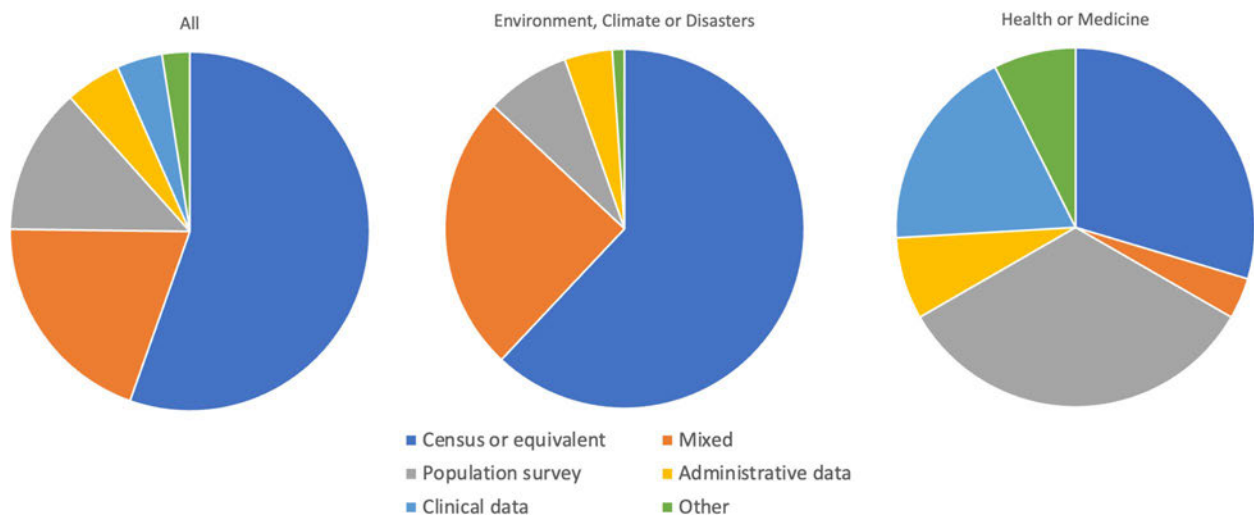
Fig. 2 Sources of data for SVI items

the items of interest [25]. In another study conducted in Kenya, the items and their coding arose solely from focus groups and qualitative work [26].

Items and domains
In total, there were 122 distinct items identified. We categorized these items into 29 domains shown in Table 2. The top three domains included in the SVIs were: at risk populations, education and micro level socioeconomic status. Of the 121 original SVIs, 76.0% included an item in the domain of at-risk populations. More (87.0%) environment, climate or disaster SVIs included this domain than health or medicine SVIs (40.7%). Of the 92 SVIs which included an item within the domain of at-risk populations, an item about older adult populations (terms senior or elderly were often used) was most common in 84% of SVIs. In the health or medicine SVIs, the most common item for at risk populations was regarding dependent populations.

Education was the second most common domain amongst all SVIs (74.4%) and equally prevalent in SVIs from all fields of study. The third most common domain was an item about individual level socioeconomic status. These items asked directly about income or wealth, sources of income, debt or savings, or food insecurity. This is different than macro level markers of socioeconomic status asked in 42.1% of SVIs where the questions focused on community poverty level, gross domestic product, or trade statistics per geographic region.

The least common domains were political instability and pollution. Only 6 SVIs included questions on displaced refugees or political armed conflict. Three SVIs inquired directly about noise or air pollution.

Interestingly, a minority of SVIs (6.6%) included items about health conditions, most of which from SVIs used in environment, climate or disaster planning fields, including one item on diseases after a flood.

The full list of items and their frequencies are provided in Additional file 5 divided by field of study as there were differences in SVI composition across fields. For example, items about social connection and capital were more likely to be included in SVIs used in health or medicine (59.3%) than environment, climate, or disaster SVIs (10.9%). There were few SVIs in health or medicine which included items about safe water and waste disposal compared to 31.5% of environmental, climate or disaster SVIs. Education, socioeconomic status and transport were equally common domains among all SVIs.

Outcomes
SVIs were used to predict outcomes in 47.9% (140/292) of studies, more so in health or medicine studies (124/156) and in studies including replicated SVIs (121/174). As shown in Fig. 3, rate of Covid-19 infection or mortality was the most common outcome measure, evaluated 32 times. SVI was significantly associated with mortality in 85.1% of 27 cases. Other common outcomes studied in association with SVI were access to healthcare services or resources and surgical access or outcomes (14 times respectively). For all seven outcomes (Covid-19, mortality, surgery, healthcare services or resources, infectious disease incidence, dentition and frailty) with at least five studies, SVI significantly predicted direction of outcome in more than 75% of the studies except for the outcome of dentition.

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Table 2 All original SVI domains and items, in descending proportion

Domains and Items in > 50% of SVIs	Domains and Items in 20–50% of SVIs	Domains and Items in < 20% of SVIs
At risk populations (76.0%)	**Gender or Sex (49.6%)**	**Disaster Preparedness (19.0%)**
Older Adults	**Density (47.1%)**	Access to Internet, Phone or Radio
Children	Population Density	Community Disaster Resources
Dependents	Urban or Rural	First Responders
Institutionalized	Building Density	**Marital Status (18.2%)**
Child Laborers	**Macro Level Socioeconomic Status (42.1%)**	**Land Use (17.4%)**
Teen Pregnancy	Community Poverty or Standard of Living	General Land Use
Victims of Domestic Violence	Gross Domestic Product or Community	Farming or Soil Use
Education (74.4%)	Finances	Forest
Micro Level Socioeconomic Status (66.1%)	Trade	Green Space
Income or Wealth	**Healthcare Infrastructure (40.5%)**	Ecological Land Use
Income Assistance	Healthcare Facilities	**Social Engagement (15.7%)**
Land Size	Medical Staff	Clubs or Community Centers
Savings or Debt	Health Insurance	Golf, Physical Leisure or Walking
Food Insecurity	Public Health	Church or Religion
Access to Banking	Basic Services	Amount of Social Engagement
Household Composition (62.0%)	Health Expenditure	Volunteering
Size of Household	Avoidable Hospital Admissions	Feelings Towards Social Engagement
Single Parent or Female-Headed Household	**Transport (33.1%)**	Activities Around the Home (e.g., gardening)
Lives Alone	Transport Infrastructure	Cards or Games
Child-Headed Household	Road Infrastructure	Hobby, Project or Further Education
Employment (61.2%)	Access to Railways, Roads or Transit (Community)	Pets
Unemployment	Able to Get Places (Individual)	**Power Sources (15.7%)**
Occupation	**Ethnicity or Race (32.2%)**	Power and Electricity Infrastructure
Housing (56.2%)	**Water and Waste (26.4%)**	Biomass
Housing Materials or Condition	Water Infrastructure & Safety	**Personal Attitudes and Expectations (10.7%)**
House Ownership	Waste Infrastructure and Collection	Control
House Without Necessities	**Social connection and capital (21.5%)**	Expectations of Self and Others
Housing Type	Relationships with Family	Satisfaction with Life
Housing Price	Relationships with Friends	Attitude Towards Life
Housing Vacancy	General Relationships	Self Worth or Self Esteem
Group Housing	Emotional Support Available	Major Life Events
Homelessness	General Support Available to Help	Hope for the Future
Population Health Statistics (55.4%)	Relationships with Neighbours	**Industry (10.7%)**
Migration	Telephone Use	Tourism or Hospitality
Average Age	Ability to Give	Specific Industries (e.g. Cotton)
Population Growth	Specific Task Support Available	General Industries (e.g. Primary)
Total Population	Help Available in a Crisis	**Environment and Climate Events (10.7%)**
Birth Rate	Relationships with Children	Flood
Mortality Rate	Community Social Support	Extreme Weather
Life Expectancy	Loving Support Available	Rainfall or Drought
	Relationships with Community	Landslides
	Relationships with Spouse	**Government Aptitude and Investments (7.4%)**
	Individual Communication (20.7%)	School Infrastructure
	Ability to Communicate (Oral or Written)	Capacity for Governance
	Sensory Problems	Corruption
		Research and Development Infrastructure
		Isolation or Loneliness (6.6%)
		Health Conditions (6.6%)
		Chronic Health Conditions or their Risk Factors
		HIV / AIDS
		Poor Mental Health
		Specific Disease Incidence
		Specific Disease after Flood
		Adherence to Medical Advice
		Political Stability (5.0%)
		Refugees Displaced
		Political Armed Conflict
		Noise or Air Pollution (2.5%)

Discussion

In this scoping review, we provide an overview of SVIs in the literature with a focus on mapping out the composition of these indices and how they are used to predict outcomes. While there are few systematic or scoping reviews on indices of social vulnerability
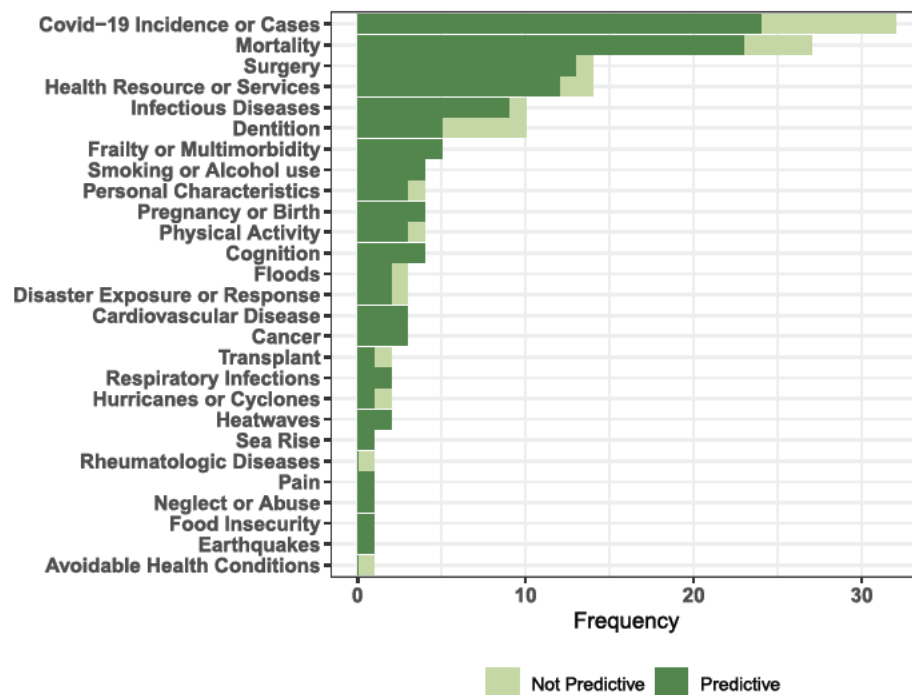
Fig. 3 Association between SVI and outcomes among studies utilizing SVI in predictive modelling

specifically, there are two grey literature narrative reviews on social vulnerability assessment tools by the United Nations Development Programme for climate change [27], and the US Corps of Engineers' Institute for Water Resources [28]. These reviews have previously hypothesized that, despite heterogeneity in the indicators used, the methods for calculating SVIs are relatively similar in most situations. Our findings support that hypothesis and add a broadened scope by including SVIs in the fields of health and medicine.

We also mapped items and domains used in the composition of SVIs as one way of answering an often-debated question: which social factors should be included in an index to represent social conditions? Despite differing fields, purposes and applications of the 121 original SVIs included in our review, we found seven domains of social factors that were used in the composition of over half of the SVIs: at risk populations, education, micro (i.e., individual, family or household) level markers of socioeconomic status, household composition, employment, housing, and population health statistics. In these domains, there are items from both the individual level, the household level and population level. Individuals' vulnerabilities cannot be separated from their systemically disadvantaged communities and our finding that one in five SVIs used mixed data sources suggest that future SVIs may be strengthened if composed of social factors reflective of vulnerabilities at the individual, family, neighbourhood and community levels.

Not mentioned in the domains above is gender or sex, despite previous consensus that this item should be included in a SVI [9]. Since it is well documented that gender and sex differences (biologically and socially) contribute to different experiences and outcomes in health [29] and disasters [30], we were surprised that less than 50% of SVIs included gender or sex. This may reflect a choice of the researchers because most items for SVIs came from census data or population-based surveys, so variables on gender or sex demographics are not readily available. There were no variables reflective of sexuality. The exclusion of sexuality as a determinant of social vulnerability can be problematic as it makes invisible the challenges faced by sexual minorities (e.g., perpetuating discrimination), masks disparities (e.g., in access to housing, healthcare access or social services) and fails to recognize the intersectionality whereby sexual minorities are often part of multiple vulnerable groups. Other commonly included SVI items that would likely be gendered depending on the context, include educational and occupational opportunities, and also marital status and living situation. We were surprised that items like single parent or female-headed household were less prevalent in the health and medicine SVIs (see Additional file 5) and overall, we had expected consideration of sex and gender-related items to be more common. While it is possible

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that gender or sex stratified analyses are being conducted instead of including specific items in the index, our findings suggest that many SVIs may be missing an important determinant of vulnerability. Researchers need to carefully consider how to construct their indices and choose data sources with information collected on sex and gender. The most frequent variable was a dichotomized proportion of sex or gender, reflecting previous literature describing how the dominant discourse in disaster management on sex and gender is binary, and does not account for gender minorities [30].

This paper adds to the literature in two key ways. First, our findings confirm that interest in measuring social vulnerability is increasing, especially in the health and medicine fields (Table 1). This growing trend seems to have been linked to researchers trying to understand the social and economic factors contributing to the differential impacts of the pandemic across various populations. The interest may also be tied to the rising importance of interdisciplinary research, the growing recognition of climate change's impact on social and health inequities and the advances in available data in which to conduct social vulnerability research. We also demonstrate that when SVIs are used to measure an outcome, the outcome was overwhelming in the health and medicine fields, and the SVI was predictive. However, the SVIs in health or medicine related fields were more often replicates than original SVIs, suggesting health and medicine studies are employing SVIs developed for other fields of literature (e.g., SVI by the CDC/ASTAR). Social vulnerability is often context dependent and having more original indices with community specific data may be a better tool for measuring social vulnerability related to health. Second, we provide a scaffold for future researchers looking to create these original SVIs. There are many ways to choose social factors in an index from theory driven to data availability to community consultations; however there is no gold standard. Here, we provide another way of making this determination by summarizing what past SVIs have used, from most common to highly context specific (Additional file 5). A strength of our approach is that it includes items and domains that take into consideration individual capacity to recover from the impact of a hazard as well as the inability of the system to respond. Our approach also encompasses global items from literature in five different languages and incorporates items from several fields of research in keeping with the interdisciplinary nature of social vulnerability.

Whether we are evaluating risks from an adverse health event or disaster event, the social production of vulnerability should be given the same degree of importance dedicated to understanding and reducing the medical or environmental risk. Our findings show the social

vulnerability index predicts many outcomes from mortality to frailty to disaster response. We also see that SVIs used globally. Unlike other measures which were developed and are more applicable to high income countries (e.g., the SVI by the CDC/ASTAR), the SVI appears adaptable and relevant to different contexts whereby original SVIs are emerging from all continents (except Antarctica). It also appears that one recent and frequent application of SVIs is for Covid-19. SVIs have been used as a research tool but also as a pragmatic policy tool to identify and support vulnerable communities through resource allocation [31]. Certain tools (i.e., the SVI by the CDC/ASTAR) that are free, easily accessible, and have complete data are most replicated and may facilitate researchers and policymakers taking an interest in social vulnerability [31]. If authors are creating SVIs, they should strive to use publicly available and free data and replicable with a simple methodology as this will reduce barriers to use of SVIs in broader research.

There remains many complexities and uncertainties for researchers hoping to employ SVIs, and our study has limitations which should inform interpretation of our findings. The choice to categorize indices into three broad categories (i.e., environment, climate or disaster, health or medicine, and other) may have resulted in loss of information or loss of opportunity to detect differences within fields. By excluding papers where social vulnerability indices were combined with other measures (i.e., weather indices), this review does miss out on other potential applications of the SVI. Furthermore, the search was very specific due to feasibility constraints of screening hundreds of full-text papers. There are undoubtedly many indices with the same underlying principle that are perhaps not called an SVI. Indices that may be made on social resilience factors were not part of the search, yet is one area of future exploration as it is unclear if an index of social strengths (i.e., a strengths-based resilience index) would yield comparable results to a social vulnerability index. Another consideration is that this review did not explicitly collect data on the methods authors used to determine inclusion of items (e.g., theory driven, data availability, factor analysis, community consultation, etc.). Nonetheless, to balance feasibility of the search, we still provide a review with a significant sample size with the inclusion of several languages.

There are several areas of future research on SVIs. First, validating and comparing different SVIs to understand their strengths and weaknesses and to identify the most appropriate indices for specific purposes is needed. Second, understanding trends in social vulnerability over time and determining what this means for building an index to represent social conditions at different stages of life is also needed. Finally, future studies should build

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on the recent pragmatic uses of SVIs during the Covid-19 pandemic, which used SVIs to plan and evaluate effectiveness of interventions designed to reduce social vulnerability.

Conclusion

Identification of social vulnerability presents an opportunity to intervene to improve the lives of individuals and communities following an adverse health or disaster event. To identify social vulnerability, social vulnerability indices are commonly used. The social vulnerability indices presented here brings together multiple fields of literature and demonstrates growing interest in using these indices in health and medical literature. We also found that SVIs predicted Covid-19 cases, mortality, surgical access or outcomes and healthcare access or resources, among other outcomes. Since we predict the use of SVIs will continue to increase, we also provide a summary of domains and items common across SVIs in the literature, which provides an alternate method of constructing SVIs in the future. The social vulnerability indices presented here brings together literature from multiple fields of literature; whether in the field of disaster planning, environmental science or health care, the SVIs are composed of similar items reflecting interdisciplinary ways of thinking.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-023-16097-6.

Additional file 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.

Additional file 2. References of included studies.

Additional file 3. Characteristics, composition and outcomes of original social vulnerability indices (in white), and characteristics and outcomes replicated social vulnerability indices (in grey).

Additional file 4. a. Frequency and proportion of replications, in descending order. b. Geographic Distribution of SVIs.

Additional file 5. Items (proportion of the domain) and domains (proportion of all SVIs).

Declarations

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Publisher's Note

Chapter 4: A Standard Procedure for Constructing a Multi-level Social Vulnerability Index Using CLSA and SOS Data as Worked Examples

[In Peer Review]

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Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and materials: Data are available from the Canadian Longitudinal Study on Aging (www.clsa-elcv.ca) for researchers who meet the criteria for access to de-identified CLSA data. The data from the Canadian Immunization Research Network's Serious Outcomes Surveillance Network have restrictions regarding their availability.

Competing interests: JCM is an Internal Medicine resident with Nova Scotia Health and receives scholarships supporting her PhD research from the Department of Medicine at Dalhousie University, Dalhousie Medical Research Foundation, Dr. Patrick Madore Foundation and the Pierre Elliott Trudeau Foundation. KR is President of Ardea Outcomes, which in the last five years has contracts with pharma and device manufacturers on individualized outcome measurement. In 2019 he attended an advisory board meeting with Nutricia. Otherwise any personal fees are for invited guest lectures and academic symposia, received directly from event organizers, chiefly for presentations on frailty. Until December 2023, he was Associate Director of the Canadian Consortium on Neurodegeneration in Aging, which is funded by the Canadian Institutes of Health Research, and with additional funding from the Alzheimer Society of Canada and several other charities. He receives career support from the Dalhousie Medical Research Foundation as the Clinical Research Professor of Frailty & Aging, Research Nova Scotia, and research support from the Canadian Institutes of Health Research, the QEII Health Science Centre Foundation, the Capital Health Research Fund and the Fountain Family Innovation Fund of the QEII Health Science Centre Foundation. KR has asserted copyright of the Clinical Frailty Scale through Dalhousie University. Use is free for research, education or not-for-profit care (users are asked not to change it or charge for its use). MKA reports grants from Canadian Consortium on Neurodegeneration in Aging (CCNA), with

Abstract

Background: The construct of *social vulnerability* aims to understand social circumstances not merely as a descriptor, but as a predictor of adverse health events. It can be measured by aggregating social deficits in a social vulnerability index (SVI). We describe a standard procedure for constructing a multi-level SVI using two working examples.

Methods: First, we describe a six-step approach to constructing a SVI. Second, we conducted a secondary analysis of a clinical dataset (Canadian Immunization Research Network's Serious Outcomes Surveillance Network (SOS)) and a population-based dataset (Canadian Longitudinal Study on Aging (CLSA)). In both datasets, we construct SVIs, use descriptive statistics to report distributions by age and sex, and perform a multivariable linear regression of social vulnerability on frailty.

Results: Procedures for drafting a list of candidate social items, selecting deficits for inclusion, and screening deficits to meet inclusion criteria were applied to yield a 18-deficit SVI for SOS and 74-deficit SVI for CLSA. Deficits in each SVI were rescored between 0 and 1, where 1 indicates the greater risk. Finally, the sum of all deficits is calculated into an index. In the SOS, SVI was associated with age only for females and was weakly associated with frailty (r = 0.26, p<0.001). In the CLSA, SVI was associated with age for both sexes and moderately associated with frailty (r = 0.41, p<0.001).

Conclusion: We present a standard method of constructing an SVI by incorporating factors from multiple social domains and levels in a social-ecological model. This SVI can be used to improve

our understanding of social vulnerability and its impacts on the health of communities and individuals.

KEY MESSAGES BOX

Steps to construct a Social Vulnerability Index

1. Draft a list of candidate items for the SVI

   Choose social factors with high face validity and comprehensibility supported by a good theoretical base, with evidence of the potential to adversely impact health outcomes.

2. Select items for inclusion as deficits in the SVI

   Deficit selection must collectively include a range of factors across multiple social domains and across multiple levels of social influence representing a holistic view of an individual's social circumstances.

3. Code deficits for the SVI

   All deficits take a value between 0 and 1; 0 is the state of lowest risk and 1 is the state of greatest risk.

4. Screen deficits

   Chosen social deficits should be screened for missingness and adequate prevalence.

5. Calculate the final SVI

   The overall SVI score per individual is calculated by summing the coded values for all social deficits and dividing by the absolute count of items included in the SVI. Therefore, the final SVI also takes a value between 0 and 1.

6. Report the SVI

   Report the number of items and domains. List the deficits and their coding. Report distribution, and correlation with age and sex/gender.

Background

The conditions in which people are born, live, work and age collectively influence their ability to anticipate, cope, resist and recover from an adverse event (1). *Social vulnerability* provides a way of understanding the social environment not merely as a descriptor, but as an attempt to quantify an individual's or community's relative vulnerability to changes in their environment, social circumstances, health, or functional status (2). In short, when all other non-social factors are equal, how do disadvantageous social circumstances lead to a community being disproportionally devastated by an epidemic or to an individual being unable to recover in the expected timeframe following an adverse health event?

Social circumstances are complex; there are many social factors, existing in multiple layers from personal supports to neighbourhood dynamics, with numerous potential unforeseen interactions between them. While measuring social vulnerability may be perceived as challenging, conveniently, often it can readily be measured using available data. One way to estimate social vulnerability is through an index that aggregates social factors. An index approach has several benefits. It can provide a holistic picture of social circumstances by including different categories of social factors (e.g., socioeconomic status, social engagement, social capital), by avoiding arbitrarily separating related factors into distinct categories and by accounting for gradations in social vulnerability (2,3).

Social vulnerability indices (SVIs) are used to measure complex social circumstances associated with health outcomes. The SVI employed by the Agency for Toxic Substances and Disease Registry / Centers of Disease Control and Prevention (4) is widely used, and in the United States, associated with many adverse outcomes, such as in SARS-Cov-2 (5), surgery (6), and heart failure re-admissions (7). Another well-known SVI by Cutter and colleagues (8) has been adapted and shown to be associated with cancer risk (9) and Lyme disease incidence (10). However, neither of these routinely used social vulnerability tools were initially developed for use in health or medical fields. Further, a recent scoping review suggested a SVI might be

strengthened if composed of social factors which reflect vulnerabilities at the individual, household, and community levels (11). To address these gaps, we aim to describe a standard procedure for constructing a multi-level SVI with relevance to the health of individuals using a social deficit approach. We provide two working examples of constructed SVIs using this approach.

Methods

Theory

Our operationalization of social vulnerability builds upon social capital theory, especially that such capital can be deployed in times of need. Broadly, social capital is the organization of social structures and how these structures facilitate actions of stakeholders in the society (12). Social capital is a collective resource; like economic capital, harnessing social capital brings advantages for the socially powerful through their entrenched networks and institutionalized relationships (13). It consists in social support, social engagement and access to resources (including economic capital) (14). Adequate social capital is productive; in its absence, achievement of desired ends would not be possible (12). To illustrate, following a hip fracture, economic capital to purchase a wheelchair or renovate a home with a ramp improves function, but so will social capital in the form of free exchanges of food, time or company provided by friends, family and community members. Whether social capital exists at the level of the individual or the collective has been the subject of much debate. We see social capital as related both to characteristics of the individual (e.g., educational), and also to other aspects at the level of culture and the environment (e.g., neighbourhood safety). These related but distinct non-medical factors - the social determinants of health (15) – exist with social capital on a continuum from individual to collective (14).

In a socio-ecological framework (16), individuals are nested within expanding spheres of social influence; this offers a useful way to think about how multiple social factors influence health (2). Social factors exist on a continuum of multiple levels of social influence—from the individual to

family and friends, neighbourhoods, and communities, and society at large—and contribute to overall social vulnerability (2). For an adult seeking healthcare, at the *micro* level, social factors are their own health behaviours and their closest links with family and caregivers. We define the *meso* level according to Newman and Newman as the interrelations among two or more microsystems that then impact the individual (17). Examples includes family-friends interactions, or friends-healthcare interactions (e.g., the health literacy of friends and relations and their access to resources and supports). The *exo* level refers to the available community supports available such as home care services or access to rehabilitation programs. The *macro* level encompasses the attitudes towards older adults in broader policy reflected in pension plans or universal health care (16). A measure of social vulnerability must account for this complexity and include social factors across the continuum from an individual to a group level. Similarly, a lone marker of social circumstances cannot adequately reflect the multifaceted interactions between social factors; therefore, a global index of social vulnerability must incorporate multiple social determinants of health.

Constructing the SVI

We describe six steps, and recommendations and considerations, in the construction of a SVI.

1. Draft a list of candidate items for the SVI

Recommendations: Choose social factors, for potential inclusion as items in the index, with high face validity and comprehensibility supported by a good theoretical base, with evidence of the potential to adversely impact health outcomes and as above on a continuum from a little to a lot. Lists of candidate social deficits may be procured based on existing data availability (18), but have also been generated through consensus with experts (19).

Considerations: For controversial social factors (e.g., retirement or rurality where the deficit state can be beneficial to some and detrimental to others), consult experts who are familiar with the population of interest.

2. Select deficits for inclusion in the SVI

Recommendations: Items selected will become deficits in the index. Collectively, they must include a range of factors across multiple social domains and across multiple levels of social influence representing a holistic view of a person's social circumstances.

- Include social deficits across multiple social domains. Examples of social domains are: access to material resources (e.g. income or socioeconomic status), social support (e.g. links to family, friends or community) and social engagement (e.g. participation in collective society) (14). Social domains can also include examples from the social determinants of health such as income & social status, employment & working conditions, education & literature, childhood experiences, physical environments, social supports & coping skills, and access to health services (15).

- Include social factors from multiple spheres or levels of influence across the continuum from individual to group levels (20). A recent scoping review summarizing the composition of items in SVIs noted more than half of all SVIs included items reflective of individual socioeconomic status, but also prevalence of at-risk populations in a geographic region (11).

- Include factors that are both objective (e.g. living alone, number of close friends) and subjective (e.g. loneliness, availability of emotional support).

Considerations: Selecting deficits for inclusion in the SVI necessitates a balance between creating a robust measure (generally optimized with a greater number of items) and data availability (in the case of secondary analysis of existing datasets) or participant burden (in the case of prospective data collection). Some SVIs use personality factors (e.g., neuroticism) and lifestyle factors (e.g., exercise and diet); we see these as independent aspects of wellbeing and representing another dimension of health, not to be used in a SVI.

Choosing deficits based on statistical correlation to one another is not recommended. Deficits are not required to be correlated with one another. Items in the SVI are more appropriately

considered causal variables rather than indicator variables (21). For example, education and feelings of loneliness may not be correlated, but they both contribute to a person's social vulnerability. Both the causal direction and the lack of correlation between the deficits renders factor analysis inappropriate. The selection of deficits rests on their potential contribution to social vulnerability rather than their intercorrelations.

3. Code deficits for the SVI

Recommendations: The coding for each item in the SVI depends on its scale of measurement. Regardless, all social deficits receive a score from 0 to 1. A value of 1 indicates the greatest state of relative vulnerability to damage (e.g., education: never completed high school = 1 and completed high school or greater = 0). For intermediate responses, deficits may take a value of 0.5 (e.g. never completed high school = 1, completed high school only = 0.5, post-secondary education = 0). Ordinal items may rank into a score according to number of levels. For example, a deficit with four levels (e.g., never completed high school, completed high school, college or university, post-graduate education) would be coded 0 for the social factor characteristic that is most protective, 0.33 and 0.66 for middle states of vulnerability and 1 for the most detrimental characteristic for vulnerability. Continuous items may be categorized according to pre-established cut points or coded into a continuous score between 0 and 1. In our education example, if measured in years, >20 years of school would be coded 0 and decreasing number of years allocated a score according to the equation 1 – (# years of school / 20 max years of school).

Considerations: The theoretical basis of coding deficits for the SVI combines a deficit accumulation principle (22) with social capital underpinnings. Living alone, for example, is not always considered a deficit (i.e., an adverse social circumstance increasing the risk of damage or prolonging recovery time following an adverse health event) and individuals can be content living alone. However, social capital refers to resources people can draw upon should a crisis

occur. Through this lens, living alone does confer an increased risk of social vulnerability and can be coded as the highest deficit state.

Another challenge with social deficit coding is the lack of self-evident cut points. We suggest two options. First, cut offs for vulnerable states could depend on expert consensus drawing on literature and experience. Second, cut offs can be determined by mapping distribution of the social variable using basic statistical techniques. Individuals with the deficit beyond the 75th percentile of a specific dataset could be coded as having the most vulnerable state for that variable. This latter is for datasets that are truly representative of a population. The coding represented here is similar to previous work (22,23).

4. Screen deficits that meet inclusion criteria.

Recommendation: Screen the chosen social deficits for missingness. The threshold for missing values is contingent on the total number of social deficits available for the construction of the index, although >5% missing data is generally acceptable as a cut off to exclude the deficits in similar indices (24). Allowing for high levels of missingness at the item level may result in losing observations when calculating the SVI scores, assuming no other methods of dealing with missing data is employed such as multiple imputation (25).

Screen deficits for prevalence. A rare social deficit in the population (i.e., <1%) could be combined with another deficit to avoid exclusion in the final calculations or inflating the denominator.

5. Calculate the final SVI

Recommendations: The overall SVI score per individual is calculated by summing the coded values for all social items (reflecting their deficits) and dividing by the absolute count of items

included in the SVI. Therefore, the final SVI also takes a value between 0 and 1, allowing for standardization and development of a common language as it pertains to social vulnerability.

Considerations: Calculate a final SVI only for individuals with sufficient data. Calculating a final SVI for individuals missing more than 20% of SVI items may not accurately reflect their social circumstances and may underestimate true social vulnerability. Using statistical methods of dealing with missing data such as multiple imputation can be considered (25).

Similar to the frailty index, our SVI builds in natural weighting. For example, individuals who are not married are more likely to score social deficits for living alone and having less social support. While there are benefits of weighting items in a SVI (e.g., gaining performance or separability measurement), we aim for the SVI to be highly generalizable across contexts.

6. Report the SVI

Recommendations: Report the number of items and domains. List the deficits and their coding. Report distribution of the SVI. Report correlation with age and sex/gender. If a SVI is to be used in the same dataset or across multiple time series, it should consist of the same variables from one iteration to the next.

Worked Examples

Samples

To demonstrate the standard approach described above, we calculate and compare SVIs in two separate datasets.

The first is a clinical dataset with a minimal number of social variables. The Canadian Immunization Research Network's Serious Outcomes Surveillance (SOS) Network is a prospective dataset of Canadians hospitalized with acute respiratory illness in six Canadian provinces. Within the SOS dataset, we selected all individuals over the age of 65 years old admitted to hospital during the 2011-2012 influenza season.

The second is a weighted population-based dataset: the Canadian Longitudinal Study on Aging, a national, stratified, prospective study of over 50,000 community-dwelling Canadian women and men aged 45 to 85 years old at time of recruitment (26). We draw on the complete sample of the CLSA using both the comprehensive and tracking cohort from the baseline CLSA assessment in 2011. This research has been conducted using the CLSA dataset Baseline Tracking Dataset version 3.3, the Baseline Comprehensive Dataset version 3.2 and CLSA Sample Weights Version 1.2. We classify each item in the SVI by the domains included in the CLSA (i.e., socio-demographic, home ownership, education, social networks, social support availability, social participation, income, built environment and psychosocial).

Statistical Methods:

We use descriptive statistics to report SVI distributions by age and sex and report Pearson correlation coefficients. We performed a multivariable linear regression of social vulnerability on frailty. Frailty is measured using frailty indices (FI) from previously published papers (27,28).

Constructing the SVIs

The SVI calculated in the SOS Network dataset is composed of 18 items. Nine domains are represented by these 18 deficits when the CLSA social domain classifications are applied as shown in Table 1 and Figure 1. Of the 18 deficits, 13 were coded as dichotomous and the remainder were ordinal.

Table 1. List of social items included in the Serious Outcomes Surveillance Network SVI

Item	Coding	Level

Socio-Demographic			
1	Current marital status	0 = married or common in law; 1 = single, divorced or widowed	Micro
Home Ownership			
2	Ever homeless	0 = no; 1 = yes	Micro
3	Lives in a rooming house, group home, shelter or is currently homeless	0 = no; 1 = yes	Meso
Education			
4	Highest level of education	0 = college, university bachelor, graduate, or professional degree; 0.33 = trades or apprenticeship; 0.67 = high school; 1 = less than high school	Micro
Social Networks			
5	Living alone	0 = no; 1 = yes	Micro
Social Support Availability			
6	Does the patient have someone to count on for help or support	0 = yes; 1 = no	Micro
7	Does the patient feel they need more help or support	0 = no; 1 = yes	Micro
8	Does the patient have someone to confide in	0 = yes; 1 = no	Micro
Social Participation			

9	How often patient participated in activities, groups or clubs in the community	0 = often (weekly); 0.5 = sometimes; 1 = never	Meso
10	Does the patient volunteer in the community	0 = yes; 1 = no	Meso
11	How often patient attends religious services	0 = often (weekly); 0.5 = sometimes; 1 = never	Meso
12	How often does the patient get together and socialize with friends	0 = often (weekly); 0.5 = sometimes; 1 = never	Micro / Meso
13	How often does the patient get together and socialize with family/relatives	0 = often (weekly); 0.5 = sometimes; 1 = never	Micro / Meso
Income			
14	Feels that income currently satisfies needs	0 = no; 1 = yes	Micro
Built Environment			
15	Does the patient say that most	0 = yes; 1 = no	Meso

	people can be trusted		
16	Does the patient feel safe in their neighbourhood	0 = yes; 1 = no	Exo
Psychosocial			
17	Does the patient feel they have control over things that happen to them	0 = yes; 1 = no	Micro/ Meso
18	Does the patient feel lonely	0 = no; 1 = yes	Micro

The population-based SVI is constructed from 74 items that met criteria in the CLSA. Items that did not meet screening criteria included: life satisfaction, retirement satisfaction, language, and desire to be more social. Church activities was combined with club and fraternal services due to low prevalence. Screening of CLSA deficits was possible due to large numbers and is available in Appendix 1. No items were excluded due to missing data due to the completeness of the CLSA dataset. Most deficits were coded as ordinal variables (55/74) and the remaining were coded as dichotomous. The CLSA SVI is composed of deficits from ten social domains that were already established by the CLSA data collection process; deficits from the social support domain were the most prevalent (20/74) as seen in Table 2 and shown in Figure 1. Figure 1 also shows how each item relates to the socio-ecological framework and each level of social influence.

Table 2. List of social items included in the Canadian Longitudinal Study on Aging SVI

	Item	Coding	Level
Socio-Demographic			

1	Marital status	0 = yes; 1 = no	Micro
Home Ownership			
2	Home owner	0 = yes; 1 = no	Micro
Education			
3	Education	0 = college, university bachelor, graduate, or professional degree; 0.33 = trades or apprenticeship; 0.67 = high school; 1 = less than high school	Micro
Social Networks			
4	Living alone	0 = no; 1 = yes	Micro
5	Child contact frequency	0 = within the last day or two or all children live in household; 0.2 = within the last week or two; 0.4 = within the past month; 0.6 = within the past 6 months; 0.8 = within the past year; 1 = more than one year ago or no children	Micro
6	Siblings contact frequency	0 = within the last day or two or all siblings live in household; 0.2 = within the last week or two; 0.4 = within the past month; 0.6 = within the past 6 months; 0.8 = within the past year; 1 = more than one year ago or no siblings	Micro
7	Relatives contact frequency	0 = within the last day or two or all relatives live in household; 0.2 = within the last week or two; 0.4 = within the past month; 0.6 = within the past 6 months; 0.8 = within the past year; 1 = more than one year ago or no relatives	Micro
8	Friends contact frequency	0 = within the last day or two or all friends live in household; 0.2 = within the last week or two; 0.4 = within the past month; 0.6 = within the past 6 months; 0.8 = within the past year; 1 = more than one year ago or no friends	Micro

9	Neighbours contact frequency	0 = within the last day or two; 0.2 = within the last week or two; 0.4 = within the past month; 0.6 = within the past 6 months; 0.8 = within the past year; 1 = more than one year ago or no neighbours	Micro
Social Support Availability			
10	Availability of support if confined in bed	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
11	Availability of someone to talk to if needed	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
12	Availability of someone to have advice from in crisis	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
13	Availability of someone that can take to the doctor if needed	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
14	Availability from someone that shows affection	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
15	Availability of someone to have a good time	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
16	Availability from someone that helps with information	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Meso

17	Availability of someone to confide	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
18	Availability of someone that hugs	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
19	Availability of someone to relax with	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
20	Availability of someone that prepares a meal	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
21	Availability of someone that gives wanted advice	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
22	Availability of someone to do things with	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
23	Availability of someone that helps with domestic chores	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
24	Availability of someone with whom to share fears	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro

25	Availability of someone who gives suggestions	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
26	Availability of someone to do something enjoyable together	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
27	Availability of someone that understands problems	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
28	Availability of someone that makes one feel wanted	0 = all the time; 0.25 = most of the time; 0.5 = some of the time; 0.75 = a little of the time; 1 = none of the time	Micro
29	Pet owner	0 = yes; 1 = no	Micro
Social Participation			
30	Reads newspaper	0 = yes; 1 = no	Micro
31	Hobby	0 = yes; 1 = no	Micro
32	Holidays in Canada	0 = yes; 1 = no	Meso
33	Holidays outside of Canada	0 = yes; 1 = no	Meso
34	Day trip	0 = yes; 1 = no	Micro
35	Internet use	0 = yes; 1 = no	Micro
36	Voted in last election	0 = yes; 1 = no	Meso

37	Family and friends' activities	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Meso
38	Sports or physical activities	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Micro/ Meso
39	Educational or cultural activities	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Micro/ Meso
40	Neighbour, community or profession activities	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Micro/ Meso
41	Volunteer	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Micro/ Meso
42	Other recreation activities	0 = at least once a day; 0.25 = at least once a week; 0.5 = at least once a month; 0.75 = at least once a year; 1 = never	Micro/ Meso
Online Social Networking			
43	Internet access	0 = yes; 1 = no	Micro
44	E-mail frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro
45	Websites frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro
46	Websites healthcare related frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro

47	Use of social networks	0 = yes; 1 = no	Micro/ Meso
48	Making friends in social networks frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro/ Meso
49	Stay in touch with friends in social networks frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro/ Meso
50	Stay in touch with family in social networks frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro/ Meso
51	Promotion in social networks frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Meso/ Exo
52	Other activities in social networks frequency	0 = daily; 0.25 = a few times a week; 0.5 = a few times a month; 0.75 = a few times a year; 1 = never	Micro/ Meso
Built Environment			
53	Home problems	0 = no; 1 = yes	Micro
54	Home satisfaction	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Micro
55	Feels part of the area	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Meso/ Exo
56	Vandalism	0 = strongly disagree; 0.33 = disagree; 0.67 = agree; 1 = strongly agree	Meso/ Exo

57	Feel lonely in the area	0 = strongly disagree; 0.33 = disagree; 0.67 = agree; 1 = strongly agree	Micro
58	Most people trusted in the area	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Meso/ Exo
59	Afraid to walk in the area	0 = strongly disagree; 0.33 = disagree; 0.67 = agree; 1 = strongly agree	Meso
60	Friendly people in the area	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Meso
61	People take advantage in the area	0 = strongly disagree; 0.33 = disagree; 0.67 = agree; 1 = strongly agree	Meso/ Exo
62	Clean area	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Meso/ Exo
63	Help available in the area	0 = strongly agree; 0.33 = agree; 0.67 = disagree; 1 = strongly disagree	Meso/ Exo
Wealth			
64	Personal income	0 = >150,000 CAD; 0.25 = 100,000-149,999 CAD; 0.5 = 50,000-99,999 CAD; 0.75 = 20,000-49,999 CAD; 1 = <20,000 CAD	Micro
65	Household income	0 = >150,000 CAD; 0.25 = 100,000-149,999 CAD; 0.5 = 50,000-99,999 CAD; 0.75 = 20,000-49,999 CAD; 1 = <20,000 CAD	Micro
66	Savings	0 = yes; 1 = no	Micro
67	Life insurance	0 = yes; 1 = no	Micro
68	Assets	0 = yes; 1 = no	Micro
69	Debts	0 = no; 1 = yes	Micro
70	Self-rated financial status	0 = manage very well; 0.2 = manage quite well; 0.4 = get by alright; 0.6 = don't manage very well; 0.8 = have	Micro

		some financial difficulties; 1 = have severe financial difficulties	
71	Adequate income for basic needs	0 = very well; 0.25 = adequately; 0.5 = with some difficulty; 0.75 = not very well; 1 = totally inadequately	Micro
72	Little money stops from doing things	0 = no; 1 = yes	Micro
73	Insufficient financial resources in the future	0 = little or no possibility; 0.5 = some possibility; 1 = high possibility	Micro
74	Leave inheritance	0 = high; 0.33 = moderate; 0.67 = low; 1 = none	Micro
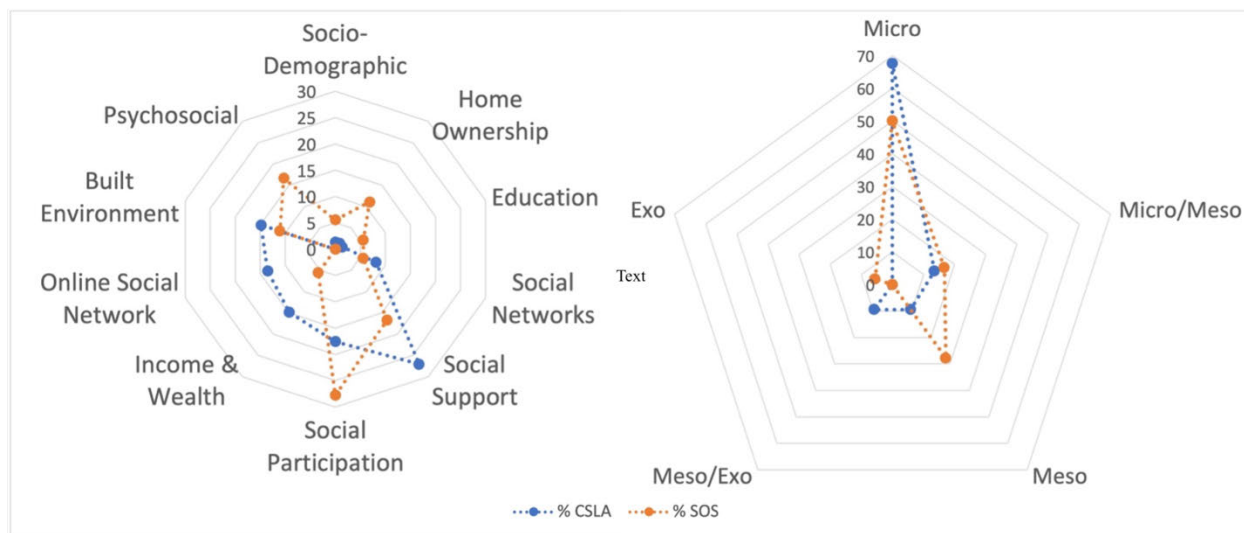
Figure 1. Proportion of items in the SOS and CLSA SVIs per social domain and per socio-ecological level

Characteristics of the Indices

The mean SVI score in the SOS network dataset is 0.30(SD 0.13) and 0.22(SD 0.10) in the CLSA dataset. Descriptive statistics for the two datasets are presented in Table 3 showing that the SOS network dataset contains individuals who are older and living with a greater degree of frailty than the individuals in the CLSA cohort, which is not surprising given that all SOS participants were hospitalized. The average SVI score for women is higher on average than for men in both cohorts. Figure 2 shows the association of SVI with age by sex. In the SOS, SVI increases with age only in women ($r = 0.11$, $p = 0.04$). In CLSA, SVI slowly increases by age in the total cohort ($r = 0.28$, $p<0.001$) and in men ($r=0.15$, $p<0.001$) and women ($r=0.29$, $p<0.001$). The distribution of the SVIs in both cohorts are shown in Figure 3.

Table 3. Characteristics of SOS and CSLA cohorts

		SOS			CSLA		
		Total	**Women**	**Men**	**Total**	**Women**	**Men**
n		571	334	237	47,716*	24,332	23,384
	Mean age (SD)	79.2 (8.1)	79.6 (8.1)	78.6 (8.1)	59.8 (10.3)	62.8 (10.4)**	63.2 (10.4)
	Age range	65-104	65-104	65-100	45-85	45-85	45-85
SVI							
	Mean	0.30 (0.13)	0.32 (0.13)**	0.29(0.12)	0.33 (0.10)	0.34 (0.10)**	0.33 (0.32)
	Range	0.00-0.94	0.00-0.78	0.03-0.94	0.01- 0.86	0.09-0.86	0.09-0.85
	99th percentile	0.64	0.66	0.60	0.62	0.61	0.63
FI							
	Mean (SD)	0.20 (0.11)	0.20 (0.11)	0.20 (0.11)	0.08 (0.06)	0.09 (0.06)**	0.08 (0.05)
	Range	0.00-0.62	0.01-0.62	0.00-0.57	0.00-0.54	0.00-0.51	0.00-0.54

	99th percentile	0.51	0.51	0.49	0.27	0.28	0.25

*12,346,610 weighted

**p<.001 t-test for differences between men vs women
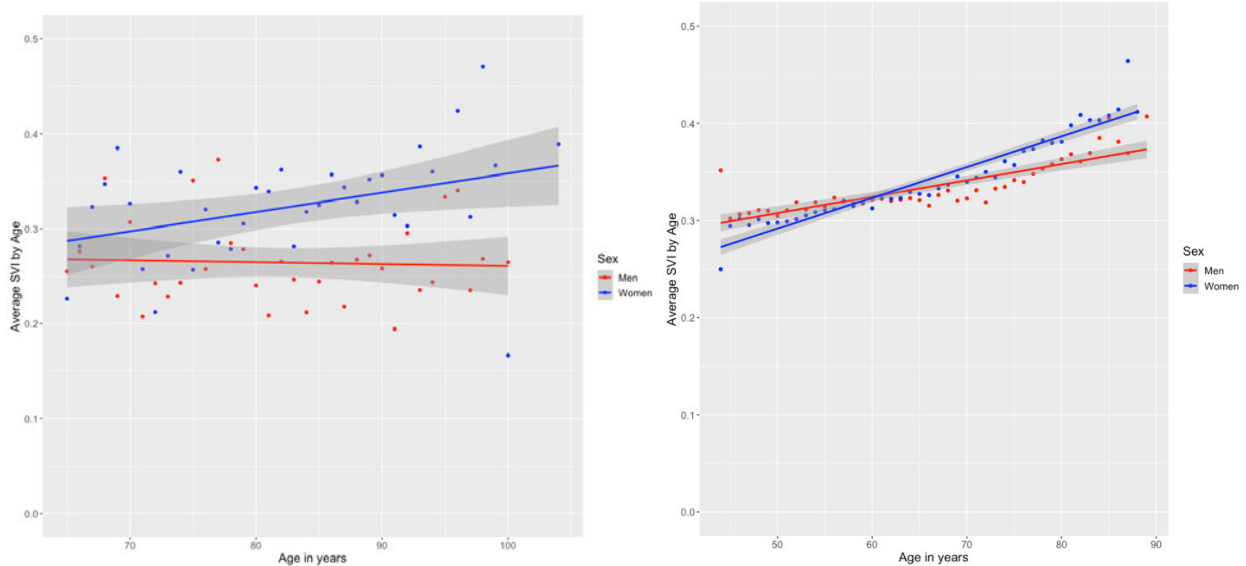
Figure 2. SVI by age and sex, in the SOS (left) and CLSA (right)
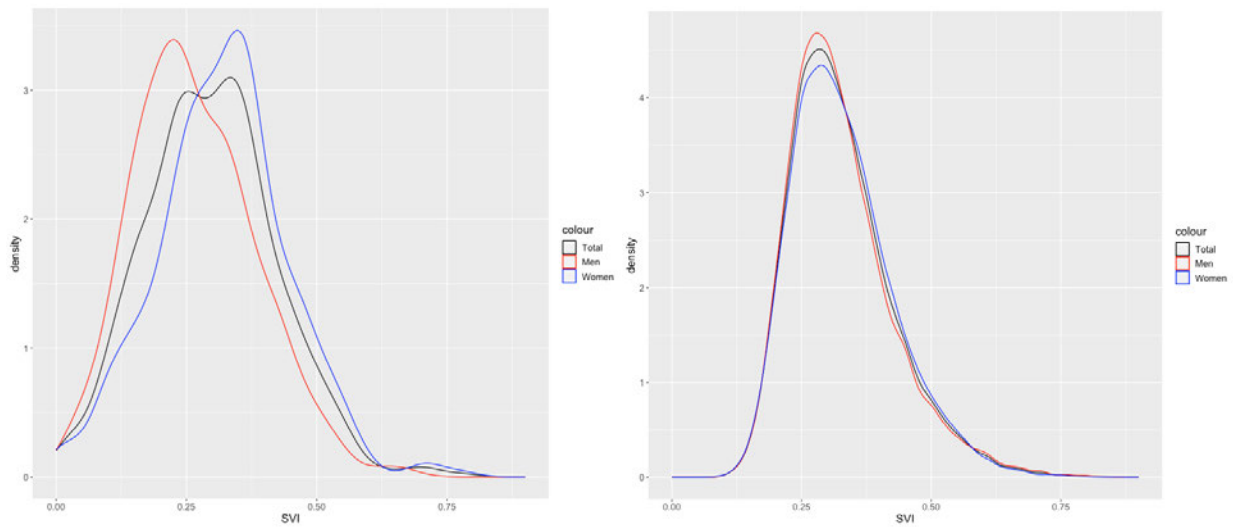
Figure 3. Kernel density plot of social vulnerability indices, by sex, in the SOS (left) and CSLA (right)

Social vulnerability and frailty

Frailty was measured using a 39-deficit frailty index and 52-deficit frailty index, each already validated in the SOS Network (29) and CLSA datasets (28), respectively. In the SOS, SVI is weakly correlated with frailty (r = 0.26, p<0.001). This relationship was stronger for women than men for frailty (Figure 4). In the CLSA, correlation with frailty was r = 0.37 (p<0.001) with a stronger correlation for women (r = 0.41, p<0.001) than men (r = 0.33, p<0.001). In a multivariable linear regression model adjusted for age and sex, a 0.1 increase in the FI was associated with a 0.28 (95% CI 0.23-0.42, p<0.001) increase in SVI in the SOS and a 0.68 (95% CI 0.63-0.72, p<0.001) increase in SVI in the CLSA.
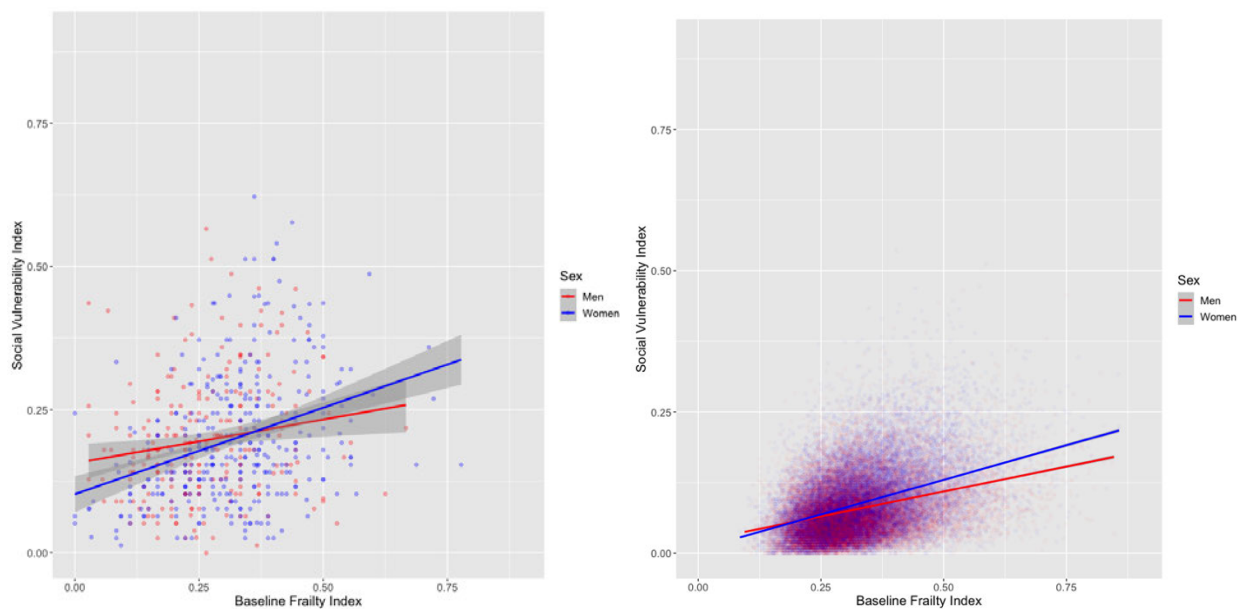
Figure 4. Association between SVI by FI by sex, in the SOS (left) and CLSA (right)

Discussion

Our research group has over a decade of experience constructing SVIs. We aim to measure social vulnerability so as to capture a rich description of an individual's social deficits (or problems), utilize data that is readily and practically measurable in population and clinical settings, respond to changing social circumstances, and predict important health outcomes.

Here we present a method of constructing a SVI that takes into consideration the whole person in society. We have highlighted the social theories underpinning the construction of this SVI and presented two examples, one in a clinical dataset with few variables and one in a larger population dataset with many variables. Here, the SVI-SOS allows us to demonstrate how to calculate the index with a smaller, homogenous population, and fewer variables. Further, we illustrate how inclusion of a SVI can be feasible with prospective clinical data collection and the SVI-CLSA provides an example of screening and selecting variables for inclusion in the index (Appendix 1). Furthermore, the CLSA SVI here demonstrates properties of previously calculated SVIs: women tend to be more socially vulnerable than men. Importantly, and unlike a perfect state of health (frailty index = 0), almost no older adult has zero social vulnerability (30). Most importantly, both SVIs are composed of deficits representing multiple domains of social circumstances and different levels of social influence from the individual to the community. In this way social vulnerability reflects how frailty can be conceptualized as being the expression of problems across multiple body systems from the cellular to organ to systems (e.g., cardiovascular) level.

Only in the last decade have SVIs become popular in the medical literature (11). SVIs developed in non-medical fields include: Cutter et al created a SVI to environmental hazards (8), The Centres of Disease Control's SVI initially developed for emergency management and disaster planning (4) and, from Brazil, a SVI as a tool for urban management and development (31). All these SVIs are composed of only geographical or census level deficits. Whereas these measures subsequently were adapted to measure health outcomes, we approach social vulnerability through a health lens from the start. We especially consider the impact of social factors on the ability to resist the adverse consequences of any adverse medical event (or procedure) or to

repair or cope with it. In deficit accumulation terms, the distention between resisting a stress as "robustness" and recovery or maintenance ("resilience") appears to be useful.

Social vulnerability measured using an index has several strengths. It gives quantitative overview of an individual's social circumstance, which would not be possible by examining each social variable or domain isolation. Calculation of the SVI allows for flexibility and gradations. Small increases in social vulnerability can be captured and studied in relation to frailty and other outcomes of interest. Social vulnerability as a gradient can be useful to better differentiate risk and vulnerability. In our experience, there is value in using the SVI in tandem with the FI. Since both constructs capture heterogenous aspects of a person's clinical picture, adding the SVI builds a better model to predict health related outcomes. Furthermore, there is great utility for policymakers and clinicians to be able to adapt or replicate the SVI in any database or population has been established, regardless of whether the data come from surveys, clinical sources, or administrative records. The SVI can help to pinpoint vulnerable populations or regions and to target social and health resources as demonstrated by the Covid-19 pandemic (5). Any such SVI can be constructed with a variety of social variables, so long as the basic tenant of encompassing multiple broad social domains and levels is met.

Many questions remain unanswered in this area. One limitation is that the temporal aspect of social vulnerability, or the chronosystem as described by the ecological model, remain an aspect of complex social environments not fully captured by this approach to a SVI. For example, the SVI may be highly influenced by cohort effects over time – social factors that were protective in the past might not be anymore (e.g., in the CLSA reading the newspaper nowadays might be substituted by social media use, and reading the newspaper in certain cohorts may indicate a vulnerable trait). Previous work with the SVI has also suggested that social vulnerability plays a bigger role in the fittest individuals (27,32). Does the lack of time dependence of social vulnerability arise only when the frailest have already died? In comparison to our work on frailty, social vulnerability is not as strongly associated with age. Future research is encouraged to examine the dynamics of social vulnerability, and how they change with age, and whether

they show temporal trends. Additionally, we build our SVI using a deficit accumulation approach, but is this the same as taking a resilience approach? Social vulnerability should ideally encompass two concepts articulated by Ukraintseva, Yashin and Arbeev: robustness (the ability to resist deviation from the healthier state) and resilience (recovery to the healthier state aided by a well connected and supportive social situation) (33). Our SVI does not distinguish whether the absence of a deficit is the same as the presence of a resilience factor. Conceivably these would not confer the same degree of (dis)advantage yet only the former is captured by our index. Such considerations are motivating additional inquires by our group.

Conclusion

We present a standard method of constructing a SVI. In our holistic approach to understanding social circumstances, our SVI incorporates factors from multiple social domains and levels in a social-ecological model. We demonstrate construction of the SVI and its feasibility in two different datasets, with the potential for operationalization in many other datasets. Social vulnerability may have reproducible associations with age, sex and frailty. This SVI can be used to improve our understanding of social vulnerability and its impacts on the health of communities and individuals.

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Chapter 5: Social Vulnerability and Frailty in Hospitalized Older Adults

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Social Vulnerability and Frailty in Hospitalized Older Adults

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ABSTRACT

Background

Social vulnerability is the accumulation of disadvantageous social circumstances resulting in susceptibility to adverse health outcomes. Associated with increased mortality, cognitive decline, and disability, social vulnerability has primarily been studied in large population databases rather than frail hospitalized individuals. We examined how social vulnerability contributes to hospital outcomes and use of hospital resources for older adults presenting to the Emergency Department.

Methods

We analyzed patients 65 years of age or older admitted through the Emergency Department and consulted to internal medicine or geriatrics at a Canadian tertiary care hospital from July 2009 to September 2020. A 20-item social vulnerability index (SVI) and a 57-item frailty index (FI) were calculated, using a deficit accumulation approach. Outcomes were length of stay (LOS), extended hospital LOS designation, alternative level of care (ALC) designation, in-hospital mortality, and discharge to long-term care (LTC).

Results

In 1,146 patients (mean age 80.5±8.3, 54.0% female), mean SVI was 0.40±0.16 and FI was 0.44±0.14. The SVI scores were not associated with admission to hospital. Amongst those admitted, for every 0.1 unit increase in SVI, LOS increased by 1.15 days ($p<.001$) after adjusting for age, sex and FI. SVI was associated with staying over the expected LOS (aOR: 1.19, 1.05-1.34, $p=.009$) and ALC status (aOR 1.39, 1.12-1.74, $p<.004$). SVI was not associated with in-hospital mortality, but was associated with incident discharge to LTC (aOR 1.03, 1.02-1.04, $p<.001$).

Conclusion

Independent of frailty, being socially vulnerable was associated with increased LOS, designation as ALC, and being discharged to LTC from hospital. Consideration of social vulnerability's influence on prolonged hospitalization and long-term care needs has implications for screening and hospital resources.

Key words: social vulnerability, frailty, emergency department, hospitalization, long-term care placement, social vulnerability index, frail elderly

INTRODUCTION

Non-medical factors influencing health outcomes are known as the social determinants of health. Social determinants are risk factors leading to poor health in older adults.[1] Social determinants also have bidirectional effects; they are risk factors for prolonged hospitalization and delayed discharge from hospital. Consider two older adults presenting to the Emergency Department (ED) with the same acute illness and the same degree of frailty. One experiences a lengthy hospital stay as an alternative level of care (ALC) patient and the other is able to return home after a short admission—many of these differences are explained by social circumstances.

The concept of social vulnerability offers a means of conceptualizing and operationalizing the collective impact of social determinants of health. Social vulnerability is defined as the degree to which an individual's or community's overall social circumstances leave them susceptible to further insults (i.e., health or socially related adverse events).[2] High social vulnerability is associated with an increased risk of mortality,[3–5] disability,[5] and cognitive decline.[6]

Well-established indices of social vulnerability include Cutter, Boruff and Shirley's social vulnerability index to environmental hazards,[7] the Centers for Disease Control and Prevention's index for disaster management planning using census data,[8] and Andrew, Mitnitski and Rockwood's social vulnerability index (SVI) using population based surveys.[9] All the indices reflect different instrumental ways of measuring similar constructs and all have been used previously for health research.

This paper uses the latter method of SVI construction as it is the most common of the three used to examine vulnerability of individuals (rather than community vulnerability). This SVI has been constructed in several large population data sets internationally including the Canadian Study of Health and Aging,[6,9] the Survey of Health, Aging and Retirement in Europe (SHARE),[5] and the Honolulu Asia Aging Study.[10] However, social vulnerability is rarely examined in hospital-based cohorts, which is a setting that can benefit from systematic social vulnerability evaluation for discharge planning.

This paper addresses the gap between population cohorts and hospital cohorts by evaluating how social vulnerability influences a patient's course in hospital, from presentation in the ED to length of stay (LOS) to discharge from hospital. Drawing upon a deficit accumulation approach to conceptualize social vulnerability, this study aims to answer the broad research question: How does social vulnerability contribute to hospital outcomes and use of hospital resources for older adults presenting to the ED?

METHODS

Hypotheses

We hypothesized that higher social vulnerability would be associated with: 1) increased risk of admission to hospital, 2) longer stays in hospital, and 3) increased risk of not returning home after hospitalization.

Study Design and Data

This is a secondary data analysis of the Geriatric Patient Information Database, a single-site cohort study of prospectively enrolled older adults presenting to the ED in a large Canadian tertiary care center in Halifax, Nova Scotia from July 2009 to September 2020. Patients 65 years or older were seen by a geriatrician, senior internist or member of their team (senior medical resident or geriatric fellow) and completed a Comprehensive Geriatric Assessment (CGA). This database, known as the Geriatric Patient Information Database (GPID) has been described in previous publications.[11,12]

The GPID was linked to Vital Statistics data (birth and death data from the Government of Nova Scotia up to March 2020) and the Discharge Abstract Database (hospital outcome database up to April 2020 developed by the Canadian Institute for Health Information). Neighbourhood level variables from the 2016 Canadian Census were linked to the GPID using the Postal Code Conversion File Plus (PCCF+) 7C.

Measures

A 20-item SVI was calculated using deficit accumulation methodology.[4,6,13] Candidate variables for inclusion in the SVI were identified from the CGA (Appendix A) based on several criteria. First, variable (or item or deficit) selection had to include a wide range of factors representing a holistic view of the patient's social circumstances. We included measures of socio-economic status, social engagement, social isolation, living situation, advanced care planning, and caregiver relationships. Second, the variables chosen had to reflect strictly social circumstances and not overlap with variables comprising the frailty index. Finally, variables included had literature demonstrating potential to adversely impact health outcomes in a deprivation state.

Building on the SVI described by Andrew and Keefe,[3] we included eight neighbourhood-level variables because an individual's social vulnerability is directly influenced by their larger social networks, cultures, environments, and institutions.[3] An example of a neighbourhood variable is the unemployment rate of a dissemination area (DA) compared to the rest of the DAs in the province. DAs represent approximately 500 individuals and are the smallest standard geographic unit for census data. The 2016 Canadian Census was chosen as the best and most recent representation of this cohort's living situation. We demonstrate the 20 SVI variables situated within an ecological framework in Figure 1.

Each social deficit is coded between 0 and 1, with 1 indicating the greatest state of relative vulnerability (e.g., being married is coded 0 and single or widowed is coded 1). For intermediate responses, deficits may take a value of 0.5. Ordinal variables rank into a score according to number
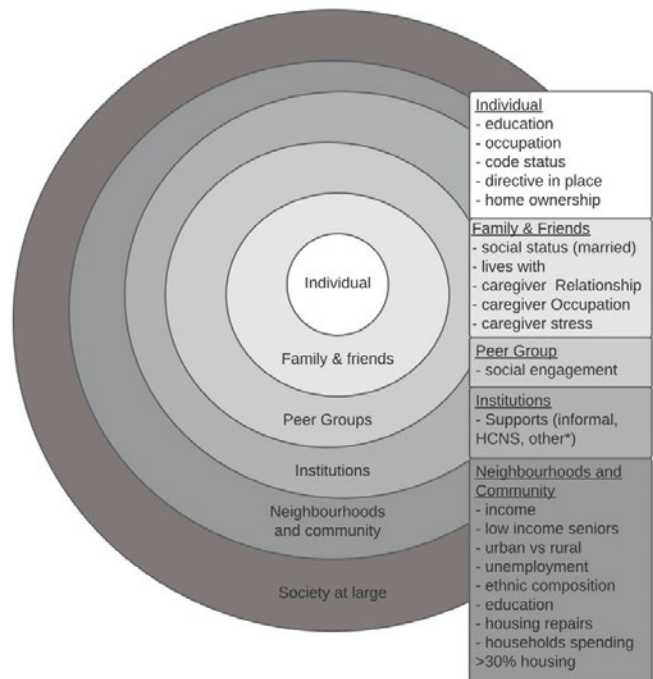
FIGURE 1. Social variables used to construct the SVI, organized within an ecological framework

of levels. For example, a deficit with four levels would be coded 0 for the social variable characteristic that is most protective, 0.33 and 0.66 for middle states of vulnerability, and 1 for the most detrimental characteristic for vulnerability. The scores for all social deficits were summed and divided by the total (/20), yielding a range of final SVI scores from 0–1. Appendix B shows each social deficit included in the SVI and their coding.

Frailty is measured as a 57-item frailty index (FI) using the same methods described above. The variables and coding of the FI is available in Appendix B and in previous publications.[11] The SVI and FI were multiplied by 10 before addition to the regression models, allowing us to interpret adjusted odds ratios (aORs) and LOS for each 0.1 increase in these indices.

Outcomes

The outcomes reflect an older adult's journey from ED presentation to hospital admission to discharge. The outcomes are: 1) admission to hospital, 2) extended hospital length of stay designation (defined as staying longer than the expected length of stay calculated for an individual's case mix), 3) LOS in hospital measured in days, 4) being designated ALC status (defined as utilizing a hospital bed but determined not to require the acuity of the services), 5) in-hospital mortality, 6) discharge to home with or without services, and 7) incident discharge to a long-term care (LTC) home (new admissions, excludes the 23 patients who were already living in a LTC home).

Statistical Methods

Summary statistics of baseline categorical and continuous variables and of missing data were produced using descriptive statistics (frequencies and proportions). *T*-tests and chi-square testing were used to describe differences in means and proportions between the older adults seen only in the ED and those admitted to hospital. Multivariable Poisson regression was used to determine the association between SVI or FI (explanatory variables) and hospital LOS (outcome). Separate multivariable logistic regression models were employed for the remaining binary outcomes described in the previous section. *P* values shown at this step are calculated from the likelihood ratio test, except for new long-term care placement. As the rarest event in the data set (<5% prevalence), the association between the odds of new LTC home placement and social vulnerability or frailty was calculated using Firth's penalized likelihood logistic regression to help remove small sample bias.[14] The final models were adjusted for age and gender, which were identified as having a priori importance as potential confounders. All analyses were conducted in RStudio (Boston, MA; www.rstudio.com).

Missing Data

Individuals (n=853) with data for at least 80% of the social variables comprising the SVI (at least 16 social deficits recorded) were compared to individuals missing more than 20% of the SVI variables (n=293). Compared to those with more complete data, individuals in the missing data group demonstrated no difference in mean age (missing group age = 79.85 [SD 8.11] vs. complete group age = 80.74 [SD 8.33], *t*-test *p*=.11), or mean frailty score (missing group FI = 0.43[SD0.14] vs. complete group FI = 0.45[SD0.14], *t*-test *p*=.14). In total, the proportion of missing data among all individuals was 15.3% and the proportion of missing data among patients admitted to hospital was 8.8%. We would expect a higher rate of missing data in the patients who were only seen in the emergency department compared to those who were admitted to hospital with a longer duration of follow-up. In instances where there are more than 10% missing data, statistical analyses are likely to be biased[15] and necessitate some method of accounting for missing data beyond complete case analysis or pairwise deletion.[16] Modern analysis methods include multiple imputation, maximum likelihood, and expectation-maximization. To date, several studies have not found significant differences between the approaches,[15,16] therefore suggesting leaving the decision at the discretion of the authors and data. Missing data at the item level was therefore handled using multiple imputation via chained equations.[17] The results of 20 imputed data sets were pooled using Rubin's rules[18] to avoid underestimation of the impact of social vulnerability on older adults for whom missing data may be due to being more socially vulnerable. Appendix C includes the fraction of missing information (the proportion of sampling error due to missing data) per effect estimate.

Ethics Approval

All individuals or their substitute decision-makers consented in writing to their data being collected as part of the GPID. This study was approved by the Nova Scotia Health Authority Research Ethics Board (NSHA-REB File No. 1022792).

RESULTS

Descriptive Statistics

Of 1,146 older adults with a mean age of 80.5 years (SD8.3), half were women (54.0%). Most were residents of Nova Scotia (98.9%), and 93.5% lived in the Halifax census metropolitan area. In the ED, the mean SVI score was 0.40(SD 0.16) and the mean FI score was 0.44(SD 0.14). Women were more likely to have greater SVI scores (*p*<.001), but not higher frailty scores (*p*=.08) (Appendix D). The association between age or frailty and SVI was not statistically significant. Over half of the older adults seen in the ED were subsequently admitted to hospital (62.0%). Individuals admitted to hospital were more likely to be older and living with greater frailty but were not more likely to be socially vulnerable. Table 1 shows the characteristics of all participants.

Hypothesis 1: Admission to Hospital

Frailty, but not social vulnerability, was associated with admission to hospital (aOR 1.25, CI: 1.14–1.36, *p*<.001). No significant interaction was found between SVI and FI or SVI and gender for admission to hospital or for any outcome discussed below.

Hypothesis 2: Hospitalization

Once admitted to hospital SVI was associated with an extended length of stay and ALC status. For every 0.1 increase in the SVI, older adults had 1.4 times increased odds of becoming ALC status on the way to incident LTC placement (adjusted OR 1.39, CI: 1.12-1.74, p =.004) or 1.2 times increased odds of having an extended hospital LOS designation (OR 1.19, CI: 1.05-1.34, p =.008) as shown in Figure 2. For every 0.1 increase in the SVI, length of stay in hospital increased by 1.15 days (CI: 1.12–1.17, $p<.001$).

Hypothesis 3: Discharge Destination

Figure 2 also summarizes the association between SVI, FI, and discharge destination. FI, but not SVI, was associated with a 70% increase in odds of dying in hospital (aOR 1.69, CI: 1.42, 2.00, $p<.001$). Among older adults who did not die in hospital, those with higher social vulnerability were less likely to return home (aOR 0.84, 95% CI 0.73, 0.96, p=.009). In a penalized regression model, SVI was also associated with greater odds of incident LTC home admission (aOR 1.03, CI: 1.02, 1.04, $p<.001$). Effect estimates, confidence intervals, and p values of all outcomes are available in Appendix C.

DISCUSSION

By aiming to understand the role of social vulnerability in this population of older adults presenting to the ED, we found that social vulnerability played a larger role once admitted to hospital, and contributed to longer stays in hospital and being unable to leave after resolution of an acute illness (designated ALC status). Frailty, rather than social vulnerability, was associated with increased risk of admission to hospital. Frailty appeared to drive in hospital mortality. Both high social vulnerability and frailty, independent of the other, were associated with decreased odds of returning home and with increased LTC home admission.

Our results indicate key similarities and differences between previous studies conducted with the SVI in large population data sets. We also found that women were more socially vulnerable than men.[19] We did not find social vulnerability to be a robust marker of mortality after adjusting for frailty. This sample of older adults demonstrated greater degrees of frailty and social vulnerability than previously studied populations, particularly in contrast to community dwelling older adults. This may suggest that when a person reaches a certain level of frailty, it is the acuity of the medical illness that drives immediate outcomes. SVI was important once the acute medical illness had stabilized. This is consistent with the lone study of this SVI in a hospitalized cohort; Godin and colleagues found that social vulnerability mattered most for admission to LTC following hospitalization in the oldest old with influenza and acute respiratory illnesses.[20]

Our finding that individuals admitted to hospital were more likely to be older and living with greater frailty but were not

TABLE 1.
Demographic characteristics: means (SD) or frequency (%)

	All	ED Only	Admitted after ED
n (%)	1146 (100)	435 (38.0)	711 (62.0)
Mean age (SD)	80.51(8.3)	79.53 (8.36)[a]	81.11(8.18) [a]
n female (%)	619(54.0)	234(53.8)	385(54.2)
Mean SVI (SD)	0.40 (0.16)	0.38 (0.13)	0.38(0.13)
Mean FI (SD)	0.44 (0.14)	0.41(0.16) [a]	0.46(0.13) [a]

[a]*T*-test met statistical significance at $p<.01$.
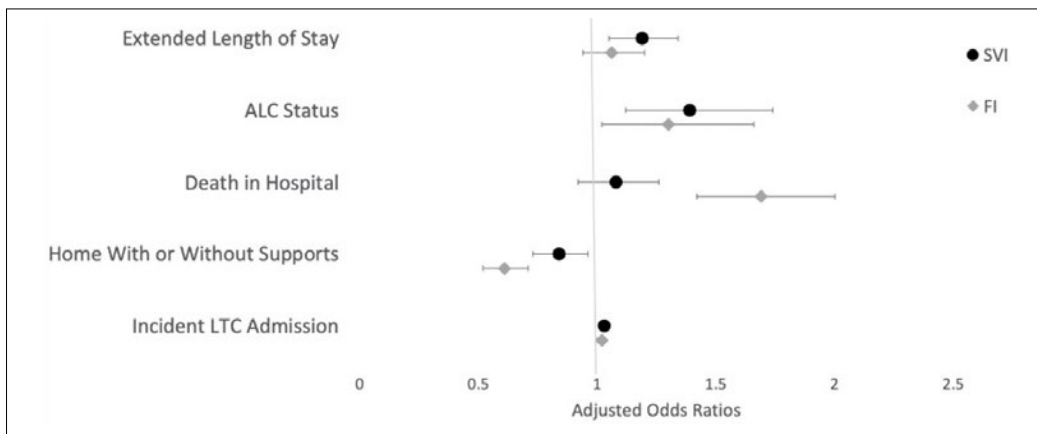
FIGURE 2. Associations between frailty, social vulnerability and hospital outcomes of extended length of stay designation, ALC status, death, and discharge destination

more likely to be socially vulnerable raises additional questions. Is the decision to [not] admit potentially a key place to intervene for the socially vulnerable to avoid lengthy hospital admissions or having to move to LTC? Or are we better at ignoring the contributions of social vulnerability in the ED and feel more comfortable for these individuals to be admitted to be assessed in a safe (in-patient) environment by a multidisciplinary team? Could the Emergency Department before admission be the ideal location to implement a hospital at-home program as described by previous studies?[21] In this situation, a dilemma arises: How do we balance safe discharge with allowing dignity of individual risk? We also found that social vulnerability, but not frailty, was associated with extended LOS defined as LOS greater than expected according to case-mix definitions. This suggests that currently used case-mix allowances for LOS do a better job accounting for frailty than accounting for SV. This would be important to policy makers, especially as these case-mix definitions are used to compensate institutions for patient stays and track performance. If a hospital admits from more socially vulnerable populations, it will be unsurprising that they will have longer LOS; for this they should be resourced, not punished.

Our study is not without limitations. The GPID represents a prospectively recruited sample of older adults seen by an internal medicine or geriatric specialist in the ED prior to admission in one province. Assessment by physicians comfortable with medically and socially complex patients may contribute to Hypothesis 1 results trending towards the null value. The same results may not be seen in a broader population of older adults presenting to the ED who were not seen by such a specialist. Furthermore, the GPID was collected at a single site, which limits generalizability of these findings. It would be interesting to repeat these analyses on a broad sample of all patients admitted across services, who have not had specialist assessment on presentation, or to repeat this study at another hospital site. As in any clinical database, there were some missing data, however no important between-group differences in age or frailty were noted for those with vs. without missing data, and a robust multiple imputation methodology was used.

One strength of this sample is that it captures older adults in crises, as the ED is often the safety net for untreated medical or social issues, and this is reflected in the high vulnerability of the FIs and SVIs.

CONCLUSION

This study demonstrated that being socially vulnerable, independent of frailty, was associated with increased LOS, becoming ALC, and being newly discharged to LTC from hospital. The findings—that the acuity of the medical illness drives admission and mortality outcomes in the most frail populations, but social vulnerability keeps them in hospital or otherwise institutionalized—contributes to the evolving literature on understanding how to use social vulnerability in different settings when caring for an aging population.

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Chapter 6: Admissions for Presumed Social Reasons: Epidemiology, Risk Factors, and Hospital Outcomes

[published]

Admissions for Presumed Social Reasons: Epidemiology, Risk Factors, and Hospital Outcomes

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Abstract

"Social admission" is a non-diagnostic label referring to an admission to a hospital for which no medical or health condition is deemed amenable to reversibility or rehabilitation; rather, the patient's social circumstances are felt to be the sole cause of hospitalization. There is a growing realization that medical facilities are experiencing an increase in socially vulnerable patient presentations. Clinicians also face challenges in caring for this patient population, which may have atypical presentations in which medical and social complexity often align. To better understand individuals admitted for social reasons and to guide future care and research, we review (i) the epidemiology, (ii) risk factors, and (iii) health outcomes associated with being labeled as "social admission." We draw attention to factors that may improve care for this patient population and offer potential solutions with clinical relevance. Clinicians should remain mindful that patients labelled as "social admissions" often have complex underlying medical problems, which may be acute, and are at high risk of poor outcomes.

Résumé

L'« admission sociale » est une étiquette non diagnostique qui fait référence à une admission à l'hôpital pour laquelle aucun trouble médical ou problème de santé n'est jugé réversible ou réadaptable; les circonstances sociales du patient semblent plutôt la seule et unique cause de l'hospitalisation. On se rend de plus en plus compte que les installations de soins de santé connaissent une augmentation du nombre de patients socialement vulnérables. Les cliniciens font également face à des défis dans la prise en charge de cette population de patients qui peuvent présenter des tableaux cliniques atypiques dans lesquels s'aligne souvent une complexité médicale et sociale. Pour mieux comprendre les personnes admises pour des motifs d'ordre social, et pour orienter les soins et les travaux de recherche à venir, nous examinons l'épidémiologie, les facteurs de risque et les résultats en matière de santé associés au port de l'étiquette « admission sociale ». Nous attirons l'attention sur des facteurs susceptibles d'améliorer les soins prodigués à cette population de patients, et proposons des

solutions possibles et pertinentes sur le plan clinique. Les cliniciens doivent garder à l'esprit que les patients considérés comme étant des « admissions sociales » ont souvent des problèmes médicaux sous-jacents complexes, qui peuvent être aigus, et présentent un risque élevé de mauvais résultats.

Introduction

The increase in the number of people presenting to the hospital for non-acute reasons and who cannot live safely at home is a worrisome trend in Canada. Emergency departments (ED) have become a final destination for some socially vulnerable patients, resulting in their occupation of hospital beds that were originally designed to treat acute medical issues.[1] People who are admitted to the hospital for presumably social reasons rather than medical reasons, often receive a non-diagnostic label. These labels are common (e.g., "social admissions," "acopia," "home care impossible," etc.) but have little clinical utility. These labels do not describe why patients present "today" and they do not prompt clinicians to initiate care pathways to further investigate the reason for emergency department presentation. Furthermore, there is a contradiction inherent in the label of "social admission." Most definitions of "social admissions" mean hospitalizations with no acute medical issues; rather, the patient's social circumstances are felt to be the sole cause of admission. This may reflect a variety of scenarios, such as the breakdown of home support or the inability of the patient and/or family to cope with the demands of living at home.[2] It is an unplanned admission in which no medical or health condition is deemed amenable to reversibility or rehabilitation.[3] Paradoxically, many individuals thus labeled as having medical conditions,[4] be they chronic or acute; otherwise, there would be minimal justification for their inability to live at home.

Individuals admitted to the hospital for primarily social reasons, colloquially known as "social admissions," face important challenges. This terminology frequently applies to patients who are often older, cognitively impaired, and medically complex.[2] These individuals may have medical conditions that are overlooked or under-diagnosed due to a focus on their social situation.[5] Unsurprisingly, patients so labeled can be inadequately prioritized and under-triaged.[6] Patients labeled as "social admissions" often lack strong social support systems and people who can advocate for their needs, which further complicates their care.

There are significant gaps in understanding the characteristics and needs of people admitted for social reasons. They often cannot advocate for themselves or are "silent by proxy" because those most commonly labeled as social admissions tend to be frail or cognitively impaired.[7] They are underrepresented in research and policy because varying definitions and admission criteria make comparisons across regions and healthcare systems challenging, despite similar social presentations. Furthermore, "social admission" terminology is non-diagnostic, thereby negating the development of guidelines to standardize approaches to meet medical or social needs. Nonetheless, hospitals face growing numbers of this patient population.[8–10] As a result, clinicians encounter challenges when it comes to delivering proper care for these patients, which often necessitate thorough evaluations, comprehensive assessments, and interdisciplinary care teams—resources that are not available in all settings. Here, we review (i) the epidemiology, (ii) risk factors, and (iii) health outcomes associated with patients who are labeled as a "social admission" to guide future care and research. In our Discussion section, we also examine factors that should be considered when moving forward.

Methods

We conducted a focused literature review in the medical databases Medline and Embase on the topic of social admissions from inception to March 31, 2023. We searched for the following key words synonymous with social admission: *social admit*, *social admission*, *acopia*, *dyscopia*, *home care impossible*, and *orphan patient*. We had searched the references of relevant papers for further peer-reviewed publications and included papers describing patient populations labeled as: *lack of community support*, *failure to cope*, *failure to thrive*, and *GP (general practitioner) problems*, and *medically inappropriate* when used as synonymous to a "social admission" (all labels will be in single quotations through the rest of the paper). Papers focused on *failure to thrive* were

excluded from this review at the screening stage because it is recognized as a geriatric syndrome by the National Institutes of Aging and a Royal College competency for Internal Medicine (i.e., competency 1.4.13.6.1.5, frailty and failure to thrive).[11] There is genuine concern that failure to thrive is used inappropriately to describe social admissions; however, unlike the other terms, failure to thrive has evaluation pathways and approaches to management.[12,13] We included any peer-reviewed publication. We described the findings narratively. We used the umbrella label "social admission" in this paper but recognized that there are often biases and stigmas associated with all synonyms.

Results

The ten original research studies included in the review are summarized in Table 1.

Epidemiology

Prevalence

Few reports estimate the prevalence of "social admissions" in the general population. One study estimated "acopia" labels accounted for 0.10% of all emergency department (ED) admissions.[14] Another estimated "acopia" labels it as accounting for 0.18% of all patients seen in one UK ED.[15] The prevalence in adults >65 years is higher (Figure 1). Social presentations ranged from 0.57% to 9.3% among patients in the ED.[15–17] and 0.44% to 4.0% among admissions to hospital.[18,19] Another report on "social admissions" found prevalence increases with age, from 3.0% for those aged 65–69 and 12.0% for those 85 years and older.[19] Using the Appropriateness Evaluation Protocol, 15.2% of admissions to a Swiss internal medicine department in an urban teaching hospital were deemed "medically inappropriate"[20] and thereby social by default. In a survey of junior doctors and consultants in the United Kingdom, 51.8% reported encountering a patient admitted as "acopia" or "social admission" a few times per week and 23.4% reported it as a daily occurrence.[21]

Characteristics

In each study, the average age (mean or median) was above 65 years (Table 1). Patients labeled as "social admissions" were predominantly women, and most of them lived in the community prior to admission. In the two studies where baseline dementia diagnosis was reported, dementia was present in 23.3% and 43.0% of social admissions.[5,18] Functional dependence was present in over half of the population in four studies where this was reported.[5,18,19,22]

Risk Factors

Few high-quality studies examine risk factors for being labeled as "social admission." Living alone, falls, rehospitalization, and living in an independent dwelling were associated with increased odds of being admitted for "failure to cope" (FTC) among individuals >70 years in one Canadian hospital.[5] In the Canadian case-control study, there was no association between a label of "failure to cope"; and medical diagnoses including falls, urinary incontinence, dementia, and conditions assessed through the Charlson Comorbidity Index (CCI). Age was not associated with "FTC" in that same study, but older age significantly increased the risk of being labeled "acopia" in another study.[15,23] Another study of individuals admitted to hospitals under internal medicine services found worse physical functioning, a worse self-health rating, receiving informal care, hospitalization by a GP, and having a spouse with worse physical or mental health status increased the odds of "medically inappropriate" (i.e., social) admission.[20]

Outcomes

Mortality

In-hospital mortality ranged from 3.0% to 34.9% (Figure 2). When compared to those admitted to an elderly acute care unit in the same time period, mortality was 8.9% for the elderly acute care unit compared to 34.9% for patients labeled as a "social admission."[3] One-to-three-month mortality post-hospitalization ranged from 12.9% to 26.0% and one-year mortality ranged from 34.0% to 43.0%. Of the 34.0% of patients who were diagnosed as "lack of community support" and went on to die, 38% died within one month of hospitalization.[22]

Care in Hospital

In the ED, one study reported that vital sign assessments were delayed in 16 of 253 "home care impossible patients"; this is associated with under-triaging.[17] One Australian study found 84% of "acopia" labels were admitted under a geriatrician.[18] The average length of stay for "social admissions" ranged from 8 to 28.7 days. In comparison to two control groups (one control group matched for age, sex, and admission date, and the other control group consisting of all

Table 1. Definitions of social admission terminology and characteristics of people admitted as social admissions.

Reference (First Author, Year) & Study Location	Type of Study (n for social admission)	Social Admission Term & Definition	Age (Years)	Sex or Gender	Living Situation	Function	Medical Conditions
Burrell 2021 London Health Science Centre, Canada	Case control (99)	Failure to cope = a condition not requiring acute medical attention, often considered a "social admission" do not provide a clinical diagnosis, and imply the patient is at fault for not managing a condition with which they should be able to cope.	Mean 84.1	57.8% female	73.5% independent dwelling 45.9% living alone 17.3% retirement home 8.6% nursing home	57.8% ADL assist 78.9% IADL assist 18.9% independent walking	80% classified as frail with CFS Mean CCI 6.03 (SD 2.2)
Elmstahl, 1999 General hospital, Sweden	Chart review (380)	Lack of community support = patients without a specific diagnosis of symptoms, and in need of home help services for ADL activities as judged by a physician.	Mean 81	66.1% women	91.1% own home 80.4% live alone	55.8% unable to walk at admission 23.7% unable to eat independently	-
Gonski 1997 Sutherland Hospital, Australia	Case control (21)	Acopia = represents what is known as a social admission. Patients with acopia are presumably admitted without acute systemic disease, with accommodation problems, failure of self-care or falls without significant injury.	All > 80 years	Most female	100% live alone or with family	-	-
Kee 2008 General hospital, United Kingdom	Chart review (93)	Acopia = a pejorative term used in hospitals to describe patients who are unable to cope with activities of daily living. The term is mainly used to describe either patients with no acute medical problems or who are deemed inappropriate admissions.	Median 85 93.8% > 65 years	69.1% female	-	-	81.5% had ≥ one comorbid conditions 12.5% had ≥ 3 comorbid conditions
Obeid 2000 Sydney teaching hospitals, Australia	Chart review (109)	Acopia = the presentation of some older patients without reference to, or recognition of, the medical or functional reasons for the presentation or the underlying multifactorial pathology. It is often used to imply that the patient's problems are only of a 'social' nature and that there is no active or 'acute' medical problem.	Mean 80 (SD 10.0) Range 28-92	64% female	96.3% own home	52% independent for ADLS 78% independent mobility with or without aid	8 diagnoses on average per person

Study	Study type (n)	Definition	Age	Sex	Living situation		Other
Perneger 1997 Urban teaching hospital, Switzerland	Cross sectional study (76)	Medically inappropriate = Defined by a tool called the Appropriateness Evaluation Protocol (AEP). The AEP uses 17 criteria (10 related to patient health status and 7 to the intensity of health service needs) to assess the appropriateness of each hospital admission and 27 other criteria to assess the appropriateness of each hospital day. Whenever an admission fulfilled at least 1 criterion, it was ruled appropriate.	22.4% <50 years 19.7% ≥80 years	65.8% male	14.5% live at home 53.9% live with another person	-	25% self rated fair to poor health
Rai 1986 Hospital, United Kingdom	Chart review (43)	Social admit = an unplanned admission in which no medical or rehabilitation cause was found	Mean 85 (SD 5.0)	1:1.7 ratio males to females	-	-	-
Richardson 1992 Hospital, Australia	Prospective descriptive study (10 social problem)	GP problem or social admit or social problem = conventionally regarded as inappropriate for an emergency department, including repeat prescriptions and routine injections	Mean 83 (SD 4.8)	59.5% women	-	-	-
Rutschmann 2005 University hospital, Switzerland	Exploratory observational study (253)	Home care impossible = describing the following situations: (1) when their primary care or referring physicians explicitly noted on their referral note that home care services and/or social and familial support were not able to support the patient at home anymore; or (2) when the triage nurse could not identify any specific chief complaint except insufficient social, familial and/or nursing support.	Mean 81 Range 65-97	60% female	30% live alone 30% live with spouse	-	-
Victor 1986 General hospital, Wales	Survey / Case control (101)	Social admits = ICD code V600 to V6055	24% between 65-69 years 25% > 80 years	72% female	100% community 23% live with spouse 61% live with children or other relative	59% housebound 72% severely disabled	-

ADL: activities of daily living; CCI: Charlson Comorbidity Index; CFS: Clinical frailty scale; IADL: instrumental activities of daily living; SD: standard deviation
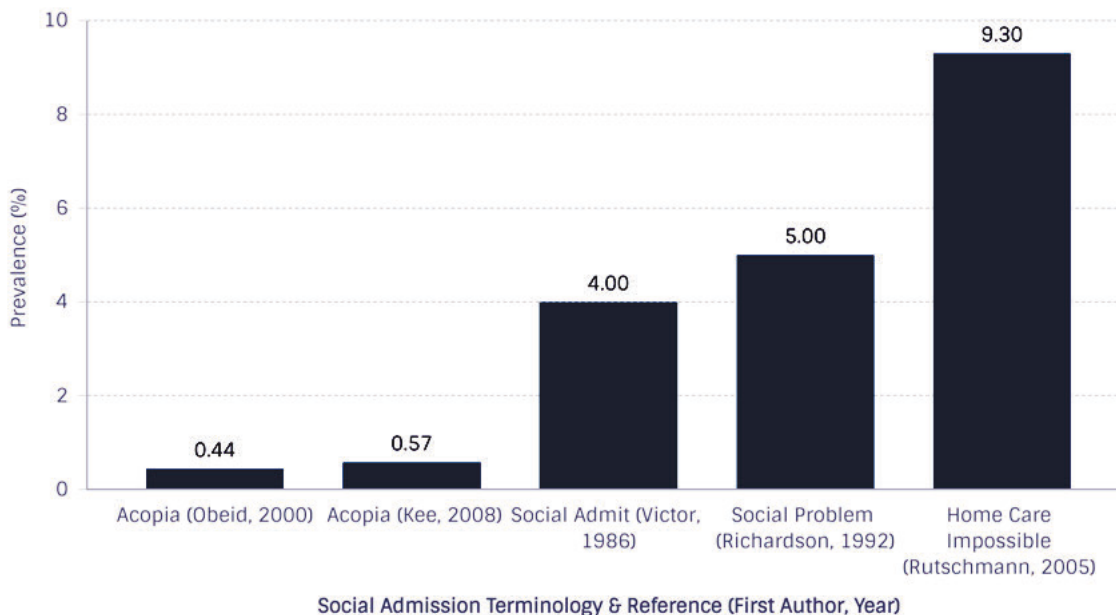
* Obeid, 2000: Patients > 65 years admitted through the ED; Kee, 2008: Patients > 65 years seen in the ED; Victor, 1986: Patients > 65 years admitted to hospital; Richardson, 1992: Patients ≥ 75 years seen in the ED; Rutschmann, 2005: Patients > 65 years seen in the ED

Figure 1. Prevalence of social admissions among older adults.
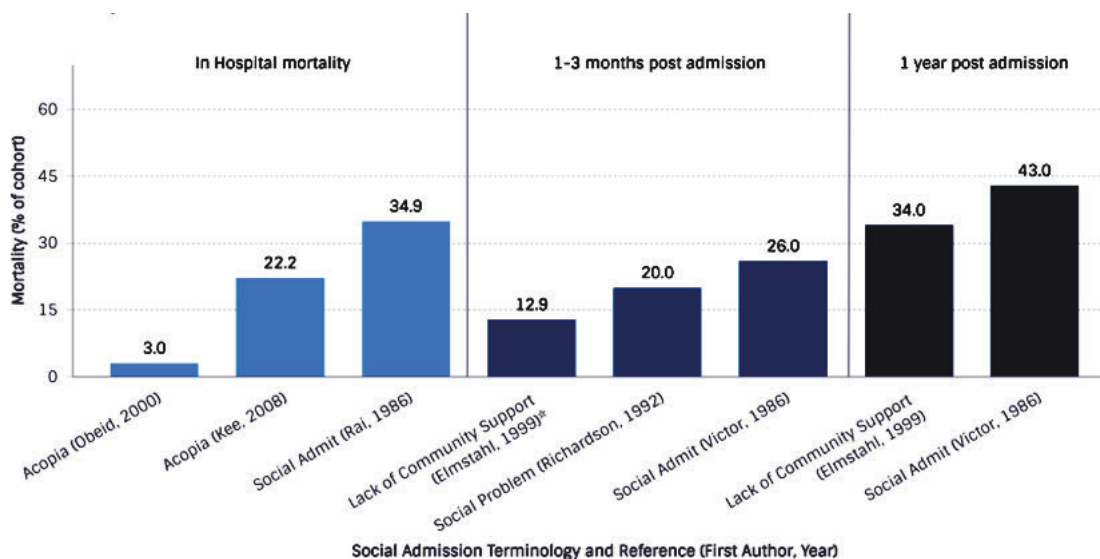
*One month from admission date

Figure 2. Mortality of social admissions.

admissions >65 years), the length of stay did not differ from an "acopia" or "social admit" reason for hospitalization.[14,19]

Discharge from Hospital
In five studies examining the final discharge diagnoses, most people were not discharged with the same "social admission label." One study found 51% of "home care impossible" labeled admissions had an acute medical issue, in whom 24% had a previously undetected infection.[17] "Acopia" was not the final diagnosis in 88.0–95.2% of patients admitted under that label.[14,15,18] Rather, falls and gait difficulties, delirium and dementia, and sepsis were all diagnosed prior to discharge. As shown in Table 2, a significant proportion of patients labeled as "social admissions" were unable to return home

Table 2. Length of stay, discharge diagnoses and disposition of social admissions.

Reference & Social Admission Terminology	Length of Stay (Days)	Discharge Diagnoses	Discharge Disposition (versus pre-admission)
Burrell 2021 Failure to cope	NR	NR	NR
Elmstahl 1999 Lack of community support	Median 14	85% found to have a physical precipitant instead of lack of community supports Cardiovascular event – 43.1% Infection – 29.5% Cerebrovascular event – 24.5% Trauma/falls – 24.0% Dementia – 19.1% Dehydration – 12.9% Hematological dx – 12.4% Endo/metabolic – 4.8%	37% went home (88.9% from home)
Gonski 1997 Acopia	Mean 17.3	95.2% did not have a final diagnosis of acopia Falls/ Parkinson disease - 19.0% Delirium / Dementia – 19.0% Cerebrovascular disease – 14.3% Fracture – 14.3% GI problems – 14.3% UTI/Sepsis – 9.5%	42.9% went home (100% from home) 38.1% to LTCH (0% from LTCH)
Kee 2008 Acopia	Median 10 Range 1-139	92.5% did not have a final diagnosis of acopia Geriatric syndrome (e.g., fall, mobility issue or confusion) – 46.9% Sepsis – 29.6% Psychiatric diagnosis – 16.1% Cardiac – 7.4% Iatrogenic 6.2%	51.9% went home (96.3% from home) 14.8% to LTCH (1.2% from LTCH)
Obeid 2000 Acopia	Mean 12.9 (SD11.7)	88.0% did not have final diagnosis of acopia Gait problem or fall – 47% Confusion – 9% Cough or shortness of breath – 9% Psychiatric disorder – 9% Metabolic or endocrine disorder – 7% Incontinence – 5% New diagnosis of cancer – 5%	50% went home (90% from home) 25% to LTCH (1% from LTCH)
Perneger 1997 Medically inappropriate	1-7 – 35.5% >23 – 11.8%	NR	NR
Rai 1986 Social admit	NR	NR	48.8% went home (100% from home)
Richardson 1992 Social problem or some social component	Mean 28.7 (SD 21.4)	Dementia - 30%	40.0% went home (90.0% from community) 30.0% to LTCH (0% from LTCH, although 10% from shelter)
Rutschmann 2005 Home care impossible	-	51% had an acute issue Infection – 24% Cardiovascular disease – 14% Stroke – 9% Hernia or abdominal pain – 7% Pulmonary disease – 5% Others – 30% (included delirium, fracture, anemia, acute renal failure, cirrhosis, hypoglycemia, hyperglycemia, uncontrolled pain, etc.)	-
Victor 1986 Social admit	Mean 8	NR	NR

LTCH: long term care home; NR: not reported

after hospitalization and instead required new long-term care arrangements.

Discussion

In our search to understand the epidemiology, risk factors, and health outcomes associated with a label of "social admission," the number of original research papers rivaled the many commentaries, letters to the editor, or editorials on this topic.[1,2,24–28] Chart reviews were the predominant study design. With the exception of one paper,[5] the literature was not recent.

Despite prevalence estimates suggesting "social admissions" were a small proportion of all patients seen by the hospital system, once admitted, the rates of reported mortality were surprisingly high, and these patients were unlikely to return home after hospitalization. These findings support the notion that those admitted under the label of "social admission" may not be medically stable. However, bringing together the literature provided few insights into the experiences and care received by this population to explain the high mortality. Out of all studies analyzed, only one provided numerical data regarding possible under-triaging from reduced and timely vital sign monitoring.[17] The study with the lowest mortality statistic admitted 84% of the acopia patients under geriatrics, which merits further consideration. It would also be important to understand how many of these acute (and ultimately deadly) medical issues were present and brewing at the time of admission and were unrecognized due to premature diagnostic closure relating to the stigma of the "just a social admission" label, versus how many of these deaths were due to complications (e.g., falls, delirium, polypharmacy) that arose during the hospitalization.

Our findings also support previous literature suggesting "social admission" terminology is used predominantly in an older adult population. This population is predominantly female, functionally limited, and arrives from independent dwellings in the community (instead of being used to describe patients admitted from long-term care facilities). The Canadian case-control study, where no association was found between a label of failure to cope and medical condition was found, may reflect under-coding and an inability to comprehensively identify medical factors that are present and/or contribute to the acute presentation. Given that the majority of people admitted for social reasons were not discharged with the same diagnoses, we propose

considering "social admissions" as a quality-of-care issue within the healthcare system.

The commentaries identified, combined with the included original research studies, provide valuable perspectives for understanding the phenomenon of "social admissions," and we briefly summarize key insights below. Following each section, we provide a brief statement on possible ways to improve based on our observations.

Communication between clinicians
The phenomenon of social admissions occurs in part because healthcare professions like using the terminology. In one UK study, 43.5% of junior doctors and consultants felt "acopia" and "social admissions" were useful terms.[21] In this same survey, 44.8% of physicians felt patients labeled with "acopia" were a burden on their time, and 62.7% believed "acopia" patients were a burden on National Health Service resources. This terminology was not unique to physicians. In two large teaching hospitals in Sydney, Australia, the terminology of "acopia" was used first by paramedics 10% of the time, triaging nurses 12% of the time, and emergency department physicians 21% of the time.[18] Language confers meaning and "social admission" terminology may bias healthcare providers against looking for underlying medical, social or functional reasons for seeking help, with the implication that "failure to cope" is a failure on the patients or caregivers.[4,29] Education and awareness of the stigma associated with "social admission" labels are potential actionable steps. There have also been calls to decrease the use of "acopia" and one organization has banned its use in their health authority altogether.[25,26] Given the limitations and stigma of current labels, future research can explore the lived experiences of these patients and caregivers for better descriptors that are sensitive to their complex social situations.

A focus on efficiency
A 2015 ethnographic study investigated how intra-professional interactions affected medical education and discovered a hidden curriculum: there was too much importance placed on "getting the patient out" of the ED.[29] Resource constraints were hidden within a discourse that shifted the problem of overcrowding in the ED onto the patients. The term "failure to cope" became activated when overworked physicians tried to avoid assuming care for high-needs patients, masking institutionally produced stress and altering the way "failure to cope patients" were being perceived.[29] In the section on risk factors, recall that there was an increased likelihood of "failure to cope admissions" in

association with multiple social risk factors but no correlation with medical conditions. This led the study to conclude that medical conditions, while very much present (average CCI was 6.03), did not play a role in the activation of a "failure to cope" label – rather the label may have been used to place blame on the individuals and their caregivers, especially the repeat visitors to hospital.[5] The clinical dilemma is summed up eloquently in one commentary: "*In a system where resources are constrained, doing the right thing for someone whose needs fall outside the mandate of the provider means taking away resources from someone else*".[24] In addition to interdisciplinary teams in the ED, one commentary provides an approach to the "social admission" patient assessment using a socio-ecological lens to facilitate the collection of information relevant to the medically or socially complex.[2] Another potential approach is to use a clinical alternative to Appropriateness Evaluation Protocol[20] prior to the determination of a "social admission" to ensure a thorough evaluation is completed for complex patients; the challenge would be feasibility.

More broadly, like any sobriquet, "social admission" serves as a reminder of our values and priorities: which patients do we accept as valuable and deserving of hospitalization? One strength of this review is its clinical perspective, which prioritizes the aspects of the literature on social admissions that have the most practical significance for clinicians. Additionally, to our knowledge, this is the first review bringing together original research on "social admission" labels, arguably one of the most vulnerable patient populations in the hospital. There are larger research fields that contribute to generating ideas for systemic changes benefiting this population, for example, the frailty literature. Like people admitted for social reasons, frail populations also encompass heterogenous, complex and often poorly defined patient groups. Generating an evidence base linking "social admissions" to adverse health outcomes can learn from frailty scholarship, which has begun to move into clinical practice as screening tools and healthcare policymaking.[30]

The biggest limitation of this review is its lack of systematic process. This means the review is largely unreplicable and does not provide a summary of the quality of the evidence. This limits the generalizability of our findings, especially looking at the dates of the original studies included. Nonetheless, there appears to be a consistent signal that "social admissions" labels involve more than just social factors. This review may also be a necessary step towards more rigorous research in this area. For example, we identified many more terms used to describe social admission than

previously expected. It can be challenging to generalize from one "social admission" label to others (although UK and Australian studies appear to use "acopia" consistently), and this raises questions about the benefits of using a more medically precise term than "social admissions". Second, terminology may vary in local healthcare settings. For example, the terminology "orphan patient," used by our region to describe a social admission, is not present in the literature as it is used to describe patients without a general practitioner. More recently, we also became aware from clinical colleagues of the term "community emergencies," which is also not described in the literature. As such, any literature search on the topic is only as good as the search terms that are used, which can be difficult because of this variation in local terminology. Future incorporation of literature on patients admitted as "failure to thrive" diagnoses is recommended as our findings parallel those found by other researchers.[6,31] Even so, we hope that our effort to bring coherence to a topic that encompasses a highly heterogeneous population will advance care and research for the most socially vulnerable individuals within our healthcare systems. There is another limitation relevant to the discharge diagnosis section above; it is unclear if the diagnoses of falls, delirium, or mobility difficulties were present at admission or were iatrogenic. Furthermore, it is not clear whether these diagnoses were acute changes that precipitated the admission or non-acute chronic comorbidities that could be managed in the community—a major gap in our data that has implications for the true characterization and progression of these patients in the hospital.

Conclusion

Our review of the literature on social admissions provides insight into the epidemiology, risk factors, and health outcomes linked with different social admission terminologies, which are used inconsistently but refer to a similar group of individuals. Our findings suggest that people who are admitted as social admissions are predominantly older adults, female, require functional assistance, and live in the community prior to hospitalization. Our findings suggest social admissions are more than their social circumstances, and their care frequently involves complex medical issues. Failure to properly assess and appreciate the complexity of a social admission may be associated with premature death and increased long-term care placement, but more research in this area is needed. In conclusion, we provide practical recommendations for healthcare providers to improve the care

of social admissions, which can be implemented in current clinical practice.

Competing interests

Authors' contributions

JCM contributed to the conceptualization and design, procurement of data, analysis of data, drafting of the original manuscript, and review of the original manuscript. SS, GL, and KN contributed to the conceptualization and design, analysis of data, and review of the original manuscript. KK, MvM, KR and MKA contributed to the conceptualization and design, procurement of data, analysis of data, and review of the original manuscript.

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Chapter 7: Managing "Socially Admitted" Patients in Hospital: A Qualitative Study of Health Care Providers' Perceptions

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Managing "socially admitted" patients in hospital: a qualitative study of health care providers' perceptions

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Abstract

Background: Emergency departments are a last resort for some socially vulnerable patients without an acute medical illness (colloquially known as "socially admitted" patients), resulting in their occupation of hospital beds typically designated for patients requiring acute medical care. In this study, we aimed to explore the perceptions of health care providers regarding patients admitted as "social admissions."

Methods: This qualitative study was informed by grounded theory and involved semistructured interviews at a Nova Scotia tertiary care centre. From October 2022 to July 2023, we interviewed eligible participants, including any health care clinician or administrator

who worked directly with "socially admitted" patients. Virtual or in-person individual interviews were audio-recorded and transcribed, then independently and iteratively coded. We mapped themes on the 5 domains of the Quintuple Aim conceptual framework.

Results: We interviewed 20 nurses, physicians, administrators, and social workers. Most identified as female (*n* = 11) and White (*n* = 13), and were in their mid to late career (*n* = 13). We categorized 9 themes into 5 domains: patient experience (patient description, provision of care); care team well-being (moral distress, hierarchy of care); health equity (stigma and missed opportunities, prejudices); cost of care (wait-lists and scar-

city of alternatives); and population health (factors leading to vulnerability, system changes). Participants described experiences caring for "socially admitted" patients, perceptions and assumptions underlying "social" presentations, system barriers to care delivery, and suggestions of potential solutions.

Interpretation: Health care providers viewed "socially admitted" patients as needing enhanced care but identified individual, institutional, and system challenges that impeded its realization. Examining perceptions of the people who care for "socially admitted" patients offers insights to guide clinicians and policy-makers in caring for socially vulnerable patients.

Emergency departments have become a destination of last resort for some patients who are made vulnerable by social circumstances, resulting in their occupying hospital beds typically designated for people with acute medical issues.[1] "Social admission" is a colloquial, nondiagnostic label used to describe a person for whom no acute medical issues are recognized to be contributing to their seeking health care. However, many health care providers understand that patients who are admitted for social reasons face challenges such as a breakdown of care supports or an inability of the patient or family to cope with the demands of living at home.[2] These patients often have lengthy stays in emergency departments or hospital wards, and frequently encounter barriers (e.g., housing or home support) delaying safe discharge

from hospital. The colloquial terms "failure to cope," "acopia," "orphan patient," or "home care impossible," among others, are sometimes used to refer to these patients.[3–5] Such terminology can be stigmatizing because it indicates a value judgment that patients require admission solely on "social" grounds, sometimes failing to account for underlying medical complexity.[6]

The "social admission" phenomenon is an under-researched area in health care. These patients, often categorized by health care providers as not being acutely ill, experience in-hospital death rates as high as 22.2%–34.9%.[7,8] Explanations may include under-triaging in the emergency department owing to poor recognition of atypical clinical presentations and delays in timely assessments.[5] Patients may be misdiagnosed or develop acute

illness during their hospital stay. In 2 international studies, by the end of hospitalization, an admission diagnosis of "acopia" was no longer the discharge diagnosis in 88%–92.5% of cases.[7,9] Diagnoses of falls, delirium, and mobility problems were common, but sepsis was initially undiagnosed in almost one-third of these patients.[7] This raises questions about health care providers' awareness of atypical presentations and decision-making for "social" presentations, which often require a nuanced understanding of both medical and social care needs.

Health care providers face challenges providing high-quality care to this patient population across Canada[1,10] and internationally.[1,4,10–13] "Social admissions" may account for as many as 1 in 10 patients (0.57%–9.3%) presenting to the emergency department and 1 in 25 admissions to hospital, with increasing prevalence with age.[14] A survey from Wales showed that 51.8% of hospital physicians consider that they frequently care for these patients, encountering them several times per week.[15]

Since "social admission" is a nondiagnostic label, its definition varies across regions and health care systems, meaning no guidelines exist to standardize approaches to meet medical or social care needs. Qualitative data evaluating how health care providers perceive and care for these patients are lacking. Therefore, we aimed to explore the perceptions of health care providers regarding patients admitted as "social admissions."

Methods

Study design

This qualitative study was informed by constructivist grounded theory, which uses inductive analysis of data collected from participants to generate new theories.[16,17] We conducted semistructured interviews with clinicians and health care administrators between October 2022 and July 2023. Given that little is known about "social admissions," grounded theory was best suited to our objective to generate an explanatory theory about this phenomenon.[17]

The research team included qualitative methods experts, geriatric medicine specialists, clinician scientists, primary care and emergency department clinicians, and members with administrative leadership roles. We also included nursing students, medical students, and internal medicine residents of diverse backgrounds.

We reported this study using the Consolidated Criteria for Reporting Qualitative Research Checklist (Appendix 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.231430/tab-related-content).[18]

Setting and participants

Studying "social admissions" can be challenging because of the variability in terminology and admission policies across different jurisdictions.[19] The Orphan Patient Policy is a standardized "social admission" pathway used at the Queen Elizabeth II Health Sciences Centre, a tertiary care centre in Halifax, Nova Scotia. Halifax is the provincial capital and the largest city in the Atlantic region of Canada. In Nova Scotia, health care is provided through a publicly funded health care system.

Since March 2012, any patient, regardless of age or living situation, can be admitted to the Queen Elizabeth II Health Sciences

Centre under the Orphan Patient Policy if they have undergone a medical assessment by a physician in the emergency department, are determined to have no acute or new medical conditions, and have been seen by a social worker or discharge planning nurse to exhaust all home care options. Inability to return home includes situations of homelessness, unavailable community supports, or waiting for transitions to long-term care. These patients are admitted to the first available inpatient bed, based on a rotating roster of all hospital admission services (e.g., medicine, psychiatry, surgery, subspecialty medicine or surgery, and hospitalist). The admitting service and its allied health care team become responsible for the patient's care and disposition, with the expectation that discharge planning is the primary issue. Although these patients are locally called "orphan patients," we use the terminology "social admission" throughout this paper.

Eligible participants included any clinical provider or administrator who worked directly with "socially admitted" patients. To identify potential participants for our study, we held initial interviews with hospital nursing bed flow managers who are responsible for administering the Orphan Patient Policy.

To recruit participants, we used snowball sampling: we emailed each health care provider or department that had been recommended by the initial interviewees (i.e., the nursing bed flow managers), and those suggested by study participants during their interviews or by key knowledge users with whom we shared preliminary findings (see Data analysis). Preliminary analyses also informed recruitment, and we used purposive and theoretical sampling[20,21] to ensure that the perspectives of multiple health care professionals within the "social admission" care pathway were included, with the aim of data saturation. We approached several departments and individuals who declined to participate or did not respond to our requests for interviews. These included recreation therapy, physiotherapy, occupational therapy, some administrative positions, and several subspecialty medicine divisions.

Data collection

The interview guide (Appendix 2a, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.231430/tab-related-content) was based on our literature review of "social admissions"[14] and informed by our chart reviews of more than 350 "social admissions" in Nova Scotia (unpublished data, 2021). The entire research team gave input on the interview guide through several iterative processes: multiple meetings to develop the guide, a pilot test with non-author colleagues, and a meeting after all interviewers had conducted at least 1 interview to discuss whether the guide was robust enough to elicit the information we were seeking. We revised the interview guide wording for clarity and understanding, and we added 2 major questions (interview guide questions 7 and 8) and several prompting questions.

Experienced qualitative researchers (C.S. and E.G.M.) provided training. We held 2 group and 1 individual interactive training and practice sessions, which provided methodological context, and practical approaches and techniques in qualitative interviewing. One research team member (J.C.M., L.E., G.A., or M.K.) administered individual interviews. Interviews occurred virtually (via Microsoft Teams) or in person in quiet rooms on hospital wards or

participants' offices. After interviews were completed, we contacted participants by email to provide self-identified demographic data. The survey was voluntary and anonymous, and participants selected from predefined categories or supplied free text for sex, gender, ethnicity, role, and profession (Appendix 2b).

Interviews were audio-recorded and transcribed verbatim. For additional rigour and contextualization during analysis, interviewers kept detailed field notes of their reflections during the interviews.

Data analysis

Data collection and analysis occurred simultaneously. All participants were invited to review their transcripts before analysis (1 participant opted to). We used Dedoose software for data coding and organization.

Two team members independently coded interview transcripts using an inductive approach.[16,17] Throughout the initial coding process, the coders (J.C.M., C.S., G.A., and M.K.) met regularly to refine, merge and expand codes, come to consensus about any disagreements and interpretations, add context to certain transcripts with their field notes from the interviews, and identify additional participants suggested by the participants. Using constant comparative and selective coding processes,[16,17] we generated categories and subcategories to form themes to reflect participants' perspectives on "social admissions."

We used several strategies to ensure rigour and trustworthiness throughout the research process. As per the grounded theory approach, we incorporated reflexivity into our analytic process and acknowledged our dual roles as researchers and health care providers delivering care. Most members of the research team were affiliated with the research site and possessed an in-depth understanding of the local context and providers involved in "social admission" care. This intimate understanding enabled us to add context to the findings. However, we also challenged our preconceptions and biases by recruiting participants with diverse experiences and perspectives, and scheduling regular meetings among research team members to triangulate findings with our internal chart review, knowledge user feedback, and data analysis.[22]

We put participant narratives at the forefront by presenting the data (from preliminary interviews and after completion of interviews) to engaged key knowledge users within our hospital and university network (e.g., experienced researchers, clinicians, social workers, and administrators) in a variety of settings (e.g., individual communications, small group sessions, or internal department presentations). The knowledge users provided feedback and suggested further participants. The data were also triangulated with findings from our recent literature review.[14]

After data saturation was achieved, we mapped our findings on the Quintuple Aim conceptual framework at the suggestion of a knowledge user and as per consensus with the research group.[23,24] This framework adequately organized and contextualized our findings and is a well-known approach to optimizing health system performance and defines 5 fundamental domains (definitions in Appendix 1) for transforming health care: enhance patient experience, better population health, optimize cost of care, improve care team well-being, and advance health equity.[23,24]

Ethics approval

Nova Scotia Health granted institutional research ethics approval (REB no. 1027628).

Results

We conducted 20 interviews (9 in person and 11 virtual) among hospital administrators and clinicians (Table 1). Clinicians were nurses

Table 1: Demographic information of hospital administrators and clinicians who were interviewed

Characteristic*	No. of participants n = 20
Age group, yr	
30–49	9
50–69	7
Missing†	4
Sex	
Male	5
Female	11
Missing†	4
Race and ethnicity‡	
White	13
Missing†	4
Stage of career	
Early	3
Mid	7
Late	6
Missing†	4
Role	
Clinical	8
Leadership or administrative	6
Both	2
Missing†	4
Professional designation	
Registered nurse	10
Medical doctor	6
Social worker	2
Other§	2
Department	
Medicine	8
Surgery	5
Emergency medicine	5
Other¶	2

*Sex, ethnicity, role, and profession were self-identified by participants, using an anonymous survey with the options of prespecified categories or free-text boxes (Appendix 2b, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.231430/tab-related-content).
†As described in the Data collection subsection of the Methods, the participants self-described their demographic information in a postinterview survey; not all participants responded to the survey.
‡Other races and ethnicities were suppressed for participant confidentiality.
§Other degrees included Bachelor of Arts and Master of Science.
¶Other departments included long-term care and psychiatry.

(charge, discharge planning, and inpatient), physicians (residents and staff physicians), and social workers, representing the following services: emergency department, internal medicine, medical subspecialties (cardiology, neurology, and geriatric medicine), psychiatry, hospitalist, and surgical specialties (orthopedics, general surgery, cardiovascular surgery, and vascular surgery). Administrators included nursing bed managers and directors of hospital divisions and long-term care. The mean interview length was 38 (range 16–76) minutes.

We categorized 9 themes into each of the 5 domains of the Quintuple Aim framework as shown in Figure 1: patient experience (patient description, provision of care); care team well-being (moral distress, hierarchy of care); health equity (stigma and missed opportunities, prejudices); cost of care (wait-lists and scarcity of alternatives); and population health (factors leading to vulnerability, system changes for addressing "social admissions"). Additional illustrative quotations are presented in Appendix 3, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.231430/tab-related-content.

Patient experience

Participants' description of patients

Participants provided diverse descriptions of these patients (Table 2). One cited financial precarity as a key problem faced by these patients. Another highlighted recurrent health care system interactions as being important. Some mentioned these patients had a mix of medical, mental health, and social problems. Most equated "social admissions" with older patients or those who were cognitively impaired. Some deemed them the most frail, vulnerable, or complex cases. Few considered that "socially admitted" patients had no medical conditions involved (Appendix 3) or that the medical conditions could wholly be managed at a primary care level.

Provision of care

Participants described "socially admitted" patients as receiving passive and hands-off care, contrasting this with active approaches for medical and surgical cases. Participants reported that patients, especially those who were older or confused, often received limited attention and workup, leaving their needs unaddressed (Table 2). The approach to care was characterized by patients being left in their beds, being the last person rounded on by the care team, and not being chosen to participate in rehabilitative programs or exercises. In short, these patients' care needs were the last in the queue of nursing and physician priorities. Beyond direct provision of care, participants identified that hospital programs (e.g., recreation therapy) benefitting these patients had been discontinued or under-resourced (Appendix 3). Almost all clinical participants considered their ward was not the place to care for these patients.
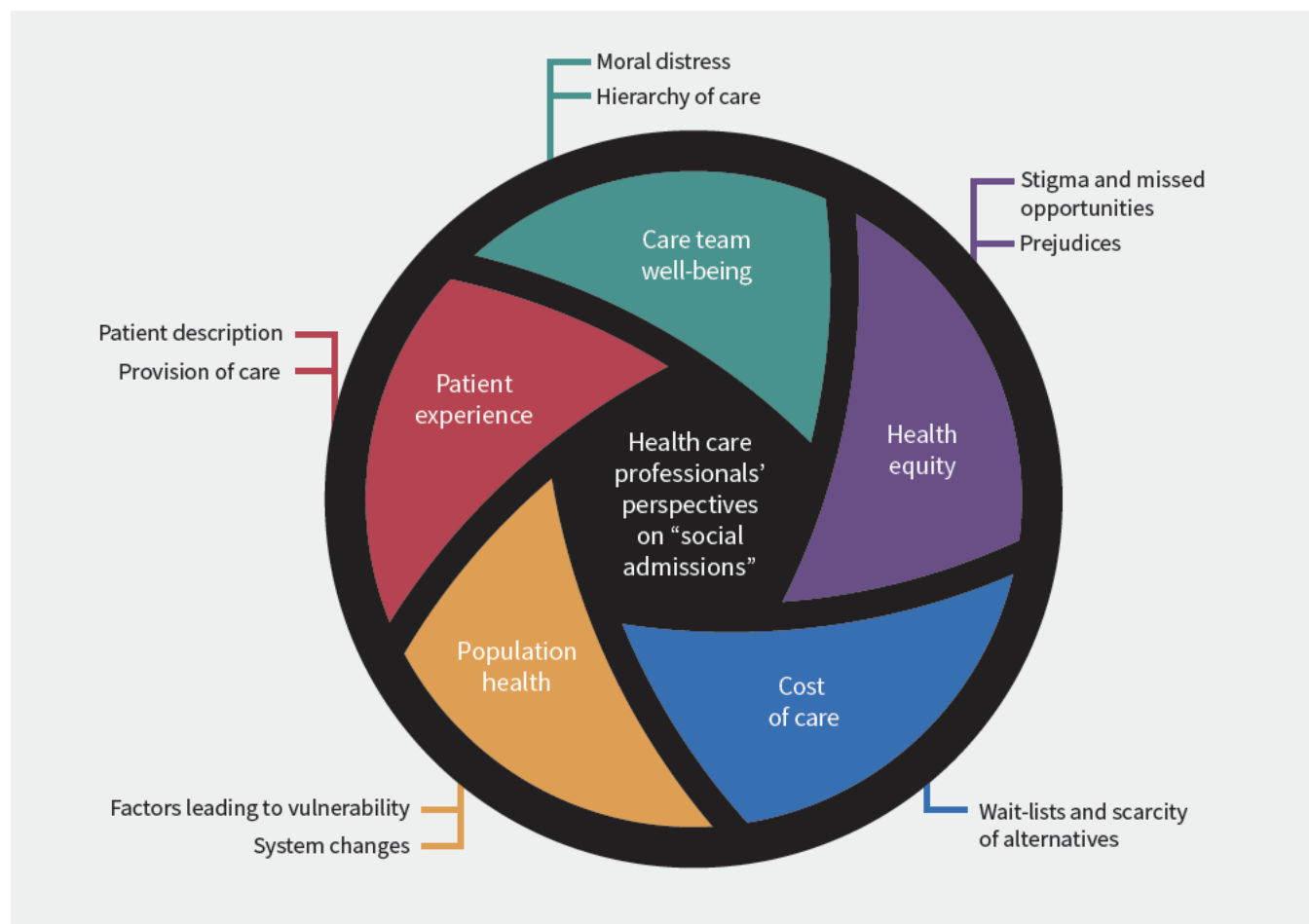
Figure 1: Domains (in the circle) and themes (outside the circle) using the Quintuple Aim framework.[23,24]

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Care team well-being

Moral distress

Health care providers described their roles as acute care or sub-specialized experts but said they felt helpless when they were unable to provide care for "socially admitted" patients, who often had complex, unrecognized, or chronic health issues. They often stated that better care should be offered yet described challenges when caring for "socially admitted" patients. These included a lack of appropriate training, struggles to arrange suitable care, and resistance when attempting to involve other services, allied health care, or social work, leading to delays in appropriate management (Table 3). As articulated by 1 participant (HC605): "I think that's a lot to ask of different providers who may not have that skill set. So, sometimes I think it does cause, you know, moral distress and challenge for people sometimes, which then gets perhaps articulated as being 'they

shouldn't be here.'" Many reported feeling negative toward the policy and labelling of these patients, and acknowledged it was used primarily to communicate with other health care providers. One participant suggested the policy prevented blame on clinicians for "admitting this [patient]" (HC840).

Hierarchy of care

Participants highlighted a hierarchy in health care, prioritizing acute care patients over "social admissions." One participant reflected on how hospitals rely on pathways with these patients not fitting into a clear "slot," representing individuals not well differentiated, individuals with complexity, or individuals with issues that are not specialty specific. Consequently, "social admissions" were passed down the hierarchy, from physicians to residents, and sometimes to nursing assistants, implying they were less worthy of routine medical attention (Table 3).

Table 2: Descriptions and illustrative quotations of the patient description and provision of care themes in the patient experience domain

Domain	Theme and key findings	Illustrative quotations
Patient experience	**Patient description** Participants' descriptions of "social admissions" were inconsistent and included a wide range of health and social indicators from the patients experiencing financial troubles, unstable housing, or psychological issues, to the patients having medical complexity. In few cases, participants expressed that they (or their colleagues) believed that "socially admitted" patients had no immediate medical needs.	"… finances is, like, one of the biggest contributing factors for a lot of them. Because we see …, like, people don't have the finances to find adequate housing. Like, a lot of people come in, they're, like, homeless or where they're living, like, the conditions are poor." — HC803 "They're obviously the ones that have accessed the health care system multiple times for the same types of presentations." — HC840 "Usually these patients are the most frail. They're the most vulnerable. They're the most complex." — HC569 "And, so, I do think they are [a] really heterogeneous group in many ways in terms of what elements go into their sort of bucket of comorbidities. And again, you know, a combination of, like, medical, sometimes some mental health issues, some psychological issues, and then the social issues." — HC300 "So, typically, the patients are elderly. They typically have multiple comorbidities. They typically have polypharmacy. As well as they may or may not have family members who are caregivers." — HC156 "As far as orphan patients, I would say it's, they oftentimes have a medical condition that I guess most people would say would be managed at the primary care level." — HC307
	Provision of care Participants described the care provided to patients. The approach to care was passive, and "social admissions" were generally deprioritized in a tertiary care setting. Further, participants shared that the hospital environment often does not meet the basic needs of patients and is not the ideal setting for anyone unless they are needing acute care. Others commented on the lack of dedicated allied health services available to these patients (e.g., physiotherapy, recreation therapy, or occupational therapy) after admission.	"The approach to caring for the patient is passive. Which is in huge contrast to our approach to caring for medical and surgical acuity — which is very active." — HC375 "… someone older or confused, or can't give a history, they kind of stop the workup there, and say, like, oh, they either have nothing going on with them or they have, like, an infection that they actually don't have, and kind of leave it like that. So, I think there are shortcuts taken on some of these patients at times." — HC840 "Nursing is built on the foundation of caring for patients holistically. And you don't see a lot of that. And I think it's very easy for nurses, especially on a unit like ours, to look at these patients and go, "Well, they don't need an IV change, and they don't need a dressing, and they don't need this. So, there's nothing for me to do." Meanwhile, this poor guy is there … unwashed, isn't dressed. You know, like there is a lot of care that can be provided, but it's not the care that they think is the 'important' stuff … ." — HC413 "I've heard this from allied health as an example over the years, is we only have so much physiotherapy. We're going to focus on those who are participating in rehab right now and we're going to be able to get them home. We don't have the resources to continue working with people who plateaued." — HC375

Note: IV = intravenous.

Table 3: Descriptions and illustrative quotations of the moral distress and hierarchy of care themes in the care team well-being domain

Domain	Theme and key findings	Illustrative quotations
Care team well-being	**Moral distress** Participants described the distress and tensions from competing priorities and values experienced by many staff when providing care to "socially admitted" patients. This is a result of these patients having complex social and chronic health issues that they feel are outside of their clinical scope. Participants caring for these patients feel better care could be provided elsewhere and they themselves do not have the right training to care for them, which can cause further distress.	"The trouble is, you know, a lot of us here in the hospital, we're sub-sub-subspecialists. And if you happen to have a disease in that subspecialty, there's somebody here that might be a world expert on it. But these people don't need that. They just need, kind of, like, you know, humane general care. And this is the worst place to get that." — HC549 "I think that's a lot to ask of different providers who may not have that skill set. So, sometimes I think it does cause, you know, moral distress and challenge for people sometimes, which then gets perhaps articulated as being 'they shouldn't be here.'" — HC605 "We really had a fight to get continuing care involved. And once they got involved, he was placed rather quickly because he was perfect for them. But it's just that initial hesitation." — HC075 "And, you know, are there any advantages to calling them an orphan patient? I'm not sure there really is, other than just trying to come up with some term for everyone to understand that, you know, this patient isn't … you know, not to blame, I guess, blame someone per se for admitting this [patient], … I think would be the only benefit really to it. So that at least the trainees aren't getting yelled at, and things like that, right." — HC840 "So, as per the — and I hate this word — Orphan Patient Policy, I think that has a huge connotation to it, and I don't use that word at the bedside. I think it removes all therapeutic rapport with someone when you say that word. I use that [term] medical facing, talking with other practitioners when I'm outside the room just to, kind of, name the policy, bring a thought to this is what exists." — HC236
	Hierarchy of care Participants described a perceived order of importance of patients and their reasons for hospital admission. Participants described the hierarchy in acute care with "social admissions" being at the bottom of that hierarchy. Participants also described the "bed blocking" that exists and how these "social admissions" can make it much more difficult to provide the appropriate care to other patients.	"… admissions to hospital require that you fit into a slot. And these patients frequently don't." — HC156 "I would say most of their medical issues, if they do arise, between the nursing, they wouldn't necessarily actually arise to the level [of] the attending. Most of it's managed by the residents." — HC307 "You don't need an RN looking after them. You could have an LPN and a CTA or something. Resources that are not as expensive." — HC151 "The patients who are a 'placement problem,' who are waiting for a nursing home or a group home, or are homeless, this is actually increasingly something we're seeing with orphan patients — who are just people who are homeless — and sit on our unit, sometimes for months, while the social workers try in vain to find a place for people to go. So, all of these things make it much harder to deliver care to acutely sick [specialty] patients who are coming in every day through the emergency department. You know, our ward is full of these people. And we can't get the really sick people up to our unit because the beds are all full of people waiting to go somewhere." — HC549

Note: CTA = care team assistant, LPN = licensed practical nurse, RN = registered nurse.

Health equity

Stigma and missed opportunities

The term "social admission" led to incorrect assumptions about medical needs and cognitive abilities. Beliefs about behaviours were noted by several participants. These assumptions were propagated as early as handovers from paramedics to emergency nursing teams (Table 4). Participants highlighted instances where these patients were not medically stable and emphasized that social stressors did not exempt patients from becoming medically ill during the admission. The label was reported to be an impediment to opportunities to look for underlying treatable medical issues, compounded by the need to make timely decisions because of pressures to free up beds.

Prejudices

Ageist beliefs underpinned assumptions about capacity, especially for older "socially admitted" patients. Some participants recognized that these patients could not effectively advocate for themselves, and others pointed out that older patients were often assumed to be cognitively or functionally impaired, and decisions were made without them. Participants provided examples of premature capacity determinations made without proper medical evaluation or consultation (Table 4). One participant described the invisibility of these patients, especially for women and minorities, and another noted how the care of "socially admitted" patients is undermined by negative attitudes similar to those encountered by individuals with substance use disorders (Appendix 3).

Cost of care

Wait-lists and scarcity of alternatives

Inadequate community support often resulted in emergency department visits and hospital admissions, with the perception that hospitals are the safest place. Participants noted lengthy wait-lists for community services like home care, physiotherapy, or occupational therapy, which led to deconditioning (Table 5). The transition to long-term care was described as

Table 4: Descriptions and illustrative quotations of the stigma and missed opportunities, and prejudices themes in the health equity domain

Domain	Theme and key findings	Illustrative quotations
Health equity	**Stigma and missed opportunities** The label comes with assumptions about the admitted patients' medical needs, cognitive abilities, and behaviours, which in turn affects the underlying assumptions held by health care providers and subsequently the care patients receive. Participants described how patients being labelled as a "social admission" early in the care chain led to an belief that they were medically stable when, in fact, they were not always.	"… often they would come to the door and the paramedic would say to the charge nurse and myself … I was sitting beside the charge nurse …. They'd say, "Okay, this patient's definitely going to be orphan." So, of course, once they're tagged with that label, it stuck, you know." — HC236 "You know, from nursing's perspective, it's like, "Oh, an orphan patient. So, they're going to be difficult behaviour, difficult discharge, and long stay." — HC151 "An orphan patient's usually a demented patient." — HC075 "And they're supposed to be categorized as, like, medically stable. Unfortunately, we've had several experiences where patients have been labelled as 'orphans' and they've not been medically stable." — HC803 "So, you may miss a diagnosis of delirium and an opportunity to treat. And I think … and if the services aren't as familiar with those issues then, you know, you miss things, I guess, and people can get worse." — HC605
	Prejudices Participants described underlying group assumptions about "social admissions." In particular, ageism that occurs when patients access acute care services for social issues was noted, for example, assuming all older patients have cognitive decline or lack capacity, or assuming certain health services would not benefit older patients. Participants reflected on how race and gender implicitly affect care.	"I just had a patient that came over from a [redacted] unit. And that patient was placed on the long-term care list …. They somehow removed their capacity but didn't get their family members to sign …. But their family is adamant they go home. The patient is adamant [they go] home. So, how in the world did [they] lose [their] capacity? … A physician removed capacity, while this patient most likely is experiencing a delirium, and made a permanent future decision for them without consulting the family." — HC676 "We take for granted what we feel and what we value is dignified aging, then we just don't include them. So, you know, there's these whole conversations occurring outside of the patient. And oftentimes myself and the other social worker on our unit will go, 'Well, did anybody talk to the patient?' 'No.'" — HC231 "I think there's just a general lack of respect for the aging process and aging with dignity …. You know, there's so many levels of invisibility that can be added to a person. So, you know, if you're a woman in comparison to a man, you're made a little less visible. If you're a minority in comparison to a White person, you're made a little less visible. If you have the history of mental health in comparison to somebody who might not have had those challenges, you're a little less visible." — HC676 "You know, not understanding frailty, what it means to be frail, how it impacts patients who are vulnerable. And I think of my mom, who is quite frail, and I think any incident could take her over that edge. But if she were to show up in emerg, I don't know that that would be so recognized. I don't. So, I do believe ageism plays a big role." — HC236

Table 5: Description and illustrative quotations of the wait-list and scarcity of alternatives theme in the cost of care domain

Domain	Theme and key findings	Illustrative quotations
Cost of care	**Wait-lists and scarcity of alternatives** Participants commented on the inadequate supports available in the community, which frequently lead to "social admissions." They described a system that is inefficient and ineffective at caring for this population because of severe resource constraints. Some of these patients have advocates or family caregivers who simply cannot do it anymore.	"If someone needs PT, OT at home, the wait-list is like 6+ months …. They're waiting 6 months for anyone to come help them. They'll be so deconditioned by that time, they'll be 'bed-sored' into the bed. So, there's the realities of the barriers of what's out there. It's out there. Can I get it? There's wait-lists for everything." — HC569 "… there's a person that I have right now that should be in a nursing home, but she is at home with twice-a-week care. Has been waiting for a month to get an increase on that twice-a-week care. And she's scared, and she's struggling, and she's confused and went to somebody else's apartment. And she knows she's getting confused. And I chatted with the care coordinator, and they say, 'Well, she should be in a nursing home. But even if we assess her for a nursing home, she might likely not get in there for 3 years.'" — HC737 "There are a lot of patients that have done, and their families have done, everything that they're supposed to do. And whether it's they've maxed out their care, or they're on the list, and this is their last resort." — HC791 "It's wrong. It's not the right… It's a real misunderstanding that that's the right place for the patients to be. The last place in the world anyone should want their patient or loved one is in the hospital. And, then, what do we do as a system to help reinforce that? Because we can't tell people that and expect them to believe it if we're not able to put supports and services in place to keep them out of the hospital." — HC375

Note: OT = occupational therapy, PT = physiotherapy.

"abysmal," leaving patients in challenging situations for extended periods. Admissions were a "last resort" after all other options were exhausted, with patients and families struggling to access necessary care. The lack of alternatives contributed to participants' distress when caring for "socially admitted" patients (Appendix 3).

Population health

Factors leading to vulnerability

Participants identified many issues that were associated with the "social admission" label, particularly for patients with cognitive impairment (Table 6). These included physical barriers (e.g.,

Table 6: Descriptions and illustrative quotations of factors leading to vulnerability and system changes for addressing "social admission" themes in the population health domain

Domain	Theme and key findings	Illustrative quotation
Population health	**Factors leading to vulnerability** Participants commented on the multitude of social issues that increase the risk of a community-dwelling adult becoming a "socially admitted" patient, such as poverty, homelessness, social isolation, lack of primary care, and substance use disorders. The inability to advocate for oneself was also a common observation.	"And I find, like, for the most part, for us, like, a lot of it comes down to, like, finances is, like, one of the biggest contributing factors for a lot of them. Because we see, especially lately in today's society, like, people don't have the finances to find adequate housing. Like, a lot of people come in, they're, like, homeless or where they're living, like, the conditions are poor. So, like, we had a patient not that long ago who he had literally was living in a shop that he once owned because he couldn't afford his apartment anymore … . During COVID, it closed because he couldn't keep up with the, like, financial pressures and everything with COVID. There's no bathroom in the place. There was no running water. And he was, like, using the garage next door to use the bathroom. So, like, we see a lot of patients that, like, homelessness is huge. And then a lot of our patient[s] are vulnerable as well in the sense of, like, their educational levels because they don't understand. And I find, too, like, sometimes they're taking… Like, they're going outside for smokes, whatever. They're going socializing, and they're, like, being taken advantage of by other patients in the hospital. Like even if it's as little as, like, "Can I have a smoke?" or "Can I have $5?" Like, I find our patients literally, like, fall under this category of, like, they just don't know better so they get taken advantage of by other people." — HC803 "One of the challenges with community supports is that, as we all know, there's lack of sufficient community support for the aging population in our community. The second part is, is that sometimes there are physical issues. So, sometimes these patients are living alone in a home that is multilevel, and they don't have a washroom on the main floor, for example, and they need to ambulate with a walker. And, so, there are physical barriers that may impair their ability to even exist in the community even with added community supports. So, those are things that have to be taken into consideration that we often as health care providers don't think about." — HC156 "… sometimes it's the home situation has gone for so long not being looked into or sort of being overlooked. We sometimes get couples or who are living alone, managing. Sort of managing the best that they can at home. But if they don't have a lot of social support or don't have a lot of family checking in on them often." — HC638 "And I think the absence of having … of that subset of people, having an advocate for them, both in the community and when they interact with the acute care system, makes them particularly vulnerable." — HC300
	System changes for addressing "social admissions" Participants shared their visions for improvement to the current system to provide appropriate care to those accessing acute care with social needs.	"The acute care system is becoming the community system. We're becoming nursing homes ... this [inter]mediate pathway between community and long-term care. Because long term care is failing at admitting people in a timely fashion." — HC506 "I would like to see more geriatrics in the hospital. I think we need to [be] more prevention-based rather than reaction-based … which is what we are." — HC236 "In an ideal world, if someone presented to the emergency department where their presentation was considered to be a social admission or a 'can't go home' situation, that there would be a multidisciplinary team that would look at that patient's situation from a holistic perspective. So, taking into account their medical history and their presentation, making sure that, you know, they've had a full workup, making sure that we understand the social factors and the kinds of resources that they've accessed, and what could be accessed." — HC300 "How do you put the patient back at the centre of the table? … . Even if you look at how our services are delivered, they're organized from a provider lens, not from a patient-need lens." — HC605 "So, there's some longstanding [type] disease or the sequela of something [type] that happened 20 years ago. We would never be involved in their care if they were in the community because there's no need." — HC549

inaccessible homes), homelessness, and financial challenges. Social isolation left individuals unsupported, managing alone until emergencies, such as falls, catalyzed hospital admission. The inability to advocate for oneself was also a common observation.

System changes for addressing "social admissions"

Participants identified systemic barriers that they considered disadvantaged "socially admitted" patients. Participants were concerned that the health care system is currently in crisis (e.g., with a lack of primary care and home support), and emergency departments cannot function as intended, causing the acute care system to become the community system or "the [inter]mediate pathway between community and long-term care" (Table 6). Some called for specialized seniors' care teams to address the unique needs of older adults. Participants emphasized the importance of understanding these patients' situations holistically, with a multidisciplinary approach to assess medical history, social factors, and available resources; several examples of ideal approaches were shared. The system's focus on individuals with higher functioning left "socially admitted" patients underserved, with emphases on services that are "organized from a provider lens, not from a patient-need lens" (HC605).

Interpretation

We sought to understand how health care providers perceive patients labelled as "socially admitted" in hospital, and we identified 9 key themes across the Quintuple Aim framework.[23,24] The themes in the patient experience domain highlighted inconsistent definitions and passive care approaches for these patients, who are often seen as low priority in hospital. Under the care team well-being domain, themes of moral distress and hierarchy of care showed the challenges and dilemmas faced by health care providers. Issues of stigma (e.g., "they have dementia"), prejudices (e.g., ageism), wait-lists, and scarcity of alternatives underscored systemic challenges under the health equity and cost of care domains. Finally, factors leading to vulnerability and potential system changes were described by participants as ways to better the health of this population.

Our findings highlight the potential adverse effects on care when patients are labelled as "socially admitted" (or as "orphan patients" in the study hospital), such as incorrect assumptions about medical needs and cognitive abilities, which impedes opportunities to look for treatable medical issues. Despite a "social admission" pathway ostensibly designed to ensure there are no acute or new medical issues, patients were still perceived as having "multiple comorbidities" or being "the most frail … the most complex" (Table 2). This finding is in keeping with the results of a case–control study (in London, Ontario), in which medical comorbidity played a minimal role in the label of a "failure to cope" admission among adults aged 70 years or older. Instead, recent failed discharge from hospital was significantly associated with a "social admission" label, leading the authors to suggest blame was an important part of the use of this label in a system that prizes efficiency.[3] This supports the viewpoint that it is more a system's failure to cope than the patient's.[10]

Our findings also demonstrate possible negative impacts on health care providers not addressed in previous research. Although similar patient populations ("failure to thrive" or "failure to cope") in British Columbia[25] and Ontario,[3] and "acopia" admissions in the United Kingdom and Australia,[7,9] have been researched, these studies did not consider the insights of providers directly caring for these patients. We highlight some structures (e.g., propagation of the label early in care) or cultures (e.g., ageism) in our health care systems, leading to system and individual tensions caring for "socially admitted" patients, especially in the context of few readily available alternatives. We observed that participants frequently reported feeling conflicted defining, prioritizing, and managing this patient population, yet unequivocally considered these patients deserved care — albeit care delivered by someone else. This latter finding contrasts with a survey of physicians in Wales in which two-thirds (62.7%) considered patients labelled as "social admissions/acopia" were a burden on national health resources, with 44.8% of physicians admitted to feeling that these patients were a burden on their time.[15]

Despite considering that "socially admitted" patients were deserving of care, our participants recounted how care was passed down to less-senior members of the health care team. This pattern of downgrading care can lead to situations in which "socially admitted" patients are looked after by team members who possess minimal experience recognizing evolving medical presentations or lack the authority to advocate strongly for clinical reassessments when needed. The implication that the care of "social admissions" should be delegated to others reflects an implicit attitude of hierarchy and detachment from the needs associated with this patient population. Not being able to provide the care that is warranted while at the same time believing that the needed care is beneath the care they provide is in keeping with cognitive dissonance literature in medicine (i.e., holding 2 or more inconsistent beliefs or behaving in a way that is inconsistent with core beliefs).[26] Cognitive dissonance can trigger negative emotions and subsequent defensive reactions resulting in fault finding in others (e.g., blaming "social admissions"), reinforced commitment to wrong actions (e.g., propagating labels), and overlooked medical errors,[26,27] offering some explanations for understanding how stigma and hierarchies of care can lead to missed acute medical illnesses (e.g., sepsis, malignancy, and strokes) in previous "social admission" populations.[5,7,9]

Existing literature indicates that "social admission" labelling may harm patients.[14] Our findings suggest that the use of this label appears to have little benefit for the health care providers who care for this patient population. Moreover, no evidence exists to date that "social admissions" labelling or pathways help the health care system. Therefore, re-evaluating an approach to caring for "socially admitted" patients is imperative, and this may include abandoning the nondiagnostic label.

Better support for this patient population may be achieved through enhanced policies that propose feasible solutions to support these patients. To achieve this, further steps are required to define "social admissions," and to highlight the importance and scope of the issues surrounding the patient population captured under this label.[28] However, we found inconsistencies in how "social admissions" are described, which adds to

the challenge in developing effective policies for these patients, and in comparing similar presentations across Canada.[29] Developing a consistent definition for "social admissions" may also prompt clinical specialties to claim responsibility for this population, as champions are key to raising issues for prioritization in health care.[30]

"Social admissions" can be considered a "wicked problem" with no single easy solution.[31] A previously proposed ecological approach can guide clinicians in managing "social" presentations.[2,32] Participants in our study made suggestions about community- and institutional-level solutions such as home care and primary care teams that support social integration, more multidisciplinary care teams in and out of the hospital, and "geriatrizing" acute care. These suggestions reflect many of the same calls for action made by previous scholars and advocates,[33,34] and are similar to solutions proposed by the National Institute on Ageing's "Ageing in the Right Place" report.[35] Scholars in France have proposed a societal-level solution involving the procedural and financial restructuring of ultraspecialized medicine, coupled with a revival of historic values combining medicine and social work to address the needs of an increasingly frail and socially complex population.[36]

Limitations

Our study was conducted in a single tertiary health centre in Nova Scotia, where "socially admitted" patients are admitted under an institution-specific Orphan Patient Policy, which likely limits the generalizability of our findings. Our participants were mainly White and female, which also limits the generalizability to other settings across the country and internationally. Furthermore, the participant sample did not include recreational therapists, volunteers, physiotherapists, or occupational therapists. In the study centre, recreation and volunteer programs had been discontinued or reduced following the COVID-19 pandemic, and there were no occupational or physiotherapists specifically assigned to this patient population. Another limitation of our study is that some interviewers had prior acquaintance with the participants they interviewed. This familiarity may introduce bias in the data collection and interpretation, although this should be balanced with constructivist grounded theory's emphasis on researchers as co-participants in the research process.

Conclusion

Our research draws attention to health care providers' challenges in managing care for "socially admitted" patients, and to perceptions regarding "social" presentations, perceived system barriers and resource shortages, and some potential solutions for better patient care. Overall, no consensus emerged as to what constitutes a "social admission" (who are the patients labelled as "socially admitted"?) or ownership for "social admissions" (who cares for these patients?), and participants reported inconsistencies in care delivered for such patients (how to care for "socially admitted" patients). To improve the patient experience and alleviate the moral distress of staff who care for "socially admitted" patients in hospital, the inherent structures of our health care system, such as hierarchies and stigmatization, should be reformed to better address the needs of patients with increasingly complex social problems who present to hospitals.

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Chapter 8: Changes in Frailty Predict Social Vulnerability Among Home Care Clients Living in the Community Followed for Ten Years

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Declarations

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Abstract

Background: Among community dwelling older adults, social vulnerability increases with age. Advanced age alone does not fully explain how or why older adults become more socially vulnerable. We aimed to understand how change in frailty relates to change in social vulnerability over time.

Methods: We analyzed older adults aged 65 years and older from the province of Nova Scotia who accessed publicly funded home care followed for up to ten years. We measured social vulnerability and frailty using indices. Controlling for time constant covariates, multi-level growth modelling was used to evaluate whether within-person changes in frailty were associated with within-person changes in social vulnerability, after accounting for between-person differences.

Results: There were 2,791 older adults in the 2005 cohort and 2,741 older adults in the 2008 cohort. Mean age, frailty index and social vulnerability index were 80.6 years (SD 7.5), 0.23 (SD 0.10), 0.22 (SD 0.07) and 80.4 (SD 7.6), 0.23 (SD 0.10), and 0.23 (SD 0.07) for each cohort respectively. After accounting for age, sex and baseline frailty, a 0.1 point increase in change of FI from baseline was associated with a 0.017 (CI 0.016 – 0.019, p<0.001) increase in SVI in the 2005 cohort and a 0.014 (CI 0.013 – 0.016, p<0.001) increase in SVI in the 2008 cohort.

Conclusion: Although social vulnerability tends to remain constant in the absence of increases in frailty, changes in frailty are closely associated with changes in social vulnerability. Incorporating within-person changes in frailty into quantitative models of late-life social vulnerability may further improve our understanding of how and why some individuals are able to stay in the community despite their vulnerabilities.

Background

Social vulnerability is the degree to which overall social circumstances leave people susceptible to, or unable to recover from, adverse health events. It helps explain, for example, how two older adults with the same medical conditions experience different outcomes whereby one lives in the community with supports and the other requires admission to a long-term care home. Meaningful associations have been found between social vulnerability and cognition [1], mortality [2–4], disability [5], and long-term care placement [6].

In populations of community dwelling older adults, social vulnerability increases with age [3–5,7]. However, advanced age alone does not fully explain how or why older adults become more socially vulnerable. A combination of factors beyond age contribute to social vulnerability including loss of friends and family, loss of purpose, economic insecurity and increasing frailty. Frailty describes the cumulative burden of accumulating health deficits which brings vulnerability to adverse health outcomes among older adults. Frailty offers a compelling explanation of the greater social vulnerability observed in geriatric populations. Individuals living with higher frailty have physical or cognitive barriers making it difficult to maintain social connections, perform daily activities, maintain independence or participate in social activities. Frail individuals may also be marginalized within societal circles through social exclusion and age or disability-based discrimination, especially in combination with language, culture, faith and sex/gender factors as well.

The association between social vulnerability and frailty is less established and is supported by limited evidence. Social vulnerability and frailty were weakly to moderately correlated (r=0.13-0.47) among Canadian older adults [3] and strongly correlated (r=0.81) among rural Tanzanian older adults [8]. Individuals with higher social vulnerability also experiencing higher frailty have been reported in several other studies and summarized in two recent systematic reviews [9–12]. These studies were primarily descriptive, cross-sectional, or only utilized baseline vulnerability, thus the dynamic nature of social vulnerability and frailty is under-researched. Social

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vulnerability, like frailty [13], is expected to change over time because it reflects accumulation of social deficits, which occurs over time especially around times of adverse events. Furthermore, there may be a bidirectional relationship between social vulnerability and frailty; but the temporal association between change in frailty in relation to social vulnerability has yet to be explored.

Using multilevel growth models, we aimed to answer the research question: how does change in frailty relate to change in social vulnerability among older adults living in the community receiving home care? In doing so, we aim to further the understanding of the relationship between social vulnerability and age, exploring whether the positive correlation may not simply reflect increasing age, but increasing health deficits. Moreover, examining the complex and evolving nature of frailty in relation to social vulnerability may lead to development of more effective strategies for supporting healthier aging in older adults who experience the problems of old age simultaneously rather than one at a time [14].

Methods

Study Population

We analyzed older adults aged 65 years and older from the province of Nova Scotia who accessed publicly funded home care (called Continuing Care) in the community. We chose this population for several reasons. First, the Canadian Community Health Survey estimated that 7.8% of Nova Scotian households received formal home care, the highest of all Canadian provinces or territories [15]. Second, this region has the largest (and fastest growing) proportion of older adults nationally, ranging from 21.2-23.6% in 2021 [16]. Since most home care clients are older, Nova Scotia's status as a 'superaged' province provides a robust home care sample size and provides insights into future trends for other regions with younger demographics. Finally, we chose to study social vulnerability in a community setting, driven by our interest to support Aging in Place policies and forestall the need for institutionalization [17].

All Nova Scotians can be assessed for eligibility to receive publicly funded home care comprised of home supports and home health care. Home care service fees are mostly income adjusted and based on household size (approximately three quarters of clients with home supports pay zero fees). although some services (e.g., hospital bed loan or nursing services) have no fees. Public funding combined with a central intake process means that all home support clients or long-term care clients receive an initial intake and structured assessment of health and functional capacity using the Resident Assessment Instrument-Home Care (RAI-HC), resulting in an abundance of routinely collected administrative data [18]. We examined two cohorts of older adults who received a full RAI-HC assessment in the year 2005 (2005-01-01 to 2005-12-31) and 2008 (2008-01-01 to 2008-12-31) with follow up for a period of 10 years. In Nova Scotia, full RAI-HC re-assessments occur annually, or are triggered by a major health incident (e.g., hospitalization) or social change (e.g., change in caregiver status or living situation). Reasons for no follow up assessments are varied: no longer eligible for supports, clients no longer desired supports, relocation, entered long-term care homes, death, other reasons not specified, etc. The period of data collected for the 2005 cohort was between 2005-01-04 to 2015-12-21 and for the 2008 cohort between 2008-01-02 to 2018-12-20. Ethics approval came from the Nova Scotia Health Research Ethics Board (REB #1025990).

Outcome measure

The social vulnerability index (SVI) is an accepted tool for measuring social vulnerability (ref). The SVI was designed as a *state variable* and provides a quantitative summary integrating multiple sources of information from several social domains (e.g., socioeconomic status, support networks, built environment) and social levels (e.g., individual, household, neighbourhood). Within the RAI-HC, an SVI was calculated following a standard methodology (Chapter 3). In short, each social item was analyzed one at a time to examine distribution, determine relevant cut points to define a deficit, and assessed for missing data. Then, each item was encoded into a score of 0 to 1, such that 0 represents the absence of a deficit and 1 represents presence of the deficit (e.g., lives with family = 0 and lives alone = 1). Intermediate values were assigned in the case of categorical variables. For example, change in social activities

was coded 0 = no decline, 0.5= decline, not distressed and 1 = decline and distressed. Next, we calculated a raw score, the sum of all social items. The final SVI score was calculated by dividing the raw score by the total number of social items generating an index value between 0 and 1, where 1 is the greater risk. We screened for missingness as indices are usually calculated only for participants with at least 80% of the item data available; all participants had complete data for at least 26 of the 28 social items in the SVI. Items included from the RAI-HC in all indices are shown in Table 1.

Table 1. Items and Coding for SVI and FI

	SVI			FI		
	RAI-HC Item	**Item Description**	**Coding**	**RAI-HC Item**	**Item Description**	**Coding**
1	BB4	Marital status	Married = 0 Never married = 1 Widowed = 1 Separated = 1 Divorced = 1 Other = 1	B1a	Short term memory okay	Memory okay = 0 Memory problem demonstrated = 1
2	BB5a	Primary language	English = 0 Any other = 1	B1b	Procedural memory okay	memory okay = 0 memory problem demonstrated = 1
3	BB5b	Interpreter required	Does not require interpreter = 0 Interpreter required = 1	B3b	In the last 90 days, client became agitated or disoriented (delirium)	No = 0 Yes = 1
4	BB6	Education	Less than high school = 1 High school = 0.67 Technical or trade school or some college/university = 0.33 College diploma or bachelor's degree or above = 0 Unknown = NA	C1	Hearing	Hears adequately = 0 Minimal difficulty = 0.33 Hears in special situations only = 0.66 Highly impaired = 1

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5	BB7a	Legal guardian/ SDM	Yes = 0 No = 1	D1	Vision	Adequate = 0 Impaired, Moderately impaired, Highly impaired, Severely impaired = 1
6	BB7b	Advanced medical directives	Yes = 0 No = 1	E1a	A feeling of sadness or being depressed	Indicator not exhibited in last three days = 0 Exhibited on 1-3 symptoms in last 3 days = 1
7	CC5	Where Lived at time of referral	Private home with no home care services = 0 Private home with home care services = 0 Board and care/assisted living/group home = 1 Residential care facility = 1 Other = 1	E1e	Repetitive anxious complaints / concerns (non health related) (E1) - FI	0 indicator not exhibited in last three days 1 – exhibited on 1-3 of last 3 days
8	CC6	Who Lived with at Referral	Lived with spouse only =0 Lived with spouse and others = 0 Lived with child =0 Lived with others (not spouse or children) = 0 Resident in group setting with non-relatives =0 Lived alone =1	H2a	Mobility in bed	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
9	CC7	Prior Residential Care Facility Placement	No = 0 Yes = 1	H2b	Transfer	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1

							Total dependence = 1
10	F1b	Openly expresses conflict with friends/family	Yes = 1 No = 0	H2c	Locomotion in home	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
11	F2	Change in social activities in last 90 days	No decline = 0 Decline, not distressed = 0.5 Decline, distressed = 1	H2d	Locomotion Outside home	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
12	F3a	Length of time client is alone during the day (morning and afternoon)	Never or hardly ever = 0 About one hour = 0.33 Long periods of time = 0.67 All the time = 1	H2e	Dressing upper body	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
13	F3b	Client says or indicates he/she feels lonely	No = 0 Yes = 1	H2f	Dressing lower body	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
14	G1ea	Informal Helpers Lives with Client	Yes informal helper lives with client = 0 No informal helper does not live with client = 0.5 No helper = 1	H2g	Eating	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1

						Maximal assistance = 1 Total dependence = 1
15	G1fa	Informal Helper Relationship to Client	Child or child in law = 0 Spouse = 0 Other relative = 0.5 Friend / neighbor =0.5 No helper from G1e = 1	H2h	Toilet use	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
16	G1la	Informal helper willing to increase help for ADLs	More than 2 hours per day = 0 1-2hours per day = 0.33 No = 0.66 No helper from G1e = 1	H2i	Personal hygiene	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
17	G2a	Caregiver status – unable to continue in caring activities	No = 0 Yes = 1	H2j	Bathing	Independent = 0 Set up help only = 0.5 Supervision = 1 Limited Assistance = 1 Extensive assistance = 1 Maximal assistance = 1 Total dependence = 1
18	G2b	Primary caregiver is not satisfied with current supports	No = 0 Yes = 1	H1aa	Meal prep	Independent = 0 Some help = 0.5 Full help or by others = 1
19	G2c	Primary caregiver expresses feelings of distress	No = 0 Yes = 1	H1ba	Ordinary housework	Independent = 0 Some help = 0.5 Full help or by others = 1

20	G3a	Number of hours and minutes informal helpers spent assisting client in IADLs over last 7 days	Number of hours / Max number of hours (120)	H1ca	Managing finances	Independent = 0 Some help = 0.5 Full help or by others = 1
21	G3b	Number of hours and minutes informal helpers spent assisting client in ADLs over last 7 days	Number of hours / Max number of hours (48)	H1da	Managing meds	Independent = 0 Some help = 0.5 Full help or by others = 1
22	H1e	Phone use	Independent = 0 Did not occur = 0 Some Help = 0.5 Full help = 1 Dependent on others = 1	H1fa	Shopping	Independent = 0 Some help = 0.5 Full help or by others = 1
23	K9a & O1f	Personal safety (includes Fearful of a family member or caregiver, fear of violence in or out of the home, safety problem going out or visiting neighbors)	No = 0 Yes = 1	H1ga	Transportation	Independent = 0 Some help = 0.5 Full help or by others = 1

24	O1b	Home environment flooring and carpeting hazards	No = 0 Yes = 1	H4a	Primary mode of locomotion indoors	No assistive device = 0 Cane = 0.5 Walk/crutch = 1 Scooter = 1 Wheelchair = 1 Activity did not occur (cannot go outdoors) = 1
25	O1c & O1d	Bathroom and toilet room hazards & Kitchen	No = 0 Yes = 1	H4b	Primary mode of locomotion outdoors	No assistive device = 0 Cane = 0.5 Walk/crutch = 1 Scooter = 1 Wheelchair = 1 Activity did not occur (cannot go outdoors) = 1
26	O1g	Physical problems with building that limit access to home	Yes = 1 No = 0	I1a	Bladder continence	Continent = 0 Continent with catheter = 0 Usually continent = 0.5 Occasionally Incontinent = 1 Frequently incontinent = 1 Incontinent = 1 Did not occur (dialysis) = 1
27	O2b	Client or primary caregiver feels the client would be better off in another living environment	No = 0 Client only = 0.5 Caregiver only = 0.5 Client and caregiver = 1	J1a	Cerebral vascular accident	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
28	P7	Trade offs during the last month, because of limited	No = 0 Yes = 1	J1b	Congestive Heart Failure	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

		funds, client made trade offs			healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
29				J1c	Coronary artery disease	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
30				J1d	Hypertension	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
31				J1e	Irregularly irregular pulse	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
32				J1f	Peripheral vascular disease	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

					healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
33				J1g	Alzheimer's dementia	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
34				J1h	Dementia not Alzheimer's	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
35				J1i	Head trauma	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
36				J1j	Hemiplegia/h emiparesis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

					healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
37				J1k	Multiple sclerosis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
38				J1l	Parkinsonism	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
39				J1m	Arthritis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
40				J1n	Hip Fracture	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

						healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
41				J1o	Other Facture	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
42				J1p	Osteoporosis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
43				J1q	Cataract	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
44				J1r	Glaucoma	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

						healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
45				J1s	Any psychiatric diagnosis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
46				J1u	Pneumonia	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
47				J1v	Tuberculosis	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
48				J1w	Urinary Tract Infection	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

					healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
49				J1x	Cancer	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
50				J1y	Diabetes Mellitus	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
51				J1z	Emphysema/ Chronic Obstructive Pulmonary Disease /Asthma	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
52				J1aa	Renal failure	Disease absent = 0 Disease present not subject to focused treatment or monitoring by

						healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
53				J1ab	Thyroid disease	Disease absent = 0 Disease present not subject to focused treatment or monitoring by healthcare professional = 1 Disease present and being monitored or treated by health care professional = 1
54				K4b	Intensity of pain	No pain = 0 Mild = 1 Moderate = 1 Severe = 1 Times when pain is horrible or excruciating = 1
55				K4c	From clients' perspective, pain intensely disrupts usual activities	No = 0 Yes = 1
56				K5	Falls frequency Number of times client fell in last 90 days	Number of falls divided by Maximum number of falls (9)
57				K6a	Unsteady gait	No = 0 Yes = 1
58				K7b	Alcoholic drink first	No = 0 Yes = 1

					thing in the morning	
59				K7c	Smoked or chewed tobacco daily	No = 0 Yes = 1
60				L1a	Unintended weight loss of more than 5% In last 30 days	No = 0 Yes = 1
61				L1b	Severe malnutrition	No = 0 Yes = 1
62				L1c	Morbid obesity	No = 0 Yes = 1
63				L3	Swallowing	Normal = 0 Required diet modification to swallow solid foods=1 Required diet modification to swallow foods and liquids = 1 Combined oral and tube feeding = 1 No oral intake = 1
64				P2a	Supplementary Oxygen	Scheduled, full adherence, partial adherence or not received = 1 No need for oxygen = 0
65				P2c	All other respiratory therapy treatments	No = 0 Yes = 1
66				Q1	Number of medicationss	0-2 = 0 3-8 = 0.5 >8 = 1
67				Q4	Compliance with meds	Always compliant = 0 Compliant 80% of the time = 0.5 Compliant less than 80% of the time = 1

Frailty Index

The 67-item FI is calculated using a similar standard procedure as used for the SVI [19,20]. The feasibility and validity of using frailty indexes (FIs) within RAI-HC assessments were previously reported [21,22]; items and coding guidance, representing health deficits, is drawn from this literature.

Covariates

Age and sex were chosen a priori as covariates due to their known association with social vulnerability and frailty. Age was grand mean centered. Age in each model represents an individual's age relative to the cohorts' mean age at baseline assessment (in years).

Statistical Analysis

The objectives of the analysis were: (1) assess the extent to which social vulnerability trajectories are patterned by between-person differences in frailty; and (2) assess whether within-person changes in frailty are associated with within person changes in social vulnerability. All analyses were conducted in R using the nlme package [23,24] for modelling multi-level growth model. FI scores were multiplied by 10 such that the model represents a 0.1 increase in FI score.

We chose multi-level modeling because this approach is recommended for longitudinal data collected at irregular time points [25]. Model 1 (null model) was used to calculate the Interclass Correlation Coefficient (ICC) to determine the degree of variation in SVI scores attributable to inter-individual differences. We included time (in years since initial assessment) to examine the trajectories of SVI scores in Model 2. In Model 2, we included a random intercept to account for data being clustered within individuals over time as well as a fixed effect to examine the relationship between SVI and time (and other covariates in later models). Model 3 included both a random intercept and a random slope for time for each person, allowing for different baseline SVIs and different rates of change over time. Model 3 included time constant covariates

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of sex, age and baseline frailty. Our last model (Model 4) included frailty change from baseline as a time-varying covariate to test whether within-person changes in frailty were associated with within-person changes in social vulnerability, after accounting for between-person differences. We used deviance (calculated as -2Log Like-2 Log Likelihood (−2LL)), Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) to assess model fit. Deviance differences were used to compare models with anovas. We checked assumptions that residuals and random effects were centered at zero, normally distributed, and independent using Q-Q plots and scatterplots (Appendix 1).

We repeated these analyses in three subgroups as sensitivity analyses to account for survivorship bias. We looked at members of each cohort who died within three years of their follow up period (2005: n=1046; 2008: n=1048). We also looked at members of the cohort who received three or fewer assessments (2005: n = 1728; 2008: n = 1877) and members of the cohort who received four or more assessments (2005: n=1063; 2008: n=864) over the follow up period.

Results

Characteristics: There were 2,791 older adults who received a baseline RAI-HC assessment in 2005. Mean age was 80.6 (SD 7.5), baseline FI was 0.23 (SD 0.10), baseline SVI was 0.22 (SD 0.07) and 68.4% were female. There were 9,136 total RAI-HC assessments in the 2005 cohort. Among the 2,741 older adults who received a baseline assessment in 2008, mean age was 80.4 (SD 7.6), baseline FI was 0.23 (SD 0.10), baseline SVI was 0.23 (SD 0.07) and 64.8% were female. There were 8,159 total RAI-HC assessments in the 2008 cohort. The mean time from baseline until the second assessment was similar in both cohorts: 1.68 years (SD 1.66) in the 2005 cohort and 1.69 (SD 1.55) in the 2008 cohort. Over ten years of follow up, at each subsequent assessment, the average FI of the remaining cohorts was greater, so that by the 10th assessment, the mean FI is 0.37 (SD0.10), although the mean SVI did not change much (0.24 [SD 0.08]). Descriptive summaries across follow-up assessments are shown in Table 2.

Table 2. Cohort characteristics across each subsequent follow-up assessment

	Baseline	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
2005											
n	2791	1939	1487	1063	709	486	307	186	101	46	21
Mean years since baseline (SD)	0	1.68 (1.66)	2.76 (1.90)	3.74 (1.88)	4.76 (1.80)	5.79 (1.83)	6.86 (1.75)	7.72 (1.52)	8.35 (1.44)	8.91 (1.31)	8.99 (1.47)
Mean age (SD)	80.6 (7.46)	82.3 (7.40)	83.2 (7.20)	83.9 (7.03)	84.2 (7.01)	84.7 (6.90)	85.3 (6.80)	85.3 (6.40)	86.2 (5.80)	87.2 (6.20)	88.0 (6.42)
Age range	65-103	65-104	66-103	67-103	69-104	70-100	70-101	71-102	72-101	75-102	75-103
%Female	68.4	71.8	73.8	76.7	78.4	78.2	79.2	79.0	78.2	80.4	81.0
Mean FI (SD)	0.23 (0.10)	0.26 (0.11)	0.28 (0.11)	0.30 (0.11)	0.31 (0.11)	0.32 (0.11)	0.32 (0.11)	0.33 (0.11)	0.35 (0.11)	0.34 (0.12)	0.37 (0.10)
FI range	0.00-0.56	0.01-0.57	0.04-0.65	0.04-0.58	0.05-0.59	0.07-0.59	0.07 –0.55	0.04-0.57	0.04-0.56	0.06-0.54	0.15-0.52
Mean SVI (SD)	0.22 (0.07)	0.23 (0.07)	0.24 (0.07)	0.24 (0.07)	0.24 (0.07)	0.25 (0.07)	0.25 (0.08)	0.25 (0.07)	0.25 (0.07)	0.26 (0.07)	0.24 (0.08)
SVI range	0.04-0.56	0.03-0.48	0.03 -0.49	0.02-0.49	0.03-0.48	0.05-0.47	0.05-0.58	0.06-0.46	0.11-0.42	0.11-0.45	0.11-0.456
2008											
n	2741	1876	1318	864	541	355	222	124	73	33	12
Mean years since baseline (SD)	0	1.69 (1.55)	2.8 (1.76)	3.98 (1.86)	5.17 (1.86)	6.31 (1.79)	7.2 (1.66)	7.97 (1.57)	8.58 (1.44)	9.32 (1.34)	9.48 (1.07)
Mean age (SD)	80.4 (7.62)	82.0 (7.41)	82.9 (7.24)	83.6 (7.04)	84.2 (6.89)	85.0 (6.78)	85.2 (6.68)	85.4 (6.92)	85.1 (6.69)	86.8 (6.51)	88.2 (6.26)
Age range	65 -103	65-104	66-102	68-102	68-101	69-100	69-102	71-103	71-101	75-99	79 -99
%Female	64.8	68.2	71.2	73.5	76.5	77.7	78.8	78.2	75.3	75.8	66.7
Mean FI (SD)	0.23 (0.098)	0.27 (0.11)	0.29 (0.11)	0.31 (0.11)	0.31 (0.11)	0.31 (0.11)	0.31 (0.11)	0.30 (0.11)	0.31 (0.12)	0.29 (0.12)	0.34 (0.13)
FI range	0.015-0.57	0.022 -0.59	0.036-0.57	0.022-0.62	0.037-0.588	0.037-0.61	0.060-0.60	0.077-0.53	0.082-0.55	0.082-0.51	0.13-0.56
Mean SVI (SD)	0.23	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.27	0.28

	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)
SVI range	0.04-0.50	0.05-0.54	0.06-0.52	0.06-0.46	0.04-0.52	0.05-0.42	0.05-0.41	0.05-0.44	0.05-0.44	0.05-0.44	0.13-0.40

Model 1: Null model

In the 2005 cohort, the ICC was 0.61, indicating that 61% of the variation in SVI scores occurred between individuals and 39% of variation between SVI scores could be due to within-person changes, warranting the use of multilevel modeling analytic approaches. In the 2008 cohort, the ICC was similar, at 0.65. The fixed intercepts of 0.23 in both cohorts are the average predicted SVI across all individuals. All models are shown in Table 3.

Model 2: Determining average trajectory

Average baseline SVI score was 0.22 (CI 0.22 – 0.23). A time estimate of 0.005 (CI 0.004 – 0.005, p<0.001) indicated participants in the 2005 cohort experienced an average increase in SVI score of 0.005 per year. The estimated coefficient for time in the 2008 cohort was 0.004 (CI 0.003 – 0.005, p<0.001).

Model 3: Adding time invariant predictors

Baseline FI, standardized age at baseline, and sex were added into model 3 as time constant fixed effects. Interactions of these co-variates with time were added to evaluate impact on the slope of SVI change. The starting point of the trajectory (the intercept) represents the SVI for a female at baseline mean age (2005: 80.6 years; 2008: 80.4 years) with an FI of 0. For both cohorts, baseline older age was associated with higher SVI scores (2005: B = 0.001, CI 0.000 – 0.001, p<0.001; 2008: B = 0.001, CI 0.001 – 0.001, p<0.001). On average male SVI scores were 0.015 lower than females in 2005 and 0.017 lower in 2008 (2005: B = -0.015, CI -0.021 – -0.010, p<0.001; 2008: B = -0.017, CI-0.023 – -0.012, p<0.001). Baseline frailty was not associated with greater SVI.

Table 3. Parameter estimates and confidence intervals

	2005 Cohort				2008 Cohort			
Fixed Models								
	Null Model	Model 2	Model 3	Model 4	Null Model	Model 2	Model 3	Model 4
Intercept	0.233*** [0.230, 0.235]	0.225*** [0.222, 0.227]	0.234*** [0.227, 0.240]	0.231*** [0.224, 0.237]	0.234*** [0.231, 0.236]	0.228*** [0.225, 0.230]	0.234*** [0.227, 0.241]	0.231*** [0.224, 0.238]
Time		0.005*** [0.004, 0.005]	0.008*** [0.006, 0.009]	0.001 [-0.001, 0.002]		0.004*** [0.003, 0.005]	0.007*** [0.006, 0.009]	0.002 [0.000, 0.003]
Age			0.001*** [0.000, 0.001]	0.001*** [0.000, 0.001]			0.001*** [0.001, 0.001]	0.001*** [0.001, 0.001]
Sex			-0.015*** [-0.021, -0.010]	-0.016*** [-0.021, -0.010]			-0.017*** [-0.023, -0.012]	-0.017*** [-0.023, -0.012]
Baseline FI			-0.002 [-0.004, 0.001]	-0.001 [-0.003, 0.002]			0.000 [-0.003, 0.003]	0.001 [-0.002, 0.003]
Time * Age			0.000 [0.000, 0.000]	0.000** [0.000, 0.000]			0.000 [0.000, 0.000]	0.000 [0.000, 0.000]
Time * Sex			0.000	0.000			0.000	0.000

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			[-0.001, 0.002]	[-0.002, 0.001]			[-0.001, 0.002]	[-0.002, 0.001]
Time × Baseline FI			-0.002***	0.000			-0.002***	-0.001
			[-0.002, -0.001]	[-0.001, 0.000]			[-0.002, -0.001]	[-0.001, 0.000]
Change in FI				0.017***				0.014***
				[0.016, 0.019]				[0.013, 0.016]
Covariance Parameters								
SD (Intercept)	0.055	0.059	0.059	0.059	0.057	0.061	0.060	0.061
SD (time)		0.008	0.008	0.008		0.008	0.008	0.008
Intercept x time		-0.396	-0.414	-0.432		-0.389	-0.409	-0.408
Residual	0.044	0.038	0.038	0.037	0.042	0.037	0.037	0.036
Model Fit								
AIC	-26518.4	-27294.2	-27294.6	-27801.9	-23868.3	-24445.0	-24474.0	-24762.3
BIC	-26497.0	-27251.5	-27209.2	-27709.4	-23847.2	-24403.0	-24390.0	-24671.2
Deviance	-26536.03	-27332.12	-27426.90	-27948.92	-23885.83	-24482.74	-24605.79	-24908.43

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

AIC = Akaike information criterion; BIC = Bayesian information criterion; FI = frailty index; ICC = intraclass correlation coefficient; SD = standard deviation

Model 4: Adding frailty as time varying predictor

Frailty (change from baseline) was added as a time varying covariate. On average, accounting for age, sex and baseline frailty, a 0.1 point increase in change of FI was associated with a 0.017 (CI 0.016 – 0.019, p<0.001) increase in SVI in the 2005 cohort and a 0.014 (CI 0.013 – 0.016, p<0.001) increase in SVI in the 2008 cohort. In model 4, baseline age and sex remained significantly correlated with SVI. The previously significant associations whereby SVI increased with time (Model 3) disappeared for both cohorts when change of frailty was added in the model.

We illustrate the expected changes in SVI of three hypothetical individuals based on model 4 in Figure 1.
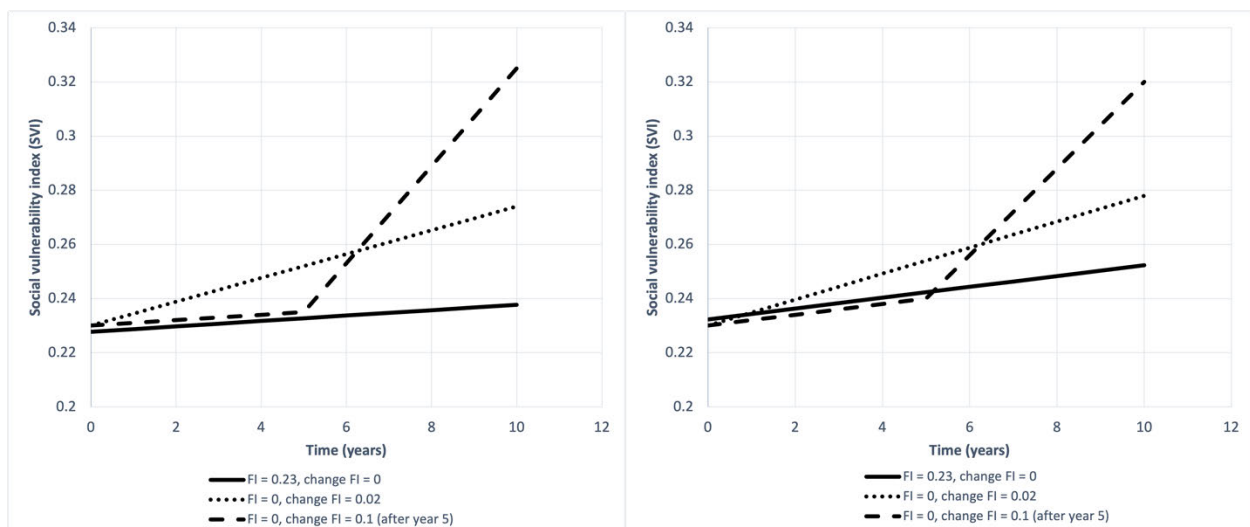
Figure 1. Model 4 predicted change in SVI for 2005 cohort (left) and 2008 cohort (right) for three hypothesized female individuals with baseline frailty index of 0.23 (cohort means), 0, and 0, and change in frailty of 0, 0.02, and 0.1 (after year 5), respectively.

Model Fit

According to model fit statistics, model 4 provides the best fit with the data and accounted for more variance in SVI change than prior models. There was significant change in deviance

between each subsequent model (p<0.001), with model 4 being the best fit for the 2005 and 2008 cohorts, also confirmed by decreasing AIC and BIC.

Examination of QQ-plots, scatterplots and density plots of residuals approximate a normal distribution with some kurtosis (Appendix 1).

Covariance Parameters

In model 4 of the 2005 and 2008 cohorts, the correlation between the random effects is estimated to be -0.43 and -0.41, indicating that groups with higher intercepts tended to have slower rates of change over time. The remaining covariance parameters are also in Table 3.

Sensitivity Analyses

Of the 2005 cohort, 10.5% died before year 1, 51.1% died before year 4 and 74.0% died before year 10. Of the 2008 cohort, 11.2% died before year 1, 49.1% died before year 4 and 75.7% died before year 10.

Repeat analyses among individuals who died within three years of cohort intake, among individuals who had three or fewer assessments and among individuals with four or more assessments yields results that are consistent (in direction and magnitude) to the primary approach. Increasing age at baseline and female sex were associated with greater SVI. The positive association of time and SVI in model 3 disappeared once change in frailty was accounted for in model 4, which again demonstrated significant associations with SVI in all subpopulations (Appendix 2).

Discussion

In a cohort of older adults assessed for public home care and residing in the community, we demonstrate a significant correlation between changes in frailty status over a 10-year period and change in social vulnerability. Notably, time alone and baseline frailty were not associated

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with greater social vulnerability in our final model. Individuals in the cohort may be frail, but if they stay at the same level of frailty, their SVI will be stable. It is an individual's change in frailty that is more significantly associated with a rise in social vulnerability (the dashed lines in Figure 1). Our findings also confirm several properties of social vulnerability indices in keeping with previous literature. No one has zero social vulnerability (minimum 0.02 in our data) [3,26]. Females have higher social vulnerability than males [7,27].

The finding that within-person changes in frailty better predict social vulnerability is notable because it adds to emerging literature on the value of within-person frailty fluctuations [28,29]. It is well known frailty becomes more common as people age, yet there is significant variation in how it progresses. Individuals start their later years in widely different states of health and follow diverse frailty paths, which can include both slow and sharp rises in frailty, as well as periods of steadiness or even improvement [13]. Using the Survey of Health, Ageing and Retirement in Europe, Stolz et al demonstrated within-person frailty fluctuations, representing loss of individual homeostasis, was associated with long-term frailty trajectories and mortality. Similar to our findings, the process of how rapidly or variably health deficits accumulated also has prognostication value, with the implications that frailty measurements in older adults should be measured more frequently to capture accurate trajectories [13].

Since it can be difficult to obtain appropriate data, our study is one of few studies examining frailty and social vulnerability dynamically over time. Our dataset, featuring repeated measurements over time, enabled us to use mixed effects models to analyze changes that would typically be reflected in observation level residuals, which are often viewed as measurement error or statistical noise [30]. Our findings are similar to previous literature showing between person social vulnerability increases with age – in a cohort of American retirees, SVI was found to be u-shaped in relation to age decreasing until age 61, then increasing such that SVI was one standard deviation larger at age 90 than 60 [7]. While we found that baseline age at intake was associated with higher SVI, increasing age thereafter (time in our models) was not associated with higher social vulnerability.

Establishing that aging alone may not lead to increased social vulnerability is important. The attractiveness of defining social vulnerability and frailty, in comparison to age, is the shift from viewing age merely as an unchangeable risk factor to a broader reflection of life course changes that may be modifiable. Our findings suggest the cumulative burden of accumulating health deficits (frailty) may have a greater risk on social vulnerability among older adults. This allows us to postulate several possible mechanisms linking increasing frailty to social vulnerability. One research team described how biological mechanisms arise from immune and physiological responses that restructure the body's priorities for recuperation following an infection, perhaps manifesting as reduced participation in normal social activities [31]. Frailty has been shown to be linked to loneliness, social exclusion, and stigma and may be influencing social vulnerability through subjective (e.g., loneliness) or objective (e.g., exclusion) separation of older adults from social networks [32–34]. Using a political economy of a health lens, scholars have commented on the relationships between chronic illness and the broader determinants of health, which not only increase risk of frailty, but also cause social marginalization by exclusion from the labor market reducing social and capital resources; the loss of which are associated with social vulnerability [35]. Nonetheless, while we looked at frailty to explain social vulnerability, it is more likely that the relationship between the two is reciprocal. For example, each standard deviation increase from baseline social vulnerability has been found to correlate with a 20% increase in frailty at any age [7]. The interplay and interaction between both likely contributes to increased mortality and decline in quality of life [36], but also offers opportunities for interventions that reduce frailty to reduce social vulnerability and vice versa. Promising interventions like HomeHealth [37], the Tsurukabuto Active Aging Project [38], or Peer-to-Peer [39], among others [40], combine social interaction with health initiatives and can consider measuring social vulnerability in addition to frailty.

Limitations

Our findings of associations between frailty and social vulnerability must be interpreted cautiously. The cohort from Nova Scotia receiving home care may not represent broader populations or different regions. Home care practices, varying due to regional rules and regulations in Canada and internationally, make comparisons challenging. Consequently, our cohort might exhibit different social vulnerability compared to others receiving home care assessments, despite similar SVI means (ranging from 0.25-0.38) found in other studies [2,3,5,11]. Additionally, in this population of Nova Scotians receiving publicly funded home care, those remaining in our sample over time are individuals who have not died, not entered long-term care homes, nor recovered such that home care is no longer required. Unfortunately, a limitation of this data is the inability to track the characteristics of individuals who are lost to follow up (or their reasons are lost to follow up) who may have experienced significant changes in their social situation. This attrition bias (that people who stayed in the cohort are different than those who left the cohort) should be considered carefully and may bias our results. People likely exit this cohort when they accumulate enough frailty and/or social vulnerability (e.g., no one able to advocate for their needs) that they are not able to manage living at home, so the faster progressors will likely have disappeared. We hypothesize most people left the cohort due to illness or death as our mortality rates are high, similar to Jacobsen *et al.*'s longitudinal study of older adults living in the community in America, where one-third of the attrition due to death and another 20% due to being too ill [41,42]. Nonetheless, in subgroup analyses, even among those who died within 3 years of home or had fewer assessments, our results remained consistent (Appendix 2).

Practice / Policy Relevance

Although our data have limitations, particularly in tracking individuals lost to follow-up, these insights still provide valuable understanding into how some individuals with high levels of frailty are able to maintain their community living. The frail individuals successfully living in the community prompt us to question what enables certain clients to remain in the community for over a decade. The findings are intriguing: while the mean frailty in the cohort increases over

time, the mean social vulnerability does not rise much. This could highlight the critical role of a narrow social vulnerability index (SVI) range in maintaining community living. It also suggests that home care in Nova Scotia may be most effective for individuals with an average level of social vulnerability. Notably, the mean SVI of the cohort does increase over time, but this increase is much smaller compared to frailty. This trend might imply that the most socially vulnerable clients exit the home care system. A key predictor of increasing social vulnerability could be the rate at which frailty changes, as illustrated in Model 4 and a hypothetical clinical scenario (Figure 1) where frailty jumps significantly after 5 years. In such cases, a client's rapidly increasing frailty might link to high social vulnerability soon to exceed the capacity of home care services. Therefore, these findings could provide insight into the trajectory of home care clients, suggesting that those who remain in the current home care system likely have a maximum threshold, or rate of change, of social vulnerability and frailty. Further exploration of FI and SVI in this population could lead to different decisions related to publicly funded health care programs within and around home care – for example, perhaps home care case management consideration of measures such as the FI and SVI could lead to additions of services and supports to stretch the maximum threshold of frailty and social vulnerability supported in the community.

Conclusion

By examining changes in social vulnerability and frailty in older adults in the community assessed for home care services, we highlight the importance of longitudinal analyses accounting for within-person changes in frailty in relation to social vulnerability. The results suggest that although social vulnerability tends to remain constant in the absence of increases in frailty, changes in frailty are closely associated with changes in social vulnerability, even after accounting for baseline frailty, age, sex and interactions with time. Incorporating within-person changes in health into quantitative models of late-life social vulnerabilities may further improve our understanding of how and why some individuals are able to stay in the community despite their vulnerabilities. The study highlights the importance of monitoring frailty and social

vulnerability in older adults with implications for predicting the trajectories of home care clients.

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Chapter 9: Social Vulnerability and Home Care Hours Among Older Adults in Nova Scotia

Abstract

Background: Home care services enable older adults to maintain independence and delay institutionalization. A key element to aging in place is a person's social circumstances, especially as health problems accumulate. We examined the influence of social vulnerability, and dynamic changes in social vulnerability, on home care use.

Methods: We analyzed data from older Nova Scotians who were assessed and remained with publicly funded home care from 2005 to 2018. Multilevel growth models were used to evaluate home care hours over time relative to baseline and change in social vulnerability (using a social vulnerability index), accounting for age, sex, frailty, dementia, receipt of nursing services and year of home care intake. Sex specific analyzes were also conducted.

Results: Among 5,170 older adults with 13,552 home care assessments over ten years, the mean age was 80.5 (SD 7.5) and 67.6% were female. Greater changes in SVI were associated with a lower number of hours of home care authorized such that each 0.1 increase in SVI per year was associated with a decrease in annual hours by 3.3% (B =-0.034, -0.052 – -0.016, p<0.001). For males, and individuals assessed for home care within 5 years of death, high baseline social vulnerability was also statistically significantly negatively correlated with hours of home care authorized.

Discussion: As the degree of social vulnerability increased, the number of home care hours decreased. This study contributes to the literature by exploring the dynamic interplay between social vulnerability and home care usage, with implications for how home care services can better serve older adults aging in the community.

Background

Meeting the needs of aging populations requires person-centered, high quality care close to home (1). Like many countries, Canada is trying to shift more care provision from hospitals and long-term care homes (LTCHs) to home and community settings (2). Economics is a key policy driver with: "expectations of cost savings, or at the very least, that such substitution might lead to more efficient use of nursing home and hospital beds" (3). The potential benefits of home care beyond delaying institutionalization include reduced caregiver distress, greater independence and decreased hospital lengths of stay (4–7). Home care services differ by province due to variable service structures, providers, and financing. Still the Canadian Home Care Association has outlined these common goals: to maintain health and independence at home, delay institutional care, ensure appropriate community service use, and support care given by family and community (8). That is why home care was once "the next essential service" in Canadian health care. It has the potential to provide support for daily living and management of chronic conditions (9).

Unfortunately, with Canada's aging population too many still chase too little home care (10,11). The problem of home care being "too little" arises from a limited trained workforce, poorly compensated workers, and too little investment by policymakers (12,13). Meanwhile, the demands for home care continue to rise. Aging and frailty are key determinants of healthcare and home care demand as people are living longer but experience more years with frailty or years with greater disability (14,15). People are also more alone and socially isolated (16). Unfavourable social circumstances (e.g., marital status, living arrangements and home accessibility) make it difficult to remain in the community and determine eligibility for receiving home care services (e.g., unsafe living environments can be too dangerous for home care workers) (17). Absence or undersupply of existing community care services, like primary care, also correlates with demand (18). With the pressures from hospitals to discharge patients, and bottlenecks in long-term care homes, home care is asked to do too much with too little resources. As there are barriers to accessing timely care, people requiring home care are likely high users of other services.

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This paper examines the role of social circumstances in home care through the construct of social vulnerability. Social vulnerability is the complex interplay of social, socioeconomic, community and environmental factors at the individual, household, and community levels increasing susceptibility to adverse health and social events. Older adults with higher social vulnerability experience greater cognitive decline, pain and disability (19–21). They face greater challenges managing their health conditions in the community, necessitating additional formal and informal care supports. However, the extent to which higher social vulnerability is associated with use of formal home care services is not yet clear. Few studies have explored a composite construct like social vulnerability within the Canadian home care setting, let alone over time. The relationship between home care and social vulnerability could be positive or negative: We hypothesize more socially vulnerable individuals require more home care to be able to live in the community. However, it is also possible that more socially vulnerable people have diminished capacity to seek, reach, pay for, and engage with home care as is seen in patterns of primary care access (22,23). Therefore, we examine the extent to which trajectories of home care usage are patterned by between-person and within-person differences in social vulnerability over time. By better understanding these relationships, we hope to generate considerations for home care allocation and resource management.

Methods

Study Design and Sample: We conducted a retrospective cohort study of all community dwelling older adults over the age of 65 years old with a full assessment by publicly funded home care (i.e., Continuing Care) in the province of Nova Scotia using the Resident Assessment Instrument-Home Care (RAI-HC), the standard for reporting home care in Canada (24,25). Older adults were included if they received a full home care assessment between January 1, 2005 to December 31, 2005, or January 1, 2008 to December 31, 2008, with follow up for 10 years. Full follow up assessments with the RAI-HC should occur annually if an older adult's file remains open, or if they experience a change in clinical (e.g., hospitalization) or social (e.g., new

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living arrangements) situation, or if their file is re-opened during the ten-year period. This study was approved by the Nova Scotia Health Research Ethics Board REB #1025990.

Social Vulnerability: The social vulnerability index (SVI) is an accepted tool for measuring social vulnerability. Using questions from the RAI-HC assessment, an SVI was constructed following standard deficit accumulation index methodology (26–28)(Chapter 4 of this thesis). The SVI combines information about an individual's social circumstances such as marital status, living situation, and support networks. Each social item was analyzed one at a time to examine distribution, determine relevant cut points to define a deficit, and assessed for missing data. A scoring system from 0 to 1 was used, with 0 indicating no deficit and 1 indicating its presence. Intermediate values were assigned for categorical variables. The SVI's final score, ranging from 0 to 1, was derived by dividing the sum of social item scores by the total number of items, with higher values indicating greater risk. The SVI's items are listed in Chapter 8 of this thesis. SVI was expressed as a continuous variable; analyses report associations with outcomes for each 0.1 increase in social vulnerability.

Outcome measure: After a full RAI-HC assessment, a service plan is determined by the home care case worker. A client may be authorized for home care supports only, nursing and home care supports, nursing supports only and/or other supports (i.e., equipment rentals, direct funding, or home oxygen). The outcome was authorized annual home care hours with or without nursing. We excluded those who only received nursing support or other supports because these likely represent a different population. Hours was log transformed due to its gamma distribution. To interpret the results in the original scale, we calculated percent change in annual hours by exponentiating the log-transformed coefficients, subtracting 1 to find net change and multiplying by 100.

Covariates: Age, sex, and frailty were chosen a priori as covariates due to their known association with social vulnerability (29,30). Age was standardized by grand mean centering, thereby representing an individual's age relative to the cohorts' mean age at baseline assessment (in years). We stratified by sex, but also considered the interaction between sex

and social vulnerability. Frailty was measured with a constructed frailty index (FI), using items from previously constructed FIs in RAI-HC assessments (31,32). As with the SVI, FI was also continuous and represents a 0.1 increase in frailty. Items and coding of the FI are described in Chapter 8 of this thesis. Additional covariates in the final model were dementia at baseline assessment, concurrent authorization of nursing services, and year of home care intake as both waves were combined in the analysis (2005 or 2008).

Statistical Analysis: We used multilevel growth modeling to analyze the observed home care hours to infer the trajectories of home care hours in older Nova Scotian home care clients. In our analysis, the modelled "growth" was trajectories of home care hours over time. "Multilevel" referred to the nested data where there are repeated home care assessments within individual home care clients. This modelling technique was also chosen because it can be used for longitudinal data collected at irregular time points (33). The null model (Model 1) represented a random intercept model used to calculate the Interclass Correlation Coefficient (ICC) to determine the degree of variation in authorized home care hours attributable to inter-individual differences. The Model 2 examined authorized home care hours and time (in years since initial assessment), including a random intercept to account for data being clustered within individuals over time as well as the fixed effect. Model 3 included both a random intercept and a random slope for time for each individual, allowing for different baseline hours and different rates of change over time. Model 3 included time-constant covariates of sex, age, frailty (FI at assessment), concurrent nursing care (yes or no), baseline dementia diagnosis, cohort (2005 or 2008 intake) and the interaction of sex and baseline social vulnerability. Our last model (Model 4) included social vulnerability change from baseline as a time-varying covariate to test whether within-person changes in social vulnerability were associated with within person changes in authorized home care hours, after accounting for between-person differences. We used deviance (-2Log Like-2 Log Likelihood (−2LL)), Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) to assess model fit. We compared models using deviance differences with one-way ANOVAs. We checked assumptions that residuals and random effects are centered at zero, normally distributed, and independent using Q-Q plots and scatterplots. All analyses were conducted in R using the nlme package (34,35).

Sensitivity analyses: We conducted separate analyses for females and males in keeping with literature suggesting social vulnerability in community dwelling adults is higher in women than men, with some nuances (29,36,37). More than half of older people with home care no longer live in the community after four years (38) For this reason, we also compared individuals who died within five years of initial home care assessment with those who did not.

Results

Of 5,532 individuals assessed for publicly available home care, we excluded 362 (6.5%) who never received any home care hours after the initial assessment. This left 5,170 individuals (93.5%) across 13,552 observations (or home care assessments).

At baseline, mean age was 80.5 (SD 7.5), 67.6% were female with a mean FI suggesting low degree of frailty. The mean SVI was 0.23 (SD 0.07). One in five (21.2%) had dementia at baseline. Most (93.9%) of the cohort lived in a private home with no previous home care services, 44.1% lived alone and 30.9% lived with a spouse, with differences by sex shown in Table 1. Individuals had more difficulties with instrumental activities of daily living (IADLs) than activities of daily living (ADLs). Table 1 also shows changes in the individuals' characteristics who remain in the cohort for multiple assessments over ten years. In general, proportionately more females remained in the community with home care. By visit 10, the cohort remaining had greater frailty, slightly greater social vulnerability and greater average annual home care hours authorized. Across all assessments, there was a higher proportion of males with dementia and males living with spouses. Males had higher mean and median authorized home care hours than females.

Table 1. Cohort characteristics by assessment number and sex

Assessment	1		2		3		4		5		6		7		8		9		10	
Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
n (%)	3494 (67.6)	1676 (32.4)	2608 (70.6)	1087 (29.4)	2005 (72.9)	744 (27.1)	1433 (75.4)	467 (24.6)	960 (77.5)	278 (22.5)	648 (78.0)	183 (22.0)	414 (79.0)	110 (21.0)	242 (78.6)	66 (21.4)	133 (76.9)	40 (23.1)	62 (78.5)	17 (21.5)
Age (mean (SD))	81.02 (7.44)	79.51 (7.49)	81.05 (7.32)	79.22 (7.49)	80.87 (7.20)	78.99 (7.54)	80.44 (7.00)	78.49 (7.38)	79.87 (7.00)	77.28 (7.19)	79.49 (6.91)	76.52 (6.92)	78.85 (6.82)	75.95 (6.56)	78.08 (6.60)	75.26 (6.49)	78.30 (5.96)	74.33 (5.94)	79.16 (5.95)	73.82 (5.73)
Time since initial assessment (years)	0.00 (0.00)	0.00 (0.00)	1.69 (1.61)	1.50 (1.34)	2.82 (1.84)	2.53 (1.63)	3.88 (1.86)	3.65 (1.83)	4.97 (1.85)	4.79 (1.79)	6.03 (1.83)	5.86 (1.84)	7.02 (1.70)	6.85 (1.76)	7.85 (1.53)	7.68 (1.59)	8.55 (1.34)	8.08 (1.71)	9.16 (1.31)	8.80 (1.41)
FI (mean (SD))	0.23 (0.10)	0.24 (0.10)	0.26 (0.11)	0.27 (0.11)	0.29 (0.11)	0.29 (0.11)	0.30 (0.11)	0.31 (0.12)	0.31 (0.11)	0.32 (0.12)	0.31 (0.11)	0.32 (0.12)	0.31 (0.11)	0.32 (0.12)	0.32 (0.11)	0.33 (0.11)	0.33 (0.12)	0.34 (0.12)	0.31 (0.12)	0.35 (0.12)
SVI (mean (SD))	0.23 (0.07)	0.22 (0.07)	0.24 (0.07)	0.22 (0.07)	0.24 (0.07)	0.23 (0.07)	0.25 (0.07)	0.23 (0.07)	0.25 (0.07)	0.23 (0.07)	0.25 (0.07)	0.24 (0.07)	0.25 (0.07)	0.24 (0.08)	0.25 (0.07)	0.24 (0.09)	0.26 (0.07)	0.23 (0.08)	0.27 (0.07)	0.24 (0.10)
Dementia (%)	692 (19.8)	404 (24.1)	687 (26.3)	341 (31.4)	544 (27.1)	235 (31.6)	375 (26.2)	146 (31.3)	232 (24.2)	81 (29.1)	141 (21.8)	46 (25.1)	78 (18.8)	24 (21.8)	47 (19.4)	13 (19.7)	26 (19.5)	<10	12 (19.4)	<10
ADL Short Form Scale (median [IQR])	0.00 [0.00, 1.00]	0.00 [0.00, 3.00]	0.00 [0.00, 2.00]	1.00 [0.00, 4.00]	0.00 [0.00, 4.00]	1.00 [0.00, 5.00]	0.00 [0.00, 4.00]	2.00 [0.00, 5.00]	0.00 [0.00, 4.00]	2.00 [0.00, 5.00]	0.00 [0.00, 4.00]	2.00 [0.00, 7.00]	0.00 [0.00, 4.00]	2.00 [0.00, 6.00]	0.00 [0.00, 4.00]	2.00 [0.00, 5.00]	1.00 [0.00, 5.00]	3.00 [0.00, 6.25]	1.00 [0.00, 4.00]	3.00 [0.00, 6.00]
IADL Difficulty Scale (median [IQR])	4.00 [2.00, 5.00]	5.00 [4.00, 5.00]	4.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 6.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]	5.00 [4.00, 6.00]	5.00 [4.00, 5.00]	5.00 [4.00, 5.00]
Lives in Private Home (%)	3302 (94.5)	1553 (92.7)	2336 (89.6)	956 (87.9)	1772 (88.4)	625 (84.0)	1237 (86.3)	375 (80.3)	821 (85.5)	220 (79.1)	546 (84.3)	143 (78.1)	338 (81.6)	88 (80.0)	197 (81.4)	48 (72.7)	100 (75.2)	30 (75.0)	52 (83.9)	13 (76.5)
Lives Alone (%)	1743 (49.9)	539 (32.2)	1344 (51.5)	365 (33.6)	1046 (52.2)	274 (36.8)	774 (54.0)	185 (39.6)	543 (56.6)	114 (41.0)	371 (57.3)	83 (45.4)	242 (58.5)	48 (43.6)	135 (55.8)	33 (50.0)	78 (58.6)	18 (45.0)	41 (66.1)	<10
Lives with Spouse (%)	767 (22.0)	830 (49.5)	498 (19.1)	520 (47.8)	389 (19.4)	329 (44.2)	260 (18.1)	198 (42.4)	175 (18.2)	114 (41.0)	118 (18.2)	72 (39.3)	77 (18.6)	43 (39.1)	48 (19.8)	23 (34.8)	20 (15.0)	17 (42.5)	6 (9.7)	<10
Lives with Child (%)	704 (20.1)	136 (8.1)	521 (20.0)	93 (8.6)	388 (19.4)	65 (8.7)	274 (19.1)	38 (8.1)	169 (17.6)	27 (9.7)	112 (17.3)	17 (9.3)	66 (15.9)	9 (8.2)	44 (18.2)	5 (7.6)	28 (21.1)	<10	12 (19.4)	<10
Caregiver cannot continue (%)	442 (12.7)	294 (17.5)	345 (13.2)	196 (18.0)	299 (14.9)	124 (16.7)	168 (11.7)	86 (18.4)	121 (12.6)	34 (12.2)	63 (9.7)	21 (11.5)	40 (9.7)	20 (18.2)	29 (12.0)	10 (15.2)	13 (9.8)	<10	<10	<10
Nursing (%)	1392 (39.8)	844 (50.4)	909 (34.9)	476 (43.8)	615 (30.7)	295 (39.7)	471 (32.9)	175 (37.5)	317 (33.0)	114 (41.0)	219 (33.8)	83 (45.4)	145 (35.0)	49 (44.5)	94 (38.8)	34 (51.5)	56 (42.1)	19 (47.5)	24 (38.7)	11 (64.7)
Cohort (%) 2005	1817 (52.0)	801 (47.8)	1366 (52.4)	527 (48.5)	1082 (54.0)	381 (51.2)	808 (56.4)	244 (52.2)	552 (57.5)	152 (54.7)	377 (58.2)	105 (57.4)	241 (58.2)	63 (57.3)	146 (60.3)	39 (59.1)	78 (58.6)	22 (55.0)	37 (59.7)	<10
Cohort (%) 2008	1677 (48.0)	875 (52.2)	1242 (47.6)	560 (51.5)	923 (46.0)	363 (48.8)	625 (43.6)	223 (47.8)	408 (42.5)	126 (45.3)	271 (41.8)	78 (42.6)	173 (41.8)	47 (42.7)	96 (39.7)	27 (40.9)	55 (41.4)	18 (45.0)	25 (40.3)	<10
Annual Home Care Hours (mean (SD))	138.50 (191.64)	140.37 (201.28)	183.16 (258.59)	193.37 (264.19)	202.56 (293.46)	215.97 (279.08)	231.37 (332.26)	228.07 (304.54)	234.29 (346.40)	272.48 (317.46)	259.51 (363.74)	295.72 (347.15)	281.87 (381.47)	374.62 (390.18)	318.97 (399.69)	404.77 (450.30)	353.03 (411.79)	444.84 (448.01)	334.53 (422.11)	359.73 (297.70)
Annual Home Care Hours (median [IQR])	60.00 [23.60, 176.73]	61.21 [20.00, 183.09]	65.43 [26.07, 247.98]	82.86 [14.79, 275.25]	69.27 [26.07, 262.25]	91.75 [15.39, 334.66]	91.38 [36.28, 313.71]	92.25 [22.31, 359.36]	91.25 [38.21, 288.47]	147.91 [39.21, 441.97]	104.29 [39.21, 317.36]	150.11 [38.22, 466.89]	112.00 [40.71, 374.00]	287.57 [47.11, 550.21]	144.18 [52.14, 410.59]	262.00 [49.89, 610.79]	195.62 [54.77, 466.07]	332.29 [42.37, 623.43]	143.79 [39.21, 481.24]	321.18 [67.41, 581.95]

FI = frailty index, IQR = interquartile range, n = number, SD = standard deviation, SVI = social vulnerability index, <10 = group denominator <10

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Main Analyses

All models are shown in Table 2. In Model 1, or the null model, the ICC of 0.60 suggests 60% of variation between authorized home care hours could be due to within-person changes. The intercepts of 1.96 represents the average predicted log hours (or ~7.08 hours) across all individuals who received a full RAI-HC assessment and received some home care hours at time zero.

Model 2 helps determine average log hours of care over time. A time estimate of 0.047 (CI: 0.043, 0.051, p<0.001) indicates each year a positive 4.8% change in annual hours of home care.

In Model 3, after adjusting for baseline age, sex, concurrent nursing services, dementia, and intake year, and accounting for assessment frailty and the interaction between social vulnerability and sex in model 3, we found no statistically significant association between baseline social vulnerability and hours of home care.

In the final model (Model 4), adding in the difference in social vulnerability from baseline social vulnerability, each 0.1 increase in SVI was associated with a decrease in annual hours by 3.3% (B: -0.034, CI: -0.052, -0.016, p<0.001). Therefore, for a female of average age with zero frailty and zero social vulnerability at baseline, if each year the difference in social vulnerability increases by 0.1, the predicted annuals hours of home care hours decrease by 3.3%. To illustrate, if this individual had 100 hours annually, then each year all other things remaining constant, their annual hours would decrease by 3.3 hours. In all models, frailty had the most substantial impact on increasing home care hours.

Model Fit

Model 4 demonstrated the strongest fit with the data and explained a greater proportion of variance in home care hours compared to other models. Statistically significant changes in deviance were observed between each successive model (p < 0.01), as supported by decreasing

AIC and deviance values. Additionally, visual inspection of QQ-plots, scatterplots, and density plots of residuals revealed an approximate normal distribution with some kurtosis, as detailed in Appendix 1.

Table 2. Log hours of home care and confidence intervals for main analysis

	Null Model	Model 2	Model 3	Model 4
Intercept	1.957***	1.883***	-8.608	-8.609
	[1.943, 1.972]	[1.867, 1.898]	[-26.569, 9.354]	[-26.534, 9.316]
Time		0.047***	0.029***	0.030***
		[0.043, 0.051]	[0.025, 0.034]	[0.026, 0.034]
Age			0.005***	0.005***
			[0.003, 0.006]	[0.003, 0.006]
Sex (Baseline = Female)			0.044	0.039
			[-0.051, 0.139]	[-0.056, 0.133]
Nursing service (Baseline = No)			0.116***	0.116***
			[0.097, 0.134]	[0.098, 0.134]
Baseline social vulnerability (SVI)			-0.017	-0.024
			[-0.042, 0.007]	[-0.049, 0.001]
Frailty (FI)			1.013***	1.054***
			[0.917, 1.110]	[0.955, 1.153]
Baseline dementia			0.169***	0.167***
			[0.135, 0.204]	[0.133, 0.202]
Cohort year (Baseline = 2005)			0.005	0.005
			[-0.004, 0.014]	[-0.004, 0.014]

			Sex*Baseline Social Vulnerability	
Sex*Baseline Social Vulnerability			-0.033	-0.031
			[-0.074, 0.008]	[-0.072, 0.010]
Social vulnerability change from baseline				-0.034***
				[-0.052, -0.016]
Covariance Parameters				
SD (Intercept)	0.448	0.475	0.439	0.438
SD (Time)		0.064	0.057	0.057
Correlation between random effects (Intercept*Time)		-0.263	-0.354	-0.360
SD (Observations)	0.379	0.330	0.331	0.331
Model Fit				
AIC	19341.2	18126.9	17363.7	17359.9
BIC	19363.7	18171.9	17468.9	17472.6
Deviance	19327.21	18096.46	17258.1	17244.75

* p < 0.05, ** p < 0.01, *** p < 0.001

Sensitivity Analyses

We examined the variability in home care hours in females (n=3,494, 9,876 observations) in Table 3. A greater change in social vulnerability from baseline is associated with decrease in log home care hours (B: -0.023, CI: -0.044, -0.002, p<0.05) after adjusting for covariates (Model 4). Among males, both baseline social vulnerability (B: -0.064, CI: -0.098, -0.029, p<0.001) and

change in social vulnerability from baseline (B: -0.070, CI: -0.108, -0.032, p<0.001) were associated with statistically significantly decreased hours of home care over time. To illustrate, for a female with 100 annual authorized hours per year at baseline, an increase in social vulnerability of 0.1 results in a decrease of 2.27 annual hours. For a hypothetical male with no baseline social vulnerability and 100 authorized annual hours, a 0.1 increase in social vulnerability per year results in a decrease of 6.8 hours. However, for a male with average baseline cohort social vulnerability (SVI=0.23), their baseline authorized hours would be 13.7% less than a hypothetical male with no social vulnerability.

Among home care clients who died within five years of initial home care assessment (n=2,743, 4,749 observations, for each 0.1 increase in baseline social vulnerability, there is a 5.6% decrease in log hours of home care (B: -0.058, CI: -0.086, -0.029, p<0.001). As above, the change (increase) in social vulnerability from baseline is associated with a decrease in hours (B: -0.071, CI: -0.110, -0.032, p<0.001. Results consistent with the main analysis were seen in those individuals followed by home care who did not die within five years of intake. We show the results of the model of best fit (Model 4) for each cohort in Table 3.

Table 3. Model 4 comparing females with males, and home care clients who died within 5 years of cohort intake with home care clients still alive after 5 years of cohort intake

	Females	Males	Died Within 5 Years	Alive After 5 Years
(Intercept)	-3.170	-20.234	-9.896	-7.767
	[-24.399, 18.058]	[-53.436, 12.968]	[-35.996, 16.203]	[-32.216, 16.682]
Time	0.028***	0.036***	0.044***	0.027***
	[0.023, 0.033]	[0.027, 0.046]	[0.030, 0.059]	[0.022, 0.032]
Age	0.006***	0.002	0.006***	0.004**
	[0.003, 0.008]	[-0.001, 0.006]	[0.003, 0.008]	[0.001, 0.006]
Sex (Baseline = female)	NA	NA	-0.040	-0.014
			[-0.080, 0.001]	[-0.057, 0.029]
Nursing service (Baseline = No)	0.121***	0.102***	0.083***	0.132***
	[0.099, 0.142]	[0.066, 0.139]	[0.050, 0.116]	[0.109, 0.154]

Baseline social vulnerability (SVI)	-0.022	-0.064***	-0.058***	-0.013
	[-0.047, 0.002]	[-0.098, -0.029]	[-0.086, -0.029]	[-0.041, 0.014]
Frailty (FI)	1.090***	0.956***	0.994***	1.123***
	[0.976, 1.205]	[0.761, 1.152]	[0.822, 1.166]	[0.999, 1.246]
Baseline dementia	0.182***	0.136***	0.006	0.005
	[0.140, 0.224]	[0.075, 0.197]	[-0.007, 0.019]	[-0.008, 0.017]
Cohort year (Baseline = 2005)	0.002	0.011	0.160***	0.177***
	[-0.008, 0.013]	[-0.006, 0.027]	[0.113, 0.206]	[0.124, 0.229]
Social vulnerability change from baseline	-0.023*	-0.070***	-0.071***	-0.022*
	[-0.044, -0.002]	[-0.108, -0.032]	[-0.110, -0.032]	[-0.042, -0.001]
Covariance Parameters				
SD (Intercept)	0.432	0.449	0.412	0.435
SD (Time)	0.056	0.061	0.068	0.059
Correlation between random effects (Intercept*Time)	-0.372	-0.333	-0.088	-0.404
SD (Observations)	0.326	0.347	0.379	0.311
Model Fit				
AIC	12159.0	5233.8	7346.4	9923.4
BIC	12252.5	5314.5	7437.0	10022.6
Deviance	12063.16	5146.823	7249.569	9821.594

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Discussion

Our study offers an innovative approach for understanding how changes in social vulnerability are associated with home care hours authorized over time using multilevel growth models. In our analyses, the "growth" refers to the trajectory of publicly funded home care hours, which we observed predominately as a decrease over the study period indicating attrition in the provision of home care as social vulnerability increased among older Nova Scotians. For males,

and individuals assessed for home care within 5 years of death, high baseline social vulnerability was also significantly negatively correlated with hours of home care authorized.

Explanations for why home care hours decreased with increased social vulnerability is worth further exploration. One possibility is the most socially vulnerable in our cohort lacked social supports or caregivers to advocate for more care hours when social circumstances changed. In one study from Scotland, on average, one hour more formal public home care support was available to older adults with an unpaid caregiver than those without (39). The type of caregiver may also matter. In the Canadian Community Health Survey 2015/2016, more formal publicly funded home care hours were received by households where the recipient of home care lived with adult children compared to those living with spouses (40). Hypothetically, an older adult without children whose spouse dies (one example of how social vulnerability could increase) may no longer have a primary advocate to ensure they receive sufficient or more home supports. Sex (and gender) differences in caregiving roles and aging can also offer insights to explain our findings. Historical gender roles often position women as the primary caregivers within spousal relationships (7,41). In our cohort characteristics, there were more males with dementia and more males living with spouses. And, although males likely started with higher authorized home care hours at each assessment, males faced a more pronounced decrease in home care hours when their social vulnerability increased. If that change in social vulnerability occurred from a death of a spouse in our example above, males may be less likely to ask for more home care supports or recognize their need for more formal supports. This is in keeping with a previous review of home care patterns demonstrating men have higher service needs although women are more likely to be home care clients (17) – whether men benefit from having spouses to advocate for home care supports to match high service needs is one hypothesis that could be explored.

Another possible explanation for our findings could relate to the criteria used to allocate home care hours (42). An increase in a person's social vulnerability may not immediately correspond to worse function or decline in activities of daily living, which are major considerations for home

care service allocation. Increases in frailty may be more likely to bring such functional challenges, which is reflected in our study findings as home care hours did increase with higher frailty. Some critics suggest home care programs in Canada are becoming more medicalized. They argue home care is focusing on addressing short-term health problems and chronic disease management, rather than working towards the original goal of Evelyn Shapiro, the "mother" of universal home care in Manitoba, that home care service "really doesn't only consist of medical services, it consists primarily of social supports" (43). Understandably, resource constraints require prioritization of certain needs over others; however, the overarching goal of home care is to maintain independence at home, delay institutional care, ensure appropriate community service use, and support care given by family and community (8). Thinking preventatively, "a small number of hours provided to someone who is not currently frail [but who is socially vulnerable] could postpone the development of frailty in the future, or ... support for an unpaid carer could reduce the carer's future need for home support or other healthcare and social care services." (18) Since social vulnerability has been associated with long-term care home entry, worsening cognition and greater mortality independent of frailty (19,36,37,44,45), home care programs could consider expansion of eligibility criteria to respond to worsening social circumstances. If home care services track social vulnerability, and proactively target services to those who have increasing social vulnerability, it is possible older adults may stay at home longer across a wider spectrum of social vulnerability.

Limitations

The extrapolation of these findings across Canada are limited due to regional variations in models of home care. In Canada, and globally, there are jurisdictional differences in eligibility criteria for public home care services, resulting in different characteristics of the population served (38). Furthermore, we could not include individuals solely utilizing private home care services. We also cannot account for hours of home care supplemented by private care, as some individuals decline public home care because they have other types of help at home. In this way, these individuals (possibly with relatively lower social vulnerability than those who lacked this help or the resources to access privately paid supports) could have been excluded from the

cohort. On the opposite side, we may have missed individuals who are the most socially vulnerable; individuals who have not accessed home care at all (e.g. older adults living in shelters) or those with no one to advocate for their need to access home care. Finally, in Nova Scotia, the authorized annual home care hours do not necessarily equate to hours delivered, so we cannot know how many hours were actually received by older home care clients.

Finally, it is difficult to account for the changing landscape of home care from 2005 to 2018 in Nova Scotia. Some context was provided by members of the study team who were leaders in Nova Scotia's home care program. For example, there was an opening of long-term care beds in Nova Scotia in the mid 2010s, which may have resulted in more socially vulnerable individuals entering long-term care homes in greater numbers than in previous years. Furthermore, long waitlists for home care services were possibly present during the study period. Previous research suggests persistently low home care service supply might reduce demand for home care by clients or influence allocation of home care hours by home care agencies (18). Waitlists may push people towards further reliance on their informal caregivers, private provision, premature long-term care home entry, emergency department visits, and hospitalizations with longer lengths of stays. While these contextual factors remain unaccounted for in our analyses, the implications of home care not supporting social vulnerability is that it may be falling short of its fundamental objectives of helping people age in place. Such a gap should be considered as policymakers design national and provincial home care strategies, accounting for the social circumstances essential for sustaining individuals in their homes especially since one in five older adults in long-term care homes have similar health needs to those living in the community (46). This is critical for realigning home care services with their foundational principles and meeting the complex needs of the aging population.

Conclusion

We found that within-person increases in social vulnerability were associated with reduced authorized home care hours over time in this cohort of older Nova Scotians followed for ten years in the home care system. Higher baseline social vulnerability was significant associated

with lower hours authorized among males but not females. Since social vulnerability may be associated with mortality and long-term care home placement, measuring social vulnerability and proactively using home care services to support those with increasing social vulnerability may help older adults age at home longer.

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Chapter 10: The Association Between Social Vulnerability and Survival and Long-term Care Entry using Routinely Collected Home Care Data

Abstract

Background: Social vulnerability is a construct used to describe the collective influence of the conditions in which people are born, live, work and age. We examined the effect of social vulnerability on survival and the effect of social vulnerability on long-term care home entry in a population of home care clients in Nova Scotia.

Methods: We used routinely collected data from the Resident Assessment Instrument-Home Care for older adults who had a complete home care assessment in 2005 and 2008. We conducted separate Cox proportional hazards analyses for the entire cohort, and sex disaggregated analyses, adjusting for age, cognition, and frailty.

Results: Among this cohort of older Nova Scotians assessed by the public home care system, after adjusting for age, frailty, sex, cognition, and cohort year, higher social vulnerability was associated with increased survival. This association was statistically significant for females but not for males. For both sexes, and overall, high social vulnerability was associated with higher likelihood of long-term care home entry.

Discussion: The associations of social vulnerability with survival and long-term care home entry in a home care population can provide insights into how addressing social needs, in addition to cognition and frailty, can better meet the aging needs of older adults in Nova Scotia.

Background

Social vulnerability is a construct describing the collective influence of the conditions in which people are born, live, work and age (i.e., the social determinants). Social vulnerability influences people's susceptibility to, and ability to recover from, adverse health or social events (Chapter 3). It encompasses multiple factors and levels of interaction from socioeconomic status to personal supports to neighborhood dynamics and even governmental policies conceptualized through a socioecological model (1). Social vulnerability is one lens to explain how disadvantageous social circumstances lead to increased mortality or morbidity among older adults, when all other non-social (i.e. health) factors are equal (Chapter 3).

Social vulnerability is associated with increased mortality. In two Canadian population based cohorts, older adults living in the community with greater social vulnerability had increased risk of mortality over 5 and 10 years, even among the fittest older adults with little to no frailty (2,3). This association was also found using the Survey of Health, Ageing and Retirement in Europe and among older men in the Honolulu-Asia Aging Study (4,5). Several mechanisms have been proposed to explain the association between social vulnerability and mortality: physiologic (e.g. poor social circumstances affect biologic stress and inflammatory responses), behavioural (e.g., health related behaviours of smoking or substance use is linked to disadvantageous social conditions), or material (e.g., highly socially vulnerable people cannot afford to buy healthcare resources (6). Not all older populations demonstrate this trend. Among older adults with high frailty presenting to the emergency department and subsequently hospitalized, social vulnerability was not associated with in hospital death, suggesting the association between social vulnerability and mortality is context dependent (7).

Long-term care home entry is an outcome of interest to the 91% of Canadians who want to age in place rather than move to an institutionalized setting (8). Since social vulnerability is also associated with greater frailty, disability, pain and cognitive decline (4,9–11), it becomes important to understand if and how social circumstances influence long-term care (an umbrella

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term that describes care from home healthcare, home support and nursing home services) use as it may influence the ability to age in place as desired. In one study of hospitalized older adults, social vulnerability's impact on nursing home or long-term care home placement (synonyms used in this paper) varied by age and frailty. Younger older adults with high frailty were less likely to move to long-term care homes if socially vulnerable, while the oldest adults with no frailty or mildly frail were more likely to move to long-term care homes if socially vulnerable (7).

Long-term care home entry does not only occur from a hospital setting; older adults commonly transition from the community. People receiving formal home care services represent a link between those who are well enough to not need supports to live at home and those who are unwell and require supports before possibly entering a nursing home. Furthermore, in most jurisdictions in Canada, entry to a long-term care home requires a centralized intake by the same organization who manages home care. Social vulnerability has not been studied in home care populations before, yet studying this population has implications for how our social systems might structure themselves to maximize ability to live and die at home rather than institutionalization. Therefore, this paper examines the effect of social vulnerability on survival and the effect of social vulnerability on long-term care home entry in a population of home care clients in Nova Scotia, followed for 10 years.

Methods

Data source: We used routinely collected data from the Resident Assessment Instrument-Home Care (RAI-HC). It is the standard for reporting home care in Canada (12). Anyone assessed for publicly funded home care completes a full RAI-HC on intake. Ten year follow up outcomes from the date of intake assessment came from Nova Scotia's SEAscape (Single Entry Access Simultaneous Client Assessment Placement Evaluation) database (13).

Study population: We analyzed older adults 65 years and older living in the community in the province of Nova Scotia, Canada, who had an assessment for a publicly funded home health service or home support service in the years 2005 (n=2789) and 2008 (n=2731). Home health care refers to nursing or rehabilitative care and other services delivered by licensed health professionals. Home support services refers to help with personal care, housework, meal preparation, and/or respite care. Definitions and scope of services differ by jurisdiction, province and countries; regardless, the goals of all services are to maintain or improve quality of life and augment functional abilities to promote greater independence and satisfaction while living at home or community (14).

Study outcomes: There were two primary outcomes: all-cause mortality and long-term care home acceptance (both collected by SEAscape). Long-term care home acceptance serves as a proxy for long-term care home entry in our study, representing the date when an offer to enter a specific long-term care home was accepted. In Nova Scotia, older adults requiring publicly funded supports are assessed by Continuing Care Nova Scotia for both home care services and long-term care home entry (15). Once Continuing Care determines criteria for long-term care home entry are met, older adults are placed on a waitlist for long-term care homes in the province. While older adults can list their preferences for a long-term care home, entry depends on their position on the waitlist and bed availability. Once a bed is available, the long-term care home reviews the person's file; if the person's needs can be met by the long-term care home, an offer is made. People may reject or accept these offers. Older adults whose home care files were closed for other reasons (e.g. declined home care) were considered censored events. For the long-term care home entry analyses, death was a censored event.

Independent variable: Social vulnerability was measured using a social vulnerability index (SVI), constructed using 28 items from the RAI-HC assessment based on the standard deficit accumulation index methodology (16)(Chapter 3). This index aggregates various aspects of a person's social circumstances such as marital status, living arrangements, support networks and home environment. Items were coded 0 to 1, where 0 represents the absence of a deficit and 1

signifies its presence, with intermediate scores assigned to categorical variables. The final SVI score also ranges from 0 to 1 and is calculated by dividing the total score of items by the number of items, with higher scores indicating increased vulnerability. The SVI is a continuous variable.

Covariates: Age, sex (as recorded by the RAI-HC), frailty and cognition were a priori covariates. Frailty was measured with a 67-item frailty index (FI) constructed using RAI-HC items also using deficit accumulation methodology and following previous RAI-HC FIs (17,18). Cognition was dichotomized and measured using the Cognitive Performance Scale, where 0 and 1 represent intact cognition and 2 to 6 represent cognitive impairment (19). We also adjusted for cohort intake year (2005 or 2008) in all models to account for changes to home care and long-term care policies.

Analyses: We conducted separate analyses for the entire cohort, and sex disaggregated analyses because of known sex and gender differences in social vulnerability, frailty, cognition, mortality and long-term care home entry. We used descriptive analyses to examine baseline characteristics and outcomes. We created Kaplan-Meier curves to illustrate time to event data and compared curves using the log rank test. To estimate the effect of social vulnerability on time to death and time to long term care home entry, separate Cox regression models were developed. Each model consists in SVI, age, sex (omitted in the sex disaggregated analyses), FI, cognition and cohort year. SVI and FI were multiplied by 10 such that the models represent a 0.1 increase in the indices. Proportional hazards ratios are displayed representing the cox regression models. Analyses were performed in R using the survminer package (20,21).

Ethics: This study was approved by the Nova Scotia Health Research Ethics Board (File #1025990)

Results

There were 5,520 individuals assessed for publicly available home care. At baseline, mean age was 80.5 (SD 7.5), 66.6% were female with a mean FI of 0.23 (SD 0.10) and SVI of 0.22 (SD 0.69). At baseline, 68.1% of the cohort was cognitively intact. At five years, half of the cohort had died. One third had accepted a long-term care home placement at five years. There were significant differences (p<0.001) between females and males for all characteristics shown in Table 1.

Table 1. Characteristics of cohort, females and males

	All	**Females**	**Males**
n	5520	3677	1843
Age (mean (SD))	80.5 (7.54)	81.0 (7.47)	79.4 (7.56)
Frailty (mean FI (SD))	0.23 (1.00)	0.23 (0.96)	0.24 (1.05)
Social vulnerability (mean SVI (SD))	0.22 (0.69)	0.23 (0.66)	0.21 (0.73)
Cognition intact (%)	3758 (68.1)	2609 (71.0)	1149 (62.3)
Death within 5 Years (%)	2967 (53.8)	1806 (49.1)	1161 (63.0)
Death within 10 Years (%)	4226 (76.6)	2752 (74.8)	1474 (80.0)
Long term care home entry within 5 Years (%)	1879 (34.0)	1336 (36.3)	543 (29.5)
Long term care home entry within 10 Years (%)	2318 (42.0)	1686 (45.9)	632 (34.3)

FI = frailty index, SD = standard deviation, SVI = social vulnerability index

Main Analysis: Survival

Survival curves for 5 and 10-year mortality of the overall cohort, by sex, by cognition and by tertiles of social vulnerability and tertiles of frailty are presented in Figure 1a. The third of individuals with the lowest social vulnerability experienced the greatest hazard of death at both 5 and 10 years. The adjusted hazard ratios (aHRs) for time to death from the Cox regression

models are illustrated in Figure 1b. After controlling for age, sex, FI and cognition, each 0.1 increase in social vulnerability was statistically significantly associated with a 7% lower risk of 5-year mortality (aHR: 0.93, Confidence Interval (CI): 0.88, 0.98, p = 0.005) and a 6% lower risk of 10-year mortality (aHR: 0.94, CI: 0.90, 0.99, p=0.01).

Main Analysis: Long-Term Care Home Acceptance

Figure 2a shows the Kaplan Meier curves for 5 and 10-year acceptance of a long-term care home. Individuals among the highest tertile of social vulnerability had the greatest risk of long-term care home entry and those in the lowest tertile of social vulnerability were more likely to remain in the community. In the adjusted 5-year models, each 0.1 increase in baseline social vulnerability was statistically significantly associated with a 43% increased risk of long-term care home acceptance (aHR: 1.43, CI: 1.34, 1.53, p<0.001) even after accounting for age, sex, frailty, and cognition. In the ten-year analysis, the positive association between high social vulnerability and long-term care home entry remained (aHR 1.36, CI: 1.28, 1.44, p<0.001) as seen in Figure 2b.

All full model details are available in Appendix 1.
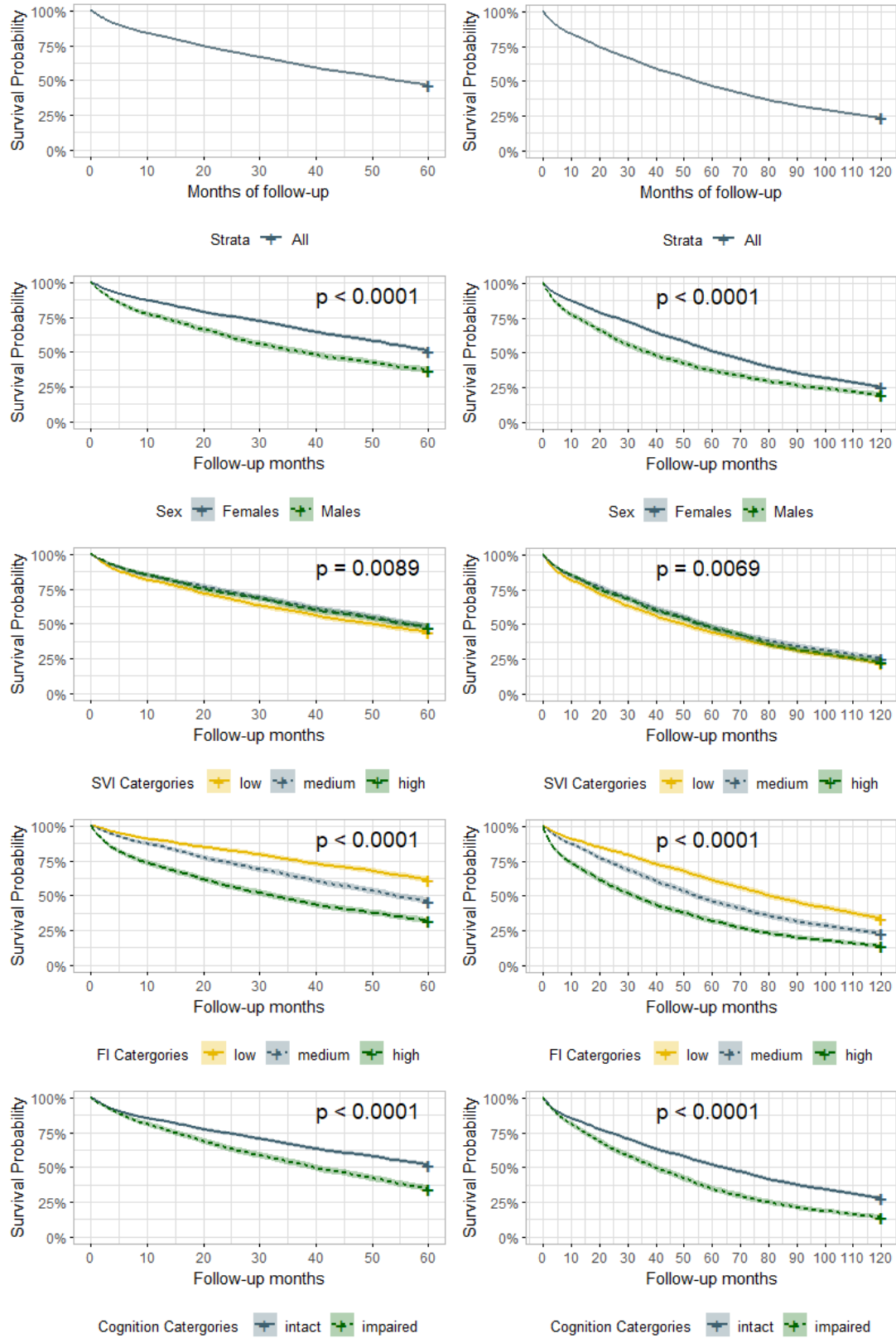
Figure 1a. Survival curves 5-year mortality (left column) and 10-year mortality (right column)

Variable		N	Hazard ratio		p
Age		5520		1.02 (1.02, 1.03)	<0.001
Sex	F	3677		Reference	
	M	1843		1.53 (1.42, 1.65)	<0.001
FI		5520		1.39 (1.34, 1.45)	<0.001
SVI		5520		0.93 (0.88, 0.98)	0.005
Cognition	intact	3758		Reference	
	impaired	1762		1.14 (1.05, 1.24)	0.002
Cohort	2005	2789		Reference	
	2008	2731		0.99 (0.92, 1.06)	0.703

0.9 1 1.1 1.2 1.3 1.4 1.5 1.6

Variable		N	Hazard ratio		p
Age		5520		1.03 (1.02, 1.03)	<0.001
Sex	F	3677		Reference	
	M	1843		1.33 (1.25, 1.42)	<0.001
FI		5520		1.31 (1.26, 1.35)	<0.001
SVI		5520		0.94 (0.90, 0.99)	0.01
Cognition	intact	3758		Reference	
	impaired	1762		1.17 (1.09, 1.26)	<0.001
Cohort	2005	2789		Reference	
	2008	2731		1.03 (0.97, 1.10)	0.30

1 1.1 1.2 1.3 1.4

Figure 1b. Hazards ratios of models for 5-year (top panel) and 10-year (bottom panel) mortality

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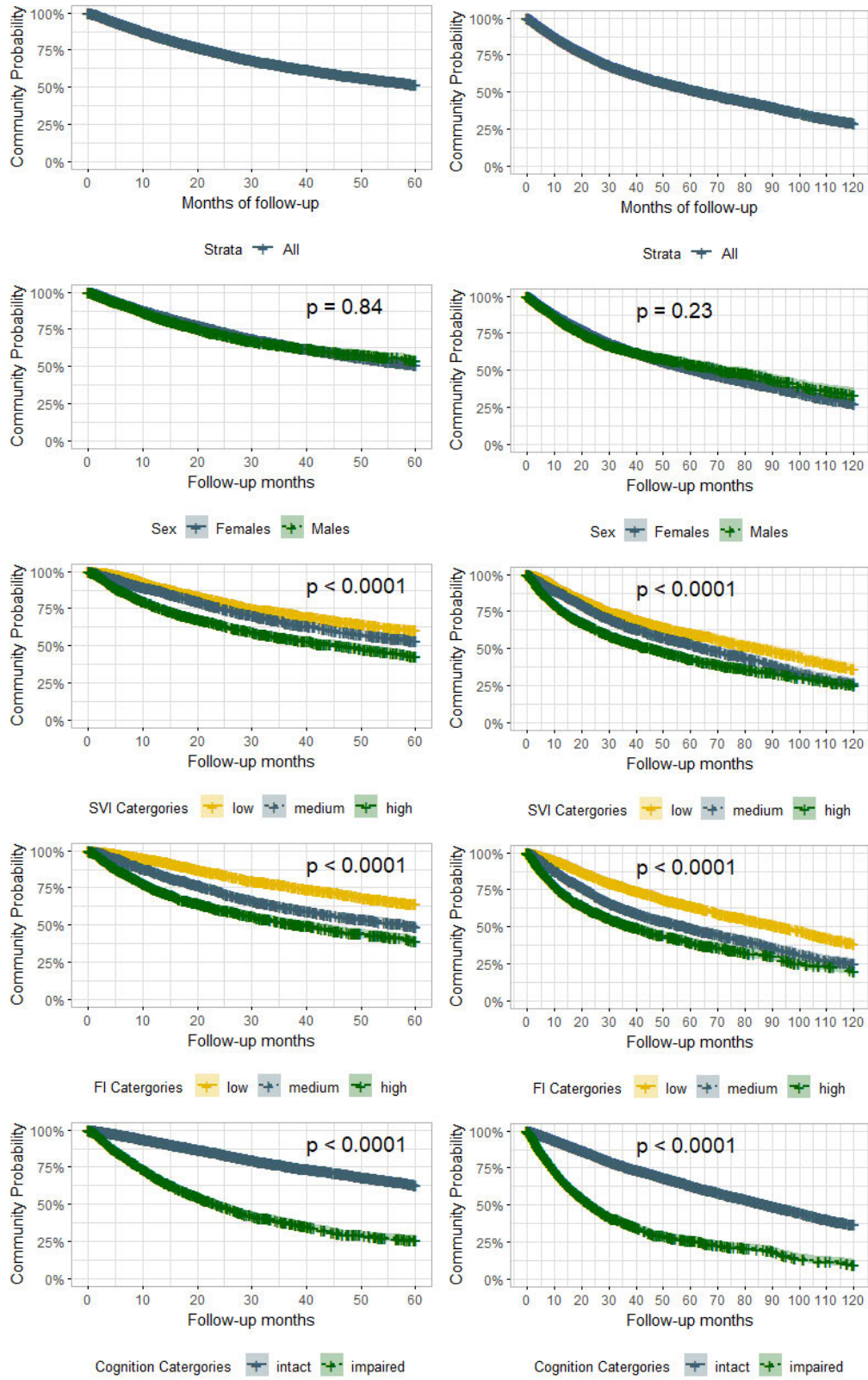
Figure 2a. Probability of remaining in the community at 5 years (left column) and 10 years (right column)

Variable		N	Hazard ratio		p
Age		5520		1.04 (1.03, 1.05)	<0.001
Sex	F	3677		Reference	
	M	1843		1.01 (0.91, 1.12)	0.9
FI		5520		1.17 (1.11, 1.23)	<0.001
SVI		5520		1.43 (1.34, 1.53)	<0.001
Cognition	intact	3758		Reference	
	impaired	1762		2.84 (2.57, 3.14)	<0.001
Cohort	2005	2789		Reference	
	2008	2731		1.04 (0.95, 1.14)	0.4

1   1.5   2   2.5 3

Variable		N	Hazard ratio		p
Age		5520		1.04 (1.04, 1.05)	<0.001
Sex	F	3677		Reference	
	M	1843		0.97 (0.88, 1.06)	0.5
FI		5520		1.15 (1.10, 1.21)	<0.001
SVI		5520		1.36 (1.28, 1.44)	<0.001
Cognition	intact	3758		Reference	
	impaired	1762		2.63 (2.40, 2.88)	<0.001
Cohort	2005	2789		Reference	
	2008	2731		1.03 (0.95, 1.12)	0.5

1   1.5   2   2.5

Figure 2b. Hazards ratios of models for 5-year (top panel) and 10-year (bottom panel) long-term care home entry

Sex Separated Analyses: Survival

For females, high social vulnerability was statistically significantly negatively associated with mortality at 5 years (aHR: 0.92, CI 0.86, 0.99, p=0.02) but not at 10 years (aHR: 0.95, CI: 0.90, 1.01, p=0.1). For males, social vulnerability was not significantly associated with mortality at 5 years with borderline significance at 10 years (aHR 0.93, CI: 0.87, 1.00, p=0.05) in adjusted models as shown in Figure 3.

Variable		N	Hazard ratio		p
Age		3677		1.02 (1.02, 1.03)	<0.001
FI		3677		1.43 (1.36, 1.50)	<0.001
SVI		3677		0.92 (0.86, 0.99)	0.02
Cognition	intact	2609		Reference	
	impaired	1068		1.14 (1.02, 1.26)	0.02
Cohort	2005	1909		Reference	
	2008	1768		0.97 (0.88, 1.06)	0.48

0.9 1 1.1 1.2 1.3 1.4 1.5

Variable		N	Hazard ratio		p
Age		3677		1.03 (1.03, 1.04)	<0.001
FI		3677		1.33 (1.27, 1.38)	<0.001
SVI		3677		0.95 (0.90, 1.01)	0.1
Cognition	intact	2609		Reference	
	impaired	1068		1.20 (1.10, 1.30)	<0.001
Cohort	2005	1909		Reference	
	2008	1768		1.02 (0.95, 1.10)	0.6

0.9 1 1.1 1.2 1.3

Variable		N	Hazard ratio		p
Age		1843		1.02 (1.02, 1.03)	<0.001
FI		1843		1.35 (1.27, 1.43)	<0.001
SVI		1843		0.94 (0.86, 1.02)	0.11
Cognition	intact	1149		Reference	
	impaired	694		1.15 (1.01, 1.31)	0.03
Cohort	2005	880		Reference	
	2008	963		1.02 (0.91, 1.14)	0.77

0.9 1 1.1 1.2 1.3 1.4

Variable		N	Hazard ratio		p
Age		1843		1.02 (1.01, 1.03)	<0.001
FI		1843		1.28 (1.21, 1.35)	<0.001
SVI		1843		0.93 (0.87, 1.00)	0.05
Cognition	intact	1149		Reference	
	impaired	694		1.14 (1.01, 1.28)	0.03
Cohort	2005	880		Reference	
	2008	963		1.05 (0.94, 1.16)	0.39

0.9 1 1.1 1.2 1.3

Figure 3. Hazards ratios of models for females (top panels) and males (bottom panels) 5-year (left panel) and 10-year (right panel) mortality

Sex Separated Analyses: Long-Term Care Home Entry

In all adjusted models for both females and males, social vulnerability was positively associated with long-term care home acceptance. The strength of the association was slightly greater at 5 years for females (aHR 1.45, CI 1.34, 1.57, p<0.001) although the confidence intervals and p values are similar across all time points for both sexes. Survival curves and full Cox models for all sex separated analyses are in Appendix 2.
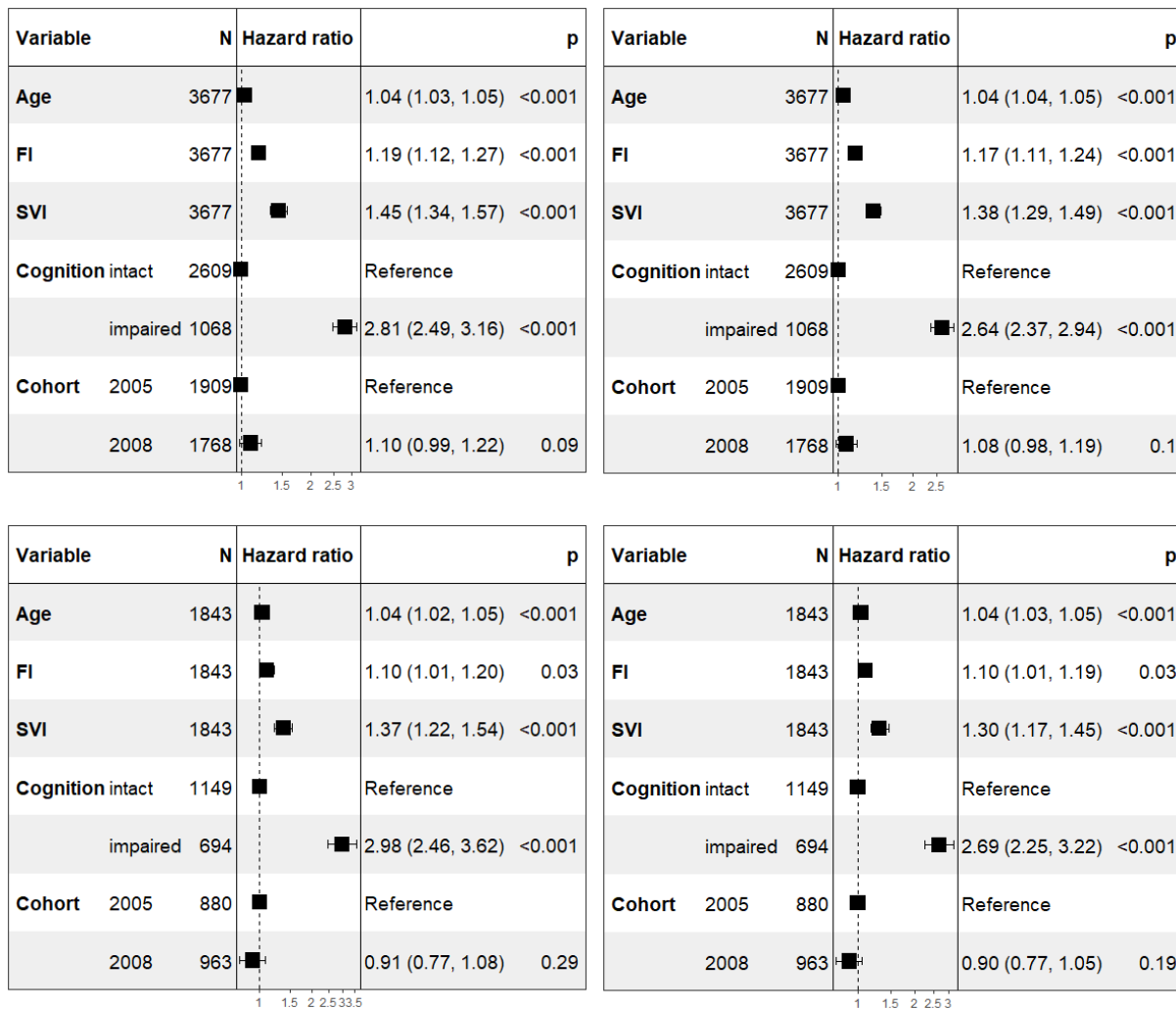
Figure 4. Hazards ratios of models for females (top panels) and males (bottom panels) 5-year (left panel) and 10-year (right panel) long-term care home entry

Other Covariates

Across all survival models, higher frailty and impaired cognition were both associated with higher hazards of dying (p<0.001). Higher frailty and higher long-term care home acceptance were correlated for females and males, although the associations were stronger and the risks were higher for social vulnerability than for frailty (also true for the main analysis). Impaired cognition compared to intact cognition in the model had the largest risk for long-term care home acceptance.

Discussion

Among this cohort of older Nova Scotians assessed by the public home care system, after adjusting for age, frailty, sex, cognition, and cohort year, higher social vulnerability was associated with increased survival rates. This association persisted for 5-year mortality but not at ten years, while for males, the relationship was not statistically significant but showed a similar direction of effect. For both sexes, and overall, high social vulnerability was associated with higher likelihood of long-term care home acceptance.

Higher vulnerability and higher survival is a curious finding and opposite to most studies examining social vulnerability in community dwelling older Canadians (2,9,22).
However, the paradox that women, despite being more likely to live in poverty and experience socioecological disadvantages, still have a longer life expectancy than men is not a new dilemma. The role of gender continues to challenge existing assumptions about the relationship between access to material resources and power and why expected patterns of life expectancy do not occur as predicted (23). Previous studies have often applied the social determinants and Bourdieu's concepts of capitals to sex and gender theories of health (23). Relevant to our older adult cohort, women who live alone without reliable supports may exhibit stronger adaptive capacities and self-resilience. They may be more likely to seek out home care (selection bias) and be over-represented in our population that looks at people who are being assessed for home care rather than all older adults in the community. If individuals with higher social vulnerability are more likely to qualify or seek out home care services, they may benefit from

more frequent home care visits which could enhance survival. Women also serve as "shock absorbers" in families, economies, and broader societies through their roles as unpaid caregivers (24). Since these roles carry substantial mental and physical health risks, those without these stressors may experience better health (25). Therefore, while females are captured as socially vulnerable in our cohort, perhaps they have developed health behaviours and psychological adaptive capacities not captured by traditional metrics.

That higher social vulnerability leads to higher long-term care home entry is not surprising. When there are no supports to help with activities of daily living (e.g., finances to outfit a home environment for mobility challenges), a long-term care home may be an attractive living arrangement. Even so, social vulnerability did not show associations with increased mortality, suggesting social vulnerability may be more relevant for maintaining quality versus length of life in older adults. This is supported by our findings that frailty has a smaller effect than social vulnerability on long term care home entry, similar to previous work looking at the role of social vulnerability in hospitalized older adults (7,26). This suggests that interventions focusing on improving social supports could help older adults maintain their independence and stay in their homes longer, reducing the need for nursing home care.

There are also interesting connotations for the role of long-term care homes. In our models, social vulnerability and cognition were the primary drivers of long-term care home entry. According to the Canadian Institutes of Health Information, 87% of long-term care home residents have cognitive impairment (27,28). If long-term care home entry is most driven by cognition, then perhaps its primary function in society especially as the incidence of dementia rises in Canada, is to become dementia centers of excellence (29). If social vulnerability is also driving long-term care home entry, then for the people who are cognitively intact, they should become social centres.

In our sex disaggregated analyses, frailty did not significantly contribute to increased risk of long-term care home entry for men at all, only social vulnerability [and cognition – discussed

above]. This suggests that long-term care home entry may inadvertently serve as society's solution to social vulnerability, especially for the females who live longer than men. Our previous work showed that as social vulnerability increases over time in a home care population, predicted home care allocated hours decreased (refer to Chapter 9). Canadian Institute of Health Research statistics suggest between one in five to one in nine individuals living in long-term care homes may not need to be living there for medical reasons (30,31), suggesting more work should be done examining the relationship between the social reasons people go into nursing homes and our structures in society facilitating this care path.

Limitations

Social vulnerability and frailty are dynamic states, and this analysis represents only one snapshot of the baseline assessment. Furthermore, this represents only one home care population in Nova Scotia and cannot be generalized to other jurisdictions where policies and eligibility criteria for home care may be different. We may be failing to capture individuals who are able to solely rely on private services, or individuals who are so disadvantaged that they cannot access home care (e.g. no fixed address). The construct of social vulnerability measured using our SVI also must be considered. The RAI-HC relies on primarily subjective responses from older adults. However, for the 30-40% of older adults with cognitive impairment, their answers are likely answered by a caregiver, so the client's perspective is "silent by proxy" (e.g., client says or indicates he/she feels lonely) (6). Previous work has questioned which factors should be included in a social vulnerability index, but concluded that with more social variables, a more complete social picture develops (2). Missing from our SVI are the macro level social factors that show associations with health, such as neighbourhood or community resources. Finally, the inability to determine if deaths occurred in long-term care homes due to data limitations prevented mediation analyses where long-term is likely on the pathway from community living with home care to death.

Conclusion

In this study of older Nova Scotians within the public home care system, higher social vulnerability was generally associated with increased survival. Higher social vulnerability was also associated with increased long-term care home entry, especially for women. Despite our commonly held perception that nursing homes are built for frail older adults, these findings suggest that in fact they are often serving the needs of socially vulnerable older adults. Whether long-term care homes are an ideal solution is another question – perhaps as a society we would prefer to support social vulnerability with community based social care rather than medicalization in long term care homes? Our findings suggest long-term care homes are addressing social needs beyond cognition and frailty concerns; therefore, focusing on how home and community care services can mitigate social vulnerability may more effectively meet the needs of older adults in Nova Scotia.

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Chapter 11. Discussion and Conclusion

In my thesis I examined the concept of social vulnerability in relation to community supports for older adults, how different healthcare settings currently deal with social vulnerability and what can be done to support socially vulnerable older adults in the context of our health care systems. In this discussion, I will start with summarizing and drawing connections between the studies described in each chapter, followed by my overall reflections on this body of work. Next, I describe future research considerations including a model of caring for older adults at risk of frailty and/or social vulnerability across healthcare settings. I conclude with reflections on policy considerations and thre potential for further exploration while acknowledging the constraints of this work.

Summary of chapters

Chapter 2 is a systematic review demonstrating complex interventions with a predominant social component, showing associations with improved function, better subjective health and lower hospital use, but not with primary care use (and there was insufficient evidence for mortality). Despite heterogeneity in the complex interventions including variations in the program components, settings within the community and targeted older adult populations, there remained overall improvement in some health outcomes. This evidence highlights the potential value of intervening to reduce social vulnerability, which later chapters show is associated with frailty, ALC status and LTCH placement.

The theory, method, and strengths of constructing a multiple level and multiple domain SVI are presented in Chapter 4. The SVI's feasibility is demonstrated in both a smaller clinical study and a larger population-based dataset and common properties of previously calculated SVIs are observed. Since there is no consensus on which social factors should be included in an index to represent social conditions, in Chapter 3, a scoping review identifies common items and

domains in the composition of most SVIs across multiple fields of literature. The review also explores the outcomes for which SVIs are used, such as COVID-19 cases, surgical complications, and healthcare access, among others.

The next chapter (Chapter 5) uses the SVI constructed from Chapter 4's methods in a secondary data analysis of a cohort of older Nova Scotians presenting to the ED. Frailty drives admission and mortality outcomes in this population, but social vulnerability keeps them in hospital or otherwise institutionalized. Within the hospital setting, qualitative interviews reveal key domains and themes of health care providers' perceptions of "socially admitted" patients. The themes in Chapter 7 describe individual, institutional, and system challenges to patient centred care for this population including care team moral distress, hierarchies of care, stigma, prejudices, long wait lists for home care and scarcity of alternatives. These themes help explain the findings from Chapter 6's scoping review that "social admission" labels are primarily used to describe older adults, and that this population experiences high mortality, low likelihood of returning to the community, and were often found to have other medical conditions when properly assessed by care teams.

Chapters 8, 9, and 10 collectively highlight the dynamic relationship between social vulnerability, frailty, and home care hours, mortality and long-term care entry in older adults accessing public home care in Nova Scotia. Chapter 8 shows that time alone is not associated with greater social vulnerability, indicating that progression of social vulnerability is not an inevitable consequence of aging. Also, changes in frailty, rather than the baseline frailty level, were associated with a steeper rise in social vulnerability over time. Like the previous chapter, Chapter 9 uses multi-level growth models demonstrating that greater social vulnerability is associated with a decrease in authorized home care hours, particularly for males and individuals assessed for home care within 5 years of death. Finally, Chapter 10 reveals that higher social vulnerability was associated with a higher likelihood of long-term care entry, and, perhaps counterintuitively, with increased survival. Important policy ramifications are discussed, including optimal functioning of home care and LTC to best meet the needs of older adults living

with different kinds of vulnerabilities (frailty, social, and/or cognitive). Along with chapter 5, these chapters contribute to the evolving literature on understanding social vulnerability in different settings when caring for an aging population.

Overall reflections

My thesis was motivated by research questions that sought to understand how social vulnerability contributes to and influences the pathways of older adults who are in healthcare settings due to the impact of their social circumstances. The findings were contrary to my original hypothesis – that the associations between social vulnerability and long-term care home use would disappear once accounting for age, sex, dementia, and frailty and that home care would be responsive to increasing social vulnerability. Instead, one possible summation of these findings suggests that healthcare's solution to social vulnerability in the Nova Scotia context, when all health and cognitive issues are equal, is institutionalization rather than home and community care. This is supported by our findings that: (a) among older adults presenting to the ED, social vulnerability did not lead to hospitalization, but was associated with longer stays in hospital, ALC status and LTCH placement, (b) in the community, higher social vulnerability with all other variables being equal (age, frailty, cognition) was associated with lower home care hours, and (c) social vulnerability in this home care cohort was more strongly correlated with long-term care entry than was frailty, and (d) healthcare providers when interviewed felt "socially admitted" patients were deserving of care, but not care delivered by them. After healthcare addresses frailty, and those who have passed away are no longer part of the system, the findings of this thesis may support the idea that the medical approach to social vulnerability might relegate individuals into institutions such as hospitals (as ALC) or long-term care homes.

There are several possible explanations for these findings. One explanation is the overmedicalization of the aging process. In Being Mortal, Atul Gawande shares his family's experience caring for their aging patriarch in India. He describes how his grandfather's loss of independence was not considered abnormal and how his family ensured he was able to make

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the rounds of his fields until the year he died. "Had he lived in the West, this would have seemed absurd. It isn't safe, his doctor would say. If he persisted, then fell, and went to an emergency room with a broken hip, the hospital would not let him return home" (1) (pg. 16). His description describes the risk-averse nature of medicine (2), echoed by one testimonial "[i]t's as though being a senior is a disease." (3) Even the results of my thesis can be argued to be a medicalization analysis "questioning the causation of the particular behavior or condition" rather than "focus[ing] instead on how the problem came to be designated as a medical one." (4) In my thesis, the segmentation of older adult populations into "ALC" and "social admissions" itself supports a medicalization of social issues because they are defined by the absence of medical criteria. A biomedical lens does contribute to the populations studied in Chapters 6 and 7, the outcomes measured (e.g., mortality rather than quality of life in Chapter 5) and ways of measuring social vulnerability (e.g., what items are collected by healthcare settings to be included in the SVI in Chapters 3 and 4). This medicalization of socially vulnerable populations may detract from the larger issues which cause older adults to end up in healthcare settings. Nonetheless it can be argued that social problems are a medical issue since greater numbers of older adults are interfacing with the healthcare system because of social vulnerability – hence the impetus for my thesis – and that the healthcare system struggles to care for the complexity of this population precisely because older adults rarely fit into one biomedical model of disease.

Another possible explanation of the findings of my thesis is that they are unintentional or intentional consequences of existing medical or social structures. If an approach to social vulnerability is to transition people to long-term care homes, is this a desired outcome in the face of larger issues? If so, surely, we must recognize that this solution does not resolve the broader social structures impacting people's inability to function independently. Rather, it addresses only a fraction of the multifaceted social challenges. One editorial published in response to Chapter 7 raised the possibility that "social admissions" (and by extrapolation ALC and long-term care entry) are medicine's answer to lack of affordable housing and safe environments for older adults (5). Often, public funding and coverage is available for services in long-term care homes, making it a more affordable option for patients compared to other living

arrangements. Furthermore, strict entry criteria for alternate programs such as rehabilitation often exclude the most socially vulnerable (e.g., patients who have been waitlisted for long-term care homes) even if they may be well served by these services. This may create a cycle described in Chapter 7 where mildly frail older adults are excluded from rehabilitation programs due their social circumstances (e.g., eligibility criteria of some rehabilitation programs require an expectation that the patient can return to community living), but without physiotherapy or occupational therapy the older adults experience greater functional decline and therefore become frailer eventually requiring the supports of an institution for physical limitations as well as social vulnerability. Furthermore, the lack of communication, reassessments, and disconnect between hospital and community resources means hospital workers rarely understood outside resources and actually felt ALC designation was helping patients in a safety focused (versus patient autonomy focused) healthcare system (2,6).

Alternatively, the possibility that the system is set up to institutionalize older adults should be considered. Extrapolating from another study, there may be a tendency for some older adults to be moved along in a busy hospital system to long-term care and become prematurely institutionalized; but on further examination this may also be an understandable consequence of a resource strapped system with efficiency in its hidden curriculum (6,7). Furthermore, the current waitlists for home care and scarcity of alternatives in the community are a form of managing too much demand and too little supply of home care. "Persistently supplying lower levels of support than the underlying level of demand can also reduce future demand. This can happen where some potential recipients are discouraged from seeking home support as they believe it will not be offered in a timely way." (8). This pushes people towards further reliance on their informal caregivers, private provision, premature long-term care home entry, emergency department visits, and hospitalizations with longer lengths of stays. Premature institutionalization evidently occurs in Canada as 1 in 5 people in long-term care homes have the same health profile as those who live in the community and 1 in 9 people could be taken care of at home (9–11). If this is the case, perhaps social long term care homes should be considered (in addition to dementia care homes – see Chapter 10). It is essential to evaluate

whether our current actions as a system are in line with our intended objectives of helping older adults age in place.

Relying on ALC stays in hospitals and long-term care entry as part of the social vulnerability solution is questionable, as these options do not adequately address social needs and can sometimes exacerbate health and social issues. Loneliness, the new epidemic, worsens in long-term care facilities with 61% of LTCH residents reporting moderate loneliness and 35% reporting severe loneliness (12). People who are institutionalized consistently reported higher social isolation and loneliness than community dwelling counterparts (12–14). In one study, nursing home social opportunities did not align with expectations of older adults because there was low reciprocity between residents, poor sense of community and social activities with staff were not structured to foster relationships (15). In ALC populations, similar to our findings in hospitalized "social admissions", a lack of recreational or social programming has been reported. Interestingly, in qualitative interviews with ALC populations, some older adults were generally satisfied with their pre-hospital living conditions despite the threat of compromised safety (16). Frailty often increases and function decline accelerates when older adults remain institutionalized: "As soon as they're designated as [needing] ALC, they're institutionalized... The food arrives for them [and is] taken away. They don't do any dishes; they don't do any laundry. Nothing normal happens in their time at the ALC beds... The hospitals inadvertently institutionalize people very quickly, and so that's where people lose a lot of function and ability... and all that's preventable." (6)

Consider the counterfactual: if given the choice, how many older adults would choose to live at risk to age in place? There is a large body of literature on dignity of risk and self-determination, especially for people living with disabilities and mental health conditions (17,18). In healthcare settings, self-determination may conflict with a culture of safety first and duty of care, and raises many ethical, legal and moral concerns (1,2). Aging older adults face an added layer of complexity if cognitive impairment plays a role. A review of dignity in aging is outside the scope of this thesis (and instead refer to this article (19)), yet its intersection with ageism, ableism and

dementophobia (phobia of dementia) contributes to making sense of the findings of this thesis and finding solutions for helping people meet their goals of aging at home.

To achieve aging-in-place, an alternative to institutionalization must be available. Unfortunately, home and community care does not appear to respond with more supports as social vulnerability increases. Critics have suggested that home and community care no longer provide basic help such as cooking, driving, visiting, and maintaining a home – the functional elements that could keep people at home (20). It has been suggested home care services are overmedicalized largely focusing on responding to short term health problems (20). Chapter 9 found that home and community care responded to frailty better than social vulnerability, supporting this claim. Tamara Daly writes about how home and community supports structurally became focused on healthcare (21). She summarizes the historic separation in Ontario of home support and home health services through the Ministry of Community and Social Service and Ministry of Health; each with very different values. However, beginning in 1990, the government consolidated the administration and funding for long-term care in the Ministry of Health and Long-Term Care, leading to changes in the quantity and type of supports available, reflecting a shift from a social care to a health care philosophy (21). In Nova Scotia, it was not until the year 2000 that the care of seniors was transferred to the Department of Health (22,23). This is relevant not only for the governance model and the resources available, but also because of the culture and perceptions attached to social care versus healthcare. Numerous questions are raised by the historical shift away from long term care being within the remit of social services and informal caregiving and towards its inclusion within healthcare, as well whether it makes sense to reverse this transition. In fact, there is mounting evidence to suggest medicine and healthcare only contribute a small proportion to the health of older adults; interventions at the social and environmental level may yield healthier populations (24,25).

Chapter 9 and 10 prompts us to consider the role of home care in Nova Scotia—whether it acts as a substitutive or complementary service, or, whether it is responsive or preventative in the

context of existing social support structures and other health and social care services (26). With informal caregivers serving as the "backbone" of the home care system, it is unclear how much the home care system considers the needs of those support networks. Walsh and Lyons expressed the dilemma: "the tension between the provision of care that meets the current needs of an individual and the provision of other care (or actions) that may reduce future need... there might be cases where a small number of hours provided to someone who is not currently frail could postpone the development of frailty in the future, or where support for an unpaid carer could reduce the carer's future need for home support or other healthcare and social care services." (8)

Future Research
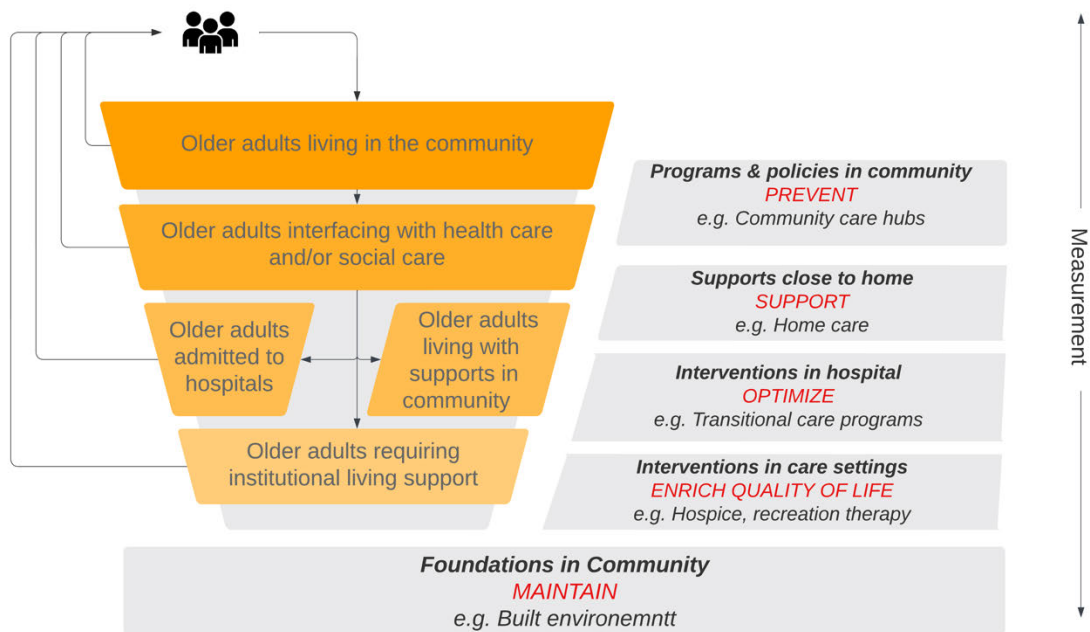
Figure 1. A model of caring for older adults at risk of frailty and/or social vulnerability across healthcare settings

The research of my thesis can be conceptualized as part of the wider healthcare system where there remains much work to be done to help older adults age in place. This conceptual model in

Figure 1 builds on work by Howe (2002) and provides an overview of the care pathways of older adults in a community and interactions with the healthcare system (27). As Chapter 2 mentions, it is important to design models that allow for complexity and tracking of social vulnerability, frailty and interventions.

The inverted pyramid on the left represents populations of older adults with increasing frailty or social vulnerability but smaller absolute numbers. Each conceivable population has distinct characteristics and needs. At the top, these are all older adults in the community, some who may never connect with healthcare services before reaching the common endpoint of death (not shown in the model). The next population are older adults who interact with healthcare through clinics (e.g., family doctor visits), programs (e.g., community health teams) or urgent care or ED visits. Smaller groups of older adults are hospitalized or require supports to remain living in the community through formal or informal care services). At the bottom of the inverted pyramid are older adults requiring institutional living support. This group is the smallest but has unique health and social profiles as well.

On the right side of the model are programs, policies, or interventions. These programs, policies and interventions act as a filtering process that progressively shapes the characteristics and size of the next population in the model. The purpose of the interventions on the right must therefore have different objectives to respond to the refined population characteristics at each level.

For **programs and policies in the community,** these aim to *prevent* worsening frailty and social vulnerability including community care hubs. For **supports close to home,** these interventions help older adults who are frail or vulnerable manage their daily functioning and help keep them living in the community. Besides home and community care, there are paramedic led programs, home visits clinicians, etc. In Nova Scotia, free Wellness Navigation is one example (28). It is inevitable that some older adults will need hospitalization and that is when **transitional care programs** arise. The goal is to *optimize* the patient's health status and social circumstances with

the goal of returning to the community. Examples include care navigator programs, but also Nova Scotia's Emergency Health Services Special Patient Program (29). Not to be forgotten, but **interventions in care settings** are still required for health, wellness and to *enrich quality of life*. One example is the United Kingdom's Cocktails in Care Homes (30). Finally, supporting all the other structures are community foundations, which can be programs like Age Friendly Nova Scotia, or universal long-term care insurance like in Japan (31,32). Examples of interventions at each level are numerous and are synthesized in Chapter 2 of my thesis.

The foundation of the model is underpinned by the social structures of the community (e.g., community values against ageism, or a built environment consistent with age-friendly communities). Although the model was created to be valuable through a physicians' lens due to the author's background, it is recognized that only 10-20% of health outcomes can be prevented or attributed to clinical care and the most modifiable determinants of health are social and economic factors (24,33).

The first use of this model is to conceptualize how each chapter fits into the larger system in Figure 2, to imagine where interventions could be made, and to recognize this work offers a small piece of a very complex puzzle. For example, future research on social vulnerability could combine with primary care work looking at older adults who lack a primary care provider.
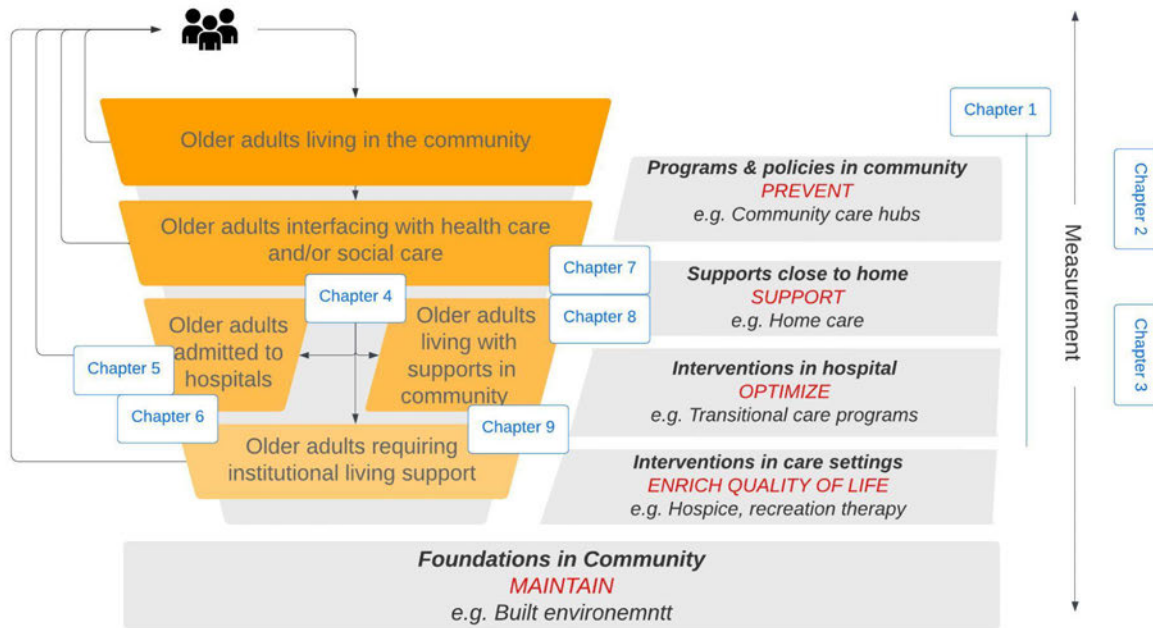
Figure 2. Thesis chapters mapped on a model of caring for older adults at risk of frailty and/or social vulnerability across healthcare settings

The next possible use of this model in future research is to track changes across systems. It can be used to monitor trends over time (e.g., projections as absolute numbers of older adults increase in the population). It can be used to monitor impacts of the system of a complex intervention. This model was designed to look at the movement of older adults throughout healthcare systems from a big picture level – recognizing the goal to help older adults age in the right place at the right time goes beyond hospital walls or physicians' offices although they are timepoints to help achieve their goals. Figure 3 offers a very simplistic illustration of how this model could be used to track the system effects of a future or current intervention in hospital designed to reduce social vulnerability. The numbers presented in the diagram are estimates from various sources for illustrative purposes only (see Appendix 1 for references and calculations for Figure 3). Let us say we were interested in tackling the issue of the approximately half of ALC patients who are expected to be able to go home from hospital with the right supports (34). The intervention could be Nova Scotia Health's Quick Response Program

in the Halifax Infirmary Hospital Emergency Department which temporarily reduces social vulnerability by providing supports to go home. Using this model, pre and post intervention numbers can be recorded to see how many people are able to return to the community with this intervention, how many end up in long-term care homes, etc. We could also measure outcomes on the individual level, to see how many days are spent in each level of the model. Future research directions can automate this process using some of the predictive models in Chapter 5, 8, 9, or 10 to see how changes in one domain (e.g. frailty) may change numbers of older adults in each care pathway. With increasing digitization, and Nova Scotia Health's recent Care Coordination Centre (a central coordination centre collecting patient flow and resource information of the healthcare system in real time) (35), there may be opportunities to use the model to understand older adult journeys throughout the healthcare system.
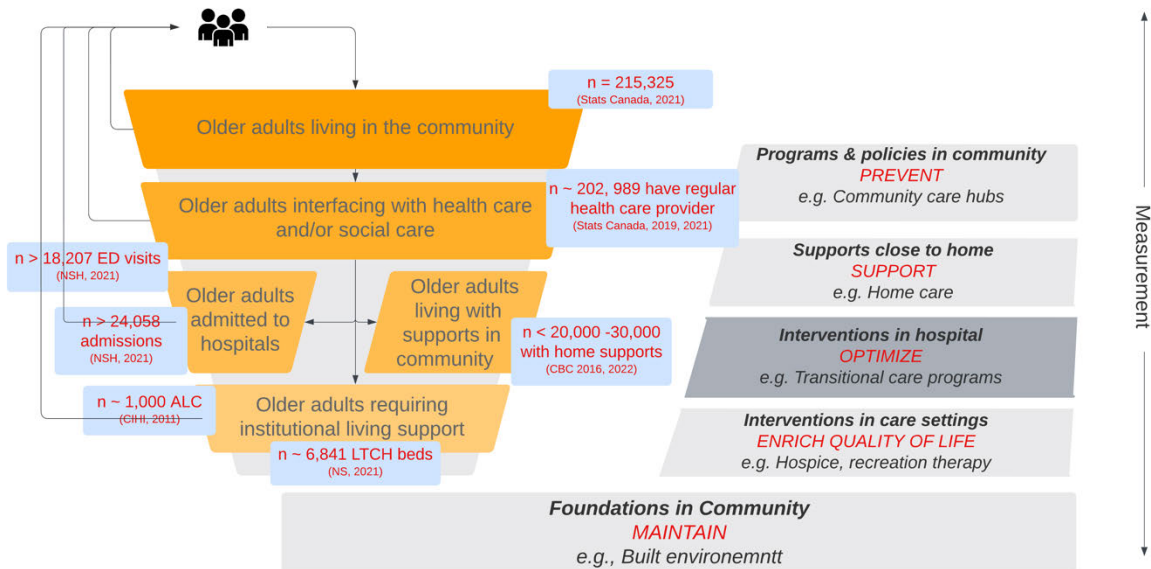
Figure 3. A use case for a model of caring for older adults at risk of frailty and/or social vulnerability across healthcare settings in Nova Scotia; ALC = alternate level of care, ED = emergency department, LTCH = long-term care home

This model allows us to view effects of major policy shifts over time using routinely collected data. In our example using a denominator of 215,325 older adults in Nova Scotia in 2021, about

8% visited the Queen Elizabeth II Health Sciences Centre emergency department, 9-14% may be using home supports and only 4% are living in LTCHs (36). The wait lists for home and community care and LTCHs could be added to the model. For example, how would the proportion of older adults at each care pathway change if guaranteed annual income was implemented as in a recent study using Canadian Longitudinal Study on Aging data (37). Another policy example that would drastically shift the care pathways is increasing the home care proportion of the long-term care budget rather than the nursing home proportion. On average, most countries in the Organisation for Economic Co-operation and Development (OECD) allocate 65% of long-term care funding to care in settings like nursing homes and only 35% to home and community-based care. Denmark does the opposite, spending 36% of its long-term care budget on nursing homes, and allocating 64% to home and community-based care. Denmark witnessed a 12% reduction in overall long-term care expenditures for individuals aged 80 and over in the decade after this change, and also did not need to construct new nursing homes for nearly 20 years while simultaneously closing thousands of hospital beds (11). In contrast, in 2018, Canada spent $27 billion of the $33 billion long-term care budget on nursing homes and only $6 billion on home and community care with $2 billion of that amount financed privately (11). Through this model, numbers and expenditures could be tracked both for smaller interventions but also to assess the health outcomes of social policies which is an important area for further inquiry in Canada (38).

Policy Considerations

While my thesis focused on social vulnerability, frailty and social vulnerability are intrinsically linked. Older adults age with multiple health and social issues which occur simultaneously. The way these many health deficits and social deficits accumulate and interact is unknown, yet they show consistent distributions and patterns across populations, sexes and ages. As a result, the solutions to reduce social vulnerability will likely reduce frailty and vice versa. Throughout the chapters, potential ways to address social vulnerability have been proposed.

The overall policy relevance is clear: 1) healthcare needs to adapt to address social complexity, 2) in its current state, the issue of socially vulnerable older adults is likely to grow with the aging demographics, so time is pressing, and 3) more investment, or a change in the proportion of investment, is necessary. My thesis also suggests that our systems of care may be pushing older adults with frailty and social complexity towards more expensive institutionalized settings with unknown benefit to older adults themselves. Chapters 2, 5, 6, 7, 9 and 10 all include interventions and programs in the literature for older adults to age with dignity. These will not be repeated here, rather the National Seniors Strategy (10) or the World Health Organization's Decade of Healthy Ageing Collaborative (39) are highly comprehensive documents with aging-in-place strategies.

Instead, this section will focus on policy considerations for how we can implement and see these solutions come about.

Coalitions, advocates and messages: A big strength of this thesis is its interdisciplinary nature and how multiple ways of thinking have shaped the conceptualization, measurement and interpretation of the studies comprising this thesis. Aging, frailty and social vulnerability are complex topics with no one definition and no one solution. Making something a policy priority involves first defining the *issue*, demonstrating a *problem* that emphasizes its severity and oversight, followed by proposing a feasible *solution* (40). Unfortunately, none of these topics are easy to define making it difficult to come to consensus on a united vision. These issues bring together different groups, coalitions, and experts to try and work towards a solution which is a strength but also creates an antithesis. Such integrated programs require collaboration between multitudes of actors; consequently, determining who takes responsibility and final ownership of the programme can be challenging. Without a specific champion group with a clear message, it can be hard to gain traction in the overly crowded policy stage. As advocacy groups and champions are key to propagating issues to priority status in healthcare (41), Shiffman (2009) argues that issues trying to make it to the top of the global health agenda must "build institutions devoted to their own issues, rather than to leave it to chance that existing global

and national institutions are going to select their issues for attention." One way to increase interested parties is to create physician, nursing and hospital payment models that increase billings and financial incentives for managing social vulnerability, frailty and aging. As pointed out in Chapter 6, at the very least, healthcare actors and hospitals should not be unintentionally penalized for caring for adults with complexity. Coalitions must also move beyond health-related actors, collaborating with politicians, lawyers, social scientists, among others, to find mutually beneficial strategies that address the multifaceted nature of social vulnerability.

Economic case: There is an economic case to be made to policymakers and institutions regarding the implications of addressing social vulnerability because this small population consists of those more likely to use expensive resources. In one recent 2020 analysis, one ALC occupied hospital bed estimated cost is between $730 to $1,200 CAD per day in staffing and resources. This equates to $5,475,000 to $9,225,000 CAD daily if there are 7,500 patients in ALC beds across Canada at any one time. Since an LTC home has an average cost of $225 to $253 CAD per day, using the same 7500 bed/patient figure, the daily cost is $1,687,500 to $1,897,500 CAD. Even in moving patients from ALC to the most expensive discharge option of a LTCH (and arguably, some patients designated ALC may be even better served discharged home with home care), our healthcare system can save millions of dollars per day, and two to three billion dollars per year nationally (42,43). Some estimates of 2009-2010 ALC costs are available for Nova Scotia (44). In other countries, the savings of LTCH vs home care have been documented in the literature (45), with similar findings in Canada, although the modelling depended on other factors like life expectancy (46,47). Instead of adding resources, there is an economic efficiency case for simply changing the proportion of relative resourcing for community care services, as discussed above for Denmark. In doing so, we may need to shift away from a medical model and share resources across sectors and healthcare silos.

Ideology: It can be argued that investment in reducing social vulnerability in older adults is a fundamental question of health equity. Paradigms of thinking of social vulnerability and frailty in older adults include libertarianism (Locke), utilitarianism (Bentham), justice as fairness

(Rawls) or Egalitarianism (Marx). Libertarianism, belief in a right to life, liberty and possessions, suggests people know their own welfare the best and the role for interventions for reducing social vulnerability or frailty by hospitals and policymakers is minimal – people will figure it out themselves. This philosophy underpins to some degree the risk taking by allowing older adults to choose to live at home to preserve autonomy. Rawlsian theories espouse that inequalities can be tolerated only if this benefits the least well off – hence the argument to avoid social exclusion overall. Utilitarianism, the greatest good for the greatest number, is the closest to the definition of efficiency in healthcare – getting the most out of resources available. This is a clear argument when scholars say the estimated cost of one ALC patient occupying a bed is four emergency patients facing delayed access to care per hour (48). Finally, there is egalitarianism – the fair distribution of healthcare by need. And these are important when we consider our solutions to these problems philosophically, but also pragmatically. Chapter 7 interviews where healthcare workers said "social admissions" no longer work with physiotherapy (because there is no time to work with people who have plateaued) is an example of horizontal equity, equal treatment of equals (people with the same health care needs receive the same amount of care) as opposed to vertical equity = unequal treatment of unequals (people in greater need should receive more care) – where "social admissions" may get more care because they are so far behind. These ways of thinking permeate models of care (e.g., utilitarianism making a model of care maximizing the sum of utility for all members of the population versus Rawlsian models which would benefit care where the least well off is best off. While there is no clear answer to one approach, the very existence of ALC or social admissions reflects the inherent ideologies of health care and our distribution of resources between social services, primary and acute care. Ultimately, the way we manage social vulnerability in our patients is an unintended consequence of ideologies in healthcare.

The Canadian Revenue Agency Disability Tax Credit is a good example of an existing Canadian policy that simultaneously addresses frailty and social vulnerability and can be viewed as a program with features of the interdisciplinary coalitions, economic rationale and ideological considerations mentioned above. From a coalition, advocacy and messaging perspective, the

Disability Tax Credit was passed in 1986 by government policymakers (49). It requires input from healthcare professionals to complete the forms. It also involves social and disability rights activists expanding the definition of disability in 1988 and again in 2005 "to include all persons who struggle with severe and prolonged impairments in mental or physical functions", opening the door for "people who faced challenges with common day-to-day tasks" – for example older adults living with frailty (49). The credit provides financial relief to Canadians with disabilities, acknowledging the economic burden and offering a practical financial solution to mitigate stressors. Unused portions of the credit can also be transferred to a supporting family member (50). The Disability Tax Credit also demonstrates some principles of utilitarianism and justice by sharing resources and not restricting eligibility to only working individuals or those with taxable income (50). A final point on this tax credit: It also recognizes that small limitations accumulate to cause significant difficulties in everyday living – this is akin to the deficit accumulation approach underpinning the frailty index and social vulnerability index. If an individual does not meet eligibility for the tax credit for the strict vision, hearing, elimination, dressing, speaking, walking, feeding or mental health criteria, a person impaired in two or more categories may still be eligible under the "cumulative effect of significant limitations" criteria "if the combined effect of their significant limitations is equivalent to a marked restriction" (51). There are limitations to the tax credit; for example, people must be aware and capable of applying and have access to a healthcare provider to complete the forms. Nonetheless, the Disability Tax Credit serves as a practical example of how frailty or social vulnerability may be mitigated with a systems level solution beyond healthcare.

Limitations

An interesting thought exercise is what the results would look like if social circumstances were conceptualized through a strengths-based approach rather than a deficit accumulation approach. The absence of a deficit likely does not convey the same effect as the presence of social capital. As mentioned in Chapter 4, the constructs of vulnerability, robustness and resilience are related but not the same, and the SVI likely does not equate to social resilience. From a resilience perspective, examining the older adults who are living with high degrees of

frailty in the community may yield further insights to helping people age in place. Additionally, the measurement properties of the social vulnerability index, including whether it follows a formative or reflective model, have not yet been tested, and this would be an important next step in validating the SVI.

As alluded to in the Future Directions section, the findings of this thesis must be interpreted in the context of the specific population cohort as many other populations have yet to be investigated. In Chapter 5, the older adults presented to the ED were seen by the internal medicine or geriatric teams prior to admission with the implication most physicians of these specialities are comfortable with medically and socially complex patients. Patients who are not assessed by these services may have different characteristics and outcomes. Chapters 8, 9 and 10 were conducted amongst older Nova Scotians with a full home care assessment in two baseline years. Data on whether this represents most older Nova Scotians using home care remains a mystery because there is no available information on how many Nova Scotians receive private home care. Furthermore, the data do not account for unmet needs of older adults on the wait lists who may benefit more from home care services. Finally, the data in Chapters 5, 8, 9 and 10, were from the province of Nova Scotia, suggesting caution when extrapolating to the broader Canadian or global context due to regional variations in health and home care. The applicability of these data to post-pandemic realities is also of question. In Nova Scotia, there was an increased push for personal budgets or direct payments in the past few years. Personal budgets refer to direct payments given to older adults to spend on hiring care workers or equipment to meet their social or health care needs. Unfortunately, many pre-existing challenges of the long-term care sector (e.g. low resources, personnel shortages) have been exacerbated since the COVID-19 pandemic.

Finally, it seems paradoxical that a thesis on social vulnerability is centred through the lens of a physician. It is outside the scope of my thesis to review pure social policies and programs in the community (except for Chapter 2) but we recognize how important these are to aging and health (recommending a review on this topic by Courtin and colleagues (38)). The

fragmentation of the healthcare, home and community care, and social care systems make it challenging to point to clear solutions or point to one culprit policy to change. This complexity likely means capturing consequences of interventions will be challenging going forward. Although not part of this thesis, thoughts on solutions for scale of home and community care innovations have been submitted in another article.

Conclusion

My thesis has examined social vulnerability in different healthcare settings. I have conceptualized and operationalized a multi-level and multi-domain social vulnerability index. I used the social vulnerability index to study associations between social vulnerability and mortality, frailty, alternate level of care designation, length of stay in hospital, and long-term care home entry in several healthcare settings among older Nova Scotians including dynamically over time. In addition to quantitative modelling, I used qualitative methods to further explore how socially vulnerable patients are perceived by healthcare providers in hospital. Overall, I argue that older adults who interface with various healthcare settings due to their social circumstances are both frail (to which our systems of care respond well), and also socially vulnerable (to which our systems of care do not respond well). Based on the findings of my thesis, I wonder if our healthcare systems unintentionally facilitate a care pathway for socially vulnerable older adults to end up in long-term care homes – which only addresses a small part of the complex social vulnerability problem. And although there are philosophical debates over whether social vulnerability is, or should be, the purview of medicine, there are pragmatic reasons to include it in our problem solving as the aging population will undoubtedly bring more and more patients with complex social presentations to seek help from healthcare settings. Lastly, I present a model to guide future research on social vulnerability, emphasizing the need for systems level thinking, comprehensive redesign, and proportional funding reform to effectively support the goal of aging-in-place in Canada.

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Chapter 1

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Appendices

Chapter 1

None

Chapter 2

Supplement A. Search Strategies

Supplement A1. Summary of Search Strategy Across all Databases

Database	Medline	Cochrane CENTRAL	Campbell Collaboration	SSCI	TRoPHI
Description	Database covers all aspects of clinical medicine, biomedicine, nursing, dentistry, allied health, health policy, genetics etc.	The Cochrane Central Register of Controlled Trials (CENTRAL) is a highly concentrated source of reports of randomized and quasi-randomized controlled trials.	Contains systematic reviews on the effects of interventions in the fields of education, crime and justice, and social policy.	Social Sciences Citation Index (SSCI) contains citations, author abstracts and cited references from over 1,700 scholarly social sciences journals.	The Trials Register of Promoting Health Interventions (TRoPHI) is unique in its focus on the coverage of trials of interventions in health promotion and public health worldwide. It covers both randomized and non-randomized controlled trials.
Platform	OVID	Cochrane Library	Campbell Collaboration	Web of Science	EPPI-Centre
Search Last Updated	May 10, 2021	May 10, 2021	May 10, 2021	May 18, 2021	May 17, 2021
Database Timespan	1946 to May 07, 2021	No inception date	Unclear	1956-present	August 2004 - present
Number of Citations	2,951	25	2 reviews (Hand searched)	2,080	136
Total Citations from Databases	5,192 (excludes 2 reviews)				
Total Citations	5,192 (Databases) + 6 (Hand-searches – see Table 1)				

Supplement A2. Grey literature: government and non-profit organizations hand-searches

Organization	Website
Administration for Community Living (United States Department of Health and Human Services)	https://acl.gov/
The Care Policy and Evaluation Centre (CPEC) An international research centre working mainly in the areas of long-term care (social care), mental health, developmental disabilities and other health issues.	https://www.lse.ac.uk/cpec/research
Government of Canada (Programs and services for seniors and National Seniors Council)	https://www.canada.ca/en/employment-social-development/campaigns/seniors.html?utm_ca

HelpAge International	https://www.helpage.org/what-we-do/health/
The International Federation on Ageing (IFA)	https://ifa.ngo/positions/addressing-inequalities/
World Health Organization (WHO) Social Determinants of Health	https://www.who.int/health-topics/social-determinants-of-health#tab=tab_2

Supplement A3. Search strategy: exclusion criteria, PICOT format

	Criteria	Examples (reference)
Exclusion Criteria		
Intervention (I)	(a) The intervention was disease specific.	(a) Efficacy of a community-based physical activity program for stroke and heart attack prevention among senior hypertensive patients (Gong, Chen, and Li 2015)
	(b) The intervention included social workers or case managers as treatment, but was only a small part of the overall intervention.	(b) REACH and REACH-II trials (Belle 2006; Nichols et al. 2017)
	(c) Intervention was a psychological intervention.	(c) A positive psychological intervention for lonely people with health problems and low socioeconomic status (Weiss et al. 2020)
	(d) The intervention focused only on physical exercise or falls.	(d) Home versus center based physical activity programs in older adults (Ashworth et al. 2005)
	(e) The intervention was primary healthcare based.	(e) Proactive primary care model for frail older people in New Zealand delays aged-residential care: A quasi-experiment (Robinson et al. 2021)
	(f) Government policy (programs written into legislation or regulation) influencing social circumstances rather than an intervention.	(f) Impact of a guaranteed annual income program (Old Age Security) on seniors' physical, mental and functional health (McIntyre et al. 2016)
	(e) No intervention, but general models of care.	(e) Naturally occurring retirement communities or village models (Cohen-Mansfield, Dakheel-Ali, and Frank 2010; Graham, Scharlach, and Price Wolf 2014)
Outcome (O)	Studies evaluated outcomes in program volunteers or caregivers rather than program recipients.	Senior Companion Program where the psychosocial benefits were measured in older adult women volunteers (Hood et al. 2018)

The outcome was physical activity.

Impact of a senior fitness program on measures of physical and emotion health and functioning (Hamar et al. 2013)

Study Type (T)	Many of the interventions were reported in more than one citation. The publication with the outcomes of interest was defined as the main paper, but data could be extracted from other papers as well.	

Supplement A4. Unedited & Exported Database Search Strategies

DATABASE: Ovid MEDLINE(R) ALL <1946 to May 07, 2021>
Search Strategy:

*Note: Medline search line 1 is a geriatric search filter from Campbell S. Filter to Retrieve Studies Related to Geriatrics from the Ovid MEDLINE Database. [Internet]. John W. Scott Health Sciences Library, University of Alberta; 2021. Available from:
https://docs.google.com/document/d/1cawy4Zx8v_FyFBPBM7PGGAb8P5_ZAgegIlA6-zSi_mI/edit

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1   **exp Geriatrics/ or exp Aged/ or Health Services for the Aged/ or Senior Centers/ or (elders or elderly or geriatric* or "gerontolog* old age" or (seniors not "high school") or (older adj3 (adult*or person* or people or man or men or woman or women)) or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old" or supercentenarian*).mp**. (3368072)
2   ((home* or in-home* or at-home* or home-based or domiciled* or communit* or community-based or population-based or neighbo?rhood* or primary-care or Senior) adj3 (visit* or support* or program* or intervention* or outreach* or Center* or Centre*)).tw,kf. (97765)
3   adult day care centers/ or community health nursing/ or community mental health services/ or community networks/ or community participation/ or home care services/ or occupational health services/ or exp senior centers/ (102086)
4   exp Case Management/ (10244)
5   2 or 3 or 4 (196449)
6   (employment or employ* training or unemployment or food security or food insecurity or poverty or income or (income adj1 (supplement* or maintenance)) or welfare or social assistance).tw,kf. (265133)
7   exp Socioeconomic Factors/ or exp Sociological Factors/ (840621)
8   Food Security/ or Health literacy/ or Residence Characteristics/ or Environment Design/ or Built Environment/ (47587)
9   (social* adj1 (capital or participation or interaction or support* or marginali?ation or integration or activit* or invest* or vulnerabl*)).tw,kf. (74006)
10   6 or 7 or 8 or 9 (1061182)
11   Mortality/ or death/ or Frailty/ or Activities of Daily Living/ or Neurocognitive Disorders/ or "Quality of Life"/ or Memory disorders/ or cognition/ (455233)
12   ((cognit* or neurocognit* or memory or neuropsy* or neuro*) adj (impair* or disorder* or dysfunction* or function* ag?ing or declin* or status or perform* or disabil* or disable* or maint* or enhanc*)).tw,kf. (287551)
13   (dement* or alzheimer* or (chronic adj2 cerebrovascular) or memory or cognition).tw,kf. (524659)
14   (quality-of-life or qol or hql or h-qol or hr-qol or wellbeing).tw,kf. (325862)
15   (mortality or death or surviv*).tw,kf. (2375542)
16   (independ* or function* or disability or morbidity or ADL or frailty or frail* or depend*).tw,kf. (6856388)
17   (((hospital* or emergency) adj2 (admission* or visit*)) or hospitali?ation).tw,kf. (214808)
18   11 or 12 or 13 or 14 or 15 or 16 or 17 (8998607)
19   1 and 5 and 10 and 18 (5614)
20   limit 19 to english language (5140)
21   limit 20 to yr="2010 -Current" (2951)

DATABASE: Cochrane CENTRAL
Date: May 10, 2021
Issue 4 of 12, April 2021
1.   MeSH descriptor: [Social Determinants of Health] explode all trees
2.   MeSH descriptor: [Sociological Factors] explode all trees
3.   MeSH descriptor: [Geriatrics] explode all trees
4.   (1 or 2) and 3 (29)
5.   limit to 2010 (25)

DATABASE: CAMPBELL COLLABORATION
Date: May 11, 2021
1.	Social Welfare coordinating Group
2.	Records Available in English
3.	1 & 2 (36)
4:	Reviews hand searches (2)
- https://www.campbellcollaboration.org/better-evidence/older-volunteers-physical-mental-health.html
- https://www.campbellcollaboration.org/better-evidence/home-visits-for-prevention-of-impairment-death-older-adults.html

DATABASE: Social Sciences Citation Index (SSCI) --1956-present
Platform: Web of Science
Date: May 18, 2021

# 20	**2,080**	(#19) *AND* **LANGUAGE:** (English) *Indexes=SSCI Timespan=2010-2021*
# 19	**2,778**	#18 AND #12 AND #8 AND #4 Indexes=SSCI Timespan=All years
# 18	**2,848,717**	#17 OR #16 OR #15 OR #14 OR #13 Indexes=SSCI Timespan=All years
# 17	**45,025**	(TS = ((((hospital* or emergency) NEAR/2 (admission* or visit*)) or hospitali?ation))) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 16	**1,121,136**	(TS = (qol or hql or h-qol or hr-qol or wellbeing or survival or independ* or function* or disability or morbidity or ADL or frailty or frail* or depend*)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 15	**85,847**	(TS = (dement* or alzheimer*)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 14	**1,542,149**	(TS = (impair* or disorder* or dysfunction* or function* ag?ing or declin* or status or perform* or disabil* or disable*)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 13	**1,439,480**	(TS = (Mortality or death or Frailty or "Activit* of Daily Living" or dementia* or "Quality of Life" or Memory or cognition or health)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 12	**544,812**	#11 OR #10 OR #9 Indexes=SSCI Timespan=All years
# 11	**127,608**	(TS = (social* NEAR/1 (capital or participation or interaction or support* or marginali?ation or integration or activit* or invest* or vulnerabl*))) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 10	**37,482**	(TS = ("Socioeconomic Factor*" or "Sociological Factor*" or "social determinant" or "social factor" or "Food Security" or "Health literacy" or "Residence Characteristic*" or "Environment Design" or "Built Environment")) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years

# 9	**414,403**	(TS = (employment or employ* training or unemployment or food security or food insecurity or poverty or income or (income NEAR/1 (supplement* or maintenance)) or welfare or social assistance)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 8	**78,758**	#7 OR #6 OR #5 Indexes=SSCI Timespan=All years
# 7	**8,306**	(TS = ("case management" or navigator)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 6	**12,206**	(TS = ("adult day care center*" or "community health nursing" or "community network*" or "home care" or "senior center*")) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 5	**62,209**	(TS = ((home* or in-home* or at-home* or home-based or domiciled* or communit* or community-based or population-based or neighbo?rhood* or primary-care or Senior) NEAR/2 (visit* or support* or program* or intervention* or outreach* or Center* or Centre*))) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 4	**345,148**	#3 OR #2 OR #1 Indexes=SSCI Timespan=All years
# 3	**155,069**	(TS = (older NEAR/3 (adult* or person* or people or man or men or woman or women))) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 2	**24,577**	(TS = (seniors not "high school")) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years
# 1	**274,612**	(TS = (elders or elderly or geriatric* or gerontolog* or old age or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old" or supercentenarian*)) AND LANGUAGE: (English) Indexes=SSCI Timespan=All years

DATABASE: EPPI-Centre TRoPHI
Date: May 17, 2021

Search #	Search	No of hits
1	Characteristics of the study population: older people (+55 yrs)	1525
2	Freetext (All but Authors): social	1877
3	Freetext (All but Authors): "income "	835
4	Freetext (All but Authors): employment	80
5	Freetext (All but Authors): literacy	226
6	Freetext (All but Authors): unemployment	6
7	Freetext (All but Authors): housing	60
8	Freetext (All but Authors): "food security"	27
9	Freetext (All but Authors): "food insecurity"	26
10	Freetext (All but Authors): poverty	90
11	Freetext (All but Authors): welfare	51
12	Freetext (All but Authors): "built environment"	12
13	Freetext (All but Authors): "social NEAR capital"	0
14	Freetext (All but Authors): "social NEAR activit*"	0
15	Freetext (All but Authors): "social NEAR activit*"	0
16	Freetext (All but Authors): "social vulnerab*"	7
17	2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16	2937
18	1 AND 17	251
19	Freetext (All but Authors): community	2778
20	Freetext (All but Authors): day	1479
21	Freetext (All but Authors): home	1290
22	19 OR 20 OR 21	4779
23	18 AND 22	139

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Supplement B. Data Collection Form

Information	Data Collected
Data Collection for Primary Objective (Effectiveness)	
General information	• Author, year, full citation • City, Country
Study design	• Study aim • Study design
Population	• Target population • Actual population (age, gender, living alone, socioeconomic status, language, baseline health, inclusion of cognitive impairment/dementia)
Intervention details	• Primary social determinant of health category targeted by intervention (Figure 1 categorizations) • Description of intervention • Intervention providers & stakeholders • Intervention setting & context • Intervention duration & frequency • Comparison group description

Results and outcomes	• Total sample size (and per group)
	• Main statistical methods
	• Missing, follow up, attrition
	• Per outcome:
	   ○ Measure
	   ○ Measurement time
	   ○ Result (effect size, measure of variance as available)
	   ○ Primary or secondary outcome
	   ○ Direction of effect

Key author conclusions	

Supplement C. Methods of Quantitative Data Synthesis

Supplement C. Characteristics of interventions included in review, by intervention category (grey columns = audit by second reviewer)

Reference, Year (Location) [Setting]	Intervention	Intervention Stakeholders	Target Population	Actual Population (Intervention)	Adoption	Facilitators	Barriers
Intervention Category = [Strengthening] Social and Community Context							
Bae et al, 2019 (Takahama City, Japan) [Community or public spaces]	Kenkojiseichi combines group based physical, cognitive, and social activities (16 times each) in 90-minute sessions twice per week for 24 weeks. Each supervised session consisted of condition checks, stretching, main activity, followed by report writing & discussion.	• Individuals • Group members • Staff (middle aged women, non-HC from community) • Funders (Government & Academic institution)	Older adults 60y+ with MCI and without a certification of needing care from Japan's LTCI (insurance).	• Age: 75.5y • Female: 43.9% • Edu: 11y • MMSE: 27.1	Retention: 67% Attendance: 70.2% (I) vs. 82.9% (C) Satisfaction: 96.1%	Program factors: 1) Allow participants to choose own activities (as long as frequency maintained), (2) (staff confirm attendance, managed scheduled and provided feedback on activity reports)	n.d.
Blancofort et al, 2021 (Barcelona, Spain) [Community or public spaces]	Sentire-nos Be (Feeling Well) is an intervention in 12 weeks. Sessions are held weekly for two hours and facilitated in groups of 15 people. 9/12 sessions were delivered in primary care centers and the remaining were held in public spaces for social & physical activities.	• Individuals • Group members • Staff (9 HC workers - SWs, RNs, GPs) • Funder (NPO, university or academic center)	Community dwelling adults 60y+ in disadvantaged urban areas who perceived their health as fair or poor. Excluded: cognitive impairment, dementia, contraindication to physical activity, any severe mental health problems	• Age: 73.6y • Female: 81.4% • Alone: 40.8% • Edu: 82.2% no formal • Meds: 5 chronic meds*	Retention: 99.5% (I) vs. 84.1% (C)	n.d.	n.d.

			or end-of-life situation.				
Boen et al, 2012 (Oslo, Norway) [Senior centers]	A programme consisting of weekly 3h group meeting 35-38 times per year with 7-10 participants. Programme included (1) transportation to and from senior centre, (2) a warm meal at low cost, and (3) a physical training program developed by physical therapists, run by trained volunteers.	• Individuals • Group members • Volunteers • Staff (RN – project lead, PT – programme developer) • Senior Centres (owned by government) • Funder (university / academic center)	65y+ living at home in the community, not regular users of the senior centre.	• Age: 59.5% > 80y • Female: 59.5% • Alone: 59.5% • Edu: 37.8% college +	Retention: 48% (I) vs. 90% (C)	Participant/program factors: 40% of women made new friends and had more friend visits at home. Program factor: Attendance tracked	Program factors: Supposed to be older adults with depression but eventually had to recruit all people due to low numbers. Participant factors: Too much stress or illness preventing participation. Also reported distress and lack of initiative. Program factors: weekly meetings for one year were too onerous.
Jacobs et al, 2020 (California, Florida and New York, USA) [Home and community or public spaces]	Peer-to-peer (P2P) is a minimum 1-year program matching an older adult with a trained volunteer in the same community. Volunteers provide transportation assistance, check-in calls, social activities, help with shopping, organizing services and trips to medical appointments.	• Individuals • Volunteers • Staff (trainers) • Community service organization • NPO	65y+, living independently in the community, living at or below the poverty line (or on a fixed income that makes living expenses challenging), who are socially isolated, and who have chronic illnesses requiring frequent community resource use.	• Age: 80y • Female: 81% • Alone: 79.7% • Ethnicity: 78% White • Language: Spanish 5%	Retention: 92.3%	Program factors: Matched dyads	Program factors: No tracking on number of services utilized

Hikichi et al, 2015 Hikichi et al, 2017 (Taketoyo, Japan) [Senior centers]	Salons are a community project where seniors can congregate and participate in social activities. Salons were not standardized across locations. Popular activities included dance classes, chatting with other participants, arts and crafts, music quizzes and games, and interactive activities with children. Seniors visited 1-3 times per month for 90-120 minutes per session. Fee of 100 yen per visit ($1USD).	• Individuals • Group members • Community volunteers • Program staff (OTs) • Funders (government, university)	All community-dwelling adults 65y+ adults who were physically and cognitively independent in the town of Taketoyo from the participants in the Aichi Gerontological Evaluation Study.	• Age: 68.3% between 65-74y • Female: 49.6% • Med: >90% had 1 or less chronic conditions	Retention (3 years) = 87.4% (participating >2 times per week)	Program factors: salons increased receipt and provision of social support and networks	Participant factors: death, functional decline, relocation
Harada et al, 2020 (Kobe City, Japan) [Community or public spaces]	Tsurukabuto Active Aging Project is an events-based community program organized by Kobe University staff to create opportunities to meet and talk with neighbors and improve neighborhood social networks. Community events once per month including musical entertainment, lectures about sleep and health promotion, moon viewing, academic festivals, gardening, and group walking.	• Individuals • Neighbours • Project facilitators • Kobe University	60y+, residents of the Tsurukabuto community from the electoral register in Nada Ward.	• Age: 72 • Female: 56.3% • Alone: 20.5% • Edu: 45.6% had a degree		System factors: Healthy Japan 21 released around the same time by Health Labour and Welfare.	Program Factors: Low dosage of intervention, (perhaps more frequent and longer duration needed) Participant factors: Potential for selection bias and reverse causality.
Liotta et al, 2018 (Rome, Italy) [Home]	The Long Live the Elderly (LLE) program includes a multi-dimensional evaluation of care needs, an individual care plan including provision of services, periodical phone calls and increased support when negative events occur. The program intensifies when a heat wave occurs and all those over 75 years are traced by phone with staff or volunteers bringing food or medicine during home visits.	• Individuals • Volunteers • Staff (operators) • Funder (government)	Population 75y+ living in three urban areas in Rome.	• Age 79.4y • Female: 60.6%	Refusal to participate: <2%	Program factors: Active focus on increasing community resilience & capacity to cope with consequences of disasters (by improving the residential environment either by dealing with the social environment or the physical environment).	

						System factors: This program builds on the existing heat watch warning systems implemented by Italian national government.	
Chapin et al, 2013 (Kansas, USA) [Home and community or public spaces]	Reclaiming Joy uses dyadic relationships between volunteers and participants to guide participants through goal setting activities and to foster connections to community resources. Meetings once a week for 10 weeks.	• Individuals • Trained volunteers • Staff (case managers from agencies on aging) • Funder (state government)	64y+, receiving Medicaid in three regions served by area agencies on aging, exhibiting at least one symptom of depression and/or anxiety.	• Age: 76 y • Female: 78% • Alone: 75% • Ethnicity: 97%	Retention: 80%	Program Factors: 1) Careful matches, 2) Program developed with input from service providers, policymakers and participants, 3) Individual follow up with case managers, and 4) Tracking of intervention progress through q2-3 week check ins with volunteers.	n.d.
Daban et al, 2021 (Barcelona, Spain) [Community or public spaces]	The intervention in disadvantaged neighbourhoods consisted of weekly outings facilitated by volunteers using a portable climbing wheelchair to promote social support and participation activities such as visiting friends, walks, going to the market or attending church. Group outings were also conducted to foster social relationships.	• Individuals • Group members • Equipment and community development plan by Primary Health Care, Social Services, Red Cross Barcelona and the Barcelona Public Health Agency	59y+, living in isolation in their homes for two or more months due to mobility limitations and/or lack of an elevator in their buildings. Excluded: bedridden persons, persons with severe dementia and those without medical authorization to leave their home.	• Age: 44.8% > 85y • Female: 58.5% • Edu:76.8% primary school or less	Retention: 91.8%	System factors: Program launched at the same time the Catalonian Department of Health launched the COMSALUT programme (redirecting Primary Health Care towards health promotion and community health) Program factors: intervention was co-produced with a number of different stakeholders. Participant factors: Those who had the least amount of social interactions benefited the most	Participant factors: Change of address, hospitalizations, death

Coll-Planas et al, 2017 (Catalonia, Spain) [Senior centers, community or public spaces]	A coordinated and group-based program aimed at building and strengthening the network between primary healthcare centers, senior centers and other community assets in the neighborhood. Meetings were 1.5 hours a week for 15 weeks and included (1) social isolation and participation discussions, (2) community assets introductions, (3) visits to community assets including primary care, and (4) arts based activities.	• Individuals • Group members • Volunteers • Group facilitators • Health and social care professionals • Funder (government)	60y+, community dwelling, who feels lonely "sometimes, often or always", can walk to the center independently, without cognitive decline, able to participate in group dynamic, and does not usually participate in social activities.	• Age: 77.2 • Female: 95% • Alone: 84% • Edu: 82% primary studies or less • Med: 79% had ≥ 4 chronic medical conditions	Retention: 68%	Program factors: low cost because it uses existing professionals and services but creates new roles including a new volunteer profile.	Participant factors: health problems or family reasons.
Chiang & Hsu, 2018 (Taichung, Taiwan) [Senior centers]	Community Care Centers (CCC) provide health promotion, food services, home visits and telephone greetings. Home visit and telephone greetings are intended to increase social participation and linkages. CCCs are required to be set up in every neighbourhood. Programs included physical activities, health knowledge courses, and leisure activities (i.e. arts)	• Individuals • Volunteers • Staff • Funders (community NPO, local government)	All older adults living in the community	• Age: 76.33y • Female: 76% • Alone: 13.7% • Edu: 70% elementary school or below	n.d.	Program/ Organizational factors: Salaried CCC managers and staff (vs. volunteers) associated with better relationships with participants and families.	Program/Organizational factors: Task oriented leadership styles (vs. laissez faire styles) as associated with reduced community participation.
Taylor et al, 2017 (Queensland, Australia) [Community or public spaces]	Men's sheds provide a variety of activities including woodwork, metalwork, group social events, mentorship, and restoration projects. It is open five days a week and overseen by a management committee.	• Individuals • Volunteers • Management committee (president, secretary, treasurer and coordinator) • NPO	Men over 65 years of age, from regional or remote areas, from low socioeconomic areas.	• Age: 71 • Alone: 13% • Language: 87.4% English • Edu: 76% high school or less	Median program attendance: 3 years	Program factors: the activities are designed to promote work interests after retirement. Also, there is a lack of hierarchy and defined commitment.	Participant factors: Many participants also volunteer with other organizations.
Intervention =[Enhance] Neighbourhood and Build Environment							
Park et al, 2021	Aging Study of PyeongChang Rural Area Intervention Study	• Individuals	65y+, living in the region, living	• Age: 77.1	Retention (30	Program factors: Long program duration.	Participant factors: Higher

Study	Intervention	Actors	Population	Demographics	Outcome	Facilitators	Barriers
(PyeongChang, South [Home and community or public spaces]	(ASPRA-IS) is a 24-week multi-component intervention program including home nutritional supplementation, depression management, discontinuation of high-risk medication, home hazard reduction and group exercise training.	• Group members • Licensed exercise trainers • Geriatrician or psychiatrist • RNs and SWs (for home assessments) • Funder (university/hospital)	alone or receiving medical aid (government public assistance program) designated for low-income status.	• Female: 75.9% • Alone: 77.0% • Edu: 4.1y • Frailty Index: 0.27	months) = 79% (I) vs. 62% (C)	Participant factors: Almost all participants receive medical care from the same provider (high fidelity)	dropout among higher disability and lower cognition.
Castle & Resnick, 2016 (Pittsburg, USA) [Affordable housing]	Staying at Home (SAH) program involves on site (1) Care Coordination, (2) Advanced Planning, (3) Medication Management, (4) Health Care Diary/Outreach, and (5) All services paid by local health provider.	• Individuals • Trained SWs & RNs • Consultant MD • Funder (state government)	Older adults living in publicly subsidized elderly high-rise buildings	• Female: 86% • Alone: 58% widowed • Ethnicity: 76% White	n.d.	n.d.	n.d.
Tohn et al, 2020 (Connecticut, USA) [Home]	An injury prevention intervention was added to the standard weatherization packages. An occupational therapist assessed home injury risk factors and identified priority modifications to reduce the risk of falls. An energy auditor accompanied the OT to improve weatherization. 1 year with 5 visits.	• Individuals • OT • Energy auditor • Community Action Agency • Government	70y+ who had a slip or fall in the prior six months, from low-income households with income up to 125% of federal poverty income, and eligibility for weatherization services or home energy upgrades.	• Alone: 88%	n.d.	System factors: weatherization energy auditors and crews offer a natural workforce that could help implement injury prevention interventions to reduce the likelihood of a costly fall related injury in home	n.d.
Gusmano, et al, 2018 (New York, USA)	Self-help Active Services for Aging Model (SHASAM) provides social services provided as part of affordable housing. On-site social workers (1) assess residents for existing government programs	• Individuals • SWs • Staff • Funder (government)	65+, who live in affordable housing buildings, and who are Medicare beneficiaries	• Age: 80y* • Ethnicity: 55% non Hispanic Asian	n.d.	n.d.	System factors: neighbourhood level factors not accounted for (i.e. crime)

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[Affordable housing]	& entitlements, (2) receive personalized functional and psychological assessments, counseling and advocacy, (3) health education & wellness programs, (4) physical activity & socialization programs, and (5) evaluation for a referral out to additional public services (i.e. chronic disease programs or in-home safety technology).						
Callaghan et al, 2017 (England, UK) [Home]	Shared Lives (SL) is a service where an adult who needs support or accommodation moves into (or regularly visits) the home of an approved SL carer.	• Individuals • SL carer • Staff (coordinators) • NPO	65y+ people with learning disabilities, using any form of SL support with capacity for consent.	• Age: 77y • Female: ~half • Ethnicity: 98% British	n.d.	Program factors: 1) Careful matching by staff, and 2) Carers are paid a fixed amount.	n.d.
Turcotte et al, 2019 (Massachusetts, USA) [Affordable housing]	Community health worker assessment followed by an individualized intervention plan. Home visits consisting of (1) environment mediations such as pest management, mattress encasements, cleaning supplies, and structural interventions like repairing ventilation or plumbing, and (2) culturally and literacy appropriate education.	• Individuals • Community health workers • Environmental assessor • Funder (government)	62y+ adults with, low-income, diagnosed with asthma by a MD, residing in public and private subsidized housing	• Age: 69.5y • Female: 69.8% • Ethnicity: 70.9% • Edu: 64% less than high school • SES: 72.1% below median household income	Retention: 92.5%	Program factors: Community health workers are culturally aware and proficient in the languages (Spanish and Khmer) of the enrolled Individuals.	Participant factors: the percentage of older adults that did not complete high school was noticeably higher than in similar children's studies. This could have decreased the effectiveness of educational interventions on asthma triggers. System factors: due to location of intervention, contractors had been pre-determined by housing authority, resulting in poor

							quality pest control (some participants had ongoing pest problems even at the end of the intervention).
Intervention = [Improving] Navigation of Health and Social Services							
Galbraith et al, 2017 Balaban et al, 2015 (Massachusetts, USA) [Home from hospital]	Patient navigators (PNs) conduct introductory visit(s) with the patient and caregivers, then weekly telephone meetings. PNs (1) organize appointments and rescheduling, (2) address barriers to obtaining or taking medications, (3) identify concerning symptoms and facilitate communication with MD offices, (4) assist with transportation, (5) reassess patients' home care needs and make connections to community services, (6) assist with health insurance issues, and support patient self-management, and (7) help patients navigate the health care system.	• Individuals • Caregivers • Patient Navigators/ Community Health Workers (trained lay people from the community) • Staff (RN) • Funder (Agency for Healthcare Research and Quality)	General medicine inpatients having at least one of the following readmission risk factors: (1) age ≥60y, (2) any in-network inpatient admission within the past 6 months, (3) length of stay ≥3 days, (4) admission diagnosis of heart failure, or (5) chronic obstructive pulmonary disease.	• Age: 74y • Female: 60.6% • Ethnicity: 58% White	Retention: 78.3% (I) vs. 77.7% (C)	Participant factors: Compared with younger participants, those >60 y showed more improved results. System factors: Increased benefit in a system with risk bearing contracts, quality performance rating and readmission penalties (not fee-for-service).	Program factors: Not long enough to see benefit in <60y participants.
Evans et al, 2021 (Chicago, USA) [Home from hospital]	The Chicago Southland Coalition for Transition Care program (CSCTC) is a social worker driven care transition program to coordinate a post hospital course. Following the Coleman Care Transition Intervention (CTI) model, it (1) manages health care, meds, and nutrition, (2) communicates more effectively with physicians, and (3) connects to community	• Individuals • Caregivers • SWs • Catholic Charities of the Archdiocese of Chicago • Funder (federal government through Medicare	Four hospitals that serviced 70 low-income zip codes in Chicago Southland area.	• Age: 71.5y • Female: 57.8% • Ethnicity: 35.3% African American	n.d.	Program factors: 1) Relatively inexpensive intervention, 2) Social workers rather than nurses (save costs & SWs can also address non-medical factors). System factors: Connections between Church charities and hospitals.	n.d.

	resources such as meal delivery, payment assistance for meds and transportation. CSCTC supplies patients with pharmacy free support services and home-delivered meals.	and Medicaid)				Participant factors: Well suited to lower SES populations.	
Prior et al, 2012 (Midwestern, USA) [Home]	A faith based, grant funded, community senior outreach program provided by a large healthcare provider. The program focuses on assisting clients towards stabilization of crisis situations and the development of a plan for ongoing social interventions. Clients receive weekly in-home visits for the first 2 to 3 months and biweekly to monthly visits thereafter depending on need. Emphasis placed on utilization of community resources, development of self-management skills, resolution or reduction of in financial concerns and connection with social and family supports. Program monies are utilized to assist with prescription costs, housing, and transportation needs to know other resources are available.	• Individuals • Caregivers • RN, SW • Financial counselors • Volunteers • Grant-funder	55y+, with histories of repeated ED or hospital visits, who are part of the senior outreach program (usually < $1000 per month, 1/3 live in subsidized housing)	• Age: 69.5y • Alone: 45% • Ethnicity: 55% White, 41% African American • Housing: 1/3 subsidized housing	Response: 58.5%	Program factors: Focused on alleviating financial concerns and increasing satisfaction with social support. Regular visits by staff improved participants' feelings of support.	n.d.
Scharlach et al, 2015 (San Diego, USA) [Home]	ElderHelp Concierge Club is a volunteer run membership program. Members receive an assessment for services eligibility which includes: (1) driving, (2) grocery shopping, (3) housekeeping, (4) home maintenance and repair, (5) financial advocacy, (6) friendly visits, (7) and pet care. There are 3 tiers of service. Dues follow a capitated model and	• Individuals • Volunteers • Staff (intake specialist, volunteer liaison, care manager) • Preferred Providers	60y+, who do not have a condition that would prevent them from participating fully in their own care.	• Age: 76y* • Female: 91% • Alone: 67% • Ethnicity: 85% White • SES: 52% <$13,000/ yr	n.d.	Program factors: 1) Attempts to increase consumer control to focus on greater consumer responsibility and involvement in service provision and payment, 2) Graded and matched levels of care coordination to need. Having a liaison to contact when	n.d.

are dependent on income and home ownership.						assistance is needed contributes to greater perceived ability to age in place, 3) Using volunteers to provide non-professional community support services increases efficiency and reduces operational cost by producing greater output, using fewer organizational resources, yielding value for exceeding program cost, and 4) heavy reliance on volunteers, discounted services from service providers and capitated user fees resulting in increased consumer control, more diversified financing resources, and increased service access for persons not eligible for Medicaid or other public programs.	
Stevens et al, 2015 (Texas, USA) [Home from hospital]	The community living program (CLP) includes (1) plan of care based on formal assessment, (2) health coaching, (3) money for purchasing formal care ($750/month), and (4) home visits & telephone calls. 6 home visits and 3 telephone calls over 10 months.	• Individuals • Caregivers • Social workers • Funder (government)	60y+, a resident of central Texas Agency in an Aging service area, functionally impaired in ≥2ADLs, memory or health problems that make it difficult to live alone, and availability of informal support system.	• Age 80.3, • Female: 52.4% • Ethnicity: 85.9% White, 10.1% Black, • Alone: 23.5% • SES: Below poverty line: 53%	Retention: 67.1%	Program factors: evidence based (follows Care Transitions Intervention & REACH II protocols).	n.d.

				• Med: 3-7 ADL limitations			
Watkins et al, 2012 (Southeastern USA) [Home from hospital]	Hospital to Home Program involves a frail elder navigator who identifies eligible participants during hospital admission, arranges social supports to begin immediately after discharge, and home visits within 72 hours of discharge. The navigator reviews orders and medications, confirms services and helps the patient and family identify other needs. Services including transportation, light housekeeping, laundry, meal preparation, prescription pick up and grocery shopping were provided at no cost to the patient up to 4 months.	• Individuals • Caregivers • Social workers • Home care agencies • Funder (NPO)	65+, eligible for Medicare +/- Medicaid, with 2+ risk factors (2+ chronic conditions, physical disability or functional decline requiring assistance with ADLs, falls, polypharmacy, cognitive decline or depression, >3 physician or ED visits or hospitalizations in the past six months, nutritional impairment, hip fracture, limited social support)	• Age: 80y • Alone: 52% • Ethnicity: 72% White • SES: 45% in poverty • Med: 88% chronic conditions	Retention: 92.5%	Participant factors: "They cared a lot about me not going back to the hospital. That was awesome that people cared so much about me." Program factors: social workers are appropriate as a transition navigator because they are trained in assessing home needs and assessing special community resources to support a safe and sustainable living environment after discharge.	Program factors: glitches in coordination or services, program could have lasted longer.
Szanton et al, 2011, 2015, 2016, & 2019 Crews et al, 2019 (Maryland, USA) Spoelstra et al 2019 (Michigan, USA) [Home]	Community Aging in Place: Advancing Better Living for Elders (CAPABLE) CAPABLE involves ~ 10 in-home sessions, each 60 minutes long, over a 6-month period (depends on paper). It draws upon best practices to enhance uptake and adoption of intervention strategies such as patient-centered care and motivational interviewing. All participants in the intervention received each component of the intervention (assessment, education, interactive identification of barriers to	• Individuals • Caregivers • Interventionists (SWs, RNs, OTs) • Handyman • Funders (grant agencies, government, universities/ hospitals)	65y+, cognitively intact, difficulty with at least 1 ADL or 2 IADLs, income <200% of federal poverty line.	• Varies according to study	Varies	Program factors: (1) expansion into several states and cities, (2) flexibility and adaptability of the intervention, (3) evidence based (i.e. society to cell resilience framework, socio-ecological), (4) flexible use of available personnel, (5) patient directed (not patient centered).	Participants: possible biases (i.e. some were part of focus groups prior to intervention, healthy worker bias) in population Program factors: training required for clinicians to focus on functional goals rather than

	function with joint discussion of possible retraining and solutions), but interventionists customized components to each participant's risk profile and goals. Includes up to $1300 USD for repairs.						disease management
Intervention = [Promoting] Education							
Suominen et al, 2015 (Helsinki, Finland) [Home]	One year intervention with tailored nutritional guidance with home visits, and discussions with the participants and their caregivers every three months with 1-2 group sessions The nutritionist visited each couple between four and eight times according to the participants' individual needs.	• Individuals • Caregiver • Nutritionists • Funder (university /hospital)	A 65y+ person with dementia living with spouse, with ability to reach the study place by taxi & the ability to stand on a scale, living in the Helsinki metropolitan area, without terminal disease, & an estimated life expectancy of at least half a year.	• Age: 78.2 • Female: 53% • MMSE: 18.8 •	Retention: 78%	Program factors: tailored nutrition program	Participant factors: death, non-adherence or difficulty following instructions.
Jo et al, 2018 (Ontario, Canada) [Educational institution]	Canada Enoch Senior's College (CESC) runs weekly sessions for a duration of 8-11 weeks biannually. Each day is divided into four time slots. The morning is an organized assembly with short lectures on Korean-relevant topics. Lunch is a traditional Korean style congregate meal. Afternoons are elective classes and small groups (arts, music, technology, medicine, etc.).	• Individuals • Volunteers • Korean church	Korean immigrant older adults in the Greater Toronto Area	• Age: 74.1 • Female: 77% • Language: Korean (majority) • Ethnicity: 100% Korean-born	n.d.	Participant factors: Korean seniors have a strong desire to maintain ethnic ties and surround themselves with familiar cultural touchdowns. "Where else can we meet Korean people". Program factors: Primary language Korean. Focus on food is a highlight. System factors: "unlike in Korea where there	Participant: Already a high functioning group.

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Study	Intervention	Stakeholders	Eligibility	Participant characteristics	Outcome	Barriers/Facilitators	Notes
						were multiple places for retired seniors to hang out, as immigrants in Canada we have no place to go, no one to talk to you, nothing to do. So it's important that we have enough college where we can meet once a week and socialize."	
Molina-Luque et al, 2018 (Catalonia, Spain) [Educational institution]	Senior Programme of the University of Lieda is a four year program. Senior students choose a field of study that puts into practice their previous knowledge. These students also participate in extra-curricular programs ("social innovation for active and healthy ageing for sustainable economic growth" (SIforAGE) and "together old and young" (TOY))	• Individuals • Classmates • Children matches • University of Leida	>55y	• Age: 58-62y •	n.d.	Participant factors: Participants felt they could recover hobbies postponed in previous stages of life due to family and professional obligations. Program factors: Challenges the idea of old age as a period in life dominated by frailty, inactivity, and passiveness, as depicted by the so-called narrative of decline.	n.d.

Intervention = [Help with] Economic Stability

Study	Intervention	Stakeholders	Eligibility	Participant characteristics	Outcome	Barriers/Facilitators	Notes
Aguila & Smith, 2020; Aguila et al, 2015 (Yucatan, Mexico) [Home]	Reconocer Urbano is a supplementary income program providing a monthly supplement of MXN$550 for 18 months.	• Individuals • State government	All 70y+ residents who are eligible for supplemental income programs.	• Age: 77.6y • Female: 54% • Alone: 13.14% • Language: Maya 77% • Edu: 1.77y	n.d.	Program factors: Town by town roll out (by size: smallest to largest).	n.d.
Herity et al, 2018	Senior PharmAssist optimizes medication management while addressing social determinants. Scheduled meetings occur every 6	• Individuals • Pharmacists • Staff (executive director,	60y+, Medicare-eligible, have an income of 200% of the federal	• Age: 69.8y • Female: 70.7% • Alone: 48.7%	24-month adherence: 39.3%	Follow-up time: 18 months*	Participant factors: (1) Insufficient time for program, (2) Became

(North Carolina, USA) [Home]	months. Meetings with pharmacists for (1) medication therapy management, (2) education, (3) medication copayment assistance, (4) Medicare insurance counseling, and (5) referral to other services. Program flexible (open 40h/week) or provides home visits.	developmen t and communicati ons director, community services director, health resources coordinator) • NPO	poverty level or less.	• Ethnicity 59.7% African American • Edu: 59.2% high school or less • Med: 6.8 chronic conditions	ineligible for copayment or co-payment no longer needed, (3) Death Program factors: Recruitment of healthy participants.

N.B:

* Indicates median reported, otherwise results reported in means or proportions

Acronyms: ADL = Activities of daily living, (C) = Control Group, ED = Emergency department, Edu =Education, GP = General practitioner, (I) = Intervention Group, HC = Healthcare, LTCI = Long term care insurance, MCI = Mild cognitive impairment, MD = Medical doctor, Med = medications or medical conditions as reported, n.d. = not described, NPO = nonprofit organization, OT = Occupational therapist, PT = Physiotherapist, RN = Nurse, y = years

Supplement D. Detailed Critical Appraisal using the Mixed Methods Appraisal Tool (MMAT)

Supplement D1. Summary MMAT quality scores

| | n | MMAT score |
		0%	20%	40%	60%	80%	100%
Quantitative, RCTs	9	1	0	1	4	2	1
Quantitative, non randomized (CBA, RC, XCS)	11	0	0	2	3	3	3
Quantitative descriptive (UBA, RU, XUS)	11	0	0	2	4	5	0
Mixed Methods	2	0	0	1	0	1	0
Qualitative	1	0	1	0	0	0	0

Supplement D2. Cross tabulations of intervention type and study design

	RCT	CBA	RCS	XCS	Total with control group	UBA	RU	XUS	MM	Total without control group	Q
Social & Community Context	3	3	1		7	3		1	1	5	
Navigation of Health and Social Services	1		1		2	4				4	
CAPABLE	3	1			4	1				1	
Neighbourhood and Built Environment	3		1	1	5			1		6	
Education	1				1				1	1	1
Economic Stability	1				1		1			1	

Supplement D3. Detailed critical appraisal using MMAT of individual studies in alphabetical order (grey columns = audit by second reviewer)

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References	1.1	1.2	1.3	1.4	1.5	Sum	2.1	2.2	2.3	2.4	2.5	Sum	3.1	3.2	3.3	3.4	3.5	Sum	4.1	4.2	4.3	4.4	4.5	Sum	5.1	5.2	5.3	5.4	5.5	Sum
	Qualitative						Quantitative, RCTs						Quantitative, non randomized						Quantitative descriptive						Mixed methods					
Aguila & Smith, 2020 Aguila, et al 2015							CT	Y	Y	Y	Y	80%																		
Bae et al, 2019							Y	Y	N	Y	Y	80%																		
Bae et al, 2019							Y	Y	N	Y	Y	80%																		
Blancafort et al, 2021							Y	N	Y	N	Y	60%																		
Boen et al, 2012							CT	CT	N	CT	CT	0%																		
Boen et al, 2012							CT	CT	N	N	CT	0%																		
Callaghan et al, 2017													Y	Y	Y	Y	Y	100%												
Castle & Resnick, 2016													N	Y	N	Y	CT	40%												
Chapin et al, 2013																			Y	CT	Y	Y	Y	80%						
Chiang & Hsu, 2018																			Y	CT	Y	N	Y	60%						
Coll-Planas et al, 2017																			Y	CT	Y	N	Y	60%						
Crews et al, 2019							CT	Y	N	Y	Y	60%																		
Daban et al, 2021																			Y	CT	Y	Y	Y	80%						
Evans et al, 2021													Y	Y	Y	Y	Y	100%												
Evans et al, 2021													Y	Y	Y	Y	Y	100%												

Study																														
Galbraith et al, 2017 Balaban et al, 2015							Y	N	N	CT	Y	40%																		
Gusmano et al, 2018													Y	N	Y	Y	CT	60%												
Harada et al, 2020													CT	Y	N	Y	Y	60%												
Herity et al, 2018																			Y	N	Y	N	Y	60%						
Herity et al, 2018																			Y	N	Y	N	Y	60%						
Hikichi et al, 2015 & 2017													CT	Y	Y	Y	Y	80%												
Jacobs et al, 2020													Y	Y	Y	Y	Y	100%												
Jacobs et al, 2020													Y	Y	Y	Y	Y	100%												
Jo et al, 2018	Y	Y	Y	Y	Y	→													Y	N	Y	N	Y	→	Y	Y	Y	Y	N	80%
Liotta et al, 2018													Y	Y	Y	Y	CT	80%												
Liotta et al, 2020													Y	Y	Y	Y	CT	80%												
Molina-Luque et al, 2018	Y	CT	CT	Y	CT	20%																								
Park et al, 2021													Y	Y	N	Y	Y	80%												
Prior et al, 2012																			Y	Y	Y	N	Y	80%						
Scharlach et al, 2015																			Y	N	Y	Y	Y	80%						
Spoelstra et al, 2019.													N	Y	Y	Y	CT	60%												
Stevens et al, 2015																			CT	CT	Y	CT	Y	40%						
Stevens et al, 2015																			CT	CT	Y	CT	Y	40%						

Study																														
Suominen et al, 2015							Y	N	N	Y	Y	60%																		
Szanton et al, 2011							N	Y	Y	Y	CT	60%																		
Szanton et al, 2011							CT	Y	Y	Y	CT	60%																		
Szanton et al, 2015 & 2016																			Y	N	Y	Y	Y	80%						
Szanton et al, 2019							Y	Y	Y	Y	Y	100%																		
Taylor et al, 2017	Y	CT	Y	N	CT	→													Y	N	Y	N	Y	→	N	Y	N	N	CT	40%
Tohn et al, 2020													CT	Y	N	CT	Y	40%												
Turcotte et al, 2019																			Y	CT	Y	CT	Y	60%						
Watkins, Hall & Kring, 2012																			Y	CT	Y	CT	CT	40%						
Watkins, Hall & Kring, 2012																			CT	Y	Y	Y	CT	60%						

Supplement E. Summary of Results

Supplement E1. Summary of Results of Studies with a Control Group, Organized by Outcome, Study Design and Intervention Type [a]

Author, Year	Study Design [b] (MMAT Score)	Sample Size (I/C) [c]	Follow Up Time [d]	Outcome (Scale Details)	Direct-ion [e]	Available Data [f]	2 Sided p value [g]	Key Author Conclusions
					Mortality			
Liotta et al, 2018	RCS (80%)	6483/5724	~1.5 years	Death rate (age specific)	▲p	• Change in cumulative mortality I: 19.1% vs. C: 71% • 13% reduction in mortality • Regression coefficient =-0.217	<0.001	Mitigation of heat related mortality likely the outcome of increased resilience from the program.
					Function			
Szanton et al, 2019	RCT (100%)	152/148	5-12 months [(ii)]	ADLs & IADLS (/16 lower=better)	Δp ◁▷s	• 5 months ADL I: 2.22(0.26), C: 2.83(0.28) • 5 months IADL I: 3.86(0.35), C: 4.39(0.34) • 12 months ADL I: 2.65(0.30), C: 2.67(0.27) • 12 months IADL I: 4.50(0.41), C: 4.28(0.37)	0.001* 0.001* 0.5447* 0.001*	Participants randomized to the CAPABLE group reported a substantial reduction in disability scores after treatment.

Study	Design	N (I/C)	Follow-up	Outcome	Symbol	Results	p-value	Conclusion
Agulia et al, 2015, 2020	RCT (80%)	1146/510	6-18 months (i)	Max peak expiratory flow (liters/min)	▲	• 6 months Men MD: 4.27(10.88) • 6 months Women MD: 17.44(8.82) • 18 months Men MD: 43.39(8.34) • 18 months Women MD: 38.64(6.33)	0.69 <0.05 <0.05 <0.05	Income program effects lasted on lung function.
Szanton et al, 2011	RCT (60%)	24/16	6 months (ii)	ADL & IADL (/6 lower=better))	Δp	• ADL I: 0.7(0.8), C: 2.1(2.3) • IADL I: 1.2(1.3), C: 1.8(1.9)	0.63 0.62	There are differences in mean change between the intervention, control groups, and baseline to follow up.
Crews et al, 2019	RCT (60%)	6/6	5 months (ii)	ADL & IADLs (Katz score /16)	Δs	• ADL I: 2.0(3.03), C: 0.7(1.2) • IADL I: 3.8(3.06), C: 3.3(3.2) Unequal baseline, mean change difference (MCD) favours intervention	0.509* 0.826*	Participants improved in functioning compared to baseline.
Park et al, 2021	CBA (80%)	187/196	3-30 months (i)	Disability score (/17)	Δ	• 6 months I: 1.08(0.84-1.39), C: 1.60(1.21-2.12) • 12 months I: 1.29(1.03-1.62), C: 1.87(1.74-2.72) Statistically significant differences until 18 months, favouring intervention.	0.04 0.03	The intervention group had numerically lower mean scores by 0.5 until 21 months.
Hikichi et al, 2015 & 2017	CBA (80%)	246/2175	5-7 years (i)	Functional disability (/6)	▲p	• HR of disability onset: 0.50 (0.32-0.80)	<0.001	Intervention contributed to prevention of incident functional disability.

Study	Design	N	Duration	Outcome		Results	p	Conclusion
Harada et al, 2020	CBA (60%)	173/489	3 years[i]	IADLs (Tokyo Metropolitan Institute of Gerontology)	Δ	• I: 4.9(1.3**), C:4.6(0.0) After time adjustment, results favoring intervention no longer statistically significant.	0.015	No effect was observed for I ADLs score and health related quality of life after adjusting for covariance and time.
Spoelstra et al, 2019	CBA (60%)	270/1350	32 weeks [i]	ADL/IADL scores (MDS-HC)	Δ	• ADL I: 7.80(2.86), C: 7.95(3.35) • IADL I: 5.62(1.09), C: 6.76(1.27)	0.45 <0.01	Improvements in function pre to post intervention (and occasionally compared to control).
Cognition								
Bae et al, 2019	RCT (80%)	41/83	6 months [i]	MMSE composite, word memory score, spatial working memory, substitution score	◁▷p	• MMSE MD I: -0.51(-1.35-0.34), C: 0.35(-0.44-1.15) • Composite word memory MD I: 0.71(-0.07-1.48), C: 0.85(0.12-1.58) • Spatial memory MD I: 0.27(-0.07-0.62), C: -0.28(-0.60-0.05) • Trails A MD I: 0.23(-2.16-2.63), C: -1.07(-3.32-1.18) • Trails B MD I: 2.75(-9.67-15.17), C:-0.82(-12.53-10.90) • Symbol digit substitution MD I: -0.5(-2.16-1.17), C: 1.70(0.09-3.2)	0.434 0.594 0.003 0.455 0.113 0.038	Intervention improved in spatial working memory only.

Agulia et al, 2015, 2020	RCT (80%)	1146/510	6-18 months (i)	Verbal recall (recall 8 nouns after 5 min)	▲	• 6 months Men I: 2.48(0.09), C: 2.69(0.09) • 6 months Men MD I: 0.62(0.07), C: 0.05(0.08) • 6 months Women I: 2.98(0.08), C: 3.20(0.10) • 6 months Women MD I: 0.49(0.06), C: -0.17(0.09)	<0.05 ced<0.05	6 months after introduction of income supplement, improvements in memory recall persisted to 12 months.
Hikichi et al, 2015 & 2017	CBA (80%)	1,067/13,195	5-7 years (i)	Cognitive disability incidence assessed by national insurance program	▲p	• OR of cognitive disability: 0.72 (0.54-0.98)	0.04	Salons may be effective for prevention of cognitive decline.
						Subjective Health		
Szanton et al, 2011	RCT (60%)	24/16	6 months (ii)	HRQoL (EuroQoL and EQ-5D)	Δs	• EuroQoL I: 75.8(15.04), C: 62.5(24.9) • EQ-5D I: 2.9(1.6), C: 3.8(2.2) Cohen's D calculated in study EuroQoL: 0.89, EQ-5D: 0.48	0.0419* 0.142*	The intervention was acceptable, feasible and showed promising results.
Blancofort et al, 2021	RCT (60%)	195/195	12 weeks – 9 months (ii)	Self-perceived health (SF-12, EQ-5D)	◁▷p	• SF-12: MCD I: 5.01(3.21-6.82), C: 3.13(1.71-4.56) • EQ-5D: MCD 1: 4.80(1.09-8.52), C: 2.34(-1.74-6.43)	0.1* 0.38*	Self-perceived health assessed using the SF-12 was not affected by the intervention.

								Measured with the EQ-5D, there was significant pre-post improvement in the intervention group.
Suominen et al, 2015	RCT (60%)	50/49	12 months (i)	HRQoL (15-D)	▲s	• MCD I: 0.006(-0.016-0.028), C: -0.036(-0.059-0.013)	0.007	Improvement in intervention group QoL measured using 15-D by 0.04 (0.02-0.03 considered clinically significant).
Boen et al, 2012	RCT (0%)	77/61	12 months (i)	Self-rated health (/4)	▽	• I: 2.24(0.72), C: 2.40(0.63) • MCD I: -0.20 (0.74), C:-0.15(0.52)	0.6554 *	No difference in changes in self-rated health between groups after intervention.
Harada et al, 2020	CBA (60%)	173/489	3 years(i)	HRQoL (SF-8)	△	• I: 46.9(6.63**), C:48.1(6.58**) • MCD I: 0.6, C: -1.1	0.005	Between group improvements in HRQoL disappear after adjusting for time.
Castle et al, 2016	CBA (40%)	736/399	6 months–	Self-perceived health (SF-12)	▲	• I: 46%, C:40% (rated good or better)	<0.05	Self-rated health improved in the intervention group.

			3 years (i)					
Callaghan et al, 2017	XCS (100%)	121/121	n.d	Overall QoL (/5 lower = better)	▲s	• I: 1.94(0.91), C: 2.18(0.97)	0.05	Small but statistically significant difference in overall quality of life.
Hospital Utilization								
Blancofort et al, 2021	RCT (60%)	195/195	12 weeks– 9 months (ii)	Visits to ED	∆s	• MCD I: -0.18(-0.55-0.19), C: 0.31(-0.10-0.72)	0.0506 *	No effect on ED visits.
Galbraith et al, 2017 & Balaban et al, 2015	RCT (40%)	747/1,190	180 days (i)	30 day hospital readmission & ED rates	∆	• Hospitalizations I: 0.44(0.35-0.52), C: 0.53(0.44-0.62) • ED visits I: 0.45(0.31-0.58), C: 0.65(0.49-0.81)	0.14 0.06	Among patients aged 60 or older, there were non-significant trends towards lower ED and hospitalization rates.
Jacobs et al, 2020	CBA (100%)	222/234	12 months	ED, hospitalizations,	◁▷p	• Hospitalization I: 0.68(0.54-0.85), C: 0.44(0.36-0.54) • ED visits I: 0.27(0.22-0.35), C:0.28(0.23-0.34)	0.005 0.87	Intervention group more likely to use the hospital than control group (although frailer at baseline).

Spoelstra et al, 2019	CBA (60%)	270/1350	32 weeks [i]	# ED visits, hospitalizations	◁▷	• Hospitalization I: 0.23(0.60), C: 0.47(2.66) • ED visits I: 027(0.65), C: 0.27(0.81)	<0.01 0.94	Fewer hospitalizations in intervention group.
Castle et al, 2016	CBA (40%)	736/399		ED visits and unplanned hospitalizations	▲	• ED I: 0.15%, C: 0.36% • Hospitalization I: 0.17%, C: 0.35%	<0.001 <0.001	Significantly less unplanned ED visits and hospitalizations in intervention group.
Tohn et al, 2020	CBA (40%)	49/35		Hospital visit or hospital transport due to falls	△	• Hospital visit I: 13% at baseline and 3% at follow up • Hospital admission I: 6% at baseline and 0% at follow up	Not calculable	For hospital admission and hospital transport, no within group differences.
Evans et al, 2021	RCS (100%)	45,522/ 127,443	7-90 days [i]	Readmission	▲	• 7 days CE: -0.0.192(SE0.00808) • 30 days CE: -0.032 (SE0.0159) • 90 days CE: -0.0479(SE0.0203)	0.017 0.039 0.018	Significant reductions in admission rates.
Gusmano et al, 2018	RCS (60%)	1248/15947		Discharge rate, length of stay (LOS)	▲	• Discharge rate I: 88.1, C:129.4 • LOS I: 6.38(5.00), C:7.38(9.23)	<0.01 <0.05	Residents in the program had lower rates of hospital discharges overall and shorter hospital lengths of stay compared to the control.
Other Healthcare Utilization (primary care visits to physician or nurse)								

Agulia et al, 2015, 2020	RCT (80%)	1146/510	6-18 months [(i)]	Number of doctor visits	▽s	• 6 months Men MD: 0.12(0.14) • 6 months Women MD: 0.35(0.20) • 18 months Men MD: 0.34(0.14) • 18 months Women MD: 0.28(0.11)	0.40 0.08 0.02 0.02	Increased for females in number of doctor visits in intervention group for women, but the same increases were not always seen for men.
Blancofort et al, 2021	RCT (60%)	195/195	12 weeks – 9 months [(ii)]	Visits to doctor (general practitioner (GP) or nurse (RN))	◁▷s	• GP: MCD I: -0.36(-1.27-0.54), C: -0.12(-1.13-0.89) • RN: MCD I: 1.72(0.43-3.02), C: -0.19(-1.64-1.26)	0.054* 0.728*	No difference in change to GP visits. There was an increase in visits to nurses in intervention group, although it was significantly lower at baseline and reached the same level as the control group at baseline.
Galbraith et al, 2017 & Balaban et al, 2015	RCT (40%)	747/1,190	180 days [(i)]	Outpatient visits to primary care physicians	◁▷	• Outpatient visits I: 7.62(6.97-8.27), C: 7.63(6.98-8.27)	0.99	No differences in outpatient visits to primary care providers.

Castle et al, 2016	CBA (40%)	736/399	6months –3 years (i)	Doctor, RN visits	▼	• Doctor I: 2.92, C: 2.66 • RN I: 5.1, C: 2.95	<0.001 <0.01	Higher doctor and nurse visits in intervention group.

[a] Intervention Type: the social determinant of health most targeted by the intervention. Pink = social and community, Green = neighborhood and built environment, Purple = navigation of health and social services, Orange = economic stability, Blue = specific intervention (CAPABLE), Grey = Education.

[b] Study design: RCT = randomized controlled trial (includes cluster, parallel and waitlist), CBA = controlled before & after study, RCS = retrospective controlled study, XCS = cross-sectional controlled study.

[c] I = intervention group, C = control group.

[d] Follow up: (i) time from start of intervention, (ii) time from end of intervention, n.a. = not applicable, n.d = not described.

[e] Effect direction: upward arrow (△▲) = positive health impact or reduction in health service use, downward arrow (▽▼) = negative health impact or increase in health service use, sideways arrow (◁▶ or ◀▷) = mixed effects/conflicting findings.

Acronyms: ADL = activities of daily living, ED = emergency department, HRQoL = health related quality of life, IADL = instrumental activities of daily living, MDS-HC = minimum data set – health care, MMSE = Mini Mental State Examination, SF = short form [health survey].

[f] Available data:

• Unless otherwise specified, data presented as mean score/frequency (standard deviation) at follow up in the intervention group (I) and the control group (C). For studies with insufficient data, the result type is specified.

• ** = standard deviation calculated as per Chapter 6.5 in the Cochrane Handbook (Higgins JPT, Li T, Deeks JJ (editors). Chapter 6: Choosing effect measures and computing estimates of effect. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.2 (updated February 2021). Cochrane, 2021. Available from www.training.cochrane.org/handbook).

• Acronyms: CE = regression coefficient, MCD = mean change difference (within group change from baseline to follow up), MD = mean difference between intervention and control groups at follow up, OR = odds ratio, SE = standard error.

[g] * = p value calculated using unpaired t-test of follow up means between groups because no p value reported in study.

Supplement E2. Summary of Results on Studies without Control Group, Organized by Outcome, Study Design and Intervention Type

Author, Year	Study Design (MMAT Score)	Sample	Follow Up Time	Outcome (Scale Details)	Direction	Available Data	Key Author Conclusions
Function							
Szanton et al, 2015 & 2016	UBA (80%)	281	5 months (i)	ADL & IADLs (/16) (lower = better)	△	• ADL T0: 3.9(3.04), T1: 2.0 (2.0)	75% of participants had reduction in ADLs and 65% of participants had reduction

Study	Type	N	Duration	Outcome	Dir	Results	Conclusion
						• IADL T0: 4.1(2.09), T1: (2.9 SD 2.22)	in IADLs. The practical effects of improving from 4 to 2 difficulties with ADLs can be life-changing.
Scharlach et al, 2015	UBA (80%)	26	6 months [i]	ADLs (/4) (lower = better)	▽	• T0: 2.33(0.91), T1: 2.57(0.87), p=0.16	Neither self-rated health nor functional limitation changed significantly.
Cognition							
Chiang et al, 2018	XUS (60%)	417	n.a.	Self-report memory improvement	△	• 45.8% of the participants reported improved memory. This outcome was related to better baseline cognitive function, better mental health and higher participation frequency.	There were positive health outcomes of participating in the intervention (improvements in self rated health, sleep quality, memory, family relationships, care for health and health literacy).
Stevens et al, 2015	UBA (40%)	149	12 months [i]	MMSE	△	• T1: 18.5(7.9), T1: 18.7(9.1), p=0.68	No significant differences in clinical outcomes.
Molina-Luque et al, 2018	Q (20%)	6	4 years	Interviews	△	• "The six senior students interviewed for this study, aged 58 to 62, have claimed that their new role as students of this program not only kept them busy and fostered their cognitive skills but also increased their social relationships."	
Subjective Health							
Chapin et al, 2013	UBA (80%)	40	90 days [ii]	QoL Index (overall/health/function)	△	• T0: 16.61(5.64), T1: 19.42(5.76), p<0.01	Results show that the intervention has potential for reducing depression and increasing health related quality of life in low income older adults with physical health conditions.
Daban et al, 2021	UBA (80%)	147	6 months [i]	Self-rated health (/5)	▲	• Participated 9-24 times, self-rated health good T0: 51.6%, T1: 77.4% • Participated >24 times, T0: 35.7%, T1: 67.9%	Improvements in patient self rated health, mental health, and reductions of anxiety. Frequency of participation is also associated with good self-rated health.
Scharlach et al, 2015	UBA (80%)	26	6 months [i]	Self-rated health (/5	△	• Self rated health good to excellent T0: 38%, T1: 48%, p=0.63	Non-significant changes but model of care coordination is

				poor to excellent)			promising, especially for low and moderate income adults.
Jo et al, 2018	MM/UBA (80%)	79	8-11 weeks	Self-perceived health (SF-36, physical components)	Δ	• Physical functioning T0: 77.1(18.8), T1: 78.9(18.9), p=0.089 • Role-Physical T0: 69.8(23.7), T1: 71.4(22.2), p=0.250 • Bodily pain T0: 74.0(23.4), 78.2(18.7), p=0.014 • General health T0: 62.6(21.5), T1: 61.9(19.8), p=0.306	Overall, the CESC program encouraged Korean senior participants to live actively and help them feel physically and emotionally stronger, while reducing social isolation.
Coll-Planas et al, 2017	UBA (60%)	36	15 weeks	Self-perceived health (SF-12)	Δs	• T0: 3.74(0.72), T1: 3.94(0.89), p=0.16	These findings are consistent with other intervention study effects: improvements in social wellbeing are generally achieved but rarely in physical health.
Turcotte et al, 2019	UBA (60%)	93	12 months [(i)]	Self-rated health	▲	• Fair to very good health T0: 66.3%, T1: 80.3%, p<0.05	Significant increase in participants reporting fair to very good health.
Stevens et al, 2015	UBA (40%)	149	12 months [(i)]	Self-rated health (/5)	Δ	• T0: 3.7(1.1), T1: 3.8(0.9), p=0.23	Non-significant change in self rated health.
Watkins et al, 2012	UBA (40%)	292	30 days-4 months [(ii)]	QoL (SF-36, physical health summary score)	▲	• T0: 25.79, T1: 30.89 (p<0.001)	The results of the study show the importance of extending social support and health education into the home after discharge from the hospital to improve physical health.
Herity et al, 2018	RU (60%)	191	6-24 months [(i)]	Self perceived health (poor-excellent/5)	▲p	• Good to excellent health T0: 55.5%, T6months: 59.7%, T24months: 68%, p=0.03	This unique model of care optimizes medication management while addressing social determinants of health.
Chiang et al, 2018	XUS (60%)	417	n.a.	Self-rated health (same, worse, better)	Δ	• 85.9% of the participants reported better health after participation.	There were positive health outcomes of participating in the intervention (improvements in self rated health, sleep quality,

							memory, family relationships, care for health and health literacy).
Taylor et al, 2018	MM / XUS (40%)	143	n.a.	Self-assessed health (SF-8)	∇p	• % participants with positive change: 18.0 • % participants with negative change: 58.6 • p=0.211	There was no change in overall self assessed health of men's shedders before compared with after joining men's shed.
Hospital Utilization							
Prior et al, 2012	UBA (80%)	193	24 months [(ii)]	Monthly ED visits, hospitalizations	▲	• Median ED visits T0: 0.17, T1: 0.11, p=0.007 • Median Hospitalizations T0: 0.21, T1: 0.13, p =0.02	Positive outcomes for the program, as well as decreasing emergency department visits and hospital admissions.
Scharlach et al, 2015	UBA (80%)	26	6 months [(i)]	ED visits or hospital stays	Δ	• T0: 38%, T1: 24%, p=0.65	While participants were more likely to report obtaining medical care, ED and hospital visits did not change significantly.
Coll-Planas et al, 2017	UBA (60%)	36	15 weeks	ED hospitalizations	□s	"No significant change was seen in visits to the ED or in hospitalization (results not shown)"	
Turcotte et al, 2019	UBA (60%)	93	12 months [(i)]	Ed visit, hospitalizations	Δ	• ED T0: 0.69, T1: 0.35, p>0.05 • Hospitalizations T0: 0.38, T1: 0.21, p>0.05	At the one-year follow-up the means for all measures of healthcare use were reduced compared to baseline.
Stevens et al, 2015	UBA (40%)	149	12 months [(i)]	ED visit, hospital stay, total nights in hospital	▲	• ED T0: 1.4(1.6), T1: 0.3(0.7), p<0.001 • Hospital stay T0: 0.9(1.2), T1: 0.4(1.0), p<0.001 • Nights in hospital T0: 5.1(8.6), T1: 0.8(2.2), p<0.001	Although not shown here, caregivers experienced equally significant improvements in all hospital or healthcare use outcomes, suggesting increased care for older adults did not come at the expense of their caregivers.
Watkins et al, 2012	UBA (40%)	292	30 days-4 months [(ii)]	Readmission	Δ	"22% of participants required hospital readmission for any cause. The hospital readmission rate of county residents age 65	Access to immediate in-home care services such as transportation, housekeeping, laundry, and

						older in 2007 was 57%. This represents a 61% reduction in hospital readmissions."	light meal preparation allows patients to avoid gaps in care that could result in a readmission.
Herity et al, 2018	RU (60%)	191	6-24 months [(i)]	Self-report ED or hospital admissions	Δp	• ED T0: 0.83(1.2), T6months: 0.60(1.1), T24months: 0.53(1.1), p=0.002 • Hospital admission T0: 0.56(1.0), T6months: 0.42(0.9), T24months: 0.4(1.1), p=0.02	These findings reinforce the original program outcome evaluation that showed a decrease in percent of participants recording an ED visit and hospital admission in the previous year.
Other Healthcare Utilization (primary care visits to physician or nurse)							
Coll-Planas et al, 2017	UBA (60%)	36	15 weeks	Physician, nursing visits	▽s	• General practitioner visits T0: 10.51(7.88), T1: 10.97(5.72), p=0.59 • Nurse visits T0: 6.65(7.71), T1: 10.42(11.24), p=0.005	No effect found other than a significant increase in visits to the nurse. This could be explained by the nurse's role in the group, which could've increased participants' trust.
Turcotte et al, 2019	UBA (60%)	93	12 months [(i)]	Physician visits	▲	• T0: 0.69, T1: 0.34, p<0.05	At the one-year follow-up the means for all measures of healthcare use were reduced compared to baseline.
Stevens et al, 2015	UBA (60%)	149	12 months [(i)]	Physician visits	▲	• T0: 7.3(6.3), T1: 4.1(4.9), p<0.001	Although not shown here, caregivers experienced equally significant improvements in all hospital or healthcare use outcomes, suggesting increased care for older adults did not come at the expense of their caregivers.

Intervention Type: the social determinant of health most targeted by the intervention. Pink = social and community, Green = neighbourhood and built environment, Purple = navigation of health and social services, Orange = economic stability, Blue = specific intervention (CAPABLE), Grey = Education.

Study design: UBA = uncontrolled before after study, RU = retrospective uncontrolled study, XUS = cross sectional uncontrolled study, Q = qualitative.

Follow up: (i) time from start of intervention, (ii) time from end of intervention, n.a. = not applicable, n.d = not described.

Effect direction: upward arrow (△▲) = positive health impact or reduction in health service use, downward arrow (▽▼) = negative health impact or increase in health service use, sideways arrow (◁▶ or ◀▷) = mixed effects/conflicting findings.

Acronyms: ADL = activities of daily living, ED = emergency department, HRQoL = health related quality of life, IADL = instrumental activities of daily living.

Unless otherwise specified, data presented as within group mean score/frequency (standard deviation) at T0 (baseline) and T1 (follow up time specified in named column).

Supplement E3. Second reviewer's audit of 9 randomly chosen studies including results and data synthesis

Reference	Study Design	Sample Size (I/C)	Follow up Time	Outcome Scale	Direction of Effect	Available Data	2-sided p value	Key Author Conclusions
Turcotte at al, 2019	UBA	93/0	12 months	Self-rated health	Positive	Fair to very good health T0: 66.3%, T1: 80.3%, p<0.05	NA	Significant increase in participants reporting fair to very good health.
				Hospital visit and stays	Positive	ED visits, mean change T1-T0 = 0.21, p>0.05 MD visits, mean change T1-T0 = -0.48 (0.14, 0.85), p<0.05 Hospitalization mean change T1-T0 = 0.34	NA	A significant reduction in healthcare utilization for Dr visits and significant improvements
Stevens et al, 2015	UBA	149	12 months	Self Rated Health (/5)	Positive	Baseline mean = 3.7(1.1SD) T12 mean = 3.8(0.9SD) p=0.23	NA	In conclusion, a program that combined CG support, specific health coaching at the critical time of transition from hospital to home, and limited amount of formal home care services appeared to have numerous positive benefits on the health and well-being of CRs and CGs. CRs had fewer physician visits, ED visits,
				MMSE	Positive	Baseline mean = 18.5(7.9SD) T12 = 18.7(9.1SD) p=0.68	NA	
				Physician visit, ED visit, Hospital	Positive	Table 3 All measures decreased & stat sig p<0.001	NA	

				stay, Total nights in hospital				hospital stays and total nights in hospital at 12 month assessment compared to baseline.
				Self-perceived health (/5)	Positive	Table 3, p=0.03, percentage of people who perceived health as good to excellent.	NA	Participants enrolled in these services experienced significant reductions in mean number of reported hospital admissions and ED visits. Our findings suggest that community-based programs that combine medication access and management with services to address basic needs should be further explored for their potential role in reducing hospital use of older adults
Herity et al, 2018	RU	191	18 months	Self-reported ED or hospital admissions	Positive	Significant declines in percent of participants who had ED visits in the past year. Non sig decline in percent of participants who had hospital admissions. Means for both decreased and were stat sig.	NA	
Watkins, Hall & Kring, 2012	UBA	292	1 to 4 months	QoL (SF-36)	Positive	Physical health T0=25.79, T1 = 30.89 (p<0.001)	NA	The results of this study demonstrate the importance of extending social support and health education into the home after discharge from the hospital. Access to immediate in-home care services such as
				Readmission	Positive	Approximately 22% of participants required hospital readmission for any cause. The hospital readmission rate of county residents age 65 older in 2007 was 57%. This represents	NA	

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Author, Year	Type	Sample	Duration	Outcome	Direction	Result	p	Notes
						a 61% reduction in hospital readmissions.		transportation, housekeeping, laundry, and light meal preparation allows patients not to experience gaps in care that could result in a readmission. In all probability, the intervention failed to meet optimistic targets, but possibly met quite modest ones. Since intention-to-treat analysis was not possible, we do not know the effect on the intervention group as a whole. A further evaluation of these programmes is necessary to expand the group programme. For the depressed, more specialized programmes to cope with depression may be a more appropriate intervention
Boen et al, 2012	RCT	77/61	12 months	Self-rated health (/4)	Negative	I: T1-T0 = -0.20(0.74SD) C:T1-T0 = -0.15(0.52SD) p = 0.07	0.66	
Liotta et al, 2018	RCS	12207(6483/5724)	June 2014 to December 2016	Mortality	Positive	13% reduction in mortality, 25 deaths adverted, B=-0.217, p<0.001	<0.001	the paper shows the impact of a community-based active monitoring program, focused on strengthening individual relationship networks and the

Author, Year	Design	Sample	Duration	Outcomes	Direction	Results	p-value	Conclusion
Jacobs et al, 2020	CBA	456(222/234)	12 months	Hospitalization, ED visits	Negative and the same	Higher hospitalization in P2P group (RR1.54, p=0.005) and no other differences in remaining outcomes	0.005, 0.87	social capital of the community, on mortality in those over 75 during heat waves. P2P support was associated with higher rates of hospitalization but was not associated with other measures of health care utilization.
Szanton et al, 2011	RCT	24/16	6 months	ADL, IADL	Positive	Diff 1.4(ADL C-I) Diff 0.62(IADL C-I)	0.63 0.62	The CAPABLE intervention was acceptable to participants and feasible to provide and showed promising results, suggesting that this multicomponent intervention to reduce disability should be evaluated in a larger trial.
				EuroQoL, EQ-5D	Positive	I: 75.8 (15.04), C: 62.5(24.9) (EuroQol) I: 2.9(1.6), C: 3.8(2.2) (EQ-5D)	0.0419 (EuroQoL) 0.142(EQ-5D)	
Bae et al, 2019	RCT	83 (41/42)	24 weeks	MMSE, composite, word memory score, spatial working memory,	Positive for one out of six only	The intervention group revealed significantly greater improvements in special working memory [P equals 0.024] following intervention compared with the control group. However in the remaining 5 tests (word memory, trails and processing	0.434 (MMSE) 0.594 (composite) 0.003 (word score)	This study showed that a 24-week multicomponent intervention program was effective in improving spatial working memory and maintaining physical activity in older adults with MCI. A follow-up investigation

				substitution score		speed) showed no significant between group differences.	0.455 (spatial) 0.113 (working) 0.038 (substitution)	is required to determine whether continuation of physical, cognitive, and social activity can prevent dementia or reverse MCI in older adults.
Evans et al, 2012	RCS	45,522/127,443	NR	MMSE (/30)	Positive	30,60,90day readmission rates. 14% or more reduction of sample mean	0.018 (30 days) 0.039 (60 days) 0.018 (90 days)	This analysis offers encouraging news for CCTP in general, and the CSCTC model in particular. We find that the CSCTC program reduced 30-day readmissions by about 17 percent.

Chapter 3

Additional File 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Title page
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	4-5
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	6-8
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	8
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	NA
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	9
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with	9

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		authors to identify additional sources), as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	9
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	9
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	10-11
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	NA
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	10-11
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10, Table 1
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	NA

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Additional File 3
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-17
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	11-17
Limitations	20	Discuss the limitations of the scoping review process.	21-22
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	17-22
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	2

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

Additional File 2. References of included studies

Originals

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Additional File 3. Characteristics, composition and outcomes of original social vulnerability indices (in white), and characteristics and outcomes replicated social vulnerability indices (in grey)

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Author, Year (Country)	Objective	Field of Study	Items From	Number of Items	Weighted Items?	Type of Scale Used in Analysis	Type of Scale Presented in Results	Outcome (if predictive)	Direction (if predictive)
Abeliansky, 2021 (USA)	To gain insights on the impact of social vulnerability on physiological aging at the individual level and at the cohort level.	Health/ Medicine	representative survey	49	No	numeric	numeric	Frailty	Positive
Adger. 2005 (Multiple in Africa)	To outline the nature of uncertainty for the major elements of adaptive capacity and illustrate these issues with the example of a social vulnerability index for countries in Africa.	Climate/ Environment/ Disaster	mixed	9	Yes	numeric	numeric	NA	NA

Aksha, 2019 (Nepal)	To investigate social vulnerability in Nepal by adapting Social Vulnerability Index methods to the Nepali context.	Climate/ Environment/ Disaster	census or geographical data	7	No	numeric	ordinal	NA	NA
Andrew, 2014 (Canada)	To investigate many social factors in relation to one another and to survival among older adults using a social ecology perspective to measure social vulnerability among older adults.	Health/ Medicine	representative survey	28	No	numeric	numeric	Mortality	Positive
Andrew, 2008 (Canada)	To operationalize social vulnerability according to a deficit accumulation approach, to compare social vulnerability and frailty, and to study social vulnerability in relation to mortality.	Health/ Medicine	representative survey	40 (1st SVI) 23 (2nd SVI)	No	numeric	numeric	Frailty, Mortality	Positive
Ouvrard, 2019 (France)	To assess the replicability of the SVI by confirming its association with mortality in the context of a French population-based study.	Health/ Medicine	-	-	-	-	-	Mortality	Positive

Andrew, 2010 (Canada)	To investigate whether social vulnerability is associated with cognitive decline in community-dwelling older adults aged 70 years and older.	Health/ Medicine	-	-	-	-	-	Cognitive decline	Positive
Armaș, 2013 (Romania)	To assess two multi-criteria methods for aggregating complex indicators: the social vulnerability index (SoVI model) and the spatial multi-criteria social vulnerability index (SEVI model).	Climate/ Environment/ Disaster	mixed	18	Yes	numeric	numeric	NA	NA
Armaș, 2016 (Romania)	To explore areas at risk and their spatial association by applying a social vulnerability index at the 2011 census.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Armstrong, 2015 (USA)	To evaluate mortality risk in relation to social vulnerability across levels of frailty among a cohort of older Japanese-American men.	Health/ Medicine	other	19	No	numeric	numeric	Mortality	Positive
Armstrong, 2015 (USA)	To look at changes in cognition in relation to frailty, social vulnerability, and	Health/ Medicine	-	-	-	-	-	Changes in cognition	Positive

	protective factors in the Honolulu-Asia Aging Study (HAAS).								
Aroca-Jimenez, 2017 (Spain)	To describe a methodological approach towards constructing the ISVI in urban areas prone to flash flooding in Castilla y León.	Climate/ Environmen t/ Disaster	mixed	38	No	numeri c	ordinal	NA	NA
Aroca-Jiménez, 2020 (Spain)	To describe the construction of an Integrated Socio-Economic Vulnerability Index (ISEVI) at the regional scale.	Climate/ Environmen t/ Disaster	mixed	60	No	numeri c	ordinal	NA	NA
Badmos, 2018 (Ghana)	To determine the social vulnerability index (SoVI) of households to climate change impacts for three identified locations in the Vea catchment, semi-arid Ghana.	Climate/ Environmen t/ Disaster	representativ e survey	11	Yes	numeri c	numeric	NA	NA
Ballesteros, 2021 (Multiple in Africa)	To create an index of vulnerability to coastal change, integrating indices of social vulnerability and exposure to coastal hazards for East Africa to	Climate/ Environmen t/ Disaster	census or geographical data	8	No	numeri c	ordinal	NA	NA

	identify 'areas of priority concern' for risk reduction.								
Berrouet, 2019 (Colombia)	To present the conceptual framework for the vulnerability assessment of the social system on which the methodological proposal and index are based. To propose an index for evaluating social vulnerability to changes in the provision of ecosystem services.	Climate/ Environment/ Disaster	census or geographical data	4	No	numeric	numeric	NA	NA
Bjarnadottir, 2011 (USA)	To presents the development of the Coastal Community Social Vulnerability Index (CCSVI) in order to quantify the social vulnerability of hurricane-prone areas under various scenarios of climate change.	Climate/ Environment/ Disaster	census or geographical data	17	Yes	numeric	numeric	NA	NA

Brazilian Social Vulnerability Atlas, 2015 (Brazil)	To describe the Índice de Vulnerabilidade Social (IVS).	Mixed	census or geographical data	16	Yes	numeric	numeric	NA	NA
Andrade, 2022 (Brazil)	To assess the spatiotemporal distribution of mortality and lethality rates of COVID-19 in a region of high social vulnerability in Brazil.	Health/ Medicine	-	-	-	-	-	Covid-19 mortality	Positive
Baggio, 2021 (Brazil)	To analyse clinical-epidemiological variables, incidence rate, mortality rate, case fatality rate and the social indicators municipal human development index and social vulnerability index.	Health/ Medicine	-	-	-	-	-	Covid-19 incidence rate, mortality rate, case fatality rate	Positive
Brito, 2020 (Brazil)	To assess the dental caries experience and associated factors among 12-year-old children in the state of São Paulo, Brazil.	Health/ Medicine	-	-	-	-	-	Dentition	No association
Nascimento, 2020 (Brazil)	To compare spatial patterns of congenital syphilis (CS) with those of	Health/ Medicine	-	-	-	-	-	NA	NA

	socioeconomic and medical variables in Paraíba Valley, São Paulo, between 2012 and 2016.								
Curi, 2021 (Brazil)	To analyze Brazilian coastal municipalities, based on two indexes: The Social Vulnerability Index and the Municipal Human Development Index.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
de Souza, 2021 (Brazil)	To analyze the mortality trend of cerebrovascular disease in Brazil and its association with Human Development Index and the Social Vulnerability Index.	Health/ Medicine	-	-	-	-	-	Cerebrovascular disease mortality	Negative
de Souza, 2019 (Brazil)	To examine the spatial and space-time distribution of leprosy and the influence of social vulnerability on the occurrence of the disease in an endemic area of Northeast Brazil.	Health/ Medicine	-	-	-	-	-	Leprosy transmission	Positive
de Souza, 2020 (Brazil)	To investigate the spatial distribution of congenital syphilis	Health/ Medicine	-	-	-	-	-	Congential syphillis	Positive

	and its association to social vulnerability indexes in northeast Brazil.								
Lopes, 2019 (Brazil)	To assess what socioeconomic factors are associated to municipalities that had larger numbers of beneficiaries from lawsuits in health in the state of Minas Gerais, Brazil, from 1999 to 2009.	Health/ Medicine	-	-	-	-	-	NA	NA
Martins-Filho, 2021 (Brazil)	To estimate the incidence and mortality rates COVID-19 in Brazilian children and to analyze its relationship with socio-economic inequalities in a state-level analysis.	Health/ Medicine	-	-	-	-	-	COVID-19 incidence & mortality	Positive
Pascom, 2018 (Brazil)	To identify sociodemographic factors associated with attrition in the 3 steps of the HIV continuum of care related to the 90-90-90 targets – access to diagnosis, treatment initiation,	Health/ Medicine	-	-	-	-	-	Access to HIV services	Positive

	and virologic suppression, in Brazilian adults in 2016.								
Ribeiro, 2021 (Brazil)	To analyse the spatiotemporal dynamics of visceral leishmaniasis cases to identify the temporal trends and high-risk areas for VL transmission, as well as the association of the disease with social vulnerability in Brazilian Northeast.	Health/ Medicine	-	-	-	-	-	Visceral leishmaniasis	Positive
Ribeiro, 2017 (Brazil)	To assess the effect of comorbidity and socioeconomic status on breast cancer survival in a large metropolitan area in Brazil with universal health care.	Health/ Medicine	-	-	-	-	-	Breast cancer survival	No association
Souza, 2021 (Brazil)	To analyze the association between quality of basic health care and social vulnerability in municipalities of the Brazilian northeast.	Health/ Medicine	-	-	-	-	-	Quality of basic health care	Positive
Wanderley, 2021 (Brazil)	To assess the effectiveness of mass treatment of	Health/ Medicine	-	-	-	-	-	Schistosoma	Positive

								mansoni infection	
	Schistosoma mansoni infection in socially vulnerable endemic areas in northeastern Brazil.								
Bronfman, 2021 (Chile)	To explore the spatial and temporal variations in social vulnerability in Chile for the last two decades.	Climate/ Environment/ Disaster	census or geographical data	30	Yes	numeric	ordinal	NA	NA
Bunt, 2017 (The Netherlands)	To adapt the Social Vulnerability Index to the Dutch language and culture for those purposes.	Health/ Medicine	clinical data	32	No	numeric	numeric	NA	NA
Burton, 2008 (USA)	To examine the spatial variability in the social vulnerability of residents to potential levee failures in the Sacramento Delta region.	Climate/ Environment/ Disaster	census or geographical data	36	No	numeric	numeric	NA	NA
Cerami, 2021 (Italy)	We assessed frailty and social vulnerability indices in 1,258 Italian residents during the first lockdown phase *via* an on-line survey. We compared indices taking into account	Health/ Medicine	representative survey	30	No	numeric	numeric	Disease risk	Positive

	age categories and gender.								
Chakraborty, 2005 (USA)	To examine spatial variability in evacuation assistance needs as related to the hurricane hazard.	Climate/ Environmen t/ Disaster	census or geographical data	10	No	numeri c	ordinal	NA	NA
Chau, 2014 (USA & Hong Kong)	To modify and use an SVI specifically designed to assess the vulnerability of older populations to emergencies and disasters across seven domains.	Health/ Medicine	administrativ e data	7	No	ordinal	ordinal	NA	NA
Chen, 2013 (China)	To replicate and test the applicability of the place-based Social Vulnerability Index developed for the United States in a Chinese cultural context.	Climate/ Environmen t/ Disaster	census or geographical data	29	No	numeri c	ordinal	NA	NA
Zhu, 2021 (China)	In this study, typhoon disaster risk zoning is conducted for China's coastal area, based on data at the county level.	Climate/ Environmen t/ Disaster	-	-	-	-	-	NA	NA

Chen, 2021 (China)	To combine flood hazard and social vulnerability index to capture the potential risk of flood.	Climate/ Environment/ Disaster	census or geographical data	21	No	numeric	ordinal	NA	NA
Cumberbatch, 2020 (Barbados)	A Social Vulnerability Index was developed for Barbados to identify geospatial variations in social vulnerability.	Climate/ Environment/ Disaster	census or geographical data	8	No	numeric	ordinal	NA	NA
Cutler, 2018 (USA)	To use multilevel statistical modeling to investigate individual- and geographic-level (e.g., census tract level and regional) social, economic, and biophysical influences on public perceptions of the adverse health impacts associated with heat waves.	Climate/ Environment/ Disaster	representative survey	8	No	numeric	numeric	Health risks of heat waves	Positive
Cutter, 2003 (USA)	County-level socioeconomic and demographic data were used to construct an index of social vulnerability to environmental hazards, called the Social Vulnerability	Climate/ Environment/ Disaster	census or geographical data	11	No	numeric	ordinal	NA	NA

	Index (SoVI) for the United States								
Anderson, 2019 (USA)	Here, the Social Vulnerability Index (SoVI®) and the vulnerability component of the Global Delta Risk Index (GDRI) are applied at census tract level in the Mississippi Delta and visually and quantitatively compared.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Barboza, 2019 (USA)	To quantify the spatiotemporal risk of child abuse and neglect in Los Angeles at the census tract level over a recent 4-year period, identify areas of increased risk, and evaluate the role of structural disadvantage in child maltreatment referrals.	Health/ Medicine	-	-	-	-	-	Child abuse and neglect	Positive
Burton, 2010 (USA)	To examine to what extent can a quantified measure	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

	of social vulnerability be incorporated into numerical hurricane impact modeling to improve loss prediction.								
Cutter, 2013 (USA)	This paper proposes a methodology for incorporating a known measure of social vulnerability, the Social Vulnerability Index (SoVI), into USACE civil works planning.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
de Oliveira Mendes, 2009 (Portugal)	The main objective is to expand the analysis of social vulnerability to technological and social risks, and to incorporate the Social Vulnerability Index as a planning tool.	Mixed	-	-	-	-	-	NA	NA
Ebert, 2009 (Honduras)	This article deals with the assessment of social vulnerability in conjunction with a new method based on contextual analysis of image and GIS data.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

Eid, 2017 (USA)	To present a decision-making framework for disaster recovery that uses a bottom-up approach to capture the needs of the impacted residents and decreases the social vulnerability of host communities.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA	
Ge, 2021 (China)	To conduct an assessment of the social vulnerability index by applying the projection pursuit cluster model.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA	-
Georgantopoulos, 2020 (USA)	To use the Veterans Administration Medical System, which provides a unique means for studying prostate cancer epidemiology among diverse individuals with ostensibly equal access to healthcare.	Health/ Medicine	-	-	-	-	-	Prostate cancer risk	Positive	
Hou, 2016 (China)	To calculate the social vulnerability index of geological disasters in China with the super-	Climate/ Environment/ Disaster	-	-	-	-	-	Exposure degree and reaction and	Positive	

	efficiency DEA (data envelopment analysis) model, carry out global and local autocorrelation tests for social vulnerability to geological disasters in each province in China and identify the characteristics of its spatial distribution pattern.								recovery ability	
Huang, 2015 (China)	This article presents an initial study of the social vulnerability of the Beijing-Tianjin-Hebei Region in China. The goal is to replicate and test the applicability of the United States Social Vulnerability Index (SoVI) method.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Lavoie, 2018 (USA)	This paper presents a ground-truthing effort to validate quantitative indices that characterize the well-being of Alaska fishing communities.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Lottering, 2021 (South Africa)	The aim of this article was to assess and identify social	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

	vulnerability amongst small-scale farmers and rural communities in the uMsinga community in the KwaZulu Natal province of South Africa using an adapted social vulnerability index (SoVI).								
Maharani, 2016 (Indonesia)	This study proposes a computational method for data analysis in terms of the number of social vulnerability variables and samples of the case study in the Merapi proximal villages.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Martinich, 2013 (USA)	To identify geographic areas in the contiguous United States that may be more likely to experience disproportionate impacts of sea level rise and to determine if and where socially vulnerable populations would bear	Climate/ Environment/ Disaster	-	-	-	-	-	protected vs abonnement in relation inundation from. sea level rise	Positive

	disproportionate costs of adaptation.								
Mengal, 2021 (Pakistan)	This study presents the first social vulnerability index study for District Gwadar in relation to imminent earthquake-tsunami hazards and shows how SoVI concepts and indicators are adopted.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Muyambo, 2017 (South Africa)	To assess and identify social vulnerability of communal farmers to drought in the O.R. Tambo district in the Eastern Cape province of South Africa using a survey data and social vulnerability index.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Nafeh, 2020 (Algeria)	This paper investigates the social vulnerability and resilience level to natural hazards, with a specific focus on seismic risk, in the province of Blida, an important cultural and	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

	economic region in Northern Algeria.									
Phelos, 2021 (USA)	Our objective was to determine if these indices correlate with injury fatality rates in the US.	Climate/ Environmen t/ Disaster	-	-	-	-	-	Injury fatality rates (overall, firearm, and motor vehicle collision deaths)	Positive
Ratnapradipa, 2017 (USA)	The purpose of this study was to determine if a relationship existed between the SoVI and Lyme Disease incidence at the national level and regional division level in the United States.	Health/ Medicine	-	-	-	-	-	Lyme disease incidence	Mixed
Schmidtlein, 2011 (USA)	This paper examines the spatial linkage between social vulnerability and estimated earthquake losses for differing levels of event magnitude.	Climate/ Environmen t/ Disaster	-	-	-	-	-	Earthquak e losses	Positive
Tellman, 2020 (USA)	This paper validates social vulnerability indicators using two flood outcomes: death and damage.	Climate/ Environmen t/ Disaster	-	-	-	-	-	Flood damage and death	Positive

Wigtil, 2016 (USA)	We evaluated place vulnerability to wildfire hazards in the coterminous US by developing a social vulnerability index.	Climate/ Environment/ Disaster	-	-	-	-	-	Wildfire potential	Mixed
Wood, 2010 (USA)	In order to assess social vulnerability to Cascadia tsunamis, we adjust a social vulnerability index to operate at the census-block level of geography and focus on community-level comparisons along the Oregon coast.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Denver, 1988 (USA)	The purpose of this article is to identify areas of social vulnerability so that a more positive, long-term approach can be established to create justice in health care planning.	Health/ Medicine	census or geographical data	13	No	numeric	categorical	NA	NA
de Loyola Hummell, 2016 (Brazil)	This article provides a social vulnerability index (SoVI®) replication study for Brazil and shows how SoVI® concepts and indicators were	Climate/ Environment/ Disaster	census or geographical data	10	No	numeric	numeric	NA	NA

	adapted to the country.								
Alem, 2021 (Brazil)	This paper addresses the design of a humanitarian supply chain to integrate logistics activities in an effective and efficient decision support system to cope with multiple disaster events over a dynamic time horizon.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
di Girasole, 2017 (Dominican Republic)	This article presents a methodology for the analysis of social vulnerability, defined and experimented in the context of the international cooperation project.	Climate/ Environment/ Disaster	mixed	30	Yes	numeric	ordinal	NA	NA
Dintwa, 2019 (Botswana)	This study applies the household social vulnerability methodology to measure social vulnerability to natural hazards in Botswana.	Climate/ Environment/ Disaster	census or geographical data	11	Yes	numeric	ordinal	NA	NA

Dintwa, 2019 (Botswana)	The study examined the applicability of the Place Vulnerability Model in Botswana, as well as to analyse underlying factors contributing to social vulnerability to natural hazards.	Climate/ Environment/ Disaster	census or geographical data	11	Yes	numeric	numeric	NA	NA
Dossou, 2021 (Benin)	The current study assessed the impact of agriculture on the Oueme basin.	Climate/ Environment/ Disaster	mixed	13	No	numeric	ordinal	NA	NA
Felsenstein, 2014 (Israel)	To assesses the socioeconomic consequences of extreme coastal flooding events.	Climate/ Environment/ Disaster	census or geographical data	4	Yes	numeric	ordinal	NA	NA
Flanagan, 2011 (USA)	This paper describes the development of a social vulnerability index (SVI), from 15 census variables at the census tract level, for use in emergency management.	Climate/ Environment/ Disaster	census or geographical data	15	No	numeric	numeric	NA	NA
Abbas, 2021 (USA)	To examine the association between patient race/ethnicity and county-level vulnerability relative	Health/ Medicine	-	-	-	-	-	Hospice utilization	Negative

	to patterns of hospice utilization								
An, 2015 (USA)	To examine the relationship between residential county social vulnerability and leisure-time physical inactivity among US adults.	Health/ Medicine	-	-	-	-	-	Physical inactivity	Positive
Angelidou, 2021 (USA)	To ascertain the percentage of neonates who were born to mothers with positive SARS-CoV-2 test results during the birth hospitalization, the clinical and sociodemographic factors associated with neonatal test result positivity, and the clinical and virological outcomes for newborns during hospitalization and 30 days after discharge	Health/ Medicine	-	-	-	-	-	Neonates with positive SARS-CoV-2 test results	Positive
Arling, 2021 (USA)	To assess the performance of the CDC SVI in classifying counties according to their COVID-19 mortality rates	Health/ Medicine	-	-	-	-	-	COVID-19 mortality rates and disaster loss	No association

Azap, 2021 (USA)	To characterize receipt of surgery and chemotherapy among Medicare beneficiaries with a diagnosis of early-stage pancreatic adenocarcinoma cancer (PDAC) relative to race/ethnicity and social vulnerability	Health/ Medicine	-	-	-	-	-	Receipt of surgery and chemothe rapy	Negative
Azap, 2020 (USA)	To characterize possible differences in "textbook outcome," a composite measure of quality, relative to social vulnerability index	Health/ Medicine	-	-	-	-	-	Surgical textbook outcome	Negative
Azap, 2021 (USA)	To understand the association of County-Level Vulnerability, Patient-Level Race/Ethnicity, and Receipt of Surgery for Early-Stage Hepatocellular Carcinoma	Health/ Medicine	-	-	-	-	-	Receipt of Surgery	Negative
Barry, 2021 (USA)	To ascertain whether inequities in COVID-19 vaccination coverage with respect to	Health/ Medicine	-	-	-	-	-	inequities in COVID-19 vaccinatio	Positive

	county-level SVI have persisted, overall and by urbanicity.								n coverage	
Ibrahim, 2021 (USA)	To examine the relationship between neighborhood social vulnerability and cardiovascular risk (hypertension and obesity) among Black/African American women.	Health/ Medicine	-	-	-	-	-	Cardiovas cular risk (hyperten sion and obesity)	Positive
Benin, 2021 (USA)	To evaluate if facility-level vaccination after an initial vaccination clinic was independently associated with COVID-19 incidence adjusted for other factors in January 2021 among nursing home residents.	Health/ Medicine	-	-	-	-	-	Covid-19 incidence	Positive
Biggs, 2021 (USA)	To examine the association between the Centers for Disease Control and Prevention (CDC)'s Social Vulnerability Index (SVI) and COVID-19 incidence	Health/ Medicine	-	-	-	-	-	Covid-19 incidence	Positive

	among Louisiana census tracts.								
Bilal, 2021 (USA)	To explore the emergence of spatial inequities in COVID-19 testing, positivity, confirmed cases, and mortality in New York, Philadelphia, and Chicago during the first 6 months of the pandemic.	Health/ Medicine	-	-	-	-	-	COVID-19 testing, positivity, confirmed cases, and mortality	Positive
Bogart, 2022 (USA)	We examined the extent to which socio-demographic and health-related background characteristics, medical mistrust, the perceived need for vaccination, confidence in vaccine efficacy and safety, social norms for vaccination, and neighborhood-level social vulnerability factors were associated with intentions to get vaccinated for COVID-19.	Health/ Medicine	-	-	-	-	-	intention or willingness to get vaccinated	Positive
Bozorgi, 2021 (USA)	To describe the geographic variation of spatial	Health/ Medicine	-	-	-	-	-	NA	NA

	accessibility to opioid treatment programs (OTPs) and identifies areas with poor access to care in South Carolina.								
Bruckhaus, 2022 (USA)	To characterize the scope of vaccine inequity in California counties through modeling the trends of vaccination using the Social Vulnerability Index.	Health/ Medicine	-	-	-	-	-	Covid-19 vaccine coverage	Mixed
Carmichael, 2019 (USA)	To compare cholecystectomy patients presenting emergently versus electively.	Health/ Medicine	-	-	-	-	-	Emergent vs elective surgery	Positive
Carmichael, 2020 (USA)	To assess the performance of the Social Vulnerability Index compared with three similar measures used in the surgical literature: Area Deprivation Index, Community Needs Index, and Distressed Communities Index.	Health/ Medicine	-	-	-	-	-	NA	NA
Carter, 2021 (USA)	To assess interest and ability to participate in the	Health/ Medicine	-	-	-	-	-	Willingnes s to participat	Negative

	Living Donor Navigator Program by the degree of social vulnerability.								e in living donor program
Chang, 2021 (USA)	To examine differences in telehealth use and barriers to adoption among primary care practices and how those differences are influenced by the socioeconomic characteristics of their communities	Health/ Medicine	-	-	-	-	-	Telehealth	Positive
Crook, 2021 (USA)	To examine the uptake of several newly allowable benefits in 2021 as well as geographic differences in benefit offerings between areas by urbanicity, MA penetration, and social vulnerability.	Health/ Medicine	-	-	-	-	-	Benefits	Positive
Cunningham, 2021 (USA)	A resource assignment framework is developed as a coupled-state transition and linear optimization model that assists planners in optimally	Mixed	-	-	-	-	-	NA	NA

	allocating constrained resources and satisfying mental health recovery priorities post-disaster.								
Dalmacy, 2022 (USA)	To examine the association of social vulnerability with the likelihood of experiencing fragmentation of postoperative care (FPC) after hepatopancreatic surgery.	Health/ Medicine	-	-	-	-	-	Fragmented post operative care	Positive
Dargin, 2021 (USA)	This research uses point of interest visitations as location intelligence data provided by SafeGraph together with Social Vulnerability Index and historical flood data to examine the critical intersection of natural hazard planning and response and the COVID-19 pandemic to assess the risks of a compound hazard situation.	Mixed	-	-	-	-	-	NA	NA

Dasgupta, 2020 (USA)	County-level data on COVID-19 cases during June 1-July 25, 2020 and from the 2018 CDC social vulnerability index (SVI) were analyzed to examine associations between social vulnerability and hotspot detection and to describe incidence after hotspot detection.	Health/ Medicine	-	-	-	-	-	At risk area to COVID-19 outbreak	Positive
Dekker, 2021 (USA)	To examine the impact of telemedicine in the disadvantaged population.	Health/ Medicine	-	-	-	-	-	Show or no-show to health appt	Positive
Delanois, 2021 (USA)	To investigate the association between demographic data, health status, and SDOHs on 30-day length of stay (LOS) and TCOC after this procedure.	Health/ Medicine	-	-	-	-	-	Post surgical outcome	No associatio n
Diaz, 2021 (USA)	To assess the association of county-level vulnerability with the probability of having a non-	Health/ Medicine	-	-	-	-	-	Elective versus non- elective operation	Positive

	elective colon resection								
Diaz, 2021 (USA)	To define the impact of high- versus low-quality hospitals on the risk of adverse outcomes among patients undergoing hepatopancreatic surgery relative to social vulnerability	Health/ Medicine	-	-	-	-	-	Post surgical outcome	Positive
Diaz, 2021 (USA)	To determine the neighborhood level characteristics that may be associated with travel patterns and utilization of high-volume hospitals	Health/ Medicine	-	-	-	-	-	Operation at a high-volume hospital	Negative
Diaz, 2021 (USA)	To examine postoperative outcomes following resection of lung and colon cancer	Health/ Medicine	-	-	-	-	-	Postoperative outcomes	Positive
Diaz, 2021 (USA)	The probability that a patient received care at a high-volume hospital and postoperative outcomes stratified by the social vulnerability of the patient's county of residence was examined.	Health/ Medicine	-	-	-	-	-	Postoperative outcomes and operation at a high-volume hospital	Positive

Diaz, 2021 (USA)	To characterize the association between patient county-level vulnerability with postoperative outcomes.	Health/ Medicine	-	-	-	-	-	Postoperative outcomes	Positive
Estrella, 2021 (USA)	We examined whether social vulnerability is associated with increased incidence of perforated appendicitis.	Health/ Medicine	-	-	-	-	-	Incidence of perforated appendicitis	No association
Fergen, 2021 (USA)	We map four themes of social vulnerability for the GLB by using the Center for Disease Control's Social Vulnerability Index (CDC SVI) for every county in the basin and compare mean scores for each sub-basin to assess inter-basin differences	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Freese, 2021 (USA)	To determine the association between the Center for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI) with the risk of COVID-19-related mortality.	Health/ Medicine	-	-	-	-	-	Mortality related to COVID-19	Positive

Fu, 2021 (USA)	We applied a geographically and temporally weighted regression (GTWR) to analyze the spatiotemporal pattern of community stay-at-home behaviors against social vulnerability indicators at the census tract level in New York City from March to August 2020.	Health/ Medicine	-	-	-	-	-	NA	NA
Gay, 2016 (USA)	This study examined the utility of using the SVI to explain variation in youth fitness, including aerobic capacity and body mass index.	Health/ Medicine	-	-	-	-	-	Youth fitness (aerobic capacity and BMI)	Positive
Gharpure, 2021 (USA)	To assess vaccine uptake in these communities and identify characteristics that might impact uptake.	Health/ Medicine	-	-	-	-	-	Covid Vaccine uptake	Positive
Givens, 2021 (USA)	To investigate the association of the Social Vulnerability Index for each patient's residence	Health/ Medicine	-	-	-	-	-	Preterm birth	Positive

	during pregnancy, personal clinical risk factors, and preterm birth.								
Godfrey, 2021 (USA)	To examine individual characteristics, motivations, and geographic locations of patients receiving abortion care through the Aid Access platform.	Health/ Medicine	-	-	-	-	-	NA	NA
Grunwell, 2022 (USA)	Composite measures of social determinants of health and readmission outcomes were evaluated in a large regional cohort of 1,403 school-age children admitted to a pediatric intensive care unit (PICU) for asthma.	Health/ Medicine	-	-	-	-	-	PICU admissions/Asthma outcomes	Positive
Harrison, 2021 (USA)	To examine the factors associated with EMS refusal in relation to COVID-19 cases, public health interventions, EMS responses, and prehospital deaths.	Health/ Medicine	-	-	-	-	-	rate of EMS transport refusals	Positive

Hathaway, 2021 (USA)	To comment on community risk of rural minority population during COVID-19.	Health/ Medicine	-	-	-	-	-	NA	NA
Hughes, 2021 (USA)	To examine equity in vaccine coverage	Health/ Medicine	-	-	-	-	-	Vaccine equity	Mixed
Hyer, 2021 (USA)	To characterize differences in "textbook outcomes" (TO) relative to social vulnerability among Medicare beneficiaries who underwent operations for cancer.	Health/ Medicine	-	-	-	-	-	Surgical textbook outcome	Negative
Hyer, 2021 (USA)	To characterize the role of patient social vulnerability relative to hospital racial/ethnic integration on postoperative outcomes among patients undergoing pancreatectomy.	Health/ Medicine	-	-	-	-	-	Surgical textbook outcome	Negative
Islam, 2021 (USA)	To examine incidence and mortality from COVID-19	Health/ Medicine	-	-	-	-	-	Incidence and mortality from COVID-19	Positive
Islam, 2021 (USA)	We examined the temporal association	Health/ Medicine	-	-	-	-	-	COVID-19 incidence	Positive

	of county-level Social Vulnerability Index (SVI), a percentile-based measure of social vulnerability to disasters, its subcomponents and race/ethnic composition with COVID-19 incidence and mortality in the USA in the year starting in March 2020							and mortality	
Javalkar, 2021 (USA)	To characterize the socioeconomic and racial and/or ethnic disparities impacting the diagnosis and outcomes of multisystem inflammatory syndrome in children (MIS-C).	Health/ Medicine	-	-	-	-	-	MIS-C diagnosis and severity	Mixed
Johnson, 2021 (USA)	This study summarizes the results from fitting a Bayesian hierarchical spatiotemporal model to coronavirus disease 2019 (COVID-19) cases and deaths at the county level in	Health/ Medicine	-	-	-	-	-	Covid-19 cases and mortality	Positive

									NA	NA		-
	the United States for the year 2020.											
Johnson, 2018 (USA)	Our research presents a web-based tool for providing data to decision-makers in support of local and regional adaptation planning processes.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA		-	
Jones, 2020 (USA)	Using data from DC Health, the Washington, DC, department of public health, this study investigated associations between neighborhood social, built, and natural environments and rates of asthma-related healthcare encounters by ZIP code between 2014 and 2017.	Health/ Medicine						NA	NA			
Karaye, 2020 (USA)	This study estimates the association between case counts of COVID-19 infection and social vulnerability in the U.S., identifying counties at increased	Health/ Medicine	-	-	-	-	-	COVID-19 case count	Positive			

	vulnerability to the pandemic.									
Karmakar, 2021 (USA)	To examine the association between county-level sociodemographic risk factors and US COVID-19 incidence and mortality.	Health/ Medicine	-	-	-	-	-	NA	NA	
Khan, 2021 (USA)	To examine whether underlying social vulnerabilities of counties influence premature cardiovascular disease mortality is uncertain.	Health/ Medicine	-	-	-	-	-	NA	NA	
Khazanchi, 2020 (USA)	To examine the relationship between social vulnerability and COVID-19 diagnosis and mortality in rural and urban communities remains unknown.	Health/ Medicine	-	-	-	-	-	NA	NA	
Killian, 2021 (USA)	To determine if racial disparities persist in LDKT independent of community-level vulnerability.	Health/ Medicine	-	-	-	-	-	NA	NA	
Killian, 2022 (USA)	To examine the association between social vulnerability	Health/ Medicine	-	-	-	-	-	Self-advocacy	Positive	

	and living donor navigator self-advocacy									
Lai, 2019 (USA)	We hypothesized that SVI is associated with SCD-related severity and utilization.	Health/ Medicine	-	-	-	-	-	Healthcare utilization	Positive
LeRose, 2021 (USA)	Our primary objective was to determine whether a correlation existed between the SVI and PPE supply shortages in Michigan SNFs. Additionally, we analyzed the potential relationship between the SVI and the number of COVID-19 cases and mortality rate.	Mixed	-	-	-	-	-	PPE shortages, number of COVID-19 cases, mortality.	Positive
Lotfata, 2019 (USA)	In this study, we analyze the spatial patterns of the social vulnerability index (SVI) in each flood zone within Louisiana parishes of East Baton Rouge, Ascension, and Livingston.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

McAlarnen, 2021 (USA)	We describe the utilization of virtual visits by patients with gynecologic malignancies and assess their social vulnerability.	Health/ Medicine	-	-	-	-	-	Telemedic ine usage	No associatio n
Mock, 2021 (USA)	We describe the utilization of virtual visits by patients with gynecologic malignancies and assess their social vulnerability.	Health/ Medicine	-	-	-	-	-	Telecare utilization	Negative
Morgan, 2020 (USA)	To examine if pediatric trauma patients high on the social vulnerability index would have significantly lower rates of rehab admission following admission to a hospital for traumatic injury.	Health/ Medicine	-	-	-	-	-	Rehab admission	Negative
Nayak, 2020 (USA)	To examine the association of Social Vulnerability Index (SVI), a percentile-based measure of county-level social vulnerability to disasters, and its sub-components (socioeconomic	Health/ Medicine	-	-	-	-	-	COVID-19 incidence and case fatality rate	Positive

	status, household composition, minority status, and housing type/transportation accessibility) with the case fatality rate (CFR) and incidence of COVID-19.								
Neelon, 2021 (USA)	We examined temporal trends among counties with high and low social vulnerability to quantify disparities in trends over time.	Health/ Medicine	-	-	-	-	-	COVID-19 incidence and death rates.	Positive
Oates, 2021 (USA)	We assessed the relationship between social vulnerability and COVID-19 testing rates, test positivity, and incidence.	Health/ Medicine	-	-	-	-	-	COVID-19 testing, incidence, positivity.	Mixed
Papageorge, 2022 (USA)	We examined the effect of Medicaid expansion on the diagnosis of HCC and associations with county-level social vulnerability.	Health/ Medicine	-	-	-	-	-	Early-stage cancer diagnosis	Negative
Paro, 2021 (USA)	To identify distinct profiles of social vulnerability among Medicare beneficiaries and	Health/ Medicine	-	-	-	-	-	Postoperative outcomes	Positive

	define the association of these profiles with postoperative outcomes.								
Phelos, 2021 (USA)	To determine if these indices correlate with injury fatality rates in the US.	Climate/ Environmen t/ Disaster	-	-	-	-	-	Fatality rates	Positive
Puvvula, 2021 (USA)	This study evaluated the association between atrazine in surface and groundwater, in relation to the incidence of pediatric cancer in Nebraska watersheds over 30 years.	Health/ Medicine	-	-	-	-	-	NA	NA
Regmi, 2021 (USA)	To use the parameters of social vulnerability index (SVI) to observe their association with the 30-day hospital readmissions in the heart failure population.	Health/ Medicine	-	-	-	-	-	30-day hospital readmissi on	Positive
Rickless, 2021 (USA)	This study explored demographic indicators of vulnerability for	Mixed	-	-	-	-	-	Presenting to medical facility following	Positive

	patients from the Hurricane Harvey impact area who sought medical care in Houston and in DFW.								natural disaster	
Saia, 2020 (USA)	We compared spatial distributions of high-risk subbasins based on SWAT results, SVI results, and the integration of SWAT and SVI results using a risk matrix.	Climate/ Environmen t/ Disaster	-	-	-	-	-	Streamflo w projection s	Mixed
Sharareh, 2020 (USA)	To highlight areas in Utah vulnerable to a Hepatitis C virus (HCV) outbreak.	Health/ Medicine	-	-	-	-	-	HCV outbreaks among persons who inject drugs	Positive
Steinkamp, 2021 (USA)	The purpose of this study was to determine what these terms (equity, diversity and inclusion) mean with respect to health care, and whether we are manifesting them in our medical practices.	Health/ Medicine	-	-	-	-	-	NA	NA
Strully, 2022 (USA)	To inform vaccine equity interventions, this analysis	Health/ Medicine	-	-	-	-	-	Influenza vaccinatio n rates	Negative

	investigates spatially varying associations between county social vulnerability and influenza vaccination rate among Medicare recipients.									
Thakore, 2021 (USA)	To understand how strategic vaccine site placement may benefit high vulnerability populations.	Health/ Medicine	-	-	-	-	-	COVID-19 vaccine site density and vaccination rates	Mixed
Troppy, 2021 (USA)	To understand the spatial heterogeneity of associations between social determinants and the use of SARS-CoV-2 testing.	Health/ Medicine	-	-	-	-	-	COVID testing	Mixed
Tummalapalli, 2021 (USA)	To examine whether disparities in COVID-19 incidence related to race/ethnicity and socioeconomic factors exist in the hemodialysis population.	Health/ Medicine	-	-	-	-	-	Acquiring COVID-19	Mixed
Turek-Hankins, 2020 (USA)	We examined racial/ethnic differences in COVID-19 incidence	Climate/ Environment/ Disaster	-	-	-	-	-	Acquired COVID-19	Positive

	among patients on hemodialysis in New York City during the first wave of the COVID-19 pandemic and assessed if SVI explained racial/ethnic differences in COVID-19 incidence.								
Upchurch, 2022 (USA)	We investigated racial/ethnic differences by gender in correlates of COVID-19 infection among veterans seeking health care services at the Veterans Health Administration.	Health/ Medicine	-	-	-	-	-	Testing positive for COVID-19	Mixed
Vickers, 2021 (USA)	To comment on individual patient vulnerability relative to surgical outcomes.	Health/ Medicine	-	-	-	-	-	NA	NA
Vo, 2020 (USA)	To measure the accessibility levels for three emergency response thresholds: zero to four minutes, four to eight minutes, and eight to fifteen minutes.	Mixed	-	-	-	-	-	Healthcare accessibility	Positive

Wang, 2022 (USA)	This study aims to examine the spatially varying relationships between social vulnerability factors and COVID-19 cases and deaths in the contiguous United States.	Health/ Medicine	-	-	-	-	-	COVID-19 cases and deaths	Positive
Wang, 2021 (USA)	The study aims to examine the vaccination inequities among different population groups for people aged 65+.	Health/ Medicine	-	-	-	-	-	Vaccination rates	Negative
Yee, 2019 (USA)	This ecological study explores the application of the SVI as a predictor of teen pregnancy rates across counties in the United States (U.S.) and identifies areas with greatest need for community-based interventions.	Health/ Medicine	-	-	-	-	-	Teen birth rate	Positive
Yee, 2021 (USA)	We aim to analyze the effects of social determinants of health on COVID-19 outcomes and public health responses.	Health/ Medicine	-	-	-	-	-	NA	NA

Zachrison, 2021 (USA)	To describe patient characteristics associated with successful transition from in-person to virtual care, and video vs audio-only participation.	Health/ Medicine	-	-	-	-	-	Patient characteristics by visit type	Mixed
Zottarelli, 2021 (USA)	To examine the effects of excessive heat and community-level social vulnerability on morbidity in San Antonio, Texas.	Climate/ Environment/ Disaster	-	-	-	-	-	Morbidity	Positive
Fraser, 2021 (Japan)	This paper introduces a methodology to create the Japanese Municipal Social Capital Index and Social Vulnerability Index, for every year from 2000 to 2017.	Climate/ Environment/ Disaster	census or geographical data	19	No	numeric	ordinal	NA	NA
Frigerio, 2016 (Italy)	To apply a proven method for assessing social vulnerability at the national scale, while considering the contribution of the socioeconomic and demographic factors that affect the Italian population.	Climate/ Environment/ Disaster	census or geographical data	12	No	numeric	ordinal	NA	NA

Frigerio, 2018 (Italy)	Evaluate the pattern of social vulnerability over time in Italy.	Climate/ Environment/ Disaster	census or geographical data	16	Yes	numeric	numeric	NA	NA
Frigerio, 2019 (Italy)	This paper seeks to identify those areas that proved socially vulnerable to the earthquake that struck central Italy on 24 August 2016.	Climate/ Environment/ Disaster	census or geographical data	16	Yes	numeric	ordinal	NA	NA
Gautam, 2017 (Nepal)	This study aims to quantify the social vulnerability on a local scale, considering all 75 districts using the available census.	Climate/ Environment/ Disaster	census or geographical data	13	Yes	numeric	numeric	NA	NA
Ge, 2017 (China)	This paper explored a new approach regarding social vulnerability to climate change.	Climate/ Environment/ Disaster	census or geographical data	24	Yes	numeric	numeric	NA	NA
Ge, 2017 (China)	A social vulnerability assessment trial was carried out for Chinese coastal cities at the county level. First, the 10 factors having the most influence on social vulnerability were identified.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA

Ge, 2017 (China)	To propose a new conceptual framework for urban social vulnerability assessment based on network theory, where a new dimension of social vulnerability (connectivity) was added into the framework.	Climate/ Environmen t/ Disaster	mixed	19	No	numeric	numeric	NA	NA
Ge, 2013 (China)	This paper presents a new method for quantifying SV based on the projection pursuit cluster (PPC) model. A reference social vulnerability index (SVI) at the county level was created for the Yangtze River Delta area in China for 1995, 2000, 2005, and 2009.	Climate/ Environmen t/ Disaster	census or geographical data	19	No	numeric	numeric	NA	NA
Ge, 2019 (China)	This paper examines social vulnerability and inequality through a joint analysis of urban agglomerations.	Climate/ Environmen t/ Disaster	census or geographical data	24	Yes	numeric	numeric	NA	NA

Godin, 2019 (Canada)	We sought to understand the association between social vulnerability and the odds of long-term care (LTC) placement within 30 days of discharge following admission to an acute care facility and whether this association varied based on age, sex, or pre-admission frailty.	Health/ Medicine	clinical data	18	No	numeric	categorical	LTC placement	Positive
Grasso, 2014 (Samoa)	To investigate the notion of social vulnerability and measure its dimensions in Samoa through a specific index: the Samoa Social Vulnerability Index (SSVI).	Climate/ Environment/ Disaster	census or geographical data	15	No	numeric	numeric	NA	NA
Gu, 2018 (China)	This paper presents a hierarchical pattern of urban social vulnerability by a SoVI assessment of the 5432 neighborhoods (residential committee, or *juwei* in Chinese)	Climate/ Environment/ Disaster	census or geographical data	17	No	numeric	ordinal	NA	NA

	in Shanghai metropolitan, China.								
Guo, 2020 (Hong Kong & China)	This study aims to explore the spatial variations in the elderly suicide rates and their correlates in Hong Kong.	Health/ Medicine	mixed	7	No	numeric	numeric	NA	NA
Gupta, 2020 (India)	This study systematically analysed important components of vulnerability and mapped them by weight for four altitude zones in the Indian Himalayas.	Climate/ Environment/ Disaster	representative survey	15	No	numeric	numeric	NA	NA
Hazards and Vulnerability Research Institute at the University of South Carolina, 2016 (USA)	To describe the Social Vulnerability Index (SoVI®) which measures the social vulnerability of U.S. counties to environmental hazards.	Climate/ Environment/ Disaster	census or geographical data	29	No	numeric	ordinal	NA	NA
Al Rifat, 2021 (USA)	To explore and understand the intersection of meteorological storm	Climate/ Environment/ Disaster	-	-	-	-	-	Property damage or loss	No association

	characteristics, physical characteristics of the areas impacted, and social-economic vulnerability variables as predictors of county-level inland property damage.								
Jagarnath 2020 (South Africa)	To investigate current and projected future heat risk, expressed as a heat stress exposure index using high-resolution climate change projections, and a social vulnerability index, to identify areas of potential future heat stress risk in the Durban (eThekwini) metropolitan area, South Africa.	Climate/ Environment/ Disaster	census or geographical data	20	No	numeric	ordinal	NA	NA

Kamiohkawa, 2021 (Phillipines)	This study empirically investigated the social vulnerability of two municipalities of Laguna Province, Philippines, on the impacts of natural disasters associated with climate change.	Climate/ Environmen t/ Disaster	representativ e survey	21	Yes	numeri c	numeric	NA	NA
Karunarathne, 2020 (Sri Lanka)	We shed light on an influential mechanism in order to measure social vulnerability to flooding in both rural and urban areas. We developed the multi-facet composite social vulnerability index (MFCSVI).	Climate/ Environmen t/ Disaster	representativ e survey	31	Yes	numeri c	ordinal	NA	NA
Kim, 2020 (Indonesia)	This paper investigates social vulnerability to foods at the municipality level on Java.	Climate/ Environmen t/ Disaster	census or geographical data	8	No	numeri c	ordinal	NA	NA
Kirby, 2019 (The Netherlands)	This study utilizes fine-scale data to construct a social vulnerability index for 147 districts of the Dutch province of Zeeland.	Climate/ Environmen t/ Disaster	mixed	7	Yes	numeri c	ordinal	NA	NA

Koks, 2015 (The Netherlands)	This study shows how a joint assessment of hazard, exposure and social vulnerability provides valuable information for the evaluation of flood risk management strategies.	Climate/ Environment/ Disaster	census or geographical data	8	No	numeric	ordinal	NA	NA
Kumar, 2020 (India)	Vulnerability index of a community has to be calculated considering physical, social, economic and environmental factors associated with the community. This research paper tries to find out an integrated social vulnerability factor.	Climate/ Environment/ Disaster	mixed	22	Yes	numeric	numeric	NA	NA
Lawal, 2015 (Nigeria)	This study sought to develop a spatially explicit index of social vulnerability, thus addressing the dearth of research in this area in sub-Saharan Africa.	Climate/ Environment/ Disaster	mixed	6	No	numeric	ordinal	NA	NA
Lee, 2014 (Taiwan)	To promote sustainable development, this study offers a case	Climate/ Environment/ Disaster	administrative data	13	No	numeric	numeric	NA	NA

	study of developmental planning in Chiayi, Taiwan and a review of the relevant literature to propose a framework of social vulnerability indicators at the township level.									
Letsie, 2015 (Lesotho)	To assess social vulnerability of communities to natural hazards by applying a place-based social vulnerability index developed for the United States, to the Lesotho context.	Climate/ Environment/ Disaster	mixed	25	No	numeric	ordinal	NA	NA	
Lin, 2016 (Taiwan)	This study applied spatial autocorrelation statistics to analyze the spatial association of vulnerability among townships in Taiwan.	Climate/ Environment/ Disaster	mixed	14	Yes	numeric	ordinal	NA	NA	
Liu, 2016 (China)	In this study, a household social vulnerability index (HSVI) to flood hazards was developed and used to assess the social	Climate/ Environment/ Disaster	mixed	8	Yes	numeric	categorical	NA	NA	

	vulnerability of rural households in western mountainous regions of Henan province, China.								
Liu, 2021 (Taiwan)	This study examined effects between SVI status and two genotypes, apolipoprotein E (ApoE) and Serotonin transporter genotyping (5-HTTLPR), on all-cause mortality.	Health/ Medicine	representative survey	32	No	numeric	ordinal	Mortality	Positive
Lixin, 2017 (China)	In this study, five social vulnerability indicators indexes (social network, community administration, community participation, community disaster prevention, and social support) are selected to build a community-based social vulnerability index (SoVI).	Climate/ Environment/ Disaster	representative survey	21	Yes	numeric	ordinal	NA	NA

Lixin, 2014 (China)	This paper presents a mathematical model to establish a model of social vulnerability index (SoVI), which includes 12 social variables, and the regional social vulnerability to natural hazards was formulated by them.	Climate/ Environment/ Disaster	mixed	12	Yes	numeric	ordinal	NA	NA
Maharani, 2017 (South Korea)	This study utilized SoVI and SOM to examine social vulnerability in the South Korea	Climate/ Environment/ Disaster	administrative data	12	Yes	numeric	ordinal	NA	NA
Martínez, 2020 (Chile)	An event with characteristics similar to those of the 1730 earthquake (Mw 9.1) was modelled considering the worst-case scenario for the coast of central Chile	Climate/ Environment/ Disaster	census or geographical data	23	Yes	numeric	ordinal	NA	NA
Mavhura, 2017 (Zimbabwe)	The study demonstrates an accessible means to assessing the spatial variation of social vulnerability to flood hazards and related for the context of	Climate/ Environment/ Disaster	mixed	17	Yes	numeric	ordinal	NA	NA

	Muzarabani district in northeast Zimbabwe.								
Mavhura, 2018 (Zimbabwe)	to analyse the overall and subcomponents of resilience to identify wards that needed policy intervention.	Climate/ Environmen t/ Disaster	-	-	-	-	-	NA	NA
Mavhura, 2021 (Zimbabwe)	to quantify social vulnerability and model its underlying drivers respectively.	Climate/ Environmen t/ Disaster	-	-	-	-	-	NA	NA
Mavromatidi, 2018 (France)	The aim of this study is the superimposition of two widely used empirical indexes – the Coastal Sensitivity Index and the Social Vulnerability Index.	Climate/ Environmen t/ Disaster	administrativ e data	10	No	numeri c	ordinal	NA	NA
de Medeiros, 2016 (Brazil)	To map areas of social vulnerability and natural hazards in Natal, taking into account the interrelationships between social vulnerabilities and differentiated	Climate/ Environmen t/ Disaster	census or geographical data	26	No	numeri c	numeric	NA	NA

	exposure to natural hazards.								
Berra, 2017 (Brazil)	To analyze the spatial risk of tuberculosis mortality and to verify associations in high-risk areas with social vulnerability.	Health/ Medicine	-	-	-	-	-	Tuberculosis mortality	Positive
Moyano, 2021 (Argentina)	To analyze the relationship between social vulnerability and the healthy use of leisure time in children and adolescents in urban contexts of Argentina.	Health/ Medicine	representative survey	10	Yes	numeric	ordinal	Use of leisure time	Mixed
Nahas, 2000 (Brazil)	To develop a map of social exclusion.	Health/ Medicine	census or geographical data	11	Yes	numeric	numeric	NA	NA
Bendo, 2010 (Brazil)	To describe the prevalence of traumatic dental injury (TDI) and associated factors in the permanent incisors of Brazilian schoolchildren.	Health/ Medicine	-	-	-	-	-	TDI	SVI covariate (no association reported)

Bendo, 2010 (Brazil)	To investigate the association between treated/untreated TDI and the impact on the quality of life of 11-to-14-year-old Brazilian schoolchildren.	Health/ Medicine	-	-	-	-	-	TDI	SVI covariate (no association reported)
Bendo, 2012 (Brazil)	To test the association between social vulnerability and the prevalence of TDI.	Health/ Medicine	-	-	-	-	-	Untreated TDI	Negative
Fernandes Bolina, 2019 (Brazil)	To verify the occurrence and factors associated to social, individual and programmatic vulnerability among older adults.	Health/ Medicine	-	-	-	-	-	Education, living conditions and income	Negative
Freire-Maia, 2015 (Brazil)	To describe the association of oral health-related quality of life (OHRQoL) and domains (oral symptons, functional limitation, emotional- and social-well-being) of children with individual and contextual variables.	Health/ Medicine	-	-	-	-	-	OHRQoL	Negative
Jorge, 2015 (Brazil)	To determine the prevalence of	Health/ Medicine	-	-	-	-	-	Tobacco use	Positive

	tobacco, use and its association with types of friendship networks, socioeconomic status and gender among Brazilian adolescents.									
Jorge, 2009 (Brazil)	To assess the epidemiology of traumatic dental injuries (TDI) to primary teeth in infants and toddlers between 1 and 3 years of age and investigate whether TDI was related to biological and social factors.	Health/ Medicine	-	-	-	-	-	Dental injury	Positive
Jorge, 2012 (Brazil)	To investigate the prevalence of dental trauma, etiological factors, predisposing factors, and associations with socioeconomic status and the risk of alcohol and illicit drug use among adolescents in the city of Belo Horizonte, Brazil.	Health/ Medicine	-	-	-	-	-	NA	NA

Jorge, 2018 (Brazil)	To evaluate the prevalence of alcohol consumption, binge drinking and their association with social capital and socioeconomic factors among Brazilian adolescents students.	Health/ Medicine	-	-	-	-	-	Binge-drinking behavior.	Positive
Martins, 2019 (Brazil)	To determine the prevalence of malocclusion in adolescents and to test its association with social vulnerability.	Health/ Medicine	-	-	-	-	-	Dental crowding / malocclusion	Positive
Martins, 2014 (Brazil)	To assess caries experience among Brazilian children aged eight to 10 years and determine social factors of this disease, through a multilevel approach.	Health/ Medicine	-	-	-	-	-	Dental caries	Positive
Martins, 2015 (Brazil)	To evaluate the impact of dental caries and social determinants in the Oral Health Related Quality of Life (OHRQoL) of children in Belo Horizonte, Brazil.	Health/ Medicine	-	-	-	-	-	OHRQoL	Negative

Martins-Oliveira, 2016 (Brazil)	To evaluate the possible alcohol dependence and related problems among adolescents and determined possible associations with socioeconomic factors and gender.	Health/ Medicine	-	-	-	-	-	Consumption of alcohol	Positive
Serra-Negra, 2013 (Brazil)	To analyze the association between children's tasks, personality traits and sleep bruxism.	Health/ Medicine	-	-	-	-	-	NA	NA
Serra-Negra, 2010 (Brazil)	To investigate the prevalence of sleep bruxism in Brazilian schoolchildren.	Health/ Medicine	-	-	-	-	-	NA	NA
Serra-Negra, 2009 (Brazil)	To assess the prevalence of sleep bruxism in children and the influence of psychosocial factors.	Health/ Medicine	-	-	-	-	-	Bruxism	No association
Serra-Negra, 2011 (Brazil)	To compare self-reported dental fear among dental students and patients at a School of Dentistry in Belo Horizonte, Brazil.	Health/ Medicine	-	-	-	-	-	NA	NA
Silva-Oliveira, 2014 (Brazil)	To establish the prevalence of inhalant use among adolescents and its association with	Health/ Medicine	-	-	-	-	-	Marijuana use	No association

	marijuana use, alcohol consumption, socioeconomic status and gender.								
Viegas, 2010 (Brazil)	To assess the prevalence of traumatic dental injury (TDI) in primary teeth and determine predisposing factors.	Health/ Medicine	-	-	-	-	-	TDI	No association
Zarzar, 2012 (Brazil)	To examine the prevalence of binge drinking/alcohol consumption and its association with different types of friendship networks, gender and socioeconomic status among students in Belo Horizonte, Minas Gerais, Brazil.	Health/ Medicine	-	-	-	-	-	Binge drinking	Positive
Nelson, 2015 (USA)	This paper describes and illustrates a hybrid method for creating a social vulnerability index (SVI) at a tax parcel level by utilizing supplementary information about tax parcels to link	Climate/ Environment/ Disaster	census or geographical data	37 (1st SVI) 30 (2nd SVI)	Yes	numeric	ordinal	NA	NA

	cadastral dasymetric mapping techniques and established social vulnerability indexing methods.								
Nguyen, 2017 (Vietnam)	This paper proposes an approach to social vulnerability assessment using new empirical definitions of Social Vulnerability Index (SVI) components and new mechanism to aggregate and account for causal relationships among these components.	Climate/ Environment/ Disaster	other	26	Can't tell	numeric	numeric	NA	NA
Nguyen, 2019 (Canada)	To describe social vulnerability, to examine its correlation with the number of chronic conditions, and to investigate which chronic conditions were significantly associated with the most socially vulnerable state in patients with multimorbidity.	Health/ Medicine	clinical data	19	No	numeric	ordinal	Chronic conditions	Positive

Nicholson, 2019 (USA)	This paper presents a new social vulnerability index construction approach that utilizes geographically weighted local regression modeling and spatial clustering to determine location-specific weights of vulnerability indicators	Climate/ Environment/ Disaster	census or geographical data	24	Yes	numeric	numeric	NA	NA
Ogie, 2020 (Australia)	To present a strength-based social vulnerability index that identifies the strengths that communities have that help minimise disaster risk exposure.	Climate/ Environment/ Disaster	census or geographical data	18	No	numeric	numeric	NA	NA
Oulahen, 2015 (Canada)	To describe the process of ground truthing a social vulnerability index with practitioners working in five municipalities in Metro Vancouver and how the index was then revised to reflect their input.	Climate/ Environment/ Disaster	census or geographical data	20	Yes	numeric	numeric	NA	NA

Prabhu, 2022 (Kenya)	To adapt a Social Vulnerability Index (SVI) originally developed in Canada for use in a study of older women living with or without HIV infection in Mombasa, Kenya.	Health/ Medicine	other	16	No	numeric	numeric	NA	NA
Quezeda-Hofflinger, 2019 (Peru & Chile)	To develop the Response Time by Social Vulnerability Index and to provide an example of the application of ReTSVI in a potential case of a severe flood event in Huaraz, Peru.	Climate/ Environment/ Disaster	representative survey	20	No	numeric	numeric	Evacuation time	Positive
Reckien, 2018 (USA)	To investigate the outcome of the variable addition— both with and without weighting of single vulnerability factors—and the variable reduction approach/model on social vulnerability indices calculated for New York City.	Climate/ Environment/ Disaster	mixed	10 (1st SVI) 9 (2nd SVI)	Yes	numeric	numeric	NA	NA

Rifat, 2021 (USA)	To explore spatial distributions and patterns of COVID-19 case rates (cases/100,000 people) and mortality rates (deaths/100,000 people) and their disparities between urban and rural counties in the contiguous US.	Health/ Medicine	census or geographical data	28	No	numeric	numeric	Covid-19 case and mortality rates	Positive
Roder, 2017 (Italy)	To show the application of the SoVI to the floodplain of northern Italy, based on the use of 15 census variables.	Climate/ Environment/ Disaster	mixed	12	Yes	numeric	ordinal	NA	NA
Rodriquez, 2018 (Palestine)	To assess the social vulnerability and resilience level of the city of Nablus, an important urban center in Palestine	Climate/ Environment/ Disaster	census or geographical data	28	No	numeric	numeric	NA	NA
Roncancio, 2020 (Colombia)	To understand the pre-existing social vulnerability throughout the territory as a first step in national disaster risk reduction and	Climate/ Environment/ Disaster	census or geographical data	29	Yes	numeric	ordinal	NA	NA

	climate change adaptation planning.								
Sánchez-Garrido, 2021 (Mexico)	To analyze the association of the SVI with mortality and disability in Mexican middle-aged and older adults	Health/ Medicine	administrativ e data	42	No	numeri c	numeric	Mortality, disability	Positive
São Paulo Índice Paulista de Vulnerabilidade Social, 2010 (Brazil)	To describe the Indice Paulista de Vulnerabilidade Social (IPVS)	Health/ Medicine	census or geographical data	9	No	numeri c	numeric	NA	NA
Alves, 2020 (Brazil)	To analyze the association of cases of childhood tuberculosis with social vulnerability.	Health/ Medicine	-	-	-	-	-	Tuberculo sis cases in children	Positive
Andrade, 2022 (Brazil)	To analyse the spatiotemporal dynamics of human visceral leishmaniasis (HVL) in an endemic state in the Northeast Region of Brazil and its spatial correlation with the Social Vulnerability Index (SVI) and the	Health/ Medicine	-	-	-	-	-	HVL incidence rat.	Positive

	Municipal Human Development Index.								
Arroyo, 2017 (Brazil)	To identify spatial and space-time clusters of risk for tuberculosis and to characterize them according to social vulnerability.	Health/ Medicine	-	-	-	-	-	NA	NA
Baquero, 2018 (Brazil)	To evaluate the association between interpersonal violence notifications, animal abuse notifications and an index of social vulnerability in São Paulo City, on a geographic scale, using Bayesian spatial models.	Other	-	-	-	-	-	NA	NA
da Cunha, 2017 (Brazil)	To investigate how social vulnerability and oral-health status factors affect QoL in 15–19 years olds who participated in the "SB São Paulo 2015" state survey.	Health/ Medicine	-	-	-	-	-	Oral health status	No association
de Jesus, 2018 (Brazil)	To analyze the relationship between of frailty and the family social relationships of the	Health/ Medicine	-	-	-	-	-	NA	NA

		Health/Medicine							
	elderly in a context of social vulnerability.								
de Jesus, 2020\ (Brazil)	To report the impact of the 12-year rotavirus vaccine program on diarrhea mortality and hospitalizations and their correlation to socioeconomic indicators.	Health/ Medicine	-	-	-	-	-	Vaccination coverage	Mixed
Franco, 2021 (Brazil)	To characterize the food environment within subway stations in São Paulo and describe the availability of food and drinks according to the social vulnerability of the area where the stations are located.	Health/ Medicine	-	-	-	-	-	NA	NA
Freitas, 2016 (Brazil)	To evaluate the contextual effects of social vulnerability over anthropometric indexes related to global and central obesity in adults living in Ribeirão Preto, Brazil, in 2006.	Health/ Medicine	-	-	-	-	-	BMI and waist circumference	Positive

Macedo, 2015 (Brazil)	To analyse situations of socio-environmental vulnerability on intra-urban scale, in a group of 62 municipalities in the three main metropolitan regions of the Macro-metropolis of São Paulo State.	Climate/ Environment/ Disaster	-	-	-	-	-	NA	NA
Martinez, 2011 (Brazil)	To investigate the spatial association between teenage pregnancy rates and socioeconomic characteristics of municipalities in São Paulo State	Health/ Medicine	-	-	-	-	-	Teenage pregnancy	Negative
Nakamura, 2016 (Brazil)	To verify association between public and private places for engaging in different types of physical activity in adults of Rio Claro City, Brazil.	Health/ Medicine	-	-	-	-	-	Physical activity and physical leisure time	Positive
Sedrez, 2019 (Brazil)	To understand spatial segregation in the city of São Paulo (a city known by its social inequality and urban poverty) by scraping	Other	-	-	-	-	-	NA	NA

	social media tags of emotions.								
Schmitz, 2001 (Austria)	To establish a 6-point scale on the basis of the patient's history to estimate prognosis of a patient.	Health/ Medicine	clinical data	6	No	numeric	categorical	Diagnosis, duration of therapy and first contact with Community Mental Health Care Units	Positive
Shaji, 2021 (India)	To compute CSoVI for the coast of Thiruvananthapuram	Climate/ Environment/ Disaster	census or geographical data	11	No	numeric	numeric	NA	NA
Sharma, 2018 (USA)	To identify vulnerable neighborhoods in the City of Chicago.	Climate/ Environment/ Disaster	census or geographical data	28	Yes	ordinal	ordinal	NA	NA
Sharma, 2021 (India)	To identify socially vulnerable wards (administrative units) using a Social Vulnerability Index (SVI), developed based on 16 indicators using Principal Component Analysis.	Health/ Medicine	census or geographical data	16	Yes	numeric	numeric	NA	NA

Shega, 2012 (Canada)	To delineate the relationship between noncancer pain and cognitive impairment with social vulnerability.	Health/ Medicine	census or geographical data	39	No	numeric	numeric	Cognitive impairment, pain	Positive
Siagian, 2014 (Indonesia)	To quantify the social vulnerability of Indonesian districts to natural hazards, determining its driving factors and mapping its variations.	Climate/ Environment/ Disaster	mixed	10	Yes	numeric	ordinal	NA	NA
Snyder, 2020 (USA)	To develop a hierarchical socio-ecological vulnerability index that compares counties in the contiguous United States to capture a range of factors that might contribute to community vulnerability to Covid-19.	Mixed	census or geographical data	18	No	numeric	categorical	NA	NA

Solangaarachchi, 2012 (Australia)	To analyze the relative levels of social vulnerability of communities at the urban–bush interface in the Blue Mountains and Ku-ring-gai local council areas in New South Wales.	Climate/ Environment/ Disaster	census or geographical data	29	Yes	numeric	numeric	NA	NA
Stanturf, 2015 (Liberia)	To characterize vulnerability at the smallest scale practicable using the best available data while providing a national-scale assessment to highlight vulnerability "hot spots" in Liberia.	Health/ Medicine	census or geographical data	18	No	numeric	numeric	NA	NA
Su, 2015 (China)	To develop a composite index to measure social vulnerability of coastal cities.	Climate/ Environment/ Disaster	census or geographical data	17	No	numeric	numeric	NA	NA
Tanir, 2021 (USA)	To investigate spatiotemporal Socioeconomic flood vulnerability of the agricultural communities in the Potomac River Watershed (PRW)	Climate/ Environment/ Disaster	census or geographical data	13	Yes	numeric	categorical	NA	NA

Tascon-Gonzalez, 2020 (Spain)	To propose a methodology for the analysis of social vulnerability to floods based on the integration and weighting of a range of exposure and resistance (coping capacity) indicators, and to demonstrate the feasibility of the method using a study case.	Climate/ Environment/ Disaster	mixed	24	Yes	numeric	numeric	NA	NA
Tasnuva, 2021 (Bangladesh)	To construct a household-level social vulnerability at the microscale in the nine wards of Chalna Municipality (CM), Dacope upazila, in southwest coastal Bangladesh by employing the social vulnerability index.	Climate/ Environment/ Disaster	mixed	33	No	numeric	numeric	NA	NA
Tate, 2016 (USA)	To investigate post-flood property acquisition from the perspectives of cost effectiveness and social equity.	Climate/ Environment/ Disaster	census or geographical data	12	Yes	numeric	numeric	NA	NA

Toké, 2014 (USA)	To examine the social condition within regions of significant seismic hazard.	Climate/ Environmen t/ Disaster	census or geographical data	20	No	numeri c	numeric	NA	NA
Török, 2017 (Romania)	To contribute to the ongoing research on vulnerability by quantifying the social vulnerability of Romanian settlements in the face of natural disasters. To facilitate decision making process and planning efforts to increase resilience of local communities.	Climate/ Environmen t/ Disaster	census or geographical data	38	No	numeri c	numeric	NA	NA
Török, 2018 (Romania)	To investigates local-scale social vulnerability to flood hazards in Romania, aiming to identify the most vulnerable social and demographic groups across a wide range of geographical locations.	Climate/ Environmen t/ Disaster	census or geographical data	28	Yes	numeri c	categorica l	NA	NA
Török, 2021 (Romania)	To improve the existing methodology by quantifying the effects of climate	Climate/ Environmen t/ Disaster	census or geographical data	35	Yes	numeri c	numeric	NA	NA

	change on social vulnerability by developing a set of vulnerability indicators.								
Tragaki, 2018 (Greece)	To assess the physical and social vulnerability of the Peloponnese (Greece) to coastal hazards.	Climate/ Environment/ Disaster	census or geographical data	6	Yes	numeric	numeric	NA	NA
Varughese, 2021 (Canada)	To create a solid organ transplant frailty index (FI) and a social vulnerability index from assessment data and to evaluate associations between the FI and assessment, waitlist, and posttransplant outcomes.	Health/ Medicine	clinical data	10	No	numeric	numeric	Composite endpoint: death/delisting on transplant waitlist and death posttransplant	Mixed
Vincent, 2004 (Zambia)	To create an index to empirically assess relative levels of social vulnerability to climate change-induced variations in water availability and allow cross-country comparison in Africa.	Climate/ Environment/ Disaster	mixed	9	No	numeric	numeric	NA	NA

Wallace, 2015 (Multiple countries in Europe)	To investigate the SVI in relation to mortality and disability, independent of frailty, in middle-aged and older European adults, and examine how this relationship differs across countries.	Health/ Medicine	representative survey	32	No	numeric	numeric	mortality, disability	Positive
Godin, 2019 (Multiple countries in Europe)	To understand the association between social vulnerability and the odds of long-term care placement.	Health/ Medicine	-	-	-	-	-	Long term care placement	Mixed
Waly, 2021 (Egypt)	To analyse the social vulnerability of Alexandria city.	Climate/ Environment/ Disaster	mixed	14	Yes	numeric	ordinal	NA	NA
Ware, 2021 (South Africa)	To determine if parity is a predictor of social vulnerability in a large random sample of young women from an urban African township and (2) assess the relationships between parity, health, social vulnerability and	Health/ Medicine	representative survey	8	No	numeric	ordinal	Household food insecurity	Positive

	household food insecurity.								
Yang, 2015 (China)	To quantify regional social vulnerability to natural hazards and map its temporal–spatial distribution in China.	Climate/ Environment/ Disaster	census or geographical data	31	Yes	numeric	ordinal	NA	NA
Yuan, 2020 (Multiple countries in Africa)	To identify which factor of social vulnerability predominantly affects infant mortality.	Health/ Medicine	census or geographical data	6	unclear	numeric	ordinal	Infant mortality rate	Positive
Zarghami, 2021 (Australia)	To develop a hybrid model to aggregate vulnerability indicators and to construct a social vulnerability index which combines F'ANP and applies it to a real world case study in a developing country.	Climate/ Environment/ Disaster	census or geographical data	5	Yes	numeric	numeric	NA	NA

Zebardast, 2013 (Iran)	To assess social vulnerability (SV) to earthquake hazards, this paper presents the development of a hybrid factor analysis and analytic network process model for aggregating vulnerability indicators into a composite index of SV to earthquake hazards.	Climate/ Environment/ Disaster	administrative data	27	Yes	numeric	numeric	NA	NA
Zhang, 2013 (China)	To analyze the social vulnerability to hazards and the sensitivity of each influencing factors, to achieve risk prevention and mitigation and to elaborate the plan of effective risk response strategies in Beijing.	Climate/ Environment/ Disaster	census or geographical data	26	Yes	numeric	numeric	NA	NA
Zhang, 2017 (China)	To assess social vulnerability to earthquake disaster.	Climate/ Environment/ Disaster	census or geographical data	27	No	numeric	numeric	NA	NA

Zhang, 2014 (China)	To create an index system of social vulnerability to floods constructed from three dimensions: population, economy, and flood prevention.	Climate/ Environment/ Disaster	census or geographical data	36	No	numeric	numeric	NA	NA
Zhou, 2014 (China)	To investigate the county-level spatial and temporal patterns in social vulnerability in China from 1980 to 2010.	Climate/ Environment/ Disaster	census or geographical data	18	Yes	numeric	numeric	NA	NA
Zhu, 2014 (China)	To assess the spatial distribution of health vulnerability to heat waves .	Climate/ Environment/ Disaster	census or geographical data	13	Yes	numeric	numeric	NA	NA

Additional Files 4. Additional count and geographic information

Additional File 4a. Frequency and proportion of replications, in descending order

Reference (Original SVI)	All Replications		Environment or Disaster		Health or Medicine		Other	
Total number of studies	174		36		130		8	
	n	%	n	%	n	%	n	%
Flanagan BE, Gregory EW, Hallisey EJ, Heitgerd JL, Lewis B. A Social Vulnerability Index for Disaster Management. Journal of Homeland Security and Emergency Management. 2011 Jan 5	90	51.7	7	19.4	78	60.0	5	62.5
Cutter SL, Boruff BJ, Shirley WL. Social Vulnerability to Environmental Hazards. Social Science Quarterly. 2003 Jun;84(2):242–61.	24	13.8	20	55.6	3	2.3	1	12.5
Nahas, M.I.; Ribeiro, C.; Esteves, O.; Moscovitch, S.; Martins, V.L. The map of social exclusion in Belo Horizonte: Methodology of building an urban management	20	11.5	0	0.0	20	15.4	0	0.0

tool. Cad. Cienc. Soc. 2000, 7, 75–88.							
Brazilian Social Vulnerability Atlas (http://ivs.ipea.gov.br/index.php/pt/) IPEA (2015). Atlas da Vulnerabilidade Social nos Municípios Brasileiros. Brasília: Editorial IPEA	15	8.6	1	2.8	14	10.8	0	0.0
São Paulo Índice Paulista de Vulnerabilidade Social. Fundação Seade. Distribuição da população, segundo grupos do IPVS. São Paulo: Fundação Seade; 2010.	13	7.5	1	2.8	10	7.7	2	25.0
Mavhura, E., Manyena, B., & Collins, A. E. (2017). An approach for measuring social vulnerability in context: The case of flood hazards in Muzarabani district, Zimbabwe. Geoforum, 86, 103-117.	2	1.1	2	5.6	0	0.0	0	0.0
Andrew MK, Mitnitski A, Rockwood K. Social	2	1.1	0	0.0	2	1.5	0	0.0

Vulnerability, Frailty and Mortality in Elderly People. PLoS ONE. 2008;3(5).							
Armaș, I., & Gavriș, A. (2013). Social vulnerability assessment using spatial multi-criteria analysis (SEVI model) and the Social Vulnerability Index (SoVI model)–a case study for Bucharest, Romania. Natural hazards and earth system sciences, 13(6), 1481-1499.	1	0.6	1	2.8	0	0.0	0	0.0
Armstrong JJ, Andrew MK, Mitnitski A, Launer LJ, White LR, Rockwood K. Social vulnerability and survival across levels of frailty in the Honolulu-Asia Aging Study. Age and Ageing. 2015 Jul;44(4):709–12.	1	0.6	0	0.0	1	0.8	0	0.0
Chen W, Cutter SL, Emrich CT, Shi P. Measuring social vulnerability to natural hazards in the Yangtze River Delta region,	1	0.6	1	2.8	0	0.0	0	0.0

China. Int J Disaster Risk Sci. 2013 Dec;4(4):169–81.								
de Loyola Hummell BM, Cutter SL, Emrich CT. Social Vulnerability to Natural Hazards in Brazil. Int J Disaster Risk Sci. 2016 Jun;7(2):111–22.	1	0.6	1	2.8	0	0.0	0	0.0
Ge, Y., Dou, W., & Dai, J. (2017). A new approach to identify social vulnerability to climate change in the Yangtze River delta. Sustainability, 9(12), 2236.	1	0.6	1	2.8	0	0.0	0	0.0
Hazards and Vulnerability Research Institute at the University of South Carolina. SoVI®: Social Vulnerability Index for the United States 2010–14 [Internet]. 2016 [cited 2022 Jan 27]. Available from: https://www.sc.edu/study/colleges_schools/artsandsciences/centers_a	1	0.6	1	2.8	0	0.0	0	0.0

nd_institutes/hvri/data_ and_resources/sovi/								
de Medeiros, M. D., & de Almeida, L. Q. (2016). Vulnerabilidade socioambiental no município de Natal, RN, BR. REDE-Revista Eletrônica do PRODEMA, 9(2).	1	0.6	0	0.0	1	0.8	0	0.0
Wallace, L.M.K., Theou, O., Pena, F. et al. Social vulnerability as a predictor of mortality and disability: cross-country differences in the survey of health, aging, and retirement in Europe (SHARE). Aging Clin Exp Res 27, 365–372 (2015).	1	0.6	0	0.0	1	0.8	0	0.0

a. Original SVIs by country

b. Replicated SVIs by country

c. SVIs in Health or Medicine by country

d. SVIs in Environment, Climate, or Disasters by country

Frequency
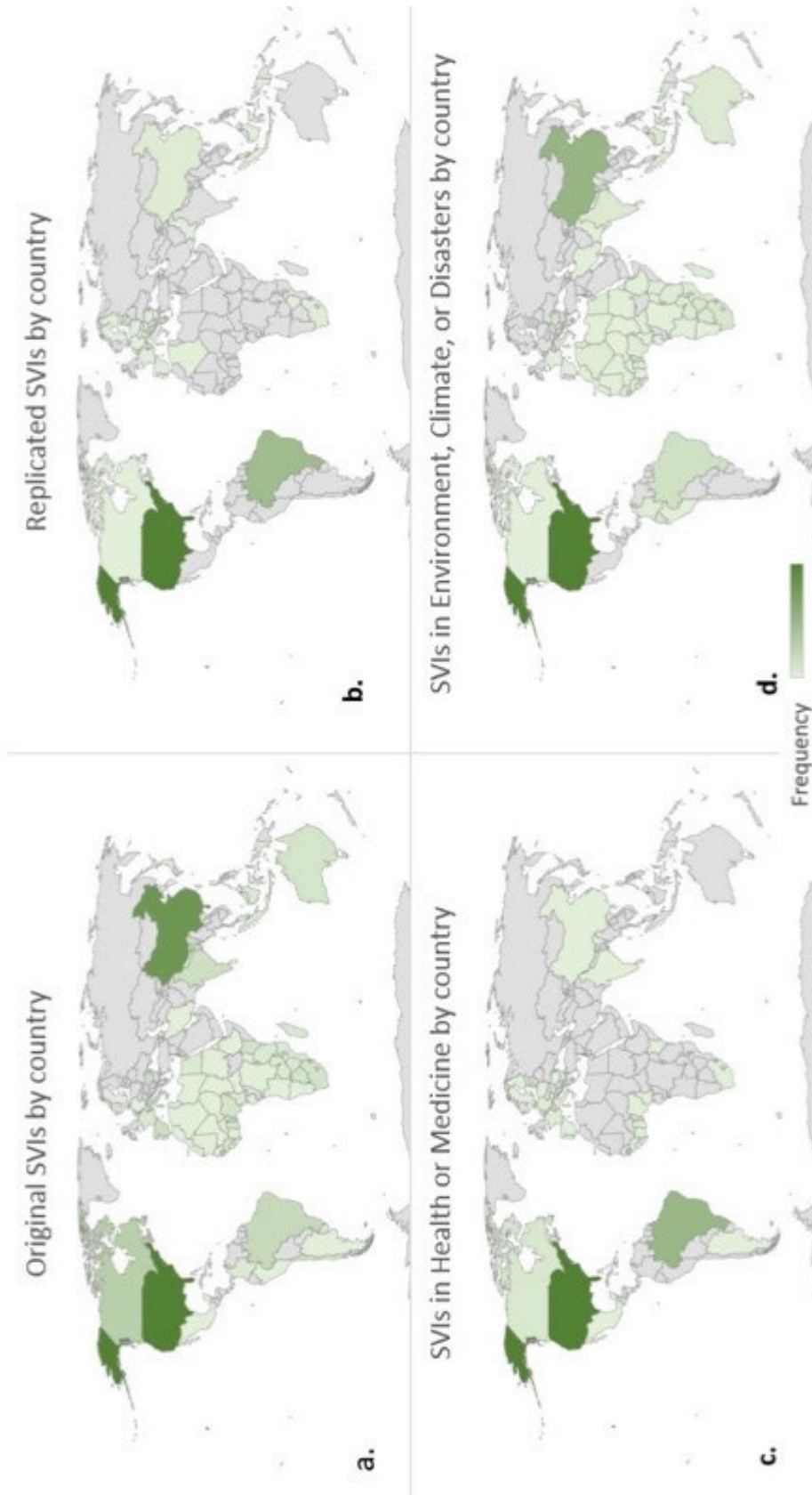
Additional File 5. Items (proportion of the domain) and domains (proportion of all SVIs)

Domain	Item	All (n = 121)		Environment, Climate or Disaster (n = 92)		Health or Medicine (n = 27)		Other (n = 2)	
		n	%	n	%	n	%	n	%
At risk populations		**92**	**76.0**	**80**	**87.0**	**11**	**40.7**	**1**	**50.0**
	Seniors or Elderly	78	84.8	73	91.3	4	36.4	1	100.0
	Children	76	82.6	71	88.8	4	36.4	1	100.0
	Dependents	50	54.3	44	55.0	6	54.5	0	0.0
	Institutionalized	14	15.2	12	15.0	2	18.2	0	0.0
	Child Laborers	3	3.3	2	2.5	0	0.0	1	100.0
	Teen Pregnancy	2	2.2	0	0.0	1	9.1	1	100.0
	Victims of Domestic Violence	1	1.1	0	0.0	1	9.1	0	0.0
Education		**90**	**74.4**	**68**	**73.9**	**20**	**74.1**	**2**	**100.0**

Micro Level Socioeconomic Status		80	66.1	58	63.0	20	74.1	2	100.0
	Income or Wealth	75	93.8	54	93.1	19	70.4	2	100.0
	Income Assistance	19	23.8	16	27.6	3	11.1	0	0.0
	Land Size	11	13.8	11	19.0	0	0.0	0	0.0
	Savings or Debt	5	6.3	5	8.6	0	0.0	0	0.0
	Food Insecurity	3	3.8	2	3.4	1	3.7	0	0.0
	Access to Banking	1	1.3	0	0.0	1	3.7	0	0.0
Household Composition		75	62.0	54	58.7	20	74.1	1	50.0
	Size of Household	50	66.7	46	85.2	4	20.0	0	0.0
	Single Parent or Female-Headed Household	35	46.7	31	57.4	3	15.0	1	100.0
	Lives Alone	17	22.7	3	5.6	14	70.0	0	0.0
	Child-Headed Household	2	2.7	2	3.7	0	0.0	0	0.0
Employment		74	61.2	63	68.5	9	33.3	2	100.0
	Unemployment	62	83.8	53	84.1	7	77.8	2	100.0

	Occupation	39	52.0	36	57.1	3	33.3	0	0.0
Housing		**68**	**56.2**	**56**	**60.9**	**12**	**44.4**	**0**	**0.0**
	Housing Materials or Condition	31	45.6	27	48.2	4	33.3	0	0.0
	House Ownership	29	42.6	25	44.6	4	33.3	0	0.0
	House Without Necessities	22	32.4	20	35.7	2	16.7	0	0.0
	Housing Type	22	32.4	17	30.4	5	41.7	0	0.0
	Housing Price	9	13.2	9	16.1	0	0.0	0	0.0
	Housing Vacancy	4	5.9	4	7.1	0	0.0	0	0.0
	Group Housing	3	4.4	1	1.8	2	16.7	0	0.0
	Homelessness	1	1.5	0	0.0	1	8.3	0	0.0
Population Health Statistics		**67**	**55.4**	**56**	**60.9**	**9**	**33.3**	**2**	**100.0**
	Migration	30	44.8	27	48.2	3	33.3	0	0.0
	Average Age	17	25.4	14	25.0	2	22.2	1	50.0
	Population Growth	16	23.9	15	26.8	1	11.1	0	0.0
	Total Population	12	17.9	12	21.4	0	0.0	0	0.0
	Birth Rate	6	9.0	5	8.9	1	11.1	0	0.0

	Mortality Rate	6	9.0	2	3.6	3	33.3	1	50.0
	Life Expectancy	2	3.0	2	3.6	0	0.0	0	0.0
Gender or Sex		**60**	**49.6**	**56**	**60.9**	**3**	**11.1**	**1**	**50.0**
Density		**57**	**47.1**	**53**	**57.6**	**3**	**11.1**	**1**	**50.0**
	Population Density	47	82.5	44	83.0	2	66.7	1	100.0
	Urban or Rural	20	35.1	19	35.8	1	33.3	0	0.0
	Building Density	14	24.6	13	24.5	0	0.0	1	100.0
Micro Level Socioeconomic Status		**51**	**42.1**	**43**	**46.7**	**7**	**25.9**	**1**	**50.0**
	Community Poverty or Standard of Living	45	88.2	37	86.0	7	100.0	1	100.0
	Gross Domestic Product or Community Finances	6	11.8	6	14.0	0	9.0	0	0.0
	Trade	2	3.9	2	4.7	0	9.0	0	0.0

Healthcare Infrastructure		**49**	**40.5**	**40**	**43.5**	**8**	**29.6**	**1**	**50.0**
	Healthcare Facilities	32	65.3	26	65.0	5	62.5	1	100.0
	Medical Staff	21	42.9	20	50.0	1	12.5	0	0.0
	Health Insurance	14	28.6	10	25.0	3	37.5	1	100.0
	Public Health	6	12.2	5	12.5	1	12.5	0	0.0
	Basic Services	4	8.2	2	5.0	2	25.0	0	0.0
	Health Expenditure	2	4.1	2	5.0	0	0.0	0	0.0
	Avoidable Hospital Admissions	1	2.0	1	2.5	0	0.0	0	0.0
Transport		**40**	**33.1**	**31**	**33.7**	**9**	**33.3**	**0**	**0.0**
	Transport Infrastructure	23	57.5	19	61.3	4	44.4	0	0.0
	Road Infrastructure	12	30.0	11	35.5	1	11.1	0	0.0
	Access to Railways, Roads or Transit (community)	8	20.0	7	22.6	1	11.1	0	0.0

	Able to Get Places (Individual)	4	10.0	0	0.0	4	44.4	0	0.0
Ethnicity or Race		39	32.2	36	39.1	2	7.4	1	50.0
Water and Waste		32	26.4	29	31.5	2	7.4	1	50.0
	Water Infrastructure & Safety	26	81.3	24	82.8	2	100.0	0	0.0
	Waste Infrastructure and Collection	24	75.0	21	72.4	2	100.0	1	100.0
Social connection and capital		26	21.5	10	10.9	16	59.3	0	0.0
	Relationships with Family	15	57.7	1	10.0	14	87.5	0	0.0
	Relationships with Friends	15	57.7	2	20.0	13	81.3	0	0.0
	General Relationships	12	46.2	4	40.0	8	50.0	0	0.0

Emotional Support Available	10	38.5	0	0.0	10	62.5	0	0.0
General Support Available to Help	7	26.9	1	10.0	6	37.5	0	0.0
Relationships with Neighbours	7	26.9	1	10.0	6	37.5	0	0.0
Telephone Use	6	23.1	0	0.0	6	37.5	0	0.0
Ability to Give	5	19.2	3	30.0	2	12.5	0	0.0
Specific Task Support Available	5	19.2	0	0.0	5	31.3	0	0.0
Help Availiable in a Crisis	4	15.4	0	0.0	4	25.0	0	0.0
Relationships with Children	4	15.4	1	10.0	3	18.8	0	0.0
Community Social Support	3	11.5	2	20.0	1	6.3	0	0.0
Loving Support Availiable	3	11.5	0	0.0	3	18.8	0	0.0
Relationships with Community	3	11.5	2	20.0	1	6.3	0	0.0

	Relationships with Spouse	3	11.5	0	0.0	3	18.8	0	0.0
Individual Communication		**25**	**20.7**	**13**	**14.1**	**12**	**44.4**	**0**	**0.0**
	Ability to Communicate (Oral or Written)	24	96.0	13	100.0	11	91.7	0	0.0
	Sensory Problems	1	4.0	0	0.0	1	8.3	0	0.0
Disaster Preparedness		**23**	**19.0**	**20**	**21.7**	**3**	**11.1**	**0**	**0.0**
	Access to Internet, Phone or Radio	20	87.0	17	85.0	3	100.0	0	0.0
	Community Disaster Resources	7	30.4	7	35.0	0	0.0	0	0.0
	First Responders	3	13.0	3	15.0	0	0.0	0	0.0
Marital Status		**22**	**18.2**	**10**	**10.9**	**12**	**44.4**	**0**	**0.0**
Land Use		**21**	**17.4**	**21**	**22.8**	**0**	**0.0**	**0**	**0.0**
	General Land Use	12	57.1	12	57.1	0	0.0	0	0.0

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	Farming or Soil Use	11	52.4	11	52.4	0	0.0	0	0.0
	Forest	5	23.8	5	23.8	0	0.0	0	0.0
	Green Space	3	14.3	3	14.3	0	0.0	0	0.0
	Ecological Land Use	1	4.8	1	4.8	0	0.0	0	0.0
Social Engagement		**19**	**15.7**	**5**	**5.4**	**14**	**51.9**	**0**	**0.0**
	Clubs or Community Centers	10	52.6	1	20.0	9	64.3	0	0.0
	Golf, Physical Leisure or Walking	10	52.6	0	0.0	10	71.4	0	0.0
	Church or Religion	9	47.4	0	0.0	9	64.3	0	0.0
	Amount of Social Engagement	9	47.4	2	40.0	7	50.0	0	0.0
	Volunteering	8	42.1	2	40.0	6	42.9	0	0.0
	Feelings Towards Social Engagement	6	31.6	2	40.0	4	28.6	0	0.0
	Activities Around the Home (i.e. Garden)	5	26.3	0	0.0	5	35.7	0	0.0
	Cards or Games	5	26.3	0	0.0	5	35.7	0	0.0

	Hobby, Project or Further Education	3	15.8	0	0.0	3	21.4	0	0.0
	Pets	1	5.3	0	0.0	1	7.1	0	0.0
Power Sources		**19**	**15.7**	**18**	**19.6**	**1**	**3.7**	**0**	**0.0**
	Power and Electricity Infrastructure	15	78.9	14	77.8	1	100.0	0	0.0
	Biomass	5	26.3	5	100.0	0	0.0	0	0.0
Personal Attitudes and Expectations		**13**	**10.7**	**1**	**1.1**	**12**	**44.4**	**0**	**0.0**
	Control	10	76.9	0	0.0	10	83.3	0	0.0
	Expectations of Self and Others	8	61.5	1	100.0	7	58.3	0	0.0
	Satisfaction with Life	7	53.8	0	0.0	7	58.3	0	0.0
	Attitude Towards Life	6	46.2	0	0.0	6	50.0	0	0.0

	Self Worth or Self Esteem	3	23.1	0	0.0	3	25.0	0	0.0
	Major Life Events	1	7.7	0	0.0	1	8.3	0	0.0
	Hope for the Future	0	0.0	0	0.0	0	0.0	0	0.0
Industry		**13**	**10.7**	**13**	**14.1**	**0**	**0.0**	**0**	**0.0**
	Tourism or Hospitality	8	61.5	8	61.5	0	0.0	0	0.0
	Specific Industries (e.g. Cotton)	3	23.1	3	23.1	0	0.0	0	0.0
	General Industries (e.g. Primary)	3	23.1	3	23.1	0	0.0	0	0.0
Environment and Climate Events		**13**	**10.7**	**12**	**13.0**	**0**	**0.0**	**1**	**50.0**
	Flood	7	53.8	7	58.3	0	0.0	0	0.0
	Extreme Weather	7	53.8	6	50.0	0	0.0	1	100.0
	Rainfall or Drought	5	38.5	5	41.7	0	0.0	0	0.0
	Landslides	2	15.4	2	16.7	0	0.0	0	0.0

Category		n	%	n	%	n	%	n	%
Government Aptitude and Investments		**9**	**7.4**	**9**	**7.4**	**0**	**0.0**	**0**	**0.0**
	School Infrastructure	6	66.7	6	66.7	0	0.0	0	0.0
	Capacity for Governance	2	22.2	2	22.2	0	0.0	0	0.0
	Corruption	2	22.2	2	22.2	0	0.0	0	0.0
	Research and Development Infrastructure	1	11.1	1	11.1	0	0.0	0	0.0
Isolation or Loneliness		**8**	**6.6**	**0**	**0.0**	**8**	**29.6**	**0**	**0.0**
Health Conditions		**8**	**6.6**	**5**	**5.4**	**2**	**7.4**	**1**	**50.0**
	Chronic Health Conditions or their Risk Factors	4	50.0	2	40.0	1	50.0	1	100.0
	HIV / AIDS	3	37.5	3	60.0	0	0.0	0	0.0
	Poor Mental Health	2	25.0	1	20.0	1	50.0	0	0.0

	Specific Disease Incidence	1	12.5	1	20.0	0	0.0	0	0.0
	Specific Disease after Flood	1	12.5	1	20.0	0	0.0	0	0.0
	Adherence to Medical Advice	1	12.5	0	0.0	1	50.0	0	0.0
Political Stability		**6**	**5.0**	**3**	**3.3**	**3**	**11.1**	**0**	**0.0**
	Refugees Displaced	5	83.3	3	100.0	2	66.7	0	0.0
	Political Armed Conflict	1	16.7	0	0.0	1	33.3	0	0.0
Noise or Air Pollution		**3**	**2.5**	**0**	**0.0**	**2**	**7.4**	**1**	**50.0**

* In this table, the unit is individual SVI (total studies remain 118)

Chapter 4

Appendix 1. Screening SVI variables in the CLSA

#	CLSA Domain	Item	Categories	Coding	Missing %	Weighted values				
						%	% 95% CI		N	Total
							Lower bound	Upper bound		
1	Socio-Demographic	Marital status	Yes	0	0.1	75.78	75.04	76.51	10,347,052	13,650,465
			No	1		24.21	23.48	24.95	3,303,413	
2	Home Ownership	Home owner	Yes	0	0.2	85.64	84.99	86.27	11,659,200	13,620,561
			No	1		14.35	13.72	15	1,961,361	
3	Education	Education	College, university bachelor, graduate, or professional degree	0	0.2	41.92	41.07	42.77	5,719,170	13,643,058

			Trades or apprenticeship	0.33		13.46	12.88	14.05	1,836,356	
			High school	0.66		22.66	21.94	23.4	3,091,517	
			Less than high school	1		21.96	21	22.96	2,996,016	
4	Social Networks	Living alone	No	0	0.1	84.35	83.79	84.9	11,521,078	13,650,566
			Yes	1		15.65	15.10	16.21	2,129,488	
5		Child contact frequency	Within the last day or two or all children live in household	0	0.1	40.96	40.05	41.87	5,580,322	13,643,820
			Within the last week or two	0.2		28.02	27.21	28.84	3,833,913	
			Within the past month	0.4		8.43	7.96	8.93	1,146,081	
			Within the past 6 months	0.6		6.7	6.37	7.26	927,780	
			Within the past year	0.8		1.06	0.92	1.22	150,082	

			More than 1 year ago or no children	1		14.73	14.11	15.38	2,005,642	
6		Siblings contact frequency	Within the last day or two or all siblings live in household	0	0.1	11.51	10.93	12.11	1,569,018	13,643,631
			Within the last week or two	0.2		24.95	24.14	25.77	4,079,446	
			Within the past month	0.4		15.81	15.14	16.49	2,155,694	
			Within the past 6 months	0.6		21.56	20.84	22.31	2,933,381	
			Within the past year	0.8		6.55	6.11	7.01	886,836	
			More than 1 year ago or no siblings	1		19.63	18.93	20.34	2,674,152	
7			Within the last day or two or all	0	0.2	14.68	14.03	15.36	2,002,766	13,624,260

			Relatives contact frequency	relatives live in household							
				Within the last week or two	0.2		25.76	24.98	26.56	3,515,059	
				Within the past month	0.4		14.72	14.1	15.37	2,002,766	
				Within the past 6 months	0.6		21.18	20.45	21.94	2,888,343	
				Within the past year	0.8		7.46	6.97	7.98	1,021,820	
				More than 1 year ago or no relatives	1		16.19	15.52	16.87	2,207,130	
8			Friends contact frequency	Within the last day or two or all friends live in household	0	0.1	31.51	30.66	32.37	4,293,872	13,631,339
				Within the last week or two	0.2		39.24	38.35	40.14	5,343,485	
				Within the past month	0.4		11.03	10.51	11.59	1,499,447	

			Within the past 6 months	0.6		7.92	7.44	8.43	1,076,876	
			Within the past year	0.8		1.37	1.18	1.59	190,839	
			More than 1 year ago or no friends	1		8.92	8.39	9.47	1,213,189	
9		Neighbours contact frequency	Within the last day or two	0	5.5	23.72	22.95	24.52	3,038,741	12,821,690
			Within the last week or two	0.2		23.83	23.06	24.62	3,051,562	
			Within the past month	0.4		9.39	8.85	9.96	1,205,239	
			Within the past 6 months	0.6		10.3	9.73	10.9	1,320,634	
			Within the past year	0.8		3.39	3.02	3.79	435,937	
			More than 1 year ago or no neighbors	1		29.36	28.5	30.24	3,769,577	
10		Availability of	All the time	0	0.8	51.74	50.83	52.66	7,008,711	13,546,020
			Most of the time	0.25		26.08	25.3	26.87	3,532,802	

	Social Support Availability	support if confined in bed	Some of the time	0.5		13.53	12.94	14.14	1,832,777	
			A little of the time	0.75		4.7	4.32	5.11	636,663	
			None of the time	1		3.95	3.6	4.34	535,068	
11		Availability of someone to talk to if needed	All the time	0	0.2	60.82	59.94	61.7	8,285,796	13,623,472
			Most of the time	0.25		26.77	25.99	27.56	3,621,119	
			Some of the time	0.5		8.15	7.7	8.64	1,542,177	
			A little of the time	0.75		2.89	2.58	3.24	505,431	
			None of the time	1		1.36	1.17	1.58	498,619	
12		Availability of someone to have advice from in crisis	All the time	0	0.6	54.73	53.82	55.63	7,419,625	13,556,779
			Most of the time	0.25		26.58	25.79	27.39	3,603,392	
			Some of the time	0.5		11.32	10.79	11.88	1,534,627	
			A little of the time	0.75		3.71	3.4	4.04	502,957	
			None of the time	1		3.66	3.31	4.04	496,178	
13		Availability of someone	All the time	0	0.4	67.40	66.56	68.22	9,170,059	13,605,429
			Most of the time	0.25		20.70	20.01	21.41	2,816,324	
			Some of the time	0.5		7.26	6.81	7.73	987,754	

		that can take to the doctor if needed	A little of the time	0.75		2.37	2.12	2.65	322,449	
			None of the time	1		2.27	2	2.58	322,449	
14		Availability from someone that shows affection	All the time	0	0.2	76.20	75.45	76.94	10,383,842	13,627,089
			Most of the time	0.25		15.56	14.94	16.21	2,120,375	
			Some of the time	0.5		5.22	4.87	5.58	711,334	
			A little of the time	0.75		1.74	1.51	2	237,111	
			None of the time	1		1.28	1.10	1.48	174,427	
15		Availability of someone to have a good time	All the time	0	0.3	61.22	60.34	62.1	8,340,772	13,624,260
			Most of the time	0.25		25.36	24.58	26.16	3,455,112	
			Some of the time	0.5		10.06	9.56	10.59	1,370,601	
			A little of the time	0.75		2	1.79	2.24	272,485	
			None of the time	1		1.35	1.15	1.58	183,928	
16		Availability from	All the time	0	0.5	54.01	53.10	54.92	7,331,283	13,573,936
			Most of the time	0.25		30.17	29.35	31.01	4,095,256	

		someone that helps with informati on	Some of the time	0.5		11.42	10.88	11.98	1,550,143	
			A little of the time	0.75		2.77	2.47	3.1	375,998	
			None of the time	1		1.63	1.42	1.86	221,255	
17		Availabilit y of someone to confide	All the time	0	0.4	57.65	56.76	58.55	7,842,880	13,604,301
			Most of the time	0.25		25.61	24.84	26.39	3,484,061	
			Some of the time	0.5		10.72	10.19	11.27	1,458,381	
			A little of the time	0.75		3.82	3.49	4.17	519,140	
			None of the time	1		2.2	1.94	2.51	299,703	
18		Availabilit y of someone that hugs	All the time	0	0.3	63.59	62.72	64.44	8,658,767	13,616,555
			Most of the time	0.25		19.48	18.78	20.19	2,652,505	
			Some of the time	0.5		10.07	9.58	10.59	1,371,187	
			A little of the time	0.75		4.19	3.85	4.56	570,670	
			None of the time	1		2.68	2.4	2.98	364,243	
19		Availabilit y of someone	All the time	0	0.4	51.54	50.63	52.46	7,014,082	13,609,007
			Most of the time	0.25		28.61	27.81	29.42	3,893,537	
			Some of the time	0.5		14.29	13.7	14.9	1,944,727	

		to relax with	A little of the time	0.75		3.43	3.12	3.78	467,333	
			None of the time	1		2.13	1.87	2.42	289,464	
20		Availability of someone that prepares a meal	All the time	0	0.7	58.11	57.23	59	7,880,108	13,560,675
			Most of the time	0.25		22.06	21.35	22.79	2,991,485	
			Some of the time	0.5		11.70	11.18	12.25	1,586,599	
			A little of the time	0.75		4.47	4.13	4.84	606,433	
			None of the time	1		3.65	3.34	3.99	495,100	
21		Availability of someone that gives wanted advice	All the time	0	0.7	45.87	44.96	46.79	6,211,864	13,542,325
			Most of the time	0.25		28.21	27.41	29.01	3,820,290	
			Some of the time	0.5		16.89	16.23	17.56	2,287,299	
			A little of the time	0.75		5.44	5.04	5.87	736,432	
			None of the time	1		3.6	3.26	3.97	486,982	
22		Availability of someone to do	All the time	0	0.6	44.57	43.65	45.49	6,054,918	13,585,188
			Most of the time	0.25		30.62	29.81	31.45	4,159,785	
			Some of the time	0.5		18.09	17.42	18.79	2,457,561	
			A little of the time	0.75		4.2	3.88	4.55	570,850	

		things with	None of the time	1		2.51	2.23	2.84	341,396	
23		Availability of someone that helps with domestic chores	All the time	0	0.6	51.79	50.87	52.7	7,031,118	13,576,207
			Most of the time	0.25		26.27	25.48	27.08	3,566,470	
			Some of the time	0.5		14.34	13.75	14.96	1,946,828	
			A little of the time	0.75		4.64	4.3	5	629,800	
			None of the time	1		2.96	2.66	3.28	401,448	
24		Availability of someone with whom to share fears	All the time	0	0.7	53.26	52.35	54.17	7,225,053	13,565,628
			Most of the time	0.25		24.41	23.65	25.19	3,311,370	
			Some of the time	0.5		12.68	12.12	13.26	1,720,122	
			A little of the time	0.75		5.22	4.86	5.61	708,668	
			None of the time	1		4.42	4.05	4.83	600,143	
25		Availability of someone who gives	All the time	0	0.5	50.45	49.53	51.36	6,852,124	13,582,009
			Most of the time	0.25		28.48	27.67	29.3	3,868,156	
			Some of the time	0.5		14.18	13.58	14.8	1,925,929	
			A little of the time	0.75		4.24	3.89	4.62	576,013	

		suggestio ns	None of the time	1		2.66	2.38	2.96	360,602	
26		Availabilit y of someone to do somethin g enjoyable together	All the time	0	0.3	53.9	52.99	54.8	7,338,401	13,614,845
			Most of the time	0.25		30.38	29.57	31.2	4,136,190	
			Some of the time	0.5		12.44	11.88	13.03	1,693,687	
			A little of the time	0.75		2.06	1.83	2.32	280,602	
			None of the time	1		1.22	1.01	1.46	165,557	
27		Availabilit y of someone that understa nds problems	All the time	0	0.7	47.29	46.37	48.21	6,408,040	13,550,518
			Most of the time	0.25		31.82	31	32.65	4,311,775	
			Some of the time	0.5		15.02	14.4	15.66	2,035,288	
			A little of the time	0.75		3.58	3.27	3.92	485,244	
			None of the time	1		2.28	2	2.61	309,358	
28		Availabilit y of someone	All the time	0	0.4	67.1	66.24	67.92	9,127,896	13,607,477
			Most of the time	0.25		20.45	19.74	21.17	2,782,729	
			Some of the time	0.5		7.60	7.16	8.06	1,033,760	

		that makes one feel wanted	A little of the time	0.75		2.75	2.48	3.06	374,614	
			None of the time	1		2.12	1.88	2.38	287,934	
29		Pet owner	Yes	0	0.3	50.3	49.38	51.21	6,854,561	13,627,357
			No	1		49.7	48.79	50.62	6,772,796	
30	Social Participation	Reads newspaper	Yes	0	0.1	57.25	56.33	58.17	7,814,949	13,650,566
			No	1		42.75	41.83	43.67	5,835,617	
31		Hobby	Yes	0	0.1	90.11	89.50	90.69	12,300,525	13,650,566
			No	1		9.89	9.31	10.50	1,349,904	
32		Holidays in Canada	Yes	0	0.1	65.93	65.04	66.81	8,999,818	13,650,566
			No	1		34.07	33.19	34.96	4,650,748	
33		Holidays outside of Canada	Yes	0	0.1	51.32	50.41	52.24	7,005,470	13,650,566
			No	1		48.68	47.76	49.59	6,645,096	
34		Day trip	Yes	0	0.1	90.7	90.17	91.21	12,381,063	13,650,566
			No	1		9.3	8.79	9.83	1,269,776	

35		Internet use	Yes	0	0.1	85.25	84.52	85.95	11,637,108	13,650,566
			No	1		14.75	14.05	15.48	2,013,458	
36		Voted in last election	Yes	0	0.1	91.82	91.25	92.36	12,533,950	13,650,566
			No	1		8.18	7.64	8.75	1,116,616	
37		Family and friends' activities	At least once a day	0	0.1	3.8	3.46	4.17	517,695	13,641,496
			At least once a week	0.25		43.99	43.09	44.89	6,000,894	
			At least once a month	0.5		39.97	39.07	40.88	5,452,506	
			At least once a year	0.75		10.47	9.88	11.08	1,428,265	
			Never	1		1.78	1.54	2.05	242,682	
38		Sports or physical activities	At least once a day	0	0.2	7.9	7.42	8.41	1,077,563	13,638,309
			At least once a week	0.25		39.95	39.07	40.83	5,448,504	
			At least once a month	0.5		15.31	14.68	15.97	2,088,025	

				At least once a year	0.75		7.4	6.9	7.93	1,008,962	
				Never	1		29.44	28.59	30.31	4,015,118	
39			Educational or cultural activities	At least once a day	0	0.1	0.63	0.5	0.8	86,073	13,640,666
				At least once a week	0.25		7.6	7.19	8.03	1,036,691	
				At least once a month	0.5		33.44	32.61	34.27	4,561,439	
				At least once a year	0.75		35.21	34.34	36.09	4,802,878	
				Never	1		23.12	22.28	23.99	3,153,722	
40			Neighbor, community, or profession activities	At least once a day	0	0.3	0.63	0.52	0.77	86,410	13,627,184
				At least once a week	0.25		6.98	6.57	7.41	951,041	
				At least once a month	0.5		16.69	16.07	17.34	2,274,377	
				At least once a year	0.75		19.88	19.18	20.59	2,709,084	
				Never	1		55.82	54.92	56.71	7,606,694	

41		Volunteer	At least once a day	0	0.2	1.50	1.33	1.70	205,095	13,636,611
			At least once a week	0.25		14.49	13.90	15.11	1,975,945	
			At least once a month	0.5		17.87	17.22	18.54	2,436,862	
			At least once a year	0.75		20.15	19.44	20.88	2,747,777	
			Never	1		45.98	45.07	46.90	6,270,114	
42		Other recreation activities	At least once a day	0	0.1	4.25	3.88	4.66	525,523	12,359,438
			At least once a week	0.25		42.45	41.52	43.39	5,246,581	
			At least once a month	0.5		25.03	24.22	25.85	3,093,567	
			At least once a year	0.75		12.7	12.04	13.4	1,569,649	
			Never	1		15.56	14.88	16.28	1,923,129	
43	Income	Personal income	≥150,000 CAD	0	4.2	3.42	3.13	3.74	445,716	13,028,831
			100,000-149,9999 CAD	0.25		6.64	6.23	7.08	865,766	

			50,000-9,999 CAD	0.5		28.56	27.74	29.4	3,721,034	
			20,000-49,999 CAD	0.75		28.95	38.04	39.87	5,074,730	
			<20,000 CAD	1		22.42	21.59	23.28	2,921,064	
44		Household income	≥150,000 CAD	0	5.3	13.31	12.71	13.94	1,718,704	12,912,874
			100,000-149,9999 CAD	0.25		17.60	16.91	18.32	2,272,666	
			50,000-9,999 CAD	0.5		35.73	34.82	36.64	4,613,770	
			20,000-49,999 CAD	0.75		26.56	25.72	27.41	3,429,659	
			<20,000 CAD	1		6.80	6.33	7.30	877,946	
45	Online Social Networking	Internet access	Yes	0	0.2	89.40	90.03	11.27	11,027,309	12,334,797
			No	1		10.60	9.97	11.27	1,307,488	
46		E-mail frequency	Daily	0	0.3	65.18	64.23	66.11	8,032,614	12,323,740
			A few times a week	0.25		13.37	12.72	14.04	1,647,684	

#			Category	Option	Value	Threshold	Mean	Lower	Upper	Count	Total
				A few times a month	0.5		4.56	4.15	5.01	561,470	
				A few times a year	0.75		1.37	1.17	1.6	168,466	
				Never	1		15.33	14.78	16.32	1,913,877	
47			Websites frequency	Daily	0	0.3	61.25	60.3	62.19	7,548,870	12,324,685
				A few times a week	0.25		17.81	17.09	18.56	2,195,026	
				A few times a month	0.5		5.44	5.03	5.89	670,956	
				A few times a year	0.75		2.05	1.73	2.42	252,040	
				Never	1		13.45	12.77	14.16	1,657,670	
48			Websites health related frequency	Daily	0	0.5	4.13	3.79	4.50	508,251	12,303,351
				A few times a week	0.25		13.63	12.97	14.31	1,676,947	
				A few times a month	0.5		28.94	28.11	29.79	3,560,590	
				A few times a year	0.75		27.70	26.87	28.55	3,408,028	

			Never	1		25.59	24.73	26.48	3,148,428	
49		Use of social networks	Yes	0	0.3	49.21	48.25	50.16	6,071,626	12,338,195
			No	1		50.79	49.84	51.75	6,266,569	
50		Making friends in social networks frequency	Daily	0	0.3	0.92	0.67	1.25	113,307	12,336,044
			A few times a week	0.25		0.66	0.51	0.85	80,801	
			A few times a month	0.5		0.77	0.62	0.95	94,420	
			A few times a year	0.75		1	0.77	1.29	122,842	
			Never	1		96.67	96.19	97.08	11,925,254	
51		Stay in touch with friends in social networks frequency	Daily	0	0.4	18.62	17.87	19.38	2,295,219	12,326,632
			A few times a week	0.25		11.85	11.26	12.47	1,460,706	
			A few times a month	0.5		5.33	4.93	5.76	657,256	
			A few times a year	0.75		1.50	1.28	1.75	184,776	
			Never	1		62.70	61.77	63.62	7,728,798	

52		Stay in touch with family in social networks frequency	Daily	0	0.4	17.51	16.79	18.26	2,157,460	12,321,300
			A few times a week	0.25		11.87	11.28	12.49	1,462,538	
			A few times a month	0.5		5.58	5.17	6.03	687,652	
			A few times a year	0.75		1.97	1.72	2.25	242,360	
			Never	1		63.07	62.14	63.99	7,771,044	
53		Promotion in social networks frequency	Daily	0	0.2	2.74	2.46	3.05	338,110	12,335,267
			A few times a week	0.25		2.47	2.17	2.80	304,311	
			A few times a month	0.5		2.47	2.17	2.80	335,643	
			A few times a year	0.75		1.20	0.95	1.51	148,023	
			Never	1		90.87	90.29	91.42	11,200,422	
54		Other activities in social	Daily	0	0.3	3.22	2.92	3.54	397,092	12,335,889
			A few times a week	0.25		1.33	1.15	1.53	163,821	

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No	Category	Measure	Response						Count	Total
		networks frequency	A few times a month	0.5		0.59	0.48	0.74	73,090	
			A few times a year	0.75		0.20	0.14	0.37	27,768	
			Never	1		94.63	94.23	95.02	11,673,452	
55	Built Environments	Home problems	No	0	0.1	78.58	77.80	79.34	9,712,785	12,360,378
			Yes	1		21.42	20.66	22.20	2,647,593	
56		Home satisfaction	Strongly agree	0	0.5	64.34	63.42	65.25	7,913,527	12,299,544
			Agree	0.33		31.46	30.57	32.36	3,869,437	
			Disagree	0.66		3.29	2.97	3.65	404,778	
			Strongly disagree	1		0.90	0.70	0.11	112,098	
57		Feels part of the area	Strongly agree	0	1.3	46.13	45.17	47.09	5,628,729	12,201,884
			Agree	0.33		47.77	46.82	48.73	5,828,840	
			Disagree	0.66		5.26	4.87	5.68	642,063	
			Strongly disagree	1		0.83	0.70	1	101,764	
58		Vandalism	Strongly disagree	0	1.3	41.57	40.63	42.51	5,101,394	12,271,816

			Disagree	0.33		52.15	51.19	53.10	6,399,752	
			Agree	0.66		5.39	5	5.81	661,942	
			Strongly agree	1		0.89	0.75	1.07	109,808	
59		Feel lonely in the area	Strongly disagree	0	0.9	36.39	35.48	37.31	4,462,998	12,264,352
			Disagree	0.33		55.27	54.32	56.22	6,778,507	
			Agree	0.66		7.27	6.80	7.75	891,005	
			Strongly agree	1		1.07	0.90	1.26	131,106	
60		Most people trusted in the area	Strongly agree	0	2.4	36.95	36.01	37.89	4,452,673	12,050,537
			Agree	0.33		58.27	57.31	59.23	7,021,848	
			Disagree	0.66		4.04	3.65	4.47	487,203	
			Strongly disagree	1		0.74	0.60	0.92	89,078	
61		Afraid to walk in the area	Strongly disagree	0	1.9	32.97	32.07	33.89	4,000,277	12,133,082
			Disagree	0.33		55.71	54.75	56.66	6,759,340	
			Agree	0.66		9.75	9.20	10.33	1,182,975	
			Strongly agree	1		1.57	1.34	1.84	190,732	
62			Strongly agree	0	1.1	35.72	34.82	36.64	4,370,131	12,234,409
			Agree	0.33		61.98	61.06	62.90	7,582,887	

			Response							
		Friendly people in the area	Disagree	0.66		2	1.74	2.29	244,199	
			Strongly disagree	1		0.30	0.22	0.41	36,459	
63		People take advantage in the area	Strongly disagree	0	1.8	32.32	31.42	33.22	3,924,797	12,143,554
			Disagree	0.33		62.92	61.99	63.85	7,640,724	
			Agree	0.66		4.21	3.80	4.65	510,879	
			Strongly agree	1		0.50	0.43	0.70	66,972	
64		Clean area	Strongly agree	0	0.8	32.38	31.49	33.29	3,972,454	12,268,234
			Agree	0.33		63.90	62.98	64.82	7,839,402	
			Disagree	0.66		3.28	2.96	3.63	401,907	
			Strongly disagree	1		0.40	0.33	0.58	54,054	
65		Help available in the area	Strongly agree	0	3.2	33.43	32.53	34.35	3,999,244	11,963,039
			Agree	0.33		61.54	60.60	62.48	7,362,054	
			Disagree	0.66		4.48	4.11	4.89	536,064	
			Strongly disagree	1		0.54	0.41	0.72	64,959	
66	Wealth	Savings	Yes	0	0.1	98.76	98.44	99.02	12,207,254	12,360,525

			No	1		1.24	0.98	1.56	153,023	
67		Life insurance	Yes	0	0.9	75.78	74.97	76.57	9,280,233	12,246,283
			No	1		24.22	23.43	25.03	2,966,050	
68		Assets	Yes	0	0.9	91.71	91.12	92.26	11,335,837	12,360,525
			No	1		8.29	7.74	8.88	1,025,058	
69		Debts	No	0	0.1	52.51	51.56	53.46	6,490,512	12,360,525
			Yes	1		47.49	46.54	48.44	5,870,013	
70		Self-rated financial status	Manage very well	0	0.8	38.50	37.59	39.43	4,716,910	12,251,713
			Manage quite well	0.2		34.39	33.50	35.30	4,213,364	
			Get by alright	0.4		22.13	21.29	22.98	2,711,304	
			Don't manage very well	0.6		1.25	1.07	1.46	152,779	
			Have some financial difficulties	0.8		3.20	2.87	3.57	392,300	
			Have severe financial difficulties	1		0.53	0.43	0.66	64,726	

71		Adequate income for basic needs	Very well	0	0.9	48.15	47.20	49.11	5,897,777	12,248,759
			Adequately	0.25		40.83	39.88	41.79	5,001,168	
			With some difficulty	0.5		8.36	7.83	8.93	1,024,486	
			Not very well	0.75		1.75	1.53	1.99	213,863	
			Totally inadequately	1		0.90	0.75	1.10	111,194	
72		Little money stops from doing things	No	0	0.1	64.72	63.79	65.64	7,999,732	12,360,525
			Yes	1		35.28	34.36	36.21	4,360,793	
73		Insufficient financial resources in the future	Little or no possibility	0	2.5	61.27	60.33	62.21	7,383,815	12,051,273
			Some possibility	0.5		33.06	32.16	33.98	3,984,151	
			High possibility	1		5.66	5.23	6.13	682,584	
74			High	0	3.8	41.77	40.82	42.72	4,969,184	11,896,537
			Low	0.33		24.71	23.85	25.58	2,939,634	

| | | Leave inheritance | Moderate | 0.66 | | 12.84 | 12.17 | 13.54 | 1,527,515 | |
| | | | None | 1 | | 20.69 | 19.91 | 21.49 | 2,461,394 | |

Chapter 5

Appendix A. Comprehensive geriatric assessment

Capital Health

Comprehensive Geriatric Assessment Form

WNL = Within Normal Limits   ASST = Assisted
IND = Independent   DEP = Dependant

Assessment Forms
CD0184MR_02_12

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Appendix B. Variables and coding used in constructing the social vulnerability index (SVI) and frailty index (FI)

SVI Variable	Deficit Scores				
	0	*0.33*	*0.5*	*0.66*	*1*
Education (yrs)	Num xx>13		9 xx<≤numxx<12		numxx<8
Classification of Occupation (number)	num=1	num=2		num=3	num=4
Socially Engaged	Frequently		Occasionally		Not
Social Status	Married				Divorced; Widowed; Single
Lives	Spouse; Other				Alone
Home	House; Apartment				Assisted Living; Nursing Home; Other
Supports	Informal; HCNS; Other; None				Req. more support
Caregiver Relationship	Spouse		Sibling; Offspring		Other
Caregiver Stress	None	Low		Moderate	High

Classification of Caregiver Occupation (number)	num=1	num=2		num=3	num=4
Directive in Place	Box is checked				Box is unchecked
Code Status	Do not resuscitate; resuscitate				Not Known
Neighbourhood Low Income Seniors	Prevalence <3.7%				Prevalence > 3.7% (>75th percentile in NS)
Urban vs. Rural	Large urban population centre				Other
Neighbourhood Unemployment	<Provincial unemployment rate (8.8)				>Provincial unemployment rate (8.8)
Neighbourhood Ethnic Composition (African NS + Aboriginal NS)	Prevalence <12.2%				Prevalence >12.2% (75th percentile in NS)

Neighbourhood Education (high school plus)	Highest quartile	Second highest quartile		Second lowest quartile	Lowest quartile
Neighbourhood House in need of Major Repairs	Highest quartile	Second highest quartile		Second lowest quartile	Lowest quartile
Neighbourhood Households Spending >30% on Shelter	Highest quartile	Second highest quartile		Second lowest quartile	Lowest quartile
	1	*0.25*	*0.5*	*0.75*	*1*
Neighbourhood Income	Highest quintile	Med-High quintile	Med quintile	Low-med quintile	Lowest quintile

Domain	*FI Variable*	*Coding*
Cognitive Status	Cognitive Status	Within normal limits = 0; Cognitively impaired, not demented/Mild cognitive impairment = 0.5; Dementia = 1
	Delirium	No = 0; Yes = 1
	Mini-Mental State Examination	xx>25 = 0; xx>20 and xx<24 = 0.33; xx>11 and xx<19 = 0.66; xx<10 = 1
	Functional Assessment Staging Scale	1 or 2 = 0; 3 or 4 = 0.5; xx>5 = 1
Emotional	Low Mood	No = 0; Yes = 1

	Depression	
	Anxiety	
	Fatigue	
	Other	
Motivation	Motivation	High or Usual = 0; Low = 1
	Health Attitude	Excellent or Good = 0; Fair = 0.5; Poor or Couldn't say = 1
Communication	Speech	Within normal limits = 0; Impaired = 1
	Hearing	
	Vision	
Strength	Strength	Within normal limits = 0; Weak = 1
	Upper/Lower Proximal/Distal Strength	No impairment = 0; 1 area = 0.25; 2 areas = 0.5; 3 areas = 0.75; All 4 areas = 1
Mobility	Transfers	Independent = 0; Assisted = 0.5; Dependent = 1
	Walking	Independent = 0; Slow = 0.33; Assisted = 0.66; Dependent = 1
	Walking Aid	None = 0; Cane or Walker or Wheelchair = 1
Balance	Balance	Within normal limits = 0; Impaired = 1
Elimination	Bowel	Continent = 0; Incontinent = 1
	Bladder	
	Use of Catheter	No = 0; Yes = 1

	Constipation	
Nutrition	Weight	If Pre-admission Weight = Good & Admission Weight: Stable = 0; Loss or Gain = 0.5 If Pre-admission Weight = Under & Admission Weight: Stable or Under = 1; Gain = 0 If Pre-admission Weight = Over & Admission Weight: Stable = 0.5; Loss = 0; Gain = 1 If Pre-admission Weight = Obese & Admission Weight: Stable or Gain = 1; Loss = 0
ADLs	Feeding	Independent = 0; Assisted = 0.5; Dependent = 1
	Bathing	
	Dressing	
	Toileting	
IADLs	Cooking	
	Cleaning	
	Shopping	
	Medications	
	Driving	
	Banking	
Sleep	Day Drowsiness	No = 0; Yes = 1
Number of Problems		Number up to a maximum of 18

Number of Medications	xx>0 and xx<4 = 0; xx>5 and xx<9 = 1; xx>10 and xx<14 = 2; xx>15 = 3

Appendix C. Adjusted odds ratios, confidence intervals, p values, and fraction of missing information of hospital outcomes

	n (/711)	SVI				FI			
		b^a	aOR^a	p	fmi	b^b	aOR^b	p	fmi
Hospital Course									
LOS (days)[c]	N/A	2.83 (0.63, 5.03)	N/A	0.012	0.050	2.46 (0.22, 4.69)	N/A	0.031	0.051
Extended LOS	364	0.16 (0.04, 0.28)	1.19 (1.05, 1.34)	0.009	0.015	0.055 (-0.06, 0.17)	1.06 (0.94, 1.20)	0.368	0.033
ALC Status	54	0.33 (0.11, 0.55)	1.39 (1.12, 1.74)	0.004	0.062	0.26 (0.02, 0.51)	1.30 (1.02, 1.66)	0.033	0.12
Hospital Discharge Destinations									
Death in Hospital	150	0.074 (-0.08, 0.23)	1.08 (0.92, 1.26)	0.352	0.038	0.52 (0.35, 0.69)	1.69 (1.42, 2.00)	<0.001	0.036
Readmission to Hospital	114	-0.04 (-0.10, -0.19)	0.96 (0.83, 1.13)	0.648	0.035	-0.17 (-0.33, -0.02)	0.84 (0.72, 0.98)	0.030	0.0035
Home With or Without Supports	488	-0.18 (-0.31, -0.04)	0.84 (0.73, 0.96)	0.009	0.033	-0.50 (-0.65, -0.35)	0.61 (0.52, 0.71)	<0.001	0.071
Incident LTC home admission	34	0.030 (0.020, 0.039)	1.03 (1.02-1.04)	<0.001	0.054	0.20 (0, 0.31)	1.02 (1.00,1.03)	<0.001	0.015

[a]All models are adjusted for age, gender, and FI.
[b]All models are adjusted for age, gender, and SVI.
aOR = adjusted odds ratio; fmi = fraction of missing information.

Appendix D. SVI and FI sex differences
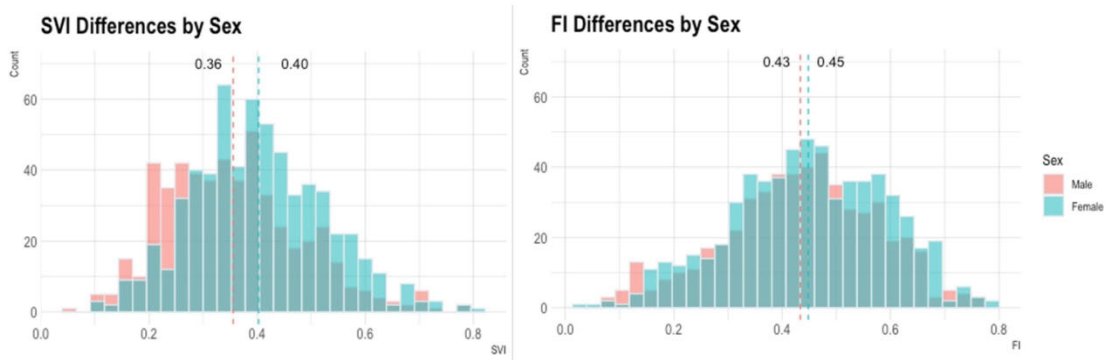
Chapter 6

None

Chapter 7

Appendix 1. Consolidated criteria for reporting qualitative research (COREQ) Checklist

Allison Tong, Peter Sainsbury, Jonathan Craig, Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups, *International Journal for Quality in Health Care*, Volume 19, Issue 6, December 2007, Pages 349–357, https://doi.org/10.1093/intqhc/mzm042

Table 1

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist.

No	Item	Guide questions/description	
Domain 1: Research team and reflexivity			
Personal Characteristics			
1.	Interviewer/ facilitator	Which author/s conducted the interview or focus group?	Interviews were conducted by JM, LE, GA, and MK. Qualitative interview training was provided by CS & EGM.
2.	Credentials	What were the researcher's credentials? *E.g. PhD, MD*	JM: MD, MSc, PhD(c) CS: BSc (Hons), MA, PhD(c)

No	Item	Guide questions/description	
			MK: MHA, MSc
			GA: BSc
			KN: BA, BHEcol
			SK: MN, NP
			JV: RN, DPN
			LE: MD
			SF: MD, FRCPC
			KK: MD, FRCPC
			MvM: MD, FRCPC
			KR: MD, MPA, FRCPC
			SS: MD, FRCPC, PhD(c)
			MA: MD, PhD, FRCPC
			EGM: PhD
3.	Occupation	What was their occupation at the time of the study?	JM: resident physician, PhD trainee
			CS: research associate, PhD trainee
			MK: medical student
			GA: medical student
			KN: research staff

No	Item	Guide questions/description	
			SK: nurse practitioner
			JV: emergency department nurse
			LE: resident physician, MSc trainee
			SF: geriatrician
			KK: geriatrician
			MvM: geriatrician
			KR: geriatrician
			SS: geriatrician
			MA: geriatrician
			EGM: professor
4.	Gender	Was the researcher male or female?	Genders of research team: Women: JM, CS, MK, GA, KN, SK, LE, SF, KK, MvM, MKA, EGM Men: JV, KR, SS
5.	Experience and training	What experience or training did the researcher have?	In addition to training provided to team members specific to this project: JM: doctoral studies topic on social vulnerability using mixed methods, clinician investigator trainee

No	Item	Guide questions/description	
			CS: doctoral studies topic on aging among Indigenous older adults residing in long term care using qualitative methods
			MK: previous research assistant
			GA: research in medicine program
			KN: knowledge mobilization training
			LE: clinician investigator trainee
			SK, JV, SF, KK
			MvM: medical education training
			KR: frailty research expert
			SS: doctoral studies in epidemiology
			MA: social vulnerability and immunization in older adults expert
			EGM: mixed methods expert, expert on patient engagement
Relationship with participants			
6.	Relationship established	Was a relationship established prior to study commencement?	JM, MK, GA, SK, LE, SF, KK, MvM, MKA, JV, KR, and SS are all clinicians in various stages of training with the potential to encounter the participants as part of their duties. JM, MK, GA,

No	Item	Guide questions/description	
			and LE were the only individuals who knew the identity of the participants when they conducted the interviews.
7.	Participant knowledge of the interviewer	What did the participants know about the researcher? e.*g. personal goals, reasons for doing the research*	The participants were aware of the researcher team, and were aware that JM, MK, GA, and LE are also junior trainees.
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. *Bias, assumptions, reasons and interests in the research topic*	Many of the authors have provided healthcare to patients admitted for social reasons in the past and have felt there are ways to improve their care. That was the primary reason for interest in this research topic.

Training was provided by experienced qualitative researchers (CS, EM). Two group and one individual Interactive training sessions were held which provided methodological context, and practical approaches and techniques in qualitative interviewing. Practice interviews were conducted during these training sessions. The interviewers and the qualitative researchers who |

No	Item	Guide questions/description	
			provided the training are authors. Through their medical training, medical students and residents have developed useful skills to be interviewers. They learn to build rapport, build trust, listen, and gather responses to open ended questions – additionally, they have knowledge of the healthcare system that many experienced qualitative interviewers would not, making them well suited to prompt and explore intricacies of this topic.
Domain 2: study design			
Theoretical framework			
9.	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? *e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis*	Constructivist Grounded Theory (Charmaz, 2014)

No	Item	Guide questions/description	
Participant selection			
10.	Sampling	How were participants selected? *e.g. purposive, convenience, consecutive, snowball*	Purposive theoretical sampling. We started with the nursing bed managers and used a theoretical sampling approach from there based on emerging codes to ensure that the perspectives of multiple healthcare professionals within the care pathway were included as interviewees, which subsequently allowed for comparisons between clinicians and administrators.
11.	Method of approach	How were participants approached? e*.g. face-to-face, telephone, mail, email*	Participants were contacted by email.
12.	Sample size	How many participants were in the study?	20
13.	Non-participation	How many people refused to participate or dropped out? Reasons?	We approached several departments (n = 3) and individuals (n~4) recommended by interviewees who declined to participate or did not respond to our requests for interviews. These included: recreation therapy, physiotherapy, and

No	Item	Guide questions/description	
			occupational therapy, and individuals in hospital administrative positions and individuals in several medicine departments.
Setting			
14.	Setting of data collection	Where was the data collected? *e.g. home, clinic, workplace*	Interviews were conducted virtually (via Teams) and in-person in the hospital. Hospital settings included participants offices or quiet rooms on a hospital ward.
15.	Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16.	Description of sample	What are the important characteristics of the sample? *e.g. demographic data, date*	In our tertiary center, specific demographic data poses a risk of identification due to the size of the community. We sent a post-survey to participants asking to self-identify several demographics. The demographics are available in Table 1.
Data collection			

No	Item	Guide questions/description	
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The interview guide received input from the entire research team through several iterative processes: multiple meetings to develop the guide, a pilot test with non-author, and a meeting after all interviewers had conducted at least one interview to discuss if the guide was robust enough to elicit the information we were seeking and discuss additional/modification of questions.
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No, each participant was interviewed once.
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Interviews were audio recorded.
20.	Field notes	Were field notes made during and/or after the interview or focus group?	Interviewers made field notes during data collection. We discussed these as a team when coding and reviewing findings. These notes were primarily used to support data interpretation but were not included as data.

No	Item	Guide questions/description	
21.	Duration	What was the duration of the interviews or focus group?	30 minutes to 60 minutes each.
22.	Data saturation	Was data saturation discussed?	Yes, at several meetings held with key stakeholders and research team members where data analysis occurred concurrently with data collection. At these meetings, data saturation was discussed, and additional participants were recommended (purposeful theoretical sampling).
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No, given the burden of paperwork already expected of healthcare professionals, we opted to present findings to key knowledge users. See item 28.

Domain 3: analysis and findings

Data analysis

No	Item	Guide questions/description	
24.	Number of data coders	How many data coders coded the data?	4 members (JM, CS, GA, MK) of the research team coded the transcripts. Each transcript was coded independently by at least 2 team members.

No	Item	Guide questions/description	
25.	Description of the coding tree	Did authors provide a description of the coding tree?	
26.	Derivation of themes	Were themes identified in advance or derived from the data?	Data were coded inductively with no preconceived themes. Based on our iterative analyses, we mapped our themes on the Quintuple Aim Framework as we felt this existing framework represented our findings.
27.	Software	What software, if applicable, was used to manage the data?	Dedoose (https://www.dedoose.com/)
28.	Participant checking	Did participants provide feedback on the findings?	To ensure our results and interpretations were representative of the participants' experiences, we presented findings to key knowledge users which includes experienced researchers, clinicians, social workers, and administrators who provided feedback and direction of additional participants from whom to seek additional data.

No	Item	Guide questions/description	
			Participants were invited to review their transcripts prior to incorporation into the data analysis stage. Only one participant did this.
Reporting			
29.	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.*g. participant number*	Yes, quotes are presented throughout in Tables 2-6 and in Appendix 3. Participants' quotes have been attributed using a number for confidentiality.
30.	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes.
31.	Clarity of major themes	Were major themes clearly presented in the findings?	We organized the major themes within the five domains of the Quintuple Aim Framework: 1) enhance patient experience, 2) better population health, 3) optimize cost of care, 4) improve care team well-being and 5) advance health equity.

No	Item	Guide questions/description	
			The five domains (aims) of the framework are: • **Enhance patient experience:** Focus on quality, responsiveness, and personalization of healthcare services for patients. • **Better population health:** Focus on public health and preventive care to better communities and populations. • **Optimize cost of care:** Decrease healthcare costs while maintaining quality care. • **Improve care team well-being:** Enhance the work environment as a way of providing better healthcare. • **Advance health equity:** Ensuring fair and just access to healthcare services for all individuals, accounting for socio-economic, racial, or geographic differences. (Nundy et al, 2022) (Itchhaporia, 2021)
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes, we present explanations and data to support subthemes in both the main text, tables, and appendix.

Appendix 2. Interview Guide & Demographic Survey

Appendix 2a. Interview Guide – Health Care Professionals and Administrators

First, I'd like to thank you for coming here to speak with me today. My name is xxxx, and I am here from Dalhousie University. We are here today to talk about your experiences with vulnerable older patients in acute care, especially those admitted for primarily social reasons.

I will be asking you a series of questions. Questions will be posed, and it will be your choice if you'd like to answer. At any time, please feel free to pass on a question you don't feel comfortable answering. The session should take no more than one hour.

Everything we say in this interview is confidential, and we will not be identifying any individuals when reporting our findings. We will make an audio recording of the interview in order to do our research analyses. Before we get started, let's review the consent form. [review consent form and have 2 signed copies, one for you and one for the participant prior to starting interview]

Do you have any questions before we begin?

1. Can you describe the most challenging patients to care for (in general, not specific to Orphan Patient Policy)? Can you share some examples?
   (a) In what ways are they more challenging?
   (b) How do you approach the most vulnerable?
   (c) What about other care team members?
2. Can you describe the most vulnerable patients?
   (a) If "orphan patients/social admissions" etc., ask Can you share an example? Can you tell me more about "orphan patients"/ "social admissions" etc..
   (b) If not mentioned: Have you ever heard of the term "social admission" or "orphan patient"? What can you tell me about your experiences with these patients?
3. What attributes or contextual factors make them vulnerable?
   (a) If "stigma" (or related) is mentioned, [Probes: How are these patients referred to? How are they treated by staff? Can you give me some examples of what you mean by this...]?
   (b) What has been your experience with older patients?
4. *Walk me through your process of determining whether using the Orphan Patient Policy [Interviewer: probe about their understanding of the Orphan Patient Policy. How often do they use of the policy? Why do they use the policy? Are there advantages of using the term 'orphan'? What characteristics of the patients? Any resource constraints?]*

(a) Once a patient has been identified as a potential orphan, who do you involve and how you tell the patient or family?
5. Describe any barriers or challenges have you experienced in providing care for these patients within our health care system?
6. Describe some changes would you like to see?
   (a) In your opinion, would this patient have been better cared for on a different service? If so, where?
   (b) If you were teaching medical students/nursing students, what would tell them about care for socially vulnerable/frail/'orphan' older adult patients?
   (c) If you could tell the hospital to change policies to help older socially vulnerable/frail/'orphan' patients, what would you ask for?
7. How would you explain what happens to this patient population to a lay person or to someone with poor health literacy (considering privacy considerations, lack of understanding of the process, etc)
8. Any recommendations on alternate ways to describe this vulnerable population we have just discussed?

[General interviewer instructions – probe around any mentions of their experiences, perceptions, concerns, barriers, facilitators, ways in which care could be improved.]

Appendix 2b. Demographics Survey – Health Care Professionals and Administrators

Demographic Information

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Please complete the survey below. Responses are from the Canadian Community Health Survey 2023.

Thank you!

What is your age group?	⌄
What was your sex at birth?	⌄
What is your gender?	⌄
Are you (ethnicity)?	⌄
Profession	⌄
Stage of career?	⌄
Do you spend most of your time in clinical or leadership/administrative roles?	⌄

Submit

Appendix 3. Table of Quintuple Aim Framework domains with themes and additional illustrative supporting quotes

Domain:	Theme: Patient	
Patient Experience	Description	"Like you can't stereotype it as always the lower socioeconomic group because that's not the case. From my experience with the orphans, they've come from different levels of, you know, economic status. In my instance, mainly it has been there's been a physical barrier, that they don't have any supports, they're at home and just can't maintain the…or have the ability to do the daily activities of living." - HC103
	Participants' descriptions of "social admissions" were inconsistent and included a wide range of health and social indicators from the patients experiencing financial troubles or unstable housing or psychological issues to being medically complex. In few cases, participants expressed that they (or their colleagues) believed "social admissions" had no immediate medical needs.	"I know people here seem to think like, oh, they don't have a medical need, so they're an orphan. But I mean they obviously have some sort of need, whether it's their... unstable cognitive behaviours. They need some kind of stabilization to be able to be placed." - HC413

"So I think the way I would describe the population is just that - it's patients who are in an unfortunate social situation where their home…where they're living at the moment is not safe for them. So they're here until we find the safest place for them." - HC638

"So an orphan patient's usually a demented patient." - HC075

 "Sometimes in most of these cases, I have to say 99% of them, are not medical-based. There's nothing acute to medically treat. Usually it's time and support, or they're waiting for home care, or waiting on this or that to come to fruition."- HC569 |

Theme: Provision of Care	"When a patient comes in as an orphan patient, it's hands-off. They're just there in a bed waiting and sleeping there until they go somewhere else. And I think that's absolutely heartbreaking. That's the reality, though, right, is there's no proactive." - HC375
Participants described the care provided to patients. The approach to care was passive and "social admissions" were generally de-prioritized in a tertiary care setting. Further, participants shared that the hospital environment often does not meet the basic needs of patients and is not the ideal setting for anyone unless they are needing acute care. Others commented on the lack of dedicated allied health services available to these patients (e.g.,	"The approach to caring for the patient is passive. Which is in huge contrast to our approach to caring for medical and surgical acuity - which is very active. And then what's super interesting is when you have a patient that's getting a lot of active care but then is no longer active, right, then that same patient falls to the bottom of the barrel in terms of priority... They're no longer a priority by any members of the care team. And I think that can be very isolating and confusing for patients too."- HC375

"So I think it's just like back to the basics of like actual just personal care for a patient, and like just their general well-being. Like we don't really... Like you know, simple things like putting the blinds up in the room so they have daylight during the day, like that is overlooked constantly here." HC413

"I truly believe hospital is not a good place for anybody. It's really good when you have a truly acute need, but it's not necessarily the best for healing or convalescence or to meet the social needs." - HC605

"I mean I think we've certainly advocated that we don't feel that this is the best placement for them." - HC413

"We've known for years emergency is a horrible place to keep patients. It is loud. It is busy. It is no sunlight. Delirium sets in. Patients aren't mobilized because we don't have PT, OT or the correct staffing ratios. There's a lot of medication errors. Charts aren't solid. They're on clipboards. There's all kinds of environmental factors that have been very well documented in the research that emergs are not the place to board patients."- HC569 |

	physiotherapy, recreation therapy or occupational therapy) after admission.	"As far as once they come to hospital, again these patients typically have multi-system disease. They're on polypharmacy. They may or may not have had a med review for a very long time. Medications may just get added. So these patients are not well served on services that can't actively participate in their care. Which is most of the services that these patients end up on. So even if they were stable when they presented to hospital, they become unstable because there isn't anyone with the ability to reassess them in an appropriate manner." - HC156

"And I was trying to really remember the last time rec therapy was a staple on our unit. My experience with rec therapy, it had always been wonderful. We'd put in a request through our manager, and then we would have a coordinator send us a schedule with who was coming, which days. They would usually come for an hour to visit with specific patients, primarily long term care" -HC638 |
| **Domain:** Care Team Wellbeing | **Theme:** Moral Distress

Participants described the distress and tensions due to competing priorities and values experienced by | "I think if you were to pull it back, sometimes that judgment is really *'I don't know how to care for this person. I'm not comfortable.'* And so, you know, I think that's a challenge. So I think when tensions run high and bed pressures are as high as they are, and there are people for whom you know clearly are waiting to get in, and for whom you know what you could do, right, and you're skilled to do it, that creates I think an ethical tension for teams. And so, yeah, I think there can be a tendency to, you know, not fully understand all the needs or not feel able to address them because they're usually so complex that there isn't an easy fix." - HC605

"So challenging ones would be the ones where, you know, that feeling of they are patients where you have...you know, huge amounts of patients waiting to see you. But then you see patients that you feel may not necessarily require your skill set, but they're kind of who is being admitted under you. So you have to take care of them." - HC605 |

| | many staff when providing care to "social admission" patients. This is a result of these patients having complex social and chronic health issues that they feel are outside of their clinical scope. Participants caring for these patients feel better care could be provided elsewhere and they themselves do not have the right training to care for them which can | "There's a gentleman that came in, he had his full head, but he had a condition where like he had the shakes so bad, and like he was… You know, he couldn't take care of himself. So we had him in, and we had him in for, you know, months. And we really had to fight and push for him to get placed. So what happens is, you know, he was at an age… And like we knew DSP couldn't place him. Because DSP, they usually place like in facilities that are not nursing homes. But this guy needed more nursing care because of his condition. So we really had a fight to get Continuing Care involved. And once they got involved, he was placed rather quickly because he was perfect for them. But it's just that initial hesitation." - HC075

"So it's very challenging, and it creates a lot of moral distress, I would say, and injury in the care teams caring for the patient. So the other group that is challenging to care for, and from two different reasons - because of their complexity and because of the impact on patient flow in acute care - are our medically stable patients who no longer need to be in hospital. And that group of patients is growing. And it's a complex problem. It's not as simple… Not everyone in that group are patients that are tied up and ready to go to long term care. Some of them, in fact, could probably go home with the right supports in place. But our system, in my experience, seems to be either under-resourced or we do not all collectively believe in home first. We do not as a system collectively believe in home first. So you may have pockets of bright spots that can focus on home first. But that's a difficult thing to do in the care of complex, frail and often geriatric patients, although not always. Because the supports they need are not available in the community. And although evidence tells us that patients don't receive good complex care in hospitals, in acute care, there seems to be a bit of a misconception that it's the safest place for them to be." HC375 |

	cause further distress.	
	Theme: Hierarchy of Care Participants described a perceived order of importance of patients and their reasons for hospitalization. Participants described the hierarchy in acute care with "social admissions" being at the bottom of that hierarchy. Participants also described the "bed	"They're supposed to have a plan that follows through with like an allied profession, like PT, OT, social work, housing, waiting on placement, that type of thing. They're not supposed to be rounded by physicians every day, having new medication orders, treating active or new pain, changing doses, and things like that." HC569 "Like our CCAs are fantastic because they worked in nursing homes. So they've got such a good way with them. Like they know how to approach them, they know how to jolly them along. They know that if the patient says no, they go away for maybe 10 minutes and then they come back and ask them. Like do you know what I mean? Whereas like so if you're a busy nurse and all that, you don't have so much time" - HC075 "But when you're in a situation where you're running at one hundred percent capacity then all of a sudden, you're not doing routine things. people have expectations that they're going to get their cancers done on time. But we can't do your cancer operation because we don't have a bed. And then when we start looking around, why don't we have a bed, it's because you have somebody in a bed that not necessarily would fit the description of needing acute care surgical services." - HC307 "I think that those patients just do require a lot of time to really ensure they're getting a good look over and ensuring they're getting…or not mistakenly called an orphan patient. Because these are the patients that are…you know, can't give a reliable history or the collateral is not there right away in the middle of the night - things like that. So then you really do need to spend that time to be able to gather all that information. Which is not quick. You know, it's much less quick than seeing someone who, you know, is coming in with heart failure, right, and it's very easy. You know what to do with that" -HC840

	blocking" that exists and how these "social admissions" can make it much more difficult to provide the appropriate care to other patients.	"I'm sure they hear about things like, *'Oh, we don't know where you're going to go.'* And they see different services, and back and forth, and stuff like that. Which I'm sure some can read between the lines and to understand that, you know, maybe it's because no one wants to take care of the patient." - HC840
Domain: Health Equity	**Theme:** Stigma and Missing Opportunities The label comes with assumptions about the admitted patients' medical needs, cognitive abilities, and behaviors, which in turn affects the underlying	"There's criteria within the orphan patient policy that they are assessed, that they are thoroughly assessed, and need to be determined orphan, that they don't require an acute care admission for a medical intervention, that they really don't need any medical treatment at all but they need to be housed in hospital. So what was happening is that was often being bypassed. So, you know, they were deemed by the paramedics not safe to go home. First of all, who should not be determining that. Then the charge nurse repeats that. So of course then they were labelled that way." -HC236 "Because people with social stressors and low social capital still get medically sick. And I think, again, once you're labeled in that way, I think we tend to miss that." -HC300 "I also think a challenge is that there is pressure to make the determination or the designation of orphan patient very early in the patient's presentation to the emergency department. And that sometimes we're making that designation with incomplete or inaccurate information. And as a result, are not providing the kinds of interventions that the person really needs. Or we're missing diagnoses or were making those diagnoses late." -HC300

	assumptions held by healthcare providers and subsequently the care they receive. Participants described how patients being labelled as "social admission" early in the care chain led to an belief that they are medically stable when in fact they were not always.	"Those who do have some sort of cognitive impairment and can't really advocate for themselves very well, or who can't provide a reliable history …because then lots of assumptions are made that something's wrong with…you know, that underlying diagnoses are the reason why they are presenting this way."- HC840
		But even if… I'm just try to think of how they hand over report, and they say, "Oh, that's the orphan patient," or, "They don't need anything," because they don't maybe physically need anything at that time, they're not going for any testing or procedures, "Oh, that's my orphan." They just… They'd go over their usual like age, code status, and then say, "They shouldn't need anything because they're just awaiting long term care."- HC638
		"You're particularly vulnerable coming in if you're an older adult too, because we may, by virtue of our bias or by not knowing any different, assume that someone had a cognitive impairment, assume what their baseline was, and what we're seeing. And then it may get worse in hospital... Without that collateral history, you may not know. So you may miss a diagnosis of delirium and an opportunity to treat." - HC605
		"So it's a very quick way to try to push the patient somewhere else, not onto their service. And I think there's bed pressures. Yes, I agree they're a soft patient. But we don't take into factor like what is a couple of weeks of PT, OT going to do with them?"-HC569
	Theme: Prejudices Participants described underlying group assumptions about "social admissions". In	"Again, it sort of reminds me of, you know, how we may have negative attitudes in the emergency department with substance use disorders, right. And the orphan patient population to me is another kind of vulnerable group where I think the lens that we use to understand their health issues and think about how we respond is not the right lens to be using. And I also think that one of the challenges is that when someone presents to the emergency department because there is an issue with what we consider to be their social health, you know, again, housing or home care or whatever, I think we are slow to recognize and respond to the component of that that is medical instability. So, you know, I've seen these orphan patients on the consult service who have undiagnosed serious neurologic and medical health conditions that no one has recognized because they were admitted under the orphan

| | particular, ageism that occurs when patients access acute care services for social issues was noted. For example, assuming all older patients have cognitive decline or lack capacity or assuming certain health services would not benefit older patients. Participants reflected on how race and gender implicitly affect care. | patient policy, and there's a prevailing attitude that that means that, you know, they can't go home or they're there waiting for social supports, but that we don't need to do any further digging or evaluation from a medical lens." -HC300

 "The biggest thing is, you know, the label – the label of that patient… I mean all my experience with orphan patients is they've all been elderly. And I just think it's a shame. I love the elderly... And I just feel that negative connotation, it's like, first impressions. They're hard to shake, the first, you know."- HC151

 "I think sometimes with older adults, people can say they have dementia, and that would not be a health care need. I would argue dementia and strong dementia care is very much a health care need." - HC605

 "But like it's very challenging in that way because we're really not set up, unfortunately, to handle like elderly and patients with dementia." - HC075

 "First of all, I think their age. I believe that there's ageism within acute care. Especially if they were frequent flyers - which is a terrible term."- HC236

 And therefore patients that need those really early complex discharge conversations, those conversations often don't happen until a decision has already been made that someone needs to go to long term care. **And an opportunity is then lost**, right, to sort of work with patients and families to come up with alternative solutions. |
| **Domain:** Cost of Care | **Theme:** Waitlists and Scarcity of Alternatives | "Generally the patients that we see who end up being presented to the emergency department do have family members who are caregivers, but present with some degree of caregiver burnout" -HC156 |

| | Participants commented on the inadequate supports available in the community which frequently lead to "social admissions". They described a system that is inefficient and ineffective at caring for this population because of severe resource constraints. Some of these patients have advocates or family caregivers who | "when I think of patients who are, to sort of say, quote-unquote, social admissions, I often think of people with complexity and frailty where their medical illness has led to a situation where the supports in the community, whether it's home care supports or social supports or mental health supports, are not adequate to meet their needs" -HC300

"And then like a lot of them don't have support people. So then you're like how do we help these people get the best care when they don't understand, they have nobody to turn to? We don't really have anywhere to send them when they're finished their procedures or what have you. And then like some of them can have like challenging behaviours, which makes it really hard of caring for them, or family dynamics. Like we have a lot of patients who the patient may be fine, but then you've got the families like that don't get along, and you're trying to appease everybody, and you never can. And you're like basically telling people to leave their baggage at home. So there's lots of factors that can contribute to challenging environments to care for these patients." - HC803

"In certain circumstances, yes, that we can. If someone needs PT, OT at home, the wait list is like 6+ months…They're waiting six months for anyone to come help them. They'll be so deconditioned by that time, they'll be bed sored into the bed. So there's the realities of the barriers of what's out there. It's out there. Can I get it? There's wait lists for everything. The system's backed up in home care. Wait lists have now increased. So today if I go send a referral with a two day turnaround, the coordinator will call in two days. They'll probably go out to see them within a week. But you could be waiting a month plus for home care. And now, instead of giving you the full request, say if you're asking for two visits a day, there are now saying, when they slowly do start picking you up after a month, they'll say, "I can pick you up Monday mornings, Thursday evenings, maybe Friday. Sundays are not going to happen for a while." Like they started doing this partial service." - HC569
"Sometimes people in the community, from the day of making that phone call saying you need help, it could be a couple of weeks before…three or four weeks before you have someone knocking on your door helping you. That's evolved into about a month. Sometimes the |

| | simply cannot do it anymore. | coordinators have such big loads and there's low staffing levels that they're taking on double coordinator capacities, and they can't get out to see you." -HC569

"The money that they're providing for this Home First, it's just impossible to find workers. So we have people funneling into emerg, saying, "I have all this cash money that I can't find anybody. Like they can't give me care. They gave me cash. I can't find anybody to do it." - HC569

"we haven't responded enough to their cries for help in a different way. And they feel the only way they can get support, we heard, is to bring their loved one to emerg. And so I can't imagine the torture that must cause for the family member because I believe most don't want to do that, to ever get to that point. But I think caregiver burnout, caregiver stress is very, very real." - HC605

"And I would use a Home First lens. I would think, is there anything else that we can do to get them home? I think you do better at home. I think that that's the safest place for people, with the right amount of supports. But the problem is, is that usually once we've gone to that orphan patient policy, we've turned over every rock." - HC569

"How do you better support people to hold on and incentivize that rather than incentivize... And I mean that in the sense that, you know, right now people get into long term care almost exclusively from hospital." - HC605

"So it's very challenging, and it creates a lot of moral distress, I would say, and injury in the care teams caring for the patient. So the other group that is challenging to care for, and from two different reasons - because of their complexity and because of the impact on patient flow in acute care - are our medically stable patients who no longer need to be in hospital. And that group of patients is growing. And it's a complex problem. It's not as simple... Not everyone in that group are patients that are tied up and ready to go to long term care. Some of them, in |
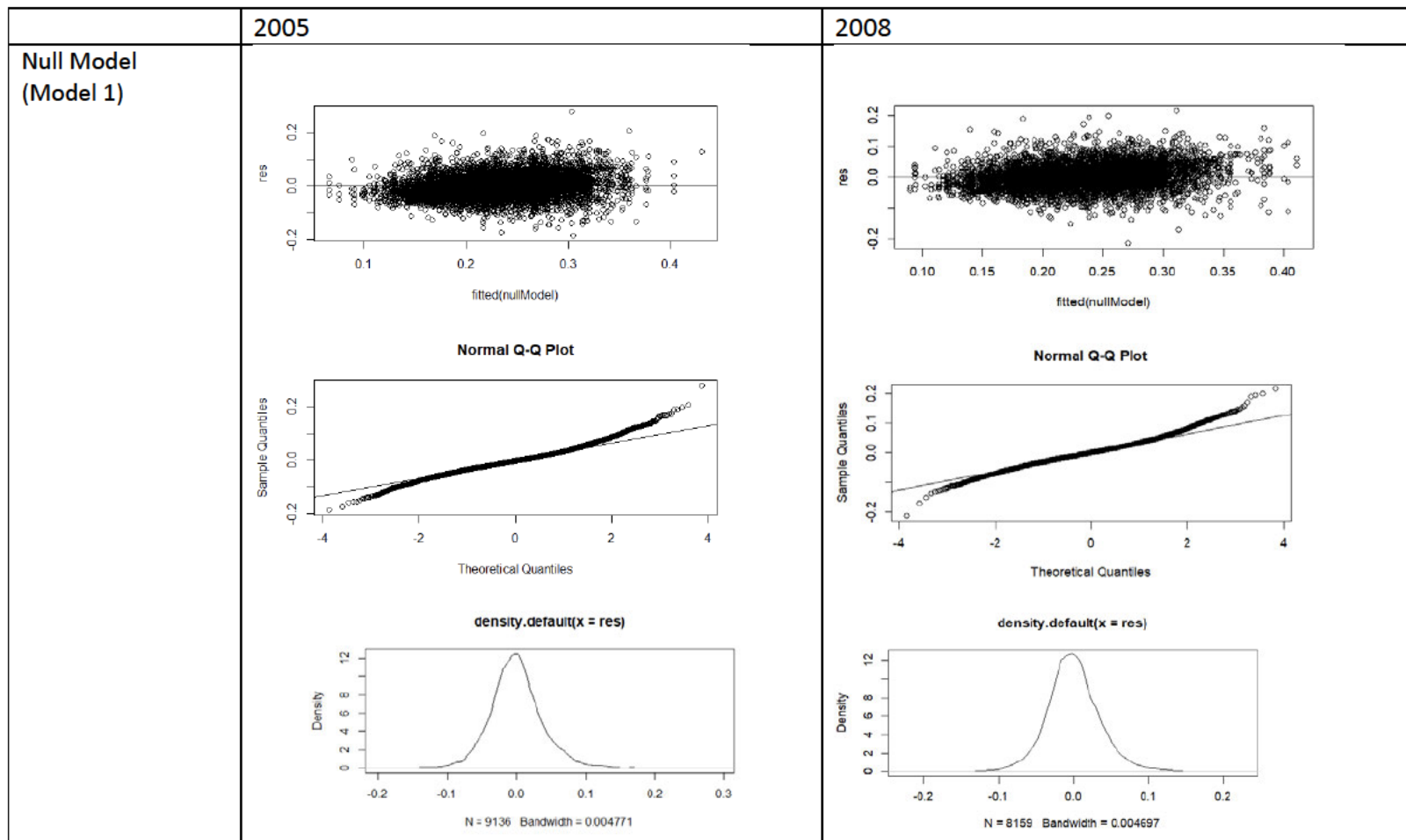
		fact, could probably go home with the right supports in place. But our system, in my experience, seems to be either under-resourced or we do not all collectively believe in home first. We do not as a system collectively believe in home first. So you may have pockets of bright spots that can focus on home first. But that's a difficult thing to do in the care of complex, frail and often geriatric patients, although not always. Because the supports they need are not available in the community. And although evidence tells us that patients don't receive good complex care in hospitals, in acute care, there seems to be a bit of a misconception that it's the safest place for them to be." HC375
Domain: Population Health	**Theme:** Factors Leading to Vulnerability Participants commented on the multitude of social issues that increase the risk of a community dwelling adult becoming a "social admission", such as poverty, homelessness, social isolation, lack of	"When you're experiencing any health issue, you're automatically vulnerable because you're dependent upon other people for support and care. So I think recognizing that inequity of power that exists, even for those who have robust social networks and ability to advocate for themselves, you're in a vulnerable spot just by virtue of needing health care. I think when you add someone who has cognitive impairment or a mental health issue or challenge, that may make it more difficult for them to articulate and advocate and process and reason all the different why they're experiencing what they are, and then be able to identify what they need." - HC605 "So bed-bound patients, psychiatric patients, dementia patients, extremely comorbid patients, substance abuse patients. Resistant patients. Resilient patients. Ones that are so proud that they won't take care until it gets them to the point that they crash and burn. You see this, "I'm fine. I'm going to be okay. I can't… No, I'm going to do on myself." And like, you know they're going home and breaking their hip. Like there's no way. And I can't force home care on you. You have the right to refuse." - HC569 "And I think the absence of having…of that subset of people, having an advocate for them, both in the community and when they interact with the acute care system, makes them particularly vulnerable to healthcare providers not understanding the full picture of their

	primary care and substance use disorders. The inability to advocate for oneself was also a common observation.	health issues and their social issues and stressor. And so if you don't have somebody in your corner that can help advocate for you with the healthcare team, I think it can be really challenging for all those reasons stated above." - HC300

"We always try to get the family docs to do it if possible. But so many people don't have them or haven't seen them for two years that often that's not usually the way it gets done" – HC231 |
| | **Theme:** System Changes for Addressing "Social Admissions"

Participants shared their visions for improvement to the current system to provide appropriate care to those accessing acute care with social needs. | "This is what the health system needs. Because increasingly we don't have people with single system issues anymore. And so the future of health care, in my opinion, is figuring out how to get from single system to holistic multi-system care. So I think the expertise that generalists or those who can look more broadly at the social determinants of health, as well as the multi-systems, and how it all interacts. For frail, for vulnerable people, it's often like a game changer, right? Like if you pull out one block, the whole thing's going to come crashing down." - HC605

"I think more home care resources, faster. I see the system as for years we've been funneling cash money into an acute care system, band-aiding it. And really, if you step back and look at it, the acute care system is becoming the community system. We're becoming nursing homes, we're becoming this kind of mediation…this mediate pathway between community and long term care. Because long term care is failing at admitting people in a timely fashion. They destabilize and come into the hospital to be placed." - HC506

"So we need a seniors care team in the emerg department, and we need senior-focused care. We need to geriatriatize care in the acute care. We need geriatricians attached to ortho, we need geriatricians attached to general surgery. I think that would decrease the mortality rate. Evidence shows that if you have a geriatrician providing post-care to orthopedic patients, especially the traumas, the hips and so on, the mortality rate decreases tenfold. So I would |
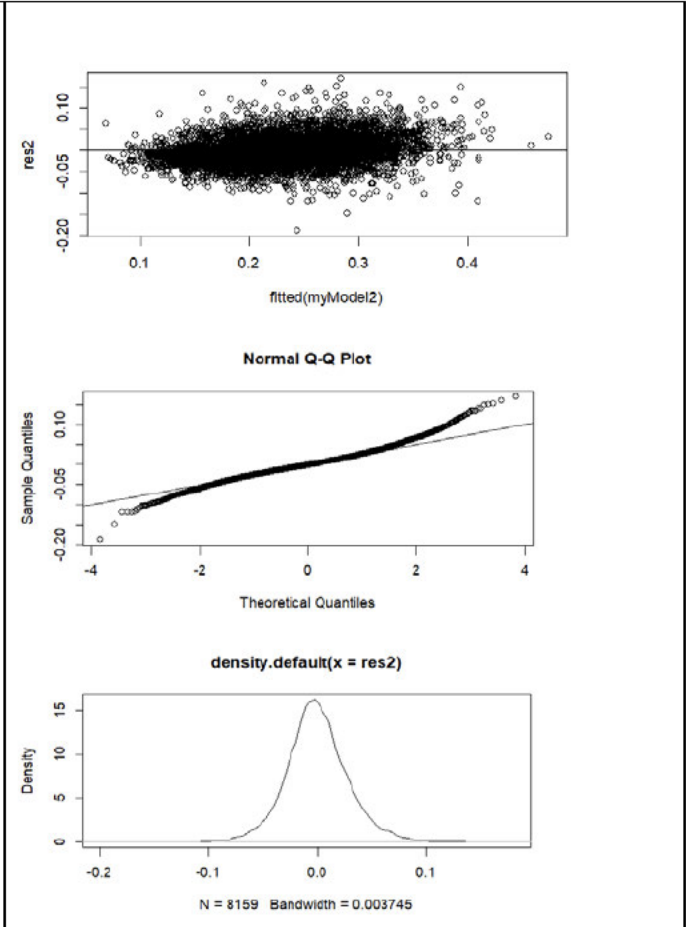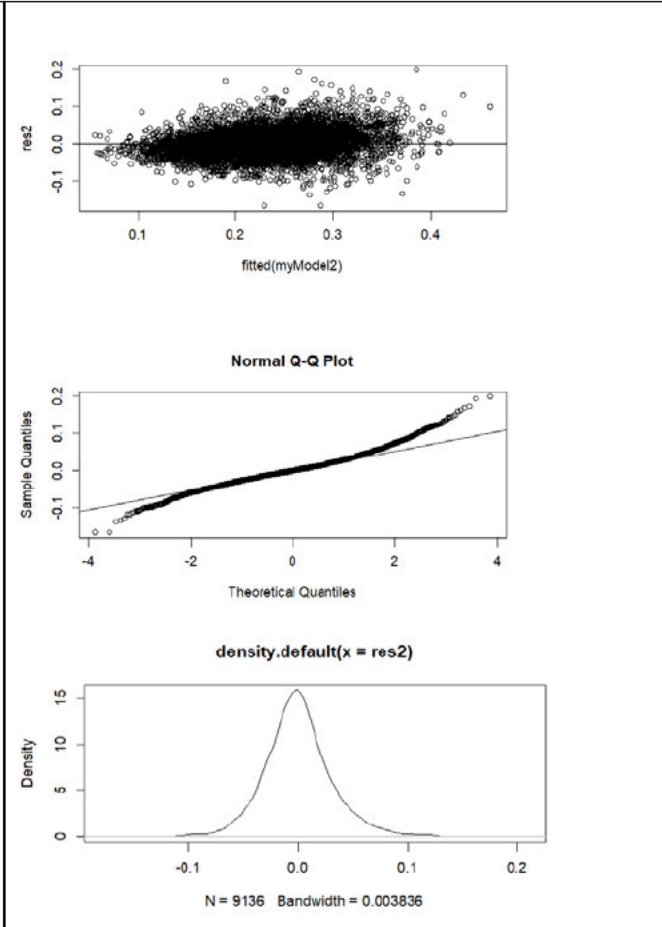
| | | like to see more geriatrics in the hospital. I think we need to more prevention-based rather than reaction-based - which is what we are." - HC236

"The biggest thing is like, you know, like looking at the bigger…like the picture as a whole. And like when you see that orphan term or, you know, somebody who's homeless, you can't just think…like don't think of the individual as that alone. Like they're a person just like anybody else. And like we all have needs that need to be met. So regardless if they're deemed orphan or not in the population, like we need to make sure that whatever needs they have are met as well. And, you know… And if there are medical concerns that arise, like we need to be the advocates for those patients because nobody else is." - HC803

"I think there's still lots of opportunity to improve, you know, of identifying some of our biases and stigma that's associated with, you know, racism, with mental health issues. I think we're doing better with that as a society, I think. So I think those things, it's so important and there's lots of work that needs to continue to happen." - HC605 |
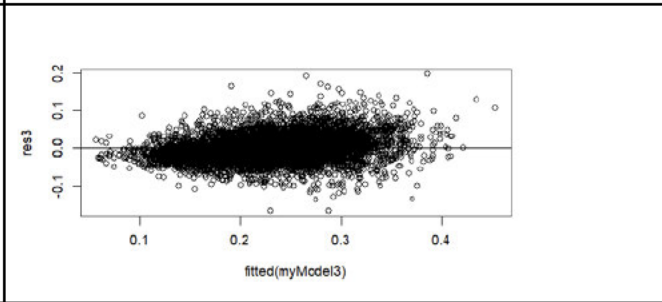
Chapter 8

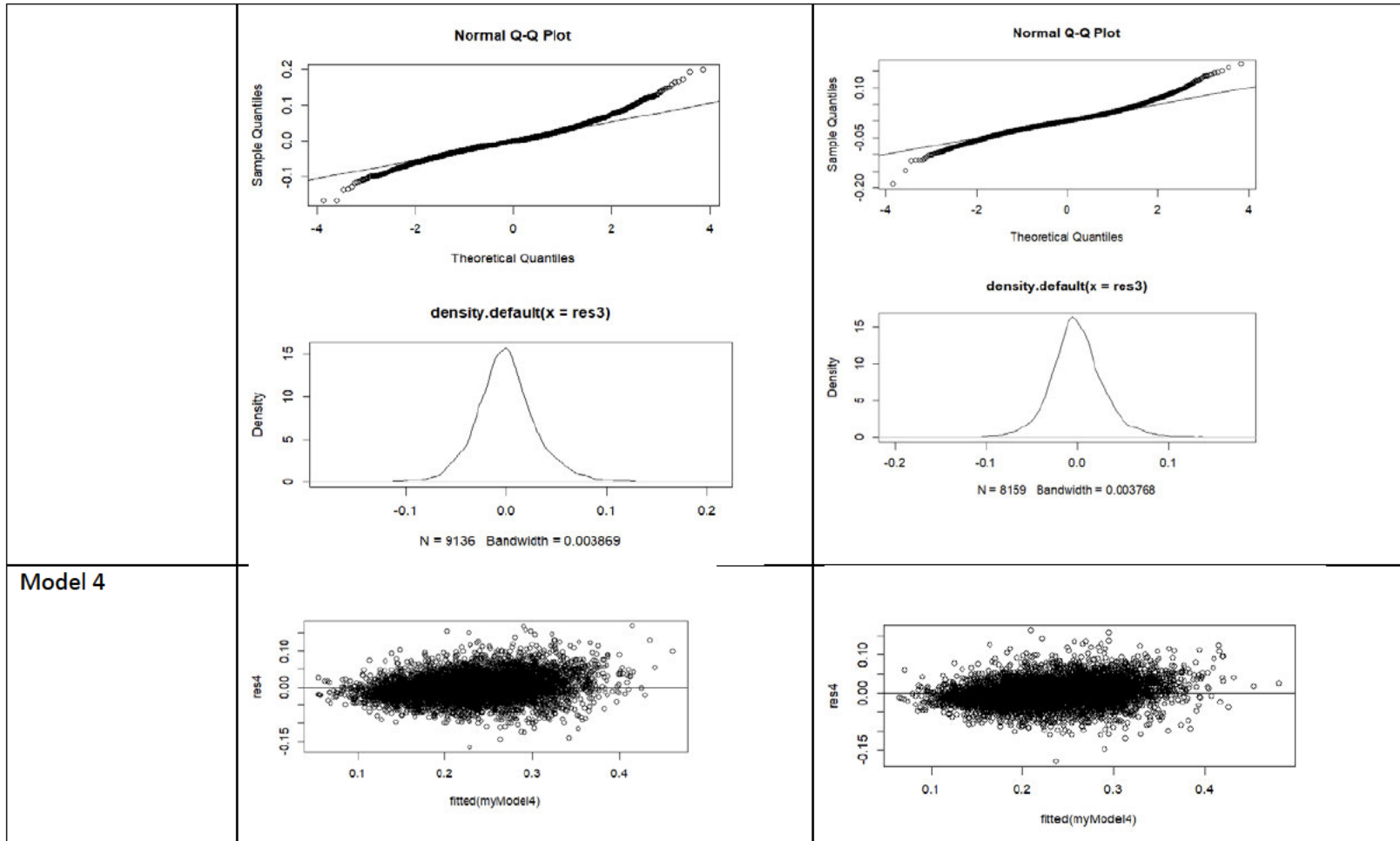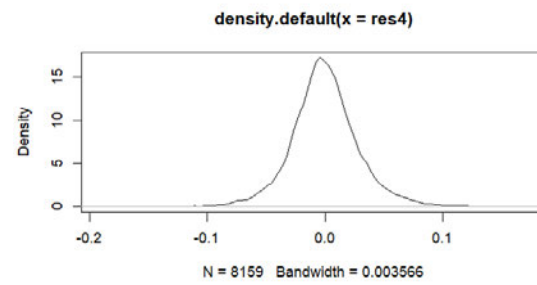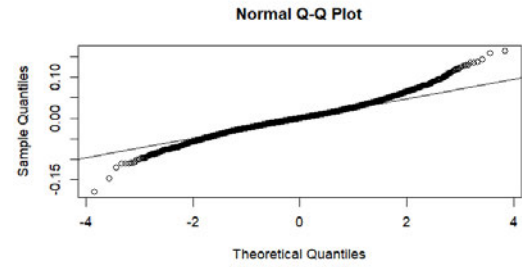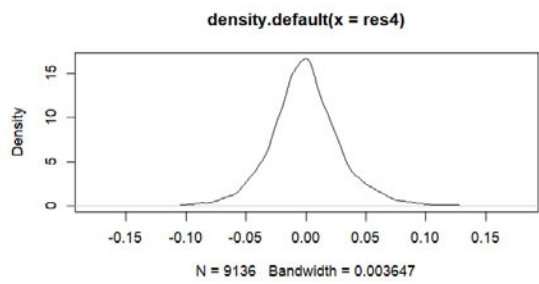## Appendix 1. Distributions, Q-Q plots and scatterplots of residuals

	2005	2008
Null Model (Model 1)		

Model 4

Normal Q-Q Plot

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N = 9136   Bandwidth = 0.003647

Normal Q-Q Plot

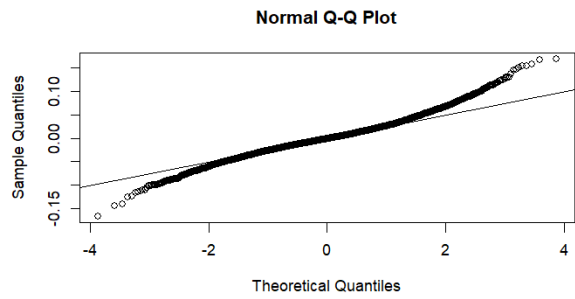**density.default(x = res4)**

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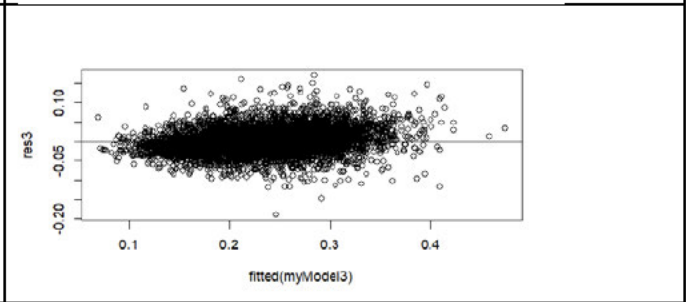
Appendix 2. Sensitivity Analyses

Appendix 2a. Sensitivity Analysis – Trends among those who died within 3 years

	2005	2005	2005	2005	2008	2008	2008	2008
	Null Model	Model 2	Model 3	Model 4	Null Model	Model 2	Model 3	Model 4
N	1046	1046	1046	1046	1048	1048	1048	1048
Num.Obs.	1813	1813	1813	1813	1717	1717	1717	1717
(Intercept)	0.228***	0.224***	0.234***	0.233***	0.223***	0.220***	0.221***	0.220***
	[0.223, 0.232]	[0.220, 0.228]	[0.222, 0.247]	[0.221, 0.246]	[0.219, 0.228]	[0.216, 0.224]	[0.208, 0.234]	[0.208, 0.233]
time		0.010***	0.018***	-0.008		0.010***	0.017**	-0.005
		[0.006, 0.013]	[0.008, 0.028]	[-0.019, 0.004]		[0.006, 0.014]	[0.006, 0.027]	[-0.017, 0.008]
new_age			0.001*	0.001*			0.001***	0.001***
			[0.000, 0.001]	[0.000, 0.001]			[0.001, 0.002]	[0.001, 0.002]

BB1M			-0.018***	-0.018***			-0.015***	-0.015***
			[-0.027, -0.010]	[-0.027, -0.010]			[-0.024, -0.007]	[-0.024, -0.007]
fibaseline			-0.001	-0.001			0.002	0.002
			[-0.005, 0.003]	[-0.005, 0.003]			[-0.002, 0.007]	[-0.002, 0.007]
time × new_age			0.000	0.000			0.000	0.000
			[-0.001, 0.000]	[-0.001, 0.000]			[0.000, 0.000]	[-0.001, 0.000]
time × BB1M			-0.004	-0.004			0.005	0.004
			[-0.012, 0.004]	[-0.011, 0.004]			[-0.003, 0.012]	[-0.003, 0.012]
time × fibaseline			-0.003	0.002			-0.004	0.001

			[-0.007, 0.001]	[-0.002, 0.006]			[-0.007, 0.000]	[-0.003, 0.005]
Diff (change in FI)				0.021***				0.016***
				[0.017, 0.026]				[0.011, 0.020]
SD (Intercept ID)	0.057	0.060	0.059	0.060	0.061	0.063	0.061	0.062
SD (time ID)		0.019	0.018	0.020		0.019	0.019	0.020
Cor (Intercept~time ID)		-0.225	-0.260	-0.342		-0.126	-0.108	-0.144
AIC	-4809.9	-4835.1	-4788.4	-4855.9	-4546.7	-4572.0	-4537.5	-4565.0
BIC	-4793.4	-4802.1	-4722.4	-4784.4	-4530.3	-4539.3	-4472.1	-4494.2
ICC	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8

Log likelihood	2413.20	2434.12	2451.31	2491.35	2281.54	2302.54	2325.67	2345.61
-2LL (Deviance)	-4826.40	-4868.25	-4902.62	-4982.69	-4563.09	-4605.09	-4651.35	-4691.22

* p < 0.05, ** p < 0.01, *** p < 0.001

Appendix Sensitivity 2b. Models among those with 3 or less visits vs 4 or more for 2005 cohort

Visits	3 or less	3 or less	3 or less	3 or less	4 or more	4 or more	4 or more	4 or more
	Null Model	Model 2	Model 3	Model 4	Null Model	Model 2	Model 3	Model 4
n	1728	1728	1728	1728	1063	1063	1063	1063
Num.Obs.	3028	3028	3028	3028	6108	6108	6108	6108
(Intercept)	0.230***	0.227***	0.236***	0.231***	0.235***	0.222***	0.236***	0.234***
	[0.227, 0.233]	[0.224, 0.231]	[0.227, 0.244]	[0.223, 0.240]	[0.232, 0.239]	[0.218, 0.226]	[0.227, 0.246]	[0.224, 0.243]
time		0.004***	0.008***	-0.001		0.005***	0.007***	0.001

			[0.003, 0.005]	[0.004, 0.011]	[-0.004, 0.003]		[0.004, 0.006]	[0.005, 0.009]	[-0.001, 0.003]
new_age				0.001**	0.001**			0.001**	0.001**
				[0.000, 0.001]	[0.000, 0.001]			[0.000, 0.001]	[0.000, 0.001]
BB1M				-0.018***	-0.018***			-0.013**	-0.013**
				[-0.025, -0.012]	[-0.025, -0.011]			[-0.022, -0.003]	[-0.022, -0.004]
fibaseline				0.000	0.000			0.000*	0.000
				[0.000, 0.000]	[0.000, 0.000]			[0.000, 0.000]	[0.000, 0.000]
time × new_age				0.000	0.000			0.000	0.000
				[0.000, 0.000]	[0.000, 0.000]			[0.000, 0.000]	[0.000, 0.000]

time × BB1M			-0.001	-0.001			0.000	0.000
			[-0.004, 0.002]	[-0.004, 0.002]			[-0.002, 0.002]	[-0.002, 0.002]
time × fibaseline			0.000*	0.000			0.000**	0.000
			[0.000, 0.000]	[0.000, 0.000]			[0.000, 0.000]	[0.000, 0.000]
Diff (change in FI)				0.018***				0.017***
				[0.015, 0.021]				[0.015, 0.019]
SD (Intercept ID)	0.056	0.059	0.058	0.058	0.054	0.059	0.059	0.059

SD (time ID)		0.007	0.007	0.007		0.008	0.008	0.009
Cor (Intercept~ time ID)		-0.382	-0.408	-0.490		-0.399	-0.416	-0.425
AIC	-8160.5	-8224.8	-8179.7	-8311.7	-18348.7	-19044.0	-18988.1	-19345.5
BIC	-8142.5	-8188.7	-8107.6	-8233.5	-18328.5	-19003.7	-18907.5	-19258.2
ICC	0.6	0.7	0.7	0.7	0.6	0.7	0.7	0.7
Log likelihood	4088.80	4130.36	4156.66	4229.40	9182.76	9540.39	9566.88	9752.76
-2LL (Deviance)	-8177.59	-8260.72	-8313.32	-8458.80	-18365.53	-19080.79	-19133.75	-19505.52

* p < 0.05, ** p < 0.01, *** p < 0.001

Appendix Sensitivity 2c. Models among those with 3 or less visits vs 4 or more for 2008 cohort

Visits	3 or less	3 or less	3 or less	3 or less	4 or more	4 or more	4 or more	4 or more

	0.231***	0.228***	0.233***	0.230***	Null Model	Model 2	Model 3	Model 4
n	1877	1877	1877	1877	864	864	864	864
Num.Obs.	3343	3343	3343	3343	4816	4816	4816	4816
(Intercept)					0.239***	0.228***	0.237***	0.235***
	[0.228, 0.234]	[0.224, 0.231]	[0.224, 0.242]	[0.222, 0.239]	[0.235, 0.242]	[0.223, 0.232]	[0.226, 0.249]	[0.224, 0.247]
time		0.005***	0.006***	0.001		0.004***	0.007***	0.002
		[0.004, 0.006]	[0.003, 0.010]	[-0.003, 0.004]		[0.003, 0.005]	[0.005, 0.009]	[0.000, 0.004]
new_age			0.001***	0.001***			0.000	0.000
			[0.001, 0.002]	[0.001, 0.002]			[0.000, 0.001]	[0.000, 0.001]
BB1M			-0.017***	-0.016***			-0.019***	-0.020***
			[-0.023, -0.010]	[-0.023, -0.010]			[-0.029, -0.009]	[-0.030, -0.010]

fibaseline			0.000	0.001			-0.002	-0.001
			[-0.003, 0.003]	[-0.002, 0.004]			[-0.007, 0.003]	[-0.006, 0.004]
time × new_age			0.000	0.000			0.000*	0.000
			[0.000, 0.000]	[0.000, 0.000]			[0.000, 0.000]	[0.000, 0.000]
time × BB1M			0.000	0.000			0.000	0.000
			[-0.003, 0.003]	[-0.003, 0.003]			[-0.002, 0.002]	[-0.002, 0.001]
time × fibaseline			-0.001	0.000			-0.002***	-0.001
			[-0.002, 0.001]	[-0.001, 0.002]			[-0.003, -0.001]	[-0.002, 0.000]

Diff (change in FI)				0.011***				0.016***
				[0.008, 0.014]				[0.014, 0.018]
SD (Intercept ID)	0.057	0.060	0.058	0.058	0.055	0.061	0.060	0.061
SD (time ID)		0.007	0.007	0.007		0.009	0.008	0.008
Cor (Intercept~ time ID)		-0.304	-0.336	-0.320		-0.405	-0.431	-0.436
AIC	-8885.6	-8958.0	-8950.6	-8990.8	-14986.5	-15501.3	-15464.9	-15716.6
BIC	-8867.3	-8921.3	-8877.3	-8911.3	-14967.0	-15462.4	-15387.2	-15632.4
ICC	0.6	0.7	0.7	0.7	0.6	0.8	0.7	0.8

Log likelihood	4451.36	4496.92	4537.67	4564.31	7501.54	7768.85	7795.35	7928.23
-2LL (Deviance)	-8902.73	-8993.85	-9075.33	-9128.61	-15003.08	-15537.7	-15590.69	-15856.46

Chapter 9

Appendix 1. Checking residuals and random effects of main analyses

Null Model
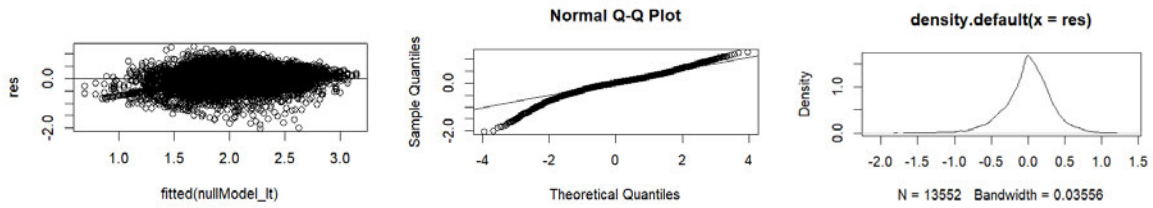
Model 2
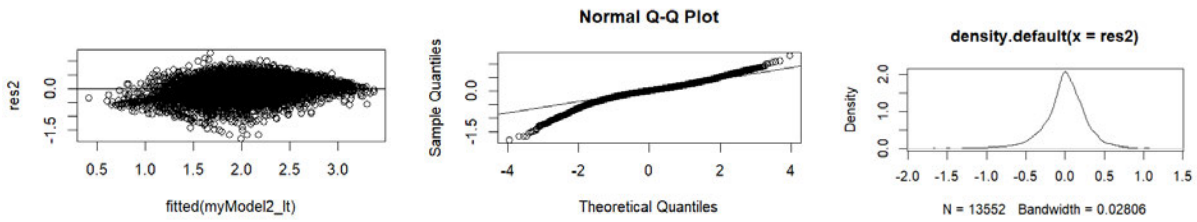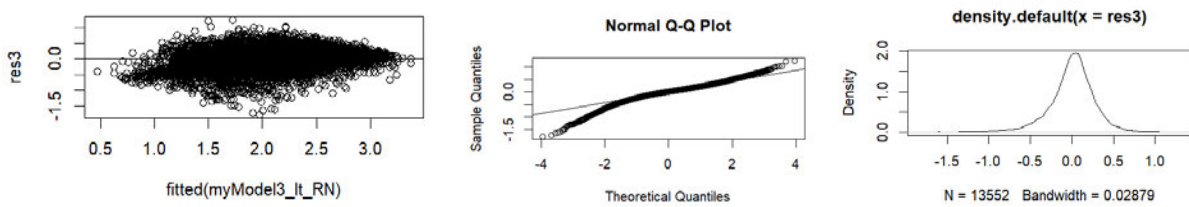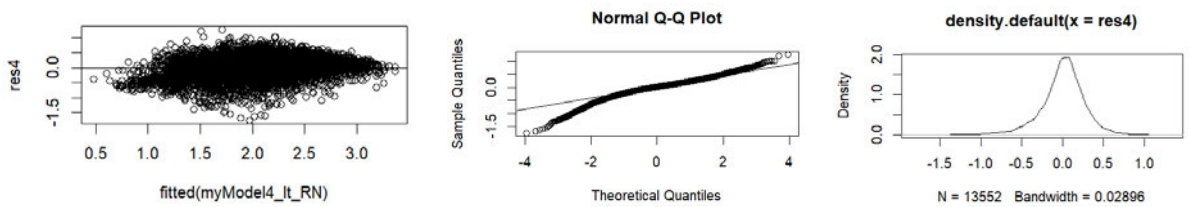
Model 3

Model 4

Chapter 10

Appendix 1. Cox proportional hazards models for full analysis

	5 Year Mortality	10 Year Mortality	5 Year LTC Entry	10 Year LTC Entry
Age	0.023***	0.028***	0.039***	0.042***
	[0.018, 0.028]	[0.024, 0.033]	[0.032, 0.045]	[0.036, 0.048]
Sex (Male)	0.426***	0.288***	0.009	-0.032
	[0.351, 0.502]	[0.223, 0.352]	[-0.093, 0.110]	[-0.126, 0.061]
FI	0.331***	0.267***	0.156***	0.143***
	[0.293, 0.370]	[0.234, 0.300]	[0.106, 0.206]	[0.098, 0.189]
SVI	-0.076**	-0.059**	0.356***	0.306***
	[-0.129, -0.023]	[-0.104, -0.014]	[0.290, 0.422]	[0.245, 0.367]
Cognition (impaired)	0.132**	0.161***	1.043***	0.967***
	[0.050, 0.214]	[0.091, 0.230]	[0.942, 1.144]	[0.874, 1.059]
Cohort (2008)	-0.014	0.032	0.041	0.027
	[-0.086, 0.058]	[-0.029, 0.093]	[-0.050, 0.132]	[-0.055, 0.109]
Num.Obs.	5520	5520	5520	5520

|				
AIC	48508.1	67454.6	29225.2	35080.6
BIC	48547.8	67494.3	29264.9	35120.3

* p < 0.05, ** p < 0.01, *** p < 0.001

AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, FI = frailty index,

Num.Obs = number of observations, SVI = social vulnerability index

Appendix 2. Separate sex analyses

Appendix 2a. Females - Survival curves 5 year mortality (left column) and 10 year mortality (right column)
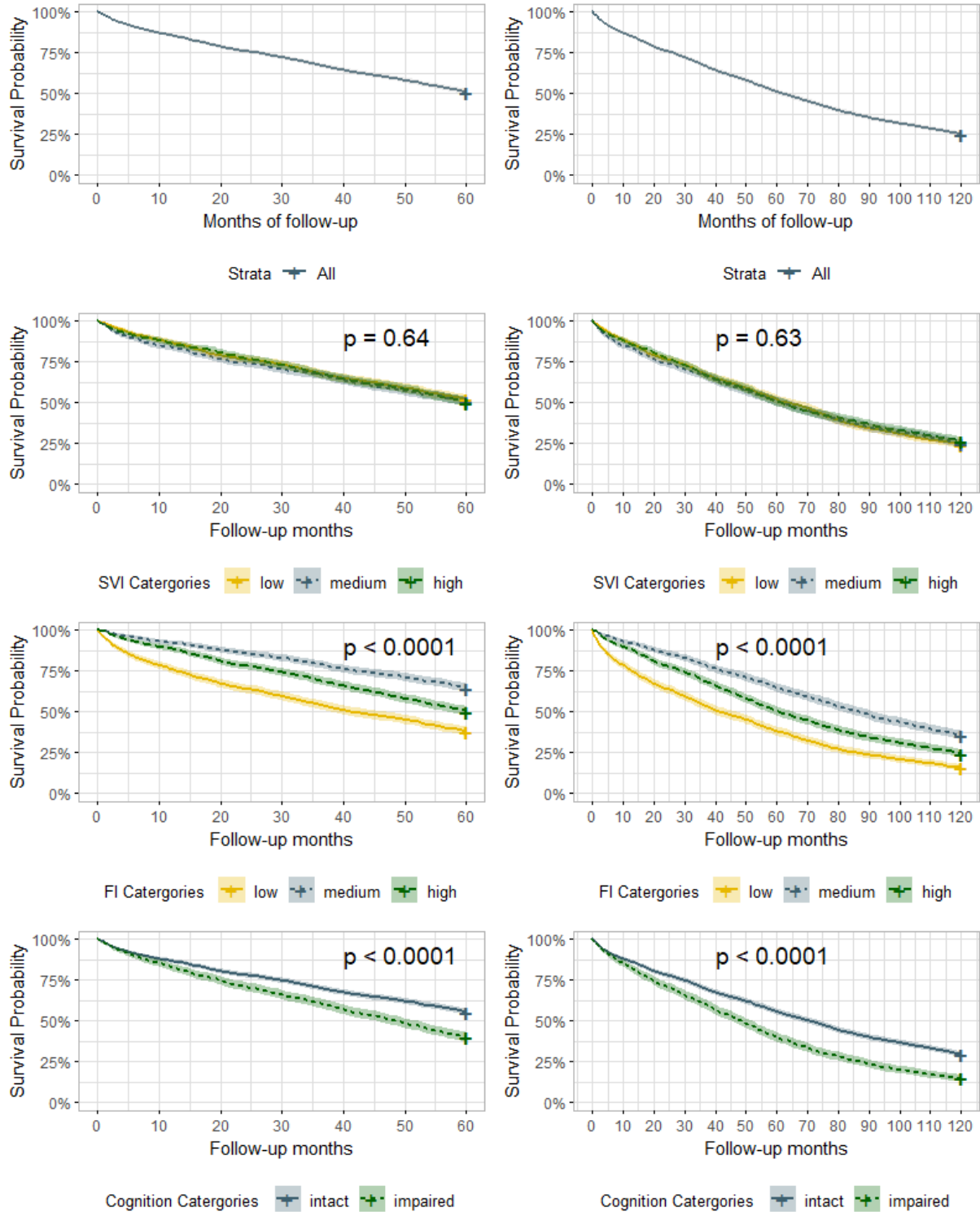
Appendix 2b. Males - Survival curves 5 year mortality (left column) and 10 year mortality (right column)
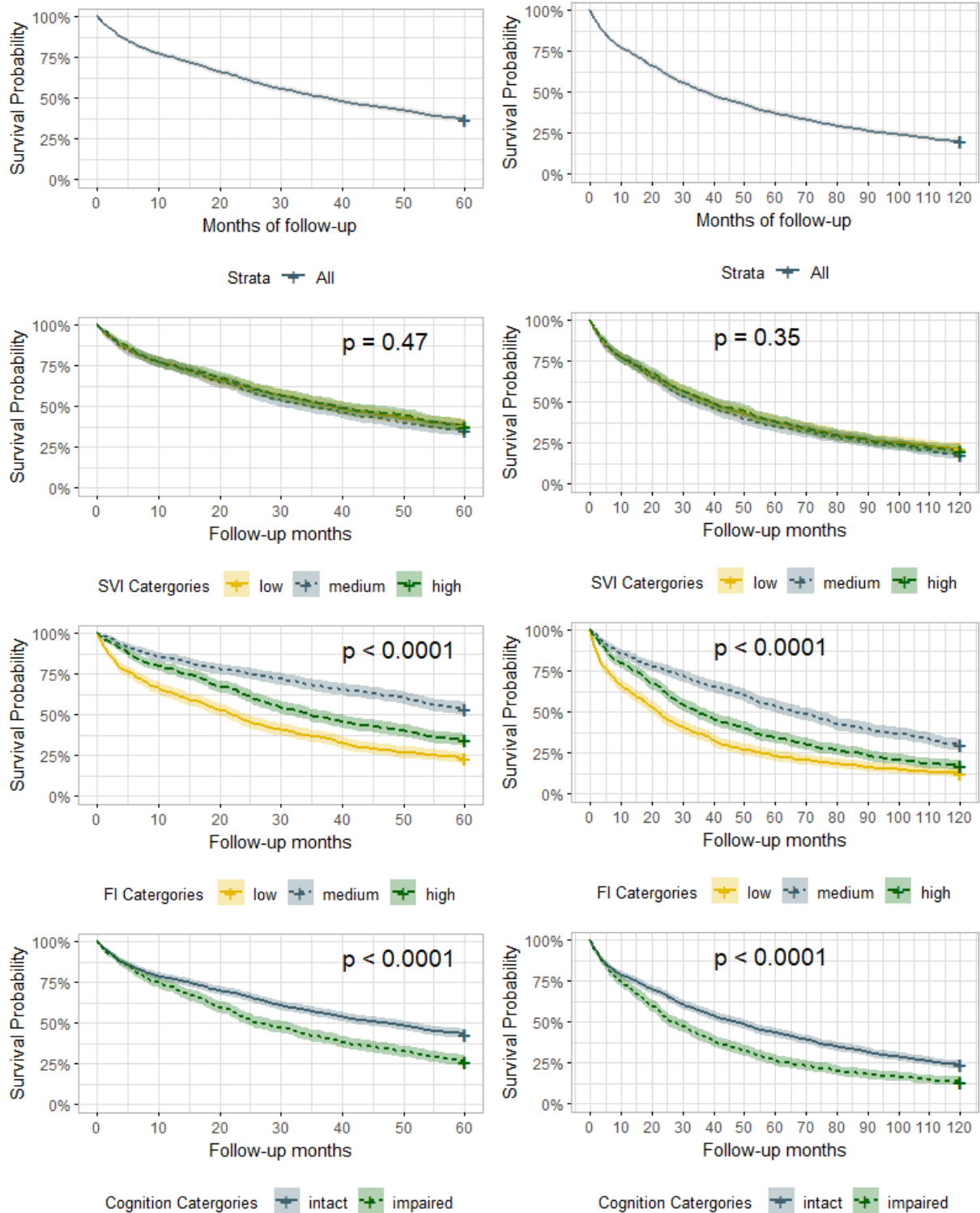
Appendix 2c. Female and males survival cox proportional hazards models

	5 Year Survival Females	5 Year Survival Males	10 Year Survival Females	10 Year Survival Males
Age	0.022***	0.024***	0.033***	0.020***
	[0.015, 0.028]	[0.017, 0.032]	[0.028, 0.039]	[0.013, 0.027]
FI	0.355***	0.297***	0.283***	0.243***
	[0.305, 0.406]	[0.236, 0.357]	[0.241, 0.325]	[0.189, 0.297]
SVI	-0.081*	-0.066	-0.049	-0.072
	[-0.151, -0.010]	[-0.148, 0.016]	[-0.106, 0.009]	[-0.144, 0.001]
Cognition (impaired)	0.128*	0.142*	0.179***	0.130*
	[0.023, 0.233]	[0.010, 0.274]	[0.092, 0.265]	[0.012, 0.248]
Cohort (2008)	-0.034	0.017	0.021	0.045
	[-0.127, 0.059]	[-0.098, 0.133]	[-0.055, 0.096]	[-0.058, 0.148]
Num.Obs.	3677	1843	3677	1843

	5 Year Survival Females	5 Year Survival Males	10 Year Survival Females	10 Year Survival Males
AIC	28267.6	16313.2	41794.7	20248.2
BIC	28298.7	16340.8	41825.7	20275.8

* p < 0.05, ** p < 0.01, *** p < 0.001

AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, FI = frailty index, Num.Obs = number of observations, SVI = social vulnerability index

Appendix 2d. Females – Probability of remaining in the community at 5 years (left column) and 10 years (right column)
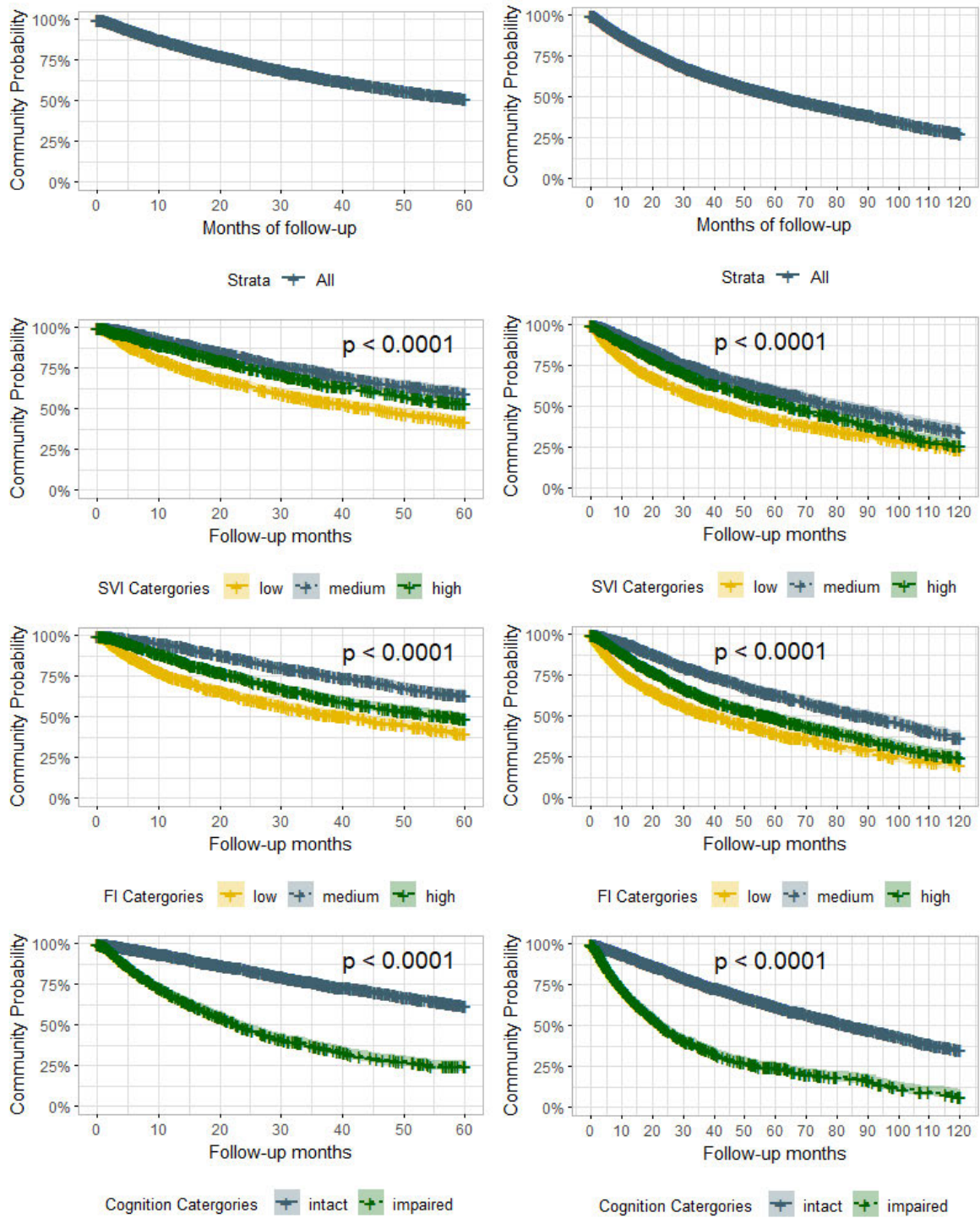
Appendix 2e. Males – Probability of remaining in the community at 5 years (left column) and 10 years (right column)
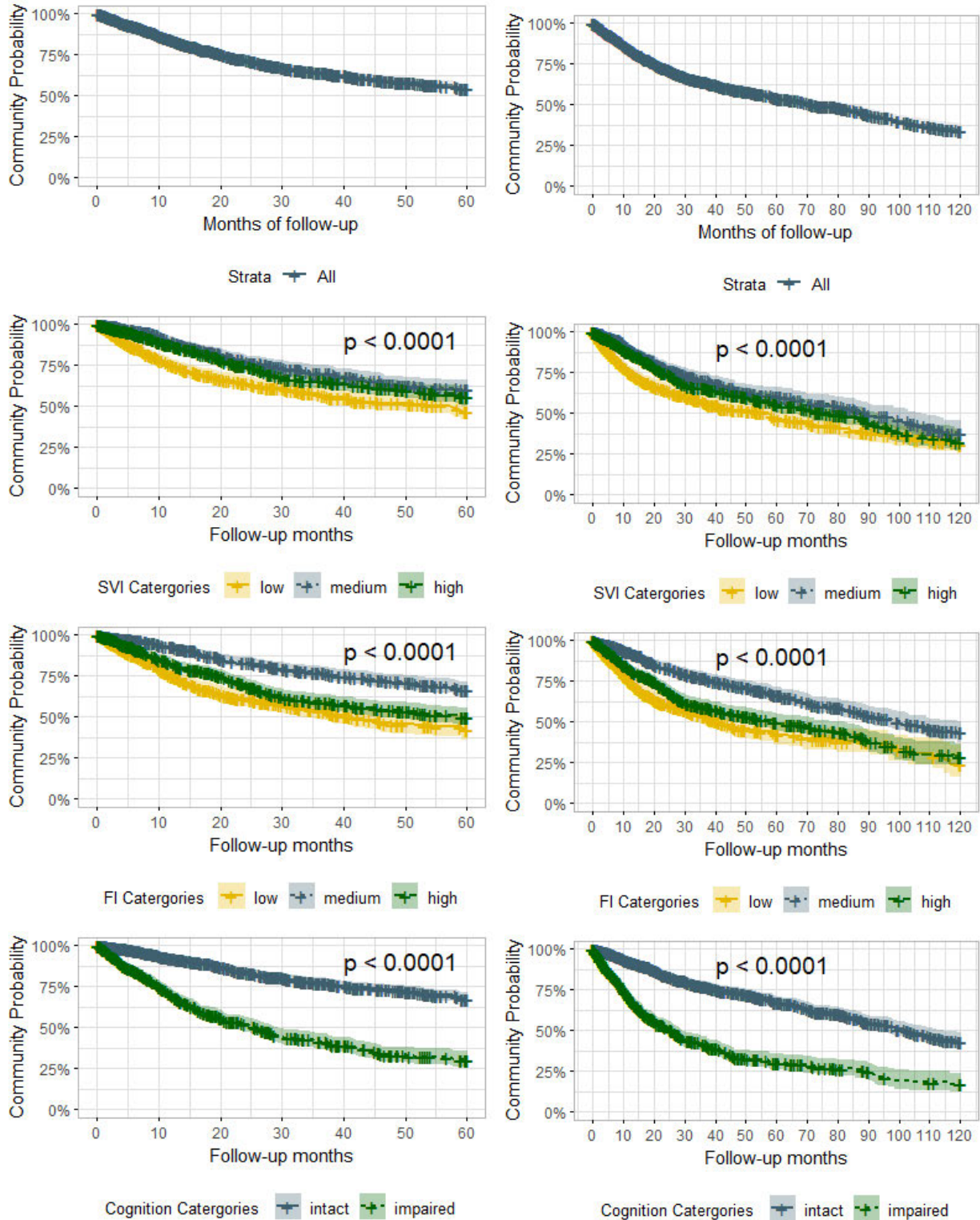
Appendix 2f. Female and males long-term care home cox proportional hazards models

	5 Year LTC Females	5 Year LTC Males	10 Year LTC Females	10 Year LTC Males
Age	0.040***	0.036***	0.044***	0.037***
	[0.032, 0.047]	[0.024, 0.048]	[0.037, 0.051]	[0.026, 0.048]
FI	0.177***	0.098*	0.161***	0.091*
	[0.117, 0.237]	[0.010, 0.186]	[0.106, 0.215]	[0.008, 0.174]
SVI	0.373***	0.316***	0.326***	0.264***
	[0.292, 0.453]	[0.198, 0.433]	[0.253, 0.399]	[0.154, 0.374]
Cognition (impaired)	1.032***	1.093***	0.970***	0.989***
	[0.914, 1.151]	[0.899, 1.287]	[0.862, 1.079]	[0.809, 1.170]
Cohort (2008)	0.094+	-0.092	0.077	-0.104
	[-0.015, 0.202]	[-0.261, 0.077]	[-0.019, 0.174]	[-0.261, 0.053]
Num.Obs.	3677	1843	3677	1843

	5 Year LTC Females	5 Year LTC Males	10 Year LTC Females	10 Year LTC Males
AIC	19784.0	7200.4	24232.2	8157.7
BIC	19815.0	7228.0	24263.3	8185.3

* p < 0.05, ** p < 0.01, *** p < 0.001

AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, FI = frailty index, Num.Obs = number of observations, SVI = social vulnerability index

Chapter 11

Appendix 1. Estimates, Notes and References for Chapter 11, Figure 3, Use Case

Level in Model	Rough Estimate	Notes	Source
Older adults living in the community	Count = 215,325	Statistic represents older adults ≥ 65 years in Nova Scotia (NS). This is the count of all older adults who could potentially all be living in the community. Year of data: 2021	Statistics Canada. 2023. (table). *Census Profile*. 2021 Census of Population. Statistics Canada Catalogue no. 98-316-X2021001. Ottawa. Released November 15, 2023. https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E (accessed July 7, 2024).
Older adults interfacing with health care and/or social care	Calculated counts = 92,915 men + 110,074 women = 202,989 people	6% Canadian males ≥ 65 years did not have a regular health care provider x 98,845 NS men from 2021 census 5.5% of Canadian females ≥ 65 years did not have a regular health provider x 116,480 NS women from 2021 census	Statistics Canada. 2020. *Primary health care providers, 2019*. Ottawa. Released October 22, 2020. https://www150.statcan.gc.ca/n1/pub/82-625-x/2020001/article/00004-eng.htm (accessed July 7, 2024). Statistics Canada. 2023. (table). *Census Profile*. 2021 Census of Population. Statistics Canada Catalogue no. 98-316-X2021001. Ottawa. Released November 15, 2023. https://www12.statcan.gc.ca/census-

		*Uses Canadian rather than NS primary health care information from 2019 with 2021 census data	recensement/2021/dp-pd/prof/index.cfm?Lang=E (accessed July 7, 2024).
Older adults admitted to hospital	Count of ED visits = >18,207	Setting only QEII Health Sciences Centre. Excludes other hospitals.	From 2021 internal Nova Scotia Health (NSH) data requests
	ED admissions count = >24,058	Emergency Department (ED) admissions exclude planned admissions or admissions through other routes.	From 2021 internal Nova Scotia Health data requests
	ALC cases = 3-6% of cases discharged from hospital = >	During 2009-2010, 9,253 ALC cases were discharged from Atlantic Canadian Hospitals, representing 3-6% of cases discharged from hospital. 88% were 60 or over.	CIHI. Alternate Level of Care in Atlantic Canada, 2009–2010. Ottawa, ON: Canadian Institute for Health Information; 2011 Feb p. 17.

Older adults living with supports in the community	Count = <20,000 – 30,000	From news reports, 20,000 people in NS received government funded home care in 2016 and 30,000 people in NS received support from home care agencies in 2022. No age specific data.	Julian, J. Nova Scotia home care wait list up 50% over past 2 years. April 4, 2016. https://www.cbc.ca/news/canada/nova-scotia/nova-scotia-home-care-1.3518830 Ryan, H. Home care in N.S. struggling during Omicron, but no clear provincewide picture. January 16, 2020. https://www.cbc.ca/news/canada/nova-scotia/home-care-in-n-s-struggling-omicron-but-no-province-wide-picture-1.6315457
Older adults requiring institutional living support	Count = 6,841	Assumes all long-term care home beds are filled. Does not include other institutional living conditions. Data as of March 31, 2021	Canadian Institute for Health Information. How many long-term care beds are there in Canada?. Released June 10, 2021 https://www.cihi.ca/en/how-many-long-term-care-beds-are-there-in-canada Accessed July 7, 2024.

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Chapter 6

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