# Design and Evaluation of LifeLink: A Persuasive Mobile Application for Caregivers Dealing with Suicidality

By

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*For my parents*
***Mr. Ganga Nath Jha*** *and* ***Mrs. Suman Jha***
*and my brother*
***Aayush Jha***

*You gave me strength and comfort, every step of the way.*
*Thank you for your patience and infinite love.*

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# Abstract

Suicide is a complex phenomenon wherein, in addition to the individual experiencing suicidal thoughts, its effects seep into many lives including their caregivers. Caregivers seek help everywhere but face unique challenges including limited access to timely resources and personal mental health struggles. Mobile health apps offer a promising solution, but addressing caregivers' specific needs and challenges remains a concern. To address this gap, we developed LifeLink, a persuasive mobile app to support caregivers of individuals experiencing suicidal thoughts. The app was developed in three phases. First, we reviewed 80 existing suicide prevention apps from app stores and the academic literature to identify gaps and different persuasive strategies' implementations using the Persuasive System Design (PSD) model. Second, based on review findings, we designed a low-fidelity prototype of LifeLink, implementing various evidence-based persuasive strategies. Through a survey and semi-structured interviews, 45 caregivers evaluated the LifeLink app prototype and shared their perspectives, challenges, needs when supporting individuals experiencing suicidal thoughts. We refined the app, incorporating caregivers' feedback. Finally, we developed and evaluated LifeLink app in another study with 50 caregivers after a week of use. Results show that LifeLink is user-friendly, engaging, elicits a positive user experience and effectively empowers caregivers. The app's persuasive strategies were found to be significantly persuasive in influencing caregiver behaviours toward supporting individuals experiencing suicidal thoughts. LifeLink usage was associated with improved mental wellbeing, increased mental health literacy and a more supportive environment for caregivers. We provide insights from two qualitative studies on caregivers' needs and challenges, design recommendations for suicide prevention apps and highlight the importance of involving caregivers in the design process. Our findings contribute to a deeper understanding of the development of persuasive technology for suicide prevention that is user-friendly, impactful and has a positive user experience.

# List of Abbreviations Used

1. ACT: Acceptance and commitment therapy
2. CBT: Cognitive behavioral therapy
3. DBT: Dialectical behaviour therapy
4. HCI: Human Computer Interaction
5. IMI: Intrinsic Motivation Inventory
6. mHealth: Mobile health
7. MARS: Mobile App Rating Scale
8. MCBT: Mindfulness-based cognitive therapy
9. NS: Nova Scotia
10. PPQ: Perceived Persuasiveness Questionnaire
11. RO: Research objectives
12. RQ: Research questions
13. SUS: System Usability Scale
14. SWEMWBS: Short Warwick-Edinburgh Mental Wellbeing Scale
15. TAU: Treatment as usual
16. UES-SF: User Engagement Scale Short form
17. UEQ-S: User Experience Questionnaire Short
18. UI: User Interface
19. UX: User experience

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# Chapter 1 – Introduction

## 1.1 Problem Statement

[**Content Warning**] "*A student of mine died by suicide about 10 years ago. It was because of online bullying and many other factors. Online bullying was a huge contributing factor. You see, technology can be very negative, a lot of the time, but I just like the idea that you're using it in a way that makes it a positive influence*" [P88].

Suicide is a hidden epidemic that affects about seven hundred thousand people worldwide each year [116]. Statistics Canada estimates that approximately 12 people die by suicide daily in Canada [117]. Suicide is the second leading cause of death among youth and young adults (15-34 years) in Canada [117]. During the COVID-19 pandemic, adults in Canada experienced an increase in suicidal ideation [50,51]. Collectively, these alarming numbers shed light on the suicide crisis which has aggravated at the global, national, and provincial levels in Canada [118]. The irony of suicide is that while it is popularly classified as a global public health issue [116], it is deeply coloured with social stigma. This stigma creates invisible barriers for families and individuals with lived experiences of suicide and similar mental health conditions. This stigma can be associated with our society, self, and health professionals [1]. Thus, removing these barriers and considering people with lived experiences is crucial when designing solutions for dealing with suicidality [1].

Suicide is a complex phenomenon wherein, in addition to the individual who is impacted, its effects seep into many lives including their caregivers. Often, caregivers seek help everywhere, but face various challenges including long wait times, difficulty accessing resources quickly, personal struggles with mental health, and time sensitivity [36,48]. In a systematic review, Marshall et al. [56] found that caregivers face significant challenges with knowing how to respond to suicidal behaviour, where to find appropriate help, and how to manage their own distress.

Suicidality is defined as a range of thoughts and behaviours related to a person's desire to die, spanning from passive thoughts of being dead to actively trying to end one's life [103]. Suicide is defined as the "intentional ending of one's own life" [106]. Researchers and clinicians are exploring how technology can be leveraged to address the global challenge of suicide. Big data, machine learning, smartphone applications, wearables and sensors are being harnessed to design technologies for suicide prevention [105]. Suicide prevention research in Human Computer Interaction (HCI) and related fields has largely prioritized the creation of technologies, such as AI-based chatbots and automated suicide detection tools, to substitute for human support, rather than assisting them. Examples include chatbots to automate therapy [27,49] and large-scale moderation tools like suicide detection technologies [17,18,20].

Additionally, mobile-health apps have been found to be promising solutions for suicide. For example, in a recent systematic review, Melia et al. [59] reported that mobile health (mHealth) technology apps are useful for individuals at elevated risk of suicide or self-harm, including reduction in depression, psychological distress, and self-harm, and increase in coping self-efficacy. In another systematic review, Jha et al. [37] found that there is scope to use persuasive strategies in suicide prevention apps to make them

persuasive and tailored to the individual. Mobile-health apps are easily accessible, available, geographic location independent and affordable as compared to face-to-face interventions [10,115]. These apps can increase the likelihood of seeking support and help reduce barriers created by social stigma.

Many mHealth apps for suicide prevention exist [70,83,119]. Nevertheless, limited research has been conducted to examine the design of such apps and their efficacy in addressing the unique mental health needs of caregivers supporting individuals with suicidal ideation. To gain a better understanding of the problem space, we[1] reviewed existing suicide prevention apps [38] and found that there is a lack of apps targeted towards caregivers of individuals experiencing suicidal thoughts [56] which involve them in the development process [48,69]. Apps lack evidence-based sources and have low user engagement. Additionally, there is less focus on evaluating the app's user experience (UX) and much potential to leverage persuasive strategies when designing suicide prevention apps [37]. Suicide remains a pressing public health concern with substantial repercussions for individuals, families, and communities [54]. Caregivers of individuals experiencing suicidal thoughts face a critical need for effective support and resources [48]. Current mental health support systems lack accessible, immediate, and effective tools tailored for caregivers [56,69], highlighting a significant gap.

The abovementioned gaps underscore the need for designing a suicide prevention app specifically for caregivers of individuals experiencing suicidal thoughts. Our work aims to fill these gaps by **(1) understanding the perspectives, challenges, concerns, and needs of caregivers supporting individuals experiencing suicidal thoughts**, **(2) using these perspectives and findings to prototype and evaluate mobile apps for suicide prevention**, and **(3) developing and evaluating a persuasive mobile app, LifeLink to support caregivers of individuals experiencing suicidal thoughts**. It must be noted that this thesis uses the terms 'caregivers', 'caregivers dealing with suicidality' and 'caregivers of individuals experiencing suicidal thoughts' interchangeably. All of these refer to caregivers who are supporting a person experiencing suicidal thoughts.

## 1.2 Solution

In this work, we ask: **how can we design mobile-based technology to support caregivers of individuals experiencing suicidal thoughts?** We further break down this overarching question into specific research questions (RQs), which guided this thesis:

- **RQ1.** What are the limitations of existing mobile apps for suicide prevention?
- **RQ2.** How can a mobile application be better designed to support caregivers of individuals experiencing suicidal thoughts? What are the needs and concerns of caregivers supporting individuals experiencing suicidal thoughts?
- **RQ3.** What persuasive strategies are most useful for designing a mobile app for suicide prevention?
- **RQ4.** How usable is the LifeLink application?

[1] This thesis uses the first-person plural voice (we, our, etc.) to indicate that the work was done by me, Smriti, under the supervision of Dr. Rita Orji.

- **RQ5.** How engaging is the LifeLink application for supporting caregivers of individuals experiencing suicidal thoughts?
- **RQ6.** To what extent did using the LifeLink application generate a positive experience for caregivers?
- **RQ7.** How persuasive is the LifeLink application for caregivers of individuals experiencing suicidal thoughts?

To address our RQs, we prototyped the LifeLink app in collaboration with a national community of practice for community-led approaches to suicide prevention called Roots of Hope [120] and conducted two user studies using surveys and semi-structured interviews with caregivers to refine and evaluate the LifeLink app prototype and the fully developed app. We developed LifeLink in three phases:

- **Phase 1**: We reviewed 25 studies to determine risk factors that are most strongly associated with suicide and considerations for developing suicide prevention technologies [37]. We then reviewed 80 suicide prevention apps [38] from app stores and academic literature to identify gaps and different persuasive strategies' implementations using the Persuasive System Design (PSD) model [71].
- **Phase 2**: Using findings from the two systematic reviews, we designed a low-fidelity prototype of the LifeLink app, implementing various evidence-based persuasive strategies. Next, 45 caregivers evaluated the user experience of LifeLink app prototype via a survey and optional semi-structured interviews [36]. We understood caregivers' needs and concerns when supporting an individual experiencing suicidal thoughts. We learnt about caregivers' opinions, perspectives, and attitudes towards the design of the app prototype. We recorded their suggestions and design recommendations to refine the app design.
- **Phase 3**: Using findings and recommendations from Phase 2, we developed the LifeLink app, and evaluated it on 50 caregivers who used for a week. Caregivers evaluated their experience with the app using a pre-study, post-study survey and optional semi-structured interviews. We assessed the usability of the app, user engagement, and overall user experience of caregivers with the app. We also evaluated the effectiveness of the persuasive strategies within the app in influencing caregiver behaviors and attitudes toward supporting individuals experiencing suicidal thoughts.

Overall, we developed LifeLink, a persuasive mobile application designed to support caregivers of individuals experiencing suicidal thoughts, iteratively and incrementally to ensure that the app is tailored to the user's preferences. The LifeLink app uniquely utilizes a user-centered design approach [65] and persuasive design principles [71], incorporating evidence-based techniques to support caregivers. It must be noted that the app is designed particularly for caregivers like partners, grandparents, families, chosen family, friends, teachers, guidance counsellors, SchoolsPlus workers [155], coaches, nurses, social workers, or mentors who are or were supporting someone experiencing suicidal thoughts.

## 1.2 Contribution

This work makes multiple contributions:

- **System**: We present the design and implementation of LifeLink, a persuasive mobile app to support caregivers of individuals experiencing suicidal thoughts using a user-centered design approach and persuasive design principles.
- **Empirical**: We present the first empirical evidence that involving caregivers in the app design process and utilizing persuasive design principles in a suicide prevention app can lead to improved mental wellbeing, positive user experience, increased mental health literacy, and a supportive environment. We provide insights from two qualitative studies on caregivers' needs, challenges and design recommendations for suicide prevention apps. These findings can inform the development of persuasive technology for suicide prevention that is user-friendly, impactful and has a positive user experience.
- **Survey**: A systematic review of existing suicide prevention apps to derive current trends, gaps, evaluation of persuasive strategies and recommendations for designing better suicide prevention apps.

This work contributes to the domains of persuasive technology, behaviour change, suicide prevention, suicide research, mental health, HCI and mental health interventions. Our findings and recommendations can guide designers, developers, researchers, practitioners, and clinicians in leveraging technology for suicide prevention. See Appendix Q. 'My Publications' for a complete list of my publications.

## 1.4 Thesis Overview

The remainder of this thesis is structured as follows:

- **Chapter 2**: We provide the background and related work, including an overview of suicide, digital interventions for suicide prevention, an app review of mobile apps for suicide prevention and theoretical bases of existing apps.
- **Chapter 3**: We describe various stages of the design and implementation process of the LifeLink app.
- **Chapter 4**: We present an overview of our study design and describe the processes of the two evaluation studies that we conducted to evaluate the LifeLink app.
- **Chapter 5**: We present results from the two evaluation studies.
- **Chapter 6**: We discuss findings from the two evaluation studies, recommendations for future research, limitations of this work and how they can be mitigated in future work.
- **Chapter 7**: We conclude the thesis, summarizing what we have done and the contributions of our work.

# Chapter 2 – Background and Related Work

"*I didn't want to be in the sport anymore (after the 2012 Olympics)...I am extremely thankful that I did not take my life*"

*American former competitive swimmer, 28 Olympic medals [record holder]*
*Michael Phelps*

Notable authors such as *Sylvia Plath*, *Virginia Woolfe*, renowned artist *Vincent Van Gogh* and music producer *Avicii* are few of the people that this world has lost to suicide. In the 21st century, suicide has become a global cause of concern [116]. Recently, suicide has garnered interest among researchers, clinicians and the general public. In pop culture, various movies, television shows and books have depicted suicide and its ripple effects. Some of these are *Anna Karenina (1878), The Bell Jar (1963)*, *Perks of Being a Wallflower (2012), 13 Reasons Why (2017)* and *Anatomy of a Fall (2023).* There is an evident body of research on understanding suicidality, its causes and preventive measures. To address the global challenge of suicide, many researchers and clinicians are exploring how technology can be leveraged for suicide prevention.

In this chapter, we start by understanding the issue of suicide, its underlying stages and risk factors (factors most strongly associated with the risk of suicide). We then review existing digital interventions that have been developed for suicide prevention. Following that, we narrow down to mobile apps for suicide prevention. We present a systematic literature review of existing mobile apps for suicide prevention. We discuss the results and observations from the reviewed apps. Next, we focus on the theoretical bases of existing interventions. These include the Fogg Functional Triad [29], Fogg's Eight-Step Design Process [28] and Persuasive Systems Design Framework [71]. Within the Persuasive System Design Framework, we further discuss how persuasive strategies have been operationalized in existing mobile apps for suicide prevention.

## 2.1 Suicide

Suicide is a termite that affects both the person who dies and his or her community. Suicides usually leave families and friends of the individual, spiralling for answers [15]. While the act of suicide itself might appear as an escape from reality [121], the causal pathway to lethal suicidal behaviour is manifested in a series of stages [72]. According to the Interpersonal Theory of Suicide [72], suicide can be classified as ideations, communications, and behaviours. The theory suggests that working up to the act of suicide is difficult to do and is a gradual consequence of many stages like passive suicidal ideation that matures into suicidal intent and eventually to lethal suicidal behavior.

Suicidality has been characterized as stages along a continuum starting with death wishes and tiredness of life to suicidal ideation, then to planning and finally attempt [103]. Understanding the intricate differences between each of the stages of suicidality is fundamental to the study of suicide research. Suicidal ideation is defined as thoughts of engaging in behaviours intended to end one's own life [63]. Suicide plans are considered

as the cognitive formulation of a specific method through which one wants to die [63]. Suicide attempts have been defined as engagement in potentially self-injurious behaviour in which there is at least some intent to die [63]. Suicide death is defined as death arising from an act inflicted upon oneself with the intent to kill oneself [61]. Suicide is defined as the intentional ending of one's own life [106]. Risk factor refers to antecedent conditions associated with an increased likelihood of adverse, deleterious or undesirable outcomes [42]. In this thesis, four separate outcomes related to suicide were identified: (1) suicidal ideation, (2) suicidal plan, (3) suicide attempt, and (4) suicide death. An additional outcome "suicide risk" was identified and was considered an overlap of suicidal ideation and suicidal plans.

To prevent suicide, it is essential to have a clear understanding of the different stages of suicide and underlying risk factors (that predict suicide). To identify risk factors that are most strongly associated with suicide and their impact on developing technological interventions for suicide prevention, a systematic review and meta-analysis of twenty-five studies was conducted [37]. Factors statistically associated with suicide were found to be: any diagnosed mental disorder, adverse life events, past suicide attempt, low education level, loneliness or high isolation, bipolar disorder, depression, multiple chronic health conditions, family history of suicide, sexual trauma and being female. Understanding risk factors that are modifiable, can be helpful for the development of technologies for suicide prevention.

## 2.2 Digital Interventions for Suicide Prevention

In recent years, there has been an increase in the use of technology for suicide prevention [7,43,101]. Suicide prevention interventions have been developed using big data, machine learning techniques, smartphone applications, wearables and sensors [103]. Data-driven approaches collect and analyze large amounts of population data to recognize patterns and predict suicide [109]. Such approaches help in objectively quantifying the impact of different risk factors and how they interact with each other. A study involving 40,000 soldiers in a psychiatric hospital used a machine learning algorithm to devise a predictive suicide risk algorithm [83]. Another study on South Korean teenage students used data mining techniques to understand the risk factors that led to a suicide attempt [77]. The authors used data mining to identify every possible interaction between a huge range of different variables (i.e., big data).

Computerized real-time facial emotion monitoring is also being used to detect subtle changes in the facial expressions of people with suicidal thoughts [92]. Such approaches can help assess suicidality in high-risk individuals who may not disclose their suicidal thoughts verbally. Non-invasive sensors which monitor EEG activity are also being used to create personalized computer models of an individual's emotional state [45]. Such sensor-based approaches can be made more robust in combination with physiological measurements from biomarkers, measurements from social interaction using smartphone sensors and clinical data. It must be noted that these approaches have some psychological implications particularly "observer effect" might arise [82]. This implies that people might modify their behaviours because of awareness that they are being monitored constantly over time. Computerized therapy and smartphone applications (apps) have also been found

to be useful for developing interventions for suicide prevention [109]. Overall, different technological approaches are being leveraged to gather rich data about the individual's complete risk profile which can be monitored to prevent suicide. These digital interventions for suicide prevention paved the way for us to explore how we can use technology, in particular, mobile-based technology for suicide prevention. Next, we investigate the scope for developing mobile apps for suicide prevention.

## 2.3 Mobile Apps for Suicide Prevention

Mobile health (mHealth) apps are useful tools for tackling stigmatized mental health issues, including suicide. Mobile apps for suicide prevention are easily accessible, increase the likelihood of honest reporting on sensitive topics and reduce stigma as compared to face-to-face or traditional interventions [10,108]. Many mHealth apps for suicide prevention exist [90,99,101]. However, existing work on mobile apps for suicide prevention lacks examination of design characteristics such as app interface and content. Such works review a small number of studies, which makes it insufficient to draw solid conclusions [52,53,59]. Very few studies evaluate the UX and persuasive strategies employed in suicide prevention apps [89,113]. These gaps bring about the need to conduct an in-depth review that would provide a more comprehensive outlook of existing mobile apps for suicide prevention.

To address these gaps, we examined the design, implementation, and evaluation aspects of mobile apps for suicide prevention. We present a systematic literature review of 80 suicide prevention apps available in app stores and academic journals. We identified current trends within the reviewed apps, the effectiveness of apps, evaluation methods, and app content. We then asked how we might leverage lessons learned from these apps to design more efficient smartphone-based interventions for suicide prevention.

### 2.3.1 Materials and Methods

We followed the latest version of the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) 2020 guidelines [81] for accurate reporting.

### 2.3.2 Search Strategy and Selection Criteria

We conducted two reviews, from app stores and literature databases each. To obtain a comprehensive review of current trends in suicide prevention apps, we focused on apps from app stores, as well as academic journals (Appendix B).

First, we performed a systematic search in four major electronic databases containing medical and computer science research papers (PubMed/MEDLINE, ACM Digital Library and IEEE Xplore for relevant titles and abstracts published between January 2013 and July 2024. We also did a manual search on Google Scholar to explore other potential articles by reviewing the references identified in the individual articles, to ensure a comprehensive examination of relevant literature on the topic. The following keywords were combined to search the databases in titles/abstract: "Suicide", "suicide prevention", "suicide management", "support", "mobile application(s)"," smartphone application(s)", "mobile intervention", "preventive intervention". These keywords were combined using the conjunctions "OR" and "AND". The inclusion criteria for articles were:

1. Should present only a ‘mobile-based’ intervention or ‘mobile app’ for suicide prevention.
2. Should assess either the design, implementation, or evaluation of the mobile app.
3. Target suicidal outcome examined should be either suicide prevention, suicide management, suicide support or suicidal ideation reduction. Suicide prevention will include suicidal thoughts, suicidal behaviours, suicidal ideation, suicidal intent, suicide plan or suicide attempt.
4. Should be published in English.
5. Should be published between 2013-2024.

Our exclusion criteria were:

- studies published before 2013
- studies that did not explicitly mention the role of mobile apps in preventing suicide
- studies that only investigated the presence of suicide risk without any intervention
- studies not published in peer-reviewed journals
- studies not published in English, and meta-analyses, systematic, narrative reviews, and book chapters. Figure 2.1 presents the PRISMA flow diagram for identifying articles from the literature.

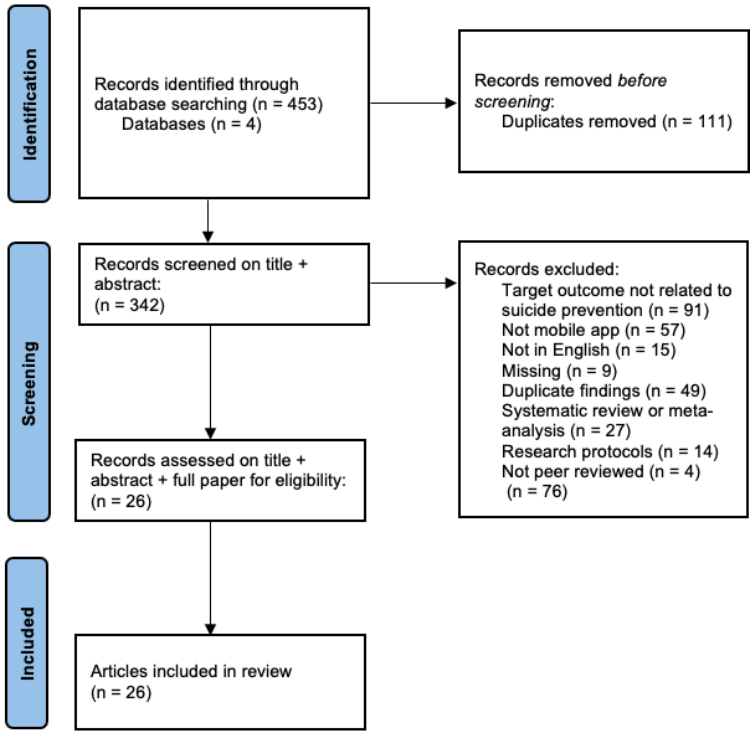


Figure 2.1 PRISMA flow diagram [81] demonstrates the systematic review process undertaken from records identification to the final pool of included articles.

Second, we reviewed publicly available mobile apps by searching the Google Play store (Android), and the iTunes store (iOS). All these search results were screened. The title, description, and price of each app were retrieved from the app store, and apps that appeared in the results for multiple search terms were removed. The inclusion criteria for apps were:

1. Should be published in English.

2. Target suicidal outcomes examined should be either suicide prevention, suicide management, suicide support, or suicidal ideation reduction. Suicide prevention will include suicidal thoughts, suicidal behaviors, suicidal ideation, suicidal intent, suicide plan or suicide attempt.
3. Should be free or free with in-app purchases.
4. Should be available to download via the Google Play store or (iOS) App store.

Apps were excluded if they: contained no suicide prevention content; were related exclusively to other mental health conditions unless suicidality was explicitly mentioned; or were not in English. Figure 2.2 presents the PRISMA flow diagram for identifying suicide prevention apps.

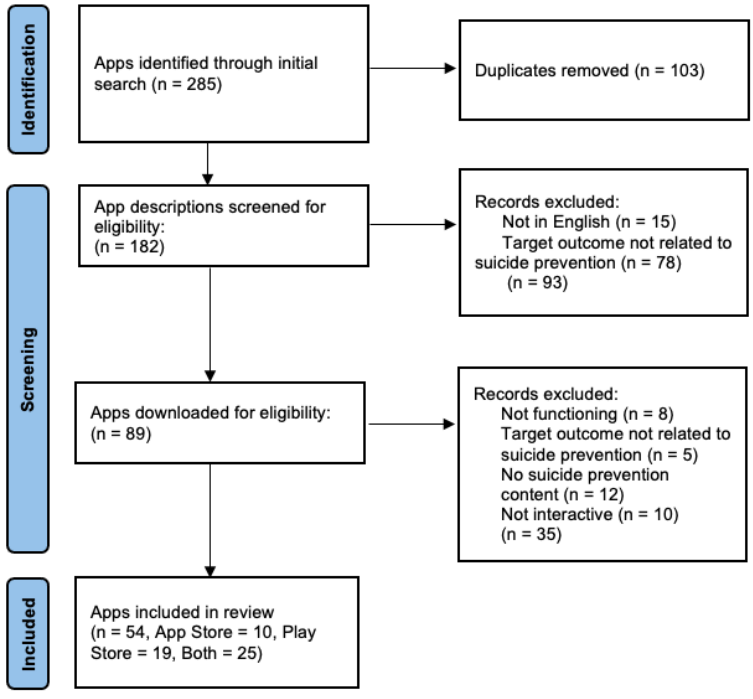


Figure 2.2 PRISMA flow diagram [81] demonstrating the systematic review process undertaken for identifying suicide prevention apps from official app stores.

During the screening stage, two reviewers independently assessed the title and description of each app and article against the inclusion and exclusion criteria. Results of the screening were compared, and discrepancies were resolved by discussion until consensus was achieved. All apps that were identified as being eligible for inclusion were downloaded and installed on a Xiaomi Redmi Note 10 (Android version 11, MIUI 12) or iPhone 14 Pro (iOS version 16) for full content review.

### 2.3.3 Data Extraction

From our search, a total of 54 apps were selected from the target platforms: App Store (n = 10), Play Store (n = 19), and both platforms (n = 25) as shown in Figure 2.2. The list of these 54 apps can be found in Appendix A. We also investigated apps published in academic journals. From our initial search of 453 papers, we obtained 342 papers for abstract and title screening. We excluded 76 studies and finally reviewed the full text of 26

studies that met all the criteria. In total, we included 54 apps from app stores and 26 app interventions from academic journals (i.e., a total of 80 apps for the present data analysis). Each app was opened and assessed independently by the two reviewers to confirm eligibility. The content and features of the apps were then independently reviewed for suicide prevention content. Each reviewer labeled different characteristics in the installed apps separately, in a coding sheet created using Microsoft Excel. The reviewers focused on evaluating the persuasive strategies implemented in apps. The list of data items for coding the included apps is presented in Table 2.1.

Table 2.1 Data items on which the included suicide prevention apps were coded for the systematic review.

| Data Item | Description |
|---|---|
| **Target suicidal outcome** | Suicidality stage that the app is targeting e.g., suicidal ideation, suicidal thoughts, self-harm, suicide attempt, suicide plan. |
| **App Name, Rating, Country, Year, Platform, Developer, Last update** | General app information like name of the app, average rating, country, year published, name of the developer, last date when it was updated. |
| **In-app purchases, downloads** | Indicating whether the app was free or free with in-app features and the total number of times the app was downloaded. |
| **Target age group** | Target population for which the app is designed. |
| **Intervention Type** | Best practice features for suicide prevention implemented within the app for e.g., safety planning, Dialectical behavior therapy (DBT), Acceptance and commitment therapy (ACT), psychoeducation, coping strategies, treatment, support, crisis line access, means safety. |
| **App Interface Implementation** | Indicating what tools and software were used to implement the app interface. |
| **User Engagement** | App features for making the app engaging e.g., gamification, avatars, color scheme, usability, aesthetics, navigation. |
| **Data Security** | Indicating whether the app had security measures in place for user's data privacy. |
| **Study Design, Duration of Evaluation, Measures of evaluation, Clinical testing** | Design of study for evaluating the app e.g., randomized control trial, pilot study, pre and post-test. Period of evaluation, scales, and tools used for evaluation. Clinical testing of the app or not. |
| **App Efficacy** | How effective the app was in the evaluation study e.g., partially successful, successful, unsuccessful, undetermined. |

| Data Item | Description |
|---|---|
| **Persuasive strategies, persuasive implementation** | **strategies'** Type of persuasive strategy from Persuasive System Design model [71] and how it was implemented within the app. |

### 2.3.4 Results from App Review

In this section, we present results derived from our analysis. We showcase the general characteristics of apps, target outcome of apps, evaluation methods adopted to test the apps, effectiveness of apps, app content and implementation.

#### 2.3.4.1 General Characteristics of Apps

Of the apps reviewed, 65% were Android (35 out of 54 apps) and 35% were iOS (19 apps out of 54 apps). 93% of the apps were free and 7% were free with in-app purchases. The majority of the apps (44%) had an app rating between 4.5 to 4.8. Forty-five percent (36 out of 80) apps were created or commissioned by healthcare providers or non-profit organizations. Most apps were developed by clinical psychologists and/or psychiatrists with experience in treating suicidal ideation and/or self-harm. Fifty-one percent (28 out of 54) apps were categorized as "Health and Fitness" in their app store descriptions, 17% (9/54) of apps were categorized as "Medical" and 42% (23/54) of apps were categorized as "Educational".

In terms of location, we observed that 33% of the apps reviewed were developed in the United States, 13% in the United Kingdom, 6% in Canada, 6% in Scotland, and 11% in Europe. Finally, the origin could not be identified for 31% of the apps. The apps were most often designed for persons experiencing suicidal thoughts (n = 59, 74%), followed by friends and family (n = 13, 16%), students (n = 9, 11%) teens (n = 7, 9%), veterans (n = 3, 4%) and clinicians (n = 1, 2%). Table 2.2 lists the general characteristics of the included suicide prevention apps. Most apps included at least three suicide prevention strategies, more commonly emergency crisis helpline information (n = 34, 43%), direct access to support (n = 54, 68%), and suicide-related education (n = 51, 64%). A total of six out of the 80 apps (8%) offered all six suicide prevention strategies which include tracking suicidal thoughts, safety plan development, suicide-related education, activities to distract suicidal thoughts, accessing support, and emergency counselling. Table 2.3 presents different suicide prevention strategies implemented and the corresponding number of apps we retrieved.

Table 2.2 General characteristics of the included suicide prevention apps.

| **Attribute** | | ***N*** | **%** |
|---|---|---|---|
| Platform | Android | 35 | 65 |
| | iOS | 15 | 33 |
| | Both operating systems | 15 | 33 |
| Developer Location | United States of America | 31 | 33 |

| **Attribute** | | ***N*** | **%** |
|---|---|---|---|
| | United Kingdom | 10 | 13 |
| | Canada | 4 | 6 |
| | Scotland | 4 | 6 |
| | Europe | 9 | 11 |
| | Unknown | 25 | 31 |
| Cost of app | Free | 50 | 93 |
| | Free with in-app purchases | 4 | 7 |
| App category on the app store | Health & Fitness | 28 | 51 |
| | Medical | 9 | 17 |
| | Educational | 23 | 42 |
| App ratings | 3.5-5.0 | 27 | 50 |
| | 1.0-3.5 | 6 | 11 |
| | Unknown | 21 | 39 |
| Target population | Person experiencing suicidal thoughts | 59 | 74 |
| | Family & friends | 13 | 16 |
| | Students | 9 | 11 |
| | Teenagers | 7 | 9 |
| | Veterans | 3 | 4 |
| | Clinicians | 1 | 2 |
| Affiliation | Healthcare provider/NGO | 36 | 45 |
| | Government | 20 | 25 |
| | University | 20 | 25 |
| | Unknown | 4 | 5 |
| Number of suicide prevention strategies | 1-3 | 57 | 71 |
| | 4-5 | 17 | 21 |
| | 6 | 6 | 7.5 |
| Technical features | In-app community | 5 | 6 |
| | Emergency contact | 34 | 43 |

| Attribute | | *N* | % |
|---|---|---|---|
| Security and Privacy | Password-protected | 12 | 22 |
| | Login | 5 | 9 |
| | User anonymity | 43 | 80 |
| | Privacy policy | 25 | 46 |
| | Informed consent | 49 | 91 |
| | Secure data transmission | 35 | 65 |
| App crashes | Yes | 9 | 17 |
| | No | 37 | 69 |

Table 2.3 Suicide prevention strategies identified within the reviewed apps.

| Suicide Prevention strategy | Number of apps (*N* = 80) |
|---|---|
| **Tracking suicidal thoughts** | 18 (23%) |
| **Safety plan development** | 33 (41%) |
| **Suicide related education** | 51 (64%) |
| **Activities to distract suicidal thoughts** | 18 (23%) |
| **Accessing support** | 54 (68%) |
| **Emergency counselling** | 34 (43%) |

#### 2.3.4.2 Target Outcome of Apps

Suicide-specific outcomes reported in the apps included suicide ideation, self-injurious thoughts and behavior also referred to as self-harm. Target outcomes and their definitions differed across studies. Various measures were used to assess suicide-specific outcomes. Bush et al. [13] used the Beck Scale for Suicide Ideation (BSS), Beck Hopelessness Scale (BHS), Beck Scale for Suicide Ideation (BSS) and the Columbia Suicide Severity Rating Scale (C-SSRS) [86]. Tighe et al. [104] used the Depressive Symptom Inventory Suicidality Subscale [60] and the Patient Health Questionnaire. Franklin [30] used the Self-Injurious Thoughts and Behaviors Interview [64], and Stallard et al. [99] used self-reported changes in self-harming behavior.

#### 2.3.4.3 Evaluation Methods Adopted

In terms of study design, nine were randomized controlled trials, five were observational pre-test/post-test studies, two were qualitative studies and one was a pseudo-randomized controlled trial in which sequential participants were alternately allocated to the intervention and control conditions. Summary of app characteristics and evaluation methods of apps from the reviewed 26 studies can be found in Appendix B.

#### 2.3.4.4 Effectiveness of Intervention

The follow-up duration of the study groups varied from 1 week to 4 months. In four articles [23,43,77,87], treatment as usual (TAU), along with app intervention, was used in the experimental group. The applications included in our review used evidence-based approaches, including cognitive behavioural therapy (CBT), DBT, and mindfulness-based cognitive therapy (MCBT) techniques for suicide prevention. Sixty apps reviewed (75%) had user-journey as a part of their design, while 20 apps did not use this component. User journeys are a design technique wherein the app provides users with a walkthrough of the features of the app to facilitate users' understanding of the app. Designers seem to support the good use of the app by the patient, in a guided manner, which promotes their care and supports the main objectives of the app. Few interventions involved people with lived experiences in the design and development stages of the app.

#### 2.3.4.5 App Content and Implementation

In terms of app content, each study presented different characteristics. The most frequent app functions were opportunities to create a safety plan, to develop coping skills and to learn emotion regulation strategies. All designed applications except one, had a contact button with crisis lines and or emergency numbers' list or links to social support resources. Four of the apps had the opportunity to evaluate the person by themselves daily. Also, the apps used CBT, DBT, MCBT and relaxation techniques. Moreover, the apps provided training for recognizing thoughts and feelings and controlling them and identifying suicide risk symptoms. The apps also included educational videos and images and could personalize information. Other apps included a variety of treatment approaches, including acceptance-based therapy [98], problem-solving therapy [93], interpersonal therapy and mood monitoring. Very few apps (1%) utilized gamification in which participants were presented with a series of visual stimuli pairs designed to condition aversive reactions to self-harming thoughts or behaviors [30].

While many apps prompted users to enter personal data, less than half (n = 39, 48.8%) included a privacy policy. Fewer studies still offered the option to protect the app with an account login, password, or personal identification number (n = 8, 10%). Nineteen apps (23.8%) demonstrated obvious bugs or reliability issues during the content review. Accessing peer support and safety plans were common features in the apps with a suicide prevention focus. Follow-up strategies were least commonly identified within the apps. Eight apps (10%) included artificial intelligence-powered chatbots. Chatbots offered advice and self-improvement strategies to users suffering from comorbid conditions like depression and other mental health disorders. The chatbots were able to tailor their advice based on the users' responses.

### 2.3.5 Insights from App Review

This app review examined app store descriptions for 182 unique apps and 89 in-app contents. Additionally, our review analysis presented the evidence for interactive suicide prevention strategies within 80 apps: 54 apps from app stores and 26 apps from existing literature. We addressed the gaps in existing work by considering a search strategy for apps with all app store categories. Relevant apps from all categories were considered in this

review. We examined app characteristics like design and content, which provide a richer overview of existing interventions. Additionally, we evaluated the UX and persuasive strategies in suicide prevention apps. We reviewed 80 apps: 54 apps from app stores and 26 apps from existing literature, which is sufficient to synthesize data. As the app market is rapidly expanding – this review comprising of a new search and rating process, provided different and updated results.

Our review of 80 suicide prevention apps raises concerns in three primary areas:

1. **Design of intervention:** how the intervention has been designed, what factors have been taken into consideration.
2. **Efficacy of intervention:** how effective is the intervention in suicide prevention.
3. **Evaluation of intervention:** how the intervention was evaluated for suicide prevention by stakeholders.

## 1. Design of Intervention

### 1.1 Specific target outcome

The majority of internet-based CBT interventions have targeted individuals with suicide-related behaviors like depression [108]. This weakens the effectiveness of apps as standalone interventions for suicide prevention [10]. Evidence suggests that interventions may be more effective if they are specifically targeted at suicide rather than depression [21,58]. Suicide-specific strategies and content should be incorporated in mHealth interventions to improve their efficacy [10]. Few interventions have involved those with lived experience of suicide in the development process [9]. Gaps in clinical care that may be overlooked by clinicians can be identified by individuals with lived experience. Patient stakeholders can thus improve the engagement, efficacy, and validity of such interventions.

### 1.2 Excluding individuals at high risk from participation

Adolescents with suicide risk have often been excluded from studies of e-health interventions [88,95]. This not only deprives adolescents (at high risk) of effective treatment but also presents a gap for researchers to develop effective interventions for them [108]. Studies have shown that teenagers tend to use internet-based interventions over face-to-face interventions as they are more likely to confide their true thoughts in an internet setting [40,88]. Additionally, middle-aged and older adults who are found to be at high suicide risk [103] should also be considered when designing interventions as existing interventions for these populations are limited. The exclusion of at-risk individuals from participation thus reduces ecological validity, contributes to sample bias, and reduces the generalizability of results [59].

### 1.3 Security and Privacy

A study reviewing 183 mHealth suicide prevention apps found that about 7% of the apps were password-protected and 3% required a login [95]. Such low barriers to security and privacy decrease user's trust in the apps and make them vulnerable to privacy leaks [46]. With the sensitivity of information involved in these apps, any compromise on users'

security and/or privacy can be counterintuitive to suicide prevention. Questions about informed consent and data sharing must be addressed in mobile interventions for suicide prevention [10].

### 1.4 In-app communities

Online communities like Reddit's r/suicidewatch [122] have been found to have positive effects on individuals posting on forums about suicide [33]. A review of 183 suicide prevention apps found only 2% of apps had in-app communities [95]. The potential of online communities as a preventive strategy for suicide is untapped and can be harnessed in mobile apps.

### 1.5 Lack of evidence-based sources

Many of the suicide prevention apps are either not publicly available or lack empirically supported material [10]. A review of 24 suicide prevention apps within Australian Google Play and iTunes stores found [46] that only 4% of the apps provided the source of the content being delivered, raising questions about the credibility and authenticity of such apps. Mobile app developers should thus adopt evidence-based strategies within suicide prevention apps.

## 2. Efficacy of Intervention

### 2.1 Low user engagement and high dropout rates of participants

A common issue in digital interventions was that participants had high dropout rates of follow up leading to attrition bias [32]. Technical and usability issues of mobile and web interventions can be optimized for simpler, faster, and easier use [108]. The needs of specific individuals can be met by leveraging personalization, user-based design methods, gamification, and adaptiveness; thus, increasing user engagement [10].

### 2.2 Integration with clinical care

A large-scale study of about 200 suicide prevention apps [96] found that only 5-7% of the apps allowed communication or sharing of content with the therapist. Effectiveness of mobile-based suicide prevention interventions can be enhanced if clinical and internet-based preventive efforts are used in tandem [10]. Feedback from clinicians and participants who are suicidal can be utilized in making mHealth interventions suitable for clinical use [95]. Another study reviewing 24 suicide prevention apps in Australia [47] found that none of the apps provided education on psychotherapy as an additional service option that individuals could seek.

### 2.3 Under-representation of suicide prevention strategies

Only about 50% out of 183 mHealth suicide prevention apps reviewed in a study, focused on creating a safety plan as a treatment strategy [95]. Exhaustive standardized safety plans, containing a list of warning signs, coping and socialization strategies, contact information,

and information on the restriction of access to means, should be more widely incorporated in e-health interventions [95]. Additionally, apps can explore the potential of psychotherapy specifically for suicide prevention, improved physician-led screening for suicidality and for assertive follow-up following a suicide attempt [47]. The majority of current mobile interventions adopt a single suicide prevention strategy instead of integrating multiple strategies within a platform [47,59]. Digital tools are capable of handling multiple processes simultaneously. They can be leveraged to develop robust interventions which incorporate multiple suicide prevention strategies.

### 3. Evaluation of Intervention

According to a scoping review of 115 studies on suicide prevention technologies [88], most of the widely used e-health suicide prevention services have never been evaluated. Another systematic review of mHealth suicide prevention applications [95] found no randomized controlled trial investigating the effectiveness of any of the mHealth apps. The effectiveness of mobile interventions in large-scale initiatives can be explored further [46]. Other observations from our review were that more than a third of the apps reviewed were developed in Western countries (USA, UK, Canada). This emphasizes the need for developing suicide prevention apps focused on non-Western populations. Most apps which offered self-screening tools alerted users towards help-seeking options if risk of suicidality was detected, although the suggestion was not always direct or immediate. Apps which allowed users to interact with one another also contained content moderation, which is important considering the potential for sharing potentially harmful content. Majority of apps only featured one interactive component like a self-screening test [99], or mood-selector [25,83].

To summarize, we reviewed 80 apps on suicide prevention and identified the trends of the apps, effectiveness of apps, evaluation methods, app content and implementations. Based on our findings, we discussed three major concerns in developing suicide prevention apps relating to design, efficacy, and evaluation of the interventions. Our recommendations for mitigating these concerns and challenges in existing interventions will guide future work in the area of suicide prevention app development and enhance the usability, effectiveness and user experience of such apps. In this thesis, these recommendations guided the development of the LifeLink app and helped us in designing for a positive user experience.

## 2.4 Theoretical Bases of Existing Interventions

In this section, we present theories and models which form the foundational groundwork for designing technologies for behaviour change. These include the Fogg Functional Triad, Fogg's Eight-Step Design Process, and Persuasive System Design Framework. In this thesis, these theories were important as they were used to design the LifeLink app to support caregivers of individuals experiencing suicidal thoughts. We discuss how these theories were implemented in existing suicide prevention apps.

### 2.4.1 Fogg Functional Triad and Eight-step Design Process

Fogg [29] proposed the 'Functional Triad' as a model to ease the creation of persuasive systems. This framework states that computers can play three main roles. First, they can function as social actors by fostering relationships, providing positive feedback, and giving social support. Second, computers can function as mediums that provide experiences to motivate and help in the rehearsal of behaviors. Third, computers act as tools by augmenting capabilities, streamlining tasks, offering guidance, and performing calculations to promote desired behaviors. Technologies can be designed to persuade as a tool, medium, social actor, or through a combination of roles. In this thesis, the LifeLink app is designed to act as a medium and tool. As a medium, the app allows users to rehearse behaviors that can support a person experiencing suicidal thoughts, such as accessing support services or discussing educational material to understand suicidal thoughts. As a tool, the app leads users through a step-by-step process of strategies for suicide prevention. It tracks and visually displays how well the person is progressing towards their personal goals such as eating healthier, improving the quality of sleep, engaging in more physical activity, and managing stress.

To design the LifeLink app, we adopted an approach developed by Fogg [28] for creating persuasive technologies. This approach is called Fogg's 'Eight-step design process' and is outlined in Table 2.4.

Table 2.4 Fogg's [28] Eight-step Design Process for Creating a Persuasive Technology

| **Eight Steps** | **Description** |
|---|---|
| 1. Target Behaviour | Choosing a simple behaviour to target. |
| 2. Target Audience | Choosing a receptive audience |
| 3. Finding what prevents the target behaviour | Find out what is blocking the behaviour change. |
| 4. Target Device/Technology | Choosing a familiar technology channel. |
| 5. Finding relevant examples of persuasive technology | Find existing persuasive technologies and learn from them. |
| 6. Imitating successful examples | Imitate existing examples that work. |
| 7. Rapid Testing & Iteration | Iterate on design by rapid testing. |

| | |
|---|---|
| 8. Expanding on Success | Experiment with new audience, try increasing the positive activity, try the same design for a similar behaviour. |

### 2.4.2 Persuasive Systems Design Framework

Persuasive technology are interactive systems designed to help users in achieving a behavior change [34]. By leveraging various persuasive strategies, persuasive technology can encourage desirable and discourage undesirable behaviors [73]. Researchers investigating persuasion and behavior change have highlighted the usefulness of various persuasive strategies to facilitate the design of effective persuasive technology [2,31,73]. The Persuasive Systems Design (PSD) model [71] is a framework for designing and evaluating persuasive systems. It comprises 28 persuasive strategies grouped into four categories of persuasive system principles: (1) primary task support, (2) dialogue support, (3) system credibility support, and (4) social support. Table 2.5 outlines each of these four categories, their description and corresponding persuasive strategies. The primary task support category comprises design features that support users in carrying out their primary tasks or the steps the users do in the application. The dialogue support category focuses on the features related to the computer-human dialogue which help users achieve their goals or target behavior. The system credibility support category focuses on design features that increase the system's credibility (i.e., they provide a means to design more credible and persuasive systems). The social support category consists of design features that motivate users by leveraging the power of social influence.

Table 2.5 Categories, description and respective persuasive strategies from the PSD framework [71].

| **Category** | **Description** | **Persuasive strategies** |
|---|---|---|
| Primary task support | Support users in performing their intended tasks | Reduction, Tailoring, Tunneling, Personalization, Self-monitoring, Simulation, Rehearsal |
| Dialogue support | Provide feedback that moves users toward the target behaviour | Praise, Rewards, Reminders, Suggestion, Similarity, Liking, Social role |
| System credibility support | Support the development of systems that are more credible | Trustworthiness, Expertise, Surface credibility, Real-world feel, Authority, Third-party endorsements, Verifiability |
| Social support | Motivate users through social influence | Social learning, Social comparison, Normative influence, Social facilitation, Cooperation, Competition, Recognition |

We incorporated the PSD model in our study as it is one of the most common and leading frameworks for the design of persuasive and behaviour change systems [6,41,76]. It is also widely applied in many areas including the mental health domain [4]. The persuasive strategies outlined within the PSD model serve as a fundamental basis for designing effective persuasive technologies.

Persuasive technologies have been utilized to encourage behavior change across various domains, such as increasing physical activity [2,16,68], promoting healthy eating [73], quitting smoking, managing diseases [78], supporting mental health [4,5], discouraging substance use [14], improving time management [3] and reducing procrastination [39].

#### 2.4.2.1 Persuasive Systems Design and Suicide Prevention

Many mHealth apps for suicide prevention exist [83,90,99,119]. However, the persuasive strategies employed in these apps and their efficacy remain unknown. We found very few studies evaluating the user experience and persuasive strategies implemented in suicide prevention apps. For example, in one study, Wilks et al. [113] reviewed the user experience of 66 apps and found that majority of the apps (89%) had at least one best practice feature for suicide risk prevention. In a different study, Reen et al. [89] reviewed 39 apps from a combination of app stores and existing literature. This was the only study that assessed the persuasive strategies adopted by suicide prevention interventions. The researchers found most apps implemented persuasive strategies but lacked in terms of managing users' privacy. Furthermore, Jha et al. [37] reviewed risk factors for suicide, derived prominent risk factors and provided considerations for developing suicide prevention technologies. This was one of the few studies suggesting the potential of persuasive strategies in suicide prevention interventions wherein the apps can be tailored to the individual's prominent risk factor.

To develop a clear understanding of how persuasive strategies have been leveraged in suicide prevention apps, we conducted a systematic literature review of 80 suicide prevention apps available in app stores and academic journals. The procedure and majority results of this app review have been discussed in Section 2.3 above. In this section, we focus on the different persuasive strategies implemented in the reviewed apps using the Persuasive System Design (PSD) model, the most and least dominant implementations of persuasive strategies.

#### 2.4.2.2 Persuasive Design Strategies Adopted in Reviewed Apps

We assessed how various persuasive strategies were employed across the reviewed apps. All suicide prevention apps implemented at least two persuasive strategies. Table 2.6 presents the various ways in which the persuasive strategies were operationalized. The most common persuasive strategies were Personalization (n = 32) and Self-monitoring (n = 29). Personalization was implemented in the apps by using features like a personal wellness plan, safety plan, color customization options, memory bank, distraction tracking, and personal alarms. Self-monitoring was implemented by features like journal entry, mood tracking, self-assessment surveys, trigger monitoring, and voice memos. This was followed by Tunneling (25), Suggestion (24) and Expertise (n = 19). Other strategies like Reduction,

Simulation, Social Comparison, Social Role, Surface Credibility, Tailoring, Trustworthiness, and Verifiability were least adopted (n = 3, 3.8%). Expertise was implemented by providing users with clinicians' tutorials, access to registered psychiatrists, crisis support helplines, local support services, and counsellor bots. Suggestion was implemented by features providing users with life tips, stress-handling techniques, and guidance. Majority of the apps used the Tunneling strategy by a guided walkthrough of the app features, step-by-step suicide management modules, and guided breathing exercises. Figure 2.3 illustrates the number of apps that employed each of the 28 persuasive strategies from the PSD model [71]. We found that primary task support strategies (i.e., persuasive strategies which support users in performing their intended tasks) were employed by the majority of the apps. The least employed category was social support strategies (i.e., persuasive strategies which motivate users through social influence) like Competition, Recognition, Cooperation, Social Comparison, and Social Learning.

Table 2.6 Persuasive strategies and how they are implemented in the reviewed suicide prevention apps.

| **Persuasive strategy** | **Implementation in the apps** |
|---|---|
| **Personalization** | Allow users to create personal wellness plan, safety plan, provide color customization options, memory bank, distraction tracking, setting personal alarms. Use personal information to suggest clinical support services. Customizable language, sound, widgets, theme, font size |
| **Self-monitoring** | Users can create journal entry. Mood tracking, self-assessment surveys, trigger monitoring, recording voice memos. Graphs or charts showing users' progress. Symptom tracking |
| **Expertise** | Providing users with clinicians' tutorials, access to registered psychiatrists, crisis support helplines, local support services, counsellor bots |
| **Suggestion** | Providing users with life tips, suicide management techniques. Suggest peer-support options in emergency mode |
| **Tunneling** | Guided walkthrough of the app features, step-by-step suicide management modules, guided breathing exercises. After self-reported survey completion, suitable wellness plans are provided. Guide users on addressing symptoms |
| **Reduction** | Predetermined list of safety plans, psychoeducation modules. Psychotherapy tutorials broken down into smaller achievable tasks to be completed |
| **Tailoring** | Safety plans are suggested based on users' current suicide risk level |
| **Simulation** | Animated visuals and avatars showing transition to a better worldview |

| Persuasive strategy | Implementation in the apps |
|---|---|
| **Rehearsal** | Rehearse guided meditation exercises, gratitude exercises, affirmations to distract oneself from suicidal thoughts |
| **Reminders** | Remind users to track their mood, suicidal thoughts using sound and text notifications. Remind or notify users to try meditation, sleep, take medications (if self-reported) using push notifications with sound and text |
| **Liking** | Attractive icons, avatars, illustrations, animations, colors. Simple, easy-to-use, aesthetically pleasing user interface (UI) |
| **Social Role** | In-app forum and chat features support conversation with other users. Virtual therapist to respond to users' queries |
| **Normative Influence** | Groups and community for users with similar goal |
| **Verifiability** | Links to external websites from where psychoeducation modules are taken. Users can verify information using links to web resources |

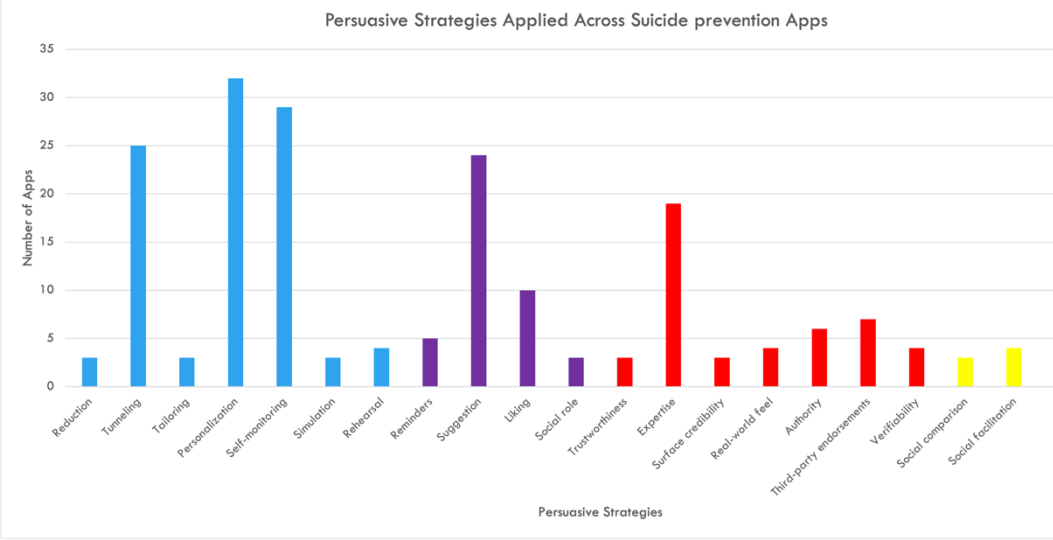


Figure 2.3 Overview of persuasive strategies employed in suicide prevention apps. Blue bars denote primary task support strategies from the PSD model [71]. Likewise, purple bars denote dialogue support strategies, red bars denote system credibility support strategies and yellow bars denote social support strategies.

#### 2.4.2.3 Discussion on Persuasive Strategies Implementations

In this section, we discuss our observations from the app review, particularly focusing on the use of PSD model in existing suicide prevention apps. There is scope to incorporate persuasive strategies such as Reduction, Simulation, Social Comparison, Social Role, Surface Credibility, Tailoring, Trustworthiness, and Verifiability when designing suicide prevention apps as they have been least implemented in existing apps. Category-wise, the least employed category (i.e., social support strategies which motivate users through social influence) like Competition, Recognition, Cooperation, Social Comparison, and Social

Learning can be leveraged, but with caution. Designers need to be mindful of the sensitivity and stigma associated with the area of suicide. Strategies like Competition and Social Comparison have been avoided in existing apps, as suicide-related target outcomes are very personal, and these persuasive strategies can potentially trigger suicidal thoughts in users or cause further harm. Other social support strategies like Recognition, Cooperation persuasive strategies can be explored at an individual level for each user within suicide prevention apps. Trustworthiness and Verifiability should be specifically incorporated as the authenticity of information is critical for users when using mHealth apps. There is potential to use Social Role strategy by having a clinician's avatar or bot within the app. Such an avatar or bot can be used for question-answering purposes. Tailoring of app content based on the age group of users (e.g., children, adolescents, young adults, middle-aged or older adults) can also be explored. In summary, our analysis showed that persuasive strategies are a promising tool that can be used in designing suicide prevention apps.

# Chapter 3 – LifeLink Prototype Design and Evaluation

In this chapter, we detail the design and evaluation of LifeLink app prototype, a persuasive Android app for supporting caregivers of individuals experiencing suicidal thoughts. In our systematic review of previous literature presented in Chapter 2, we found that existing suicide prevention apps lacked in terms of their design, efficacy, and evaluation of the intervention [38]. We identified the following five gaps in existing suicide prevention apps, as the focus of this thesis:

1. There is a lack of apps focused on caregivers of individuals experiencing suicidal thoughts. In the app design process, target users (i.e., caregivers) have limited-to-no involvement.
2. There is much potential to leverage persuasive strategies when designing suicide prevention apps [37]
3. There is a lack of evidence-based sources within the app.
4. There is less focus on evaluating the app's user experience (UX).
5. There is low user engagement within the apps leading to a high dropout rate of participants.

These five gaps underscore the need for designing a suicide prevention app specifically for caregivers of individuals experiencing suicidal thoughts. Providing evidence-backed sources within the app and designing for a seamless UX can prevent a high dropout rate of users. We involved caregivers in the app design process and in selecting the persuasive strategies that are most suitable for supporting them.

We addressed the above-mentioned gaps by incorporating the Persuasive Systems Design (PSD) model [71] as the fundamental principle of our app design and adopting a user-centred design [65] approach. In this approach, we involved the target users, understood their needs and concerns, and evaluated the perceived persuasiveness of persuasive strategies by target users in the LifeLink app for caregivers of individuals experiencing suicidal thoughts. We designed and evaluated the LifeLink app with a focus on enhancing user experience and increasing engagement.

This section describes what the user-centred design [65] approach for creating LifeLink entailed. In general, it involved designing in iterative stages with the user as our focal point for decision-making. Figure 3.1 presents the iterative design and development stages undertaken.

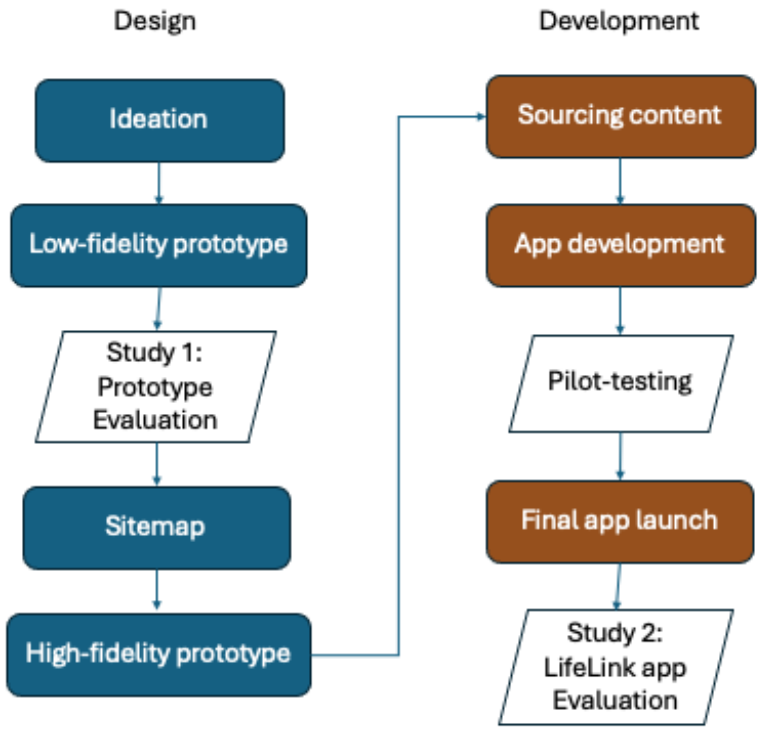


Figure 3.1 Iterative design and development stages.

## 3.1 App Prototype Design Process

### 3.1.1 Ideation

We started with brainstorming ideas for what the overall app and underlying study design would look like. We first defined our RQs, which would be useful for deciding the scope of the problem. We used mind mapping, a design technique involving the creation of a visual diagram that structures a complex concept into a clear hierarchy of thoughts [123]. We created a mind map of the LifeLink design and evaluation project (see Figure 3.2) using Miro, a visual collaboration tool [124]. This mind map was used to brainstorm potential ideas and conceptualize various granular aspects of the project with researchers in psychiatry, persuasive computing, health centre leaders and community leaders working on suicide prevention in Nova Scotia (NS), Canada. Particularly, we partnered with Roots of Hope Nova Scotia [120] to conceptualize the app's vision and other aspects. Researchers in psychiatry and clinicians from Nova Scotia Health provided their insights working with caregivers and their potential needs. This helped us define the scope of the problem statement and potential ways to evaluate the app with caregivers. Throughout these brainstorming sessions, the RQs were refined to reflect the feasibility and applicability of LifeLink app.

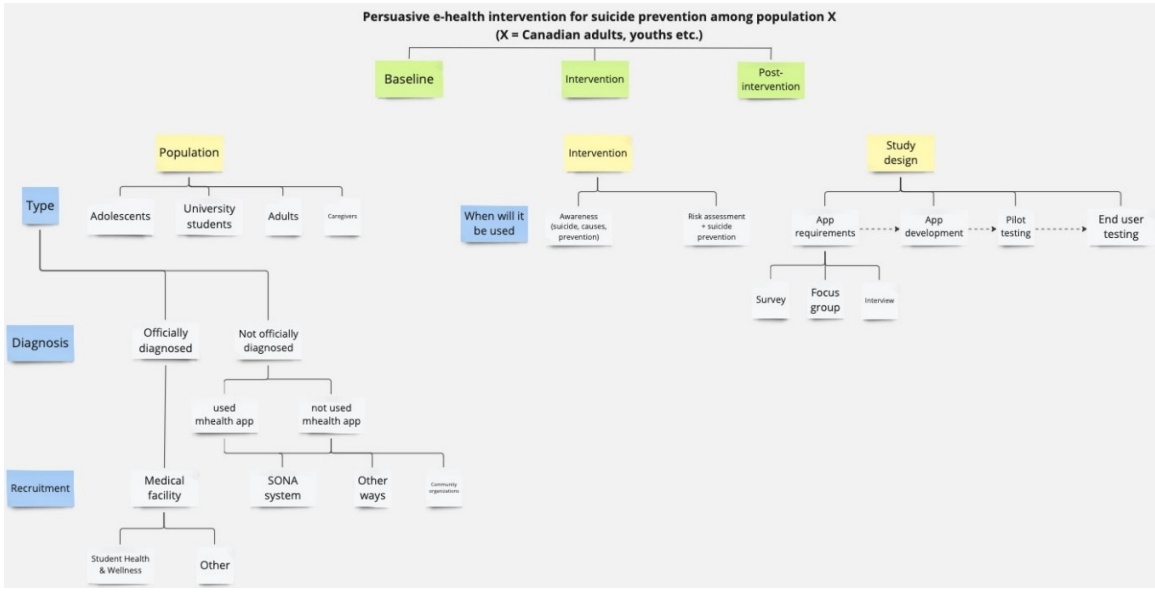


Figure 3.2 Mind map of potential directions for the LifeLink design and evaluation project.

### 3.1.2 Low-fidelity prototype

Based on the brainstorming sessions, gaps and recommendations from our reviews of existing suicide prevention apps [37,38], we conceptualized and designed paper prototypes of LifeLink. These paper prototypes were refined to design our low-fidelity prototype using Balsamiq (a design tool used for creating mockups [125]). The low-fidelity prototype consisted of the following features and their corresponding persuasive strategy:

- **Home** (*reduction, rehearsal, and surface credibility*): This feature provides the user with a menu of the key features of the app. Figure 3.3c shows that the user can choose from different options like 'Learn', 'Network', and 'Favorites' each of which can help them in supporting an individual with suicidal thoughts.
- **Network** (*customization*): This feature lets the user connect with anyone in their network e.g., their friend, family member, clinician, or local community organization. Figure 3.3d shows that the user can manually add their relevant contacts to their 'Network'.
- **Favourites** (*personalization* and *customization*): This feature lets the user store their favourite content to support their person. This includes favourite 'Artwork', 'Clips' (videos), 'Photos', and 'Things to do' (hobbies like hiking). Figure 3.3e shows that the user can manually add their choice of content and suggest these to the person they are supporting. The favourite content can also serve as a distraction technique when trying to navigate or talk through difficult thoughts of suicide with the person they are supporting.
- **Learn** (*reduction*): This feature provides the user with educational content about different topics within suicide and suicide prevention e.g., 'Symptoms', 'Triggers', 'Mindfulness', and 'Techniques to support your person'. (See Figure 3.3f)
- **Crisis** (*expertise* and *verifiability*): This feature lets the user contact the 'Nearest Emergency' centre or the toll-free suicide 'Helpline' in case of crisis (See Figure

3.3g). A (suicide) crisis is an emergency in which a person is attempting to kill themselves or is seriously contemplating or planning to do so [126].

- **Analyze** (*self-monitoring, similarity*, and *liking*): This feature lets the user log their sleep (hours), (emotional) triggers, diet, mood, stressors, and physical activity (minutes). Figure 3.3h shows that the user can check their 'Progress' (weekly or monthly statistics).
- **Registration** (Figure 3.3a) and **Welcome** (Figure 3.3b): These screens are displayed to the user when they sign up or sign in to the app.


**A.** Registration **B.** Welcome

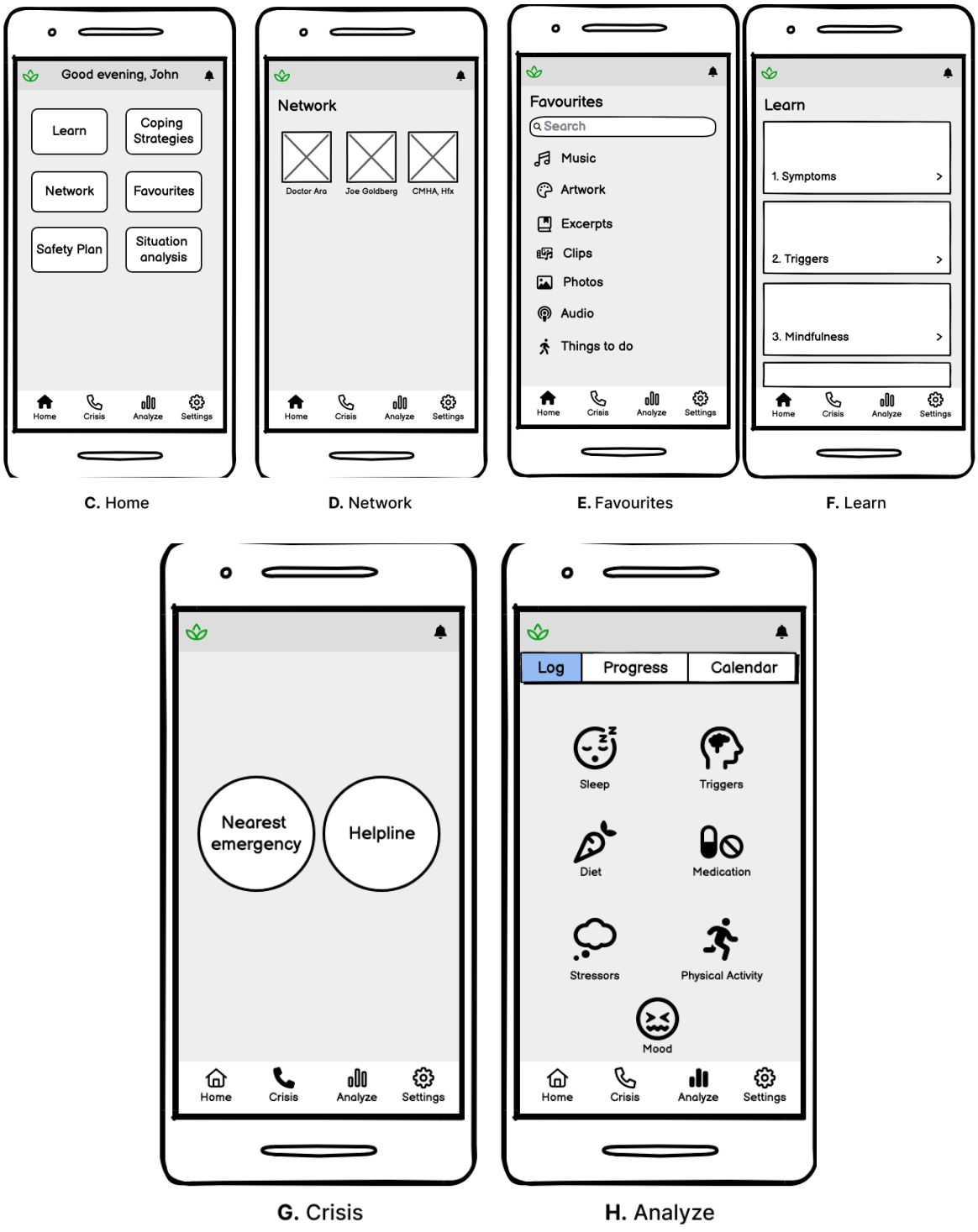


Figure 3.3 Screenshots of LifeLink's low-fidelity prototype created using Balsamiq.

### 3.1.3 Study 1: Prototype Evaluation Overview

After obtaining ethics approval (2023-6824), we advertised and recruited participants through our partnership, professional network via email, local mailing lists, sharing circles, snowball sampling and social media. Note that the terms 'participants' and 'caregivers' are

interchangeably used in this work as our participant pool consisted of caregivers of individuals experiencing suicidal thoughts. The recruitment notice (Appendix C) and recruitment poster (Appendix D) consisted of a link to the pre-study survey for participants to express interest. Respondents were then contacted by the researcher to complete the consent form (Appendix E and F), online survey, and arrange a subsequent (optional) interview. We conducted the study with 45 caregivers of individuals experiencing suicidal thoughts who were living in Canada [36]. In the first phase of this study, participants were asked to explore our mobile app prototype and record their experiences by completing an online survey. The survey (Appendix G) was hosted online on Dalhousie's Opinio software [127] and took about 10-15 minutes to complete. The survey consisted of questions about participants' demographics, their experience dealing with suicidality and questions about the prototype evaluation. An example of the question asked is "What are your concerns when using an existing mobile application for dealing with suicidality? (Choose all that apply)". After completing the survey, participants were invited to participate in an optional one-on-one semi-structured interview online to obtain further insights about their experiences dealing with suicidality and their feedback on the app design. The interview was conducted by asking questions related to participants' general experience when supporting a person with suicidal thoughts and questions related to their experience with the app in terms of usefulness, persuasiveness, and design recommendations for the features. The interview questions can be found in Appendix H. In this upcoming sections we will discuss the methodology, evaluation and results of study one i.e., prototype evaluation of the LifeLink app.

## 3.2 Prototype Evaluation Study: Methodology

The aim of study one was to collect the perspectives of caregivers of individuals experiencing suicidal thoughts using a mobile app prototype. A mixed-methods research approach was employed to collect and analyze quantitative and qualitative data. We intended to capture both the subjective experiences of caregivers when supporting individuals experiencing suicidal thoughts and the reasoning behind these experiences. We also wanted to decipher caregivers' opinions, perspectives, and attitudes on the app prototype for suicide prevention and for supporting those dealing with suicidal thoughts. Finally, we wanted to assess participants' perceived persuasiveness of the implemented strategies and determine the most effective strategies that support caregivers dealing with suicidality. To answer RQ2 and RQ3, we designed a low-fidelity prototype of the LifeLink app implementing 10 persuasive strategies. We then evaluated the app prototype by conducting an online survey with 45 participants and an optional semi-structured interview involving 14 participants. The interview was aimed at understanding participants' needs, and concerns when supporting an individual experiencing suicidal thoughts, their perception and feedback about various aspects of the app prototype.

### 3.2.1 Participants

Caregivers who are supporting (or have supported in the past) individuals experiencing suicidal thoughts were considered for the evaluation of the prototype. To participate in this research, participants had to be 16 years of age or older, live in Canada and be proficient in English. We targeted this age group to ensure diverse voices inform the development of

the app. Caregivers included partners, grandparents, families, chosen family, friends, teachers, guidance counsellors, SchoolsPlus workers [155], coaches, nurses, social workers, or mentors who were supporting someone with suicidal thoughts. We recruited young adults and adults residing in Canada.

Out of the 60 valid survey responses received, 45 were complete (i.e., they answered all questions and passed the attention-check test). Thus, the final pool consisted of 45 participants for the online survey and 14 participants for the post-survey interview. The quantitative study collected data about participants' experiences dealing with suicidality and interacting with the low-fidelity prototype of LifeLink while the interview captured more in-depth qualitative data. Participants were predominantly cis women (69%), aged 19-35 (58%) and living in a rented or owned apartment/house (91%). All participants were employed and had supported one or more individuals experiencing suicidal thoughts.

The sample size of 45 participants for the survey was informed by relevant literature on understanding the role of technology in preventing suicide, which recruited 18 [70] and 6 participants [87] for the online survey. The interview sample size of 14 participants was determined a priori and based on previous studies where they conducted 18 [70] and 6 interviews [87]. We believe that a sample of 45 participants is enough for us to explore users' perspectives on a mHealth suicide prevention app prototype considering the number of features we were investigating.

### 3.2.2 Recruitment

We advertised and recruited participants through our partnership, professional network via email, word of mouth and social media. We engaged in digital outreach on social media platforms such as LinkedIn, Facebook, Twitter, Instagram, and WhatsApp groups to share our recruitment notice (Appendix C). The recruitment poster can be found in Appendix D. As suicide is an area colored with social stigma, individuals with lived experience of suicidal thoughts and their caregivers may not publicly identify themselves. Thus, we anticipated that it would be challenging to recruit participants using traditional techniques. To address this, we partnered with Roots of Hope, a NS Health initiative working to help build capacity against suicide [120]. Roots of Hope NS supported us with recruitment via their online and offline channels (events, social media, direct relationships with participants and relationships with other community organizations working on suicide prevention in Canada).

We also used local mailing lists and snowball sampling [82] to obtain sufficient participants. The recruitment and study phase lasted from November 6, 2023 to November 26, 2023, with participants joining the study at different times. The recruitment notice consisted of a link to the pre-study survey for participants to express interest. Respondents were then contacted by the researcher to complete the consent form (Appendix E and F), online survey (Appendix G), and arrange a subsequent (optional) interview. To show our appreciation for the participants' time, their emails were added to a lucky draw and two random email addresses were selected to win a $50.00 Amazon Gift Card each.

### 3.2.3 Study Design and Procedure

The study consisted of two phases: (1) an online survey, and (2) a semi-structured interview. An overview of the study procedure is shown in Figure 3.4. Participants were provided with a detailed description and guidelines of our study, and it was mandatory to give informed consent before proceeding to the survey. Both the survey and interview questions were designed to (1) understand the needs and concerns of caregivers supporting individuals experiencing suicidal thoughts, (2) collect caregivers' opinions about the design, concept, and features of the app and (3) evaluate the persuasiveness of the persuasive strategies implemented in the app.

In the first phase of the study, participants were asked to explore a mobile app prototype and record their experiences by completing a survey hosted online on Dalhousie's Opinio [127]. The survey consisted of nine questions about participants' demographics, 11 questions about users' experience dealing with suicidality, 52 questions about the prototype evaluation and five attention-check questions to filter random respondents [55].

After completing the questionnaire, participants were invited to participate in an optional one-on-one semi-structured interview online via Microsoft Teams [156] to obtain further insights about their experiences dealing with suicidality and their feedback on the app design. The interview was conducted by asking four questions related to participants' general experience when supporting a person with suicidal thoughts and nine questions related to the user's experience with the app in terms of usefulness, persuasiveness, and design recommendations for the features. The interview was audio-recorded, transcribed, and analyzed using thematic analysis [11].

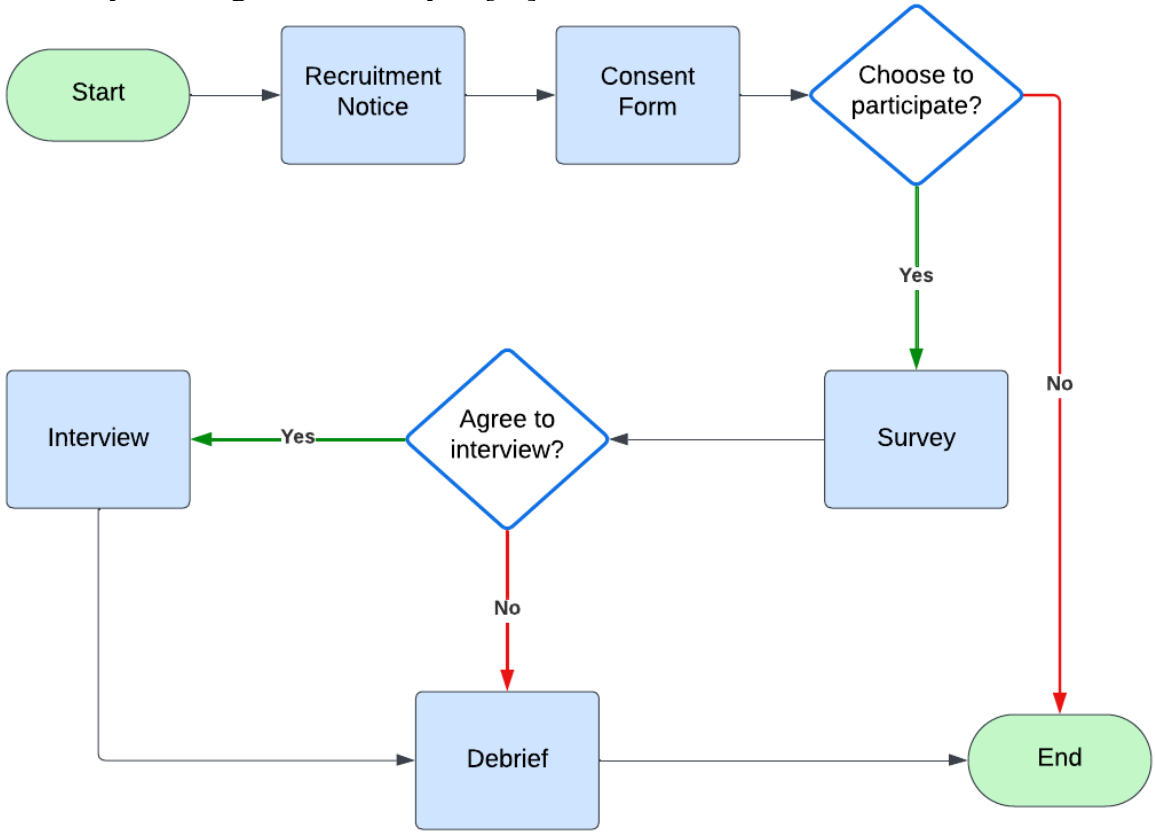

Figure 3.4: Flow chart showing study one procedure

### 3.2.4 Measurement Instruments

An adapted version of the System Usability Scale (SUS) [154] was used to evaluate the usability of LifeLink. The adapted version of SUS (a 7-item questionnaire) used in this study included appropriate modifications and questions relevant to evaluating the usability and utility of LifeLink. 3 items from the original version of SUS were dropped [157] in the adapted version as they were not relevant to the area of suicide nor aligned with our app goals. Additionally, the Perceived Usefulness scale [22], PPQ [24], Simplicity scale [19], and adapted versions of the MARS [102], UES-SF [67] were used for the survey.

The SUS [154], is a 5-point Likert scale that is a widely accepted benchmark for evaluating the usability of digital health apps [35]. The SUS consists of 10 items and has been used to evaluate a wide variety of products, services, and applications, including mHealth apps [97]. It consisted of questions such as "I thought the app was easy to use". The Perceived Usefulness Scale [22], evaluated the app's usefulness using questions such as "The app would help me support a person experiencing suicidal thoughts". The Perceived Persuasiveness Questionnaire [24] was adapted from Orji et al. [76]. It evaluated the persuasiveness of the app with questions such as "The app would make me reconsider my approach when supporting a person experiencing suicidal thoughts". Simplicity was evaluated using twelve statements where participants were asked to indicate their level of agreement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). It consisted of questions like "The app has unnecessary functions I don't want". The Mobile App Rating scale (MARS) [102] consisting of 6 statements was used wherein participants were asked to indicate their level of agreement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). It consisted of questions like "The app would help me have better knowledge about suicide prevention". Engagement was measured using the short form of the User Engagement Scale (UES-SF) [67], which consists of 12-items where participants were asked to indicate their level of agreement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

In summary, Study One evaluated the low-fidelity prototype of the LifeLink app via survey and interviews with 45 and 14 participants respectively. We uncovered some useful insights about participants' opinions, perspectives, and attitudes towards the design of the app prototype. We gained a better understanding of the needs and concerns of caregivers supporting an individual experiencing suicidal thoughts. We also investigated the strategies used by participants to deal with suicide-related concerns. We incorporated their ideas and suggestions to refine the app design. This user-centered approach ensured that the needs of the caregivers of Canadian adults and young adults dealing with suicidality were reflected in the app.

## 3.3 Prototype Evaluation Study: Results

We analyzed both quantitative and qualitative data to answer our research questions. We now present participants' demographic information, results from quantitative (survey) and qualitative (interview) data analysis.

### 3.3.1 Participant Demographics

A total of 45 adults participated in this study. Although anyone above the age of 16 was eligible to participate in the study, we did not have any participants between the ages of 16-18. Participants' demographic information is summarized in Table 3.1.

Table 3.1 Demographic breakdown of participant characteristics ($N$ = 45)

| **Characteristics** | **Frequency (%)** |
|---|---|
| Age | 19-25: 29%, 26-35: 29%, 36-45: 22%, 46-55: 16%, over 56: 4% |
| Gender Identity | Cis man: 22%, Cis woman: 69%, Trans man: 2%, Trans woman: 4%, Non-binary: 2% |
| Marital status | Single: 44%, Married: 42%, Separated: 4%, Divorced: 4%, Registered Partnership: 2%, Common Law: 2% |
| Ethnicity | White: 58%, South Asian: 11%, Black: 11%, Southeast Asian: 4%, Asian: 4%, Middle Eastern: 4%, Mixed-race: 2%, Indigenous: 2%, Prefer not to say: 2% |
| Education level | Less than high school: 2%, High school: 7%, College diploma: 13%, Bachelor's degree: 29%, Master's degree or PhD: 49% |
| Type of locale | City: 47%, Rural area: 47%, Town: 7% |
| Employment | Full-time work: 56%, Part-time work: 27%, Student: 31%, Own business: 7%, Casual work: 7%, Home duties: 4%, Retired: 2%, Not working: 0% |
| Province | Nova Scotia: 69%, Ontario: 13%, British Columbia: 7%, Manitoba: 4%, Prince Edward Island: 2%, Quebec: 2%, Alberta: 2% |
| Housing | Apartment/house owned or rented: 91%, School: 4%, Hotel/motel: 2%, Friend's house/couch surfing: 2% |

### 3.3.2 Quantitative Results

We reported SUS scores and item means to provide a high-level view of the usability of the LifeLink app prototype. Next, we computed descriptive statistics and one-sample t-tests for engagement, simplicity, user experience and perceived persuasiveness. Bar charts were generated to visualize the survey data for user engagement, simplicity, user experience and perceived persuasiveness.. In this section, we present the results of each of our measures of evaluation.

#### 3.3.2.1 Caregivers' Needs and Concerns when Dealing with Suicidality

Results showed that the majority of participants (caregivers) were supporting a friend ($N$ = 26, 58%) followed by a family member ($N$ = 17, 38%). Participants' relationship with the person experiencing suicidal thoughts is shown in Figure 3.5. Caregivers' preferred pathways (Figure 3.6) for dealing with suicide-related concerns were seeking human-based assistance by talking to friends ($N$ = 37, 83%), clinical help ($N$ = 30, 67%), talking to family members ($N$ = 25, 56%), (community) support groups ($N$ = 18, 40%). Humans are inherently social [111] and consequently, participants sought human-based support, especially from friends, for dealing with suicide-related concerns. Interestingly, music and suicide helplines were equally chosen by participants ($N$ = 14, 32% each) for coping with

suicide-related concerns. In terms of frequency of mobile app usage, about half of the participants ($N = 22$, 49%) had never used a mobile app for suicide-related concerns. Figure 3.7 shows that 22% of the participants ($N = 10$) had used a mobile app a few times a month, weekly or daily.

We asked caregivers about their concerns in existing mobile apps for suicide prevention. Figure 3.8 shows that caregivers were primarily concerned about security, data privacy, and confidentiality ($N = 19$, 42%) followed by limited access to culturally appropriate resources ($N = 16$, 36%). About a third of the participants reported concerns about lack of evidence-based sources ($N = 15$, 33%), lack of relevant content ($N = 12$, 27%), and missing suicide prevention strategies ($N = 12$, 27%). Interestingly, very few participants ($N = 4$, 9%) were concerned about the lack of social forums in existing apps. This reinforces our finding from the previous review wherein we found that social support (persuasive) strategies had been avoided in existing apps [38]. We hypothesized that this is because suicide-related target outcomes are very personal, and such persuasive strategies can potentially trigger users or cause further harm. This hypothesis was confirmed by participants' feedback in our survey.

Most participants ($n = 43$, 95%) agreed/strongly agreed that there is a need for a mobile app for caregivers supporting an individual with suicidal thoughts (Figure 3.9). Majority of the participants ($n = 38$, 84%) said that they were likely/very likely to use a mobile app designed to help them support someone with suicidal thoughts and only 7% ($n = 3$) said they were unlikely to use such an app (Figure 3.10). In terms of the type of technology, 84% of participants ($n = 38$) said they sought systems and mobile apps that provided practical support (e.g., apps that help find support services, track mood, recommend strategies to support someone) and 71% participants ($n = 32$) reported interest in apps that provide suicide-related educational content (e.g., information about symptoms, triggers of suicidal thoughts, basic knowledge about suicide prevention).

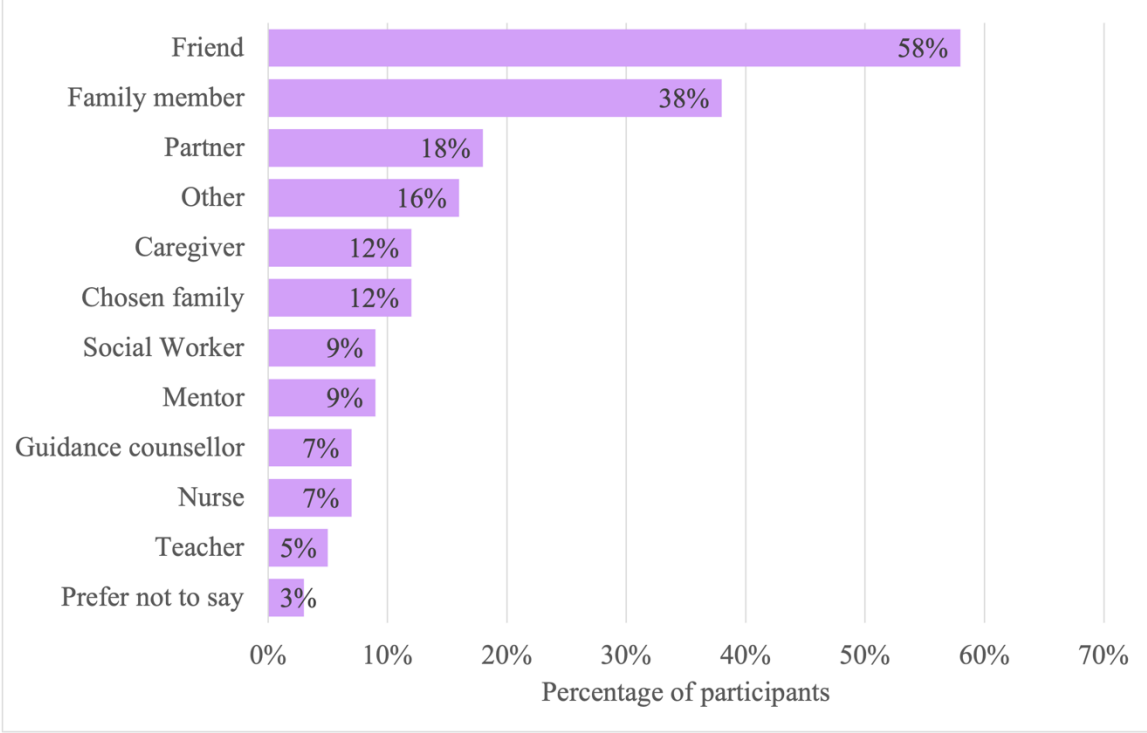


Figure 3.5: Relationship of caregivers (participants) with the person experiencing suicidal thoughts whom they are supporting ($N = 45$).

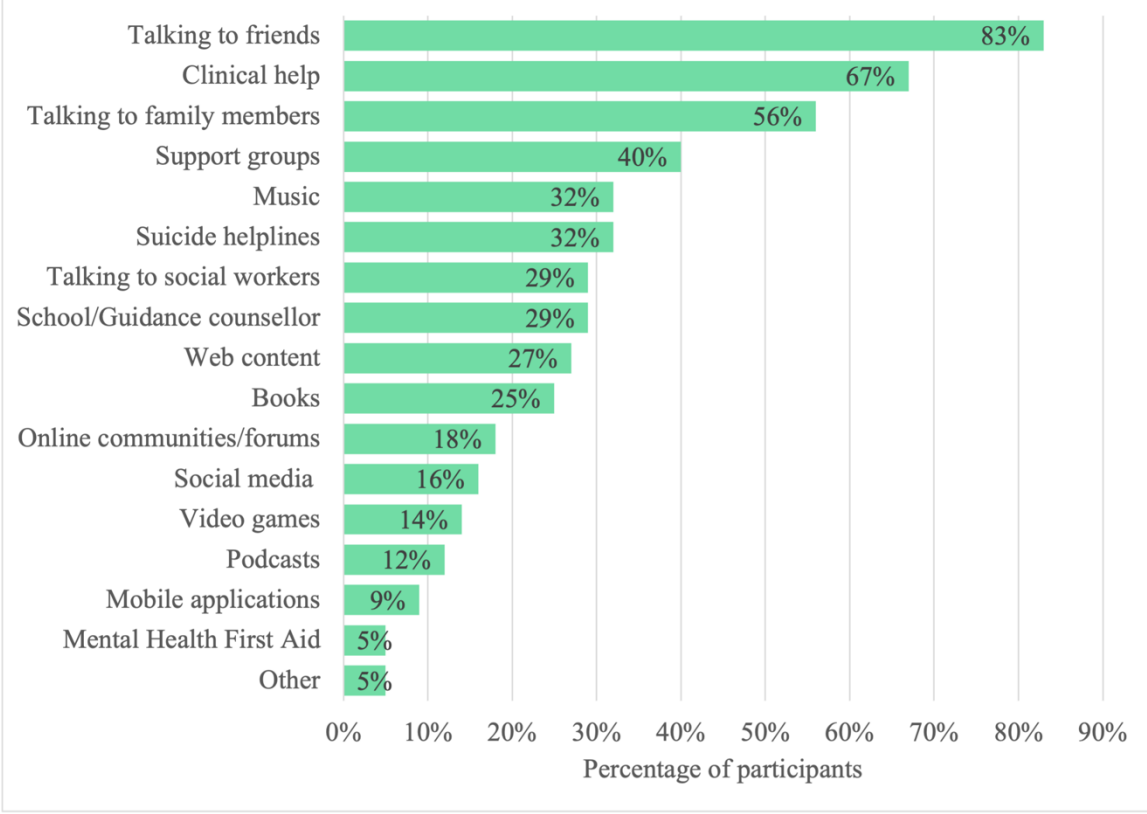


Figure 3.6: Pathways adopted by caregivers to deal with suicide-related concerns ($N = 45$).

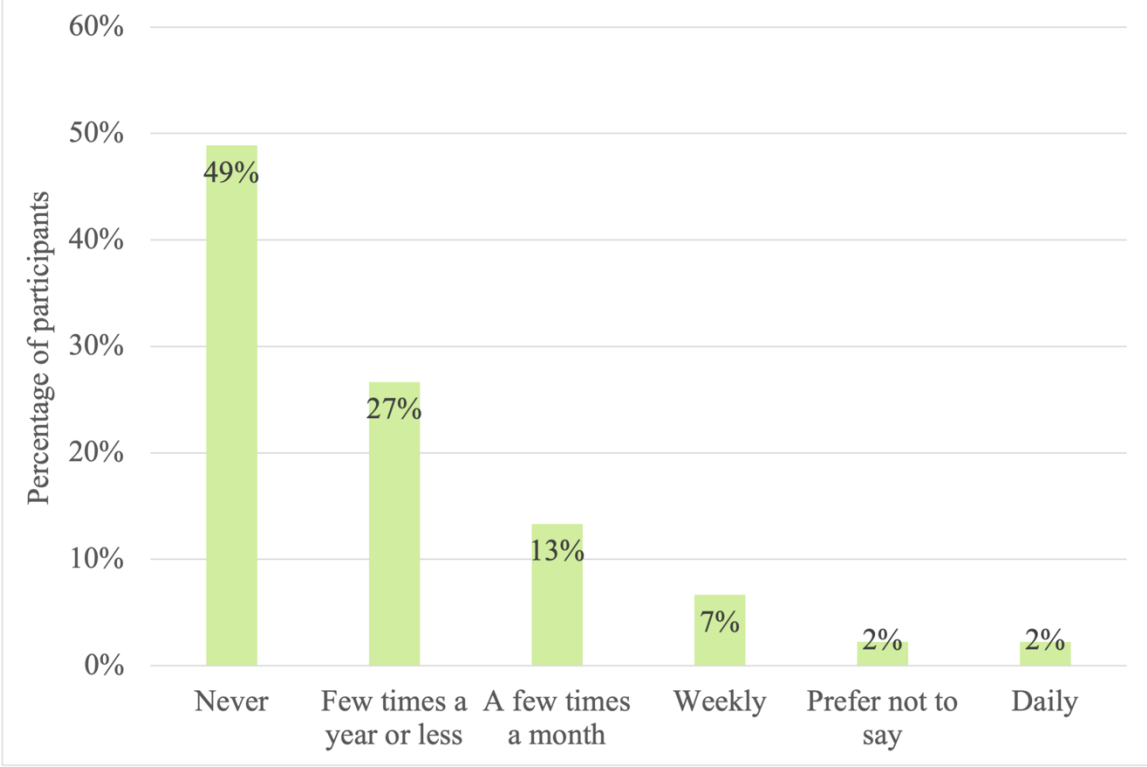


Figure 3.7: Frequency of mobile app usage by caregivers for suicide-related concerns ($N$ = 45).

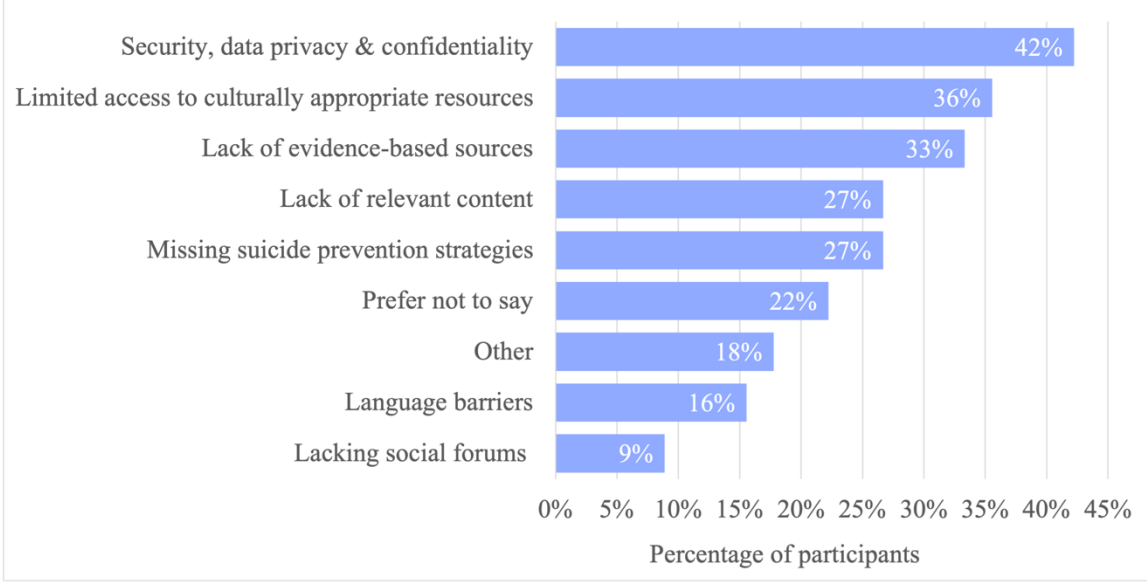


Figure 3.8: Caregivers' concerns for existing mobile apps for suicide prevention ($N$ = 45).

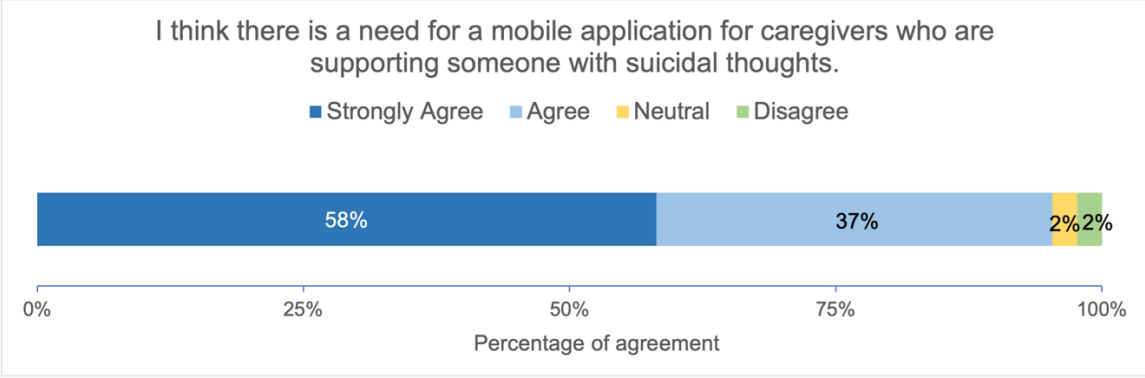


Figure 3.9: Frequency distribution of participants rating on the need for a mobile app for caregivers supporting someone with suicidal thoughts ($N = 45$).

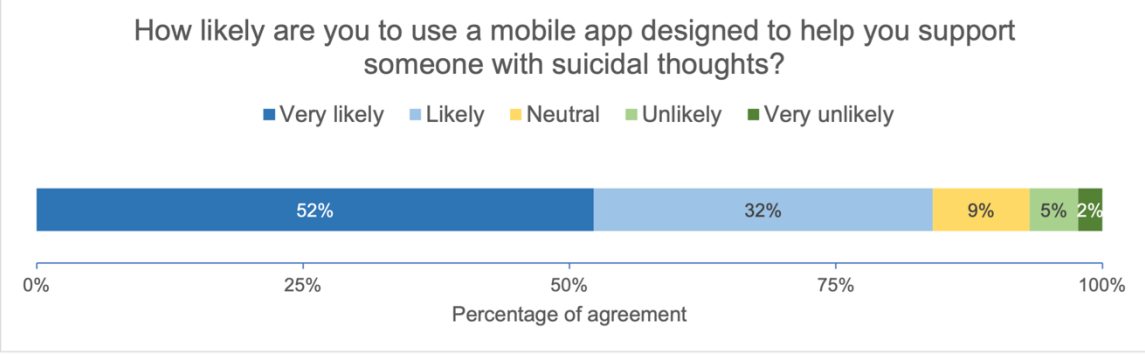


Figure 3.10: Frequency distribution of participants rating on likelihood of using a mobile app designed to help them support someone with suicidal thoughts ($N = 45$).

#### 3.3.2.2 System Usability

The System Usability Scale (SUS) scored on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) revealed an average score of 74.3 ($SD$ = 18.2), indicating that the overall usability of our app is "above average" [173]. A one-sample t-test was performed to compare mean usability scores against a midpoint of 3 to further analyze the data (Table 3.2). The results indicate that there is a statistically significant difference in users' SUS ratings when compared to the midpoint of 3 ($M$ = 3.97, $SD$ = 0.73) suggesting a significant difference from the midpoint ($t(44) = 8.98$, $p = < 0.001$). Table 3.2 provides the descriptive statistics and results of a one-sample t-test for engagement, simplicity, and user experience of the LifeLink app prototype.

Table 3.2 Descriptive statistics and results of one-sample t-test for engagement, simplicity, and user experience of LifeLink app prototype.

| $N = 45$, Mid-point = 3 | | **Descriptive statistics** | | **One-sample t-test** | | |
|---|---|---|---|---|---|---|
| **Measures** | **Dimensions** | ***M*** | ***SD*** | ***t*** | ***df*** | ***p*** |
| Engagement | Visual appeal | 3.57 | 0.93 | 4.13 | 44 | 0.001 |
| | Novelty | 4.04 | 0.67 | 10.42 | 44 | 0.001 |
| | Knowledge | 4.13 | 0.75 | 10.05 | 44 | 0.001 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Perceived usability | 3.97 | 0.73 | 8.98 | 44 | 0.001 |
| | Overall engagement | 4.01 | 0.75 | 9.05 | 44 | 0.001 |
| Simplicity | Organization | 4.03 | 0.55 | 12.57 | 44 | 0.001 |
| | Component complexity | 2.96 | 0.98 | -0.31 | 44 | 0.760 |
| | Aesthetic simplicity | 4.02 | 0.85 | 8.06 | 44 | 0.001 |
| | Reduction | 3.36 | 1.16 | 2.04 | 44 | 0.050 |
| User Experience | Perceived usefulness | 4.10 | 0.61 | 12.12 | 44 | 0.001 |
| | Perceived persuasiveness | 3.74 | 0.72 | 6.92 | 44 | 0.001 |
| | Satisfaction | 4.00 | 0.77 | 8.66 | 44 | 0.001 |

#### 3.3.2.3 User Engagement

User engagement consisted of five dimensions (visual appeal, novelty, knowledge, perceived usability, and overall engagement) that we analyzed. Results of a one-sample t-test showed that participants reported high levels of knowledge ($M$ = 4.13, $SD$ = 0.75) compared to midpoint of 3. Perceptions of novelty revealed high mean ratings ($M$ = 4.04, $SD$ = 0.67) alongside the perceived usability dimension showing above mean ratings ($M$ = 3.97, $SD$ = 0.73). The dimension of visual appeal showed above-average ratings ($M$ = 3.57, $SD$ = 0.93). Finally, the dimension of overall engagement produced high mean ratings ($M$ = 4.01, $SD$ = 0.75). In brief, all dimensions' mean ratings were higher than the mid-point of 3 and all findings were found to be statistically significant with $p$ = < 0.001. Figure 3.11 and Table 3.2 summarizes the results.

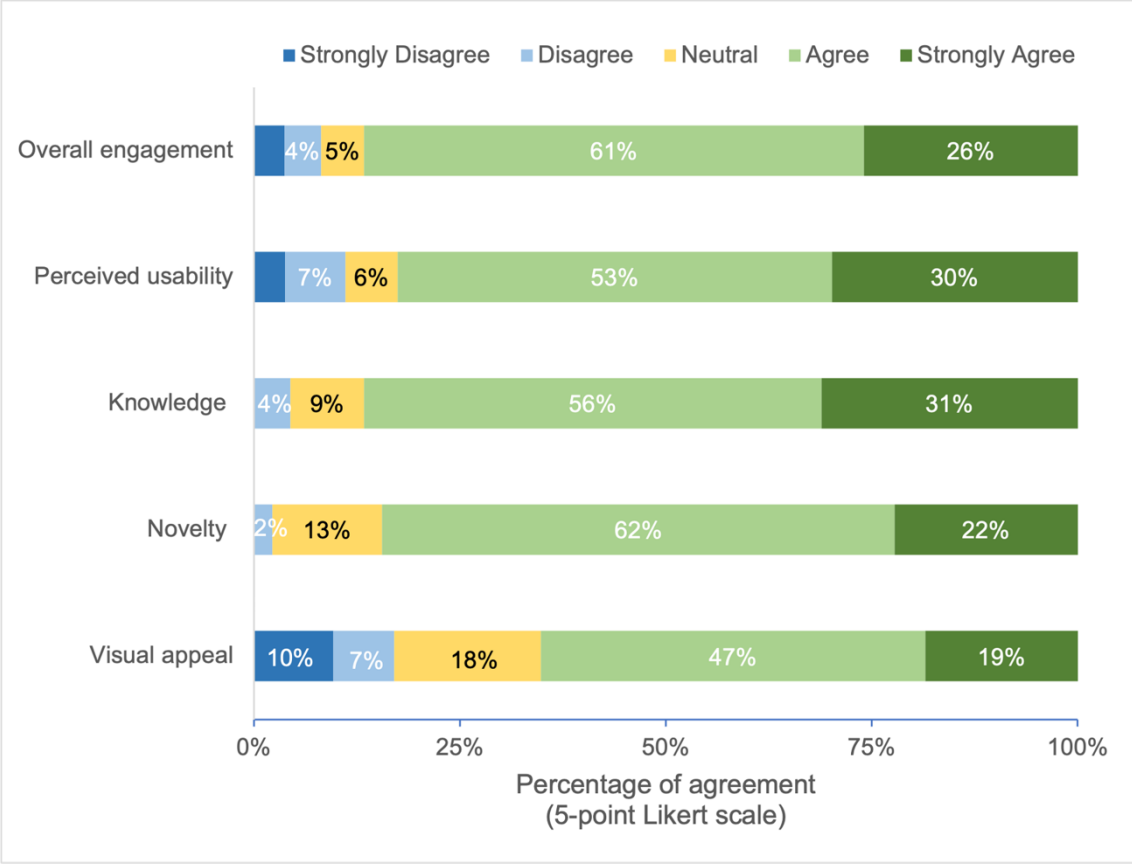


Figure 3.11: Frequency distribution of Engagement ratings ($N = 45$).

#### 3.3.2.4 User Experience

All aspects of user experience (perceived usefulness, satisfaction, overall perceived persuasiveness) showed high mean ratings (higher than midpoint of 3) that were statistically significant $p = < 0.001$. The dimension of perceived usefulness produced a high mean rating ($M = 4.10$, $SD = 0.61$) alongside the satisfaction dimension showing a high mean rating ($M = 4.00$, $SD = 0.77$). Figure 3.12 and Table 3.2 both show details of user experience ratings.

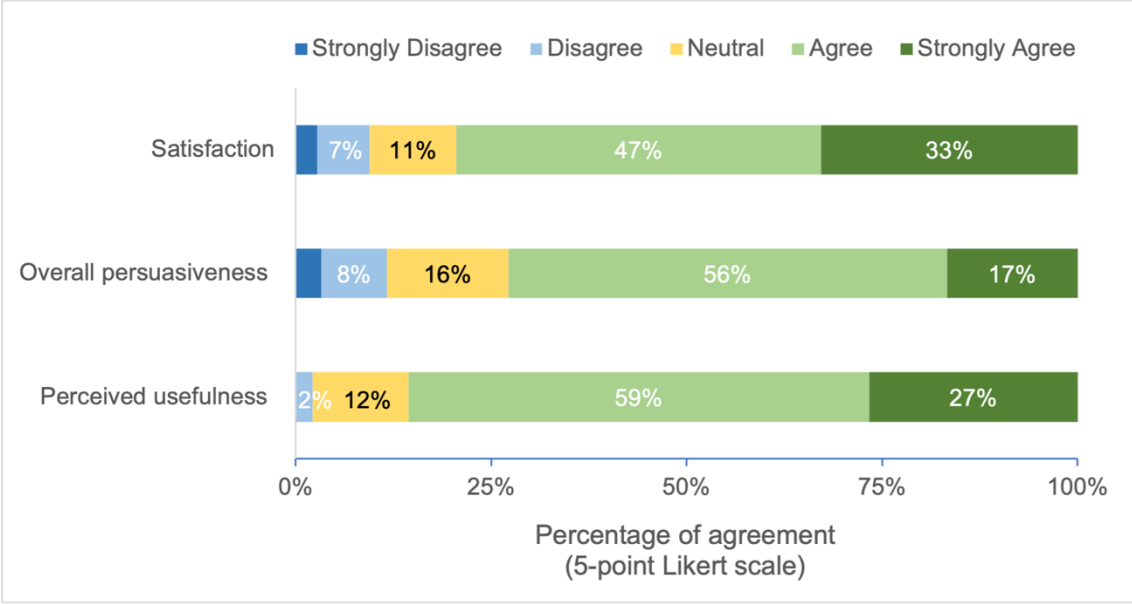


Figure 3.12: Frequency distribution of User Experience ratings ($N = 45$).

### 3.3.2.5 Simplicity

Simplicity consisted of four dimensions: organization, component complexity, aesthetic simplicity, and reduction. The dimension of organization revealed high mean ratings ($M = 4.03$, $SD = 0.55$) across the midpoint, alongside the aesthetic simplicity dimension showing high mean ratings ($M = 4.02$, $SD = 0.85$). The dimension of reduction showed above mean rankings ($M = 3.36$, $SD = 1.16$). The dimension of component complexity had a slightly below-average rating ($M = 2.96$, $SD = 0.98$) but it was found to be statistically insignificant ($p = 0.76$). Overall, participants rated all dimensions of simplicity above average (compared to midpoint of 3) except for component complexity. Figure 3.13 and Table 3.2 both show results on simplicity ratings.

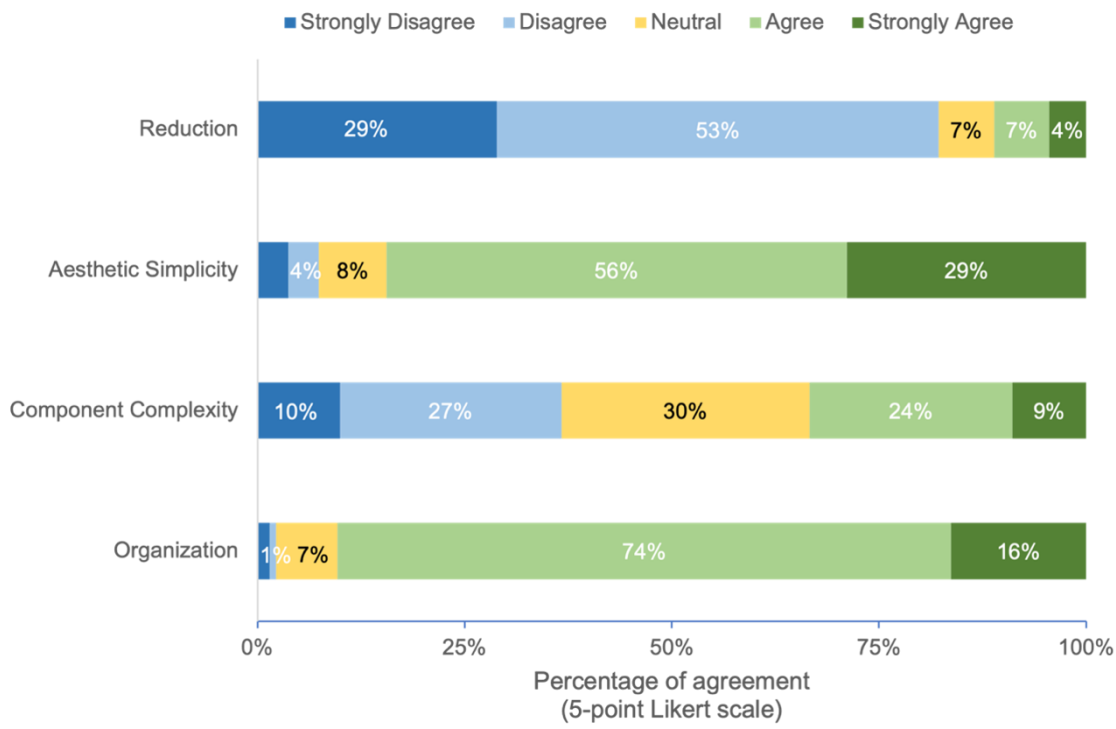


Figure 3.13: Frequency distribution of Facets of simplicity ratings ($N = 45$).

### 3.3.2.6 Perceived Persuasiveness

We computed the mean value of perceived persuasiveness for each of the 10 persuasive strategies implemented in LifeLink. Figure 3.14 shows that the mean score of perceived persuasiveness for all 10 persuasive strategies (*personalization, rehearsal, reduction, customization, surface credibility, expertise, verifiability, self-monitoring, similarity, liking*) was higher than the average neutral score of 4 (red middle dashed line). To further evaluate whether the obtained persuasiveness scores were statistically significant, we conducted the one-sample t-test. As shown in Table 3.3, all 10 persuasive strategies were perceived to be significantly persuasive ($p$ = <0.001) by the participants. The persuasiveness score for all the 10 persuasive strategies implemented was found to be statistically higher ($p$ = <0.001) than the neutral score of 4. This means that our participants perceived all the strategies as persuasive or effective for supporting an individual experiencing suicidal thoughts. Table 3.3 shows the descriptive statistics and results of one-sample t-test for perceived persuasiveness of all persuasive strategies implemented in LifeLink. We observed that the participants found the Expertise and Verifiability strategies in the Crisis feature to be most persuasive based on the mean scores ($t(44) = 28.49$, $M$ = 5.34, $p$ = < 0.001).

We also generated the frequency distribution of perceived persuasiveness ratings. All dimensions of perceived persuasiveness (reconsider current approach, relevance, convince and influence) showed high mean ratings (Figure 3.15). Finally, we computed the mean score for overall persuasiveness and found that it showed above-average ratings ($M = 3.74$, $SD = 0.72$, $p$ = <0.001). Figure 3.15 and Table 3.3 show the results of overall perceived persuasiveness.

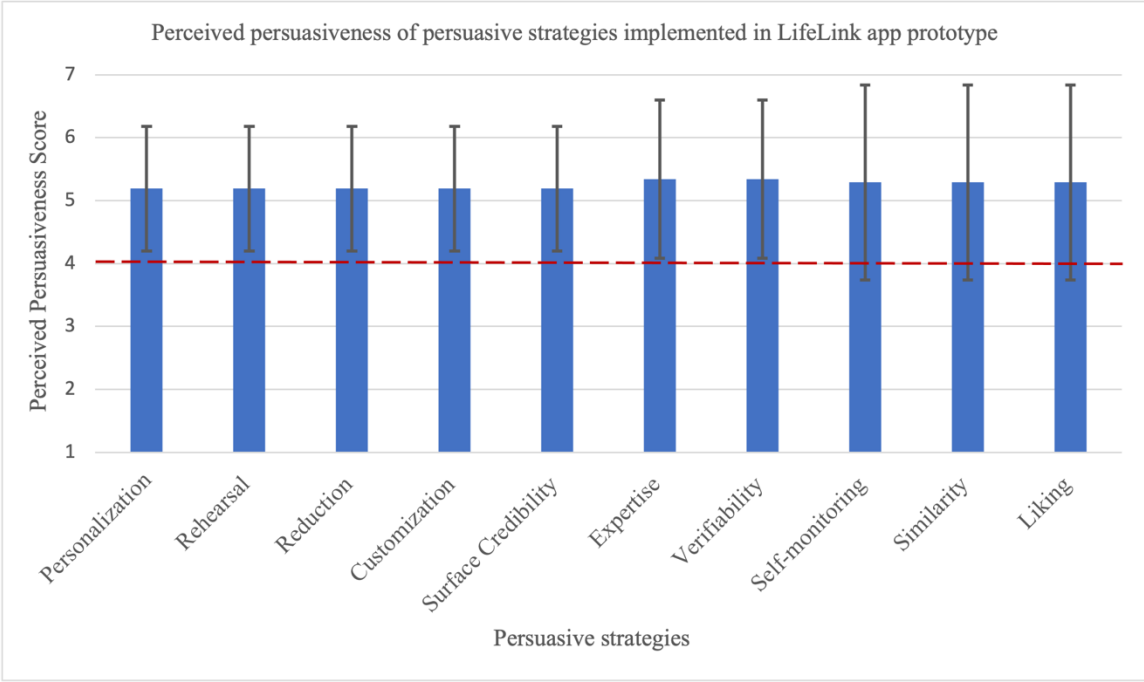


Figure 3.14: Bar plots showing the mean persuasiveness score, 95% confidence interval, for each of the 10 implemented persuasive strategies (y-axis). Red dashed horizontal line in the middle represents average persuasiveness score (i.e., neutral score of 4).

Table 3.3: Descriptive statistics and results of one-sample t-tests for perceived persuasiveness of persuasive strategies implemented in LifeLink. *M* = Mean, *SD* = Standard Deviation, *t* = T statistic or Test statistic of the one-sample t-test, *df* = degrees of freedom for the test, p = probability.

| *N* = 45, Mid-point = 4 | **Descriptive statistics** | | **One-sample t-test** | | |
|---|---|---|---|---|---|
| **Persuasive Strategy** | ***M*** | ***SD*** | ***t*** | ***df*** | ***p*** |
| Personalization | 5.19 | 0.99 | 35.00 | 44 | 0.001 |
| Rehearsal | 5.19 | 0.99 | 35.00 | 44 | 0.001 |
| Reduction | 5.19 | 0.99 | 35.00 | 44 | 0.001 |
| Customization | 5.19 | 0.99 | 35.00 | 44 | 0.001 |
| Surface Credibility | 5.19 | 0.99 | 35.00 | 44 | 0.001 |
| Expertise | 5.34 | 1.26 | 28.49 | 44 | 0.001 |
| Verifiability | 5.34 | 1.26 | 28.49 | 44 | 0.001 |
| Self-monitoring | 5.29 | 1.55 | 22.96 | 44 | 0.001 |
| Similarity | 5.29 | 1.55 | 22.96 | 44 | 0.001 |
| Liking | 5.29 | 1.55 | 44.96 | 44 | 0.001 |

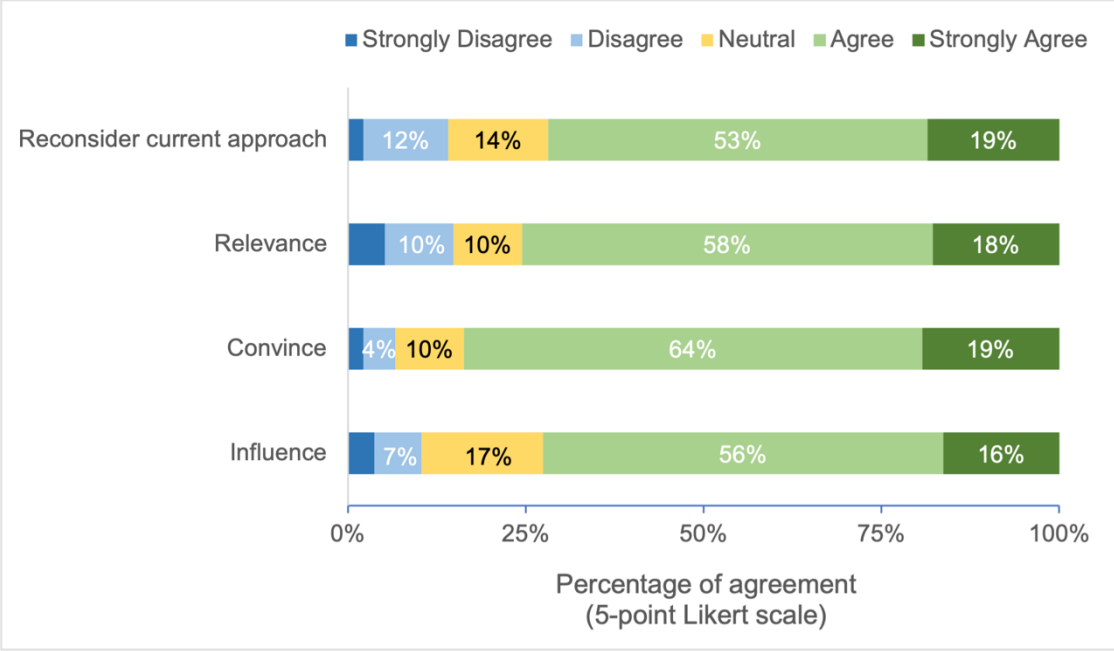


Figure 3.15: Frequency distribution of perceived persuasiveness ratings ($N = 45$).

Based on the results presented in Table 3.2, the dimensions describing user experience were all statistically significant, scoring above the mid-point suggesting that the app prototype yields a good user experience. Likewise, the same pattern was observed for other dimensions describing engagement and simplicity (except component complexity). It is possible that participants found our prototype's icons and layout as visually dense, which is why the dimension component complexity was rated as below average.

### 3.3.3 Qualitative Results

We conducted a thematic analysis [11] of the qualitative data (participants' comments, opinions, and interview data) to understand the needs, concerns of caregivers when supporting an individual with suicidal thoughts and their evaluation of our app prototype. We followed the six-phase framework developed by Braun and Clarke [11] for conducting a thematic analysis. We generated the following five major themes: (1) caregiver's experiences and concerns, (2) caregiver's approaches for dealing with suicidality, (3) caregiver's app needs, (4) views on the LifeLink app prototype, and (5) app design recommendations. Figure 3.16 shows the final themes along with corresponding sub-themes. The remainder of this section describes each theme in more detail along with sample quotes to support the theme. Quotes are presented verbatim with no spelling or grammar corrections.


Figure 3.16: Five main themes and corresponding sub-themes from the qualitative analysis.

#### 3.3.3.1 Theme 1: Caregivers' Experiences and Concerns

Several participants mentioned that supporting an individual was a challenging and tiring experience. One of the challenges was difficulty accessing professional support services quickly and long wait times at crisis lines. Participants reported that individuals with suicidal thoughts felt guilty and inadequate. Caregivers at times felt guilty for the sufferings of the individual, constant pressure and a sense of responsibility when supporting an individual. For example, one participant said "*It's been very **difficult** and very **frustrating** just being able to find the supports that we needed both for that person and for the family. Incredible **responsibility** and **pressure** on you*" [P19] and another said, "*People with suicidal thoughts are **feeling guilty** most of the time because you always think that you are not doing your best or it's happening because you are not good enough or you are not*

*helping them enough*" [P16]. Participants found that individuals would lack interest in any activity like their hobbies, social plans, using their phone and gradually lose hope in life. A participant said "*You (caregiver) need to **bring them back to life**, because now they've seen a thin line between life and death*" [P17] and another said "*They don't even like to use their phone or they're not in the mood for anything*" [P16]. Participants reported that dark jokes about suicide are quite common nowadays. Sometimes it can be difficult to understand the gravity of a situation from the tone of an individual's words when they casually mention thoughts of death. A participant said "*I have a friend who used to say, "Well I failed my test, I guess I'm gonna go die now". Well, does that mean you are **joking** or is that something that we need to actually talk about right now?*" [P37].

Participants mentioned that they were unaware of any apps for suicide-related concerns. There is a lack of awareness and public discussion on the existence of suicide prevention apps. One participant said "*People don't talk about it because I've never heard from others about any sort of application like that. But if you need for example a fitness application, you can have like 100 recommendations from people. But when this is for some serious material or something that you might actually need help, it's **not easy to come across these stuff**"* [P16]. Participants talked about the prevalence of stigma around mental health and suicide. This leads to fear of judgement, difficulty in opening up and talking about suicide for both the caregiver and the individual. Participants often felt alone and uncomfortable in discussing their concerns publicly. Individuals would hide their true feelings in front of people to avoid talking about their struggles. One participant said "*If they were in an environment where they didn't want others in the household to hear them, they tended to miss more appointments because it depended on who was home and if they could speak freely or not. Accordingly, they were **very guarded in their communication***" [P28]. Another one said "*You **feel really alone** because you can't discuss this matter with others. You **don't want them to judge** your loved one. Because of the **stigma around, mental health and suicide**, it's not easy to bring this topic up and talk to others. Even if you are not living in your home country, the stigma still is around with you. You **don't want others to feel you coming from a difficult family** or you know, your family is not strong enough*" [P16].

Participants reported that suicide is a multifaceted problem and can look different from person to person. There is no one-size-fits-all approach or a definitive checklist to handling it as it is person and context-dependent. A participant said "*It's such a **complex problem** when people are experiencing it and it's really **multifaceted**. I feel like you have to treat everybody like on a case-by-case basis - it is **challenging**, but it is possible*" [P81]. Another participant said "*An important thing to keep in mind is, **suicidal thoughts manifest in every person in different way**, like on social media you keep seeing that people who look sad or isolate themselves are more likely to have suicidal thoughts. But that's not the case, people can be really happy, they can carry on the daily activity, carry on their life, and still struggle with suicidal thoughts*" [P52]. Several participants mentioned that supporting someone can be draining and impacted their mental health. A participant said "*When you are supporting someone, you are also struggling with some sort of anxiety all the time. It is a lot of work and **mental drain** especially if you're doing it by yourself*" [P37]. Another participant said "*You need counselling yourself because it is pretty traumatic. We need a big system of support, so that the supporters aren't burning themselves out supporting folks*" [P24]. Participants emphasized the time-sensitive nature of an emergency. A

participant said "*It's like **a serious thing**. because it's **one's life which is at stake***" [P32] and another participant said "*When you are really into a situation, your first instinct is just to call for help. Sometimes the **emergency, it's like milliseconds***" [P16].

#### 3.3.3.2 Theme 2: Caregivers' Approaches for Dealing with Suicidality

Several participants reported that connecting with people who have had similar experiences helps individuals feel less alone. It is helpful for them when they hear stories about people with similar problems and how they overcame them. A participant said "*Sometimes when folks are experiencing suicidal ideation they feel alone, and they **feel like they can't get by it**. And sometimes when they hear a similar story from like a public speaker or keynote, that's what really can trigger them to say, I can live, this is a **role model** for me now*" [P24]. Participants used educational resources like online materials, programs, and crisis lines to support their individual. Interestingly, a few participants revealed that online support material lacked interest from individuals who needed support. Such resources can be beneficial for caregivers, who are looking at every available option for support, but not necessarily for the individual as they find it difficult to maintain attention and lack interest. A participant said "*If I see some **online materials** that I feel are related to you know depression or are related to how we can cheer ourselves up or something like that, I will send that to them and try to discuss that topic, that materials with them as well to make sure that they had a chance to watch that*" [P16]. Another participant said, "*In my experience both personal and professional, those that needed support found it **difficult concentrating**, **navigating online supports** and were easily frustrated*" [P28].

Participants described that they tried to identify the individual's root cause of suicidal thoughts i.e., the problems they're facing. They tried to help the individual identify their reason for life and emphasized their dreams which could anchor them to life. Participants also used their community connections to help the individual solve their problems. A participant said "*You try to quickly **understand the reason why they actually want to end it**, because without that root cause, you won't be able to provide them something positive to **change their mindset** at that point*" [P17]. Other ways that participants used for supporting included financial help, suicide intervention skills training, monitoring individual's behaviors and suggesting distraction techniques. A participant said "*I just **keep an eye** on them to see if they have any strange or unusual behavior. For example, if they still enjoyed their hobby, if they still carry on their daily activity, try to **notice if there's any pattern**: do they still eat the usual amount they eat every day, do they sleep regularly?"* [P52]. Another participant said "*I tried to support her, because she is Muslim, I told her, for example, to do some prayer, to read Quran, to watch some movies, to go outside, to **do something**, to travel"* [P55]. Participants sought professional help to support their individual with suicidal thoughts. Some participants stated that they failed because the individual did not acknowledge that the professionals could help them or found therapy as not useful as it was held virtually. A participant said "*We went through our family doctor and worked with both private clinicians, therapists. Also went through mental health (supports) at the hospital. During COVID, some of his therapy was done online through zoom and just through telephone. Neither of those seemed to work for him*" [P19].

Participants described that they try to shift the person's mentality or idea of ending their life to something positive. They try to motivate the person, open up meaningful

conversations to help positively impact their lives and help them to think beyond their negative thoughts. A participant said "*You're trying to **change the perception** of what the person has already made out of their lives which is to give it up. So it's **not really easy**, but that's how it works*" [P17]. Participants reported that social media, online forums, memes, and content from social media influencers are some other approaches they found useful in supporting. At times caregivers suggested content from these channels to the person to help them feel better. A participant said "*We have **positive communities on social media** where you have people talking. So it's good sometimes to actually use social media to kind of go through people's experiences, and then you **begin to think I'm not alone**, that this is practically just a situation that can improve*" [P17]. Another participant said "*I mostly suggested her some influencer who has some **sense of humor**. And also some TikTok videos*" [P55]. Participants mentioned that they talked to the person, comforted them, and would try to be present for them. Talking to friends was a common way of seeking help. Some participants tried to meet the individual in a natural environment which felt more comfortable for them to talk openly at, for example, a garden. A participant said "*Usually if you **let people talk**, I find that that helps alleviate a lot like in terms of their how they're feeling in distress"* [P81]. Another participant said "*This person if they were starting to think of suicidal thoughts, they'd frequently come to my room and be like, can I just watch you play video games? Can I just sit here and color? and I **made that space available for them** and two years ago they messaged me and said, you know, thank you because **you were the reason that I'm still alive***" [P24].

#### 3.3.3.3 Theme 3: Caregivers' App Needs

Participants reported that it was very important for individuals to preserve their anonymity in any suicide-related app. Individuals would like not to disclose that they use the app or their identity for reasons like safety, their environment or fear of judgment. A participant said "*Chat option is very important because sometimes there is this **anonymity which makes them actually talk more***" [P17] and another one said "*I'm not sure, but I feel like people will be really embarrassed to have app as this is more or less regarding to suicide stuff and maybe they will try out to **hide it from other people***" [P55]. Participants found a mobile app to be an easily accessible option as compared to traditional approaches for supporting someone. A participant said "*The caregiver is **looking for help wherever they can get it**. And so if they had an app on their phone, it would be just **make life so much easier**. You don't have to call somebody and wait and maybe get a person or maybe not get a person. And **it's 24/7**, I like that as well. You have access to all the materials that you need at one place*" [P19]. Participants suggested that an app should primarily be easy to use and user-friendly as they are dealing with convoluted thoughts. In such cases, it can be difficult to focus or concentrate, so the app should hold their attention and not be difficult to navigate. A participant said that "*I would hope it would be **easy to use** because when you're in that mode of helping somebody, you're **already frazzled***" [P19]. Participants expressed that the app should not require technical assistance and be simple to use. A participant said "***Not too busy or too complicated to use**, and I'm thinking of my husband who's **not very tech savvy** at all, it would have to be pretty simple for him to be able to use it*" [P19]. Some participants reported concerns about the privacy of their data and their identity. A participant said "*With respect to **privacy**, this depends on the authority who's handling the data and how they handle it*" [P32]. Participants reported that the reliability and authenticity of the app are crucial for them to be able to trust the app. They suggested

that the app should be factual and vetted by credible mental health sources. Participants also said that since the app would be in the field of healthcare, they would try the app themselves first before recommending it to someone. They would be careful with what they recommend and would like to make sure that it has nothing problematic. A participant said "*So because now you're online, you can access anything, (so) you cannot be positive if they are correct materials or just someone wrote their thoughts*" [P16].

#### 3.3.3.4 Theme 4: Views on the LifeLink app prototype

Participants provided their views on the prototype overall as well as on key features of the app namely Home, Crisis and Analyze. We present results from each of these categories below.

Overall, participants found the layout of the app uncomplicated and well-organized. Some participants stated that there is scope to utilize white space on screens with more visuals. Participants liked the category-wise breakdown of buttons using card views [71] on different screens. A participant said "*It **doesn't look complicated**, and I like that everything is in one place, so if I went to the app I could find what I needed for both myself and for whoever I was helping*" [P19]. Another said "*It's nice because I just know that the mindset of someone who is in that, like low place, it's very difficult to focus on. Like it's just so much noise in someone's head. So it's nice that it's **quite streamlined***" [P37] and "*I like the home screen like with the six tabs and the Good Evening John, just because I just **like how that's laid out** and the learn section. Those the screens that kind of **stick out for me***" [P88]. Participants found the app design easy to use, navigate, easy to understand, not too busy and technically convenient to work with. A participant said "*It looks **user friendly** like **not something too difficult to navigate**. I like how it set out because if there's too much information when you first go on, it'll be overwhelming to somebody to try to find what they might need.*" [P81] and another said that "*It was **easy to understand,** navigate and work with, which is really **good aspect of design**. I really like that aspect, you know what you expect the app. It was very **clear** what I had to do if I wanted to go to a certain area*" [P16]. One participant said "*I think what I like is that I'm pretty sure I could use it and I'm **pretty sure my husband could use it**, which is saying a lot. Like I said, **he's not very techie***" [P19]. Participants found the resources within the app as helpful for increasing their knowledge and learning about suicide prevention. Many participants said that the Learn feature with all the resources and information guide was beneficial for them as caregivers. A participant said "*I would say the most important part is having access to resources. When you are struggling with this issue, you are keen on learning. So you'll start to learn things that you've never thought of because you want to support your loved one. I **will use the app for sure** because I can **learn so much** about different mental health parts and as I **increase my knowledge**, I'd be able to support my loved ones better. Learn is my favorite part from the app*" [P16]. Another participant said, "*My favorite features would be 'favorites' and 'learn' - having like a guide on what to watch out for will be **really helpful**"* [P52].

Participants found the icons easy to understand and engaging. Some participants found the Network feature lacking in terms of engagement. Participants suggested having more colours, which aren't flashy as it can seem too busy for a user who is already in a stressful situation. Some participants mentioned that some app features were not very visually appealing at this stage of design. A participant said "*The buttons on Crisis are nice and big*

*it really **draws your attention** to the two that are there so that if you were in that headspace where you absolutely were in crisis, you could easily find what you need. I really like the icons on Analyze - it's kind of **motivating** and just **makes me interested** to go and find out more. The other two screens (network and learn) were a little not as engaging, I guess just **kind of plain***" [P19]. One participant said "*Maybe if you can make it have a dark mode, and make the background be a neat color. I **like the icons** - those make sense, it's nice to be able to look at it and know what it means immediately. That does help. The carrot is cute*" [P37]. Another participant said "*It is nice, but I'm not sure if this is just a prototype, so it's not the final version, but I think we need **more color**, not too much, but really more color which is soft on the eyes*" [P55]. Participants found the app useful and helpful for themselves. They reported that the app would make a huge difference in improving their approach to supporting someone with suicidal thoughts. The app was found to help track caregiver's mental health so that they can be there for the individual experiencing suicidal thoughts. Participants mentioned that they would use and recommend the app to caregivers including parents, guidance counsellors, friends, teachers, and campus housing leaders. A participant said "*I think it can be a **really useful tool**. I was blown away by it. It's **designed in a way that can be really helpful**. I would **strongly recommend it** for my professional affiliation to adopt it as a tool for our peer staff. It could be very **impactful**. It's one of those tools that will support folks a little bit better than the current mental health tools."* [P24]. One participant said that "*This is **new technology**. Even those that are marginalized, a phone, is a necessity for life. It's their connection. So if there's some way to keep people supported and engaged and even loved ones engaged through this sort of technology, I think it would be very useful"* [P28]. Another participant said "*A student of mine died by suicide about 10 years ago, because of online bullying. Technology can be very negative, a lot of the time, but I just like the idea that you're using it in a way that make it **a positive influence**. So it's great. I could see a lot of students using something like this in regard to trying to help their friends*" [P88]. Another said "*I like the home screen with the good evening John and the different options. I think that's really good to give people a **sense of empowerment***" [P54] and "*I'm just so thankful that you're doing this. It's **something that we really need**"* [P19]. One participant said "*This app would be really **helpful for folks** in campus housing leadership roles. And mainly because when I was in those leadership roles, **you are the only person awake**. Oftentimes, you're the closest thing to professional support someone will get*" [P24]. Another mentioned that "*I **like that the app name is about life**. It's not called like help phone or crisis or, you know, something like that or even, like mental health something. It doesn't have to give away right away so that's nice*" [P37].

Some participants mentioned that the kind of music that is available on the app is crucial as it can be a potential trigger. Similarly, games on the app, if provided, need to be simple card games and not first-person shooter games which can trigger individuals. A chatbot, if provided, will also have to be reconsidered as its responses need to be sensitive to the heavy nature of suicide. A participant said, "*I **like the music approach**, but with music you **don't know what the trigger is** at that particular point in time.*" [P17] and another said "*I'm not sure how a **chatbot** will react. If it goes sarcastic out of the blue, I'm not sure what would happen*" [P32]. Participants found the app to be simple and neat in terms of design. A participant said "*I thought it is **really neat**, like the design is **simplistic and minimal**, so there's not a lot of distraction when you try to use the app*" [P52]. Another said "*I do like*

*that it is simplistic, without it looking like you put it together in 5 minutes. Looks like you put thought into it being so simple*" [P37].

For the home feature, participants appreciated having art therapy as a way of distracting the individual from suicidal thoughts. A participant said "*I like the fact that you have sort of like* ***an art and a movement piece****. I know a lot of people work through their mental health with their art. Whether it be music or poems or something else*" [P24]. Participants found the Learn feature helpful for learning and increasing their knowledge about topics within suicide. Some participants also felt that music can be a calming tool to help individuals feel better. Participants emphasized the importance of trying different activities for a person struggling with suicidal thoughts. A participant said that "*I love the favorites, because when somebody might be having a down moment sometimes they forget what they need to do or it's just confuzzled, it's scrambled. So, you know, going back to what are the* ***things you need to do to help with your coping****. Are you going to journal? Are you gonna exercise? Is it music? And that's just those friendly triggers and reminders that sometimes they just forget to do. Or they keep going back to one and that one is just getting boring for them*" [P28].

Within the crisis feature, participants reported that access to instant professional help during a crisis - was a must. A participant said "*I really like the option to contact the nearest emergency center. It's* ***really helpful*** *because* ***in the event of emergency****, you wouldn't remember the suicide prevention hotline, right? Or you would not know which is the nearest hospital for example. So just clicking on the button and being able to reach the nearest support would be really helpful.*" [P52] and another participant said "*That's a* ***very important feature*** *because people have to dial numbers for suicide intervention and things like that, which doesn't make sense*" [P32]. One participant said "*I really liked the nearest emergency and helpline buttons. I think that makes it* ***really easy to escalate if needed***" [P24]. Some participants said that in the event of a crisis, the individual with suicidal thoughts or the caregiver might not be in the position to pick up an app. However, having these resources would be helpful for them to check in advance. A participant said "*When you are really* ***in this matter of crisis****, maybe you are* ***not even think of opening your app*** *and going to this section. It's good to see them in advance*." [P16] and another said "*I really* ***like that you're targeting the caregiver*** *because the person who is in the middle of the crisis, sometimes an app isn't something they're gonna pick up. But the person who is helping them, they're* ***looking for help wherever they can get it****. And so if they had an app on their phone, it would be just make life so much easier*" [P19].

In terms of the analyze feature, participants found it helpful for tracking their well-being. Some participants stated that it would be difficult for them to have access to the sleep, diet, stressor information of the individual that they are supporting and so it would be good that the app lets the caregiver track these data for themselves. A participant said "*If I want to enter it for my brother, I* ***don't have always access to all of this information*** *because we are not living together now, I'm not even sure because you're not all the time near them. You're not sure how they are feeling and for their stressors, they are not willing to tell you, and even for their diet. Sleep I guess you can monitor easily, but for other parts I'm not sure, even about medication. They are not willing to always tell you what medication they're taking. I guess if it's something that we can put our information that that is more*

***helpful to track*** *you know as a supporter rather than the person that you are trying to support*" [P16]. Participants found that the Analyze feature can provide them with a sense of control and progress by tracking their wellbeing. Oftentimes, the progress gets overlooked and visualizing your wellbeing metrics can be helpful. A participant said "*It gives them a little* ***sense control and progress*** *as well. That's* ***positive***." [P28] and another said "*This log is a really good idea because sometimes you don't think about what you've done all day, so being able to really think about that for minute might* ***give a little bit more perspective***" [P54].

#### 3.3.3.5 Theme 5: App Design Recommendations

Participants suggested that the app should connect people with others who have experienced similar situations in the past and overcame those struggles. Such stories or videos would be motivating and helpful for caregivers and individuals for their journeys. A participant said "*If you can* ***connect to others with the same issue*** *using some scenarios that you can read and put yourself in their shoes and see how others are experiencing something or maybe others can share their stories. So you can read their power stories or how they support their loved one. When we see successes, we begin to think, wow, this person did it. Even I can do it something like that*" [P16]. Participants mentioned that journaling in a diary is another feature that would help deal with suicidality. A participant said "***Diary*** *is one thing I'm not seeing here and is very effective when you're dealing with* ***a very complicated issue*** *like this*" [P17]. Participants reported that the app should direct users to specific solutions as caregivers and individuals are already dealing with difficult thoughts. The app should be very on the point. A participant said "*Maybe you are in really bad crisis or in really low mood and you* ***need to see specific materials****. So maybe like a different search bar or different categories of issues*" [P16]. Participants suggested having a chatbot which can interact dynamically with the user to provide specific answers to questions. Some participants mentioned that although a chatbot would be effective in providing a fast response, it is important to assess the emotionality and sensitivity of a chatbot when responding to questions about suicide. An AI chatbot that is not properly trained, can potentially trigger, and cause more harm than good in a sensitive area like suicide. A participant said "*Actually,* ***AI chatbot*** *is also helpful sometimes. It will give you really* ***good advice*** *as compared to Google search, but* ***not really as good as human****. Because* ***humans have emotional stuff****, so they can really help more, in certain situations*" [P55].

Some participants suggested that the app's flow needs improvement and can be made clearer. A participant said "*I don't know if this is the app is directing me to the right place.* ***Let the flow be consistent*** *and clear*" [P17]. Participants suggested that it would be interesting to add games and gamification to the app. But the choice of games needs to be decided very carefully such that it doesn't potentially trigger users. Some participants expressed skepticism about incorporating gamification within the app, given the topic in hand. A participant said "*What I don't know is the* ***choice of games*** *that will actually serve them, because at this particular point in time, imagine somebody is thinking about suicide and you have a first shooter person game. So the choice of games at this particular point in time will have to be something as simple as moving cards around this card games*" [P17]. Another one said "*Games and gamifying it's always good. But again, this* ***might not be the right application for gamification***" [P24]. Participants reported that some of the

terminology used for app feature names would have to be revised to be more neutral and convincing. A participant said "*Saying crisis looks very harsh. I think I would use a better word like contact or something. The network name doesn't really go well. Because at that particular point in time, they want to see something that will make them to seek help. Similarly, if you tell me learn it's like, yeah, you're harsh on me, right? So the* ***words*** *should actually be a little* ***bit more convincing, succinct and look more neutral***" [P17]. Another participant said "*I have been told the term trigger can be a trigger for those that experience gun violence. So that might need revising*" [P24].

Participants suggested that the content and app design should be adaptable and personalized as per different users' needs. A participant said "*It should have like a* ***dark mode****. I know a lot of people struggle with calls. For them text message is less stressful. So it would be good to have both chat and call option for contacting your friends etc."* [P37]. Another participant said "*For me, I learn better with videos, that part for my education works better so it is different. It* ***depends on different people****. Some people are easier with texts, so we can have that sort of,* ***adaptability*** *based on your preference, that would be great*" [P16]. A very common design recommendation was that caregivers would like to have some aftercare or self-care tips for themselves within the app. This is because supporting another person with suicidal thoughts can be very challenging and mentally draining. It is important to remind caregivers to take care of their mental health so they can show up for the individual they are supporting. A participant said "*I would want strategies or some* ***after care steps*** *that the caregiver could try. Things to say, things to not say and also places where I could get help and things I could do for* ***self care****. That was the one thing that I wasn't very good at, was self care because I was too busy taking care of him. And so I've learned from this that I* ***need to take better care of myself so that I can be there for other people***" [P19]. Another participant said "*A section of us, a supporter guide of self care for that person and our own mental health. It just needs to be like a reminder or some tidbit on* ***what caretakers could do for themselves*** *or a bit of a scope of practice as far as where their responsibility as being a good human being lies, but because people will feel a* ***real sense of responsibility to try to help***" [P88]. Participants suggested that there should be images and videos besides text in the content to make the app more visually appealing. A participant said "*I imagine there would be some banner* ***photo*** *that would go with each of the tile. Or possibly some small* ***videos*** *included. I am a sucker for* ***visuals****, I* ***would love engaging*** *with it*" [P52].

## 3.4 Discussion

The design and evaluation of LifeLink app prototype was a necessary step within our user-centred design approach before we started developing the application. Using a mixed-methods approach to evaluate a prototype of the LifeLink app, our results showed good usability, and it was also easy to use, easy to understand, navigate and work with. Participants found that the LifeLink app prototype increased their knowledge, was novel, useful and impactful for caregivers. Furthermore, participants rated the LifeLink app prototype to be engaging but could be improved by adding more images and videos. Our quantitative and qualitative results revealed that the app prototype was simple, minimalistic, neat, clear, and well-organized. Participants emphasized that the simplicity aspect of the app design was crucial as they wanted the app to not be too busy or

complicated as caregivers are already in a stressful situation when supporting an individual experiencing suicidal thoughts. Anything too complicated to use would be problematic as it can then be hard to maintain attention or concentrate on the app. Participants reported positive experiences with the app prototype in terms of its usefulness, satisfaction, perceived persuasiveness, motivation for app usage, impact, and utility. Our results show that the app prototype designed with persuasive strategies (*personalization, rehearsal, reduction, customization, surface credibility, expertise, verifiability, self-monitoring, similarity, and liking)* is effective for caregivers supporting an individual with suicidal thoughts.

When asked about their app needs, participants reported that ease of use, access, technical convenience, privacy, reliability or authenticity of content and anonymity were important to them. Our app prototype incorporated some of these aspects and we decided to include the rest in our final prototype before commencing app development. Some features recommended in the design (e.g., games, chatbot, and elements) already present in the app like music were found to contain potentially triggering contents. Depending on the individual, these elements may or may not work well in the app. We planned to reconsider some of these aspects in the design. Participants shared that the time-sensitive nature of emergency (crisis) mediates the need for quick access to professional help. Many participants struggled to find immediate access to professional help. Our app's Crisis feature was found to be very important and useful for seeking instant professional help by caregivers. Participants reported that individuals experiencing suicidal thoughts have a lack of interest in doing anything and a loss of hope. The "Things-to-do" feature in our app prototype was found to be useful for suggesting and trying different activities that motivate users to come out of their convoluted thought patterns.

Participants mentioned that as caregivers they experience personal struggles with mental health in the process of supporting another individual. To combat this, our app design already included a feature called Analyze which helps them track their wellbeing in terms of diet, sleep, stressors, physical activity etc. Participants found the Analyze feature to be one of their favourite features as it helped them get a sense of control and progress. To assist caregivers, we decided to add self-care or aftercare resources in our refined version of the prototype. Educational resources and learning about suicide were crucial elements for caregivers trying to seek help for their loved ones. Participants found that the Learn feature of our app prototype helped increase their knowledge and helped them learn about different topics that fall under the umbrella of suicide. One of the common approaches used by caregivers was talking to the individual and being there for them. To facilitate this, the Network feature of our app prototype helps users connect with friends and family. In line with the person-dependent needs and multifaceted nature of suicide, we decided to refine the prototype to have more adaptable features like dark mode, call and chat feature, more images, and videos, etc. Other app design recommendations like connecting with similar community experiences, adding a diary feature, enhancing app flow, revising terminology to be more neutral and convincing were also incorporated to refine the prototype before commencing app development.

Interestingly, participants mentioned that technology is at times a confounding factor for suicidal thoughts in the form of online bullying, harassment, toxic online environments,

online contagion, disruption of in-person social interaction, isolation, influence on mental health [107], and dark humour on mental health. So, participants found it useful and empowering that our app leveraged technology to have a positive influence and impact. Another interesting finding was that participants reported dark jokes on suicide as quite common nowadays. This is not surprising as pop culture and social media are frequently seen glamorizing and monetizing mental health conditions including suicide. In recent years, dark jokes and internet memes casually reference suicidality and mental illness to produce content that is marketable and clickbait-worthy. Consequently, it can be difficult for caregivers to decipher the state of mind from the tone of an individual's message or words when they casually mention thoughts of suicide. Figure 3.17 illustrates two memes on suicidality from subreddits r/SuicideMeme [178] and r/BPDmemes [177]. As of August 2024, these subreddits are quite popular with many followers (r/SuicideMeme – 18K, r/TrollCoping – 145K and r/CPTSDmemes – 107K members) [178,179,180]. Figure 3.18 shows a Reddit post expressing concern about the glamorization of suicide on social media using dark humour and memes [181].


Figure 3.17: Memes on suicidality from popular subreddits r/SuicideMeme [176] and r/BPDmemes [177].

Figure 3.18: A Reddit post expressing concern about the glamorization of suicide on social media using dark humour and memes [181].

To summarize, a complex and multifaceted problem like suicide cannot be addressed by a straightforward approach. Hence, it was important for us to understand what caregivers looked for in an app being designed for them and their perception towards an initial app prototype. In the next chapter, we will look at the final app design and app implementation.

# Chapter 4 – LifeLink Final App Design and Implementation

This chapter describes the user-centred design [65] approach for creating LifeLink's main app. We will look at the final design and the app implementation in the upcoming sections.

## 4.1 Final App Design Process

### 4.1.1 Sitemap

We incorporated feedback from our prototype evaluation to iteratively refine the low-fidelity prototype and align it further to our target audience's needs. In particular, we included a Power Stories feature to helps users see stories and videos of people in similar situations and how they overcame their stuggles. We also added a Journal feature that would help users reflect on their thoughts. We improved the app's navigation and app flow. We revised certain terminologies in the app to be more convincing and neutral. Finally, we added aftercare steps for caregivers to support them based on their suggestion. This ensured that our app design reflected user expectations and needs. We then developed a sitemap, a visual tool used to represent the structure and hierarchy of website or app pages [128]. The sitemap (see Figure 4.1) was created using Lucidchart (a diagramming application [129]) and provided a hierarchical overview of how the app's sections were interconnected. This acted as a blueprint for organizing our app's content and establishing a user-friendly interface. With this blueprint, we were able to visualize the user flow, modify our prototype to improve the user experience and ultimately create the final design.

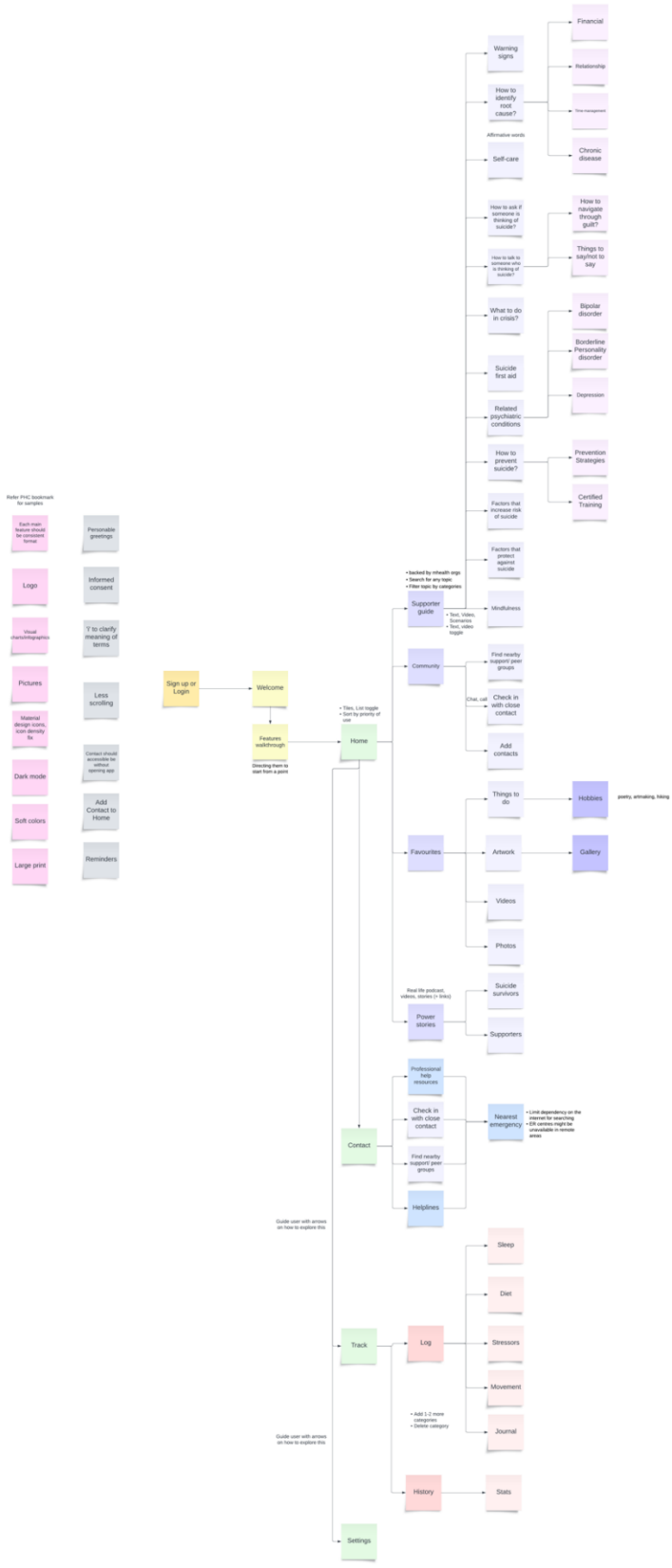


Figure 4.1 Sitemap of LifeLink providing an overview of the app pages and how they are interconnected. Access an enlarged version of this image online [130].

### 4.1.2 High-fidelity prototype

To validate the final app design and prevent complex technical issues during the development process, we designed the high-fidelity prototype of LifeLink. We used Figma, an interface design tool [131] well-adopted by UX designers, for creating the high-fidelity prototype. The high-fidelity prototype was not formally evaluated as we had already gathered feedback from users in our previous prototype evaluation study. This is because we wanted to put less pressure on our users and thought that testing with a low-fidelity prototype would be more comfortable for them. With low-fidelity prototypes, users may better understand that we are testing the design and not them and be more likely to express negative reactions [132]. We evaluated the high-fidelity prototype with some colleagues to check for navigation, interactivity, visuals and received positive feedback. However, minor areas for improvement were suggested and the prototype was refined. To ensure that users can access different videos within Power Stories, an auto-swipe feature was added to the videos. Icons were added to the diet page to make it more intuitive for the user. National helplines within Contact were rearranged into tiles to make it easier for users to access them.

### 4.1.3 Final design: App features

This section outlines the final design of LifeLink, a persuasive app designed to support caregivers of individuals experiencing suicidal thoughts. The app provides resources for caregivers to navigate crisis and community resources to support a person with suicidal thoughts. It was designed based on findings from study one wherein we received feedback on our initial prototype from 45 caregivers residing in Canada [36].

To summarize, LifeLink:

- Provides the user with a supporter guide for supporting a person with suicidal thoughts.
- Helps the user organize their favourite content for supporting a person with suicidal thoughts.
- Empowers the user with power stories of real-life suicide survivors and supporters.
- Helps the user find community resources like support centres in their province, helplines and quickly check in with their close contacts.
- Helps the user track their sleep, diet, stressors, movement, and journal.

LifeLink consists of the following features:

- **Home**: Users can choose from various options like 'Supporter Guide', 'Favourites', and 'Power Stories' (see Figure 4.2). It displays other options like ‘Contact’, ‘Track’ and ‘Settings’ in the bottom bar. 'Quick Links' allows the user to reach specific features like 'Find Nearby Support' instantly.

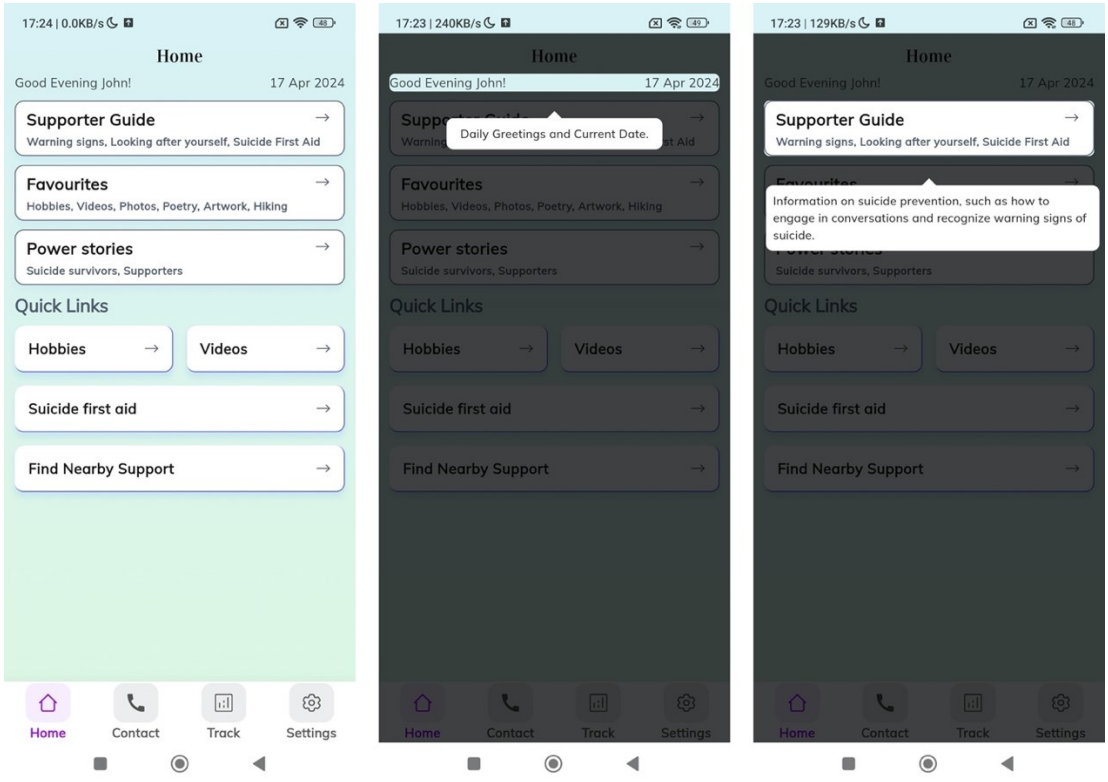


Figure 4.2 Screenshots of LifeLink's final design: Home page and guided tutorial on the Home page.

- **Supporter Guide**: This feature provides users with information about various topics related to suicide and suicide prevention (see Figure 4.3). Users can search for a topic by entering any keyword. Users can also visit the information source on the web by clicking the hyperlink below each page. This feature helps caregivers in finding information about different topics related to suicide prevention.

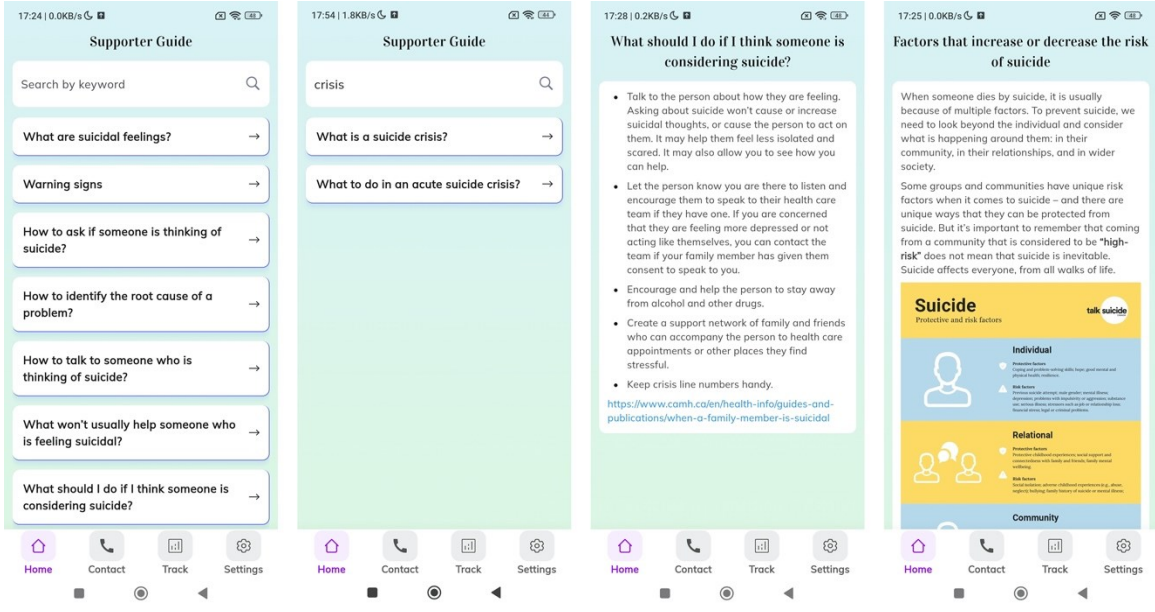

Figure 4.3 Screenshots of LifeLink's final design: Supporter Guide.

- **Favourites**: Users can store favourite content of their choice like 'Videos', 'Photos', and 'Artwork' (see Figure 4.4). Under 'Hobbies', users can read 'Poems', add their 'Artwork', and log their 'Hiking' trips. Users can also find poems online by entering words in the search bar. This feature helps caregivers in storing favourite content of the person they are supporting, starting conversations with them and engaging in activities together.
- **Hobbies**: Users can select from a list of options to try different hobbies (see Figure 4.4). These hobbies can be used as a distraction technique or as a starting point for conversation when supporting someone with suicidal thoughts.
- **Poetry**: Users can read from existing poems or search for a poem online (see Figure 4.4).

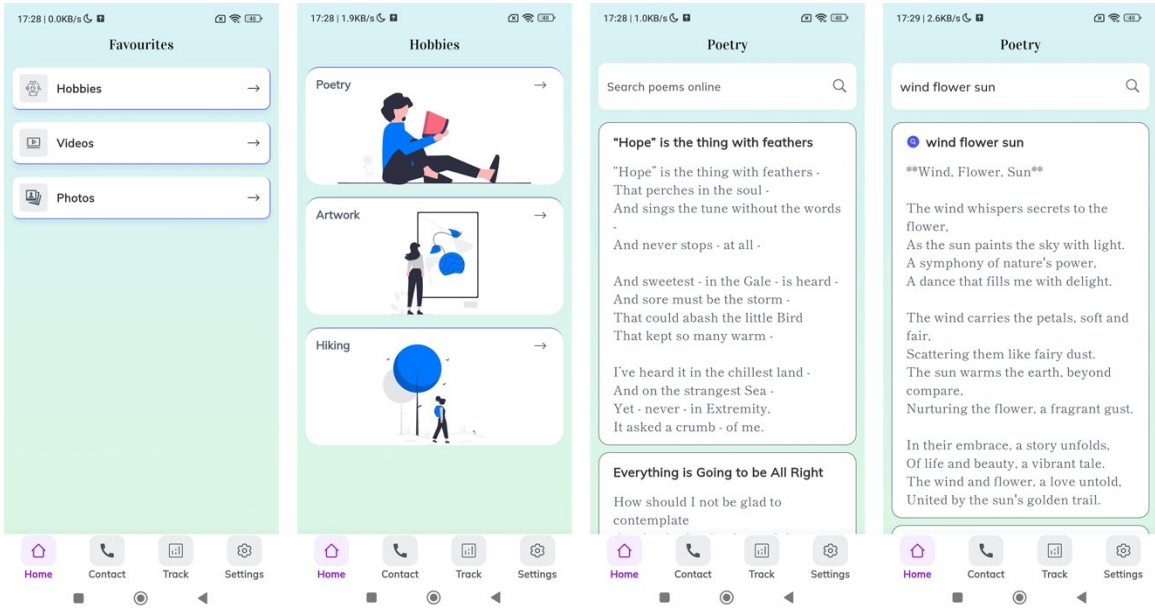


Figure 4.4 Screenshots of LifeLink's final design: Favourites, Hobbies and Poetry.

- **Artwork**: Users can upload their artwork here, use the camera to take a picture or view existing art samples (see Figure 4.5). Users can zoom in to view the fine details of existing or uploaded artwork.
- **Hiking**: Users can log their hiking trips and upload a photo from their hike (see Figure 4.5). This can serve as a place to record hikes and engage in an outdoor activity.
- **Videos**: Users can upload their favourite videos, share any uploaded videos or delete them (see Figure 4.5).
- **Photos**: Users can upload their favourite photos or delete them (see Figure 4.5). Users can zoom in to view the fine details of all photos.

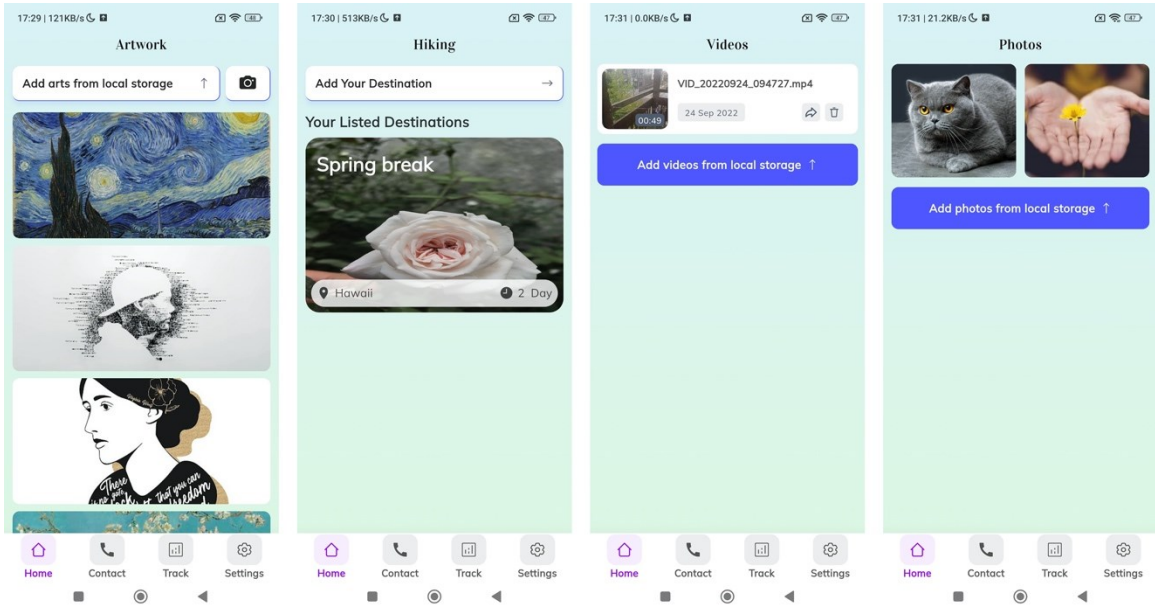


Figure 4.5 Screenshots of LifeLink's final design: Artwork, Hiking, Videos and Photos within Favourites.

- **Power Stories**: Users can browse 'Videos' and 'Stories' of real-life 'Suicide survivors' and 'Supporters' (see Figure 4.6). This feature helps caregivers in knowing how people in similar situation overcame their situation.

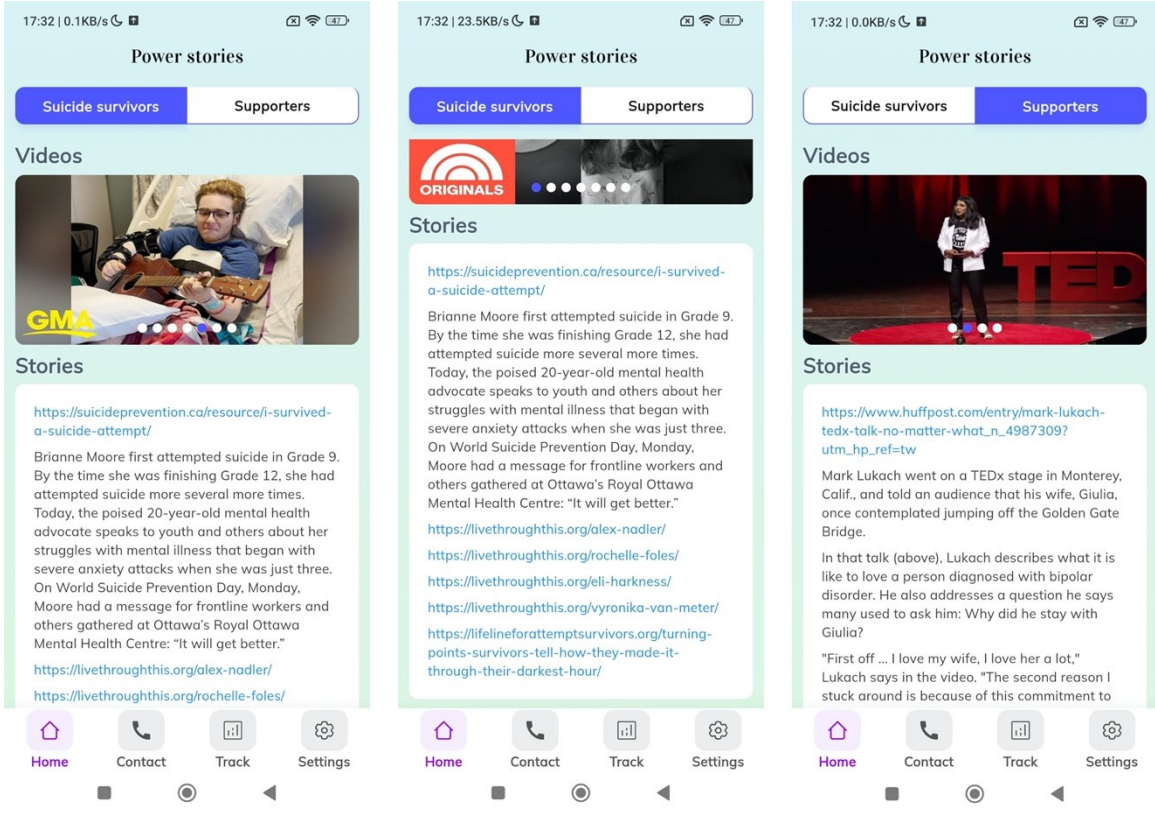

Figure 4.6 Screenshots of LifeLink's final design: Power Stories for both Suicide Survivors and Supporters.

- **Contact**: Users can find community resources like support centres in their province by clicking on 'Find nearby support', find 'National Helplines' and connect instantly via chat or call (see Figure 4.7). After selecting their province, users can instantly connect to support centres via chat or call. Users can 'Add their trusted contacts' and instantly chat with or call them. This feature helps caregivers in easily accessing support resources in their region, if a need for help arises. It also helps them connect with their closed network of trusted individuals.
- **Find nearby support**: Users can find national helplines i.e. crisis lines that work Canada-wide (see Figure 4.7). For provincial resources, users can select their province and then find a list of community resources in their province. Users can instantly connect to support centres via chat or call. They can also check out the respective website.
- **Add contact**: Users can 'Add their trusted contacts' and instantly chat with or call them (see Figure 4.7).

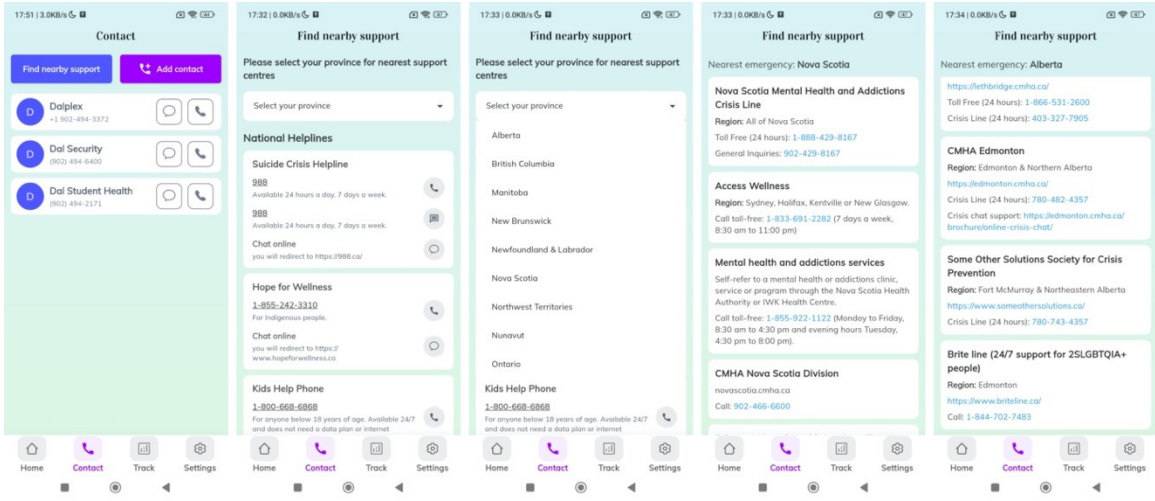


Figure 4.7 Screenshots of LifeLink's final design: Contact (Add contact) and Find Nearby Support.

- **Track**: Under 'Log', users can track their 'Sleep', 'Diet, 'Stressors', 'Movement' or 'Journal' their thoughts (see Figure 4.8). Users can see their daily and monthly sleep records. Users can visualize their daily calorie intake. Users can select from different causes of stress. Users can log their movements and journal to reflect on their day. Under 'History', users can see their overall daily progress in sleep, diet, stressors, movement and journal logs (see Figure 4.9). This feature helps caregivers in tracking their own wellbeing so they can be healthy and effectively available to support another person experiencing suicidal thoughts.
- **Sleep**: Users can add their daily sleep record (see Figure 4.8). They can see their monthly sleep records or filter by date to view their sleep record for a specific date. They can also see if their current sleep record is good, moderate or bad in comparison to recommended sleep hours.

- **Diet**: Users can log their food intake for different meals (breakfast, lunch, dinner, snacks). They can also add a custom meal and corresponding calorie intake (see Figure 4.8). Users can filter by date to view their diet intake on any date. They can also see visualize if their daily calorie intake meets the average recommended value via a progress bar.
- **Stressors**: Users can select from different causes of stress (one or more of the available options) and record their stressors daily (see Figure 4.8). Users can filter by date to view their stress percentage on any given day.
- **Movement**: Users can log their daily exercise duration and how the exercise felt (difficult, good, moderate, poor, great, awesome). They can view their movement history on any given day by filtering the date (see Figure 4.9).
- **Journal**: Users can journal their thoughts, read past journal entries and delete any entries they wish to (see Figure 4.9).

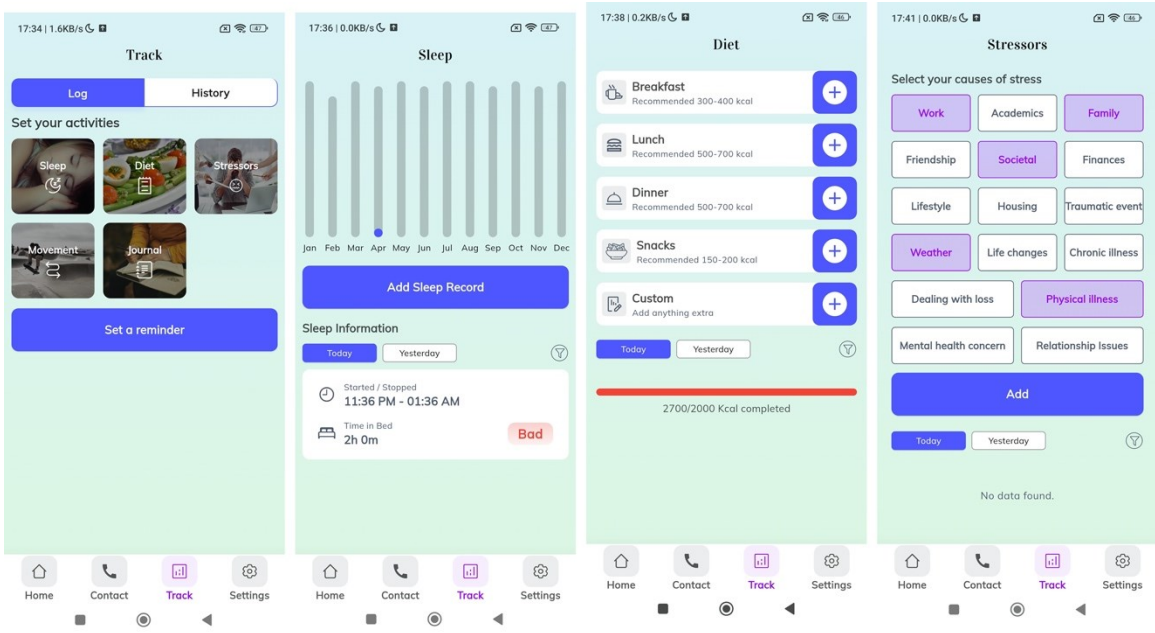

Figure 4.8 Screenshots of LifeLink's final design: Track (Log), Sleep, Diet and Stressors.

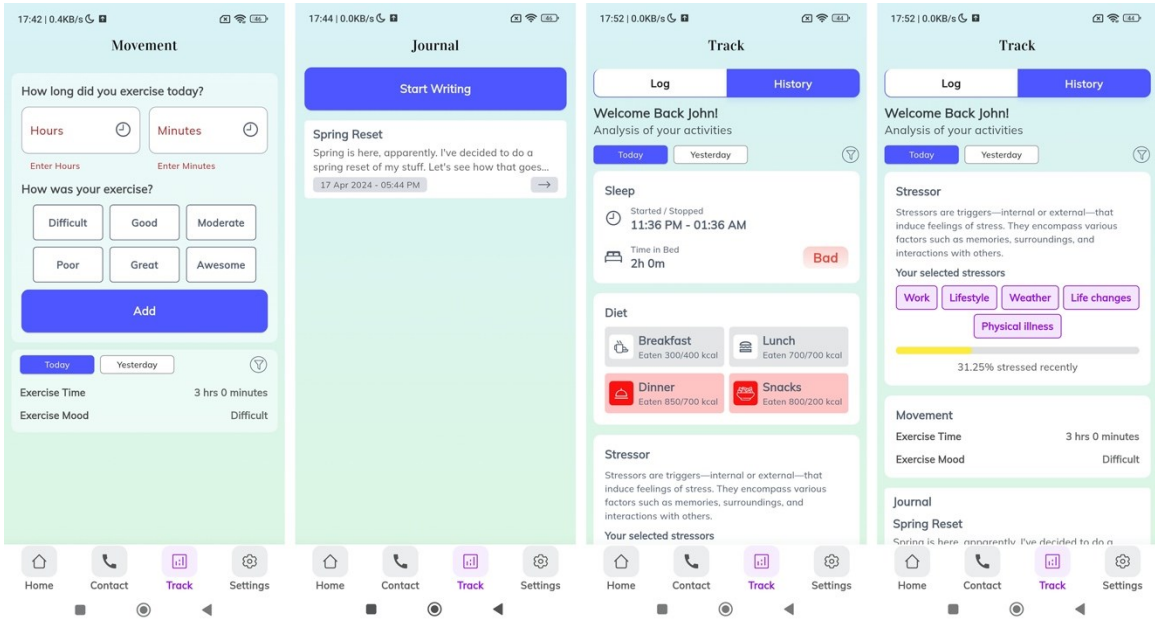


Figure 4.9 Screenshots of LifeLink's final design: Movement, Journal and Track (History)

- **Settings**: Users can 'Edit their Profile', read the 'Privacy Policy', read app information in 'About Us', toggle 'Notifications', change 'Theme mode' to light or dark, 'Delete account' or 'Log Out' (see Figure 4.10). This feature helps caregivers in customizing different aspect of the app.

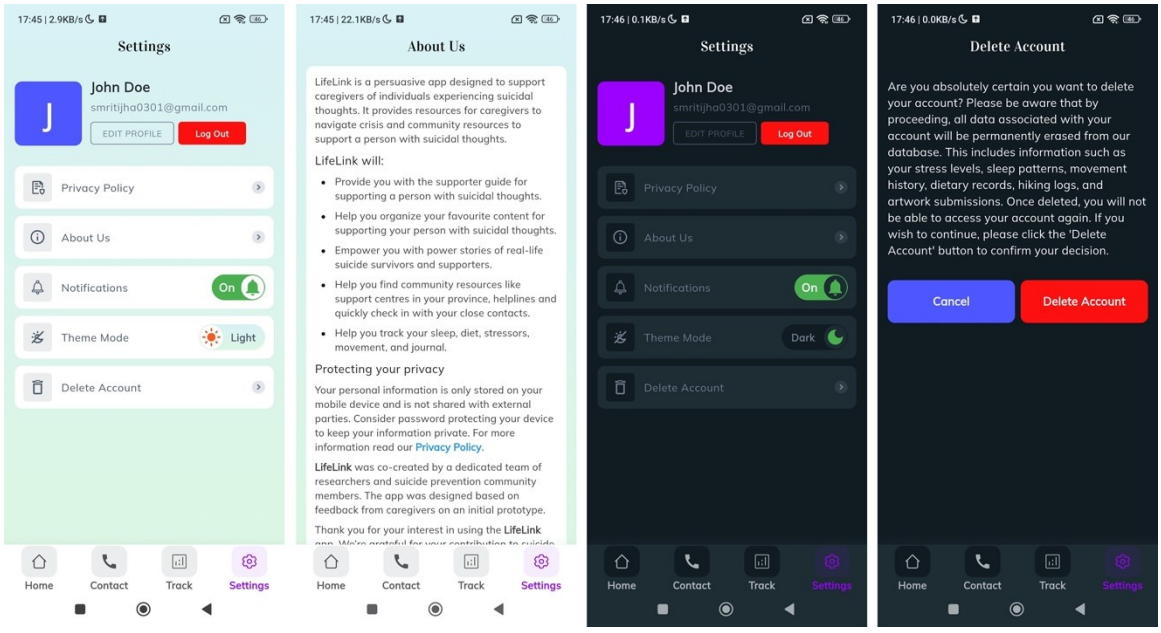


Figure 4.10 Screenshots of LifeLink's final design: Settings, About Us, Dark Theme and Delete Account.

- **Welcome** and **Registration**: Users can sign up or log in to the app. Users can reset their password using the 'Forgot password' option (see Figure 4.11).

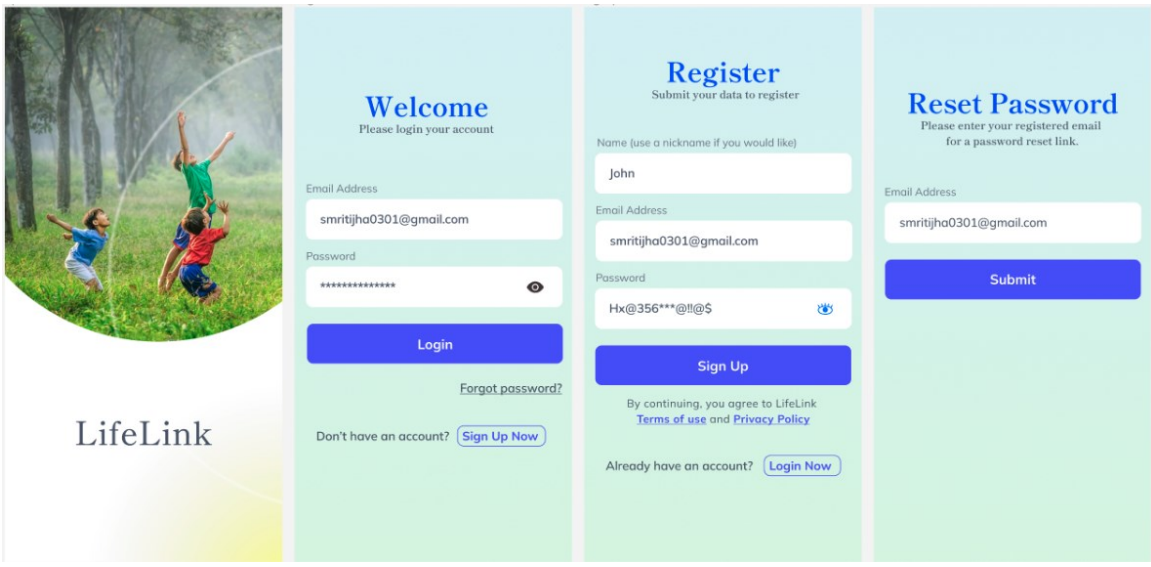

Figure 4.11 Screenshots of LifeLink's final design: Welcome, Register and Reset password.

### 4.1.4 Final design: Persuasive Systems Design

We incorporated the Persuasive Systems Design (PSD) model [71] as our app design's fundamental principle as it is a widely known framework for designing persuasive technologies [16,66]. Findings from our systematic reviews [37,38] and feedback from caregivers on our prototype [36] guided the choice of persuasive strategies that were integrated into the design of LifeLink. Based on the PSD model, the 11 persuasive strategies we implemented were: Tunneling, Personalization, Rehearsal, Reduction, Tailoring, Customization, Simulation, Real-world feel, Verifiability, Self-monitoring, and Liking. The persuasive strategies and their implementations within the app are:

1. **Tunneling:** In the Home feature, users were presented with a guided walkthrough of the app's main features upon signing up. This tutorial guided users through the process of using the app's functionalities (see Figure 4.2).
2. **Personalization:** In the Home feature, the app offered personalized greetings based on the user's time zone (see Figure 4.2). In the History tab with the Track feature, the app displayed a personalized breakdown of the user's logged sleep, diet, stressor, movement and journal entries for their chosen date (with today's data by default) (see Figure 4.9).
3. **Rehearsal:** The app provided users with means for availing suicide prevention support resources using 'Find Nearby Support' within 'Contact'. Users could instantly seek professional help via call or chat by accessing their provincial resources (see Figure 4.7).
4. **Reduction:** In the Supporter guide, information on suicide prevention was broken down into a list of suicide-related topics (see Figure 4.3). Users could search for any topic by typing a keyword into the search bar, thus reducing effort in finding any topic. Within Favourites, different options like Hobbies, Videos, Photos were presented as a list and Hobbies were further categorized into Poetry, Hiking and Artwork for clearer access (see Figure 4.4). In Find Nearby Support, users were presented with support resources by breaking it down into national and provincial resources. Users were allowed to select their province and were successively

presented with a list of available support centres in different regions and their contact information (see Figure 4.7). This made it clear for a user to find resources catered to their context.

5. **Tailoring:** Within Contact, the app provided different 'nearby support centres' information for different user groups based on their province (see Figure 4.7).
6. **Customization:** Users could add their trusted contact within Contact for instant access during a crisis (see Figure 4.7). Users could change the app's theme to dark or light mode based on their visual preference and turn on or off notifications from the app. Users were also provided the option to delete their account if they wished to discontinue using the app (see Figure 4.10).
7. **Simulation:** Videos in Power Stories displayed images of real-life suicide supporters and survivors who shared their stories. Users were shown these video thumbnails with automatic swipes so that they could observe and get inspired by seeing people who overcame the challenges of suicide as both supporters and survivors (see Figure 4.6).
8. **Real-world feel:** About Us within Settings showcased information about the app, and the people behind the app (see Figure 4.10). A privacy policy consisting of the developer's contact information was presented on both the About Us and the Registration page (see Figure 4.11).
9. **Verifiability:** To verify the accuracy of our app's content via outside sources, all topics within the Supporter guide included website links from where the content was sourced (see Figure 4.3). Likewise, Videos and Stories of suicide survivors and supporters within Power Stories included website links or redirected to the website by clicking the thumbnail (see Figure 4.6). Within Contact, both the national helplines and nearby support centre information included website links or redirected directly to the website's chat/support page so that users can verify the credibility of the resources (see Figure 4.7).
10. **Self-monitoring:** Users were able to track their well-being by recording their sleep, diet, movement, stressors and journaling (see Figure 4.8 and Figure 4.9). Users were shown their daily progress within each of sleep, diet, movement, stressors and journal. Within Track, users were also presented with a History of their well-being. This included a snapshot of their progress in sleep, diet, movement, stressors and journal entries on any selected date.
11. **Liking:** Within Favourites, Hobbies included illustrations for each of the Poetry, Artwork and Hiking buttons to make it visually attractive for users (see Figure 4.3). Artwork and Photos included sample images of famous artwork, cute animals and nature to encourage users to add their artwork or photos (see Figure 4.5).

### 4.1.5 Other Design Elements

We wanted to design the app and its logo to evoke a sense of hope, renewal, and faith in life. In line with these themes, we chose a green colour for the app and logo. Green has a strong association with growth, health, and expresses renewal and life [133,134]. It provides a restful and secure feeling which aligns with the app's goals of supporting caregivers of individuals with suicidal thoughts. For the logo icon, we chose leaves as they symbolize growth and fertility [135]. Green leaves have been found to depict hope, renewal, and revival [135] which fits well with our app's overarching goal.

When thinking about the app name, we wanted it to be empowering and positively reinforcing for the user. The app name needed to be engaging and leave a positive impression on the user so that they are motivated to try the app again. We considered a few potential names such as: 'RescYou' and 'LifeSave' before finalizing 'LifeLink', which seemed most encouraging and relevant to our app's goals. For the app's colour scheme, we chose soft shades of blue, green and purple that would be visually calming for caregivers. We also provided users with a 'Dark theme' (a low-light UI that displays mostly dark surfaces) as it would let users customize the app's appearance as per their visual preference. The app's colour scheme was adjusted to display content in contrast with the dark theme background.

To facilitate users in accessing key features of the app, we added a 'Quick Links' button on the 'Home' screen. Users could easily access 'Suicide first aid', and 'Warning signs' from the Quick Links section. As we designed the app for the Android environment, we chose fonts and icons from Google's Material Design 3 guidelines [136], particularly Material Symbol icons [137]. Additionally, we used personalized greetings like 'Good Evening John!' on the welcome and home screens. Sample art pieces within 'Artwork' and sample images within 'Photos' were zoomable with a pinch-to-zoom gesture i.e., the user can zoom in or out by pinching the screen. This ensured that the images were accessible to a diverse set of users. Videos within 'Power Stories' were displayed with automatic swipe gestures so that users would know the different video options available to them and not miss out on any.

We looked at some apps from the health and wellness domain for design inspiration. These were Wellpath [119], DBT Coach [138], Mindfulness Coach [139], Calm [93], Headspace [140], Mindshift CBT [141], Balance [142], Tao [143] and Waking Up [144]. We also took inspiration from a music-playing app – Spotify [145], when designing some components of LifeLink. Spotify and Waking Up are two apps that we have personally used and have observed to be well-designed. When designing LifeLink, we focused on keeping the interface clean, minimalistic and intuitive. This was especially necessary because of the heaviness and sensitivity associated with the area of suicide. We wanted to design for a positive user experience.

## 4.2 App Implementation Process

### 4.2.1 Sourcing content

As we moved towards developing LifeLink, we first created a document to organize and manage all the content of the app. Stock images for splash screen, 'Poetry', 'Artwork' and 'Hiking' cards were taken from online illustration resources [146]. Content for each of the subtopics within 'Supporter Guide' was sourced from various healthcare websites online. It was important for the app's content to be trustworthy and authentic for users hence we first curated a list of potential subtopics and then searched for relevant content. We included URLs of the sources which would be displayed within the app for the user to access the websites directly if they wished to. All images or infographics within the 'Supporter Guide' were also taken from online healthcare resources. Within 'Poetry', we included a few sample poems that were centred around revival, hope and faith. Within 'Artwork', we

included four sample art pieces to give users a starting point for adding their artwork. These sample artworks featured *Van Gogh*, *Virginia Woolfe* and *Avicii* – influential artists from the art, literature and music fields who have died by suicide. These artists' have personally influenced me with their work, and we wanted LifeLink to pay homage to them in some way.

Videos of suicide survivors and supporters within 'Power Stories' were taken from YouTube (including TED talks). These videos were selected such that they had to be relevant and include a diverse array of content. Stories of suicide survivors and supporters within 'Power Stories' were taken from online resources featuring real-life stories of people who survived or supported someone with suicidal thoughts. For 'Find Nearby Support' within 'Contact', we curated a list of national helplines and a list of the nearest support centres for each province in Canada. Next, we included contact information (phone numbers, text lines, availability if specified online, website links) for each of the helplines and support centres. The list of nearest support centres in each province also included the region where the service was available. All the support resources were sourced from online healthcare websites. We tried to incorporate a diverse array of resources that is representative of all kinds of users including 2SLGBTQIA+, Indigenous, Black and other ethnic communities. It must be noted that for some provinces, we found a lot of resources, so we had to limit the content to fit the app layout without appearing too lengthy or boring for the user. For some other provinces, we found more generic resources and fewer resources catered towards specific ethnic groups. In such cases, we incorporated whatever information we could find. For categorizing 'Sleep' within 'Track' as good, moderate or bad, we used the sleep hours recommendation from a renowned researcher working on sleep [147].

### 4.2.2 App Development

To develop LifeLink, we utilized a variety of cutting-edge technologies to create a robust, efficient, and seamless experience. We used Android Studio [148] for the development of the app. The app was built with the Dart programming language and Flutter framework, which provided a rich set of pre-designed widgets, allowing for fast and flexible UI development. Our backend was powered by Firebase [149], utilizing Firebase Auth for secure user authentication, Cloud Firestore [150] for real-time database management, Crashlytics for monitoring and resolving app crashes, and Firebase Storage for handling user-generated content. Additionally, we utilized Flutter Animation to create smooth, visually appealing transitions and animations, enhancing the overall user experience.

In Canada, the two most popular operating systems for smartphones are Apple's iOS and Google's Android, which have a market share of 99% [151]. For the development of LifeLink, we chose to build an Android app over an iOS app because of the flexibility and customization capabilities of Android platform which allowed us to tailor the app to meet specific user needs effectively. These capabilities include a flexible development environment - which gives developers greater freedom to access and modify system-level components, enhancing the app's capabilities and performance. Furthermore, Android platform allowed for direct APK file distribution to users, facilitating easier beta testing and distribution in specific scenarios. While Apple holds a significant market share in Canada (58.85%) [151], [151], Android still commands a substantial portion (40.65%)

[151], ensuring we have access to a broad and diverse user base. It must be noted that the abovementioned market share figures were the most up-to-date figures available at the time of app development.

### 4.2.3 Pilot-testing

After developing LifeLink, we conducted a pilot test with nine users (researchers and UX designers) to ensure the app's functionality, usability, and overall user experience met our standards before a full-scale launch. The users (mean age 26) were recruited from Dalhousie University by word-of-mouth. This pilot test allowed us to gather valuable feedback in a controlled setting, identifying any issues or areas for improvement early on. We provided users with access to the app along with instructions on its features and intended use. Throughout the testing period, we closely monitored their interactions with the app, collected feedback through a survey, and analyzed the data to understand their behaviour and pain points. Our findings from the pilot test revealed a few minor bugs and usability enhancements. These included: fixing deletion of journal entries, enhancing the heading colour of all pages to improve readability, enhancing the image resolution of infographics within Supporter guide for easy reading and improving the text within About Us to convey more information to users. We addressed these bugs to refine the app further before its public release.

### 4.2.4 Final app launch

Following the pilot test, we launched the public APK of LifeLink. This final release incorporated all the feedback and improvements identified during the pilot phase, ensuring a more polished design and user-friendly experience. This broader release allowed us to gather even more extensive user feedback and continue refining the app.

The LifeLink app addresses the identified five gaps in existing suicide prevention apps, in the following way:

1. The app is focused on caregivers of individuals experiencing suicidal thoughts. We involved target users (i.e., caregivers) in the app design process by conducting a user study with them.
2. The app leverages persuasive strategies [37] for suicide prevention.
3. The app includes evidence-based sources including hyperlinks to webpages.
4. We focused on evaluating the app's user experience (UX) by conducting a study. This study is detailed in the next chapter.
5. We designed the app with a focus on enhancing user engagement and got feedback on initial prototype of the app.

In the next chapter we will look at the evaluation process of the LifeLink app and results from the app evaluation.

# Chapter 5 – LifeLink App Evaluation

This chapter presents the methodology we adopted for evaluating the LifeLink app. The evaluation aimed to assess the app's usability, engagement, user experience, and perceived persuasiveness for caregivers of individuals experiencing suicidal thoughts. As discussed in Chapter 3 and 4, we utilized a user-centered design approach [65] and persuasive design principles [71] to design and evaluate LifeLink. We conducted two full user studies to evaluate our app prototype and the final version of a fully developed app.

## 5.1 Research Objectives

Based on the RQs, we formulated the following research objectives (RO) for this thesis are as follows:

- **RO1:** To identify and analyze the limitations of existing mobile apps for suicide prevention.
- **RO2:** To understand the perspectives, needs, concerns, and challenges of caregivers supporting individuals experiencing suicidal thoughts. To collect opinions and attitudes toward the LifeLink app prototype for supporting caregivers of individuals experiencing suicidal thoughts.
- **RO3:** To evaluate and prioritize persuasive strategies that are most useful in designing mobile apps for suicide prevention.
- **RO4:** To develop the LifeLink mobile app that addresses the identified needs of caregivers, incorporating evidence-based strategies and user-centered design principles. To assess the usability of the LifeLink app.
- **RO5:** To analyze user engagement with the LifeLink app.
- **RO6:** To evaluate the overall user experience of caregivers with the LifeLink app
- **RO7:** To evaluate the effectiveness of the persuasive strategies within the LifeLink app in influencing caregiver behaviors and attitudes toward supporting individuals experiencing suicidal thoughts.

Table 5.1 summarizes the RQs, ROs, what they measured, and the instruments or procedures used.

Table 5.1 Research questions, objectives and their corresponding measures, instruments/procedures.

| Research Questions | Research Objectives | Measures | Instruments / Procedures |
|---|---|---|---|
| RQ1 | RO1 | Limitations of existing mobile apps for suicide prevention. | App review of 80 existing suicide prevention apps. |
| RQ2 | RO2 | Perspectives, needs, concerns, and challenges of caregivers supporting individuals experiencing suicidal thoughts. Opinions and | Prototype evaluation (Study one) via a survey with 45 caregivers and a semi-structured interview with 14 caregivers living in Canada. |

| Research Questions | Research Objectives | Measures | Instruments / Procedures |
|---|---|---|---|
| | | attitudes toward the LifeLink app prototype for caregivers. | Perceived Usefulness Scale, Simplicity Scale. Adapted versions of SUS, Mobile app rating scale (MARS), User engagement scale short form (UES-SF). Optional semi-structured interview. |
| RQ3 | RO3 | Persuasive strategies that are most useful in designing mobile apps for suicide prevention. | App review of 80 existing suicide prevention apps evaluating persuasive strategy implementations. Prototype evaluation (Study one) via a survey with 45 caregivers and a semi-structured interview with 14 caregivers living in Canada.<br><br>Perceived Persuasiveness Questionnaire (PPQ) |
| RQ4 | RO4 | Usability of the LifeLink app. | LifeLink app evaluation (Study two) via a pre-test, post-test survey with 50 caregivers and a semi-structured interview with 20 caregivers living in Canada.<br><br>SUS |
| RQ5 | RO5 | User engagement with the LifeLink app. | UES-SF |
| RQ6 | RO6 | Ability of the LifeLink app to generate a positive experience for caregivers. | User experience questionnaire short (UEQ-S), IMI-Value Usefulness Subscale, Simplicity Scale, Perceived Usefulness Scale. Wellbeing (SWEMWBS) Scale for pre-test and post-test. Optional semi-structured interview. |
| RQ7 | RO7 | Effectiveness of the persuasive strategies within the LifeLink app in influencing caregiver behaviors and attitudes toward supporting individuals | PPQ |

| Research Questions | Research Objectives | Measures | Instruments / Procedures |
|---|---|---|---|
| | | experiencing suicidal thoughts. | |

## 5.2 Study Design Overview

The entirety of the study was conducted in three phases. The user-centered design approach of the study necessitates the involvement of target users in the development of the app. Engaging the user in the design process will ensure that the needs of caregivers dealing with suicidality are reflected in the app. The user-centric design methodology increases the quality of content, interface design and usability of mHealth applications. Based on our RQs, the three phases we defined are as follows:

- **Phase 1:** Literature review identifying risk factors that are most strongly associated with suicide and considerations for developing suicide prevention technologies [37]. App review of 80 existing mobile apps for suicide prevention [38].
- **Phase 2:** Development of the app prototype. Prototype evaluation study with end users via a survey and interview.
- **Phase 3:** App development. Pilot test with designers. App evaluation study via a pre-test survey, one week of app usage, a post-test survey and an interview.

Figure 5.1 presents an overview of the study design.

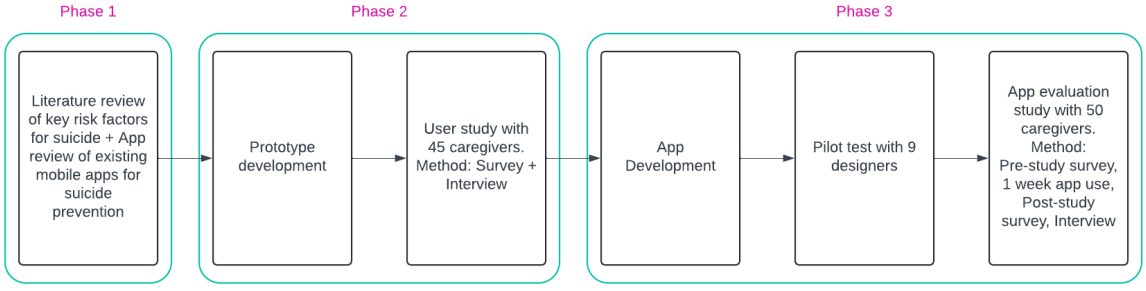


Figure 5.1: Study progression over three phases.

## 5.3 LifeLink App Evaluation: Methodology

The aim of study two was to assess the usability, user engagement, overall user experience and persuasiveness of the LifeLink app with caregivers of individuals experiencing suicidal thoughts. Study Two was informed by results from Study One. Similar to Study One, a mixed-methods research approach was employed to collect and analyze quantitative and qualitative data. We intended to capture caregivers' subjective experiences with the app and the reasoning behind these experiences. We wanted to collect their experiences in terms of usability, user engagement and overall user experience. We also wanted to collect caregivers' opinions, perspectives, and attitudes on the app for suicide prevention and for supporting those dealing with suicidal thoughts. Finally, we wanted to evaluate participants' perceived persuasiveness of the implemented strategies for influencing caregiver behaviours toward supporting someone with suicidal thoughts. To answer RQ4, RQ5, RQ6, and RQ7, we developed the LifeLink app implementing 11 persuasive

strategies. We then evaluated the app by conducting a pre-test, post-test survey with 50 participants and an optional semi-structured interview involving 20 participants. The interview was aimed at understanding participants' perceptions and feedback about the usability, engagement, overall user experience and perceived persuasiveness of the app.

### 5.3.1 Participants

Similar to Study One, caregivers of individuals experiencing suicidal thoughts were considered for the evaluation of the app. To participate in this research, participants had to be 16 years of age or older, live in Canada, be proficient in English, own an Android device and have supported or are supporting an individual experiencing suicidal thoughts. We targeted this age group to ensure diverse voices inform the development of the app. We recruited young adults and adults residing in Canada. To ensure that the app was used only by caregivers, we had a screener question in the pre-test survey which explicitly asked if the participant is a caregiver to another individual experiencing suicidal thoughts.

We received 247 responses to our pre-test survey (Appendix L), out of which 74 were valid. The pre-test survey consisted of the consent form (Appendix K), information about the study, questions about participants' demographics, familiarity with using a smartphone, and their feelings and thoughts in the past week. Out of these 74 valid pre-test survey responses we received, 63 were complete (i.e., they answered all questions and passed the attention-check test). Out of these 63 complete pre-test respondents, 50 completed the post-test survey. Thus, the final pool consisted of 50 participants for the online survey and 20 participants for the post-survey (optional) interview. The quantitative study collected data about participants' well-being, their experiences with using a smartphone, and interacting with the LifeLink app while the interview captured more in-depth qualitative data. Participants were predominantly single (68%), having a high school degree or above (98%), employed (95%), and living in a city (76%) in an apartment or a house that they owned or rented (90%). All participants had supported one or more individuals experiencing suicidal thoughts.

The sample size (50 participants for the survey and 20 participants for the interview) was informed by relevant literature on evaluating mobile-based interventions for suicide prevention, which recruited 18 [70], 6 [87], 14 [62], 20 [57], 37 [99], and 21 [83] participants for the online survey. The interview sample size was determined a priori and based on previous studies where they interviewed 18 [70], 16 [25] and 6 [87] participants. We believe that a sample of 50 participants is adequate for us to evaluate users' perspectives on a suicide prevention app considering the number of features we were investigating. This is supported by previous research suggesting that approximately 40 participants are an appropriate number for most quantitative usability studies [97].

### 5.3.2 Recruitment

We advertised and recruited participants through our partnership, professional network via email, local mailing lists, word of mouth, sharing circles, snowball sampling and social media. We engaged in digital outreach on social media platforms such as LinkedIn, Facebook, Twitter, Instagram, Reddit, and WhatsApp groups to share our recruitment notice (Appendix I). The recruitment poster can be found in Appendix J. As discussed in

Section 4.3.2, we partnered with Roots of Hope (a NS Health initiative working to help build capacity against suicide) [120] to support us with recruitment via their online and offline channels. We conducted an online seminar [158] in collaboration with Roots of Hope NS to talk about this research study, create awareness among local communities and familiarise more people about . The recruitment and study phase lasted from April 10, 2024 to June 21, 2024, with participants joining the study at different times. In the recruitment notice, participants were asked to indicate their interest by emailing the researcher. The researcher then contacted respondents to complete the consent form, pre-test, post-test survey, and arrange a subsequent (optional) interview. To show our appreciation for the participants' time, their emails were added to a lucky draw and 5 random email addresses were selected to win a $50.00 Amazon Gift Card each.

### 5.3.3 Study Design, Tasks and Procedure

The study consisted of four phases: (1) a pre-test survey, (2) one week of app use, (3) a post-test survey, and (4) a semi-structured interview. An overview of the study procedure is shown in Figure 5.2. Participants were provided with a detailed description and guidelines of our study, and it was mandatory to give informed consent before proceeding to the pre-test survey. Both the survey and interview questions were designed to address RQ4, RQ5, RQ6, and RQ7 (i.e., to understand participants' perceptions and feedback about the usability, engagement, overall user experience and perceived persuasiveness of the app).

When participants expressed interest to the researcher over email, they were provided with a pre-test survey link via email. The pre-test survey (Appendix L) was hosted on Dal Opinio [127] wherein they read the consent form (Appendix K) containing information about the study. If participants consented, they could proceed with the survey which included a Demographic questionnaire (Appendix L1), the IT Familiarity questionnaire (Appendix L2), and the Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (Appendix L3). The pre-test survey consisted of nine questions about participants' demographics, one question about their most frequently used smartphone function, seven questions about their familiarity with using a smartphone, seven questions about their feelings and thoughts in the past week, and two attention-check questions to filter random respondents [55].

After completing the pre-test survey, participants were provided with a link to the LifeLink app, instructions to install the application and how to use the app. After 4 days of signing into the app, participants were sent a follow-up email checking in to ensure that the app was properly set up on their device and to remind them to keep using the app. Participants used the app for a week. At the end of one week, participants received an email advising that the testing period was over and containing a link to the post-test survey (Appendix M). Participants filled out the post-test survey which consisted of the User Engagement Scale short form (Appendix M1), System Usability Scale (SUS) questionnaire (Appendix M2), Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) (Appendix L3), User Experience Questionnaire short (Appendix M4), IMI value usefulness subscale (Appendix M5), Simplicity scale (Appendix M7), Perceived Usefulness Scale (Appendix M6), and the Perceived Persuasiveness questionnaire (Appendix M8) for various features of the app.

The post-test survey consisted of seven questions about participants' feelings and thoughts in the past week, nine questions about the user experience of the app, seven questions about their engagement with the app, eight questions about the simplicity of the app, nine questions about the usability of the app, one question about their frequency of use of the app during the testing period, 10 questions about the value or perceived usefulness of the app, 35 questions about the app's perceived persuasiveness, one question for any additional feedback on the app and three attention-check questions to filter random respondents [55] At the end of the post-test survey, participants were asked if they were willing to participate in the optional one-on-one interview. If the participant opted to participate in the optional interview, a suitable time was determined via email, an interview was scheduled, and an invite link was shared via email. The interview was conducted online using Microsoft Teams, and interview transcripts were audio-recorded for analysis. The interview was conducted by asking 12 questions (Appendix N) related to participants' experience with the app in terms of usefulness, perceived persuasiveness, overall user experience, engagement, effect on their well-being, intention to use and recommendations for improving the app. After completion of the study, participants were sent a debriefing email which included support resources, if needed.

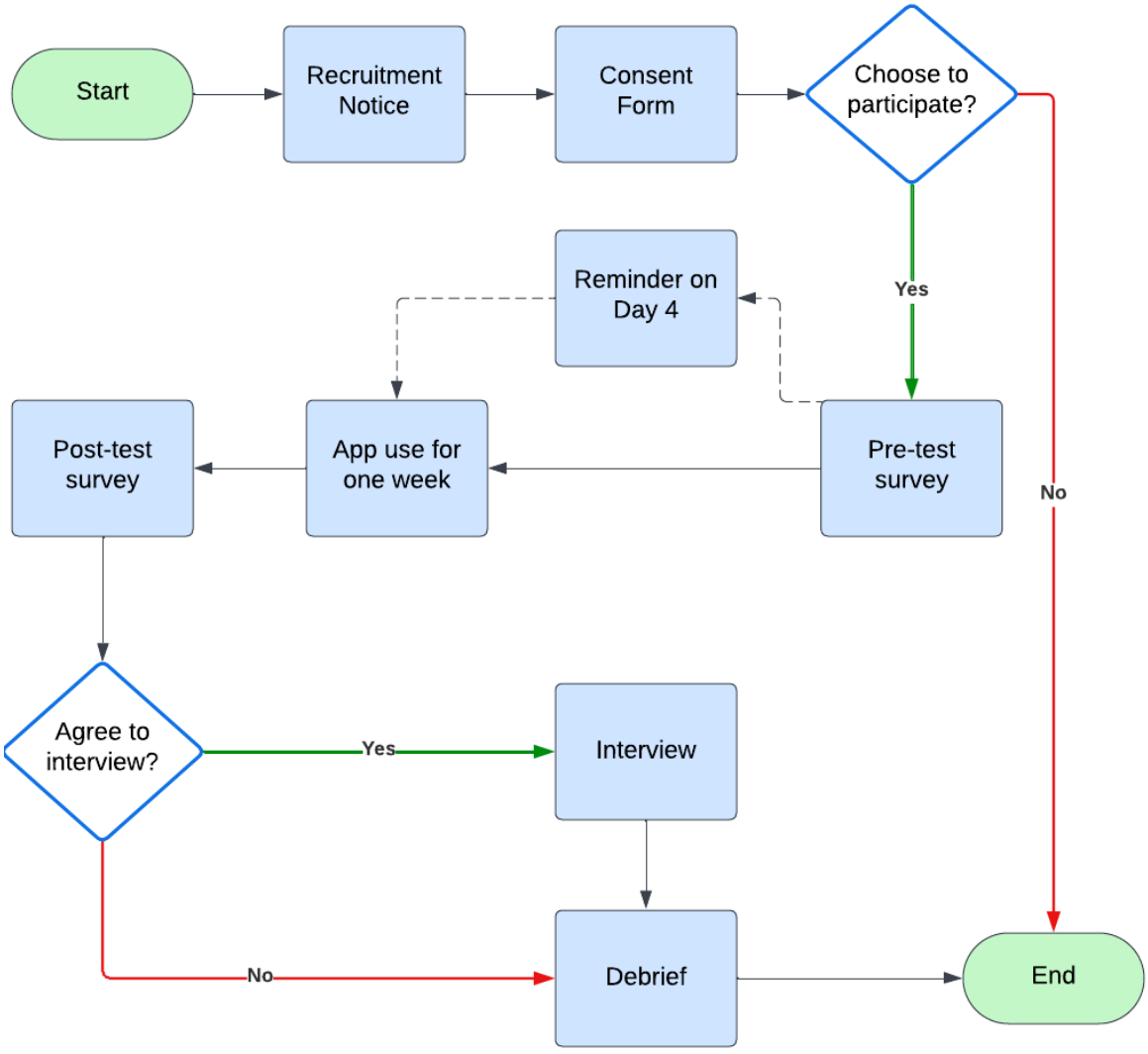


Figure 5.2: Flow chart showing study two procedure

### 5.3.4 Measurement Instruments

An adapted version of the System Usability Scale (SUS) [154] was used to evaluate the usability of LifeLink. The adapted version of SUS (a 9-item questionnaire) used in this study included appropriate modifications and questions relevant to evaluating the usability and utility of LifeLink. Additionally, the IT Familiarity questionnaire [46], Perceived Usefulness scale [22], Perceived Persuasiveness Questionnaire (PPQ) [24], Simplicity scale [19], Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) [153], UEQ-S [159], IMI value usefulness subscale [94], UES-SF [67] were used for the survey.

The Information Technology (IT) Familiarity Questionnaire [46] was utilized to evaluate the participants' familiarity with smartphones and consisted of eight questions on frequency of use of IT which participants rated using a Likert scale (1= daily use to 3= never used). The total score was the average of the scores of the eight questions. It included questions such as "I use my smartphone to obtain information on a wide range of topics". The Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) [153] was used to comprehensively measure mental wellbeing. The SWEMWBS uses 7 items about thoughts and feelings of respondents in the past week(s), such as ''I've been feeling relaxed'', measured on a five-point Likert scale from 1 (none of the time) to 5 (all of the time). The SWEMWBS is scored by first summing the scores for each of the seven items, which are scored from 1 to 5. The total raw scores are then transformed into metric scores and final scores range from 7 to 35. Higher scores signify better wellbeing. User experience was evaluated using the User Experience Questionnaire Short (UEQ-S) [159], a 7-point semantic differential scale [-3 = most negative anchor value (horribly bad) to +3 = most positive anchor value (extremely good or excellent)]. Value/usefulness was measured by the IMI [93] The IMI is a multidimensional instrument designed to evaluate participant subjective experience related to a target activity using a 7-point Likert scale (1 = not at all true to 7 = very true). It consists of various subscales including the value/usefulness subscale which was used in our study. The subscale consisted of questions like "I think the LifeLink app is useful for supporting caregivers of individuals experiencing suicidal thoughts".

### 5.3.5 Ethical Considerations

All participants were required to sign a consent form (Appendix E and K) before starting the survey in both studies one and two. It was made clear that participants are voluntarily engaging in the study and are free to discontinue at any time. Interview participants were also required to provide their consent, for recording audio and transcribing the interviews for data analysis. The researcher reviewed the consent form briefly before beginning each interview. The data collected from the study was de-identified, and stored in a secured device, which only the researcher could access. Considering the sensitivity of the topic, confidentiality of participants' data was given the utmost priority.

To support participants who may be potentially triggered when responding to the survey or interview questions, some additional measures were taken. We provided participants with a list of support resources available at the beginning of the survey (Appendix G and L) and interview (Appendix H and N). These resources included suicide hotlines for adults [160], young adults [161], and support service directory [162]. Additionally, with assistance from

Roots of Hope NS [120], a suicide first-aid trained facilitator was made available for supporting triggered participants. The facilitator was a certified safeTALK [163] and ASIST [164] trainer, with knowledge and skills to provide suicide intervention and to navigate people to appropriate supports. We added this information in our consent form (Appendix E, F and K) and at the beginning of the survey and interview along with our existing resources.

Before the survey and interviews, participants were reiterated the information about available support resources. Finally, the interviewer was safeTALK [163] certified, which is a suicide response training offered by the Canadian Mental Health Association [165] and developed by LivingWorks Canada [166]. The training equipped the interviewer with skills to respond to triggered participants. Both the studies were approved by the Dalhousie University Institutional Ethics Review Board (2023-6824 and 2024-7043) (Appendix O) before the commencement of evaluation.

### 5.3.6 Data Analysis

We analyzed participants' quantitative and qualitative data to address our research questions RQ2 through RQ7. All analyses were performed by one researcher. To analyze quantitative data from the surveys, we employed exploratory statistical analysis to find trends and outliers that can help gain insights from the data. Prior to computation of statistics, a number of validity checks were performed to ensure quality of data. These included removing responses to attention check questions, filtering out responses based on attention check questions, checking for outliers, checking for missing values and flipping the reverse coded questions. All collected data was then analyzed and plots were generated using Microsoft Excel [167], SPSS software [168] and Python programming language [169]. Using validated scales, we evaluated the user experience, well-being, simplicity, usability, perceived persuasiveness, and engagement. We used Microsoft Excel to visualize the data in plots and to get further insights. We utilized Python, particularly its Plotly [170] package, to create data visualizations that complemented other statistical findings.

Statistical analysis techniques (like one-sample t-test, descriptive statistics, Cronbach's alpha test, Shapiro-Wilk test, and Wilcoxon-signed rank test) were used to quantify insights from the data. All analyses were conducted with a significance level of 0.05. We created frequency distribution graphs to visualize participants' evaluation of the app's simplicity, engagement, user experience, and perceived persuasiveness. Bar plots were generated to visualize other data e.g., participants' frequency of mobile use for suicide-related concerns. Stacked bar charts were created for capturing insights from specific questions e.g., likelihood of using a mobile app designed to help support someone experiencing suicidal thoughts. Box plots were created to visualize changes in well-being before and after using the app.

For the qualitative interview data, we made observational notes and audio-recorded the interview sessions. All recorded interviews were transcribed for performing an inductive thematic analysis [11]. The data was then analyzed using ATLAS.ti [171], a qualitative data analysis software. We followed the six-phase framework by Braun and Clarke [11] for conducting the thematic analysis. To begin, all interview data was collated, read, and re-read to familiarize ourselves with the contents of the data. This was followed by

systematically coding any interesting remarks that seemed relevant to our RQs. Together with their attached data, similar codes were clustered together to identify a central organising concept that could give rise to a potential theme. As the themes evolved, they were repeatedly checked against the data set to ensure they continued to tell a coherent story of the data.

Finally, an analysis of each theme was developed and connected with selected extracts to form an analytic narrative of our participants' experiences. The extracts are presented as is without any spelling or grammatical corrections. We generated sub-themes, jointly and iteratively categorized them into major themes. Themes were visualized using Figma [131]. This qualitative analysis helped us gain a better understanding of participants' experiences and obtain richer feedback about the app.

## 5.4 Results

We analyzed both quantitative and qualitative data to answer our research questions. For both our evaluation studies, we present participants' demographic information, results from quantitative (survey) and qualitative (interview) data analysis. The reliability analysis showed that all scales demonstrated good internal consistency, with Cronbach's alpha (α) [172] values above the recommended threshold of 0.7 (Table 5.2).

Table 5.2: Cronbach's alpha for all scales used in this study.

| **Scale** | **Cronbach's alpha ($\alpha$)** |
|---|---|
| User Experience Questionnaire | 0.89 |
| IT Familiarity Questionnaire | 0.79 |
| User Engagement Scale | 0.84 |
| Mental Wellbeing Scale | 0.93 |
| Perceived Persuasiveness Questionnaire | 0.97 |
| (Intrinsic Motivation Inventory) Value-Usefulness Subscale | 0.90 |
| Simplicity Scale | 0.80 |
| System Usability Scale | 0.88 |
| Perceived Usefulness Scale | 0.83 |

### 5.4.1 Participant Demographics

A total of 50 youths and adults participated in this study. Participants' demographic information is shown in Table 5.3. About two-thirds ($n$ = 33, 66%) of the participants were aged 19-35 and just 2% ($n$ = 1) were aged above 56 years. Participants' age distribution is displayed in Figure 5.3. In terms of gender identity, 46% ($N$ = 23) of the participants were Cis women, 38% ($n$ = 19) were cis men, 6% ($n$ = 3) were non-binary, 2% ($n$ = 1) were trans woman, agender and gender non-conforming each. The gender identity distribution is shown in Figure 5.4. Most participants were single ($n$ = 34, 68%). Our participants were ethnically diverse, primarily Black ($n$ = 21, 37%) and White ($n$ = 18, 32%), with smaller

representations of Asian and Middle Eastern communities ($n$ = 1, 2% each). Most participants ($n$ = 37, 74%) had either a bachelor's degree, master's degree or PhD. The education distribution of participants is displayed in Figure 5.5.

Most participants lived in a city ($n$ = 38, 76%) in an apartment or house they owned or rented ($n$ = 45, 90%). Few participants reported having no fixed address or living at a friend's house/couch surfing ($n$ = 1, 2% each). About half of the participants ($n$ = 27, 54%) were from Nova Scotia, while others hailed from various Canadian provinces, including Ontario, British Columbia, Manitoba, New Brunswick, Alberta, and the Northwest Territories. Participants were predominantly working either full-time or part-time ($n$ = 36, 70%) as displayed in the employment distribution (Figure 5.6). We asked participants about their most frequently used smartphone function and found that social media was overwhelmingly the most used function ($n$ = 43, 86%). This was followed by a mix of educational, entertainment, tools/productivity, gaming, and lifestyle purposes. Figure 5.7 illustrates the most frequently used smartphone functions among users.

To evaluate participants' familiarity with information technology (IT), particularly, with using a smartphone, we utilized the IT Familiarity Questionnaire [26]. The scale consisted of eight questions on frequency of use of IT which participants rated using a Likert scale (1 = daily use to 3 = never used). One question was dropped as it was not relevant to our ROs. The total score was the average of the scores of the seven questions. We found that the median score for IT Familiarity was 1.00. The range of the scores was 1.00 – 2.14, as per the Likert scale [1 = Daily use for this activity, 2 = Seldom use for this activity, 3 = Never use for this activity]. 81% ($n$ = 40) of the participants reported using a smartphone daily, 16% ($n$ = 8) used it seldom and 3% ($n$ = 2) reported never using a smartphone. 97% ($n$ = 48) of participants had a daily to seldom use of smartphones for social media, education, entertainment, productivity, games or lifestyle purposes. In conclusion, majority of the participants were familiar with using a smartphone.

Table 5.3 Demographic breakdown of participant characteristics ($N$ = 50).

| **Characteristics** | **Frequency (%)** |
|---|---|
| Age | 16-18: 6%, 19-25: 28%, 26-35: 38%, 36-45: 18%, 46-55: 6%, over 56: 2%, Prefer not to say: 2% |
| Gender Identity | Cis man: 38%, Cis woman: 46%, Trans woman: 2%, Non-binary: 6%, Agender: 2%, Gender non-conforming: 2%, Prefer not to say: 4% |
| Marital status | Single: 68%, Married: 20%, Separated: 4%, Divorced: 4%, Common Law: 2%, Prefer not to say: 2% |
| Ethnicity | White: 32%, South Asian: 18%, Black: 37%, Asian: 2%, Middle Eastern: 2%, Mixed-race: 7%, Indigenous: 4% |
| Education level | Less than high school: 2%, High school: 12%, College diploma: 12%, Bachelor's degree: 30%, Master's degree or PhD: 44% |
| Type of locale | City: 76%, Rural area: 14%, Town: 8%, Prefer not to say: 2% |
| Employment | Full-time work: 43%, Part-time work: 27%, Student: 21%, Own business: 3%, Casual work: 1%, Home duties: 4%, Not working: 1% |

| Characteristics | Frequency (%) |
|---|---|
| Province | Nova Scotia: 54%, Ontario: 26%, British Columbia: 6%, Manitoba: 2%, New Brunswick: 4%, Northwest Territories: 2%, Alberta: 6% |
| Housing | Apartment/house owned or rented: 90%, Relative's house: 6%, No fixed address: 2%, Friend's house/couch surfing: 2% |

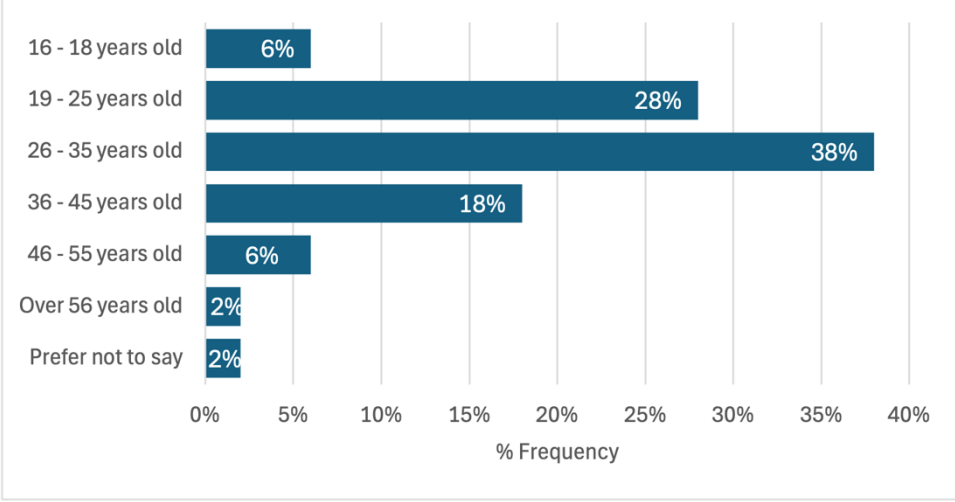


Figure 5.3: Age distribution of participants ($N = 50$).

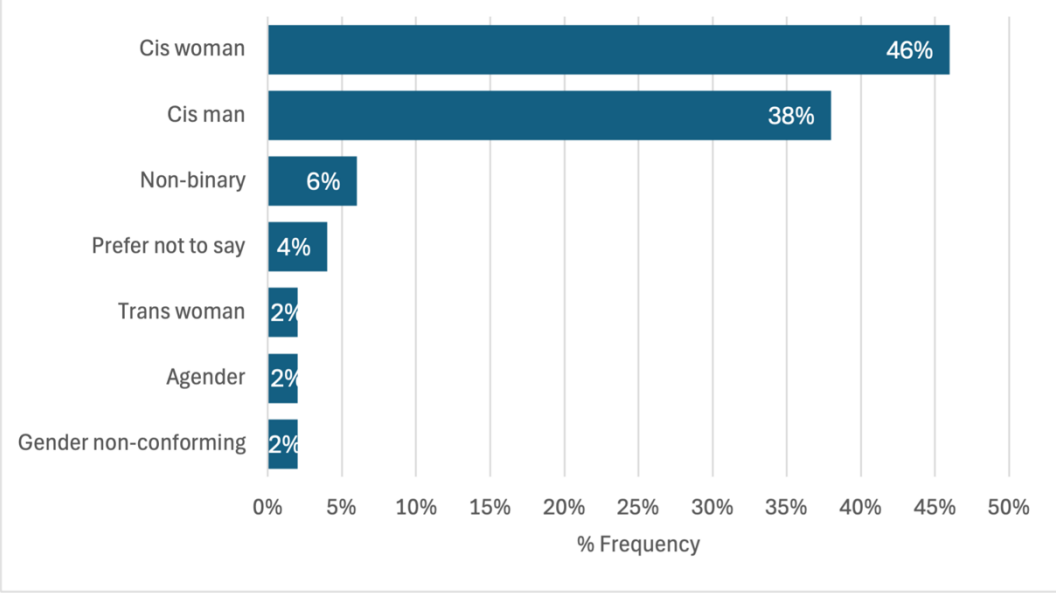


Figure 5.4: Gender identity distribution of participants ($N = 50$).

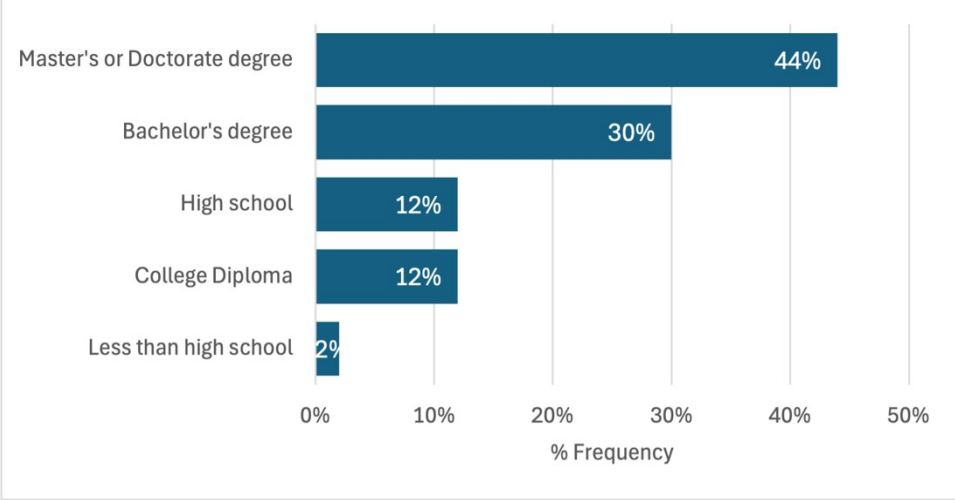


Figure 5.5: Distribution of participants by education level completed ($N = 50$).

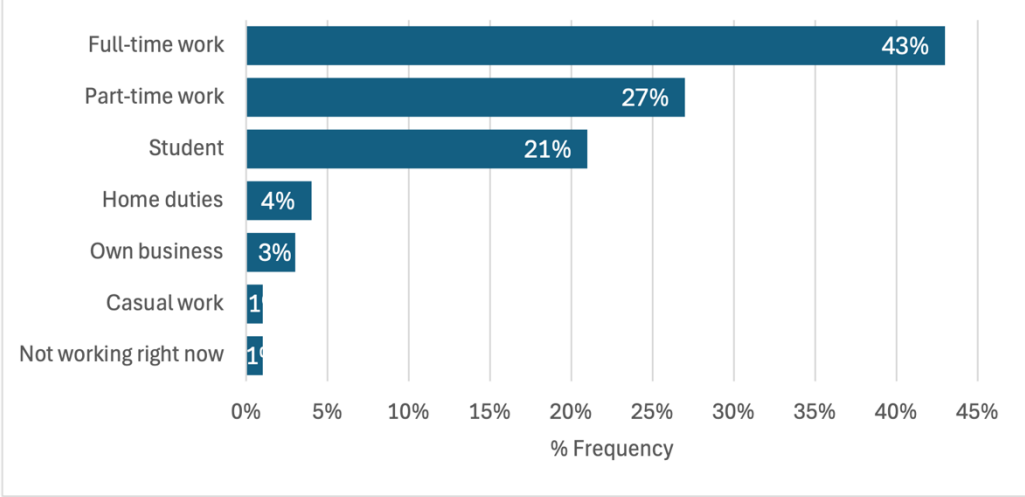


Figure 5.6: Employment distribution of participants ($N = 50$).

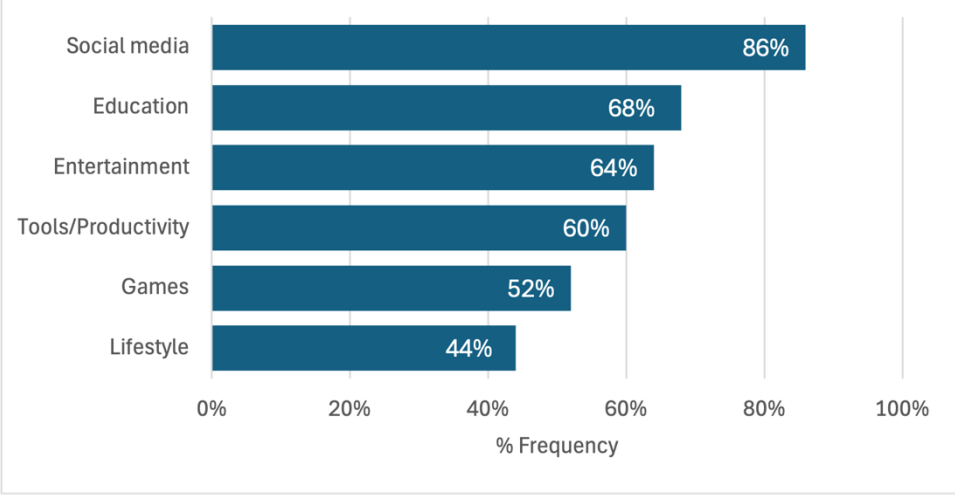


Figure 5.7: Distribution of participants based on their most used smartphone function ($N = 50$).

### 5.4.2 Quantitative Results

#### 5.4.2.1 System Usability

To answer our **RQ4,** "*How usable is the LifeLink application?*", we computed the SUS scores, which provide a high-level view of the app's usability. The SUS revealed an average score of 72.08 (*SD* = 18.32), indicating that the overall usability of our app is "above average" [173]. A one-sample t-test was performed to compare mean usability scores against a midpoint of 3 to further analyze the data (Table 5.4). The results indicate that there is a statistically significant difference in users' SUS ratings when compared to the midpoint of 3 (*M* = 3.70, *SD* = 0.98) suggesting a significant difference from the midpoint; ($t(49) = 5.05$, $p = 0.001$ (Table 5.4). Table 5.4 displays the mean, median and standard deviation for the SUS scores alongside the one-sample t-test statistics.

Table 5.4 Mean scores for SUS scale. The *t* standard score and *p* values indicate how significant the mean score is compared with neutral score of 50.

| *N* = 50 | **Descriptive statistics** | | | **One-sample t-test** | | |
|---|---|---|---|---|---|---|
| **Scale** | ***M*** | ***SD*** | ***t*** | ***df*** | ***p*** | **Cohen's *d*** |
| System usability scale | 72.08 | 18.32 | 26.67 | 49 | .001 | 18.31 |

#### 5.4.2.2 User Engagement

We analyzed user engagement across five dimensions (focused attention, aesthetic appeal, reward, perceived usability, and overall engagement). We examined these dimensions to answer **RQ5**, "*How engaging is the LifeLink application for supporting caregivers of individuals experiencing suicidal thoughts?*". We used the User Engagement Scale questionnaire, scored on a five-point Likert scale (1 = strongly disagree, 5 = completely agree). The subscales we considered were: Focused Attention (to what extent the app is able to receive focused attention by users), Perceived Usability (the usability of the app as perceived by the user), Aesthetic appeal (to what extent the app is aesthetically attractive), reward (to what extent the user experience of interacting with the app is rewarding for the user). We computed descriptive statistics and one-sample t-test statistics for each of the dimensions of user engagement. Among all dimensions, participants reported the highest mean ratings for aesthetic appeal (*M* = 3.90, *SD* = 0.84) compared to the midpoint of 3, followed closely by reward (*M* = 3.89, *SD* = 0.88). Perceptions of usability revealed above-average mean ratings (*M* = 3.70, *SD* = 0.98) alongside the dimension of focussed attention (*M* = 3.54, *SD* = 1.01). Finally, participants rated their overall engagement as above average (*M* = 3.79, *SD* = 0.73). In brief, all dimensions' mean ratings were higher than the mid-point of 3 and all findings were found to be statistically significant with $p = 0.001$. Figure 5.8 and Table 5.5 both summarize the results. Additionally, we asked the participants to report their frequency of using the LifeLink app. We found that the majority of users engaged with the LifeLink app regularly, with over half (56%) using it multiple times per week or daily. Figure 5.9 illustrates the frequency of LifeLink app usage among participants.

Table 5.5 Descriptive statistics and results of one-sample t-test for engagement, simplicity and intention to use LifeLink.

| *N* = 50, Mid-point = 3 | | **Descriptive statistics** | | | **One-sample t-test** | | | |
|---|---|---|---|---|---|---|---|---|
| **Measure** | **Dimensions** | ***M*** | **Median** | ***SD*** | ***t*** | ***df*** | ***p*** | **Cohen's *d*** |
| Engagement | Focused attention | 3.54 | 4.00 | 1.01 | 3.76 | 49 | .001 | 1.014 |
| | Aesthetic appeal | 3.90 | 4.00 | 0.84 | 7.58 | 49 | .001 | 0.839 |
| | Reward | 3.89 | 4.00 | 0.88 | 7.18 | 49 | .001 | 0.877 |
| | Perceived usability | 3.70 | 4.00 | 0.98 | 5.05 | 49 | .001 | 0.979 |
| | Overall engagement | 3.79 | 3.93 | 0.73 | 7.66 | 49 | .001 | 0.728 |
| Simplicity | Organization | 3.88 | 4.00 | 1.08 | 5.76 | 49 | .001 | 1.081 |
| | Component complexity | 3.54 | 4.00 | 1.18 | 3.23 | 49 | .002 | 1.182 |
| | Aesthetic simplicity | 3.93 | 4.00 | 0.77 | 8.53 | 49 | .001 | 0.774 |
| | Satisfaction | 3.62 | 3.67 | 0.78 | 5.60 | 49 | .001 | 0.782 |
| Intention to use | Value added | 3.92 | 4.20 | 0.78 | 8.36 | 49 | .001 | 0.785 |
| | Perceived usefulness | 3.94 | 4.00 | 0.71 | 9.32 | 49 | .001 | 0.778 |

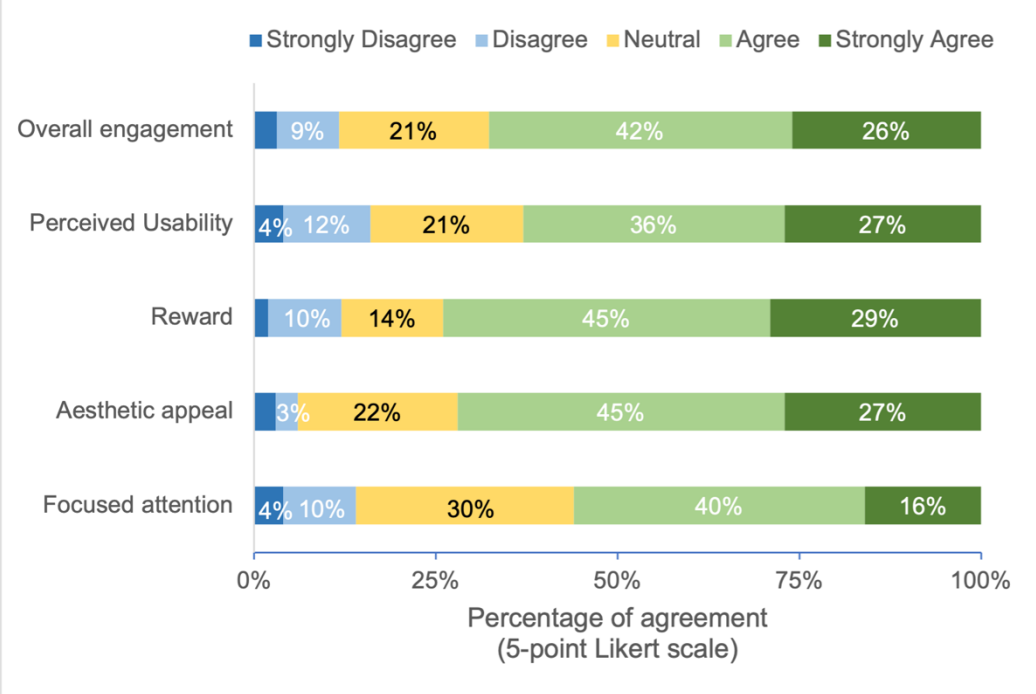


Figure 5.8: Frequency distribution of Engagement ratings (*N* = 50).

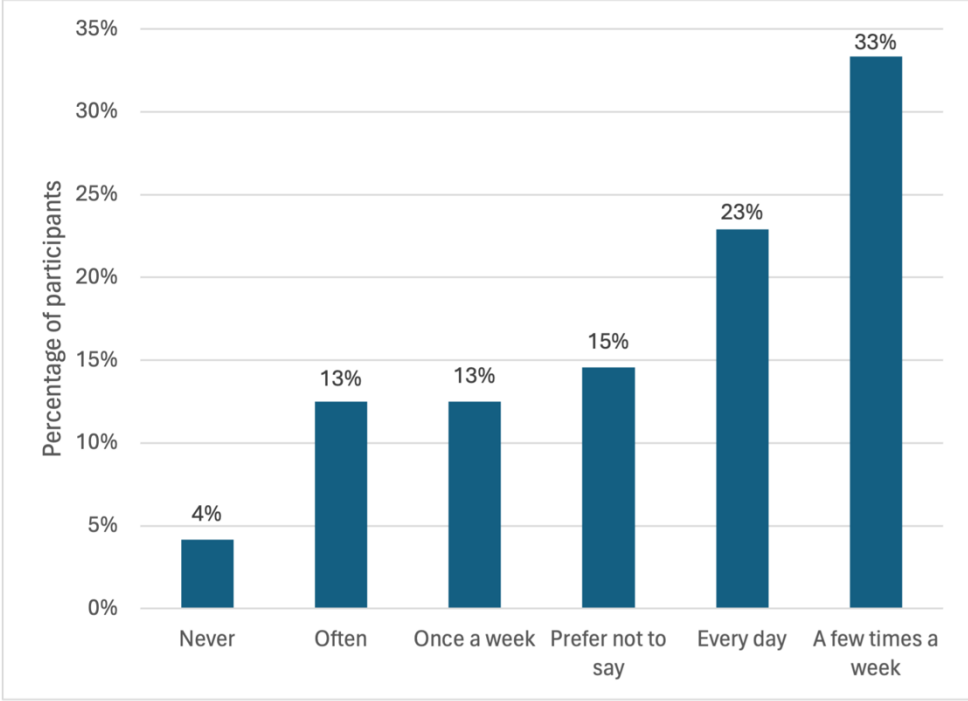


Figure 5.9: Frequency of use of LifeLink app ($N = 50$).

#### 5.4.2.3 User Experience

Table 5.6 shows the average scores of overall user experience (UEQ) scale. The scores indicate that LifeLink was given positive reviews by the users. The average score for overall user experience was $M = 1.415$, $SD = 1.284$. The scores were statistically significant $p = 0.001$. The overall score was higher than 0.8, which meant that the app elicited a positive user experience. The benchmark results from the UEQ Data Analysis Tool [159] showed that the overall user experience score was good (the evaluated product is among the best 10% of results). This revealed a positive evaluation from users. Figure 5.10 shows a comparison of LifeLink's user experience results with benchmark data.

Table 5.6 Mean scores for UEQ scale. The *t* standard score and *p* values indicate how significant the mean score is compared with a neutral score of 0.8.

| $N = 50$ | **Descriptive statistics** | | | **One-sample t-test** | | |
|---|---|---|---|---|---|---|
| **Scale** | ***M*** | **Median** | ***SD*** | ***t*** | ***df*** | ***p*** |
| UEQ (Overall user experience) | 1.415 | 5.75 | 1.284 | 3.39 | 49 | .001 |

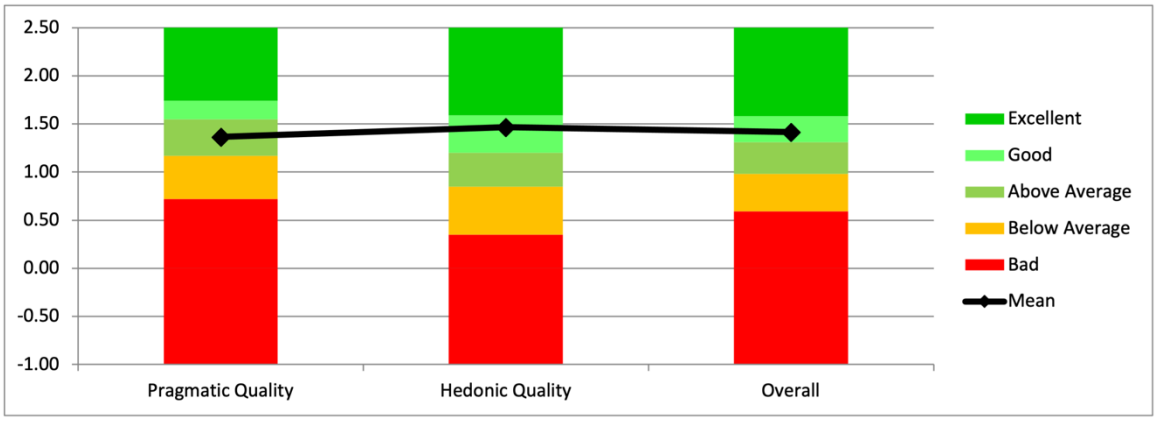

Figure 5.10: Comparison of results of LifeLink's user experience with benchmark data to understand the relative quality of our app as compared to other products.

#### 5.4.2.4 Simplicity

Simplicity consisted of four dimensions: organization, component complexity, aesthetic simplicity, and satisfaction. The dimension of aesthetic simplicity revealed the highest mean ratings ($M$ = 3.93, $SD$ = 0.77) across the midpoint. The dimension of organization showed high mean ratings ($M$ = 3.88, $SD$ = 1.08). The dimension of satisfaction showed above mean rankings ($M$ = 3.62, $SD$ = 0.78), followed by the dimension of component complexity which had above average rating ($M$ = 3.54, $SD$ = 1.18). All ratings were statistically significant ($p$ = 0.001 for all dimensions except component complexity which had $p$ = 0.002) Overall, participants rated all dimensions of simplicity above average (compared to midpoint of 3). Figure 5.11 and Table 5.5 both show results on simplicity ratings.

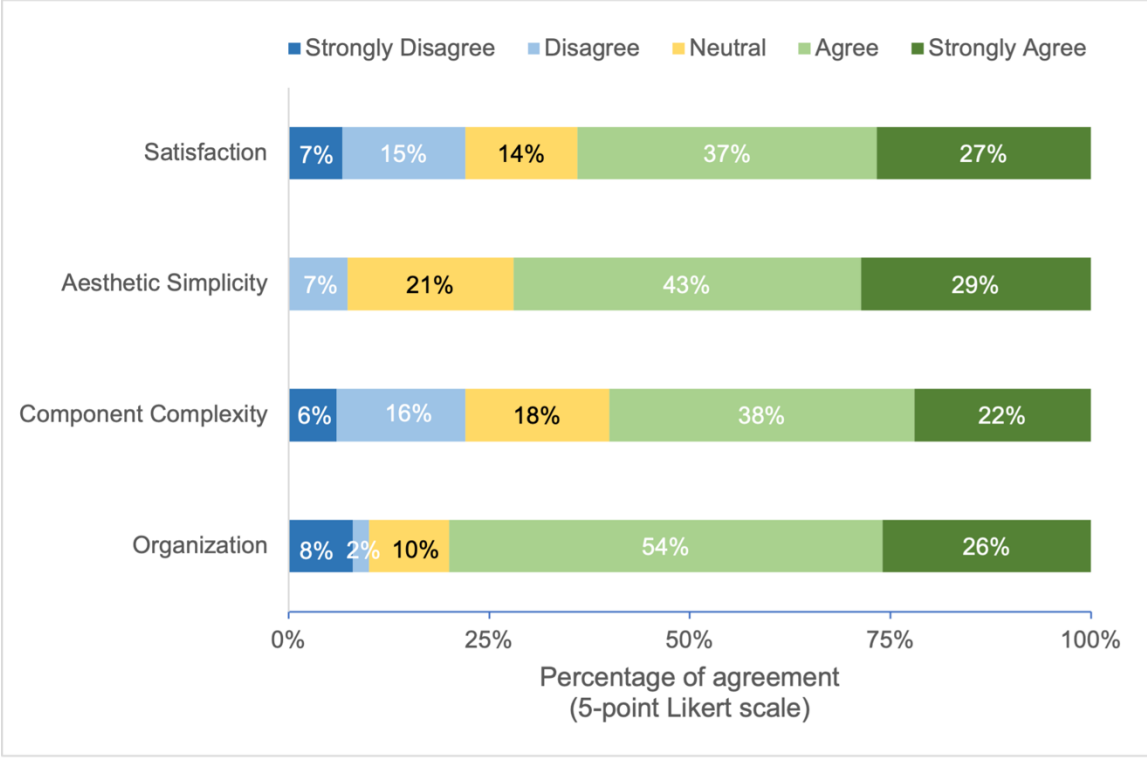


Figure 5.11: Frequency distribution of Facets of simplicity ratings ($N = 50$)

#### 5.4.2.5 Value and Perceived Usefulness

We analyzed user's intention to use the app by measuring the value added by the app and their perceived usefulness. We used the IMI value/usefulness subscale to evaluate the value added and the perceived usefulness scale. The dimension of value added revealed high mean ratings ($M = 3.92$, $SD = 0.78$) compared to the midpoint, alongside the perceived usefulness dimension showing high mean ratings ($M = 3.94$, $SD = 0.71$). The results of one-sample t-test for both dimensions were found to be statistically significant ($p = 0.001$). Figure 5.13 shows the mean ranking for the perceived usefulness scale, with average scores above the midpoint of 3. In summary, participants found that the app added value to them and was deemed to be useful for supporting someone experiencing suicidal thoughts. Table 5.5, Figure 5.12 and Figure 5.13 showcase the results on value added and perceived usefulness ratings.

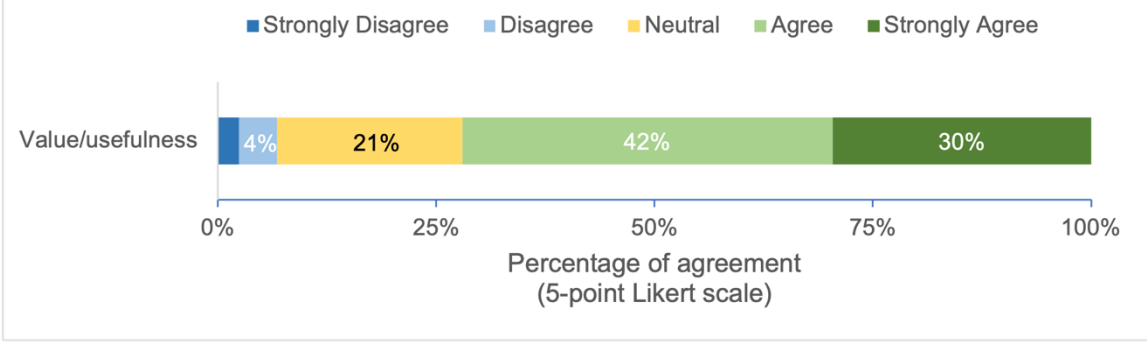


Figure 5.12: Frequency distribution of Value/usefulness ratings ($N = 50$)

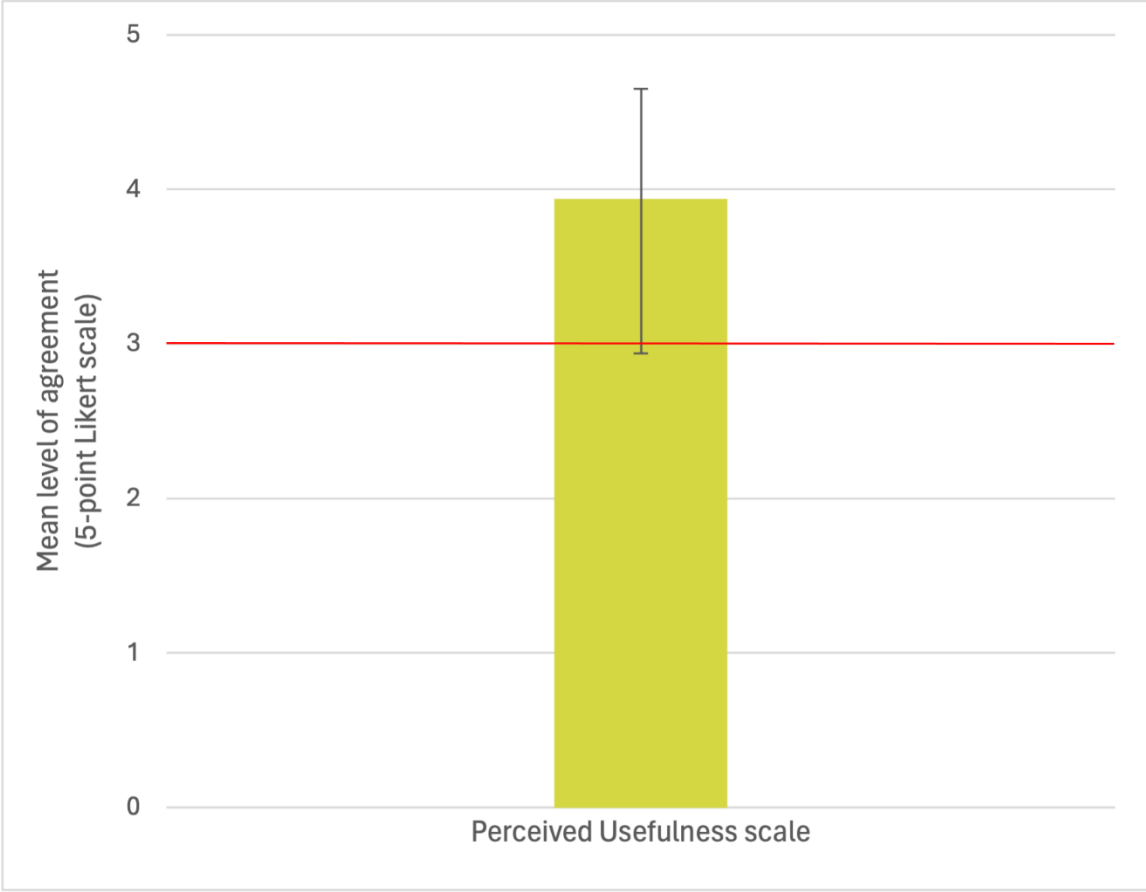

Figure 5.13: A bar chart showing the perceived usefulness of the app on a five-point Likert scale ranging from 1 to 5. The horizontal line indicates a neutral score of 3.

#### 5.4.2.6 Impact of LifeLink app on Mental Wellbeing

To answer **RQ6,** "*To what extent did using the LifeLink application generate a positive experience for caregivers?"*, we computed the change in wellbeing of users before and after using the app. We used the Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) which comprehensively measures mental wellbeing. The SWEMWBS uses 7 items about thoughts and feelings of respondents in the past week(s), such as ''I've been feeling relaxed'', measured on a five-point Likert scale from 1 (none of the time) to 5 (all of the time). The SWEMWBS is scored by first summing the scores for each of the seven items, which are scored from 1 to 5. The total raw scores are then transformed into metric scores and final scores range from 7 to 35. Higher scores indicate higher positive wellbeing.

We first computed the descriptive statistics for wellbeing scores. As illustrated in Table 5.7, the mean value of SWEMWBS (wellbeing) score for pre-study was found to be 24.20 and for post-study was 26.86. Thus, we observed that the average wellbeing scores increased from baseline (pre-study) to follow-up (post-study). To understand how much change in wellbeing scores is considered meaningful, best estimates suggest that a range

from 1 to 3 points difference in wellbeing scores between 'before' and 'after' time points indicates 'meaningful' improvement or decline in mental wellbeing [174]. As participants started the study, their mental wellbeing was median = 23.21, $M = 24.20$. Mental wellbeing scores increased by the end of the study to median = 25.53, $M = 26.86$. In our study, the mean changes in wellbeing scores from baseline to follow-up was of 2.66 points which demonstrates that mental wellbeing meaningfully improved over the course of the study. Figure 5.14 displays the increase in wellbeing scores from pre-test to post-test.

We conducted a Shapiro-Wilk test to check for normality (Table 5.7). The Shapiro-Wilk test showed significant departure from normality, $W(50) = 0.91$, $p = 0.001$ for pre-study and $W(50) = 0.93$, $p = 0.008$ for post-study wellbeing scores.

Table 5.7 Descriptive statistics and Shapiro-Wilk test results of Mental Wellbeing (SWEMWBS) scale. ($M$ = Mean, $SD$ = Standard Deviation, $W$ = test statistic, $df$ = degrees of freedom, $p$ = probability value)

| $N = 50$ | | **Descriptive Statistics** | | | **Shapiro-Wilk test** | | |
|---|---|---|---|---|---|---|---|
| **Scale** | **Condition** | **M** | **Median** | ***SD*** | ***W*** | ***df*** | ***p*** |
| Mental Wellbeing (SWEMWBS) | Pre | 24.20 | 23.21 | 5.45 | 0.91 | 50 | 0.001 |
| | Post | 26.86 | 25.53 | 5.07 | 0.93 | 50 | 0.008 |

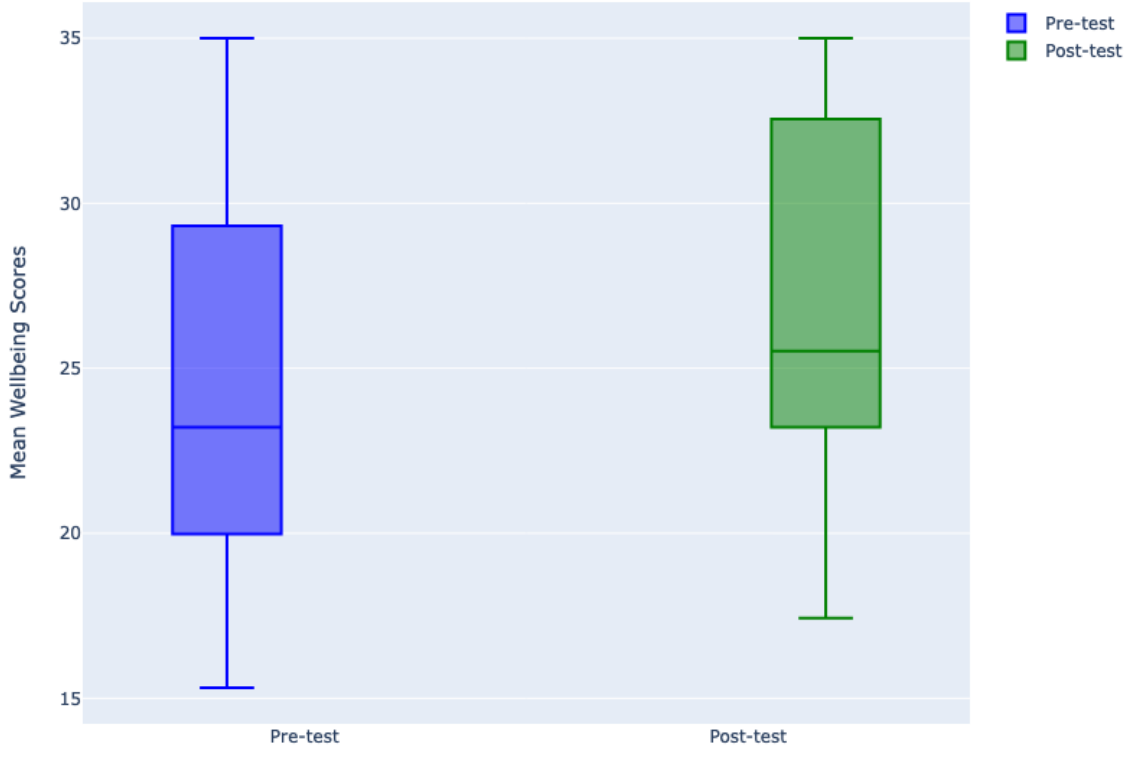


Figure 5.14: Pre and post-test means of caregivers' mental wellbeing.

Since the distribution of the Wellbeing scale is not normal, a paired t-test was not feasible [175]. Henceforth, we performed a non-parametric rank test particularly, Wilcoxon signed-rank test, which does not assume normality. A Wilcoxon signed-rank test on the wellbeing scores showed that one week of LifeLink app use did elicit a statistically significant change in mental wellbeing in caregivers dealing with suicidality ($Z$ = -5.514, $p < 0.001$). Table 5.8 shows results from Wilcoxon signed-rank test. We also computed the mean ranks from the Wilcoxon signed-rank test, results of which are shown in Table 5.9. The mean rank results (Table 5.9) shows that 40 participants had a higher wellbeing score post-study (i.e., after using the app) than pre-study. However, one participant had a higher wellbeing score pre-study and 9 participants saw no change in their wellbeing scores.

Table 5.8 Wilcoxon-signed rank test results, $N$ = 50.

| **Scale** | ***Z*** | ***p*** |
|---|---|---|
| Mental Wellbeing (SWEMWBS) | -5.514 | <.001 |

Table 5.9 Ranks table with mean ranks result from Wilcoxon-signed rank test

| | **Mean Ranks** | | | | ***Z*** | ***p*** |
|---|---|---|---|---|---|---|
| **Wellbeing scores Post study – Wellbeing scores Pre study** | Positive ranks | Negative ranks | Ties | Total | -5.514 | <.001 |
| | 40 | 1 | 9 | 50 | | |

#### 5.4.2.7 Perceived Persuasiveness

To address **RQ7,** *"How persuasive is the LifeLink application for caregivers of individuals experiencing suicidal thoughts?"*, we computed the mean value of perceived persuasiveness for each of the 11 persuasive strategies implemented in LifeLink. We used a five-point Likert scale with the PPQ instead of a seven-point Likert scale for uniformity with other questions in the post-study survey. Thus, we compared the mean score of perceived persuasiveness with the midpoint of 3. Figure 5.15 shows that the mean score of perceived persuasiveness for all 11 persuasive strategies (*tunneling, personalization, rehearsal, reduction, customization, simulation, real-world feel, verifiability, self-monitoring, liking*) was higher than the average neutral score of 3 (red middle dashed line). To further evaluate whether the obtained persuasiveness scores were statistically significant, we conducted the one-sample t-test using SPSS Statistics 28 [168]. As shown in Table 5.10, all 11 persuasive strategies were perceived to be significantly persuasive ($p$ = 0.001) by the participants. The persuasiveness score for all the 11 persuasive strategies implemented was found to be statistically higher ($p$ = 0.001) than the neutral score of 3. This means that our participants perceived all the strategies as significantly persuasive or effective for supporting an individual experiencing suicidal thoughts. Table 5.10 shows the descriptive statistics and results of one-sample t-test for perceived persuasiveness of all persuasive strategies implemented in LifeLink. We observed that the participants found the Simulation strategy within Power Stories ($t(49)$ = 9.99, $M$ = 4.02, $p$ = 0.001) and the Rehearsal and Tailoring strategies within Contact ($t(49)$ = 9.10, $M$ = 3.99, $p$ = 0.001) to be most persuasive based on the mean scores. Out of all the 11 persuasive strategies we

implemented, participants found the Real-world feel and Customization strategies within Settings to be least persuasive based on the mean scores ($t(49) = 5.73$, $M = 3.71$, $p = 0.001$). It must be noted that all implemented persuasive strategies were rated above the average score of 3 and were perceived to be significantly persuasive. Finally, we computed the mean score for overall persuasiveness and found that it showed high-mean scores ($M = 3.85$, $SD = 0.72$, $p = 0.001$). Overall, the persuasive strategies within the LifeLink app were found to be effective in influencing caregiver behaviors and attitudes toward supporting individuals experiencing suicidal thoughts. Figure 5.15 and Table 5.10 show results of perceived persuasiveness.

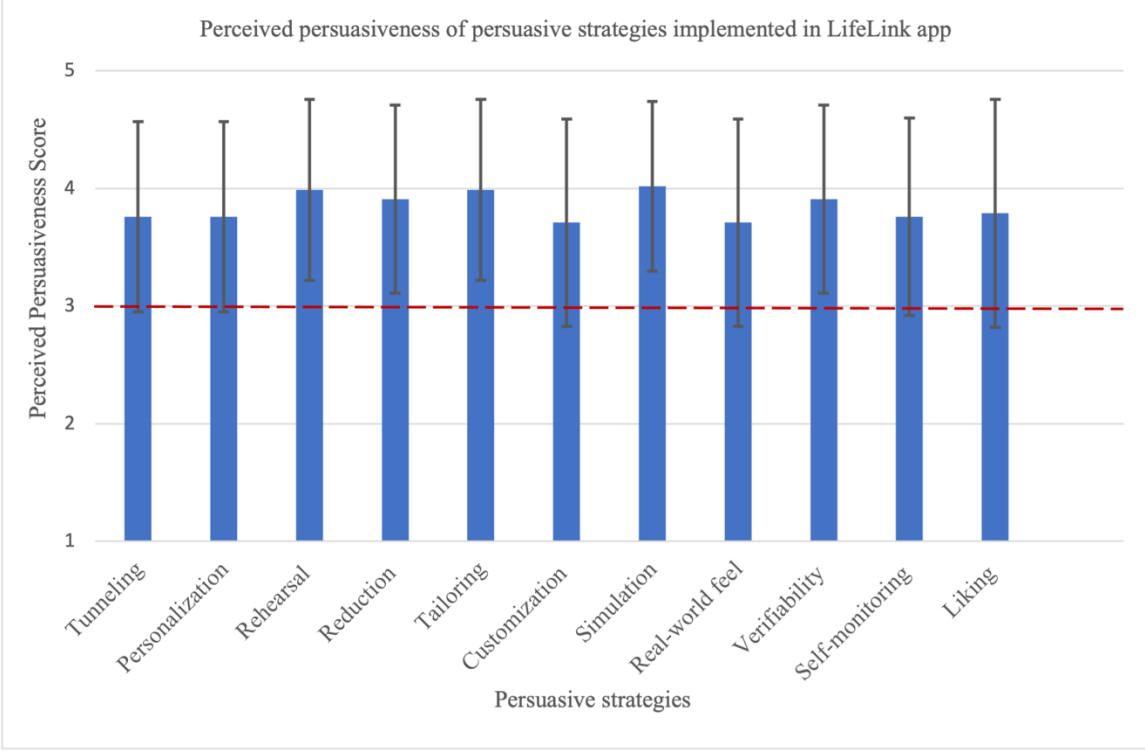


Figure 5.15: Bar plots showing the mean persuasiveness score, 95% confidence interval, for each of the 10 implemented persuasive strategies (y-axis). Red dashed horizontal line in the middle represents average persuasiveness score (i.e., neutral score of 3).

Table 5.10 Descriptive statistics, results of one-sample t-test and Shapiro Wilk test for perceived persuasiveness of persuasive strategies implemented in LifeLink. $t$ = T statistic or Test statistic of the one-sample t-test, $df$ = degrees of freedom for the test.

| $N$= 50, Mid-point = 3 | | | | **One-sample t-test** | | | |
|---|---|---|---|---|---|---|---|
| **Persuasive Strategy** | ***M*** | **Median** | ***SD*** | ***t*** | ***df*** | ***p*** | **Cohen's *d*** |
| Tunneling | 3.76 | 4.00 | 0.81 | 6.64 | 49 | .001 | 0.809 |
| Personalization | 3.76 | 4.00 | 0.81 | 6.64 | 49 | .001 | 0.809 |
| Rehearsal | 3.99 | 4.10 | 0.77 | 9.10 | 49 | .001 | 0.768 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Reduction | 3.91 | 4.00 | 0.80 | 8.03 | 49 | .001 | 0.803 |
| Tailoring | 3.99 | 4.10 | 0.77 | 9.10 | 49 | .001 | 0.768 |
| Customization | 3.71 | 4.00 | 0.88 | 5.73 | 49 | .001 | 0.877 |
| Simulation | 4.02 | 4.00 | 0.72 | 9.99 | 49 | .001 | 0.719 |
| Real-world feel | 3.71 | 4.00 | 0.88 | 5.73 | 49 | .001 | 0.877 |
| Verifiability | 3.91 | 4.00 | 0.80 | 8.03 | 49 | .001 | 0.803 |
| Self-monitoring | 3.76 | 4.00 | 0.84 | 6.47 | 49 | .001 | 0.836 |
| Liking | 3.79 | 4.00 | 0.97 | 5.75 | 49 | .001 | 0.969 |
| **Overall** | 3.85 | 4.01 | 0.72 | 8.31 | 49 | .001 | 0.720 |

To summarize, the results in Table 5.5 indicate that the dimensions describing user engagement, simplicity, value, and perceived usefulness were all statistically significant, scoring above the mid-point. Likewise, the same pattern was observed for other measures describing usability, user experience, and perceived persuasiveness suggesting that the LifeLink app yielded a good user experience. Additionally, LifeLink app usage was associated with improved mental wellbeing, indicating a positive impact on mental health.

### 5.4.3 Qualitative Results

We performed a thematic analysis of qualitative data, comprising participant comments, opinions, and interview transcripts, to gather user feedback on our app. Following Braun and Clarke's [11] six-phase framework, we extracted and organized the data into themes and sub-themes, presented in Figure 5.16. We generated the following six major themes: (1) usability of the app, (2) level of engagement, (3) feature-specific feedback, (4) impact and user experience, (5) usefulness and value added, and (6) suggestions for improvement.

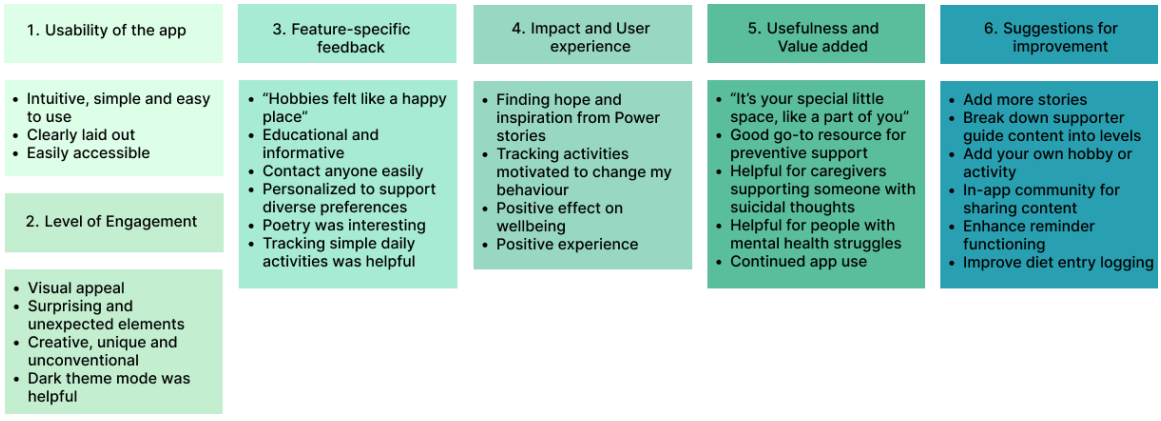


Figure 5.16: Six main themes and associated sub-themes from the qualitative analysis.

#### 5.4.3.1 Theme 1: Usability of the app

**Intuitive, simple and easy to use.** Participants found the app intuitive, direct, simple, straightforward, smooth and easy to use. They mentioned that the app's easy-to-follow nature helped them access different features instantly. A few participants stated that they needed some time initially to understand how the app works but after a while, they were able to follow and had a great experience using it. A few participants reported feeling happy because the app was easy to read, and it was easy to access any information they needed.

"*Like when I think about suicide, my mind kind of goes a little frayed because people don't really talk about it. So it's kind of a bit of a* ***taboo subject****, but I think approaching something like this is* ***necessary*** *and* ***it's so important****. The way this whole idea is established and put together, it's a really good concept. It's* ***intuitive****,* ***easy to follow*** *and that's helpful. It seems like it's* ***simplified****, like with the tracking piece, having today and yesterday, and then the history piece. So that's kinda cool actually*" [P08].

**Clearly laid out**. Participants found that the app had an approachable and clear layout. Some participants felt that their day was more manageable because of the way the app was laid out. Participants liked that the nearby support resources were laid out province-wise making it easier to connect with the appropriate resource. Below are some quotes of what participants said related to this sub-theme:

- "*The supporter guide, other suicide prevention stuff and power stories, I found very useful, the* ***links were helpful****. Everything in there was very clearly laid out*" [P18].

- "*I really like the quick links. So suicide first aid and the nearby supports and you* ***break it down by province****. So not just Nova Scotia, but like other provinces in Canada, which is really* ***handy****. It's very simple and laid out* ***very easy to read*** *and everything. I think it's a really great application. I* ***like the reasoning behind it****, the way that it is laid out, you know* ***what it's trying to achieve*** *is really good*" [P31].

- "*I like the way the tracking is broken down because I don't know this kinda* ***makes me feel like the day is more manageable***" [P08].

**Easily accessible**. Participants emphasized that nowadays smartphones are ubiquitously found and having all the resources readily available within the app was quite beneficial for caregivers dealing with suicidality. Few participants stated that having the Contact button accessible from the home screen was helpful in time-sensitive crisis situations.

- "*If I'm having a hard time while supporting somebody, there's literally contact numbers,* ***resources that are readily available*** *and it's like it's* ***at your fingertips****. The four main buttons, like you can access so much from home, but having contact right there and readily available is so good. If it were, you know, a very dire situation and like it was degrading very fast and you wanted to get that person help. It's right there. Immediately, like even from the home screen, it is the next button over and I really enjoyed that. It was so* ***accessible****, that's the big word for me that I keep coming back to. I think that was really* ***well thought out***" [P13].

- "*I do think that it's very **helpful** because when people have downtime like, you know, as a caregiver to somebody, **sacred time by yourself is sometimes scarce**. So being able to whip your phone out and take like, you know, 45 seconds or two or three minutes to find something out that **can reassure you**, it's awesome. It's like **targeted information***" [P08].

#### 5.4.3.2 Theme 2: Level of Engagement

**Visual appeal**. Participants reported that the app was enjoyable to use and colourful. Participants found that the app's colour scheme and typography were soft, calming and welcoming.

- "*I think you chose like, **nice colours** and **fonts that are really soft**. And I think that that's nice. And like **welcoming**. Like, it's funny but those things are **very powerful**. It looks like there's darker greys instead of black on the category names and stuff. **Little details matter**. I also loved this green colour*" [P08].

- "*The colours are very **calming**, I really liked that*" [P20].

**Surprising and unexpected elements**. Participants mentioned that they found the favourites an unexpected feature within the app where the user could document their behaviours. Additionally, participants were surprised to see the features find nearby support, track, poetry and power stories in the app.

- *"I **didn't expect the power stories**. Like when I kind of heard about what the app was I was like, oh, it'll have resources and things like that, and I **didn't expect the tracking** and the hobbies and things for self, like for the caregiver. And I really like that because I think that, you know, as people who do help individuals, especially at most vulnerable times, we have to **be able to take care of ourselves as well**. So building that into this support system for people I think was just really nice"* [P16].

- "*I think the amount of information and how it was dissected like I wasn't prepared for that, like it's a really good resource, so that was an **exciting surprise**. I didn't know that there would be a situation where you could upload your videos and document your hobbies and stuff, that was a nice surprise*" [P08].

**Creative, unique and unconventional**. Participants found the app to be creative, unique, and unconventional. Participants liked the app's concept, the reasoning behind the app and the way it was created.

- "*It's a really great initiative from an application perspective. It's **not a conventional or monolithic app**. It's **beyond creativity**. Also, **solving a real-life problem***" [P16].

- "*I **love the app and the way it was created**. Great idea for an app*" [P24].

**Dark theme mode was helpful**. Participants liked the inclusion of a dark theme mode in the app. They appreciated the customization and flexibility of changing the app's theme as per their preference.

- "*When I opened the app it opened up in light mode. I immediately switched to dark mode and I'm **glad that the app has a dark mode theme** on it because everything I use, I prefer dark mode. I like that the app sort of fits well within the theme that I use, as it's **easy on the eyes***" [P05].

- "*I was using the dark mode the whole time, it's a **good addition***" [P32].

#### 5.4.3.3 Theme 3: Feature-specific Feedback

**"Hobbies felt like a happy place"**. Participants found the Hobbies feature appealing and enjoyable. They particularly liked that it involved various activities like adding artwork, reading poetry, and uploading photos or videos.

- "*The hobbies was a really nice thing because I was kind of thinking about it and it feels to me like a **positive place** for documenting your behaviours, which can be like a positive reinforcement of the good things that you are actually doing, as **hobbies are like happy things**. So sometimes if you're feeling down, having a place where those things all are is just really nice*" [P08].

- *"I really like the Hobby section where I could search for poetry or add my own artwork and things like that. I'm not sure if it could be shared with someone else, but that was good. That was the **most enjoyable, appealing and new thing** for me*" [P05].

**Educational and informative**. Most of the participants reported that the app was educationally comprehensive and highly informative. Participants particularly mentioned the Supporter Guide feature as a rich source of information on various topics within suicide and suicide prevention. They appreciated access to the resources within a mobile app, especially because of the taboo associated with suicide which makes it difficult to seek information from others openly. Participants found the information within the supporter guide with online references as positively reinforcing. Participants stated that the supporter guide increased their knowledge about suicide prevention and how to support someone experiencing suicidal thoughts. One participant felt that although the app was dense with information on suicide prevention, the content seemed more suited for a website instead of a mobile app.

- *"It was useful in keeping myself a bit calm and reminding me about the good things, but also to be aware of suicidal tendencies and what one might go through. Like how it is for the other person, why they're experiencing it, how to not shy away from it, how to handle it when someone else is facing such thoughts, which is like really good. The supporter guide explains all that. It **reminded me of both the positives and negatives** since **this is a sensitive topic** and **not a lot of people actually know***

***about it***. *For example, when one of my friend reached out in the past when he had such thoughts, I didn't know anything else except for like, reaching out to Google and my phone. But if I had an app where it's like I had my information at fingertips, I guess it would have been a bit different"* [P05].

- "*I just am **blown away by the number of resources**, it's really incredible. Everything in the supporter guide, it's excellent because, you know, these are things that I try to tell my family members when they're taking on too much, just like these positive reminders. It's just like, you know, you're not gonna change the reality of your world. But just remember to make time for yourself. And I think having it in writing with actual references, it's **powerful**. It's like getting a scientific document*" [P08].

- "*The suicide prevention stuff, the supporter guide, the power stories, the suicide first aid, find nearby support were very useful. There is definitely a lack of mental health resources, in particular about suicide prevention and education. So I think you're on a very good track. Now, although the **suicide portion is well developed**, it doesn't seem well suited to be an app. This felt more informative and may have been better suited to be just a website*" [P18].

- "*It provided me with necessary information but also **info about things I never thought would be vital**. I know a lot of things right now using the app*" [P22].

**Contact anyone easily**. Participants found the Contact feature helpful for connecting with a close family member, friend or trusted individual. This was found to be especially useful in a crisis situation wherein one would need support instantly. Participants appreciated that users could check in with their trusted contacts via text or call directly from within the app. Besides personal contacts, participants stated that the national helplines provided within the Contact feature were also useful if someone was looking for help outside their community. The Contact and Find Nearby Support features were found to be easily accessible from the Home screen, making them handy in crisis situations.

- "*You have contact where you can add your friend who you might want to get in touch with if you want support or if you want to call someone, you can have them in your support network. So that's good, like **having a dedicated space** in the app*" [P05].

- "*The calling feature directly to like near and dear ones, is **very useful in particular situations** if a person is attempting a suicide or something*" [P16].

- "*I really found the **emergency contact feature handy**, I could add my emergency contacts, call them or send them a message*" [P47].

**Personalized to support diverse preferences**. Participants reported that having various resources within Supporter Guide, Power Stories and Find Nearby Support was beneficial as it catered to users with different needs. Participants acknowledged that the range of

provinces covered within Find Nearby Support made it easier for them to access relevant provincial resources. Participants appreciated that the Contact feature included a diverse range of supports like national helplines and specific helplines for kids, 2SLGBTQIA+, indigenous communities etc.

- "*The contact is really cool, like you can just click on it and it immediately brings you to national help lines, Kids help phone, LGBT like you have a **diverse range of supports** in here for different people. I've really enjoyed that. I think it made me more confident in supporting someone else because, having those resources readily available in one place, broken down by province, broken down by many different demographics that could fit the individual that I'm supporting just **helps me feel reassured** that **I can find the right resource to help that person***" [P31].

- "*I like the fact that we have a **lot of resources** available on the app to kind of **support different needs** at any particular point in time. So the fact that we have varying features in the app makes it more **intuitive** enough to guide anyone to know which feature actually best matches their preference*" [P04].

- "*I did think all of the supports were awesome as you broke it down by province, so not just Nova Scotia, but other provinces in Canada. It's really amazing. I think that it's so handy and **gives people independence***" [P08].

- "*I liked that I could see all the resources within the province I'm living in, so it was **very personalized**. I think for an app like this it's fully packed*" [P47].

**Poetry was interesting**. Participants found Poetry to be an interesting and surprising feature which kept them engaged. They described that reading poetry can be a potential hobby that the app motivated them to try. It was also deemed useful as a distraction technique.

- "*I was **amused** by the poetry inclusion, it was **quite surprising**. It's like if I am not into poetry and if I read every day I might add reading poetry as a hobby. So it's a good thing*" [P16].

- "*I really like the poems feature, that was a really cool thing. It **helped me distract my mind** by reading poems. It **kept me engaged** for a while and felt good*" [P47].

**Tracking simple daily activities was helpful**. Participants appreciated how the track feature allowed them to log their daily activities like sleep, diet, stressors, movement, journal their thoughts, all in one place. Majority of the participants mentioned that this was helpful as these simple daily activities form the cornerstone of our physical and mental wellbeing. Tracking these activities helped them observe their current behaviour, see their progress and make changes to their routine accordingly. Some participants reported that tracking activities consistently made them feel like their day was more manageable. A few participants mentioned that the Stressors feature made them rethink about stress and its role in our lives. Some participants mentioned that articulating their worries via the Journal

helped minimize their stress levels. The activity records within Track gave users something to come back to regularly, as per many participants. Some participants stated that using Track feature made them realize the importance of practicing self-care for caregivers so they can be fully present for someone else.

- "*I actually tried the movement, I just said, let me try to pop in exercise I do daily like for me, I like walking. This is a nice one to actually track how well you're exercising and getting enough exercise, which makes it* ***very important for the body and mind****, at this particular point in time. I was also particularly interested in the sleep and diet thing. Personally, I just wanted to see how well I'm doing because I find it difficult to sleep because I have this routine of almost overworking myself*" [P04].

- "*Stressor was an interesting thing which* ***made me think about stress***" [P05].

- "*I like the sleep piece and the stressors. That's another thing, like where I don't have a lot of people to talk to honestly. It's like a record that kind of helps you return to something, maybe a little bit like journaling. And then* ***when you start to like, articulate*** *and document, the specific areas that you're experiencing stress and worry sometimes it* ***helps to minimize them and the stress they cause***" [P08].

- "*The tracking everything in one place was really good.* ***It's like a notepad*** *thing. I was not expecting it in the app*" [P16].

- "*Tracking has been very helpful because it it's* ***something that I want to come back to*** *and track on a day-to-day. I don't have a very good memory when it comes to forming habits, so I really enjoyed that. It's* ***very simple*** *and laid out very like easy to read and everything*" [P31].

- "*It (Track) made me realize that if I have some weak point, I need to take care of myself first before helping somebody else. So if I'm not well, I'm not going to be any of any help to someone who is having suicidal thoughts. It helped me in* ***keeping track of my mental health***" [P47].

#### 5.4.3.4 Theme 4: Impact and User Experience

**Finding hope and inspiration from Power Stories**. Participants reported feeling inspired and hopeful by the Power Stories. They stated that seeing people in a similar situation who were able to pull through, motivated and impacted them. The stories were found to be touching and made participants feel less alone in this difficult journey. Participants reported that seeing another person who was also struggling but overcame it gave them hope.

- *"The* ***power stories really kind of drive home impact*** *and realize like hey, you're supporting somebody who's going through this, they're not the only person. And if I have been in that position before, seeing that others do suffer from these things too makes me feel that* ***I'm not dealing with it alone****"* [P31].

- *"So, watching videos of people who actually survived suicide **gives hope**, like if this person has actually thought about doing this in the past, and then there was a way they waved through it and they were able to come out of that. So I think those stories were kind of **inspiring for me**"* [P04].

- *"It (Power Stories) set an example of how people who were once struggling are in a better situation now. It **made me more aware of my abilities**, that if others can do it, I can do it too"* [P07].

- *"The stories were **touching** and would make people realize the **seriousness of suicides** and why people need help. This app does a good job with that"* [P05].

**Tracking activities motivated me to change my behaviour**. Participants reported that tracking daily activities motivated them to adjust their behaviour. The colour-coded progress bar within Sleep, Diet, and Stressors was also found to be helpful by participants in identifying areas for improvement. Few participants mentioned that seeing their progress was positively reinforcing.

- "*The diet thing showed a red flag that I've actually been eating less calories or more calories, so **I began to change my way of eating**. Daily I'm able to know how well I'm performing in these areas and also to begin to adjust to become healthy. I like the fact that I see if I'm losing sleep for let's say two to three days, I can make up for it and see how I can improve my sleep over time*" [P04].

- "*I don't have a lot of human connection in my life, so there's not a lot of like positive interaction and positive reinforcement. So for me it was nice to be able to like track something regularly and I could see that with every daily entry the monthly bars would rise. So, tracking simple things **allowed me to see a consistent practice in my daily life**. Sleep is healthy, and being able to monitor doing something healthy, consistently - was nice. The record provided was like **a positive reinforcement***" [P17].

- "*It did remind me to sleep well. So the first time when I tracked my sleep through the app, I realized I wasn't getting enough sleep. Eventually I could like see my progress and **aim to do better***" [P08].

**Positive effect on wellbeing**. Participants reported that the app had a positive effect on their wellbeing. They mentioned that tracking activities regularly was motivating and can help shape their wellbeing over time. Few participants said that journaling their thoughts helped minimize their worries and feel a sense of control. Some participants felt that the app gave them something to look forward to. Participants reported feeling happy and having increased confidence levels while using the app. Some participants mentioned that the app's content helped them feel calm and reminded them about the good things in life. Participants mentioned that the app guided them about some issues that caregivers face

while dealing with suicidality. They stated that the Power Stories helped them develop a positive outlook on life.

- "*I think it affected me positively. I experienced like a lot of anxiety before using the app but then I started to try it and it's like that **power of writing something down**. Then it's not a worry in your mind and that just kinda did help me like **to feel a little bit more in control**"* [P08].

- "*It (the app) gave guidance towards some of the problems. I felt that when I use that app every day, there's less negativity. If I like read or see the power stories and all like supporters' stories, the next day, it **gives me more positivity around the society** and makes me realize that others are also struggling and it's not only me"* [P24].

- "*It did affect my wellbeing positively, again because **I could take the time to check in with myself** whether it was my sleep or writing a little bit of information about how I was feeling in the journaling piece and ensuring that I was tracking my diet"* [P31].

- "*I think there is a change in my wellbeing because **I now have something to look forward to**. It has kind of **increased my confidence level**"* [P22].

**Positive experience**. Participants reported having a positive experience using the app. They found it beneficial, impactful, powerful, trustworthy, informative and easily accessible. Participants felt happy and enjoyed using the app.

- *"I had a great time using the app and I must say that it has **given me a different perspective about life**"* [P36].

- *"I thought it was a very **beneficial app** personally. It provided the right and most useful information. On a bigger scale, I think it's awesome. Like you know, **everybody has a phone** like me. I think that that made the fact that you can actually access something like this, quite easy. I like that **it's like, everything in one shot**. It has these positive reminders and like having it in writing with actual references, it's powerful"* [P08].

- *"While using the app you know, I enjoyed all of the things and felt really good, but I feel like my most important one is that now I can carry myself. I think it brought out a whole lot of things. I love the app. It **impacted me in a positive way**"* [P24].

- *"The app that's created, **it's like a step in the right direction** I would say. Definitely improvements could be there for sure, but for like a start, this is at least for me, since this is the first time I'm hearing something like this, this is great"* [P05].

#### 5.4.3.5 Theme 5: Usefulness and Value-added

**“It’s your special little space, like a part of you”**. Participants reported feeling a sense of bonding with the app, like a friend. This was described while using the Track and Favourites features of the app. Tracking daily activities that users already enjoyed doing felt good. Additionally, documenting their favourite things within Favourites made the app feel like a special little private space of their own. Some participants appreciated that they could add their favourite photos from their device to the app’s Favourites section like a collection of memories. The app was found to be a positive place where participants could come back to if they’re feeling low and see their progress or favourite things.

- “*If someone likes doing exercise then seeing exercise as part of the feature of the app will make them really kind of contemplate how **this is really something to bond with**. Like **this app is my kind of friend**. For me, movement piece was quite good because that was perfect, like what I do daily. So this is just like, **it's part of me**. So I would like to add my record there”* [P05].

- “*You can share things with yourself that are positive. So **it's your special little space**. Like I think the **privacy feature is so special to me**. Like you can store things in here. **You begin to think that it's yours**. I didn't know that there would be a situation where you could upload your videos and your hobbies and stuff, but I think that that's a really nice thing because it feels to me like a positive place. Documenting your behaviours can be like a positive reinforcement of the good things that you are actually doing, and then hobbies are like happy things. So sometimes if you're feeling down, having a place where those things all are is just really nice”* [P08].

**Good go-to resource for preventive support**. Participants appreciated the targeted information in the app on supporting someone with suicidal thoughts. They found the app to be a good go-to resource for supporting others. Participants found the support resources within the app useful for supporting people with different needs.

- *“I think that it's very helpful. It's like **targeted information on suicide prevention**. The support guide, the power stories, the suicide first aid, the nearby support were very useful”* [P18].

- *“I think it has **made me more confident** in supporting someone else because you know the checking in with myself is good and making sure that I'm taking care of myself. But again, having those resources readily available in one place, broken down by province, broken down by many different demographics that could fit the individual that I'm supporting just helps me feel reassured that I can find the right, the right resource to help that person”* [P31].

- *“It is a **good go-to resource** for support”* [P42].

**Helpful for caregivers supporting someone with suicidal thoughts**. Participants found the app beneficial for caregivers of individuals experiencing suicidal thoughts. Some participants mentioned that the app can be useful for professionals, parents, teachers or

other people who are supporting students, friends, youths. The app was found to provide the most useful information on supporting someone with suicidal thoughts.

- *"If I had known before about this app, **it would've helped support my friend** who was having such thoughts. I would definitely recommend this to someone who's looking to support their friends"* [P05].

- *"**As a caregiver, this app has really been helpful**. Most of the information I needed I could find it here, so it has been helpful to me"* [P42].

- *"If I'm having a hard time supporting somebody, there's literally contact numbers. There are resources that are readily available and so it's just like at your fingertips. I do work with individuals who are at risk and there are times when people that I work with may reach out and be feeling that or talk about those things that they're experiencing. And for me to be able to say, OK, hey, **let's get you some support**, is quite helpful. I think it would be a good app for caregivers like parents, teachers and other support people in youth's lives. It is laid out in a way that they don't necessarily have to be people who work in a realm around that, but a good support for people who may not know"* [P31].

**Helpful for people with mental health struggles**. Some participants pointed out that the app is helpful not only for supporting someone with suicidal thoughts but also for someone struggling with mental health issues. They mentioned that suicidal thoughts can be an after-effect of other mental health conditions and are interdependent.

- *"The links were very helpful, and I did actually pass those on to other people that I associate with who do have some mental health issues and **they found that those links were very helpful** as well"* [P18].

- *"I think we can recommend this to support suicidal thoughts patients or people struggling with mental health. So it doesn't really help only with suicidal thoughts, right. **So suicidal thoughts can actually be an after-effect of this whole thing on mental health** generally. Or one can actually lead to the other. So they **are both dependent on other**. So it's either someone struggling with mental health can begin to think that I need to commit suicide at this particular point in time. And then somebody thinking of suicide, can actually begin to go through mental health issues that will compound a lot of things you're tracking right now. So it's very good, not only for them, it's good for people having mental health issues as well"* [P04].

- *"My **personal experience with mental health issues has been hard**. So like, **I have a lot of hope for this app**. I think it's really a great idea"* [P08].

**Continued app use**. Participants mentioned that they would like to continue using the app, especially the Track feature. They found monitoring activities within Track useful on a daily basis. Participants also mentioned that they would like to cover all the educational content within the app.

- *"I actually found journal & the sleep thing to be awesome. And I would love to continue doing that. Tracking was really **inspiring**"* [P08].

- *"I'm looking forward to keep using the app because **I still have a lot to to learn**"* [P24].

- *"I **could use this app if like I'm feeling a little bit down** and I would like to use this app to keep track of my activities"* [P03].

- *"I will probably still fill out my logs as I find that **good for checking in with myself**"* [P42].

#### 5.4.3.6 Theme 6: Suggestions for Improvement

**Add more stories**. Participants stated that the content within Power Stories was not enough and could be expanded regularly to include new stories of suicide survivors and supporters.

*"I kept seeing the same stories. So it won't make me go back and watch the same story. If I'm a story lover, I **would like to see more stories coming**, you know, like, based on what I watched or something like that. There should be a notification telling me there are new stories for me based on my preference"* [P04].

**Break down supporter guide content into levels**. Participants suggested breaking down the topics within the Supporter Guide into different levels to make it easier for a new user to find the right information.

*"If you were to take the supporter guide and maybe you were able to **break it down into like different levels or stages**, then it would be better"* [P31].

**Add your own hobby or activity**. Participants suggested that they should be able to enter their own category of hobby or activity for greater flexibility.

*"The only thing that would be useful to add is for the participant using the app to be able to **enter their own activities, fitness, hobbies** etc."* [P27].

**In-app community for sharing content**. Few participants suggested including an in-app community for sharing the content within Hobbies like photos, videos, artwork, poetry, hikes etc.

- *"If there's already a community within this app, I will see the relevance of the photos I'm uploading like I'm sharing it within the community. So I know people around this community will give me hope, like positive comments"* [P04].

- *"It **would be nice to have a community in the app**. Then maybe we can post stuff there and learn from others. Sharing all the artwork, the poetry, the photos, I really*

*think it would have been at another level. So, you know, people can relate, share their story and be able to, you know, put themselves in the shoes and understand a whole lot of things"* [P24].

**Enhance reminder functioning**. Participants suggested that the reminder functionality can be improved with better notifications. Some participants did not receive a reminder despite setting it.

- *"I saw that there was a notification feature on but* ***didn't get any notification*** *regarding anything"* [P16].

- *"I feel incorporating like a notification message would help call the attention of the user to the app daily. It could be something like 'Art of the day' notification to arouse the interest of user"* [P49].

**Improve diet entry logging**. Some participants stated that they had difficulty logging their diet. They suggested that it would be helpful to automate the calories based on the entered food item, instead of having it entered manually by the user.

*"More information on the 'Diet' tab would be useful i.e. how to calculate the kcal. This tab* ***did not work for me****. It didn't seem to save. I found it confusing as to what should be entered under food item - should each item you ate be entered, can you enter 'pizza' or do you need to enter each item that makes up the pizza? The Kcal option would be better if it automatically calculated the amount for you based on the food item"* [P18].

# Chapter 6 – Discussion

"*When one of my friend reached out in the past, when he had such thoughts, I didn't know anything else except for like, reaching out to Google or something. But if I had an app where it's like I had my information on fingertips, I guess it would have been a bit different. This is, at least for me, the first time I'm hearing something like this and would have been great if I had known before, to support my friend*" [P05].

In this chapter, we discuss insights from our results of evaluating the LifeLink app. Additionally, we propose design recommendations for designing suicide prevention apps for caregivers and reflect on the limitations of our work.

## 6.1 User Experience and Engagement

More than two-thirds of our participants reported using their smartphones primarily for education purposes. Consequently, participants appreciated the educationally comprehensive and informative nature of the LifeLink app, during the interviews. Participants found the app usable, intuitive, easy to use, clearly laid out and easily accessible. One participant said, "*I like the way it's broken down, this kinda make me feel like the day is more manageable*" [P08]. This can be attributed to our intentional design choice to make the app easy to use, after participants in our previous study had highlighted the challenging nature of supporting someone with suicidal thoughts. When asked about their app needs, participants in our previous study had suggested that the app should be user-friendly and easy to use as it can be difficult to focus amidst convoluted thoughts while supporting someone. Participants found the app to be aesthetically appealing, providing a rewarding experience, attention-grabbing and engaging overall. Majority of the participants (68%) agreed/strongly agreed that "the app was overall engaging". Our qualitative results further confirmed this finding as participants found the app visually appealing, enjoyable, welcoming, creative, unique, unconventional, consisting of surprising and unexpected elements. Given the heavy nature of the field of suicide, the app's colour scheme and typography were specifically chosen to be soft and calming. The app's logo, layout, and design elements were designed to evoke a sense of calmness, hope and renewal in life for caregivers who are already in an exhausted situation. In our previous study, a participant said, "*I would hope it (the app) would be easy to use because when you're in that mode of helping somebody, you're already frazzled*" [P19].

Participants liked the app's concept, the reasoning behind the app and the way it was created. To the best of our knowledge, LifeLink is the first app designed specifically for caregivers of individuals experiencing suicidal thoughts and involving caregivers in the app design process. In our app review [38], we found that there are several apps geared towards individuals experiencing suicidal thoughts but none for their caregivers, which can potentially guide them toward better supporting the person with suicidal thoughts. Additionally, in our previous study participants had brought up that there is a lack of accessible support resources for the caregivers who look everywhere in the quest for supporting their person. A participant said "*The caregiver is looking for help wherever they can get it. And so if they had an app on their phone, it would just make life so much easier.*

*It's 24/7, I like that as well. You have access to all the materials that you need at one place*" [P19]. Participants in our previous study also mentioned that the individuals experiencing suicidal thoughts tend to lack interest in trying out new technology, so it is better to design for caregivers who would be more interested in leveraging an app for dealing with suicidality. A participant, after using the LifeLink app said, *"If I had known before about this app, it would've helped support my friend who was having such thoughts. This is great, at least for me, since this is the first time I'm hearing of something like this"* [P05].

Since we adopted a user-centred design approach [65], caregivers were involved in informing the app design. We observed that this approach of involving caregivers in the app design process was appreciated by participants during our second study. It ensured that the app addressed the needs and concerns of our target users (i.e., caregivers) for whom the app had been developed. Since the conception of the LifeLink app, we wanted to 'design-for-all' i.e., design to meet the vast diversity of users' needs and requirements [182]. Additionally, participants in our previous study mentioned that suicide is a multifaceted problem and handling it is person and context dependent. In line with this, we included customization features like selecting the province for nearest support centres, and dark theme mode which gave users the flexibility to change the app's content or appearance as per their preference. We also included various resources within Supporter Guide, Power Stories and Find Nearby Support to cater to users with diverse needs. Participants appreciated that the Contact feature included a diverse range of supports like national helplines and specific helplines for kids, 2SLGBTQIA+ and Indigenous communities. Participants liked the inclusion of the dark theme mode, mentioning that it fitted well with what they used on a daily basis.

Participants had not expected the tracking of daily activities for the caregiver in the app. The Track feature was found to be one of the favourite features of the app as it helped them keep track of their activities on a regular basis. Participants in our previous study had specified the need to have some aftercare steps or self-care resources for the caregiver hence we built the daily activity tracking for the caregiver within the app. Additionally, a section on 'Aftercare steps' was included within the Supporter Guide so that users could access self-care resources that can help them take care of themselves. One participant said "*It (Track feature) made me realize that I need to take care of myself first before helping somebody else. So if I'm not well, I'm not going to be of any help to someone who is having suicidal thoughts*" [P47]. Interestingly, participants mentioned that tracking their behaviour was helpful as these simple daily activities (sleep, diet, stressors, movement, journal) form the foundation of our physical and mental wellbeing [12,112,183]. By targeting these simple daily activities, one can shape their wellbeing over time.

Participants rated the overall user experience with the LifeLink app as good. The app was found to elicit a positive user experience. Our qualitative results further confirmed this as participants mentioned that they felt happy using the app. Participants also stated that the "*Hobbies feature felt like a happy place*". Hobbies are enjoyable activities done regularly in one's leisure time for pleasure. Incorporating hobbies (like poetry, artwork, hiking, photos, and videos) into the app was an intentional design choice and in turn was found to be a positive experience. A participant said, "*I had a great time using the app and I must say that it has given me a different perspective about life*" [P36]. Another participant

mentioned "*While using the app you know, I enjoyed all of the things and felt really good. I think it brought out a whole lot of things. I love the app*" [P24].

Participants found the app simple, with all dimensions under the Simplicity scale rated above the midpoint of 3. Furthermore, qualitative results revealed that participants found the app direct, straightforward and smooth to use. Participants mentioned that the app was easy to read which helped them access different features instantly and made them happy. The app's design was intentionally kept simple and minimalistic from the start, keeping in mind the sensitivity around the area of suicide. A participant said, "*Like when I think about suicide, my mind kind of goes a little frayed because people don't really talk about it. The app is intuitive, easy to follow and that's helpful. It seems like it's simplified, like with the tracking piece, having today and yesterday, and then the history piece. So that's kinda cool actually*" [P08]. Interestingly, participants from our previous study had also reported finding the app prototype as simple, minimalistic and easy to follow. Participants reported during the interviews, that the app was clearly laid out and our quantitative results confirm the same. 80% participants agreed or strongly agreed that "the app was well-structured" as part of the organization dimension within the Simplicity scale. In summary, the LifeLink app yielded a good user experience.

Participants found the app valuable and deemed it useful for supporting someone experiencing suicidal thoughts. Majority of the participants (72%) agreed or strongly agreed that "the app added value or was useful to them". Our qualitative results revealed that the app was found to be beneficial, impactful, powerful and trustworthy. In terms of the app's impact, participants reported feeling inspired and hopeful by the Power Stories. The Power Stories included written stories and videos of suicide survivors and supporters which users could see and understand how people in similar situations had overcome adversity. Participants mentioned that tracking daily activities motivated them to adjust their behaviour. The colour-coded progress bars in the Track feature helped identify their areas of improvement. The categorization of progress bars into good, moderate, and bad helped users see their current behaviour and motivated them to change. Seeing their progress on a daily or weekly basis also was found to be positively reinforcing. Participants reported feeling a sense of bonding with the app, like a friend. This was mentioned while using the Track and Favourites features of the app. Both these features involved users documenting their personal behaviours or things. The personalized nature of tracking one's daily activities (like diet, sleep, stressors, movement, journal) or documenting one's favourite things (like photos, videos, hobbies, artwork) appealed to users and made them feel a sense of connection with the app. Interestingly, one of the design recommendations from our previous study [36] was that the app should be adaptable and personalized as per different users' needs. Hence, we updated the final design to be more personalized to the user.

## 6.2 Emotional Support and Wellbeing

In a taboo field like suicide, people can find it hard to publicly open up about themselves or their family members dealing with suicidality. They often feel uncomfortable or alone in their struggles. A participant in our previous study said, "*You feel really alone because you can't discuss this matter with others. You don't want them to judge your loved one.*

*Because of the stigma around, mental health and suicide, it's not easy to bring this topic up and talk to others. Even if you are not living in your home country, the stigma still is around with you. You don't want others to feel you coming from a difficult family or you know, your family is not strong enough*" [P16]. It was thus essential that the app comforted the user or gave them a positive space where they could feel less alone and strong. The Favourites feature of the app was found to be a special private little space for participants. The Track feature was found to be something participants wanted to come back to, to see their progress. Participants mentioned that if they're feeling low, they could see their daily progress in Track or favourites things in Favourites and feel better. The Power Stories, showcasing stories of people who pulled through similar situations was also found to make participants feel hopeful and less alone in the journey of supporting someone else.

In terms of value, participants found the app to be a good go-to resource for preventive support. They appreciated the targeted information in the app on supporting someone with suicidal thoughts. In our previous study, participants had recommended that the app should be very on point and should direct users to specific materials as they are already in a difficult situation. We incorporated this app design recommendation into the final design. Before developing the app, we ensured that we sourced accurate and appropriate information for different sections of the app like Supporter Guide, Find Nearby Support, Power Stories, Track and Favourites. Finally, participants found the app beneficial for caregivers including parents, teachers or other people who are supporting someone experiencing suicidal thoughts. Interestingly, a participant highlighted that suicidal thoughts are not standalone and can stem from underlying mental health conditions. Consequently, some participants mentioned that the app is helpful not only for supporting someone with suicidal thoughts but also for supporting someone struggling with mental health issues. A participant said, "*I think we can recommend this to support with suicidal thoughts or people struggling with mental health. So suicidal thoughts can actually be an after-effect of this whole thing on mental health generally. Or one can actually lead to the other. So they are both dependent on each other. Somebody thinking of suicide, can actually begin to go through mental health issues that will compound a lot of things you're tracking right now. So it's very good, not only for them, it's good for people having mental health issues as well*" [P04].

To understand the app's impact on mental wellbeing, we measured change in participants' wellbeing scores from baseline (pre-study) to follow-up (post-study). We observed that the average wellbeing scores increased from pre-study (M = 24.20, median = 23.21) to post-study (M = 26.86, median = 25.53). The mean change in wellbeing scores from baseline to follow-up was 2.66 points, demonstrating that mental wellbeing meaningfully improved over the course of using the LifeLink app. Mean ranks computed from the Wilcoxon-signed rank test revealed that 80% participants had a higher wellbeing score post-study (i.e., after using the app) than pre-study. 18% participants saw no change in their wellbeing and 2% participants saw a decline in their wellbeing after using the app. This decline in wellbeing score can be accounted for by other confounding factors which the study didn't take into consideration e.g., trauma, comorbid health conditions, other risky behaviours, debt, housing, work-life balance, income, environment, food security, loss of loved one and poor family functioning. Some of these factors are internal and others are external to an individual. Nonetheless, these factors were not controlled for during the study and could

have contributed to some of the unexpected scores. Our qualitative results confirmed the consensus opinion that the app had a positive effect on participants' wellbeing. Tracking daily activities was found to be motivating and helpful in shaping one's wellbeing over time. Journaling thoughts was found to help minimize participants' worries and make them feel a sense of control. Interestingly, the journal feature was a design recommendation by participants from our previous study, which was incorporated into the final design. The information within Supporter Guide, Find Nearby Support and Power Stories was found to be useful in guiding caregivers about how to support someone experiencing suicidal thoughts. The app was found to give participants something to look forward to, made them feel confident, calm and helped develop a positive outlook on life. Overall, LifeLink app usage was associated with improved mental wellbeing, indicating a positive impact on mental health.

## 6.3 Perceived Persuasiveness

In terms of perceived persuasiveness of the app, all persuasive strategies implemented in the app had a statistically higher persuasiveness score than the midpoint score. This means that our participants perceived all the strategies as significantly persuasive or effective for supporting an individual experiencing suicidal thoughts. Participants found the Simulation strategy within Power Stories ($t(49) = 9.99$, $M = 4.02$, $p = 0.001$) to be most persuasive. This was further confirmed by our qualitative results wherein participants mentioned that Power Stories was one of the most appealing aspects of the app. Participants said that seeing others in a similar situation and observing how they were able to pull through their struggles gave them hope, inspiration and made them feel less alone in their own journey. Interestingly, our previous study found that one of the caregivers' approaches to dealing with suicidality is connecting with people who have had similar experiences. As found in our previous study, caregivers can sometimes feel exhausted, drained out and alone while supporting someone experiencing suicidal thoughts. The LifeLink app was able to build on this identified concern from the previous study by incorporating the Power Stories feature. This feature was suggested by some participants in the previous study and was found to be most persuasive or effective in supporting someone experiencing suicidal thoughts. This shows the importance and impact of a user-centred design. We asked our users what they wanted in an app being designed for them (study one), delivered the feature they suggested (in this case, Power Stories) and in turn found it to be the most persuasive or effective feature for supporting someone experiencing suicidal thoughts. Overall, the persuasive strategies within the LifeLink app were found to be effective in influencing caregiver behaviours and attitudes toward supporting individuals experiencing suicidal thoughts.

We found that real-world feel and customization persuasive strategies were the least persuasive of all the implemented persuasive strategies. Contrastingly, our qualitative results revealed that participants found the dark mode theme helpful and appreciated the customization capabilities of the app. To understand these opposing results, we must first reflect on what the 'real-world feel' persuasive strategy means. It states that 'a system that highlights the people or organization behind its content or services will have more credibility". So, having the developer and app information in 'About Us' section (implementation of real-world feel strategy) or having the 'Dark Mode Theme' toggle (implementation of customization strategy) within Settings, although useful for users, was

least effective or persuasive in influencing caregiver behaviours and attitudes toward supporting individuals experiencing suicidal thoughts. In other words, the Settings feature of the app while being useful, was the least effective or persuasive (in comparison to other app features) in influencing caregiver behaviours and attitudes toward supporting individuals experiencing suicidal thoughts.

## 6.4 Accessibility and Inclusivity

One participant felt that although the app was dense with information on suicide prevention, the content seemed more suited for a website instead of a mobile app. On the other hand, several participants emphasized that nowadays smartphones are ubiquitously found and having all resources readily available within the LifeLink app was more accessible, beneficial and handy for time-sensitive crisis situations. A website, while capable of presenting enough information, would not be the preferred platform for a caregiver looking for help instantly. During the conception of this app, we had found numerous websites with resources on suicide prevention but not a single smartphone app designed specifically for caregivers, that would be handy and easy to use. With that gap in mind, we set forward to develop the LifeLink app. Accessing helplines, locating and connecting to nearest support centres from websites can be a cumbersome and exhausting task, as mentioned by many participants in our previous study. We made that easier by curating provincial and national resources and making them accessible by call or chat directly from users' handheld devices.

A recurring finding from both our studies was that participants were unaware of any apps for suicide-related concerns. Some participants compared this dearth of apps for suicide prevention to apps for fitness, for which they could easily get several recommendations from people. The societal stigma around suicide is deeply rooted and this creates invisible barriers in our society for those that deal with suicidality. As a society, this calls for policies, technologies and open discourse on suicide that can reduce fear of judgement and mental health stigma. Another common finding from both studies was that tracking daily activities (in turn their wellbeing) was found to give users a sense of control and progress. This progress often gets overlooked and seeing one's progress in wellbeing using metrics can be helpful. Some participants found that tracking daily activities with the app made their day more manageable. This finding highlighted the crucial role a sense of control and progress play in maintaining one's wellbeing and emotional health.

In our previous study, participants suggested that some of the app feature names could be revised to be more convincing and neutral. In line with this, we revised the name Crisis to Contact, Network to Add Contact, Analyze to Track, Learn to Supporter Guide, Things-to-do to Hobbies, and Progress to History. In our previous study, some participants had found music to be a calming aspect of the Home feature. Simultaneously, some participants highlighted that the music available on the app is crucial as it is difficult to determine what type of music can potentially trigger. In light of this, we dropped the music feature from the final design. This was not a costly decision in terms of design, given the number of features we were already incorporating in the LifeLink app.

## 6.5 Design Recommendations

Based on our findings, we offer several key design recommendations for researchers, designers, and developers creating smartphone apps especially those for caregivers dealing with suicidality:

- **Design Recommendation 1: Improve Emotional and Motivational Appeal through Storytelling.** Users found the Power Stories—narratives of suicide survivors and their caregivers—particularly inspirational and motivational. As one participant noted, "*The power stories really drive home impact and make you realize you're not alone*" [P31]. Storytelling fosters emotional connections and provides motivational support. Designers should prioritize including personal narratives and consider rotating stories to keep users engaged. Tailoring stories to user preferences can further enhance personalization and impact.
- **Design Recommendation 2: Integrate Tracking and Self-Reflection Feature as a Coping Mechanism.** Many users valued tracking features like sleep and diet, which enabled them to reflect on their wellbeing. One participant remarked, "*It helped me keep track of my own well-being, and I now realize I need to take care of myself first"* [P47]. Tracking provides a sense of control and helps caregivers manage their wellbeing. Designers should ensure tracking features are intuitive and simple. Additionally, integrating reminders and progress visualizations and providing self-care resources can be beneficial for enhancing motivation and engagement.
- **Design Recommendation 3: Ensure Ease of Use and Accessibility.** Users appreciated LifeLink's simplicity and straightforward design, crucial for caregivers under stress. A complex interface can hinder effective use. Designers should streamline the interface, ensure smooth functionality across devices, and simplify features like calorie tracking. A minimalistic design with essential functionalities and strategic use of whitespace can reduce information overload and cognitive load.
- **Design Recommendation 4: Use Art, Poetry, and Creativity for Therapeutic Purpose.** Users valued creative features such as poetry and artwork for emotional relief and engagement. Art provides a therapeutic outlet. Designers should consider expanding expanding these features, allowing users to share their creations, and offering customization options (like theme preferences) can boost engagement.
- **Design Recommendation 5: Provide Contact and Support Resources.** The app's ability to quickly connect users with emergency contacts and resources was highly valued. One participant said, "*The emergency contact feature was handy for accessing resources in my province*" [P07]. Timely access to crisis support is vital. Designers should ensure accuracy and availability of local resources, integrate real-time updates and geolocation services, and make crisis contact information easily accessible.
- **Design Recommendation 6: Ensure Users' Privacy and Offer Personalized Contents.** Users appreciated the app's privacy settings, particularly around personal data and suggested further personalization based on user preferences. Privacy is a significant concern, especially in sensitive mental health contexts. Designers should implement robust privacy measures, clearly explain data use, and

enhance personalization by allowing users to adjust settings and preferences. Offering customizable themes, notifications, and content based on user context can increase satisfaction and relevance.

- **Design Recommendation 7: Provide Comprehensive Resources.** Users appreciated the app's comprehensive set of resources, which catered to different needs and preferences. The variety of features, such as power stories, tracking tools, supporter guides, and crisis contacts, provided a holistic approach to supporting caregivers. One participant said, "*I really like the fact that we have a lot of resources available on the app to kind of support different needs at any particular point in time*…" [P04]. Designers should focus on providing a diverse range of resources that cater to different user needs and preferences and ensure they are easily accessible and navigable.
- **Design Recommendation 8: Expand and Diversify Educational Content.** Designers should incorporate comprehensive and easily digestible educational content on suicide prevention to empower caregivers with knowledge and skills. Breaking down complex topics into manageable segments and using multimedia can enhance understanding. Integrating visual content (e.g., image and video) and coping mechanisms can make the app more engaging, supportive, and enhance overall experience.

By using these recommendations, app developers can create more effective and user-friendly tools for caregivers navigating the challenges of supporting individuals experiencing suicidality.

## 6.6 Limitations and Future Work

Although our study revealed valuable insights, our work has some limitations. We outline the limitations of our app and study below along with plans for addressing them in future research:

i. Our sample size was limited with participants mostly living in Canada, English-speaking, having stable housing and employment. Majority of our participants were from Western countries, which could introduce geographical and cultural biases. Therefore, our findings may not represent the experiences of others and might not be generalizable to all populations. Future studies evaluating the app with broader populations and greater sample size, including people from different cultural or socio-economic backgrounds can provide more insights on the app's generalizability.

ii. Our study was focused on Android smartphones, preventing generalization to all smartphone users. This is because of iOS's more restrictive development environment for developers in comparison to Android. Future work can investigate adapting the LifeLink app for iOS users.

iii. Our study did not include a control group, making it difficult to isolate the effects of LifeLink app on caregivers' wellbeing. Confounding factors that were not controlled for during the evaluation could have impacted the study outcomes. These factors include other caregiving resources that participants may have had access to outside the app, external support systems like family members, variations in participants' mental health status, stress levels, and personal coping mechanisms.

Future studies with a control group can provide a better understanding of the app's impact on caregivers' wellbeing.

iv. Our study was conducted over a short period. A longitudinal study can provide further insights into the app's long term effects on caregivers' mental wellbeing.

v. Subjective approach is a common approach for conducting research however there may be bias due to self-reporting.

vi. Future studies can also incorporate app design recommendations provided by users to refine the app and evaluate the newer version of the app.

# Chapter 7 - Conclusion

In this work, we explored how mobile-based apps can be better designed to support caregivers of individuals experiencing suicidal thoughts. Designing mental health technologies for and with caregivers is crucial, as they face unique challenges while dealing with suicidality. We designed LifeLink, a persuasive mobile application to support caregivers of individuals experiencing suicidal thoughts. LifeLink utilizes a user-centered design approach and persuasive design principles to support caregivers. To inform the design of LifeLink, we used findings from our review of existing literature and created a low-fidelity prototype of LifeLink, implementing various evidence-based persuasive strategies. Through a survey and semi-structured interviews, 45 caregivers (residing in Canada) evaluated the user experience of LifeLink app prototype and shared their perspectives, challenges, needs when supporting individuals experiencing suicidal thoughts. We incorporated caregivers' design recommendations to refine the app design and then developed the LifeLink app.

Through surveys and semi-structured interviews, 50 caregivers (residing in Canada) evaluated their experience with the LifeLink app after using it for a week. LifeLink was found to be easy to use, minimalistic, engaging, useful, elicited positive user experience, helpful and impactful for caregivers. We found that all the persuasive strategies implemented in LifeLink were effective and significantly persuasive in influencing caregiver behaviours toward supporting individuals experiencing suicidal thoughts. Additionally, LifeLink app usage was associated with improved mental wellbeing, indicating a positive impact on mental health. We found that the educational content, inspirational stories, daily activity tracking and diverse resources provided by LifeLink increased mental health literacy and fostered a supportive environment for caregivers. We present recommendations for designing mobile-based technologies for supporting caregivers dealing with suicidality. We also highlight the importance of involving caregivers, as experts through experience, in the design process.

This work broadens our understanding of the perspectives, needs and challenges of caregivers supporting an individual experiencing suicidal thoughts and how a mobile application can be designed to reflect their needs and experiences. Some of the key takeaways from our work are: First, caregivers often face stressful situations when supporting someone experiencing suicidal thoughts. A complicated user interface can hinder their ability to use any app effectively. Designers should maintain a simple and minimalistic interface to reduce the cognitive load on users. Second, suicide is a multifaceted phenomenon and manifests differently in different people. Apps should have customization and personalization capabilities to cater to different user types. This will enhance user experience of the app, increase user satisfaction and make the app's content more relevant. Third, caregivers in the process of supporting someone else often struggle with their own mental health. Apps should provide self-care resources and ways for caregivers to monitor their own mental wellbeing while supporting others. Fourth, immediate access to professional help is critical in emergency situations. Apps should provide quick access to crisis support resources by ensuring that such information is easily accessible from the app's home screen. This is essential because of the time-sensitivity

associated with emergency situations. Finally, incorporating educational content related to suicide prevention within apps in an easily digestible format can help caregivers with knowledge and skills. Caregivers have expressed difficulty finding learning resources on suicide prevention in a comprehensive format. Apps utilizing multimedia content, with regularly updated content, can be beneficial to caregivers. This will also override caregivers' difficulty in finding information openly because of fear of judgement and mental health stigma. Content which portrays stories of people in similar situations can also be helpful. The insights gained highlight the importance of designing apps that are not only supportive of caregivers' roles but also address their wellbeing and provide immediate resources in critical situations. Based on our findings we offer design recommendations for future work.

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# Appendices

## Appendix A: List of 54 apps included from Google Play Store & iOS App Store.

| | |
|---|---|
| 1. | 1n5-reach-out |
| 2. | a-friend-asks |
| 3. | A Teen Suicide Prevention Animation |
| 4. | Absurd World |
| 5. | Alachua Talk |
| 6. | Alaska Careline |
| 7. | Albany County Hope |
| 8. | ALNG Soldier and Family Support |
| 9. | Anemone Crisis App |
| 10. | AuxiliaApp |
| 11. | BackUp |
| 12. | Be Calm |
| 13. | Be Safe |
| 14. | Better Stop Suicide |
| 15. | Calm Care |
| 16. | Calm Harm |
| 17. | Calm Urge: Self Harm Tracker |
| 18. | Calma |
| 19. | Case Western Reserve Reach Out |
| 20. | Cycle Against Suicide |
| 21. | DHS - Columbia Protocol |
| 22. | Distract |
| 23. | Don't Panic |
| 24. | First Step Oregon |
| 25. | Friend2Friend |
| 26. | HarmLess: Self Harm Tracker |
| 27. | Hello Lifeline |
| 28. | Hope by CAMH |
| 29. | I am Strong |
| 30. | Insist |
| 31. | iwontbesilent |

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|---|---|
| 32. | Jewish Care |
| 33. | Kansas - A Friend Asks |
| 34. | LifeSupport |
| 35. | notOK |
| 36. | Operation Life |
| 37. | Operation Reach Out |
| 38. | R U Suicidal? |
| 39. | ReliefLink |
| 40. | ReMinder Suice Safety Plan |
| 41. | Safety Net |
| 42. | Shatter the Silence |
| 43. | Stay Alive |
| 44. | Suicide Alternative Channel |
| 45. | Suicide Lifeguard |
| 46. | Suicide Safe by SAMHSA |
| 47. | Suicide Safety Plan |
| 48. | TalkCampus |
| 49. | TalkLife |
| 50. | The LifeLine |
| 51. | There Is Hope |
| 52. | Tufminds |
| 53. | Virtual Hope Box |
| 54. | Yellow Ribbon App |

## Appendix B. Summary of app characteristics and evaluation methods of apps from the reviewed 26 studies.

Legend: BIS-II – Baratt Impulsivity Scale -II, BSS – Beck Scale for Suicidal Ideation, C-SSRS – Columbia Suicide Severity Rating Scale, DSI-SS – Depressive Symptom Index-Suicidality Subscale, GHQ-12 - General Health Questionnaire, GAD-7 - Generalized Anxiety-Disorder 7, MINI - Mini International Neuropsychiatric Interview, MFQ – Mood and Feelings Questionnaire, NSSI – Non-suicidal self injury, PHQ-9 – Patient Health Questionnaire, RCADS – Revised Child Anxiety and Depression Scale, RCT – Randomized Control Trial, SDQ – Strengths and Difficulties Questionnaire, SIDAS – Suicidal Ideation Attributes Scale, SITBI – Self-Injurious Thoughts & Behaviors Interview, SSF-II-R – Suicide Status Form

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| BackUp | (Pauwels et al., 2017) | Belgium | 18-54 years; Adults | 21 individuals with suicidal ideation | Safety plan, hope box and coping strategies. | Pre–post single group | BSS | Small and nonsignificant decrease in suicidal ideation |
| BeSafe | (Huggett et al., 2017) | Canada | Youths | Youth and young adults | Safety plan aimed at the adolescent population contains information on mental health and addiction resources, plus a "get help" script that helps users find the right words for seeking help | Mixed-method | Not Reported | 86% of participants showed interest in the app. |
| BeyondNow | (Melvin et al., 2018) | Australia | 16-42 | 36 patients with suicidal ideation | Safety planning | Open-label single group trial | C-SSRS | Significant reduction in suicidal ideation. Increased suicide related coping strategies and suicide resilience. |
| BlueIce | (Stallard et al., 2018b) | UK | 12-17; Young people | 40 young people who were currently self-harming or had a history of self-harm | Personalized toolbox of strategies based on theoretical approaches, including DBT, CBT, mindfulness, and behavioral activation. | Pre-test/post-test | MFQ, RCADS, SDQ | App was accessible, easy to use and convenient. Many highlighted the mood diary and mood lifter sections as particularly helpful in offering a way to track their moods and offering new strategies to |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | manage their thoughts to self-harm. |
| Brake of My Mind | (Jeong et al., 2020) | South Korea | 12-16; adolescents | 4 adolescents with past history of suicide attempt | Safety Plan | Pilot study one group pre–post test | Not Reported | Decrease of positive attitude toward suicide, subjective norms and suicide intent. |
| BRITE app | (Kennard et al., 2018) | USA | 12-18; adolescents | 66 adolescents hospitalized for suicidal ideation or recent suicide attempt (34 intervention group; 32 control group) | Comprises four modules: chain analysis and safety planning; distress tolerance and emotion regulation; increasing positive affect by planning pleasant activities; and review of the skills, safety plan | RCT | C-SSRS | No significant differences in suicide attempt |
| CALMA | (Rodante et al., 2020) | Argentina | 18-65; adults | 21 individuals with suicidal ideation/attempt/plan/self-injurious behaviours (11 intervention group, 10 control group) | Psychoeducation and DBT strategies to cope with suicidal crisis. | Pilot cluster RCT | SITBI | Higher but nonsignificant reduction in suicidal behavior in the intervention group as compared to control group |
| Crisis Care | (McManama O'Brien et al., 2016) | USA | 13-18; adolescents | Suicidal adolescents recruited from an outpatient psychiatric department | Adolescent mode: coping skills + receive immediate help. Parents mode: listening strategies, coach adolescents in coping skills, receive immediate help. | Not Reported | Not Reported | Results demonstrated acceptability and usability of the app, as an adjunct to treatment for suicidal adolescents and their parents following discharge from acute care settings. |
| DBT Coach | (Rizvi et al., 2016b) | USA | 19-49; adults | Patients with Borderline Personality Disorder and history of self-harm and/or suicide attempt | The app includes content from all 4 modules of DBT skills manual (mindfulness, distress tolerance, emotion regulation and interpersonal effectiveness skills). | Pre-test/post-test | Not Reported | Results indicate good acceptability and usability of the DBT Coach. App reduced subjective distress and urges to self-harm following app use. |
| Ecological Mental Momentary Assessment (EMMA) | (Morgiève et al., 2020) | France | 18+; adults | Patients with recent suicide attempt or suicidal ideation | Self-help tool for suicidal crisis management (warning signs, coping strategies, distraction activities, social support). | Not Reported | Not Reported | Patients have different clinical and digital profiles and needs that require a highly scalable, interactive, and |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | customizable app. Recommended that EMMA should be integrated into existing emergency procedures. |
| iBobbly | (Povey et al., 2016) | Australia | 18-60; Aboriginal adults | Aboriginal and Torres Strait Islander adults | Based on ACT and MBCT. Self-help tool with three self-assessment and three activity modules. Self-assessment modules ask the user whether they are experiencing intrusive thoughts, including suicidal thoughts; if so, they are directed to emergency line. Three activity modules help users manage upsetting thoughts and emotions, identify ideals and set realistic goals. | RCT | DSI-SS, PHQ-9, BIS-11 | Three themes were observed: personal factors, environmental factors and app characteristics. Personalized adaptations, such as local production, culturally relevant content and graphics, a purposeful journey, clear navigation, meaningful language, options to assist people with language differences, offline use and password protection may facilitate app usage. |
| iBobbly ACT | (Tighe et al., 2020) | Australia | 18-35; Young adults | Indigenous Australian adults with recent suicidal ideation or suicide attempts | Identification of feelings and thoughts, emotion regulation, identification of values using ACT | Pre-test/post-test | Not Reported | Regression analysis in this study did not indicate a significant effect of app use on psychological wellbeing. Engagement with the app was however positive. App was considered culturally safe and of therapeutic valu e. Qualitative analyses demonstrated that app use was associated with self-reported improvements in psychological wellbeing, mental health literacy and |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | reductions in shame. |
| LifeApp'tite | (O'Toole et al., 2019b) | Denmark | 18-65; adults | 129 patients of a suicide prevention clinic admitted due to rec ent suicidal thoughts (60 intervention group, 69 control group) | Psychoeducation, self-rating assessment, sleep recording, appetite and stress levels, safety plan, digital hope kit. | RCT | SSF-II-R | Intervention group experienced a smaller decrease in suicide risk |
| LifeBuoy | (Torok et al., 2022) | Australia | 18-25; young adults | 455 young adults with SI (228 intervention group, 227 control group) | DBT-based intervention to improve emotion regulation and distress tolerance. | Parallel, double blind RCT | SIDAS, PHQ-9 | Significant improvements in suicidal ideation severity |
| MEmind and eB2 | (Porras-Segovia et al., 2022) | Spain and France | 18+; adults | Psychiatric patients with history of suicidal thoughts and behaviours | MEmind: active EMA (ecological memory assessment) that explores 4 areas: passive SI, negative feelings, sleep disturbances, appetite. eB2: passive EMA that provides feedback to the patient about weekly physical activity and sleep habits. It includes a mood diary module. | Not Reported | Not Reported | High participation rates; retention rates decreased steadily over the follow-up period. Passive EMA showed higher retention rates than the active EMA. |
| Mobile Application for the Prevention of Suicide (MAPS) | (Primack et al., 2022) | USA | Adult veterans | 8 veterans hospitalized for suicidal ideation or suicide attempt | EMA to identify suicide risk in the moment and to deliver treatment strategies in real time. | Not Reported | Not Reported | Veterans reported high levels of satisfaction with MAPS, and all opted to extend their use of MAPS beyond the 2-week trial period. App may be a useful adjunctive to treatment as usual for high-risk veterans. |
| MYPLAN | (Stefanopoulou et al., 2020) | Denmark | Young people and adults | Young and adult users attending Danish Suicide Prevention Clinics, relatives, and clinicians | Safety plan. | Qualitative, RCT | Not Reported | Helpful for learning to recognize early signs of an impending crisis, and for coping by actively finding personalized problem-solving strategies. Learning how to effectively implement a safety plan was not perceived to be simple, and |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | additional support should be considered for MYPLAN users. |
| Run4Love | (Li et al., 2019) | Not Reported | 18-51; adults | 300 Outpatients with HIV and depression (150 intervention group, 150 control group) | Based on adaptive/behavioral stress management, delivered through the social platform WeChat. Included coping strategies, encouragement of physical activity, social support, progress tracking and personalized feedback | RCT | Questions about suicidal thoughts & suicide attempts | 57.6% reduction of suicidal ideation or attempts in the intervention group v/s 15% in control group ($p < 0.001$) |
| SafePlan | (O'Grady et al., 2020b) | Ireland | 14-16 | Students | Mental health support and safety planning. | Qualitative | Not Reported | Participants perceived the main benefits of the SafePlan app to be its overall user interface design and emphasis on user confidentiality. Small number of potential improvements were suggested. |
| StopBlues | (Anaı¨s et al., 2019) | France | Not Reported | General population | Psychoeducational program aimed at the general population. Contains general information about mental health, a mood tracker, self-assessment questionnaires, a safety plan, relaxation techniques, mindfulness exercises, and a "get help now" button to directly contact emergency services | Cluster randomized clinical trial | GHQ-12, PHQ-9, GAD-7, MINI | App was considered acceptable, usable. Demonstrated good retention rates. |
| Strength Within Me (SWiM) | (Bruen et al., 2020) | UK | 18-61 | Psychiatric inpatients with history of suicidal thoughts or suicide attempt | Journaling and safety plan. | Not Reported | Not Reported | Study highlighted he importance of building key relationships and the implications of using Facebook as a source to detect suicidality. |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| TalentLMS | (Schiffler et al., 2022) | Austria | 18-23; transitional age youth | Patients with Borderline Personality Disorder | Offers DBT-based contents and downloadable worksheets to train DBT skills. | Not Reported | Not Reported | Six overarching themes were identified through qualitative analysis: (1) experiences with DBT skills, (2) phenomenon of self-harm, (3) feelings connected with self-harm, (4) dealing with disorder-specific symptoms, (5) prevention of self-harm, and (6) attitude toward skills apps. In general, the provision of an app with DBT content achieved a positive response among participants. Participants could imagine its benefits by integrating their use of the app as a supportive measure for personal psychotherapy sessions. |
| Therapeutic evaluative conditioning (TEC) | (Franklin et al., 2016b) | Canada, USA, Australia, Europe | Young adults and adults | Individuals with self-injurious thoughts and behaviors.<br>Study 1: 114 (55 intervention group; 59 control group);<br>Study 2: 131 (62 intervention group; 69 control group);<br>Study 3: 163 (78 intervention group; 85 control group) | Consisted of a brief, game-like treatment that could be accessed by any device with an Internet connection. | RCT; 3 studies | SITBI | Study 1: fewer NSSI episodes and suicide plans in intervention group; no significant differences in suicidal ideation.<br>Study 2: no significant differences in NSSI, suicidal ideation or suicide plans.<br>Study 3: fewer NSSI episodes and suicide plans in intervention group; no significant differences in |

| App | Study | Country | Age Range | Study Population & Characteristics | Intervention Characteristics | Study Design | Suicidal Outcome Measures | Main Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | suicidal ideation. |
| TransLife | (Dubov et al., 2021) | USA | 18+; adults | Transgender individuals | Mood logger | Not Reported | Not Reported | Engaging, acceptable, and potentially effective mental health intervention. Participants reported that the app was easy to use and understand, supported mental self-care, promoted self-awareness and helped them to identify triggers of negative moods. |
| Virtual Hope Box (VHB) Buus | (Bush et al., 2017; Denneson et al., 2018) | USA | Adults | 118 veterans with SI (58 intervention group; 60 control group) | Patient-tailored coping tools. | RCT | BSS; C-SSRS | High-risk patients and their clinicians used the app more regularly and found it beneficial, useful, easy to use, and said they were likely to use it in the future and recommend it to peers. |
| WellPATH | (Kiosses et al., 2022) | USA | 50-85; Middle-aged and older adults | Psychiatric inpatients with suicide risk | List of triggers and negative emotions associated with suicidal ideatino and personalized cognitive reappraisal techniques to reduce negative emotions. | Not Reported | Not Reported | Participants and their therapists reported high satisfaction with the app and provided several feedbacks for future research and development. |

## Appendix C. Recruitment Notice Study One

**Project Title:** Design and Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Description**

You are invited to participate in a research study being conducted by Smriti Jha at Dalhousie University. The purpose of the study is to evaluate the design of a mobile application that supports caregivers of individuals experiencing suicidal thoughts. You will be asked to explore an app prototype and provide your opinion. Through a questionnaire and an optional interview, you will be asked your feedback on the content, functionality, format, and design of a mobile application for suicide prevention in Canadian youths and adults. The questionnaire and optional interview may take 15 minutes and 30-40 minutes respectively.

**Who Can Take Part in the Research Study**

To take part in this study, you must:

- Be 16 years of age or older.
- Live in Canada.
- Be proficient in English.
- Have supported or are supporting an individual experiencing suicidal thoughts including their caregivers, partners, grandparents, families, chosen family, friends, teachers, guidance counsellors, SchoolsPlus workers, coaches.

By participating you can also enter in a lucky draw in which 2 winners will receive a $50 Amazon Gift Card each.

To express your interest in participating in this study, please email the lead researcher, Smriti Jha at smriti.jha@dal.ca.

This study has been approved by the Dal Research Ethics Committee (Project ID 2023-6824)

## Appendix D. Recruitment Poster Study One

## Appendix E. Consent Form for Study One Survey

DALHOUSIE UNIVERSITY

**CONSENT FORM**

**Project Title:** Design and Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Lead Researcher:** Smriti Jha, Faculty of Computer Science, Dalhousie University

Smriti.Jha@dal.ca

**Supervisor**: Dr. Rita Orji, Faculty of Computer Science, rita.orji@cs.dal.ca

**Introduction**

We would like to invite you to participate in a research study being conducted online by Smriti Jha. You may leave the study at any time. This is a study, and participation is entirely voluntary. The information provided below explains what is involved in the research, what you will be asked to do, and any benefits, risks, or inconvenience or discomfort that you might experience. Participating in the study may not benefit you, but it is possible that we will learn something that will benefit others. You should ask Smriti, the lead researcher, any questions you have about this study. Please feel free to ask as many questions as you want. If you have any further questions, please contact the researcher, Smriti Jha (smriti.jha@dal.ca)

**Purpose and the Research Study**

The study's goal is to create a mobile application that supports caregivers of individuals experiencing suicidal thoughts. The study will include a survey and an optional one-to-one interview after the survey. You will be asked to explore a mobile app prototype and give your opinion about the design, concept, and features. If you chose to participate in the one-on-one interview, you will also be asked to share your feedback, experience, and share your likes and dislikes about the prototype along with your valuable suggestions about the design of the app. The survey may take up to 15 minutes.

**Who Can Take Part in the Research Study**

To participate in this study, you must be living in Canada, 16 years or older in age, proficient in English and have supported or are supporting an individual with suicidal thoughts.

**Possible Benefits**

The answers that you and other participants share with us will teach us about the needs and concerns of caregivers supporting an individual experiencing suicidal thoughts. It will help us understand how digital technologies for suicide prevention can be better designed to support caregivers and individuals like you in the future.

**Possible Risks and Discomfort**

There is no potential economic risk associated with this study. Some of the questions - might make you feel uncomfortable, or make you remember things that were upsetting. If

any questions are upsetting, I want you to let me know so I can arrange for you to speak to someone. Also, you are totally allowed to skip a question that you don't feel comfortable answering. That is 100% okay. If you decide you want to stop altogether ~ that's okay too. In addition, we want to let you know of the support resources available, including:

1. If you are under 16: Kids Help Phone (text CONNECT to 686868. No data plan or internet connection needed.)

2. If you are an adult (18+): Talk Suicide Canada (24/7 toll-free helpline 1-833-456-4566)

3. Support Services Directory (Search for nearest support centre at https://suicideprevention.ca/resources/#support-service)

4. Seana Jewer: a suicide first-aid trained facilitator can be reached at Seana.Jewer@nshealth.ca. Please let us know if you would like to speak to them and we can arrange it.

All the answers you share, will be totally anonymous. Only the research team and I will know what you entered. When your answers get entered into the computer ~ your name and answers will be kept completely separate. We will give your responses a "Unique ID" so that no one will ever be able to put your answers and your name together. It's totally private. During the analysis process we will be combining responses from all of the participants together, which will make it impossible for anyone to identify your answers independently, or your identity.

**Compensation**

Your email will be entered into a lucky draw for a chance to win 1 of 2 Amazon gift cards worth 50$ each whether you choose to complete the study or not. Please note that only two persons would be randomly selected to win the two 50$ worth Amazon gift cards.

You can check the box below to enter. This is completely voluntary, and not mandatory for the research.

☐ I want to enter the lucky draw to win 1 of 2 Amazon gift cards worth 50$ each.

**How your information will be protected**

All survey responses will be saved on a secure Dalhousie server and password-protected computers to be used for analysis. Only the researcher and supervisor (i.e., Smriti Jha and Dr. Rita Orji) will have access to the data. The collected data would be retained until the data is analyzed, and results are shared in the thesis report, conference, or journal publications. The lead researcher (i.e., Smriti Jha) will destroy all the survey responses and information in 4 months after reporting the results.

**If You Decide to Stop Participating**

If you wish to stop participating, at any point, you can do so by closing the browser. Incomplete responses will not be included in the study. You can also withdraw from the

study at any time as long as the data has not been analyzed (i.e., approximately 2 months from beginning the study).

**How to Obtain Results**

When the entire study will be completed, the results will be published which may hold anonymous comments from participants using participant ID such as P1, P2. No individual results will be provided. You can check the below check box to receive a copy of the publication.

☐ I want to receive the details when the study is published

**Questions**

We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Smriti Jha (Smriti.Jha@dal.ca) or Rita Orji (at rita.orji@dal.ca) at any time with questions, comments, or concerns about the research study. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at 902-494-3423, or email: ethics@dal.ca. and reference REB Submission Project ID 2023-####.

**Consent**

I have read the explanation of this study. I have been given the opportunity to contact and discuss any question related to study and my questions have been answered to my satisfaction.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the survey if I choose.

- Name:
- Email id: _(This email will be used to contact you to inform you if you're the winner or if you have expressed interest in receiving details when the study result is published)
- Date:

☐ **I Consent, and I agree to participate**

Please follow the link [a link to the questionnaire would be inserted here].

## Appendix F. Consent Form for Study One Interview

DALHOUSIE UNIVERSITY

**CONSENT FORM**

**Project Title:** Design and Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Lead Researcher:** Smriti Jha, Faculty of Computer Science, Dalhousie University

Smriti.Jha@dal.ca

**Supervisor**: Dr. Rita Orji, Faculty of Computer Science, rita.orji@cs.dal.ca

**Introduction**

We would like to invite you to participate in a research study being conducted by Smriti Jha on an online platform called "Microsoft teams". You may leave the study at any time. This is a study, and participation is entirely voluntary. The information provided below explains what is involved in the research, what you will be asked to do, and any benefits, risks, or inconvenience or discomfort that you might experience. Participating in the study may not benefit you, but it is possible that we will learn something that will benefit others. You should ask Smriti, the lead researcher, any questions you have about this study. Please feel free to ask as many questions as you want. If you have any further questions, please contact the researcher, Smriti Jha (smriti.jha@dal.ca)

**Purpose and the Research Study**

The study's goal is to create a mobile application that supports caregivers of individuals experiencing suicidal thoughts. The study will include a survey and an optional one-to-one interview after the survey. You will be asked to explore a mobile app prototype and give your opinion about the design, concept, and features. You will also be asked to share your feedback, experience, and share your likes and dislikes about the prototype along with your valuable suggestions about the design of the app. The interview session will last 30-40 minutes. It may take lesser time than this estimate. With your permission, the interview will be audio recorded. If you wish to discontinue at any point of the study, your data will be deleted, and your account will not be used in the study.

**Who Can Take Part in the Research Study**

To participate in this study, you must be living in Canada, 16 years or older in age, proficient in English and have supported or are supporting an individual with suicidal thoughts.

**Possible Benefits**

The answers that you and other participants share with us will teach us about the needs and concerns of caregivers supporting an individual experiencing suicidal thoughts. It will help us understand how digital technologies for suicide prevention can be better designed to support caregivers and individuals like you in the future.

**Possible Risks and Discomfort**

There is no potential economic risk associated with this study. Some of the questions - might make you feel uncomfortable, or make you remember things that were upsetting. If any questions are upsetting, I want you to let me know so I can arrange for you to speak to someone. Also, you are totally allowed to skip a question that you don't feel comfortable answering. You can say "skip", "pass" or "I don't want to answer that". That is 100% okay. If you decide you want to stop altogether ~ that's okay too. In addition, we want to let you know of support resources available, including:

1. If you are under 16: Kids Help Phone (text CONNECT to 686868. No data plan or internet connection needed.)

2. If you are an adult (18+): Talk Suicide Canada (24/7 toll-free helpline 1-833-456-4566)

3. Support Services Directory (Search for nearest support centre at https://suicideprevention.ca/resources/#support-service)

4. Seana Jewer: a suicide first-aid trained facilitator can be reached at Seana.Jewer@nshealth.ca. Please let us know if you would like to speak to them and we can arrange it.

All the answers you share, will be totally anonymous. Only the research team and I will know what you enter. When your answers get entered into the computer ~ your name and answers will be kept completely separate. We will give your responses a "Unique ID" so that no one will ever be able to put your answers and your name together. It's totally private. During the analysis process we will be combining responses from all of the participants together, which will make it impossible for anyone to identify your answers independently, or your identity.

**Compensation**

Your email will be entered into a lucky draw for a chance to win 1 of 2 Amazon gift cards worth 50$ each whether you choose to complete the study or not. Please note that only two persons would be randomly selected to win the two 50$ worth Amazon gift cards.

You can check the box below to enter. This is completely voluntary, and not mandatory for the research.

☐ I want to enter the lucky draw to win 1 of 2 Amazon gift cards worth 50$ each.

**How your information will be protected**

The audio recordings of the interview will be securely stored in password-protected OneDrive, accessible only to the lead researcher (i.e., Smriti Jha) and will be deleted after the results are published.

**If You Decide to Stop Participating**

If you wish to stop participating in the optional interview, you can leave the session. Your contribution will be discarded if you wish to leave. You can also withdraw from the study

at any time as long as the data has not been analyzed (i.e., approximately 2 months from beginning the study).

**How to Obtain Results**

When the entire study will be completed, the results will be published which may hold anonymous comments from participants using participant ID such as P1, P2. No individual results will be provided. You can check the below check box to receive a copy of the publication.

☐ I want to receive the details when the study is published

**Questions**

We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Smriti Jha (Smriti.Jha@dal.ca) or Rita Orji (at rita.orji@dal.ca) at any time with questions, comments, or concerns about the research study. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at 902-494-3423, or email: ethics@dal.ca. and reference REB Submission Project ID 2023-####.

**Consent**

I have read the explanation of this study. I have been given the opportunity to contact and discuss any question related to study and my questions have been answered to my satisfaction.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the interview if I choose.

I understand that my responses during the optional interview will be audio recorded. I agree that direct quotes from my responses may be used without identifying me:

☐ Yes

☐ No

- Name:
- Date:

☐ **I Consent, and I agree to participate.**

## Appendix G. Study One Survey

**<u>Section 1:</u> Demographic Information**

Thank you for kindly agreeing to participate in this study. Please answer all the questions to the best of your knowledge. If you do not wish to answer, you may select "Prefer not to say".

Collecting demographic information helps us understand the diversity of people in a population by knowing information such as their age, race, gender, employment status, and more. In this study, this information will help us to understand how different groups of people deal with suicidality and their varying needs when designing a mobile application for suicide prevention.

*[Q1. – Q4. were consent related questions]*

Q5. Please choose your age range:

- 16 – 18 years old
- 19 – 25 years old
- 26 – 35 years old
- 36 – 45 years old
- 46 – 55 years old
- Over 56 years old
- Prefer not to say.

Q6. Please choose which of the following best describes your gender identity:

- Cis woman
- Cis man
- Trans man
- Trans woman
- Non-binary
- Non-gender conforming
- Other, Please specify: _____

- Prefer not to say.

Q7. What is your marital status?

- Single
- Married
- Widowed
- Divorced
- Separated
- Registered partnership
- Other (Please specify): _____
- Prefer not to say.

Q8. What is your race or ethnicity? (Choose all that apply)

☐ Indigenous (e.g., First Nations, Inuit, Métis)
☐ Black (e.g., African, Caribbean)
☐ White
☐ South Asian (e.g., East Indian, Pakistani, Indian, Sri Lankan)
☐ Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese)
☐ Middle Eastern (e.g., Armenian, Egyptian, Iranian, Lebanese)
☐ Asian (e.g., Chinese, Korean, Japanese)
☐ Filipino
☐ Latin American (e.g., Mexican, South American, Central American)
☐ Mixed race
☐ Other (Please specify):
☐ Prefer not to say.

Q9. Where do you currently live?

- City
- Town
- Rural area
- Other (Please specify): _____

- Prefer not to say.

Q10. Please choose the highest level of education you have completed:

- Less than high school level
- High School or equivalent
- College Certificate or Diploma
- Bachelor's degree
- Above a university bachelor's degree (i.e., Master's, Doctorate, JD, MD)
- Prefer not to say.
- Other (Please specify): _____

Q11. What are your current work or study arrangements? (Choose all that apply)

- Full-time work
- Part-time work
- Casual work
- Own business
- Student
- On government assistance
- Retired
- Not working right now
- Home Duties
- Other (Please specify): _____
- Prefer not to say.

Q12. Over the past month, where have you been staying most days?

- Apartment or house (you or your family rent or own)

- Friend's house/couch surfing
- Relative's house
- Supportive or transitional housing
- In a housing facility (such as a foster home, group home, transition house, halfway house, safe house)
- Boarding arrangement
- No fixed address
- Shelter
- Outdoors, street, park, encampment, stairwell, car
- Jail, correctional facility, or prison
- Hotel/motel/single room occupancy
- Other (Please specify): _____
- Prefer not to say.

Q13. In which province or territory are you currently located?

- Alberta
- British Columbia
- Manitoba
- New Brunswick
- Newfoundland and Labrador
- Nova Scotia
- Ontario
- Prince Edward Island
- Quebec
- Saskatchewan

- Yukon
- Nunavut
- Northwest Territories
- Prefer not to say

**<u>Section 2:</u> Dealing with Suicidality**

Q14. What is your relationship with the person experiencing suicidal thoughts, whom you would like to support? If you have supported/are supporting multiple individuals with suicidal thoughts then please choose all roles that apply to you.

☐ Partner

☐ Family member (e.g. spouse, former spouse, child, stepchild, grandchild, parent, stepparent, grandparent, sibling)

☐ Chosen family

☐ Friend

☐ Teacher

☐ Mentor

☐ Guidance counsellor

☐ SchoolsPlus worker

☐ Coach

☐ Social Worker

☐ Caregiver

☐ Other (please specify): _____

☐ Prefer not to say.

Q15. Which of the following pathways do you try, or have you tried in the past to deal with suicide related concerns? (Please choose all that apply)

☐ Clinical help (therapist, psychiatrist, psychologist)

☐ School/Guidance counsellor

☐ Talking to social worker(s)

☐ Talking to friends

☐ Talking to a family member(s)

☐ Sharing circles, talking circles, peer support, support groups, community initiatives

☐ Suicide helplines

☐ Online communities/forums (e.g., r/SuicideWatch)

☐ Social media (Instagram, Facebook, LinkedIn, Snapchat, Twitter, WhatsApp, Discord, TikTok)

☐ Web content (e.g., articles)

☐ Books

☐ Podcasts

☐ Music

☐ Mobile applications

☐ Video games

☐ Other (please specify): _____

☐ Prefer not to say.

Q16. Have you ever used a mobile application for dealing with suicide related concerns?

- Yes
- No
- If yes, what is the name of the mobile app(s) used? _____
- Prefer not to say.

Q17. How often do you utilize a mobile phone for dealing with suicide related concerns?

- Never
- Few times a year or less
- A few times a month
- Weekly

- Daily
- Prefer not to say.

Q18. What are your concerns when using an existing mobile application for dealing with suicidality? (Please choose all that apply)

☐ Lack of relevant content

☐ Lack of evidence-based sources

☐ Lacking social forums

☐ Missing suicide prevention strategies

☐ Limited access to culturally appropriate resources and materials

☐ Language barriers

☐ Security, data privacy & confidentiality

☐ Other (please specify): _____

☐ Not Applicable

☐ Prefer not to say.

Q19. I think there is a need for a mobile application for caregivers who are supporting someone with suicidal thoughts.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree
- Prefer not to say.

Q20. How likely are you to use a mobile application or technology designed to help you support someone with suicidal thoughts?

- Very likely
- Likely

- Neutral
- Unlikely
- Very unlikely
- Prefer not to say.

Q21. To answer this question, please choose "Agree".

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Q22. How likely are you to sign up for a mobile app that supports you in helping someone with suicidal thoughts?

- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely
- Prefer not to say.

Q23. What kind of technology do you think could support you with suicide prevention? (Please choose all that apply)

☐ Systems and mobile applications that provide access to suicide related educational content (e.g., web sites that inform about the symptoms/triggers of a suicidal individual and provide basic suicide prevention related knowledge).

☐ Systems and mobile applications that teach people suicide prevention strategies (e.g., means reduction, coping strategies, safety planning).

☐ Systems and mobile applications that provide practical support (e.g., apps that help find nearby support groups, support services, help track mood of your person, recommend strategies to support your person).

☐ Communication systems that connect people to suicide prevention support networks (e.g., live chat and phone/video call with healthcare professionals, online discussion forums).

☐ Other, please specify_____

☐ Prefer not to say.

Q24. Please suggest any other aspects or features you would look for in a mobile app for supporting individuals with suicidal thoughts:

- _____
- Prefer not to say.

Q25. Please suggest any additional concerns you would have when using a mobile app for supporting individuals with suicidal thoughts:

- _____
- Prefer not to say.

**Section 3: Prototype Evaluation**

Below are screenshots of a persuasive mobile app prototype called LifeLink. LifeLink is designed for supporting caregivers of individuals experiencing suicidal thoughts. Please take a few minutes to look at these screenshots and read the descriptions carefully and respond to the questions that follow.

Q26. **[Feature name]:**

[Feature description]

[Feature screenshot]

(Q26.) Please rate your level of agreement or disagreement with each of the following statements:

The [feature] would:

| | | Strongly Disagree | Disagree | Somewhat disagree | Neutral | Somewhat agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|---|
| 1. | influence me. | | | | | | | |
| 2. | be convincing. | | | | | | | |
| 3. | be personally relevant to me. | | | | | | | |
| 4. | make me reconsider my approach when supporting a | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | person experiencing suicidal thoughts. | | | | | | | |
| 5. | help me support a person experiencing suicidal thoughts. | | | | | | | |
| 6. | Choose the first option—”Strongly Disagree”—in answering this statement. | | | | | | | |

Q27. Please justify why you think the [feature] would/would not support you in helping a person experiencing suicidal thoughts:

- _____
- Prefer not to say.

Q28 – Q31. Repeat Q26. and Q 27. for each of the features

Q32. Please study all the screenshots of the LifeLink app properly and respond to the questions that follow.

[Screenshots of entire prototype]

(Q32.) Please rate your level of agreement or disagreement with each of the following statements:

| | Statements | Strongly Disagree | Disagree | Neither | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| 1. | I found the app unnecessarily complex. | | | | | |
| 2. | I think the app would be very cumbersome (i.e., complicated) to use. | | | | | |
| 3. | Overall, I think the app would be easy to use. | | | | | |
| 4. | I think that I would need the support of a technical person to be able to use the app. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5. | I would imagine that most people would learn to use this app very quickly. | | | | | |
| 6. | I would need to learn a lot of things before I could get going with this app. | | | | | |
| 7. | I would feel very confident in using the app. | | | | | |
| 8. | I would feel comfortable using this app. | | | | | |
| 9. | Information in the app is well structured and systematic. | | | | | |
| 10. | The icon images in the screen are visually dense. | | | | | |
| 11. | To respond to this statement, please choose option number five, “Strongly Agree.” | | | | | |
| 12. | The layout of the screen is visually dense. | | | | | |
| 14. | The app has some content that stimulates my curiosity. | | | | | |
| 15. | The content of the app would be relevant to me. | | | | | |
| 16. | The content of the app would be useful to me. | | | | | |
| 17. | The purpose of the app makes sense to me. | | | | | |
| 13. | The app would capture and hold my attention. | | | | | |
| 18. | The app design is aesthetically pleasing. | | | | | |
| 19. | The screen design is neat. | | | | | |
| 20. | The screen design is modern. | | | | | |
| 21. | The screen design is well balanced. | | | | | |
| 22. | The app design looks sophisticated. | | | | | |
| 23. | To answer this question, please choose option number four, “Agree”. | | | | | |
| 24. | The app would help me have better knowledge about suicide prevention. | | | | | |
| 25. | The app would help me support a person experiencing suicidal thoughts. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 26. | The app would make me reconsider my approach when supporting a person experiencing suicidal thoughts. | | | | | |
| 27. | The app would address my needs related to supporting a person with suicidal thoughts. | | | | | |
| 28. | The app would influence me. | | | | | |
| 29. | The app features are convincing. | | | | | |
| 30. | The app would be personally relevant to me. | | | | | |
| 31. | The app has unnecessary functions I don't want. | | | | | |
| 32. | The app shows menu categories systematically. | | | | | |
| 33. | The app is designed to provide functions consistently. | | | | | |
| 34. | I would be dissatisfied with using this app. | | | | | |
| 35. | I would like to use this app. | | | | | |
| 36. | I would be disappointed with using this app. | | | | | |

**Section 4: Final Thoughts**

Q1. Is there anything else you would like to share or any additional comments you have regarding the LifeLink app prototype, this survey, or the way this study was conducted? Please feel free to provide any feedback or suggestions in the space provided below.

_____

Q2. Are you interested in participating in an optional one-on-one interview to discuss your experiences further? The interview session may take 30-40 minutes or less. For participants that select 'Yes', we will contact you to schedule a time for the interview.

- Yes
- No

End of survey.

Thank you for your time and contribution to suicide prevention research that may positively improve lives in Canadian communities.

## Appendix H. Interview Questions Study One

**Section 1: Suicide Prevention through a mobile application**

1. What has your overall experience been like when supporting a person with suicidal thoughts?
2. What are some of the current approaches you've used to support someone with suicidal thoughts?

    1. Is there anything you would like to change about your approach when supporting your person?

    2. How do you think a mobile application can help you achieve such a change?

    3. Do you prefer to use mobile applications to help you support your person? Why? Or why not?

3. Do you have any concerns or doubts about using a mobile application for suicide prevention?

    1. What kinds of concerns or doubts?

    2. What challenges or concerns have you faced when using an existing mobile application for supporting your person?

    3. Can you please provide some examples?
4. Let's say you have to design a mobile application for supporting a person with suicidal thoughts.

    1. What would it look it?

    2. What features would you want?

**Section 2: Feedback on the app prototype**

1. What were your overall opinions on the app prototype?

    1. What did you like?
    2. What didn't you like?

2. What were your general thoughts about the Home Screen features?

    1. Would you use it?

    2. What did you like?

    3. What would you change?

3. What were your general thoughts about the Crisis feature?

    1. Would you use it?

    2. What did you like?

    3. What would you change?
4. What were your general thoughts about the Analyze feature?

    1. Would you use it?

    2. What did you like?

    3. What would you change?

5. Which feature did you like the most? Why?
6. Is there any feature that you did not like? Why?
7. Do you have any ideas for improving the app? Do you have any suggestions/comments about the app overall?
8. Do you think if we were to proceed to develop this prototype into an actual application, would you use it?
9. Is there anything else you would like to share about your experience that I have not asked you?
10. Do you have any questions for me?

## Appendix I. Recruitment Notice Study Two

**Project Title:** Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Lead Researcher:** Smriti Jha, Master of Computer Science, Faculty of Computer Science, Dalhousie University
**Academic supervisor**: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University
**Contact Person:** Smriti Jha, smriti.jha@dal.ca.

### Description

You are invited to participate in a research study being conducted by Smriti Jha at Dalhousie University. The study's purpose is to evaluate the design of a mobile application called LifeLink that supports caregivers of individuals experiencing suicidal thoughts. This study consists of a pre-test survey, after which you will be given access to the LifeLink application. You will be asked to use the LifeLink app for 1 week. After 1 week, you will be asked to fill out a post-test survey. The pre-test survey and post-test survey will take around 10 and 15 minutes to complete respectively. If you wish, you can also choose to be part of an optional interview session to give more feedback on your experience with the app. The interview can take between 30 to 45 minutes and will happen online.

### Who Can Take Part in the Research Study

To take part in this study, you must:

- Be 16 years of age or older.
- Live in Canada.
- Be proficient in English.
- Own an Android device
- Have supported or are supporting an individual experiencing suicidal thoughts including their caregivers, partners, grandparents, families, chosen family, friends, teachers, guidance counsellors, SchoolsPlus workers, coaches.

Your participation is highly appreciated and is completely voluntary. All data will be treated confidentially and for research purposes only.

By participating you can also enter in a lucky draw in which 5 winners will receive a $50 Amazon Gift Card each.

To express your interest in participating in this study, please email the lead researcher, Smriti Jha at smriti.jha@dal.ca.

This study has been approved by the Dal Research Ethics Committee (Project ID 202X-XXXX)

## Appendix J. Recruitment Poster Study Two

## Appendix K. Consent Form for Study Two Survey and Interview

DALHOUSIE UNIVERSITY

**CONSENT FORM**

**Project Title:** Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Lead Researcher:** Smriti Jha, Faculty of Computer Science, Dalhousie University

Smriti.Jha@dal.ca

**Supervisor**: Dr. Rita Orji, Faculty of Computer Science, rita.orji@cs.dal.ca

### Introduction

We invite you to participate in a research study conducted online by Smriti Jha. You may leave the study at any time. This is a study, and participation is entirely voluntary. The information provided below explains what is involved in the research, what you will be asked to do, and any benefits, risks, or inconvenience or discomfort that you might experience. Participating in the study may not benefit you, but it is possible that we will learn something that will benefit others. You should ask Smriti, the lead researcher, any questions you have about this study. Please feel free to ask as many questions as you want. If you have any further questions, please contact the researcher, Smriti Jha (smriti.jha@dal.ca)

### Purpose and the Research Study

The study's goal is to evaluate a mobile application called LifeLink designed to support caregivers of individuals experiencing suicidal thoughts using persuasive strategies. For my research I am using Google's Firestore as a database (which will be used to collect data from the mobile app such as your name) for the mobile application. This database is being used to support the application and the users. This database will store users' email id, pictures uploaded by the users, the voice recordings and the log data. This means we will be able to check if any feature stops working in the app so that we can fix it. We will also be able to check which app feature is being used how many times by how many users. No identifiable data will be collected. The data is being stored in this database to prevent the user from losing their data as soon as they use the app on some other phone or uninstall the app. If you delete the account, the entire data will be deleted. The following app permissions will be required to run the app: Microphone (for voice notes feature); Camera (for posting pictures).

### Who Can Take Part in the Research Study

To participate in this study, you must be living in Canada, 16 years or older in age, proficient in English, have access to an Android device and have supported or are supporting an individual with suicidal thoughts.

**What you will be asked to do**

If you choose to participate in this research, you will be asked to fill out a pre-test survey, after which you will be given access to the LifeLink application. You will be asked to use the LifeLink application for 1 weeks. After 1 week, you will be asked to fill out a post-test survey. The pre-test survey and post-test survey will take around 10 and 15 minutes to complete respectively. You can also choose to be part of an optional interview session to give more feedback on your experience with the app. The interview may take thirty to forty-five minutes or less.

**Possible Benefits**

The answers that you and other participants share with us will teach us about the needs and concerns of caregivers supporting an individual experiencing suicidal thoughts. It will help us better understand how digital technologies for suicide prevention can be better designed to support caregivers and individuals like you in the future.

**Possible Risks and Discomfort**

There is no potential economic risk associated with this study. Some of the questions - might make you feel uncomfortable, or make you remember things that were upsetting. If any questions are upsetting, I want you to let me know so I can arrange for you to speak to someone. Also, you can skip a question you don't feel comfortable answering. That is 100% okay. If you decide you want to stop altogether, that's okay too. In addition, we want to let you know of the support resources available, including:

1. If you are under 16: Kids Help Phone (text CONNECT to 686868. No data plan or internet connection needed.)

2. If you are an adult (18+): Suicide Crisis Helpline (24/7 toll-free helpline. Call or text 988 and a responder will be there to listen and talk things through with you)

3. Support Services Directory (Search for nearest support centre at https://suicideprevention.ca/resources/#support-service)

4. Seana Jewer: a suicide first-aid trained facilitator can be reached at Seana.Jewer@nshealth.ca. Please let us know if you would like to speak to them and we can arrange it.

All the answers you share will be totally anonymous. Only the research team and I will know what you entered. When your answers get entered into the computer ~ your name and answers will be kept completely separate. We will give your responses a "Unique ID" (e.g., P203) so that no one will ever be able to put your answers and your name together. It's totally private. During the analysis process, we will combine responses from all participants together, which will make it impossible for anyone to identify your answers independently or your identity.

As mentioned above, I will be using Google's Firestore as a database (which will be used to collect data from the mobile app such as your name) for the mobile application. This database will hold users email id, pictures uploaded by the users, the voice recordings, and the log data which can be classified as potentially sensitive data. The potentially sensitive data stored in Google Firestore is not stored within Canada. It is stored in data centres located in the United States, owned by Google. Google can/will not sell your data to third parties as Firestore services are certified under major privacy and security standards (particularly ISO and SOC certifications). The data centre location has been chosen to maximize the availability and durability of our database. Firestore services encrypt data in transit using HTTPS and logically isolate the data. In addition, several Firestore services also encrypt their data at rest. During/after the study period only the lead researcher has access to the data. Your data will be protected as only the lead researcher has access to the database as it's created using her Gmail dedicated only to this database. The Gmail account has two step verification on, linked to the phone number of the lead researcher. The lead researcher is a student and has no intention to use this data for any other purposes other than this thesis project. I will ensure adequate security and non-disclosure of your data to third parties, including their identity. This app will not provide any discomfort to your mobile phone's performance. There are no plans to store data on Google Firestore for long-term purposes. The data needs to be stored on Google Firestore only for the app functionality to work properly i.e., to identify bugs, glitches or any other issues with the working of the app during the study.

You would be free to stop using the app at any time, but you should inform the lead researcher about that. If you successfully complete using the app for two weeks and then while filling the forms you want to stop, you may go ahead and not submit it but if you submit it and then do not want to go for the one-on-one interview then your form contribution cannot be discarded/deleted by the lead researcher. Data stored on Google Firestore will be deleted along with the study data if you decide to withdraw (formally or by not completing the post-test survey).

You would be free to leave the one-on-one interview at any time and the lead researcher will destroy your data.

**Compensation**

Your email will be entered into a lucky draw for a chance to win 1 of 5 Amazon gift cards worth 50$ each whether you choose to complete the study or not. Please note that only five people would be randomly selected to win the five 50$ worth Amazon gift cards.

You can check the box below to enter. This is completely voluntary, and not mandatory for the research.

- I want to enter the lucky draw to win 1 of 5 Amazon gift cards worth 50$ each.

**How your information will be protected**

Your email address will be collected as part of the pre-test survey in order to contact you for the post-test survey and optional interview; hence your data will be identifiable but protected and confidential and will only be accessible to the researchers including the lead researcher Smriti Jha and supervisor Dr. Rita Orji. All survey responses will be saved on a secure Dalhousie server and password-protected computers to be used for analysis. The optional interview will be conducted using Microsoft Teams. The researchers will use their Dalhousie University credentials for the Microsoft Teams meeting, which will ensure that the Teams meeting recordings are securely stored in Canada. During the live Teams meeting, audio and video content is routed through the United States, and therefore may be subject to monitoring without notice, under the provisions of the US Patriot Act while the meeting is in progress. After the meeting is complete, meeting recordings made by Dalhousie are stored in Canada and are inaccessible to US authorities. Only anonymized data will be analyzed and accessed on a secure computer (encrypted drive and password protected) that only the lead researcher and the supervisor will have access to. The anonymity of textual data will be preserved by using pseudonyms in any journal or conference presentation.
For the one-on-one interview, only the researcher will know your data and it will be kept confidential.

We will describe and share general findings of this research in the lead researcher's master's thesis and possibly through publications in conferences and journals. Direct quotes from your responses in this study may be used in publications and these will be anonymized so they cannot be linked to you.
The lead researcher (i.e., Smriti Jha) will destroy all the survey responses and information in 4 months after reporting the results.

**If You Decide to Stop Participating**

If you wish to stop participating, at any point, you can do so. Incomplete responses will not be included in the study. You can also withdraw from the study (survey or interview) at any time as long as the data has not been analyzed (i.e., approximately 2 months from beginning the study and approximately 1 month from the interview session). If you intend to withdraw, please contact the lead researcher at smriti.jha@dal.ca

**How to Obtain Results**

When the entire study is completed, the results will be published which may hold anonymous comments from participants using participant ID such as P1, P2. No individual results will be provided. You can check the check box below to receive a copy of the publication.

- I want to receive the details when the study is published.

**Questions**

We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Smriti Jha (Smriti.Jha@dal.ca) or Rita

Orji (at rita.orji@dal.ca) at any time with questions, comments, or concerns about the research study. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at 902-494-3423, or email: ethics@dal.ca. and reference REB Submission Project ID 202#-####.

**Consent**

I have read the explanation of this study. I have been given the opportunity to contact and discuss any question related to study and my questions have been answered to my satisfaction.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the survey if I choose. I understand that my responses during the optional interview will be audio recorded. I agree that direct quotes from my responses may be used without identifying me.

- Name:
- Email id: _(This email will be used to contact you to inform you if you're the winner or if you have expressed interest in receiving details when the study result is published)
- Date:

☐ **I Consent, and I agree to participate**

Please follow the link [a link to the survey would be inserted here].

## Appendix L. Pre-study Survey Study Two

Thank you for kindly agreeing to participate in this survey. Please answer all the questions to the best of your knowledge. If you do not wish to answer, you may select "Prefer not to say". If any questions are upsetting, I want you to let me know so I can arrange for you to speak to someone. We want to let you know of support resources available, including:

1. If you are under 16: Kids Help Phone (text CONNECT to 686868. No data plan or internet connection needed.)

2. If you are an adult (18+): Suicide Crisis Helpline (24/7 toll-free helpline. Call or text 988 and a responder will be there to listen and talk things through with you)

3. Support Services Directory (Search for nearest support centre at https://suicideprevention.ca/resources/#support-service)

4. Seana Jewer: a suicide first-aid trained facilitator can be reached at Seana.Jewer@nshealth.ca. Please let us know if you would like to speak to them and we can arrange it.

Your responses will remain confidential and anonymous (i.e., Your data will be coded using a participant ID i.e., P1, P2).

**Appendix L1: Demographic Questionnaire**

Q1 – Q10. Same as Appendix G. Section 1.

Q11. What do you most frequently use your Android smartphone for? (Select up to 3 options)

- Tools/Productivity
- Games
- Entertainment
- Social media
- Education
- Lifestyle
- Other
- Prefer not to say.

**Appendix L2: IT Familiarity Questionnaire**

| Please circle the number that corresponds most closely to your use of your smartphone to access the internet. | | | |
|---|---|---|---|
| | Never use | Seldom use | Daily use |
| I use my smartphone to send and receive email. | 3 | 2 | 1 |
| I use my smartphone to obtain information on a wide range of topics. | 3 | 2 | 1 |
| I download applications from the internet to my smartphone. | 3 | 2 | 1 |
| I use my smartphone to shop, manage my calendar and/or make travel arrangements. | 3 | 2 | 1 |
| I use my smartphone to bank and pay my bills. | 3 | 2 | 1 |
| I use my smartphone for social networking. | 3 | 2 | 1 |
| I use my smartphone to watch movies/videos, listen to podcasts and/or music, or share photos/images | 3 | 2 | 1 |
| I use other forms of electronic technology such as ebooks (Kindle) or tablets (iPad, LifeBook etc.) | 3 | 2 | 1 |

**Appendix L3: Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS)**

| Below are some statements about feelings and thoughts. Please select the number that best describes your experience of each over the last week. | | | | | |
|---|---|---|---|---|---|
| | None of the time | Rarely | Sometimes | Often | All of the time |
| I've been feeling optimistic about the future. | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| I’ve been feeling useful. | 1 | 2 | 3 | 4 | 5 |
| I’ve been feeling relaxed. | 1 | 2 | 3 | 4 | 5 |
| I’ve been dealing with problems well. | 1 | 2 | 3 | 4 | 5 |
| I’ve been thinking clearly. | 1 | 2 | 3 | 4 | 5 |
| I’ve been feeling close to other people. | 1 | 2 | 3 | 4 | 5 |
| I’ve been able to make up my own mind about things. | 1 | 2 | 3 | 4 | 5 |

End of survey.

Thank you for your time and contribution to suicide prevention research that may positively improve the lives of Canadian community.

## Appendix M. Post-study Survey Study Two

Thank you for kindly agreeing to participate in this research and your time for completing this survey. Please answer all the questions to the best of your knowledge. If you do not wish to answer, you may select "Prefer not to say". If any questions are upsetting, I want you to let me know so I can arrange for you to speak to someone. We want to let you know of support resources available, including:

1. If you are under 16: Kids Help Phone (text CONNECT to 686868. No data plan or internet connection needed.)

2. If you are an adult (18+): Suicide Crisis Helpline (24/7 toll-free helpline. Call or text 988 and a responder will be there to listen and talk things through with you)

3. Support Services Directory (Search for nearest support centre at https://suicideprevention.ca/resources/#support-service)

4. Seana Jewer: a suicide first-aid trained facilitator can be reached at Seana.Jewer@nshealth.ca. Please let us know if you would like to speak to them and we can arrange it.

Your responses will remain confidential and anonymous (i.e., Your data will be coded using a participant ID i.e., P1, P2).

**Appendix M1: User Engagement Scale Short Form (UES-SF)**

| Please select to what extent you agree or disagree with the following statements about the app. | | | | | |
|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| I lost myself in this experience. | 1 | 2 | 3 | 4 | 5 |
| The time I spent using the LifeLink app just slipped away. | 1 | 2 | 3 | 4 | 5 |
| I was absorbed in this experience. | 1 | 2 | 3 | 4 | 5 |
| I felt frustrated while using the LifeLink app. | 1 | 2 | 3 | 4 | 5 |
| I found the LifeLink app confusing to use. | 1 | 2 | 3 | 4 | 5 |
| Using the LifeLink app was taxing. | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| The LifeLink app was attractive. | 1 | 2 | 3 | 4 | 5 |
| The LifeLink app was aesthetically pleasing. | 1 | 2 | 3 | 4 | 5 |
| The LifeLink app appealed to my senses. | 1 | 2 | 3 | 4 | 5 |
| The LifeLink app was worthwhile. | 1 | 2 | 3 | 4 | 5 |
| My experience was rewarding. | 1 | 2 | 3 | 4 | 5 |
| I felt interested in this experience. | 1 | 2 | 3 | 4 | 5 |

**Appendix M2: SUS Questionnaire**

| Please select to what extent you agree or disagree with the following statements about the app . | | | | | |
|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| | 1 | 2 | 3 | 4 | 5 |
| I found the app unnecessarily complex | 1 | 2 | 3 | 4 | 5 |
| I thought the app was easy to use | 1 | 2 | 3 | 4 | 5 |
| I think that I would need the support of a technical person to be able to use this app | 1 | 2 | 3 | 4 | 5 |
| I found the various functions in this app were well integrated | 1 | 2 | 3 | 4 | 5 |
| I thought there was too much inconsistency in this app | 1 | 2 | 3 | 4 | 5 |
| I would imagine that most people would learn to use this app very quickly | 1 | 2 | 3 | 4 | 5 |
| I found the app very cumbersome to use | 1 | 2 | 3 | 4 | 5 |
| I felt very confident using the app | 1 | 2 | 3 | 4 | 5 |
| I needed to learn a lot of things before I could get going with this app | 1 | 2 | 3 | 4 | 5 |

## Appendix M3: Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS)

[Same as Appendix L3.]

## Appendix M4: User Experience Questionnaire Short

| Please select the number that best matches your experience using the LifeLink app. | | |
|---|---|---|
| Boring | 1 2 3 4 5 6 7 | Exciting |
| Not interesting | 1 2 3 4 5 6 7 | Interesting |
| Inventive | 1 2 3 4 5 6 7 | Conventional |
| Obstructive | 1 2 3 4 5 6 7 | Supportive |
| Complicated | 1 2 3 4 5 6 7 | Easy |
| Usual | 1 2 3 4 5 6 7 | Leading edge |
| Inefficient | 1 2 3 4 5 6 7 | Efficient |
| Clear | 1 2 3 4 5 6 7 | Confusing |

## Appendix M5: Intrinsic Motivation Inventory Value/usefulness subscale

| For each of the following statements, please indicate how true it is for you: | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Not at all true | | | Somewhat true | | | Very true |
| I believe the LifeLink app could be of some value to me. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I think that the LifeLink app is useful for supporting caregivers of individuals experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I think the LifeLink app is important because it can support caregivers of individuals experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I would be willing to use the LifeLink app again because it has some value to me. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I think using the LifeLink app could help me to support an individual experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I believe using the LifeLink app could be beneficial to me. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I think this is an important mobile application. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Appendix M6: Perceived usefulness Scale**

| Please select to what extent you agree or disagree with the following statements about the LifeLink app. | | | | | |
|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
| The app would capture and hold my attention. | 1 | 2 | 3 | 4 | 5 |
| The content of the app would be relevant to me. | 1 | 2 | 3 | 4 | 5 |
| The content of the app would be useful to me. | 1 | 2 | 3 | 4 | 5 |
| It would be easy to understand and use the app. | 1 | 2 | 3 | 4 | 5 |
| The app would help me support an individual experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 |
| The app would build my confidence in my ability to support an individual experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 |
| The app would help me support an individual experiencing suicidal thoughts. | 1 | 2 | 3 | 4 | 5 |

**Appendix M7: Simplicity scale**

| Please select to what extent you agree or disagree with the following statements about the LifeLink app. |
|---|

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| The app has unnecessary steps to use certain functions. | 1 | 2 | 3 | 4 | 5 |
| The app has complicated steps to use certain functions. | 1 | 2 | 3 | 4 | 5 |
| The app is designed to provide functions consistently. | 1 | 2 | 3 | 4 | 5 |
| Information in the app is well structured and systematic. | 1 | 2 | 3 | 4 | 5 |
| The icon images in the screen are visually dense. | 1 | 2 | 3 | 4 | 5 |
| The layout of the screen is visually dense. | 1 | 2 | 3 | 4 | 5 |
| Screen design is neat. | 1 | 2 | 3 | 4 | 5 |
| Screen design is modern. | 1 | 2 | 3 | 4 | 5 |
| Screen design is well balanced. | 1 | 2 | 3 | 4 | 5 |
| I am satisfied with the app. | 1 | 2 | 3 | 4 | 5 |
| I like the app. | 1 | 2 | 3 | 4 | 5 |
| I am dissappointed with the app. | 1 | 2 | 3 | 4 | 5 |

## Appendix M8: Perceived Persuasiveness Questionnaire

[Same as Appendix G. Q26, Q27.]

## Final Thoughts

Q1. Is there anything else you would like to share or any additional comments you have regarding the LifeLink app, or this survey? Please feel free to provide any feedback or suggestions.

_____

Q2. Are you interested in participating in an optional one-on-one interview to discuss your experiences further? The interview session may take 30-45 minutes or lesser. If you select 'Yes', we will contact you to schedule a time for the interview.

- Yes
- No

End of survey.

Thank you for your time and contribution to suicide prevention research that may positively improve the lives of Canadian community.

## Appendix N. Interview Questions Study Two

1. Could you please describe your overall experience with using the app.

    1.1 What did you like about the app?
    1.2 What did you not like about the app?

2. What was the most appealing part about the app? Why?
3. Did this app help you or was it useful in any way? How did it help you?
4. In the last week, how did you feel while you were using the app?
    4.1 After using the app for 1 week, how did you feel?
    4.2 Did the app affect your wellbeing in any way in the past week?
5. Did the app introduce any changes in your ability to support someone with suicidal thoughts?
6. Do you think you can continue using this app after this study? Why or why not?
7. Was there anything surprising or unexpected about the app? Could you please provide an example?
8. Was there anything missing from the app that you expected?
9. Do you have any suggestions for improving the app?
10. Do you think you would recommend this app to a caregiver who is supporting someone with suicidal thoughts? Why or why not?
11. Is there anything else you would like to share about your experience with the app or this study that I have not covered?
12. Finally, do you have any questions for me?

## Appendix O. Research Ethics Board Approval Letter Study One and Two

**REB # 2023-6824 Letter of Approval**

do-not-reply-DAL@researchservicesoffice.com <do-not-reply-DAL@researchservicesoffice.com>
Tue 2023-10-17 1:08 PM
To:Smriti Jha <sm286919@dal.ca>
Cc:Rita Orji <rt924119@dal.ca>;Research Ethics <ethics@dal.ca>
***To respond to this message, click "**Reply All**" and adjust recipient list as required. Do **NOT** click "Reply".***

**Health Sciences Research Ethics Board**
**Letter of Approval**

October 17, 2023

Smriti Jha
Computer Science\Computer Science

Dear Smriti,

**REB #:** 2023-6824
**Project Title:** Design and Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Effective Date:** October 17, 2023
**Expiry Date:** October 17, 2024

The Health Sciences Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Jennifer Isenor
Chair, Health Sciences Research Ethics Board
Dalhousie University

## REB # 2024-7043 Letter of Approval

do-not-reply-DAL@researchservicesoffice.com <do-not-reply-DAL@researchservicesoffice.com>
Wed 2024-02-14 9:54 AM
To:Smriti Jha <sm286919@dal.ca>
Cc:Rita Orji <rt924119@dal.ca>;Research Ethics <ethics@dal.ca>

***To respond to this message, click "**Reply All**" and adjust recipient list as required. Do **NOT** click "Reply".***

DALHOUSIE UNIVERSITY

**Health Sciences Research Ethics Board**
**Letter of Approval**

February 14, 2024

Smriti Jha
Computer Science\Computer Science

Dear Smriti,

**REB #:** 2024-7043
**Project Title:** Evaluation of LifeLink: A Persuasive mHealth Application for Suicide Prevention in Canadian youths and adults

**Review Type:** Delegated Review
**Effective Date:** February 14, 2024
**Expiry Date:** February 14, 2025

The Health Sciences Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be ethically acceptable in accordance with the *Tri-Council Policy Statement Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Jennifer Isenor
Chair, Health Sciences Research Ethics Board
Dalhousie University

## Appendix P. Permission to Use

In presenting this thesis in partial fulfilment of the requirements for the master's in computer science degree from Dalhousie University, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Dalhousie University in any scholarly use which may be made of any material in my thesis.

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**Head of the Faculty of Computer Science 6050 University Ave,**

**Dalhousie University,**

**Halifax, Nova Scotia, Canada B3H 1W5**

## Appendix Q. My Publications

1. **Smriti Jha**, Gerry Chan, Rita Orji. 2023. Identification of Risk Factors for Suicide and Insights for Developing Suicide Prevention Technologies: A Systematic Review and Meta-Analysis. *Human Behavior and Emerging Technologies Journal 2023*: 1–18. https://doi.org/10.1155/2023/3923097
2. **Smriti Jha**, Gerry Chan, Seana Jewer, Vincent I O Agyapong, Rita Orji. Mar. 2024. Can Your Smartphone Save A Life ? A Systematic Review of Mobile-Based Interventions For Suicide Prevention. *International Journal of Human–Computer Interaction*, 1–19. https://doi.org/10.1080/10447318.2024.2323274
3. **Smriti Jha**, Gerry Chan, Seana Jewer, Vincent I O Agyapong, and Rita Orji. May 2024. Engaging Caregivers in the Design of LifeLink : A Persuasive Mobile Application for Suicide Prevention. *International Journal of Human-Computer Interaction*. Submitted.
4. **Smriti Jha**, Gerry Chan, Seana Jewer, Vincent I O Agyapong, and Rita Orji. Sep. 2024. "Bring them back to life": LifeLink Application for Caregivers Dealing with Suicidality. *2025 CHI Conference on Human Factors in Computing Systems*. Submitted.
5. **Smriti Jha**, Ngoc Song Ha Pho, and Rita Orji. 2023. ProTaskinator: A Persuasive Mobile Application for Reducing Procrastination in University Students. *2023 IEEE 11th International Conference on Serious Games and Applications for Health, SeGAH 2023*. https://doi.org/10.1109/SEGAH57547.2023.10253783