Utility of Synoptic Reporting to Improve Operative Reports for Spinal Cord Injury Patients

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Internship report submitted in partial fulfillment of the requirements of

Master of Health Informatics Program

Dalhousie University, Health Informatics: Faculty of Computer Science and Medicine

Nova Scotia, Canada

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Internship period: April 15, 2011- July 19, 2011

Date Submitted: Aug 19, 2011

Acknowledgements

This report has been written by me and has not received any previous academic credit at this or any other institution.

I would like to express my sincere gratitude to my mentors, *Dr Grace Paterson*[1] and *Dr Sean Christie*[2] for their persistent guidance and encouragement throughout the project life cycle, which will remain an asset to me forever.

Besides my mentors, I would like to thank *Ginette Thibault-Halman*[3] and *Catherine Wheeler O'Neil*[4] for providing me all the necessary information related to ongoing dictation-based operative reporting as well as valuable suggestions regarding preparation of electronic template-based synoptic operative reports.

I am also thankful to *Lorraine Smith*[5] and *Deirdre Harvey*[6] for their administrative support.

My sincere thanks goes to the *Rick Hansen Institute* for giving me the opportunity to work on this wonderful project.

Last but not least, I would like to thank all my instructors in the MHI program, Dalhousie University.

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Executive Summary

The author did his internship in the Division of Neurosurgery of Capital District Health Authority (CDHA) in Halifax. This organization is one of the acute care and rehabilitation hospitals across the country, which is responsible for management, collection and analysis of important data from Canadians with spinal cord injuries through the Rick Hansen Spinal Cord Injury Registry (RHSCIR). During his internship, he worked as Health Informatics research support staff in “Improving Neurosurgery Operative Reports through an Electronic Template for Patients with Spinal Cord Injury” project. While attempting to improve the quality of reporting of operative procedures on spinal injury patients, some of the operative reports of spinal injury patients, who were treated in the past in that organization, were evaluated to detect the drawbacks with the current reporting system and also to find out the possible ways to improve the quality of reporting.

A survey of the literature was also done and it was found that the use of template for synoptic operative reporting was one of the possible ways to improve the completeness, accuracy and conciseness of operative reporting on spinal injury patients.

An electronic template was created using Microsoft Office InfoPath 2007 which may be published in a SharePoint environment (as discussed in Appendix C). The template is web enabled and browser compatible. It may be filled out in the SharePoint environment even without having InfoPath software on the user’s computer.

While composing the content of the synoptic operative report (SOR) template, the author further surveyed the literature, consulted with domain experts and reviewed organizational policies for selection of different data fields so that the SOR would be a good repository for secondary analysis of health data to improve the quality of health care for spinal injury patients (as discussed in Appendix B). Secondary analysis of health data is the use of personal health information for purposes other than direct health care delivery.

Tools have also been developed in order to assess the completeness, accuracy and conciseness of the synoptic operative report template (as discussed in Appendix D).

The literature survey revealed the importance of standard medical terminology in operative procedure reporting to support interoperability and promote sharing of medical information among different organizations. The author did an “Evaluation of SNOMED CT to represent Spinal Cord Injury Registry” which was reported in the form of an article in Appendix A. In that article the author tried to show the importance of Systematized Nomenclature of Medicine-Clinical Terms (SNOMED CT) as a standard medical terminology that can improve the quality of reporting for spinal injury patients. A study was conducted to explore the potential for SNOMED CT in the 15 forms with well designed data fields by RHSCIR to track the experiences and outcomes of people with traumatic forms of spinal cord injury (SCI) during their journey through acute care, rehabilitation and community reintegration.

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List of Abbreviation

Abbreviation	stands for
CDHA	Capital District Health Authority
CIHI	Canadian Institute for Health Information
RHSCIR	Rick Hansen Spinal Cord Injury Registry
SCI	Spinal Cord Injury
SNOMED CT	Systematized Nomenclature of Medicine -- Clinical Terms
WHO	World Health Organization
LOINC	Logical Observation Identifiers Names and Codes
SOR	Synoptic Operative Report
MOSS	Microsoft Office SharePoint Server
HL7	Health Level 7
HIMSS	Healthcare Information and Management Systems Society
DICOM	Digital Imaging and Communications in Medicine

1. Introduction

In the summer of 2010, the author reviewed the medical records of 25 patients with spinal cord injury, who were treated in 2007-2010 at Capital District Health Authority (CDHA) in Halifax. Operative reports in the medical record were part of the review. The author noted that the operative reports were incomplete in many instances and as the reports were hand written; it was often difficult to read in full. The problem addressed during the internship is based on this prior work. An operative report is a document which is produced by a surgeon or other physician, who has participated in a surgical intervention. It contains the preoperative and postoperative diagnoses, names of the primary performing surgeon, and any assistants, as well as a detailed account of the pre-operative clinical findings, the procedure used and the specimens removed [1]. An operative report is one of the components of the medical record. A medical record consists of systematic documentation of a single patient's long-term individual medical and surgical history and care. The operative report therefore contains data that are essential in providing additional health care and also for planning future operative procedures [2]. It also plays an important role in research projects, quality assurance, billing, and medical-legal conflicts [3].

In order to improve the quality of operative reporting of patients with spinal cord injury, a survey of literature was conducted by the author. It was found that the concept of synoptic reporting is rapidly gaining importance at various levels of data recording and reporting in different departments of healthcare services, such as radiology, pathology, and surgery with an aim to provide a report in a synoptic and easy retrieval form [4].

An electronic synoptic operative report template has been developed by the author to permit good quality of data storage as well as retrieval. Thereby, it will play a significant role in monitoring the improvement of the quality of healthcare by retrospective data analysis.

2. Description of the organization

The author has worked in the Division of Neurosurgery at CDHA in Halifax, which is one of the centers, where the Rick Hansen Spinal Cord Injury Registry (RHSCIR) is active. The Division of Neurosurgery of CDHA has 9 members in the faculty. Two faculty members of the Division of Neurosurgery, Dr. Sean Christie and Dr. Steven Casha are involved in the Spine program with collaboration of Dr. W. Oxner and Dr. D. Alexander from the Division of Orthopedic Surgery and Dr. Christine Short and Dr. Sonja McVeigh from the Department of Medicine (PM&R). The Spine program enhances research with special emphasis on management of acute spinal injury and low back pain [5].

The RHSCIR is led by the Rick Hansen Institute which was established in order to improve the quality of life of people, who are surviving with Spinal Cord Injury (SCI) and related-disabilities. It is an independent institute having Canada-wide collaboration. The Rick Hansen Foundation provides leadership and assistance to the Institute, in order to accomplish financial sustainability and expand its programs internationally. The Foundation's work has been to create opportunities for collaboration and to support identification and sharing of new knowledge by working in close proximity with researchers and people with disabilities [6].

In order to achieve the goal of the Rick Hansen Institute, the RHSCIR has been implemented to track the experiences and outcomes of people with traumatic forms of SCI during their journey through acute care, rehabilitation and community reintegration. It also provides the baseline information needed to accelerate spinal cord injury research in Canada and around the globe. At present, the RHSCIR is active in 35 major Canadian acute care and rehabilitation hospitals across the country to collect, manage and analyze important data from Canadians with spinal cord injuries. These data are then collected in a central location, with ensured individual privacy and security of information. It can then be used by researchers and clinicians to better understand SCI and the effectiveness of specific treatments, practices or programs for improving functional outcomes and quality of life after SCI [7].

3. Description of the work performed at the organization

The author worked as Health Informatics research support staff in "Improving Neurosurgery Operative Reports through an Electronic Template for Patients with Spinal Cord Injury" project. The author surveyed the literature and explored the importance of electronic templates in improving neurosurgical operative reporting in patients with spinal cord injury. He also identified the data fields which are essential in an electronic template for synoptic operative reporting for secondary analysis of health data (as mentioned in appendix B). Secondary analysis of health data is the use of health data for purposes other than direct health care delivery, such as research, marketing, quality and safety measurement [8]. An electronic template for operative reporting for patients with spinal cord injury was developed by the author using Microsoft Office InfoPath 2007 (as shown in appendix C). Tools for evaluation of accuracy, completeness and conciseness of synoptic operative reports in the template were also developed for use in future studies (as mentioned in appendix D). The author also did an "Evaluation of SNOMED CT to represent Spinal Cord Injury Registry" which was reported in the form of an article in Appendix A.

4. Discussion on how this work relates to health informatics

The author applied the knowledge of Health Informatics while evaluating SNOMED CT to represent the RHSCIR (reported in the form of an article in Appendix A) in order to support interoperability and to promote sharing of medical information among different organizations to improve the quality of medical care for patients with spinal cord injury. In addition, in developing electronic templates for synoptic operative reporting, the knowledge of Health informatics has been applied extensively, which is discussed in the following sections.

4.1 Determination of the content of an operative report template

An operative report template should be concise but should contain enough information because in cases with intra-operative or postoperative complications, the operative report helps in patient management and also plays an important medico-legal role. Eichholz *et al* (2004) noted that "the content of the operative report should include any aspects of the surgery that were particularly difficult or clinically significant. All abnormal operative findings, as well as significant normal findings, should be described. In addition, the specimens removed during surgery should be listed in the operative note. For most routine procedures, the description of the entry and closure should be brief but complete and accurate. Inclusion of some procedural details, such as types of clamps at each step, needle size, every suture type should be avoided except in selected procedures where this level of detail is important, such as urethropexy. Documentation of any preventive measures, such as testing the bladder by filling it with methylene blue, should be done" [9].

4.2 Role of standard terminology and data format in an operative report

Use of simple template-based synoptic operative reporting is not sufficient because it will allow free use of multiple terminologies for the same condition, resulting in differences in format and data reporting conventions across and within the organization. This practice may lead to poor quality of data. Variations have often been detected in the extracted data, which have also been discussed with Canada Health Infoway and most agree that standardization could improve the usability of data for secondary purposes, such as quality monitoring, trending and research [8, 10].

In Canada, there is a goal of implementation of electronic health records (EHR), in physician offices across the country. This implementation will enable health care providers to update and share patient-centric health records. In 2006, Canada Health Infoway and the Canadian Institute for Health Information (CIHI) agreed to establish a new Canada-wide coordination function to support and sustain health informatics standards on a national scale. There are different national and international standards, which form the basis of pan-Canadian standards, such as Health Level 7 (HL7), Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), Logical Observation Identifiers Names and Codes (LOINC), Digital Imaging and Communications in Medicine (DICOM), Health Canada Drug Product Database, International Classification of Diseases -10 Canadian version (ICD-10-CA), Integrating the Health care Enterprise (IHE), International Organization for Standardization's Health Informatics Technical Committee (ISO/TC 215) and Unified Codes for Unit of Measure (UCUM) [11].

According to Tim Benson, Health Level 7 (HL7) and SNOMED CT are the two key standards, which permit health care interoperability. These have to be used together to provide a language for information interchange. HL7 provides the grammar, whereas SNOMED CT provides the terminology or the words [12].

Quality assurance and improvement in healthcare services have become a priority in health care. Operative reports are often examined for research purposes and for quality assurance and improvement initiatives [13, 14]. Warsi *et al*. (2002) have analyzed 3 major oncology databases and have found that operative details are missing in up to 89% of entries [15]. Similarly, Edhemovic *et al.*(2004) have used a rectal cancer template to extract data from narrative operative reports and found that a mean of 54.1% of important peri-operative data are not reported. To ameliorate this documentation deficit, an operative report template using standardized data forms and computerized databases has been proposed [16].

4.3 Critical belief about the synoptic operative report

Some critics believe that synoptic reporting may allow less flexibility for nuanced diagnoses or microscopic findings and there may be loss of context within reports. Synoptic reports have also been criticized to be relatively cumbersome and time-consuming because they may require additional steps to edit worksheets compared to usual free text reports [17]. It is to be noted that flexibility of synoptic reporting using a template can be extended by use of free text boxes in addition to standard data points in the template [18]. The overall consistency in the use of synoptic reporting depends upon the user's training, experience and acceptability [17]. Template-based synoptic reporting may take slightly more time than the dictation format but does not demand the additional time necessary for subsequent verification as needed for the dictated reports [19].

4.4 Synoptic operative report methodology: Its current trend and future expectation

In order to improve the quality of reporting, the method of operative reporting is gradually changing from the unstructured dictation-based method to electronic template-based methods which are discussed in the following sections.

4.4.1 Unstructured dictation method

Traditionally in teaching institutions, there is a practice of documenting the information about the operative procedure in hand written format by a resident under the guidance of a staff surgeon. Wide variation has been noticed related to the content as well as the format of the operative reports. Often failure to record important elements, related to the operative procedure, has been noted during medical audits [20]. Dictated operative reports often do not provide sufficient details, thereby affecting treatment decisions and interfering with quality assessments and reimbursement [9, 21]. According to Eichholz *et al*. (2004), formal teaching about operative dictation is uncommon in U.S. residency programs but is felt to be an important component by most residency program directors [9]. Failure to record specific details using the traditional reporting system may be wrongly interpreted as a negative finding rather than a true omission. [4]. According to a survey conducted by Moore (2000), 82% of respondents reported having no formal instruction on the dictated operative note as part of their residency curriculum.

Documentation of the operative procedure is an important part of the medical record because, if litigation occurs, it plays an important role in the retrospective analysis of the critical situation of the patient and the medical activities done by the surgeon. Hence, every surgeon should have at least some formal education about the dictation of the operative note [22].

4.4.2 Structured or template based dictation method

Gillman *et al*. (2010) found that there is a definite improvement in the comfort level with dictation following use of a dictation template as well as the potential to improve the quality of dictation among junior residents [23].

The Canadian Association of General Surgeons noted that there are no validated or reliable tools to assess the quality of the dictated operative note. Hence, the Association developed a Structured Assessment Format for Evaluating Operative Reports (SAFE-OR) in general surgery to assess the quality of the dictated operative note. This instrument includes a structured assessment format and a global quality rating scale [3]. This instrument i.e. SAFE-OR may be adapted to assess the quality of synoptic operative reporting using our template in the future.

4.4.3 Electronic dictated form without standard terminology

Conversion of dictation to an electronic version of template-based reporting may represent an improvement over the current standard but is not sufficient because it allows free use of different terminology by different users for the same condition, resulting in poor quality of data analysis [10].

4.4.4 Semantic web based synoptic operative report

Semantic web-based reporting has been the ultimate form of synoptic operative reporting with use of standard medical terminology and HL7 permitting interoperability across different organizations.

4.5 Success Story of Synoptic Report in Different Domain of Healthcare

Synoptic histo-pathological reporting in pancreatectomy: According to Gill *et al*. (2009), in case of pancreatectomy specimen, synoptic reporting of pancreatic resection has proven to be a simple mechanism for improvement in the information content within the histopathology report [24]. Austin *et al*. (2009) also noticed an improvement in the quality of pathological reporting following use of the synoptic report format [25].

Synoptic reporting in pancreatic surgery: Park *et al.* (2010) have shown that in the case of pancreatic surgery, synoptic operative reports are more reliable in providing more complete information within a reasonable time compared to the conventional dictation method [26].

Synoptic reporting in rectal cancer: Alberta Cancer Surgery Working Group has shown that a web-based synoptic surgical medical record (WebSMR) for rectal cancer resection has better documentation of the important aspects of rectal cancer surgery compared to dictated reports. This group has shown an improvement in the capture of key data elements from 46% for dictated operative reports to 99% for WebSMR [16]. Chan *et al*. (2008) have done a retrospective analysis of pathological reporting of colorectal carcinoma specimen and has found a significant improvement in the reporting following introduction of a standardized synoptic reporting protocol [27].

Synoptic reporting in thyroidectomy: According to Chambers *et al*. (2009), Web-based technology has allowed the documentation of all operative details that are required for the postoperative management of patients in a single, comprehensive document [18]. Iyer *et al*. (2011) have commented that the web-based synoptic reporting of thyroid surgery is user-friendly and comprehensive [4].

5. Discussion of a problem that was analyzed and the corresponding solution

While reviewing the medical records in the summer of 2010, the author noted that the operative reports were incomplete in many instances. As the reports were hand written, it was often difficult to read in full. Use of different terminologies by different surgeons to express the same condition was also noted. Due to these problems, effective monitoring of healthcare services was not possible.

The author did a survey of literature to overcome the problems related to dictation-based operative reporting as preparatory work for the grant funding proposal that would fund his internship. He submitted the first proposal, "Improving Neurosurgery Operative Reports through an Electronic Template for Patients with Spinal Cord Injury" on March 15, 2011 to CDHA, Halifax. Later based on peer review, changes were made and the revised proposal, "Utility of Synoptic Reporting to Improve Operative Reports for Spinal Cord Injury Patients", was funded by the Rick Hansen Institute. He also worked on the 'ImagineNation challenge' for Canada Health Infoway submitted on May 15. 2011.

In order to overcome the problems related to dictation-based operative reporting, a survey of the literature was done and a critical analysis has been documented in the following sections.

5.1 Difficulty in reading the hand written operative reports

Electronic template-based operative reporting overcomes the problem of reading the hand written reports.

5.2 Incomplete information in dictation-based operative reports

Template-based synoptic operative reporting can improve the quality of information in a reasonable time compared to dictated operative reports. Schwartz *et al*. (2011) noticed an improvement in the communication of diagnostic radiology findings through structured reporting. In addition, the use of standardized language not only reduces the chances of miscommunication, but also makes the data accessible for secondary purposes such as research and quality improvement. In general surgery, the use of structured reporting in operative note has been found to increase the consistency of information conveyed [28]. Template-based synoptic operative reporting will be an excellent method to ensure completeness for required data elements in an operative report and the resulting designs will serve as a mental guideline to facilitate the learning processes of students and junior residents [20, 23].

5.3 Delay in case of dictation-based operative reports

Traditionally after transcription of the operative report, the surgeon must review, correct errors, and ultimately verify the dictated report. There may be delay in different stage of the process beginning from the time of initial dictation by the surgeon, transcription of the dictated report up to the final verification by the surgeon. Delay or lack of structure in dictation may also increase the likelihood that important elements may be missing from the final report. Timely use of a template results in accelerated generation of operative reports in the medical record with standardized format and content, in comparison to the dictated reports. The template also increases overall compliance with national standards for operative note documentation and avoids transcription costs. One study found that documentation with templates took slightly more time than dictation, but this figure did not include the additional time necessary to subsequently verify the dictated report [19].

5.4 Importance of an operative report in controlling variation in medical practice

Variation in medical practice is very common because it is a complex process where the knowledge is not generally available outside the profession. The most important reason for variation in medical practice is its rapid evolution. In reality, it is expensive and time consuming to determine best practices for all clinical scenarios because individual clinical scenarios are multi-layered and complex and, in many cases, evidence is poor or fragmentary. An improvement in the quality of healthcare with the optimum use of existing resources and available best evidence has been noticed through use of guidelines and protocols [29].

Methodology attempted to control the variation in medical practice: Consistent behavior is an essential element to measure the outcome of any process systematically. Development of a protocol or guideline is one of the steps toward consistent behavior thus limiting variation in medical practice. It requires follow-up and feedback for refinement based on experience and scientific evidence [29]. The process of guideline development, implementation and outcome analysis can be evaluated through medical audits [30, 31], which are only possible through maintenance of complete and accurate medical records. Hence, a synoptic operative report can be used as an important tool to assess variation in medical practice.

5.5 Operative report as an essential communication tool for medical audit

The quality of health services and the safety of patients in the practice of medicine mainly depend on accurate communication among physicians, patients, families, and allied health professionals [9]. Operative reports are a key form of communicating intra-operative events with medical and allied health professionals [3]. After an operative procedure, it is imperative for the surgeon to dictate the operative findings and key aspects of the procedure immediately in an accurate and concise manner [9] because this information is required for providing post-operative care and planning future operative procedures, if needed. Unfortunately, dictated reports are frequently incomplete or delayed. Electronic templates could potentially improve this process [19].

5.6 Expected overall benefits of synoptic operative reporting in healthcare

Operative reports may be used in both clinical and administrative healthcare services as a resource for secondary analysis of data for evaluating the quality of care and planning for future improvements [8, 9].

6. Conclusion

Based on the work performed to date, the author assumes that an electronic template-based synoptic operative reporting with standard terminology will improve the completeness and accuracy of the data, providing a valuable resource for secondary data analysis. Further research will be undertaken in the Division of Neurosurgery to test this assumption.

7. Recommendations

Since the literature suggests that electronic template based synoptic operative reporting may be an important tool to improve the quality of healthcare, we have created a synoptic operative report template for patients with spinal injury using Microsoft Office InfoPath 2007 and published it in a Microsoft Office SharePoint server. A pilot study should be conducted in the future to evaluate the accuracy, completeness and conciseness of this template, for which, we have developed an evaluation tool. Use of standard medical terminology like SNOMED CT as well as use of HL7 should be promoted in the development of synoptic operative reporting in the future.

Ethics: Ethics approval submission form for non-interventional studies was submitted to Capital Health Research Ethics board. Ethics submission was for the "Utility of Synoptic Reporting to Improve Operative Reports for Spinal Cord Injury Patients". Minor corrections on the submitted proposal have been requested by the ethics board to grant permission for the pilot study to assess the completeness, accuracy and conciseness of the synoptic operative report. The author will continue to work on this project until November 2011 (see Appendix E).

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Appendix A

Evaluation of SNOMED CT to Represent Spinal Cord Injury Registry

Abstract

Rick Hansen Spinal Cord Injury Registry (RHSCIR) has been developed with 15 forms having well designed data fields to track the experiences and outcomes of people with traumatic form of spinal cord injury (SCI) during their journey through acute care, rehabilitation and community reintegration. The aim is to provide the baseline information which is needed to accelerate spinal cord injury research in Canada and around the globe. The process of collection and dissemination of information demands an environment of interoperability in the health care system, for which, there is a need of an interoperable electronic health record, based on Standards like SNOMED CT, HL7 etc. We have conducted a study to explore the potential for SNOMED CT to represent spinal cord injury domain in the electronic health record environment. Data fields of some of the forms of RHSCIR have been taken as sample and both manual and automatic coding with SNOMED CT browser have been done and compared in term of sensitivity, specificity, positive predictive value and negative predictive value.

1. Introduction

Worldwide the priority of healthcare service is gradually changing from cure of disease to disability limitation and rehabilitation. In order to achieve this changed goal, information technology is also shifting its focus from data and information management to knowledge management [1, 2]. *Rick Hansen Spinal Cord Injury Registry* (RHSCIR) is an example, which has been developed as an initial step in the transition process from data management to knowledge management in a collaborative environment in order to improve the treatment outcomes and quality of life for people, living with Spinal Cord Injury (SCI) [3]. This registry system has been planned in order to overcome insufficient communication and missing information, which have been identified as a major contributing factor to adverse events in medicine and also responsible for poor research outcome [4]. Application of advanced information technology in the registry system is expected to bring significant improvement of knowledge sharing by lowering the temporal and spatial barrier between knowledge workers by improving access to information about knowledge in the time of need at place of care [5].

2. Rick Hansen Spinal Cord Injury Registry

Rick Hansen Institute is established in order to improve the quality of life of people, who is surviving with Spinal Cord Injury and related-disabilities. It is an independent institute having Canada-wide collaboration. The *Rick Hansen Foundation* provides leadership and assistance to the Institute, in order to accomplish financial sustainability and expand its programs internationally. Foundation’s work has been to create opportunities for collaboration and to support identification and sharing of new knowledge, by working in close proximity with the researchers and people with disabilities [6].

In order to achieve the goal of Rich Hansen Institute, *Rick Hansen Spinal Cord Injury Registry* (RHSCIR) has been implemented to track the experiences and outcomes of people with traumatic form of spinal cord injury (SCI) during their journey through acute care, rehabilitation and community reintegration, to provide the baseline information needed to accelerate spinal cord injury research in Canada and around the globe. The ultimate aim is to improve the treatment outcomes and quality of life for people, living with spinal cord injury. At present RHSCIR is active in 35 major Canadian acute care and rehabilitation hospitals across the country to collect, manage and analyze important data from Canadians with spinal cord injuries. This data is then collected in a central location, with ensured individual privacy and security of information. It can then be used by researchers and clinicians to better understand spinal cord injury (SCI) and the effectiveness of specific treatments, practices or programs for improving functional outcomes and quality of life after SCI [3].

Sharing of information and its optimum benefit through the RHSCIR is only possible when the system is interoperable in a collaborative environment because according to Tim Benson, sharing of healthcare knowledge is essential for both improvement and safety of healthcare system but interoperability is an indispensible requirement for the process [7].

3. Importance of Interoperability in Healthcare

Interoperability is the ability of two or more systems or components, to exchange information and to use the information, that has been exchanged. With respect to software, the term *interoperability* is used to describe the capability of different programs to exchange data via a common set of exchange formats and to read and write the same file formats [7]. Depending upon the level of exchange of information, interoperability may be classified into three types:
(1)Technical interoperability: it is just the exchange of information. It is domain independent. It does not know or care about the meaning of what is exchanged.
(2) Semantic interoperability: It is the exchange of information with the ability to use that information. It ensures that system A and system B understand the data in the same way.
It allows computers to understand, interpret and use data without ambiguity. This is specific to domain and context, and usually involves the use of codes and identifiers. Semantic interoperability is at the core of what we usually mean by health care interoperability.
(3) Process interoperability: It is achieved when human beings share a common understanding, so that business systems interoperate and work processes are coordinated. They only obtain benefits when they use the new system in their day to day work.

Benefits of Interoperability: Sharing of healthcare knowledge is essential for both improvement and for safety of healthcare system. The interoperability acts as a bridge for sharing of information. The type of benefits depends upon the type of vendors like patient, health care provider, service delivery organization and jurisdiction [7].

Role of IT support in Interoperability: IT support in healthcare system has shown the potential to significantly reduce the rate of adverse events by selectively providing accurate and timely information at the point of care. It has been constantly engaged in the development of different integrating and interoperability standards for the organizational process in the healthcare system [8].

4. Implementation of Interoperability in Healthcare

For the implementation of an interoperability environment in the health care system, there is a need of an interoperable *electronic health record*, based on *Standards*, which will facilitate information exchange. EHR data is an essential component to support clinical trial recruitment, research collaboration, and retrospective studies. An integrated architecture can be created to allow sharing of patient information across the systems by implementing interoperability between the integrating systems. Creation of an interoperable EHR needs standards like standard clinical vocabularies like SNOMED CT, Healthcare message exchanges like HL7 and EHR ontology [9].

In Canada there is a goal of implementation of Electronic health records, in physician offices across the country as the *Pan Canadian implementation of EHR* with an expectation, that Pan-Canadian health information standards will enable health care providers to update and share integrated patient-centric health records. In 2006, Canada Health Infoway and the Canadian Institute for Health Information (CIHI) agreed to establish a new Canada-wide coordination function to support and sustain health informatics standards on a national scale. There are different national *and international standards*, which forms the basis of pan-Canadian standards are as follows [21]:

- Health Level 7 (HL7)
- Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT)
- Logical Observation Identifiers Names and Codes (LOINC)
- Digital Imaging and Communications in Medicine (DICOM)
- Health Canada Drug Product Database
- International Classification of Diseases -10 Canada version (ICD-10-CA)
- Integrating the Health care Enterprise (IHE)
- International Organization for Standardization's Health Informatics Technical Committee (ISO/TC 215)
- Unified Codes for Unit of Measure (UCUM).

According to Tim Benson, Health Level 7 (HL7) and SNOMED CT are the two key standards, which permit health care interoperability. These have to be used together to provide a language for information interchange. HL7 provides the grammar, rather like English or French grammar, while SNOMED CT provides the terminology or the words [7].

5. Use of terminology in EHR

According to Health Information Management Systems Society's (HIMSS), Electronic Health Record (EHR) is a longitudinal electronic record of patient health information, generated by one or more encounters in any healthcare delivery setting. It has the ability to generate a complete record of a clinical patient encounter, as well as supporting of other healthcare-related activities including evidence-based decision support, quality management, and outcomes reporting. Non-standard vocabularies and system interface are the current challenges in the implementation process of EHR [9].

An EHR enables researchers to analyze the efficacy of different medications as well as procedures in patients. The presentation of data, its format and the level of detail depends upon the service venue and the role of the user. An integrated architecture can be created to allow sharing of patient information across the systems by implementing interoperability between the integrating systems. Capturing the data electronically can reduce duplicate data entry, improve longitudinal follow-up, and enhance the ability to conduct meta-analyses. Registration, admissions, discharge, and transfer (RADT) data are key components of EHR, which allows an individual's health information to be aggregated for use in clinical analysis and research. Creation of an interoperable EHR needs standards like standard clinical vocabularies like SNOMED CT, Healthcare message exchanges like HL7 and EHR ontology [9].

Clinical Vocabularies: Vocabularies play an indispensable role in providing access to computerized health information because clinicians use a variety of terms for the same concept and without a structured vocabulary, an automated system will not be able to recognize these terms as being equivalent. Standard vocabularies like Systematized Nomenclature of Medicine—Clinical Terms (SNOMED-CT), Logical Observation Identifiers, Names and Codes (LOINC) etc. are a means of encoding data for exchange, comparison, or aggregation among systems. Implementation of standardized clinical vocabularies into clinical data capture systems can minimize terminology inconsistencies when data is captured at the point of care. It can provide more detailed and relevant clinical analyses for clinical research support [9].

Healthcare message exchanges: HL7 is a messaging standard, which is used in messaging across health care applications. It is used to send structured, encoded, data from one application (such as the laboratory system) to another (such as the EHR). The HL7 version 3 Reference Information Model (RIM) provides an object model of clinical data that can be extended to cover other biomedical models [9, 10].

Ontology: It is a specification of a representational vocabulary for a shared domain of discourse. It can be read by people as well as databases that need to share domain information. It is structured in such a way that it consists of computer-usable definitions of basic concepts in the domain together with their relationships [9].

6. Monitoring of implementation of standards in EHR

Certification Commission for Healthcare Information (CCHIT) has been established to certify vendors, which have been implementing HL7 and other standards in such a way that the resulting applications can exchange data with a minimum of customization [9].

7. SNOMED CT concepts and relationships

Terminology design research is focused toward development of comprehensive terminologies, which will be easy to use as well as facilitate access to semantically correct concept. SNOMED CT meets these requirements through use of description logic (DL), which is more advanced than one dimensional relationship, used in traditional terminologies [7]. It is the most comprehensive, multilingual clinical terminology in the world. It is resulted from the merger of SNOMED Reference Terminology (SNOMED RT) developed by the College of American Pathologists (CAP) and Clinical Terms Version 3 (CTV3) developed by the National Health Service (NHS) of the United Kingdom. There is no paper version of it. It is only used in computer systems. SNOMED CT is composed of components, which include concepts, relationships, descriptions, subsets and cross maps, each of which is identified by a SNOMED CT Identifier [7]. According to the SNOMED Clinical Terms International Release on July 2010 by the International Health Terminology Standards Development Organization (IHTSDO), it contains over 292,000 active concepts, 760,000 active English descriptions and 824,000 relationships [11]. Each concept may have multiple synonyms. Numeric codes (the SNOMED CT Identifier – SCTID) identify every instance of the three core building blocks: concepts, descriptions and relationships. Each *concept* represents a single specific meaning; each *description* associates a single term with a concept (any concept may have any number of descriptions or names); and each *relationship* represents a logical relationship between two concepts. SNOMED CT is designed for clinical documentation and reporting. The terminology is made up from concepts, terms and relationships to represent clinical information to support analysis and clinical decision. The content of SNOMED CT is organized into a number of hierarchies including: clinical finding, procedure, observable entity, body structure, organism, substance, staging and scales, etc. An important principle of SNOMED CT is that of permanence. Once a concept or description has been created, it is never deleted, but may be given an inactive status. Terms are encoded using Unicode (UTF-8), which supports all languages. The fully specified name (FSN) is a phrase that names a concept in a way that is both unique and unambiguous. SNOMED CT supports multiple dialects and languages. For example, British English (en-GB) and US English (en-US) are different dialects of English in which many medical terms have different spellings [7].

SNOMED CT has been specified as health information standards for the description of following [7]:

- Diagnosis
- Family History
- Adverse Reaction
- Allergy
- Risk Factor
- Exposure
- Therapeutic Interventions
- Other Health Interventions
- Clinical Symptom/Health Problem (Clinical Finding)
- Physical Assessment Finding
- Psychological/Mental Assessment

*Pre-coordinated expression***:** In SNOMED CT it is the simplest form, in which any concept can be defined using a single identifier [7].

Example of SNOMED CT coding of fully specified name:

- Coding of Cauda Equina syndrome is Concept ID 192970008.
- Coding of neurological deficit is Concept ID 264552009.
- Coding of pH is Concept ID 27327002.

Example of SNOMED CT coding of synonym:

- Coding of Non-prescription medication is "80288002|non-prescription drug|".
- Coding of Unassisted respiratory rate is "271625008|rate of spontaneous respiration|".
- Coding of Myelopathy is "48522003| spinal cord disease|"

Post-coordinated expression: SNOMED CT uses compositional grammar consisting of standard syntax; to create post-coordinated expressions that represent clinical meaning by using a combination of two or more codes [7, 12 and 13]. Example of SNOMED CT coding using post-coordinated expression:

- Coding of 'AIS (Abbreviated Injury Scale) head and neck' is "273254002| Abbreviated injury scale|:10546003|Site|=361355005|head and neck|".
- Coding of 'anal sensation' is 34381000 |anal canal structure|: 47429007 | associated with| = 276435006| pain / sensation finding|".
- Coding of 'Peripheral nerve injury with cord injury' is 73590005|peripheral nerve injury|
  : 47429007 | associated with| = 90584004|Spinal cord injury|".

8. Evaluation of SNOMED CT to represent spinal cord injury registry data field

The interest for SNOMED CT as a standard vocabulary to represent spinal cord injury was initiated by the conclusion of a study, conducted by Paterson [14] to explore the enhancement of semantic interoperability of clinical documents for chronic conditions, such as chronic kidney disease, hypertension and diabetes by creating a standardization platform for the vocabulary, used in the document from reference vocabularies, such as SNOMED CT and UMLS. The study of Paterson was carried forward by Sampalli et.al [15] and De Silva et.al [16] in an attempt to evaluate the coverage of multidisciplinary health concepts in complex chronic health condition as well as representation of computed tomography procedure respectively. The results were promising in both the cases. The work of Lee et.al [17] and Elkin et.al [18] related to evaluation of coverage of SNOMED CT for encoding of clinical dataset as well as clinical problem list respectively encouraged us further to evaluate its potential to represent spinal cord injury domain.

9. Methodology of Study

9.1. Study material

Source: RHSCIR Protocol Version 1.7 (effective in Feb20, 2010) contained 15 types of forms, which were designed for the Rick Hansen Spinal Cord Injury Registry (RHSCIR) to collect data about spinal cord injury patients in a central location from 35 major Canadian acute care and rehabilitation hospitals across the country. Data fields were related to people with traumatic form of spinal cord injury (SCI) during their journey through acute care, rehabilitation and community reintegration. These 15 forms including the modified version of diagnosis and procedure forms (effective in March10, 2010) were used for collection of Data fields for this study.

Inclusion criteria: Out of 15 forms, 9 forms were selected, which were having predominantly medical terminologies. The selected forms were medical history–general, medical history–injury, neurology, intervention, diagnosis, procedure, respiratory, pain and trauma.

Exclusion criteria: Remaining 6 forms were excluded from study because they contained predominantly demographics and administrative information, which were better managed with HL7. Excluded forms were demographic, socio-demographic, admission/discharge, questionnaires, hospital and consent.

9.2. SNOMED-CT browser

The CliniClue Xplore Browser with ClueData International Edition 2010-01-31 was used for the study [19]. It is a SNOMED CT terminology tools, developed by Clinical Information Consultancy Ltd. It has a graphical user interface for searching and navigating medical concepts as well as for building post-coordinated expression using compositional grammar.

9.3. Scanning and coding of the selected forms

First, a master list was created with all the medical and non-medical terminologies present in each of these 9 forms. In the second stage all the duplicated terminologies were deleted from the list, leaving only unique data field elements (as shown in table 1). In the third stage counting of total number of medical and non-medical terminologies present in each form were done (as shown in table 2). In the fourth stage, coding of all medical and non-medical terminologies was attempted using CliniClue browser (as shown in table 3).

Table 1: Name of the forms

Serial No.	Name of the Form	Total number of terminologies present
1	Demographics	30
2	Socio-Demographics	67
3	Admission / Discharge Information	34
4	Medical History - General	50
5	Medical History - Injury	13
6	Consent Status	9
7	Neurology	21
8	Interventions	58
9	Hospital	10
10	Questionnaires	8
11	Diagnosis	139
12	Procedure	93
13	Respiratory	20
14	Pain	36
15	Trauma	21
	Total	**609**

Table 2: Terms coded in each form

Serial No.	Name of the Form	Total number of terminologies present	Number of terminologies coded using pre-coordinated SNOMED CT	Number of terminologies coded using post-coordinated SNOMED CT	Total Number of terminologies coded using SNOMED CT
1	Medical History - General	50	38	7	45
2	Medical History - Injury	13	6	4	10
3	Neurology	21	16	1	17
4	Intervention	58	43	11	54
5	Diagnosis	139	103	35	138
6	Procedure	93	63	17	80
7	Respiratory	20	13	1	14
8	Pain	36	21	13	34
9	Trauma	21	13	8	21
	Total	**451**	**316**	**97**	**413**

N.B: Total number of terminologies present in 9 forms is 451, which is finally adjusted to 447 by excluding duplication.

While coding, data field items i.e. terminologies from the master list of spinal cord injury dictionary were matched, first with the SNOMED CT concepts as fully specified names and subsequently, the remaining unmatched terminologies were attempted to be coded with the SNOMED CT concepts as synonyms. As use of pre-coordinated concepts to represent every terminology was not practical, post-coordinated expression of SNOMED CT had been tried to code the remaining data elements as far as possible. Hence both the pre-coordinated (single Concept ID) and post-coordinated expressions within SNOMED CT was used to represent spinal cord injury patient (as shown in table 3). An increase in the percentage of coverage of terminology was noted with the additional use of post-coordinated expression of SNOMED CT (as shown in table 3 and 4).

Table 3: Number of terms coded pre-coordinated as well as pre-coordinated and post-coordinated combined

Name of Forms	Pre-coordinated (%)	Post-coordinated (%)
History - General	76	90
History - Injury	46.15	76.92
Neurology	76.19	80.95
Interventions	74.13	93.10
Diagnosis	74.10	99.28
Procedure	67.74	86.02
Respiratory	65	70
Pain	58.33	94.44
Trauma	61.90	100

9.4. Statistical analysis

We investigated the sensitivity, specificity, positive and negative predictive values of SNOMED CT for both pre-coordinated and post-coordinated expressions of SNOMED CT. Both spinal cord injury and administrative data were included in the sample data in each form in order to assess the ability of SNOMED CT to correctly differentiate spinal cord injury from non- spinal cord injury cases.

Table 4: An evaluation of terminologies present in all 9 forms of RHSCIR

Evaluation of Terminologies present in all 9 forms of RHSCIR		Remark
Total Number of Medical and Non-medical Terminologies present in 9 forms	447	Excluding duplication
Total Number of Medical Terminologies present	428	To be coded (i.e. Positive)
Total Number of Medical Terminologies coded using both pre and post coordinated expression of SNOMED CT	413	Actually coded
Total Number of Medical Terminologies could not be coded using SNOMED CT	15	Unable to be coded even using post –coordinated expression
Total Number of Administrative and other non-medical Terminologies	19	Not to be coded (i.e. Negative)

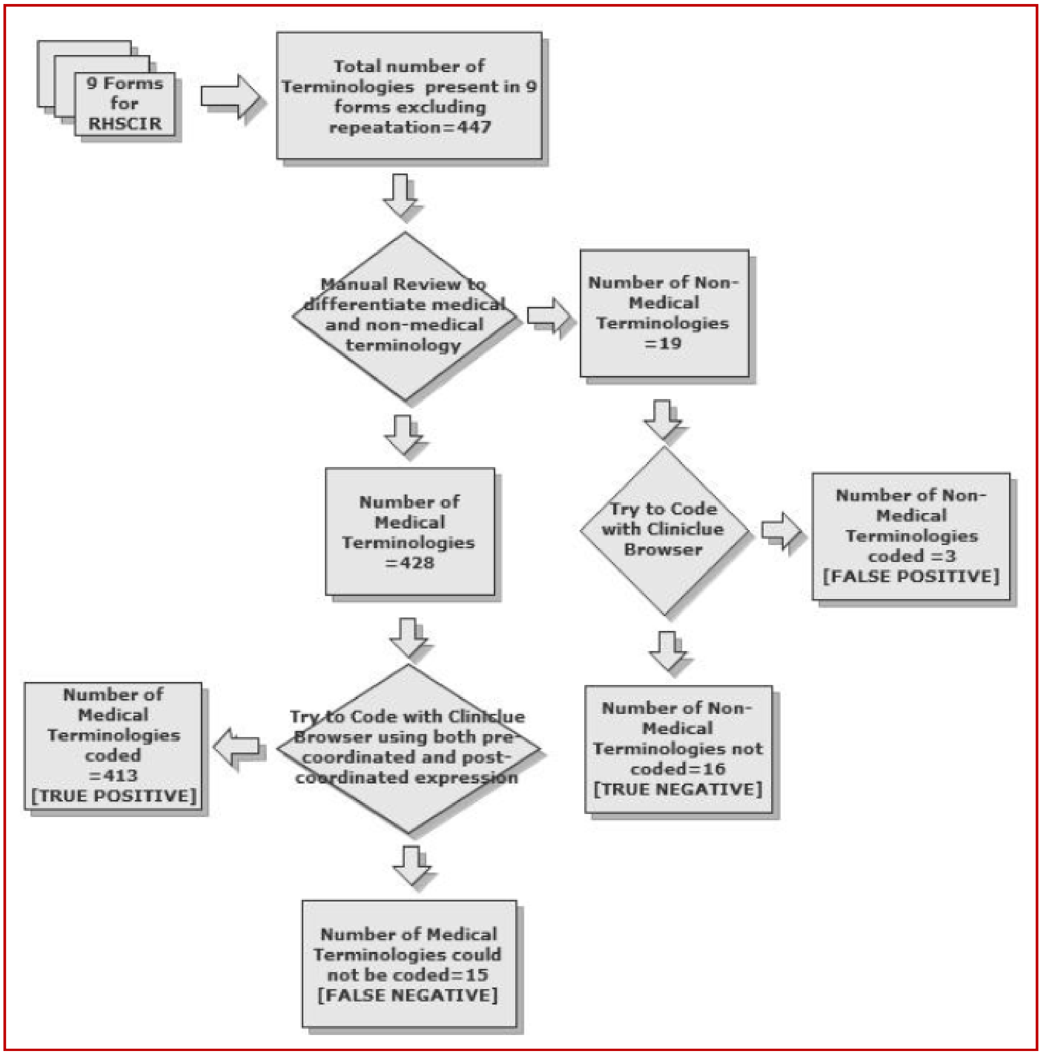

Figure 1: Methodology of evaluation of SNOMED CT

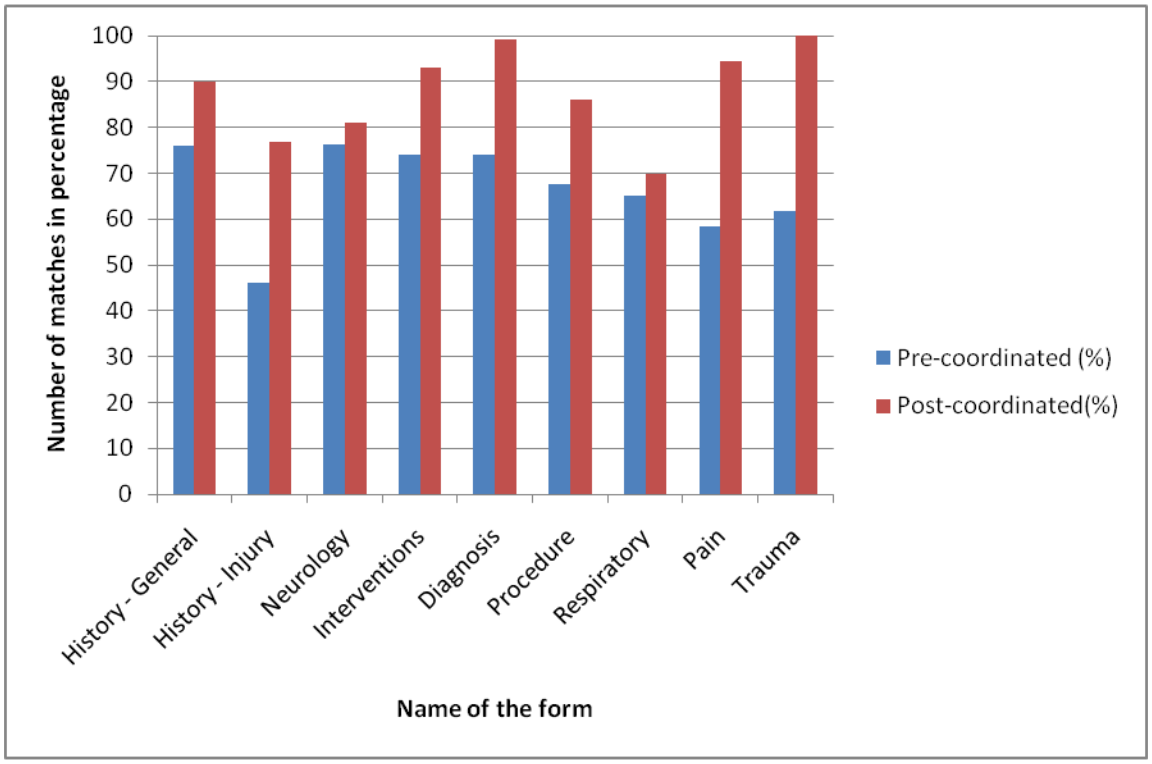

Figure 2: Showing number of terms coded with SNOMED CT using only pre-coordinated as well as both pre-coordinated and post-coordinated expressions combined.

9.5. Results

In the first stage, manual examination of 9 forms excluding repetition of terminologies detected 434 medical terminologies and 19 non-medical terminologies all together (as shown in table 1 and 2). Coding of these terminologies was attempted using CliniClue browser. Using pre-coordinated expression of SNOMED CT we could code only 316 medical terminologies reflecting 73.8% sensitivity. Out of 434 medical terminologies, only 413 terminologies could be coded (i.e. true positive) using both pre-coordinated and post-coordinated expression in SNOMED CT. While coding of non-medical terminologies, 3 of 19 non-medical terminologies were coded as medical terminologies (i.e. false positive). The sensitivity as well as positive predictive value had been found to be increased from 73.8% to 96.5% and 99.1 to 99.3% respectively following additional use of post-coordinated expression (as shown in 3).

Table 5: Reviewers' evaluation for the representation of spinal cord injury cases in the nine forms of RHSCIR using SNOMED CT

Reviewers' evaluation for the representation of spinal cord injury cases in the nine forms of RHSCIR using SNOMED CT.								
	True Positive	False Negative	True Negative	False Positive	Sensitivity	Specificity	PPV	NPV
RHSCIR forms represented by SNOMED CT using pre-coordinated expressions	316	112	16	3	73.8	84.2	99.1	12.5
RHSCIR forms represented by SNOMED CT using pre-coordinated and post-coordinated expressions	413	15	16	3	96.5	84.2	99.3	51.6

9.6. Discussion

Manual addition of synonyms and modifiers to SNOMED CT increased the overall sensitivity to 96.5%. De Silva et al also found similar result while representing computed tomography procedure using SNOMED CT [16].Results of our study also replicated the result of Chalmers and other terminology researchers [16,17,18,20]. Chalmers examined how well SNOMED CT performs in encoding the most common clinical problems in the Mayo Clinic Master Sheet Index (MSI). Use of post-coordinated expressions illustrated the importance of compositional grammar within SNOMED CT in representing more concepts in spinal cord injury domain as the coding of medical terminology with post-coordinated expression was associated with increased sensitivity and positive probability in representing concepts in SNOMED CT.

9.7. Limitation of the study

The study sample of this research was a convenience sample of data fields, collected from 9 types of forms, related to RHSCIR database. A larger sample size of other type of neurosurgical registry would have offered additional insights and strength to the study. Further research is also needed to evaluate the ability of SNOMED CT to represent cases, other than spinal cord injury cases in the neurosurgical domain.

10. Conclusion

Our study showed that SNOMED CT, when used with compositional grammar to represent spinal cord injury registry database, had a sensitivity of 96.5 % and PPV of 99.3 %. Results of the study confirmed that SNOMED CT had the potential to provide a satisfactory level of representation for use in the spinal cord injury domain. Hence *Health care organization* should be encouraged to investigate the potential for SNOMED CT to represent spinal cord injury domain in their electronic health record environment. The *vendor community* should consider SNOMED CT as a preferred terminology for their application to represent spinal cord injury domain.

Ethics: As the data did not include any personal identifiable information, ethics approval was not necessary for this study.

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Appendix B

Protocol for the Selection of Data Fields Related to Synoptic Operative Reporting of Spinal Cord Injury Cases

In order to frame the protocol for the selection of data fields for the synoptic operative report template, we has been divided the content of the synoptic operative report (SOR) into different section (as shown in table given below).Later in subsequent tables, data field related to each section of the SOR and the name of the main organization for which the specific data field has been aimed to be captured, has been mentioned. While setting the priority for capturing of data using synoptic operative report template, in addition to the base organization i.e. CDHA, we have also targeted CIHI, RHSCIR and the ongoing as well as possible future clinical study to provide information, which might be needed for monitoring and improvement of quality of health care.

Important Note: This protocol has been framed to capture only traumatic case of spinal cord and non-traumatic cases are not included.

Abbreviation used:

RHSCIR: Rick Hansen Spinal Cord Injury Registry
CIHI: Canadian Institute for Health Information
CDHA: Capital District Health Authority
WHO: World Health Organization
Miscellaneous: Misc (i.e. for current or future clinical study)

Table 6**:** Different sections present in the synoptic operative report

Section No	Different Sections present in the Synoptic Operative Report
A	Demographic data
B	Start and end time of procedure
C	Pre-operative diagnosis
D	Additional pre-operative diagnosis
E	Post operative diagnosis
F	Type of Intubation
G	Decompression Neural Elements: Date and Time
H	Type of anesthetic procedure
I	Type of Surgical Approach
J	Pre-operative clinical status
K	Per-operative clinical status
L	Post-operative clinical status and future plan
M	Procedures /Implant /Bone graft

Table 7**:** Data field related to Pre-operative diagnosis

Serial no.	Data field related to Pre-operative diagnosis	Value set	Required by
1	Injury	Open	RHSCIR
		closed	
2	Nature of pathology at the site of spinal cord injury	Primary	RHSCIR
		secondary	
3	Injury at Cervical region (C0-C2)	Dislocation: Occipital-cervical	RHSCIR
		Dislocation: Complete C1-2	
		Occipital condyle #	
		Arch #: Anterior	
		Arch #:Posterior	
		Jefferson	
		Rotary subluxation, fixation	
		Instability	
		Hangman's #: Undisplaced	
		Hangman's #: Displaced and angulated	
		Hangman's #: with dislocated C2-3 facets	
		Odontoid #: Type II	
		Odontoid #: Type III	
		Unclassifiable #, C1	
		Unclassifiable #, C2	
4	Injury at Cervical region (C3-C7)	Posterior arch #	RHSCIR
		Anterior wedge compression #	
		avulsion flakes,	
		Minimally displaced unilateral facet #	
		Unilateral facet #/subluxation	
		dislocation/subluxation	
		Three column burst # without dislocation	
		Three column fracture dislocation	
		Bilateral facet dislocation	
		Unclassifiable #, C3-C7	
5	Soft Tissue Injury - Cervical	Sprain	RHSCIR
		Torticollis	
		SCIWORA	
		Transient paralysis (spinal cord concussion)	
		Brachial plexus and/or peripheral nerve injury	

6	Injury at T1-T12 region	Compression: < 50 % height loss	
		Compression: >= 50 % height loss	
		Burst	
		Flexion distraction: Bony	
		Flexion distraction: Ligamentous	
		Flexion distraction: Mixed	
		Translational injury: Bony	
		Translational injury: Ligamentous	RHSCIR
		# Hyperextension Injury	
		Isolated posterior: # spinous process	
		Isolated posterior: # isolated transverse	
		Isolated posterior: # laminar	
		Isolated posterior: # facet	
		Isolated posterior: # pars	
7	Soft Tissue Injury - Thoracic	Sprain	
		SCIWORA	
		Transient paralysis (spinal cord concussion)	RHSCIR
		Brachial plexus and/or peripheral nerve injury	

Table 7: Data field related to pre-operative diagnosis (continuation)

Serial no.	Data field related to Pre-operative diagnosis	Value set	Required for
8	Injury at L1-L5 region	Compression: < 50 % height loss	RHSCIR
		Compression: >= 50 % height loss	
		Burst	
		Flexion distraction: Bony	
		Flexion distraction: Ligamentous	
		Flexion distraction: Mixed	
		Translational Injury: Bony	
		Translational Injury: Ligamentous	
		# Hyperextension Injury	
		Isolated posterior element injury: # spinous process	
		Isolated posterior element injury: # isolated transverse	
		Isolated posterior element injury: # laminar	
		Isolated posterior element injury: # facet	
		Isolated posterior element injury: # pars	
		Unclassifiable #, L1-L5	
9	Soft Tissue Injury - Lumbar	Sprain	RHSCIR
		SCIWORA	
		Transient paralysis (spinal cord concussion)	
		Brachial plexus and/or peripheral nerve injury	
10	Other Trauma	Penetrating spinal cord injury without significant vertebral column injury: Cervical	RHSCIR
		Penetrating spinal cord injury without significant vertebral column injury: Thoracic	
		Penetrating spinal cord injury without significant vertebral column injury: Lumbar	
		Penetrating spinal cord injury without significant vertebral column injury: Cauda equina	

Table 7: Data field related to pre-operative diagnosis (continuation)

Serial no.	Data field related to Pre-operative diagnosis	Value set	Required for
10	Other Trauma (continued)	Other cervical trauma	RHSCIR
		Other thoracic trauma	
		Other lumbar trauma	
		Sacral # : Ilium involved	
		Sacral # : Ilium not involved	
		Sprain, sacrum or coccyx	
		Coccyx #	
		SCIWORA, Cauda Equina	
		Pathological fracture collapsed vertebra (excludes that due to oncology)	
		Psychogenic paralysis	
		Other trauma, specify	

Table 8: Data field related to additional pre-operative diagnosis i.e. co-morbidity

Serial no.	Value set for data field related to Additional pre-operative diagnosis (i.e. co-morbidity)	Required for
1	Myocardial Infarction	RHSCIR
2	Congestive heart failure	
3	Peripheral vascular disease	
4	Cerebrovascular disease	
5	Dementia	
6	Chronic pulmonary disease	
7	Connective tissue disease	
8	Ulcer disease	
9	Liver disease mild	
10	Liver disease moderate or severe	
11	Hemiplegia	
12	Renal disease moderate or severe	
13	Diabetes with end organ damage	
14	Any malignancy	
15	Metastatic solid malignancy	
16	AIDS	
17	Osteoarthritis/degenerative arthritis	
18	Osteoporosis	
19	Poliomyelitis	
20	Achondroplasia	
21	Mental retardation	
22	Major psychiatric conditions	
23	Cerebral palsy	
24	Muscular dystrophy	
25	Previous spinal cord injury	
26	Diabetes	
27	Renal disease mild*	
28	Malignant lymphoma	
29	Unknown	
30	None	

Table 9 : Data field related to post operative diagnosis

Serial no.	Data field related to Post operative diagnosis	Value set	Required for
1	This field is important because in some case it has been noted that the post operative diagnosis may be more elaborative than pre-operative diagnosis or occasionally may be completely different .	Same as pre-operative diagnosis but the conclusion is taken after the look up operation whereas pre-operative diagnosis is based on clinical examination and other diagnostics procedures	RHSCIR

Table 10: Value set for Data field related to type of intubation

Serial no.	Value set for Data field related to Type of Intubation	Required by
1	Awake	RHSCIR
2	Fibreoptic	
3	Laryngoscope	
4	Rapid sequence	
5	Previously intubated	
6	Other	
7	Unknown	

Table 11: Value set for data field related to decompression of neural elements

Serial no.	Value set for data field related to Decompression Neural Elements: Date and Time	Required for
1	Date	RHSCIR
2	Time	

Table 12: Value set for data field related to type of anesthetic procedure

Serial no.	Value set for Data field related to Type of anesthetic procedure	Required for
1	General	RHSCIR
2	Spinal	
3	Epidural	
4	Combined general and neuraxial	
5	Other nerve block	
6	Monitored anesthesia care	
7	Local anesthesia	
8	No anesthetic	
9	Other anesthetic not monitored by anesthetist	

Table 13: Data field related to pre-operative clinical status

Serial no.	Data field related to Pre-operative clinical status	Value set	Required for
1	Glasgow Coma Scale	3 to 15	RHSCIR
2	ASIA impairment scale	A,B, C, D, E	
3	ASA Grade	l, ll, lll, lV,V	

Table 14: Data field related to per-operative clinical status

Serial no.	Data field related to Per-operative clinical status	Required for
1	Estimated blood loss	RHSCIR
2	IV Fluid administered	optional
3	Urine Output:	RHSCIR
4	Blood transfused	optional

Table 15: Data field related to post operative clinical status

Serial no.	Data field related to Post-operative clinical status	Value set	Required for
1	Hemodynamic status		optional
2	Post operative future plan		optional

Table 16: Data field related to procedure; vertebral column

Serial no.	Data field related to Procedure: Vertebral Column	Value set	Required for
1	Decompression	Laminectomy	RHSCIR
		Foraminotomy	
		Laminoplasty	
2	Corpectomy		
3	Discectomy	Partial	
		Total	
4	Fixation		
5	Fusion	posterolateral (un-instrumented)	
		interbody	
		posterolateral (instrumented)	
6	Osteotomy		
7	Vertebroplasty		
8	Excision tumor	Intradural	
		Extradural: Intralesional, marginal, wide	
9	Thoracoplasty		
10	Sub-occipital craniectomy		
11	Transoral odontoid resection		
12	Coccygectomy		
13	Removal of Instrumentation		

Table 17: Data field related to procedure: drainage/debridement irrigation

Serial no.	Data field related to Procedure: Drainage/Debridement Irrigation	Value set	Required for
1	Insertion shunt	lumboperitoneal	RHSCIR
		syringoperitoneal	
2	Insertion subarachnoid catheter		
3	Incision & Drainage wound infection		
4	Incision & Drainage abscess (non-epidural)		

Table 18: Data field related to procedure: cord, nerve or canal

Serial no.	Data field related to Procedure: Cord, Nerve or Canal	Value set	Required for
1	Excision spinal vascular malformation		RHSCIR
2	Exploration & restoration of subarachnoid space		
3	Repair meningocele		
4	Release tethered cord		
5	Repair dural tear		
6	Dural patch		
7	Rhizotomy	facet	
		spinal nerve	
8	DREZ lesion		

Table 19: Data field related to Procedure: Pumps

Serial no.	Data field related to Procedure: Pumps	Required for
1	Replacement/removal/implant of infusion pump	RHSCIR
2	Replacement/removal/implant of IPG (battery)	
3	Insertion of spinal stimulator electrode	
4	Spinal stimulator(complete system) to include pulse generator/receiver	

Table 20: Data field related to Procedure: Other

Serial no.	Data field related to Procedure: other	Value set	Required for
	Biopsy	Vertebral	RHSCIR
		Soft tissue	

Table 21: Data field related to Procedure: Implant

Serial no.	Data field related to Procedure: Implant	Required for
1	Anterior Cervical Plate	RHSCIR
2	Posterior Cervical Rod-Screw system	
3	Cannulated screws (e.g. UCSS)	
4	Prefabricated prosthetic replacement(e.g. cage)	
5	USS	
6	Moss/ Miami/Monarch	
7	CD Horizon	
8	Other rod system	
9	Wires	
10	Z plate	
11	Other	

Table 22: Data field related to Procedure: Bone graft

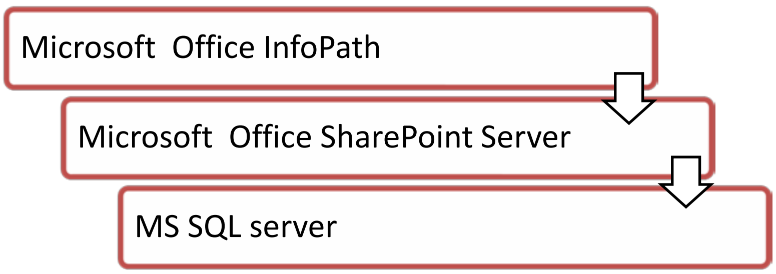
Serial no.	Data field related to Procedure: Bone Graft	Value set	Required for
1	Autograft	Local (vertebra)	RHSCIR
		Fibula	
		Rib	
		Structural Ilium	
		Morcelized Ilium	
2	Allograft	Structural	
		Morcelized	
3	Synthetic	BMP	
		Osteoset	
		PMMA(e.g. cement)	

Appendix C

Experience with Microsoft Office InfoPath and SharePoint

1. Introduction

We have used *InfoPath 2007* for generation of Synoptic operative report (SOR) template for Spinal cord injury, which is later published into Microsoft Office SharePoint 2007. After the publication of web based, browser enabled version of the SOR template, it can be filled on the web without being dependent on the availability of InfoPath software on the client's computer and the data filled in the template are saved in XML format (as shown in figure XX). The SharePoint is connected to SQL server for storage of data for future use.



2. Microsoft Office InfoPath 2007

Microsoft Office InfoPath 2007 is a member of Microsoft Office products. It is included in Microsoft Office 2007 Ultimate, Professional Plus, Enterprise edition, and is also available separately.
Uses: It is a software application for designing, publishing, filling and submitting electronic forms containing structured data. It may be used to fill in a form but the form must be designed first using the designer component part of the software to develop an InfoPath template or may use the pre-designed form template.
Working environment of Microsoft Office InfoPath 2007: It may be used to integrate with Microsoft Office SharePoint technology or Microsoft Office Form Server.
Technical specialty of Microsoft Office InfoPath 2007: All the data stored in InfoPath forms are stored in an XML format, which is referred to as the "data source". It provides several controls like textbox, radio button, and checkbox to present data in the data source to end users and for each of these controls, certain actions or "rules" can be bound in. Data Validation can be achieved while input of data into fields, by comparing the input data to patterns and also confirming the correct data type such as a String or an Integer.
Importance of browser enabled form: It is to be noted that every time when we open the form to fill, we need the InfoPath software in the user machine to read it. If we can publish the browser enabled version of the form using some software like MOSS 2010, we will not need InfoPath software in the user machine to fill it.

Experience gained from use of Microsoft Office InfoPath 2007: The most crucial point in designing the form is to decide first whether we want to create a web based form or not. Because in case of web based form, all the functionalities of InfoPath are not compatible and hence at the beginning, when the option “Enable browser compatible features only” is selected, it will disable the incompatible functionalities of InfoPath in the design mode.

InfoPath 2007 also allows us to design the form on CDA conformant XML schema and there by act as an important tool for interoperability utilizing HL7 version 3 clinical document architecture schemas. It also permits the use of SNOMED CT Concept ID for each data field using ‘properties’ feature of different ‘control’ functionalities and thereby promote use of standard medical terminology.

Steps of creation of form (e.g. synoptic operative report):

Although for filling the web based form, the client does not need InfoPath software but at the software is essential in the designing phase. It is started through start menu →all programs →Microsoft Office → Microsoft Office InfoPath (as shown in Figure 3).

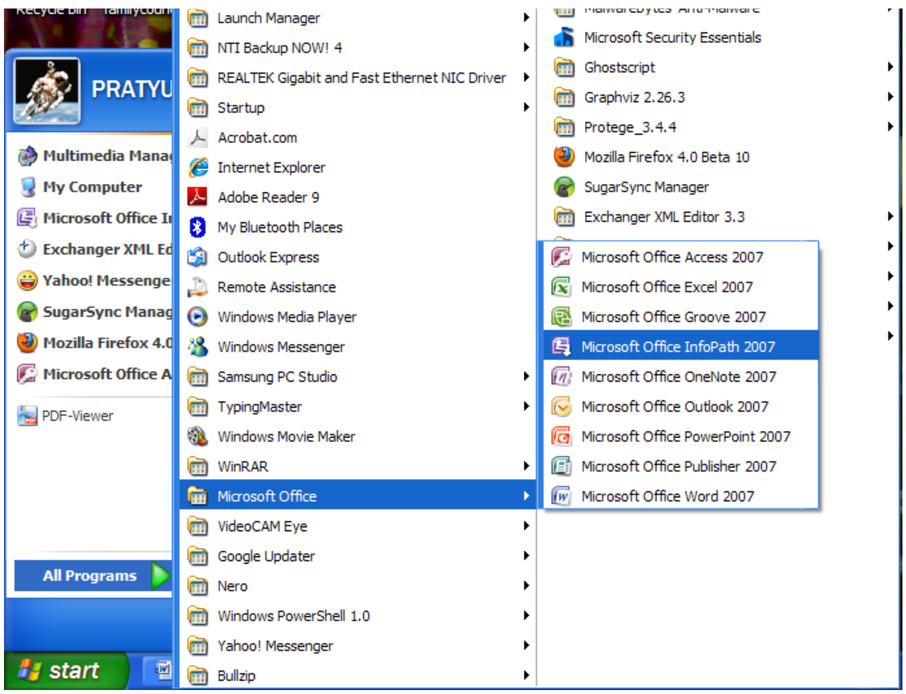


Figure 3: Way to start an InfoPath.

Once the program is started, we will get an interface for filling predesigned form or for designing a new form (as shown in figure 4). In this step we will have to select “Enable browser-compatible features only” for creation of web based form. In this step we will have to select either to design complete form template or a template part which can be used in many form. The introduction of schema e.g. CDA conformant XML schema is also permissible in this interface.

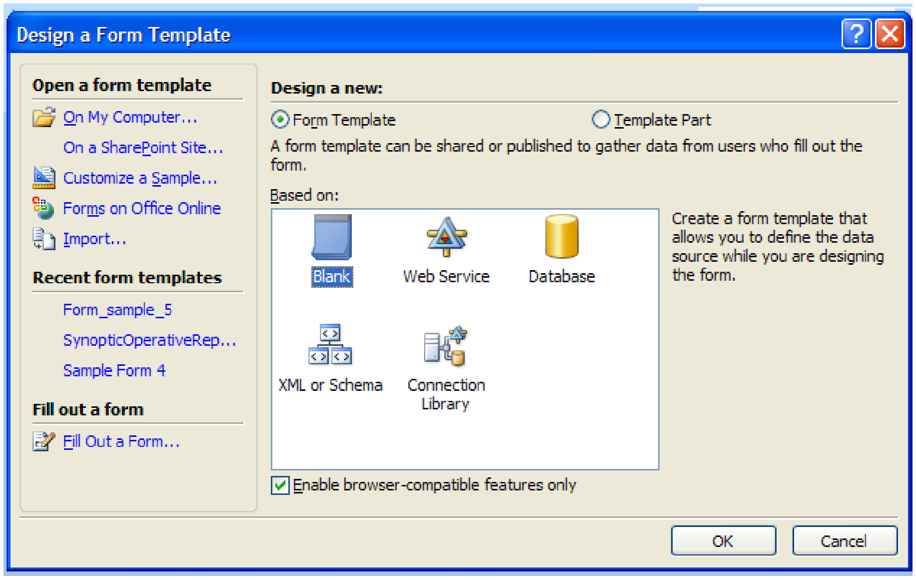


Figure 4: Selection of browser compatible feature for the form to be designed.

After selection of browser enabled features and option for form template, we will get the main interface, which will allow designing our form through "layout" and also permits corporation of functionalities through "controls" (as shown in figure 5).

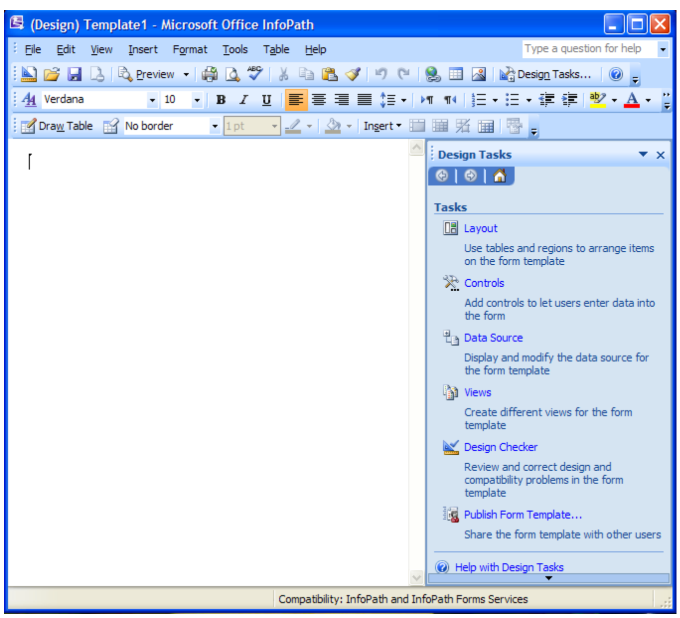


Figure 5: Design tasks in the InfoPath.

'Layout' permits designing of table by insertion of table with title and varying number of column (as shown in figure 6).

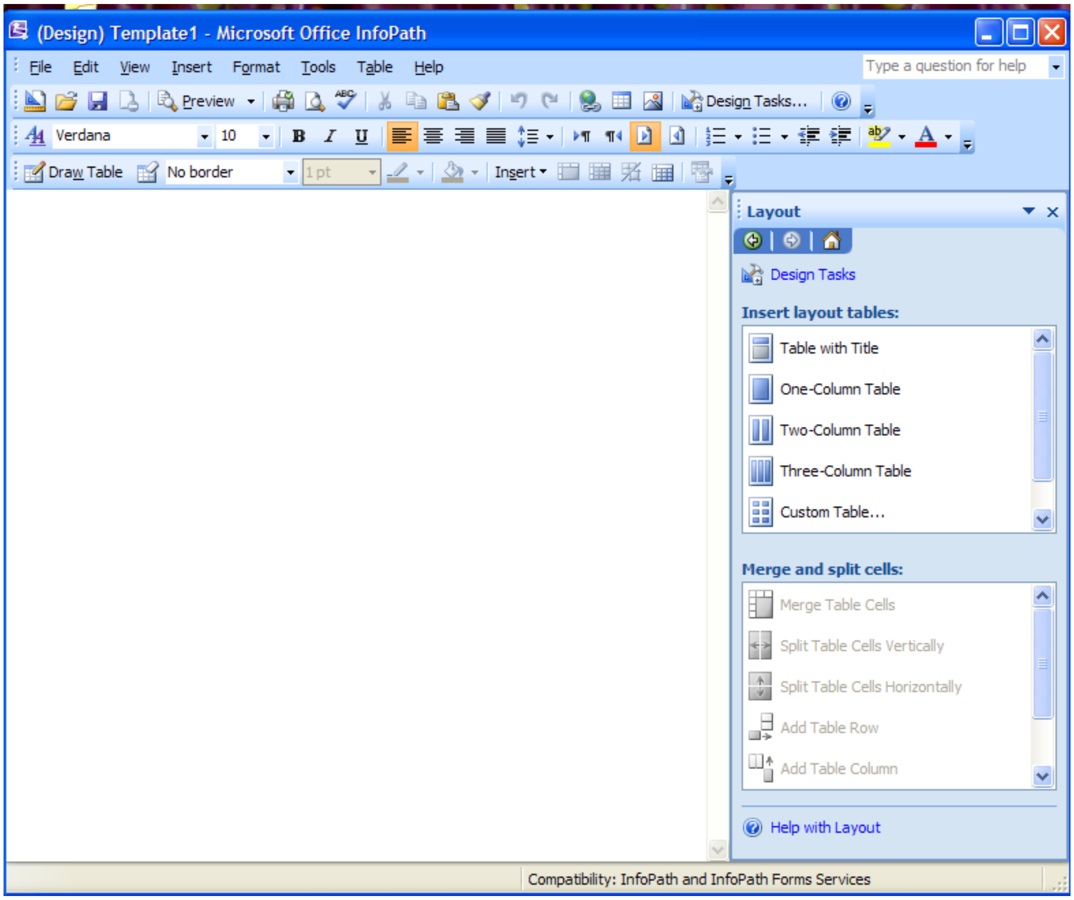


Figure 6: Different layouts available in the design task of an Infopath.

'Controls' feature allows us to insert functionalities like text box, drop down list, option button. The selection of functionality depends upon the design of our form. These functionalities help to capture value of each data field in the form {as shown in figure 7). The quality of value of data can be controlled using the variety of 'properties' features depending upon type of functionality (as shown in figure 8 & 9).

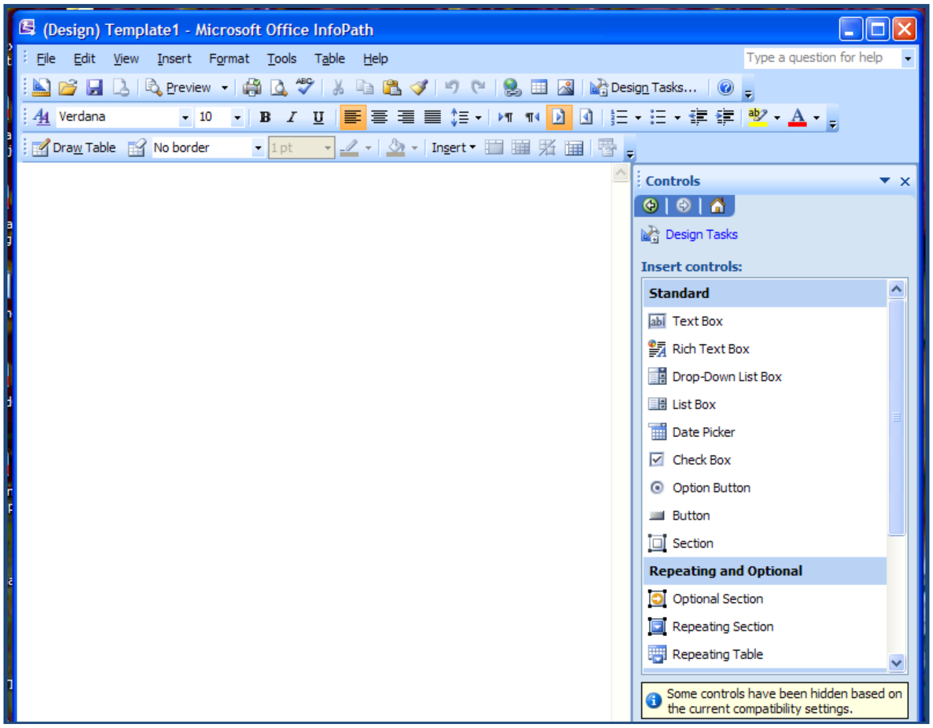


Figure 7: Different ‘controls’ available in the browser compatible setting of design task in the Infopath.

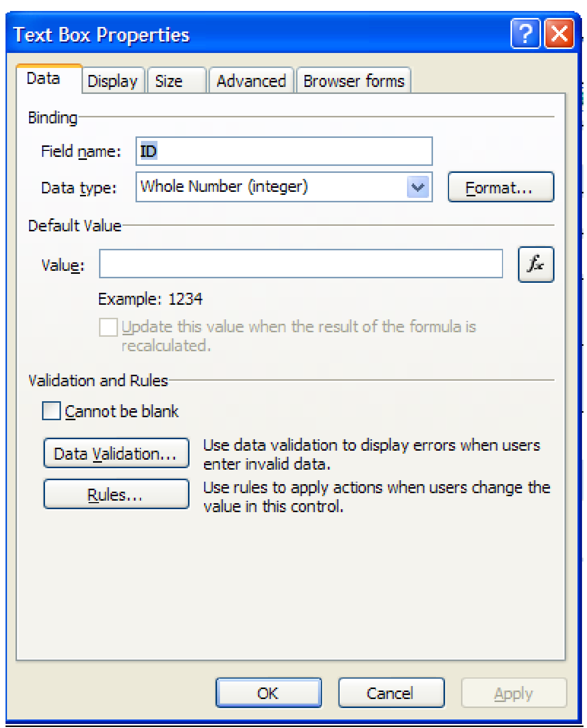


Figure 8: Text box properties available for the ‘text box control’ in the InfoPath.

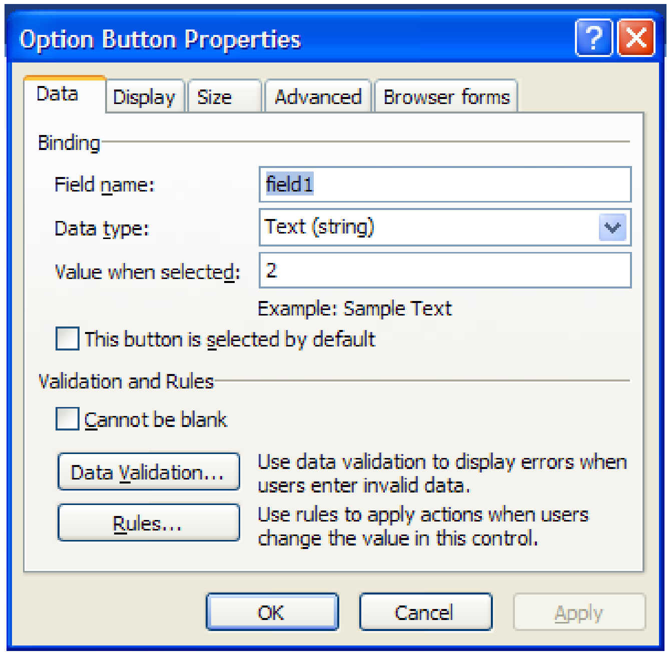


Figure 9: Option button properties for the 'option button control' in the Infopath.

After the completion of the designing phase of the form and introduction of functionalities, the form may be published in either SharePoint server or Form server. In order to publish we will have to format the 'Submit option' present in the tool tab where we will have to specify the place for submission (as shown in figure 9 & 10).

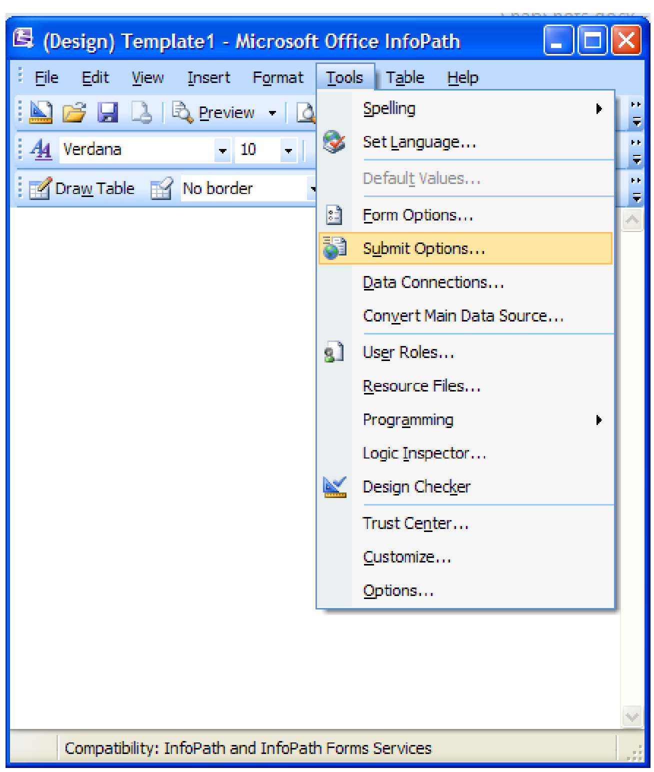


Figure 10: Submit options in the 'tools' of the InfoPath

In addition the destination of submission, we may also provide customized message in case of successful submission as well as in case of failure (as shown in figure 10).

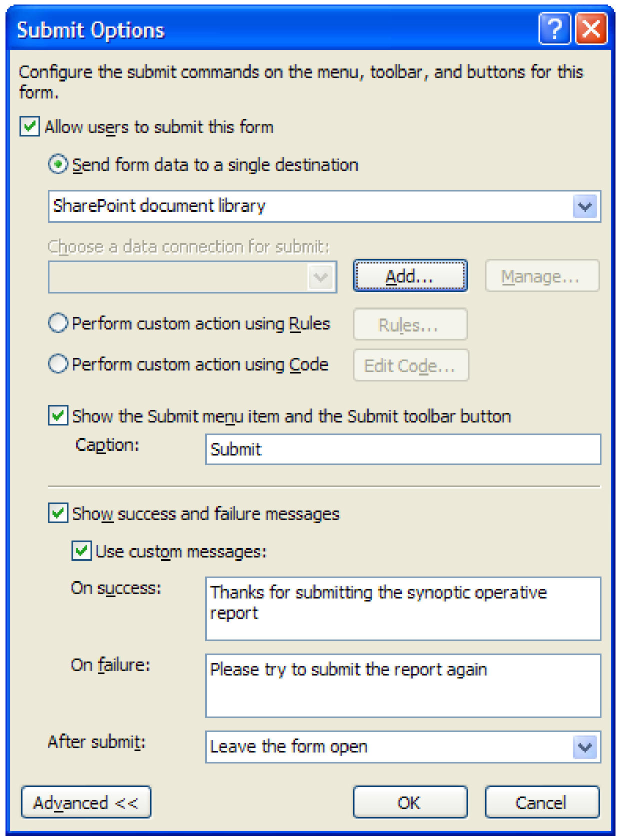


Figure 11: Configuration option available to submit the form designed in the InfoPath.

After the completion of ‘submit option’, the next step is the completion of ‘form option’ present in the tool tab (as shown in figure 12 & 13).

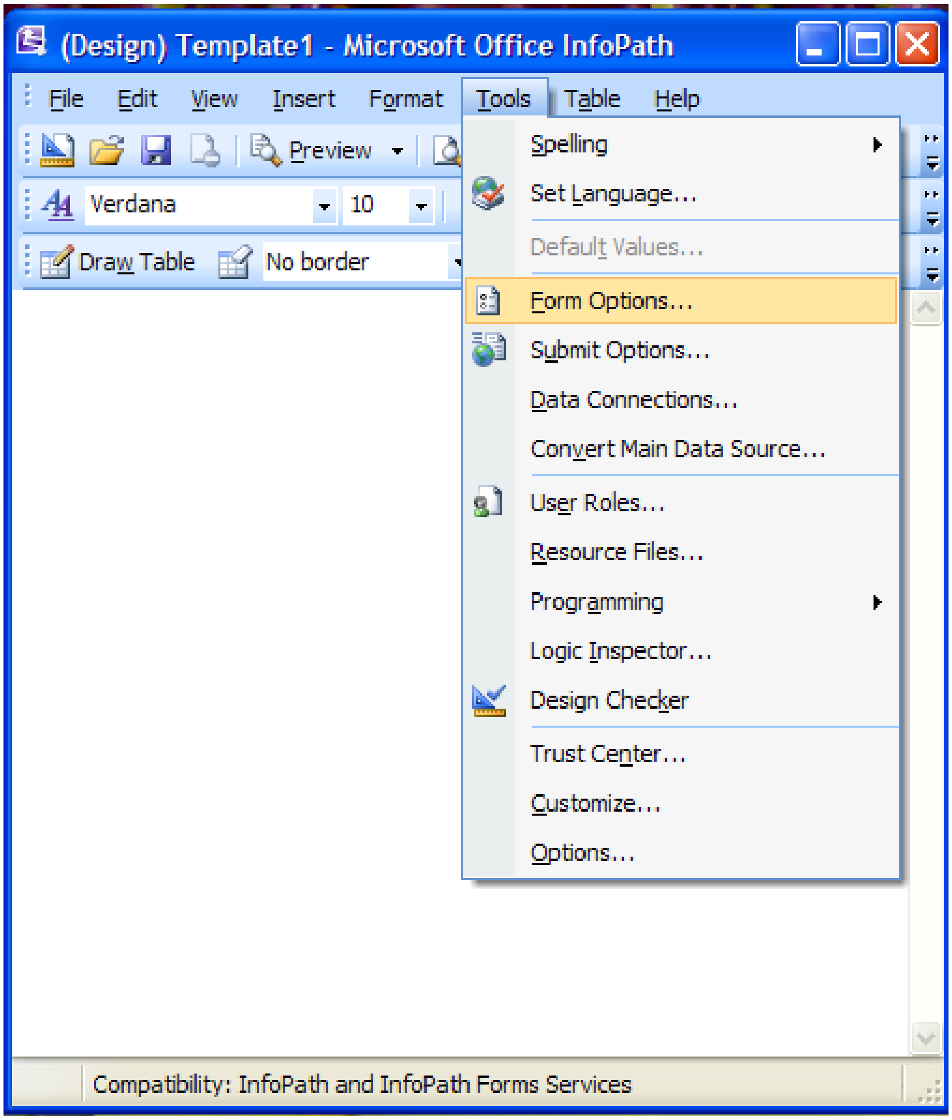


Figure 12: ‘Form options’ available in the ‘tools’ of the InfoPath

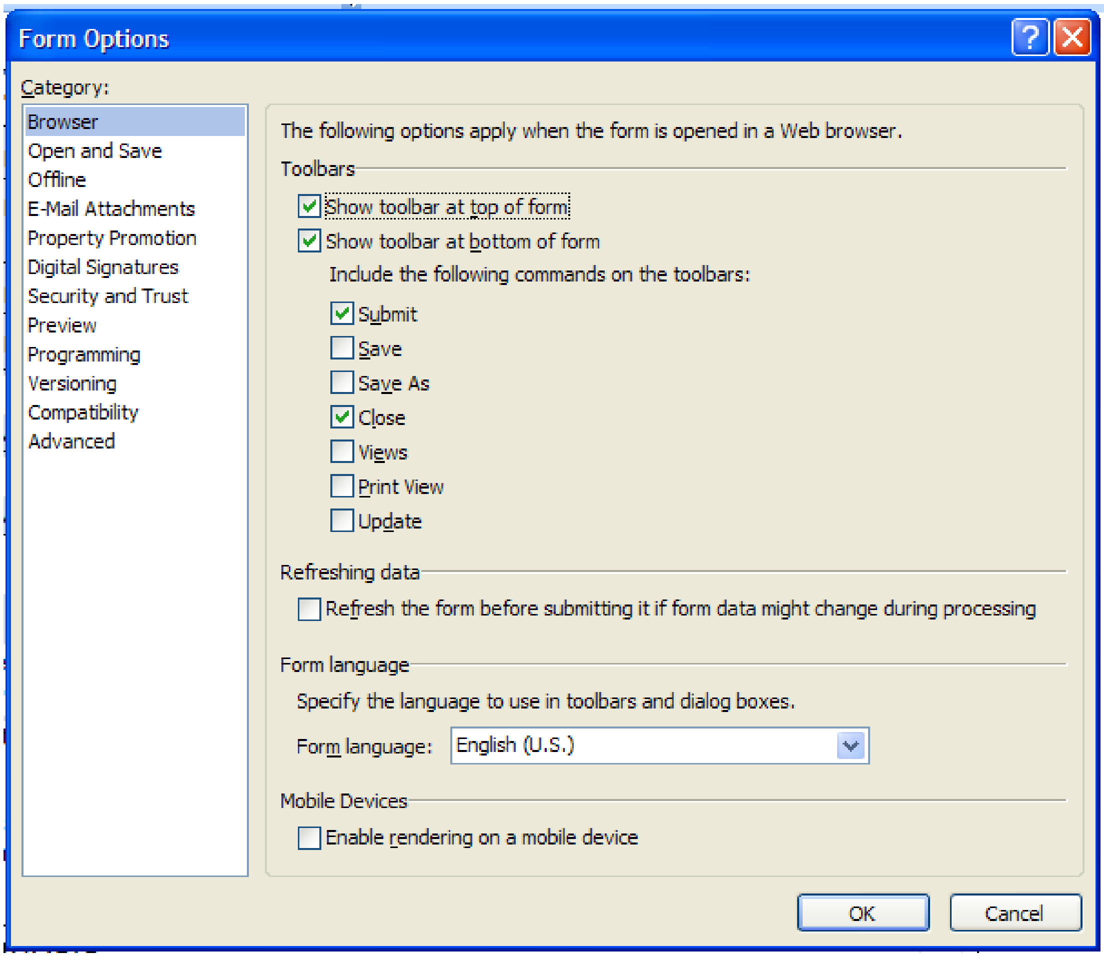


Figure 13: Available options for the form when it is opened in a web browser

Final the process of publishing of the form into SharePoint through publish tab present in the file menu (as shown in figure 14 and 15).

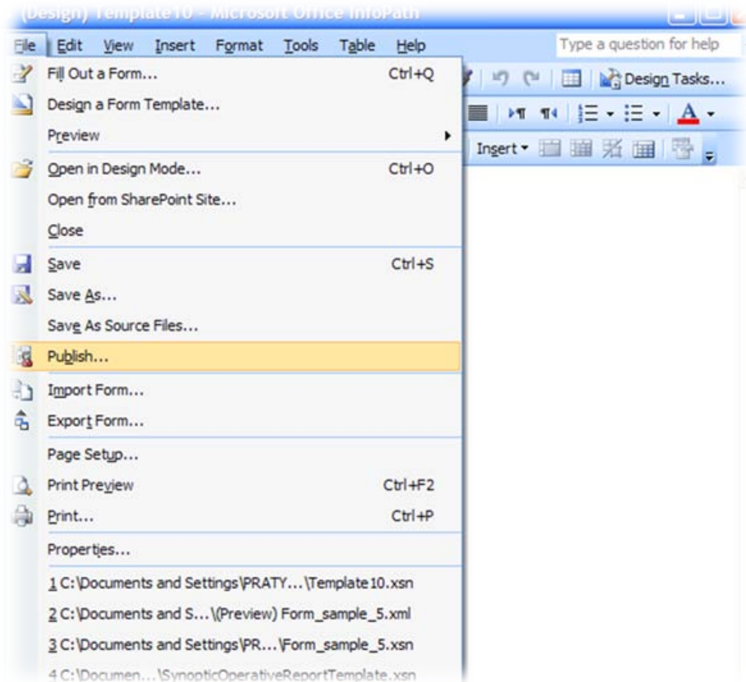


Figure 14: Publish option in the 'file' of the InfoPath

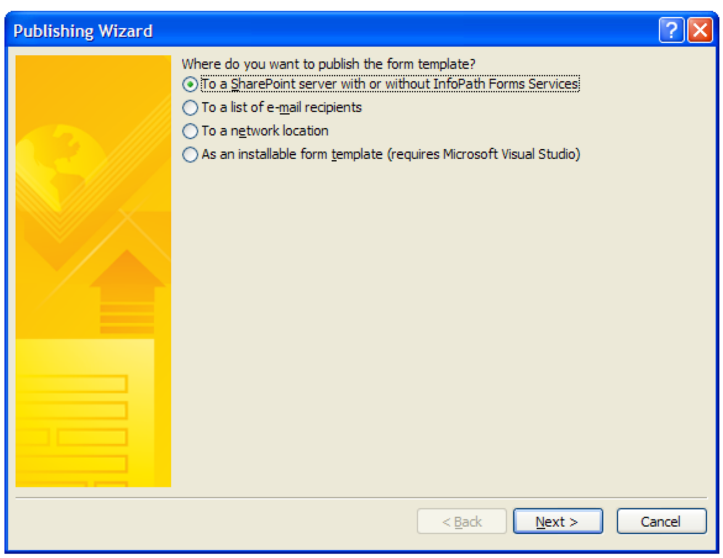


Figure 15: Different available options to publish the designed form

During the process of publishing the form, we have to mention the path of our SharePoint website, where we will be planning to publish our form (as shown in figure 16).

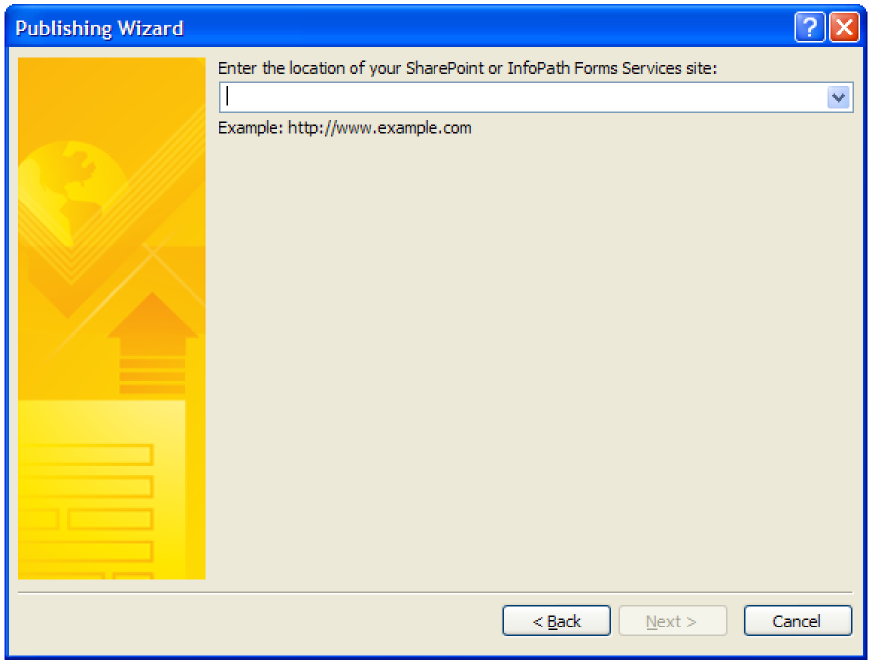


Figure 16: Selection of location of SharePoint or InfoPath to publish the form

It is to be noted that for successful process of publishing the form in SharePoint server, the Microsoft office SharePoint server has to be configured beforehand so that it will able to receive form from InfoPath and will able to show the form in the browser.

3. Microsoft Office SharePoint

Microsoft Office SharePoint is a web application platform developed by Microsoft. It is designed as a centralized replacement for multiple web applications as it also provides various methods for customization and configuration of web areas. It provides multi-purpose platform and thereby allows management of intranet portals, extranets and websites.

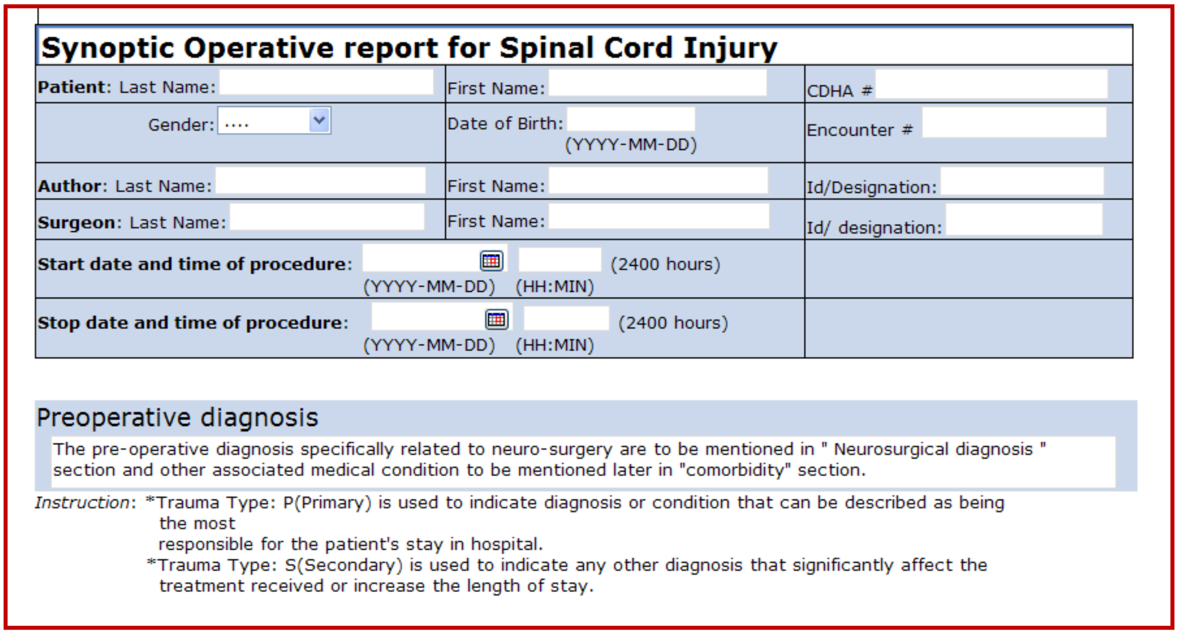
It is typically associated with web content management and document management systems. It also provides collaboration spaces, social networking tools, enterprise search, business intelligence tooling, process/information integration, and third-party developed solutions.

The most common uses of SharePoint include:

- Intranet portal: to centralize access to enterprise information. It helps a company to manage its data, applications, and information easier by centralizing process management and providing tacit knowledge capture.
- Enterprise content and document management: SharePoint is often used to store and track electronic documents or images of paper documents. It is usually also

capable of keeping track of the different versions created by different users. It also provides the benefit of a central location for storing and working on documents, which can significantly reduce emails and duplicated work in an organization.

- Extranet sites: SharePoint can be used to provide password-protected, web-facing access to people outside an organization and thereby integrate third parties into business processes.
- Internet sites: SharePoint can be used to manage a public website.



Synoptic Operative report for Spinal Cord Injury

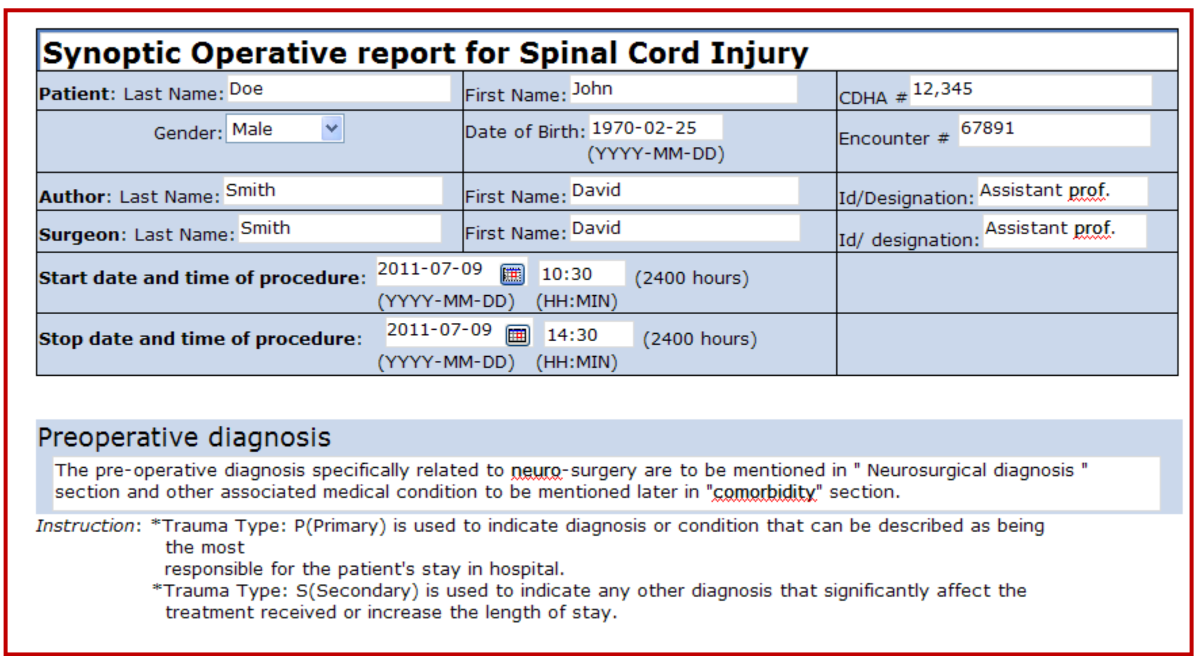
Patient: Last Name:	First Name:	CDHA #
Gender:	Date of Birth: (YYYY-MM-DD)	Encounter #
Author: Last Name:	First Name:	Id/Designation:
Surgeon: Last Name:	First Name:	Id/ designation:
Start date and time of procedure: (YYYY-MM-DD) (HH:MIN) (2400 hours)		
Stop date and time of procedure: (YYYY-MM-DD) (HH:MIN) (2400 hours)		

Preoperative diagnosis

The pre-operative diagnosis specifically related to neuro-surgery are to be mentioned in " Neurosurgical diagnosis " section and other associated medical condition to be mentioned later in "comorbidity" section.

Instruction: *Trauma Type: P(Primary) is used to indicate diagnosis or condition that can be described as being the most responsible for the patient's stay in hospital.
*Trauma Type: S(Secondary) is used to indicate any other diagnosis that significantly affect the treatment received or increase the length of stay.

Figure 17: A sample of a part of the synoptic operative report designed in the InfoPath



Synoptic Operative report for Spinal Cord Injury

Patient: Last Name: Doe	First Name: John	CDHA # 12,345
Gender: Male	Date of Birth: 1970-02-25 (YYYY-MM-DD)	Encounter # 67891
Author: Last Name: Smith	First Name: David	Id/Designation: Assistant prof.
Surgeon: Last Name: Smith	First Name: David	Id/ designation: Assistant prof.
Start date and time of procedure: 2011-07-09 10:30 (YYYY-MM-DD) (HH:MIN) (2400 hours)		
Stop date and time of procedure: 2011-07-09 14:30 (YYYY-MM-DD) (HH:MIN) (2400 hours)		

Preoperative diagnosis

The pre-operative diagnosis specifically related to neuro-surgery are to be mentioned in " Neurosurgical diagnosis " section and other associated medical condition to be mentioned later in "comorbidity" section.

Instruction: *Trauma Type: P(Primary) is used to indicate diagnosis or condition that can be described as being the most responsible for the patient's stay in hospital.
*Trauma Type: S(Secondary) is used to indicate any other diagnosis that significantly affect the treatment received or increase the length of stay.

Figure 18: A filled out sample of the part of the newly designed synoptic operative report

```xml
<?xml version="1.0" encoding="UTF-8"?><?mso-infoPathSolution solutionVersion="1.0.0.40"
productVersion="12.0.0" PIVersion="1.0.0.0"
href="file:///C:\Documents%20and%20Settings\PRATYUS%20SWAIN\Local%20Settings\Application%20Data\Microsoft\InfoPath\Designer2\816fd92d10ea461a\manifest.xsf" ?><?mso-application
progid="InfoPath.Document" versionProgid="InfoPath.Document.2"?><my:myFields
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xhtml="http://www.w3.org/1999/xhtml"
xmlns:my="http://schemas.microsoft.com/office/infopath/2003/myXSD/2011-06-08T22:21:58"
xmlns:xd="http://schemas.microsoft.com/office/infopath/2003" xml:lang="en-us">
	<my:Patient_Last_name>Doe</my:Patient_Last_name>
	<my:Patient_first_name>John</my:Patient_first_name>
	<my:ID>12345</my:ID>
	<my:Encounter_number>67891</my:Encounter_number>
	<my:Date_of_birth>1970-02-25</my:Date_of_birth>
	<my:Gender>Male</my:Gender>
	<my:Author_Lname>Smith</my:Author_Lname>
	<my:Author_Fname>David</my:Author_Fname>
	<my:Author_design>Assistant prof.</my:Author_design>
	<my:Surg_Lname>Smith</my:Surg_Lname>
	<my:Surg_Fname>David</my:Surg_Fname>
	<my:Surg_design>Assistant prof.</my:Surg_design>
	<my:Start_Date_of_procedure>2011-07-09</my:Start_Date_of_procedure>
	<my:Start_time_of_procedure>10:30:00</my:Start_time_of_procedure>
	<my:Stop_Date_of_procedure>2011-07-09</my:Stop_Date_of_procedure>
	<my:Stop_time_of_procedure>14:30:00</my:Stop_time_of_procedure>
```


Figure 19: A sample of the XML form of data that is saved from a filled out InfoPath form.

Appendix D

Tools for evaluation of accuracy, completeness and conciseness of synoptic operative report template

Recruitment Questionnaire for Evaluating Operative Reports for Spinal Cord Injury Patients

User number:

Please tick **only one** answer per question. Thank you.

Demographics:

What is your level of medical training? □ Clerk □ Resident □ Neurosurgeon □ Other Physician

Is English the language that you first learned at home in childhood? □ Yes □ No

Computer Experience:

	Never	Once or Twice	Monthly	Weekly	Daily
I have used a word processor (e.g. MS Word) to compose a text document					
I have used a database program (e.g. Access)					
I have used an internet search engine (e.g. Google) to find clinical information					
I have searched the Medline database using the PubMed search engine					

Medical Education:

I have received formal training regarding what content should be included in a synoptic operative report □ Yes □ No

I have previously used the Capital Health Enterprise Express Voice Dictation and Transcription System to dictate an operative report. □ Yes □ No

Assessment Form for Evaluating Operative Reports for Spinal Cord Injury Patients

1.	Date of surgery	Yes	No
2.	Patient Identifiers	Yes	No
3.	Name of surgeon and assistants	Yes	No
4.	Name of anesthetists	Yes	No
5.	Pre-Op patient diagnosis	Yes	No
6.	Post-Op patient diagnosis	Yes	No
7.	Procedure performed	Yes	No
8.	Brief History of present illness	Yes	No

Likert scale 1 (low) to 5 (high)

1-No description of pre-operative course or indications
3-Preoperative course and indications were described but some detail was lacking
5- Complete description of preoperative course and indications for procedure

(Note: Tools have been adopted from the study of Vergis et al (2008), with customization for Spinal Cord Injury patients).

Feedback Questionnaire for Evaluating Operative Reports for Spinal Cord Injury Patients

User number:

Thank you for taking part in this study. We appreciate your taking the time to do this.

1. Please respond to the following statements regarding the **Electronic Synoptic Operative Report**:

Statement	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
I was able to enter all the important data elements					
I found the diagnosis terms I needed in the template					
I found the terms related to operative procedure I needed in the template					
I found that structuring content into Procedure, Graft and Implant sections was relevant to me					
I am comfortable using a computer for data entry of Operative report Template					
I found the **Electronic Synoptic Operative Report** easy to use					

2. Please respond to the following statements regarding the **Transcription System**:

Statement	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
I was able to enter all the important data elements					
I dictated in a way that makes it easy for transcriptionists to transcribe the dictation					
I was sufficiently informative for the purpose of an operative report					
I am comfortable using dictation for data entry of operative report					
I found the **Transcription System** easy to use					

3. Rate the style of your operative report produced after you completed the **Electronic Synoptic Operative Report**:

	Agree	**Neutral**	**Disagree**
Colour choices were appropriate			
Layout was logical			
Text was large enough			
Information was expressed as expected			
Amount of content was appropriate			

Appendix E

The plan for the pilot study which was submitted to Capital Health Ethics Research Board with Ethics approval submission form for non-interventional studies

Utility of Synoptic Reporting to Improve Operative Reports for Spinal Cord Injury Patients

Sean Christie, MD, FRCSC and Grace Paterson, PhD

Executive Summary

Health data gathered about clinical activities on individual patients is key to learning about what works and why. Currently, spinal surgeons and the residents they train use narrative reporting methods to document spinal cord injury operations on patients. It can be difficult to use the reports from several different patients to get information and statistics about the group as a whole. Furthermore, research studies have demonstrated that the existing, narrative operative record is not as complete as it could be, and this makes it less useful, both for care of the patient as well as for research and administrative purposes. One solution is to move towards electronic capture of the operative report using an electronic template based on "synoptic methodology". This means that a library of key words and phrases would be created to capture clinically relevant information in a standardized way. Synoptic operative reports represent a significant advance toward ensuring higher quality medical treatment of spinal cord injury patients. They enable the capture of discrete data items and transform a narrative operative report that is qualitative in nature to a qualitative one that can be aggregated to generate information and knowledge. Electronic synoptic operative reports have replaced dictated reports at many institutions because users could demonstrate improvements in reliability, completeness and timeliness with this alternative.

Our hypothesis is that we can improve the quality of data for primary and secondary use through implementing an electronic template for synoptic operative reports for spinal cord injury patients. Success in this project would improve the quality of data, which is already collected for other research projects, such as the Rick Hansen Spinal Cord Injury Registry (RHSCIR), as well as for the Canadian Institute for Health Information Discharge Abstract Database (CIHI DAD), which collects health information from institutions across the country.

Surgical residents will be recruited to produce an operative report using both the current method of recall dictation for a narrative report and the proposed method of electronic template. All participants (residents) will be given a recruitment questionnaire and a feedback survey. Participants will be given a quick orientation about the template and its use. We seek to investigate the acquisition of a skill using a *teaching at the time of practice* approach. We will randomly assign participants to two groups. Group 1 will be asked to dictate an operative report followed by template, and Group 2 will be given template followed by dictation. The narrative (dictated) and synoptic reports will then be compared. We will look at accuracy, conciseness, completeness and reuse.

Through improvements at the time of data entry, we believe that synoptic reporting will

enhance the transfer of information, which will lead to improvements in the clinical data captured on spinal cord injury operations for secondary use (RHSCIR and CIHI DAD).

Utility of Synoptic Reporting to Improve Operative Reports for Spinal Cord Injury Patients

Background

The care of patients involves many different individuals who rely on information documented about patient care and management. If the documented information is incomplete, it weakens the ability of the team to carry out informed decision-making. By improving data quality at the time of data capture, we should enable higher data quality for use in patient care and for reuse by healthcare administration and researchers.
The two introductory sentences in Tim Benson's book, Health Interoperability HL7 and SNOMED, state why transformation in healthcare is necessary:
"Healthcare quality improvement is an economic and moral necessity. The transformation, which is needed to improve productivity and effectiveness, will rely on computer interoperability to deliver information when and where required, support soundly-based decision-making, eliminate unnecessary repetition, reduce delays and avoid errors." [1]

Rationale

Electronic templates support the creation of clinical documents that are of higher quality than those produced by the same individual using dictated narrative reporting method [2]. The template serves as a prompt for pertinent information, which could be reused to support information needs of researchers and administrators. Electronic synoptic operative reports are dependent upon predefined templates for individual procedures. Such templates are based on synoptic methodology; the synoptic concept starts with the creation of a library of key words and phrases to show a preferred way to communicate a clinical concept in an operative report. This enables the capture of discrete data items and transforms a narrative operative report that is qualitative in nature to a quantitative one that can be aggregated to generate information and knowledge [3]. The Alberta Cancer Surgery Working Group has developed and implemented a web-based synoptic surgical medical record, Alberta WebSMR. Albertans reported that following the implementation of a rectal cancer template, the synoptic report captured 99% of the required data elements versus 45.9% captured via a dictated narrative report [4]. This showed that the science of surgical technique could be better measured using a synoptic reporting method. The synoptic checklist approach has consistently shown superior results to narrative reports for completeness [5].

The adoption rate for the Alberta WebSMR grew from 13.8% as of May 2007 [6] to 75% as of November 2010 [7]. Although feedback suggests that use of the template is time-saving and user-friendly, the adoption rate indicates some surgeons are reluctant to change practice. A Surgical Synoptic Reporting Tools Project (SSRTP) was phased into

Capital Health District Authority (CDHA). It uses a web-based system to enable surgeons to provide comprehensive reports after surgeries on breast and colorectal cancer patients [8]. They have engaged family physicians and provided a sample synoptic renal report on the public CDHA website [9] to help familiarize family physicians with the structured document produced by the synoptic reporting method.
Documents, such as an operative report, are composed of sections and statements within these sections. A particular construct for electronic templates called the Health Level 7 (HL7) Clinical Statement is a standardized form of communication that is understandable by humans and computers. It enables computer interoperability because the health information standard, HL7 Clinical Statement, acts as a common language for exchange of clinical data. The Electronic Template for Spinal Cord Injury Patients is based on the use of HL7 Clinical Statements for expressing discrete data items. In its human-readable form, it is a narrative document.

In this study, residents will be shown how their operative report will be used for secondary purposes, specifically the Spine Procedure Form of the Rick Hansen Spinal Cord Injury Registry (RHSCIR; CDHA-RS 2008-028) and the procedures section of the Canadian Institute for Health Information Discharge Abstract Database (CIHI DAD). The proposed study will gather data on usefulness, usability and use of an electronic template for Neurosurgery operative reports for spinal cord injury patients. Better capture of data using an electronic template will allow us to extract more complete data for resident feedback for training purposes and for current and future research examining treatment for spinal cord injury patients.

Hypothesis

Our hypothesis is that we can improve the quality of the data for primary and secondary use through implementing an Electronic Template for Spinal Cord Injury Patients. The secondary uses of this data include the Spine Procedure Form for the Rick Hansen Spinal Cord Injury Registry (RHSCIR) and the Canadian Institute for Health Information Discharge Abstract Database (CIHI DAD).

Subjects

Our study population is those surgical trainees listed on the Neurosurgery House Staff Master Schedule 2011-2012. The inclusion criteria are:

- Trainee is eighteen (18) years or older;
- Trainee is registered as a clerk or resident at Dalhousie University Medical School;
- Trainee is willing to take part in this study, including signing the Consent Form after carefully reading it.

There are no exclusion criteria.

Research Plan

This study will build on prior work done by these investigators between July 2010 and

February 2011. At that time, the data elements in 15 forms used for data collection for RHSCIR were expressed using Health Level Seven International (HL7) Clinical Statements and vocabulary systems, especially SNOMED CT. One of the 15 forms expressed in this manner was the Spine Procedure Form, which is used by RHSCIR to gather information about surgery for spinal cord injury. We will build, using the expressions generated by this earlier work, a synoptic template for operative reports. In this study, the template will be tested to see whether it is better at capturing information than narrative operative reports. This template will be designed to support capture of data elements that are considered by consensus between the investigators to be important for data collection.

Instruments required for the study will be adapted from instruments used in a previous study [2]. These include the score sheet for completeness of the operative report, recruitment questionnaire and feedback questionnaire.

We will use a repeated-measures design, also known as within-subjects design. We will seek to investigate the acquisition of a skill using a teaching at the time of practice approach. To account for learning effects, we use a counterbalancing technique. We will randomly assign the participants to Group 1 or Group 2. Group 1 will be asked to complete their operative report using dictation followed by electronic template for spinal cord injury patients, while Group 2 will be given template followed by dictation.

The time required should not exceed 1 hour. The average time needed to dictate an operative report for later transcription is 15 minutes. Dictation of this report is standard practice, and the narrated report will be transcribed as per standard practice and uploaded into the electronic patient record (Horizon Patient Folder) as per usual practice. It may take slightly longer to complete the electronic operative report using a template. The trainees will be familiar with the transcription system from their other rotations. All participants will be given a Quick start Guide and User Manual for the synoptic template. These information sources provide a quick orientation about the template and its relationship to a library of clinical statements for expressing discrete data items. Each participant will also be asked to complete a recruitment questionnaire (Appendix D) examining possible control variables (e.g., demographics, computer experience) and a feedback questionnaire (Appendix D). These instruments will be adapted from a previous study as described above. Participants (residents) will be consented by the Principal Investigator and/or Research Coordinator.

Sample Size

The benefits of the crossover design are the elimination of the between subject variance, a decrease in the sample size needed, and the discovery of possible learning effects. Learning effects occur when participants rely on experiences obtained in the first leg in the study to implicitly improve their performance in the second leg. We control for examiner variance by using the same examiner, an International Medical Graduate enrolled in the Dalhousie Master of Health Informatics program, to score the trainee's operative report produced using either dictation or template method. The scoring instrument will be adapted from a previous study [2]. In the study by Flyer et al [10] significant differences were detected in a non-randomized study of 11 residents. In the study on cases for assessing clinical competence, they predict that a sample of 10 would achieve reliability of 0.8 (Cronbach's alpha) [11].

Analysis

We will examine the accuracy, completeness, and conciseness of the data, as well as its suitability for re-use for RHSCIR and the Canadian Institute for Health Information (CIHI).

Accuracy will be measured by assessing the validity of the operative report (dictated and synoptic) as a source for administrative data reported to CIHI (see Appendix D, Accuracy Assessment Scoring Sheet).

Completeness will be measured using the Completeness Assessment Form (see Appendix D). This form is adapted from that used in a previous study [14].

Conciseness will be scored on a five-point Likert scale (see Conciseness Assessment Scoring Sheet, Appendix D). The number of words in synoptic and operative reports will also be compared.

Reuse will be measured by comparing the percentage of concepts codable to SNOMED CT in dictated and synoptic reports. Coded concepts are required for information reuse in RHSCIR and CIHI Discharge Abstract Database.

Confidentiality

Data will be kept on a local computer which is password-protected and stored in a locked office. Paper copies of the residents' questionnaires will be kept in a locked filing cabinet in a locked office. Residents will be assigned a 4-digit code, to be used on questionnaires so that no direct identifiers will be contained in questionnaires. An electronic file matching the code to the participant's name will be kept on a CDHA password-protected computer by the research coordinator. All study personnel are bound by CDHA privacy and confidentiality policies

Only study personnel will have access to the patient's personal information contained within the operative reports. Access to this information is required so that we may evaluate the two types of report. Only study personnel will have access to the questionnaires completed by the residents. The data will also be available to the Research Ethics Board, if required, for auditing purposes.

Study information will be kept for 7 years in a secure storage area owned or leased by Capital District Health Authority. All Capital Health policies and procedures with respect to archiving study information will be respected. It will be disposed in accordance with the confidential waste paper disposal policies and electronic media destruction.

Harms

With respect to potential harms for the subjects, they may find completion of the synoptic report or questionnaires unpleasant. The potential risk to patient information has been minimized through administrative safeguards (confidentiality agreements) and technical safeguards (all information will be stored on a CDHA server).

Benefits

This research aims to improve the quality of data gathered in operative reports for spinal cord injured patients. Operative records can be used for a variety of reasons, including planning of care and of future operative procedures, quality assurance, billing, and research projects. Dictated reports are often delayed and incomplete; electronic reports are more efficient, and could increase accurate communication between physicians and the care team. They are also cost-effective, as they avoid transcription and verification errors. This study also hopes to improve the quality of the data collected by the RHSCIR about operative procedures. We believe that the quality of data collected for CIHI will be used as well.

Liability

Liability during this research project will be that to which the investigators, Dalhousie University and Capital District Health Authority would ordinarily be subject.

Disclosure of Any Financial Compensation:

Research subjects will not receive any financial compensation.

Appendices contain the tools for evaluation of completeness, accuracy and conciseness of the synoptic operative report template (as mentioned in appendix D).

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