SURGICAL CLOSURE OF PELVIC PRESSURE INJURIES IN SCI ADULTS

SURGICAL CLOSURE OF PELVIC PRESSURE INJURIES IN SPINAL CORD INJURED ADULTS: CASE IDENTIFICATION, COSTS, HEALTH CARE UTILIZATION AND RISK FACTORS FOR SURGICAL COMPLICATIONS

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TITLE: Surgical Closure of Pelvic Pressure Ulcers in Spinal Cord Injured Adults: Case Identification, Costs, Health Care Utilization and Risk Factors for Surgical Complications

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PREFACE

This thesis is a "sandwich" thesis that includes four scholarly papers that will be submitted for publication, plus introductory and concluding chapters. All chapters are original work written entirely by Laura Teague.

The introductory chapter provides background on spinal cord injury (SCI), pressure injuries (PI), surgical closure of PI, and identifies the research gaps in cost, health care utilization, case identification and risk factors for complications, providing a foundation for the necessity for study in this population.

The second chapter is the first scholarly paper. It provides an estimate of hospital costs and OHIP fees associated with surgical closure of PI in SCI patients, from a public payer perspective. Members of Ms. Teague's thesis committee (Dr. Gina Browne, Dr. Lehana Thabane, Dr. Stephen Birch and Dr. Karen Campbell) provided guidance during the development of the research proposal and with the data interpretation; they reviewed this chapter. Dr. Gary Foster provided statistical analysis support; Maya Deeb provided assistance with patient level data collection from hospital records and administrative assistance with REB communications; Dr. Mahoney and Dr. McGillivray provided advice during the development of the research protocol.

For the second scholarly paper (Chapter Three) members of Ms. Teague's thesis committee (Dr. Browne, Dr. Thabane, Dr. Birch and Dr. Campbell) provided guidance during the development of the research proposal, and assistance with the data interpretation reviewed. Dr. Susan Jaglal, an ICES scientist, and Dr. Jennifer Voth, provided direction

and guidance with project activation and choosing co-variates within the ICES database. Andrew Calzavara, an ICES analyst, provided analysis of individual level data that was linked to the ICES databases. Dr. Mahoney and Dr. McGillivray provided advice during the development of the research protocol. All committee members, Dr. Mahoney, Dr McGillivray and Dr. Jaglal, were co-investigators for the Ontario Neurotrauma Foundation Grant #2017-RHI-SURGIC-1024.

For the third and fourth scholarly papers (Chapter Four and Five) Ms. Teague's thesis committee (Dr. Browne, Dr. Thabane, Dr. Birch and Dr. Campbell) provided guidance during the development of the research proposal, and assistance with the data interpretation. Dr. Jaglal and Dr. Voth provided direction and guidance with project activation and choosing co-variates within the ICES database. Andrew Calzavara provided analysis of individual level data that was linked to the ICES databases. Dr. Mahoney and Dr. McGillivray provided advice during the development of the research protocol. All committee members, Dr. Mahoney, Dr McGillivray and Dr. Jaglal, were co-investigators for the Ontario Neurotrauma Foundation Grant #2017-RHI-SURGIC-1024.

The conclusion chapter (Chapter Six) is written by Laura Teague provides a summary of all four of the research papers, including key findings, strengths and limitations and finally, implications for future research and practice. PI in SCI persons is extremely complex and requires interdisciplinary and intersectoral collaboration. Nurses in clinical and leadership and can play a pivotal role in navigating these patients through their health care encounters and

LAY ABSTRACT

Pressure ulcers, also known as pressure injuries (PI) or bedsores, are a common secondary complication in persons with spinal cord injury (SCI). While surgical closure is an option offered to patients, little is known about the long-term outcomes, including cost and use of health care services following the surgery. Risk factors for complications following surgery are known from a physical/co-morbidity/technique perspective, but environmental and behavioural factors have not been included these studies, and the use of health care administrative databases to accurately identify these patients for research has not been studied. A historical cohort study was conducted at one tertiary care centre in Toronto, Canada to identify known cases of SCI and PI reconstruction. Hospital codes were recorded in an algorithm used to evaluate the accuracy in identifying the known cases in the database. Health care usage and costs were also recorded, and risk factors for complications were also evaluated.

ABSTRACT

Impaired wound healing in SCI patients contributes to the progression in severity of PIs. Best practice guidelines suggest that surgical flap reconstruction is an option for chronic stage 4 PIs that have failed to heal with more conservative measures, but little is known about the epidemiology of surgically reconstructed PIs in SCI patients. Rates of surgical wound complications are high, and cost of management is extensive. Accordingly, this study aims to establish a systematic approach for identifying SCI patients with surgically reconstructed PIs, to facilitate study of predictors of sustained wound closure, quantify costs of surgical reconstruction, and evaluate efficiency of treatment and recovery options.

To address gaps in the literature, this study's objectives were: (1) estimate surgical reconstruction hospital costs for stage 4 PIs in SCI patients and characterize the relationship of demographic, socioeconomic and lifestyle factors to cost at discharge, (2) explore a standardized method of identifying these cases in large databases, (3) identify and validate risk factors for complications at discharge from wound care follow-up, and (4) identify long-term cost and health care utilization of persons with SCI who have undergone surgical flap closure.

It proved difficult to identify our own cohort of patients using administrative codes applied, making population-based study using administrative data less than ideal. Factors associated with open incision at three-to-six weeks post-index surgery included number of nursing visits in the previous year, and revision surgery within the six-week follow-up period. The cost of persons with SCI and PI was high one year prior to surgery (look-back)

and almost double in the first year look-back. However, significant cost and health care utilization was demonstrated in Year 2 and 3 post-index surgery.

Further prospective studies exploring models of health care delivery and addressing some of modifiable risk factors may improve cost-effectiveness and outcomes.

ACKNOWLEDGEMENTS

Giving thanks seems to be so small in comparison to the years, months and days spent conceiving and executing this thesis. I am deeply grateful to Dr. Gina Browne for inspiring me and then inviting me to become one of her PhD students. She has guided me through so many obstacles that I encountered throughout this program. Dr. Browne has been a true mentor for me and I deeply respect and truly like her. Gina's charming and warm Kentucky accent and her quintessential "Gina" responses ('you are fabulous, keep going honey') always gave me the gentle push to keep trying. Next, I would like to thank Dr. Lehana Thabane, for stepping in as chair as I finished my thesis. Sir, you are one of the kindest and brilliant people that I will ever know. Dr. Stephen Birch, thank you for being present through my comprehensive exam defence and for your very detailed suggestions throughout this thesis process. Dr. Karen Campbell, my external committee member, has been a life-long mentor and has been a wonderful reviewer and always provided constructive feedback.

My sincerest thanks to Dr. Keith Hayes and the Ontario Neurotrauma Foundation for their significant financial support with both the education portion and research. Support of this kind enables clinicians like me to focus on school without severe financial consequences.

The Institute for Clinical Evaluative Sciences (ICES) has been a tremendous support. I thank Dr. Susan Jaglal, Andrew Calzavara and Dr. Jennifer Voth for helping me through

the project activation process and with multiple meetings to discuss the data analysis after the hospital record data was linked with ICES. These people were brilliant and patient with me throughout my first experience at using administrative data for research.

A very special thanks to Dr. James Mahoney, with whom I have worked side by side through the some of the best days of my clinical career. Dr. Mahoney has always 'had my back' both clinically and professionally. We grew a wonderful wound care program together. He is a rare and special human being.

Thank you to St. Michael's Hospital Research Ethics Board, Decision Support and Medical Records staff for your support and access to medical records. Thank you to the clinical wound team who stood by me for the first part of my thesis. I will never forget you.

Thank you to my family for tolerating living amongst boxes of paper in my office (dining room) over the years. A very special thanks to my loving husband David, for always being there, for his expertise in navigating complexities of Excel, and for supporting me during the hardest times.

This thesis is dedicated to all of the people with spinal cord injury who struggle with pressure injuries. It has been a privilege working on this thesis. I hope that this research will lead to new insights that can potentially improve access and surgical outcomes for this difficult and common problem.

Finally, this thesis is also dedicated to my beautiful Mom, my uncle and three aunts who passed away as I was studying at McMaster; and to my 90 year Dad who always supported me through every post-secondary program. Mom, I hope you can join me on the podium when I receive my degree.

Love can't be empirically measured; but if it could, I would have to give McMaster University a 10/10. I am so proud to tell people where I have studied. McMaster's teaching style and culture espouses a foundation built around setting up students for success, in every department. I have been privileged to have met and be taught by some of the finest people in health care research.

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LIST OF ABBREVIATIONS

95% CI	95% confidence interval
AIS	American Spinal Injury Association Impairment Scale
ASA	American Society of Anesthesiologists Classification Scale
CADTH	Canadian Agency for Drugs and Technology in Health
CCI	Canadian Case Costing Initiative
CCRS	Continuing Care Reporting System
CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Database
Dx	Diagnostic codes
EPUAP	European Pressure Ulcer Advisory Panel
FC	Fee Code
ICES	Institute for Clinical Evaluative Science
IQR	Interquartile range
LOS	Length of stay
NACRS	National Ambulatory Care Reporting System
NTSCI	Non-traumatic spinal cord injury
NPIAP	National Pressure Injury Advisory Panel
NPV	Negative predictive value
NRS	National Rehabilitation Reporting System
PPV	Positive Predictive value

OCCI	Ontario Case Costing Initiative
ODB	Ontario Drug Benefit Program
OHIP	Ontario Health Insurance Plan
P	p value
PI	Pressure injury
RPDB	Registered Persons Database
RNAO	Registered Nurses' Association of Ontario
SCI	Spinal cord injury
SD	Standard deviation
SMH	St. Michael's Hospital
TSCI	Traumatic spinal cord injury

Declaration of Academic Achievement:

I, Laura Teague, declare this thesis to be my own work. I am the sole author of this document. No part of this work has been published or submitted for publication or for a higher degree at another institution.

To the best of my knowledge, the content of this document does not infringe on anyone's copyright.

My supervisors, Dr. Gina Browne and Dr. Lehana Thabane, and the members of my supervisory committee, Dr. Stephen Birch and Dr. Karen E Campbell, provided guidance and support at all stages of this project. Dr. Susan Jaglal and her team (Andrew J. Calzavara and Dr. Jennifer Voth) collaborated to link the original data set to administrative data at the Institute for Clinical Evaluative Studies and provided descriptive and analytic findings as per the Data Usage Agreement and the Confidentiality Agreement.

CHAPTER ONE

Introduction

What is spinal cord injury?

Spinal cord injury is devastating, involving nerve damage within the spinal cord. Sensory and/or motor nerves become damaged at the level of a traumatic injury or where disease processes or birth defects have occurred. Sensory impairment and loss of motor function can keep SCI patients from doing what we all take for granted: walking, self-care, activities of daily living, and sexual function, to name a few (Chiodo et al., 2007; Krause et al., 2008; Lala et al., 2014; Zarchi, Martinussen and Jemec, 2015).

In 2010 the estimated prevalence of SCI in Canada was 85,556 persons with 51% being traumatic SCI (TSCI) and 49% non-traumatic (NTSCI) (Noonan et al., 2012). Estimated discharge incidence was 1,785 cases per year (41 per million) and for the NTSCI, the discharge incidence was 1,389 (41 per million people) (Noonan et al., 2012).

What is surgical closure of pressure injuries?

The permanent impairment in mobility and sensation associated with SCI often leads to multiple serious secondary complications, pressure injuries being among them. Pressure injury (PI) is defined as an area of tissue damage that occurs as a result of prolonged tissue compression and shear forces, causing tissue deformation and ischemia, which can ultimately lead to tissue death (NPIAP/EPUAP, 2019). Lack of sensation,

prolonged pressure and repetitive shearing forces contribute to PI. In persons with SCI, PI often develop over bony prominences including, but not limited to, the sacrum, ischia and trochanteric areas (Houghton and Campbell, 2013). These bony prominences are more prone to PI as persons with SCI maintain their mobility through powered or unpowered wheelchairs and are often seated for prolonged periods of time.

When a person with SCI develops a PI, specifically in the pelvic region, normal daily activities such as work, socializing and family life are severely impacted (RNAO, 2016, NPIAP/EPUAP, 2019). PI in SCI significantly impacts quality of life (Lala et al., 2014, Singh et al., 2010).

PI treatment requires pressure redistribution, shorter times in the seated position, local wound care, optimal nutrition and debridement (RNAO, 2016, Health Quality Ontario, 2017). These wound-related activities impact quality of life. Although there are no studies to determine average healing time in this population, SCI patients with PI can take many years to achieve wound closure, especially when the injuries involve exposure of muscle, tendon and/or bone (NPIAP/EPUAP, 2019; Houghton and Campbell, 2013). Consequently, PIs are a common and serious secondary health condition in those individuals and result in a societal and health care burden (Dorsett and Geraghty, 2008; Garber and Rintala, 2003; Hitzig et al., 2008).

The prevalence of PIs in the SCI population exceeds that of the general population. Estimates range between 8 and 59% (Chen et al., 2005; Dorsett and Geraghty, 2008; Garber and Rintala, 2003; Saunders et al., 2012; Teague, 2014. A longitudinal observational study

in Alberta, Canada revealed that in 233 patients post SCI, 46 (19.8%) were treated for PI (Dryden et al., 2004).

The economic burden of PI in the SCI population is high. The majority of these costs are associated with emergency room visits, hospitalization, visits and admissions (Chen et al., 2018). In the U.S., a study by Brem et al. (2010) estimated the direct health care cost of treating a single stage 4 PI in community and hospital to be $124,327 and $129,248 USD respectively. A systematic review the cost of PI treatment per patient ranged from 1.71€ to 470.49€ per day, across different health care settings (Demarre et al., 2015). The authors noted considerable methodological heterogeneity among the studies, such as type of health economic design, perspective, cost components, as well as health outcomes (Demarré et al., 2015). In a retrospective study based in Denmark, 52 cases of PI surgical closure had a mean direct cost of 20,957€, with the majority of the cost being associated with hospitalization days (Filius et al., 2013).

In Canada, the economic burden of PI in SCI persons is significant, but not fully understood. In a small Ontario sample of community dwelling SCI persons, the estimated societal costs of chronic PI were estimated to be $4,725 Cdn/month, or $56,700 annually (Chan, et al., 2012). Given that PIs are a significant complication in the SCI population, and given the cost of PI management, there is good reason to examine associated costs, health care utilization and predictors of complications within this population.

What is pressure injury ?

Best practice guidelines suggest that surgical reconstruction with a flap is an option for chronic Stage 4 PIs that have failed to heal through more conservative measures (Ahluwalia, Martin & Mahoney, 2011; Houghton, Campbell & CPG Panel, 2013; Saneem, et al., 2010; Schryvers, Stranc & Nance, 2000; National Pressure Ulcer Advisory Panel/European Pressure Ulcer Advisory Panel, 2019; RNAO, 2016). Surgical reconstruction of PI involves debridement and excision of the ulcerated area and any infected bone, with myocutaneous or fasciocutaneous coverage over the tissue defect. Surgical closure of PI has been shown to improve quality of life in persons with SCI (Singh et al., 2010; Ahluwalia, Martin & Mahoney, 2011). Patients often become candidates for surgery after comprehensive assessment, which includes staging of the PI, past medical history, current medications, fitness for anesthesia, physiological and lifestyle barriers to healing, and willingness to participate in a post-operative period of bed rest and progressive seating program (Larson et al., 2012; Keys et al 2010; Sorensen et al., 2004).

Despite some of the measures employed to choose optimal surgical candidates, studies indicate that the complication rates related to PI surgical flap closure remain high, ranging between 8.9% and 58% (Saneem et al., 2012; Bigliari et al., 2014; Bamba et al., 2017). Moreover, estimated PI recurrence rates among SCI persons whose PIs were treated through surgical flap closure range from 11% to 29% in cases with post-operative complications, and 6% to 61% in cases without postoperative complications (Guihan et al., 2008; Holmes, Rintala, Garber & Friedman, 2002; Krause & Broderick, 2004; Larson et al., 2012; Schryvers, Stranc & Nance, 2000). Reports describing various surgical flap

treatments, complication rates, and risk factors for PU recurrence, suggest the importance of structured rehabilitation care in the post-operative phase (Ahluwalia, Martin and Mahoney, 2011; Kruger et al., 2013). The high rate of surgical wound complications and the extensive costs associated with PI management suggest the importance of identifying predictors of sustained wound closure, quantifying the cost of surgically reconstructing PIs, and evaluating the cost-effectiveness of treatment and recovery options (Ahluwalia, Martin & Mahoney, 2011; Biglari, et al., 2014; Keys et al., 2010; Sameem et al., 2012; Schryvers et al., 2000**).**

Use of administrative databases for population-based observational research

In Ontario, large health care administrative data are stored at the Institute for Clinical Evaluative Science (ICES). ICES is a prescribed entity under the Personal Health Information Privacy Act (PHIPA) that stores and allows for use of patient health information without patient consent for ethics approved research (ICES.ca). Moreover, the Praxis Spinal Cord Institute (formerly the Rick Hansen Institute Registry (RHI)), is a pan-Canadian observational registry of individuals sustaining traumatic SCI (https://praxisinstitute.org/). Although databases have been successfully used to conduct substantive SCI population-based studies (Guilcher, Parsons, Craven, Jaglal & Verrier, 2015; Munce et al., 2009), they have not been mined for studying the epidemiology of surgical closure of stage 4 PIs in SCI patients. Currently, there has been no systematic method developed to accurately identify this patient population in these databases.

Moreover, the RHI database, while substantive, is relatively new and does not have specific PI data collected on Canadian patients whose SCI occurred prior to 2007.

Diagnoses and procedures are typically coded by hospitals and large administrative databases, such as the Canadian Institute for Health Information (CIHI), using the International Classification of Diagnoses (ICD) system, a standard developed by the World Health Organization. ICD codes have been used to systematically extract diagnoses for research purposes in the past, but ICD coding is not without its limitations. Re-abstraction studies have shown that diagnostic and procedure coding can vary in completeness and accuracy in these large databases (Bechimol et al., 2011; Hagen et al., 2009; Wickramasinge et al., 2008). The most significant problems are related to data selection, data quality and specific data availability, due to the fact that data collection methods are determined by the registry (Sorensen, 1997). Misclassification of discharge diagnoses in hospital registries due to variation in coding practices can also threaten data quality. Accordingly, misclassification of existing data can only be revealed by comprehensive validity studies of data quality (Sorensen, 1997; Wickramasinge et al., 2008). Validating an algorithm that enables the reliable and valid identification of SCI patients with surgically reconstructed PIs in the ICES database will facilitate research on this population. In turn, this research has the potential for informing clinicians and decision makers.

Although PIs in SCI carry a significant health care and societal burden, there is a paucity of population-based research and case identification has not been validated in administrative databases. Moreover, while physiological and lifestyle risk factors for wound complications have been explored, systems and environmental covariates have not

been included in these analyses. Finally, long-term outcomes, such as cost and health care utilization following surgical reconstruction of PIs in SCI patients has not been explored within a publicly funded health care system.

Structure and Objectives

The main body of this thesis is structured into four scholarly papers which explore the gaps identified in the research. Four explicit research questions are addressed in these individual papers, using one cohort of patients with SCI who underwent surgical closure of PI. The first research question describes hospital costs and physician fees associated with SCI persons undergoing pelvic PI reconstruction. Our current model of care includes surgery, immediate post-operative care, transfer to an alternate facility for a three-to-six-week period of bed rest, followed by rehabilitation involving progressive seating. The costs in the first paper involve the hospitalization portion of the entire surgical encounter. The mean cost was found to be $12,960.00 (SD $\pm$ $6493.48).

From the same cohort of patients, the second paper explores case identification of SCI undergoing PI reconstruction using administrative code algorithms. These patients with confirmed SCI and PI reconstruction are used as the reference standard. Confirmed control patients (SCI and PI patients admitted to hospital who did not have PI reconstruction) were identified. Sensitivity, specificity, positive and negative predictive values were calculated in 21 code algorithms. The most appropriate algorithm of billing codes combined with diagnostic codes had low sensitivity (69.1%).

The third paper explores physiological, lifestyle and some environmental covariates associated with surgical wound complications at three-to-six weeks post-PI reconstruction. These covariates were recorded from patient records and administrative databases. In this cohort, volume of nursing care visits one year prior to the index surgery and need for surgical revision were identified as risk factors for open vs. closed incisions at three-to-six weeks post-index surgery. The main findings were lower nursing visits and revision surgery being associated with wound complications at three-to-six weeks following the index surgery.

The fourth paper describes cost and health care utilization of patients with SCI and PI reconstruction, from a public payer perspective. The time horizon in this study is a total of four years, with the first year looking back, and the next three years following the index PI reconstructive surgery. Health care utilization in the year prior to the index surgery (look-back) is high, with the majority of the visits being home nursing visits. In the three years following the index surgery, nursing visits accounted for the largest reduction in use of health care services. The median cost of SCI persons with PI in the look-back year was $42,012 (IQR 21,351-64,279). One year following the index surgery, the median cost was $80,041 (IQR 46,390-109,560), but in the second and third-year follow-up, the median costs decreased to $10,194 (2,607-35,475) and $13,184 (IQR 2435-37,890) respectively.

These research questions have illuminated some important findings, including hospital costs, challenges with case identification using administrative databases, risk factors for complications and cost, and health care utilization in SCI undergoing PI reconstruction in Toronto, Canada. Limitations of retrospective cohort studies within this

relatively rare population include misclassification bias and potential covariate confounders that could not be utilized in the data analysis. Further prospective studies exploring models of health care delivery and addressing some of the modifiable risk factors may improve cost effectiveness and surgical outcomes.

CHAPTER TWO

Exploring estimation of hospital costs and associated factors among persons with cord injury undergoing surgical closure of stage 4 pelvic pressure injuries

Laura M. Teague, MN, NP-Adult, PhD(c), Gina Browne, RN, PhD, Lehana Thabane, PhD, Stephen Birch, PhD, Colleen McGillivray, MD, Gary Foster, PhD, Maya Deeb, BSc, MD, and James Mahoney, MD, FRCSC

Authorship contributions for this paper:

Laura Teague, PhD student conceived the research questions and design and was directly responsible with research ethics board applications/amendments/closure communications, data sharing agreements with the Institute of Clinical Evaluative Sciences and is the primary author of this manuscript.

Dr. Gina Browne was the PhD student's Thesis Chair until 2019. She provided guidance with research design, provided continuous feedback and took the role of Principal Investigator for the Ontario Neurotrauma Foundation grant.

Dr. Lehana Thabane has been on Ms. Teague's supervisory committee and assumed the role of Thesis Chair in 2018. Dr. Thabane contributed substantially to the data analysis and interpretation of the data and reviewed the manuscript.

Dr. Stephen Birch, a member of the PhD student's thesis committee, provided direct feedback around the design of the research questions. He also reviewed and provided feedback for this manuscript.

Dr. Colleen McGillivray provided feedback with conception of research study and part of the Ontario Neuro Foundation Grant.

Dr. Gary Foster provided data analysis support for this manuscript. He has reviewed and approved the first paper.

Maya Deeb is a medical student at the University of Toronto, who provided data collection and administrative assistance during initiation of the study.

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Key words: *pressure injury reconstruction, spinal cord injury, hospital cost*

ABSTRACT

Background

Pressure injuries (PI) are a common secondary health complication in persons with spinal cord injury. Surgical reconstruction is often required in stage 3 and 4 pressure injuries when wound healing is protracted or stalled with conservative wound management.

Objectives

The primary objective of this study was to estimate the mean cost of hospitalization for persons with spinal cord injury (SCI) who have undergone surgical reconstruction for pelvic PI in the publicly funded health care system in one tertiary care hospital in Toronto, Ontario. The secondary objective was to explore factors that explain variations in hospital costs.

Methods

Study sample: The study included a cohort of 108 consecutive patients with spinal cord injury (SCI) who have undergone surgical reconstruction for pelvic PI in 2002-2015 and 136 cases of the index PI reconstruction.

Data: Demographics, co-morbidities, procedure type, anatomical location of PI and discharge encounter numbers were used to identify cost of hospitalization using the Ontario Case Costing Initiative (OCCI) methodology. Physician billing codes for these encounters

were also recorded. All pricing was inflated by 1.5% annually to reflect 2015 OCCI and physician billing costs.

Statistical analysis: Descriptive statistics were employed to analyze the data. We used generalized estimated equations to account for multiple hospitalizations for each patient to explore factors associated with hospital total costs.

Results

One hundred and one (72%) of the subjects were male, with a mean (standard deviation, SD) length of stay (LOS) of 9.4 (13.2) days. Fifteen (11.0%) of the encounters had revision surgery. The estimated adjusted mean total hospital cost for SCI persons undergoing surgical closure of pelvic PI was $12,960(Can) SD = $6493.48. Covariates associated with significantly increased cost per case on the log scale included LOS (Coefficient estimate: 0.06 95% confidence interval [CI]: 0.05, 0.07 $p < 0.001$), discharge to institution other than rehabilitation (0.19; 95% CI 0.08, 0.29; $p < 0.001$), being female (0.11, 95% CI: 0.02, 0.20; $p = 0.010$), having bladder incontinence (0.21, 95% CI: 0.05, 0.36 $p = 0.010$) and those who had a myocutaneous flap (0.11, 95% CI 0.03, 0.19; $p = 0.010$). Covariates associated with significantly less cost on the log scale included discharge disposition to the community (-0.16, 95% CI -0.25, -0.07; $p < 0.001$), living in a rural area (-0.14; 95% CI -0.23, -0.04; $p < 0.001$) and smoking (-0.07, 95% CI -0.15, -0.001; $p = 0.055$).

Conclusion

This study attempts to quantify hospital and physician billing costs and explores variations with these costs in SCI persons undergoing PI surgical closure procedures in Ontario, Canada. Patients undergoing this type of surgery represent a significant cost to the health care system. There are significant variations in costs which are explained in part by length of stay, discharge disposition, where the patient lives, incontinence, and smoking. While it is helpful to have an estimate of cost for decision makers, it is also important to further explore care processes that could potentially reduce the total costs of care for this complex patient population.

INTRODUCTION

Spinal cord injury (SCI) is devastating to patients and their families, causing permanent disability, high morbidity and mortality (Chiodo et al., 2007; Krause et al., 2008; Lala et al., 2014; Zarchi, Martinussen & Jemec, 2015). Beyond the immobility that results from the injury, denervation exposes SCI patients to higher risk of pressure injuries (PI) and impaired wound healing (Andriessen, van Asbeck, Lindman, VanderWoude, deGroot & Post, 2013, Houghton, Campbell & CPG Panel, 2013). Estimates of PIs in the SCI population exceeds that of the general population, ranging from 8 - 59% (Chen, DeVivo & Jackson, 2005; Dorsett & Geraghty, 2008; Garber & Rintala, 2003; Saunders, Krause & Acuna, 2012). Accordingly, PIs are a common and serious secondary health condition (Dorsett & Geraghty, 2008; Garber & Rintala, 2003; Hitzig, Tonack, Campbell, McGillivray, Boschen, Richards et al., 2008; Munce, Wodchis, Guilcher, Couris, Verrier Fung, Craven, et al., 2013).

In Canada, the economic burden of PI in SCI persons is significant, but not fully understood. In a small Ontario sample of community dwelling SCI persons, the estimated societal costs of chronic PI were $4,725 Can$/month, or $56,700 annually (Chan, Nanwa, Mittman, Bryant, Coyte & Houghton, 2012). The majority of these costs were associated with hospital visits and admissions. In the US, a study by Brem, Maggi, Nierman, Rolnitzky, Bell, Rennet, et al. (2010), estimated the direct health care cost of treating a single stage IV PI in community and hospital to be $124,327 and $129,248 USD, respectively. In a systematic review, the cost of PI treatment per patient ranged from 1.71€ to 470.49€ per day, across different health care settings. The authors noted considerable methodological heterogeneity among the studies, such as type of health economic design,

perspective, cost components, as well as health outcomes (Demarre, Van Lancker, Van Hecke, Verhaeghe, Grypdonck, Lemey et al., 2015). In Europe, a review of 52 cases of PI surgical closure in Denmark by Filius, Damen, Schuijer-Maaskant, Polinder, Hovius, & Walbeehm (2013), reported a mean direct cost of 20,957€, with the majority of the cost being associated with hospitalization days. Clearly, PIs are a significant complication in the SCI population. Research, including clinical and health economic outcomes of treatment, is warranted.

Best practices for treatment of PIs in SCI persons includes identifying and mitigating the cause, addressing patient factors and concerns, wound debridement as required, good local wound care and optimizing nutrition (Houghton, Campbell & CPG Panel, 2013; RNAO 2016). Surgical reconstruction of PI is one option offered to SCI patients who fail to progress to wound closure (RNAO 2016, HQO 2017).

In order to ensure that the resources devoted to caring for patients with SCI are used in the most productive way, both effectiveness and costs must be considered. While hospitalization costs are only one component of care, there is a paucity of data in Canada describing these costs using systematic case identification and standardized costing data collection. St. Michael's hospital (SMH) is a tertiary care centre in Toronto, Ontario, Canada. Over the past three decades, the hospital has become a referral centre that performs surgical closure of PIs.

Accordingly, the primary purpose of this research is to estimate the hospitalization costs of persons with SCI who have undergone surgical flap closure of stage IV pelvic

pressure ulcers in a single payer system from SMH in Toronto, Ontario, Canada. The secondary purpose is to explore factors that are associated with the costs.

Study Population and Sampling

The study population consisted of a convenience sample of consecutive male and female SMH SCI patients aged ≥ 18 with a stage 4 pelvic PI who underwent flap closure of the PI at SMH between April 1, 2002 and March 31, 2015.

Cases were selected through the following steps:

(1) All procedures performed by one physician as a surgical flap closure through the Ontario Hospital Insurance Plan (OHIP) (billing codes R005, R590, R073, or R074), were extracted.

(2) SMH patient records of patients who underwent surgical flap closure were reviewed to identify and confirm cases where the flap closure was performed for a stage IV pelvic PI in SCI patients.

Methods

This research was achieved with an observational, retrospective cohort of known SMH cases of SCI who had undergone PI surgical flap closure. Figure 1 provides a study flowchart.

Research Ethics approval was obtained from SMH throughout the duration of this study. Data sharing agreements were obtained between McMaster University and SMH. All identifiers were removed from database prior to transfer to McMaster University.

Unique identifier numbers were assigned to each patient encounter. Patient names, OHIP numbers and encounter numbers were stored in separate files, and securely stored at SMH.

Data Sources

Patient Records

Demographics, health history, surgical details and outcome of surgery were collected from patient records.

Rick Hansen Institute Registry

The Rick Hansen SCI Registry (RHSCIR) is a pan-Canadian prospective observational registry of individuals sustaining a traumatic spinal cord injury (Noonan, Kwon, Soril, Fehlings, Hurlbert, Townson et al., 2012). SMH is one of 13 sites that collect patient data for this registry. SMH began to register patients who sustained SCI in 2007 (Dr. Henry Ahn, personal communication, 2016). Unfortunately, subjects in this cohort study had either sustained SCI prior to 2007 or received their initial SCI care at another institution. Therefore, the RHSCIR registry could not be used for data collection.

Ontario Case Costing Initiative

Case costing was obtained from the Ontario Case Costing Initiative (OCCI) database (CADTH, 2015). The OCCI integrates clinical, financial and statistical data that provides hospitals with a method to present patient-level case costing for each hospital visit or encounter. OCCI includes length of stay, number of ward days, number of ICU days,

emergency room services, perioperative services, laboratory, diagnostic imaging, pharmacy, food and allied health charges (CADTH, 2015). Finally, OCCI includes indirect administrative costs.

Physician billing

OHIP billing for procedures and were recorded for each encounter from the surgeon's billing records stored in the OHIP PMP billing database.

Statistics

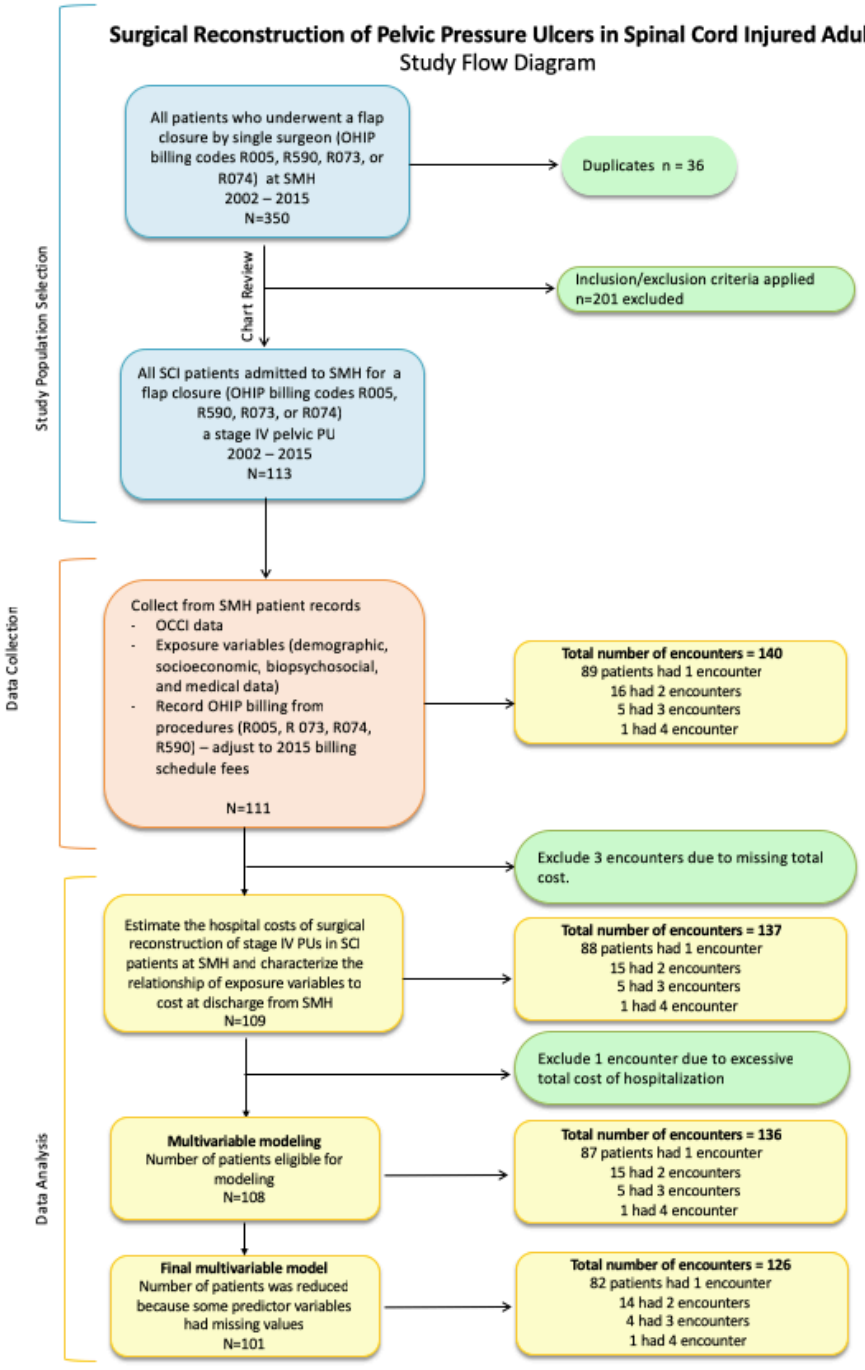
Descriptive statistics were employed to describe the sample in this study: frequency was expressed as a percentage for categorical variables; and mean (standard deviation [SD]) was used to describe continuous variables. The Generalized Estimating Equations (GEE) was employed to account for patients who had more than one episode of surgery or hospitalization (Norman & Streiner, 2008) to explore factors associated with costs. Complete case analysis assumed a serial auto-correlation (AR (1)) structure for the costs. Logarithmic transformation was also employed as the residuals of the model (and adjusted total cost) had a strong right skew (Feng, 2013). Multiple imputation (Markov chain Monte Carlo method) was used to perform sensitivity analysis (Daniel & Cross, 2010; Schmitt, Mandel & Guedj, 2015; Stern, White, Carlin, Spratt, Royston, Kenward et al., 2009) to assess the robustness of the results to missing data. For these exploratory GEE analyses, the criterion for statistical significance was set at alpha = 0.05. All analyses were performed using SAS 9.2 (Cary, NC).

RESULTS

From 350 potential subjects, 111 SCI persons with 140 encounters of PI reconstruction surgery were selected from OHIP billing codes of one surgeon at SMH from 2002-2015. Patients were included if they were >18 years of age, spinal cord injured (traumatic or nontraumatic) and were admitted for surgical reconstruction of pelvic stage IV PI. Patients were excluded if they were <18 years of age, were not spinal cord injured, or had SCI with surgery that was not PI reconstruction in the pelvic region. One hundred percent agreement between two reviewers (expert and research assistant) was achieved. From this sample, three of the encounter numbers could not be identified in the administrative database. One further encounter was excluded from the modeling due to case costing in extreme excess of the rest of the cohort. For the complete case costing analysis, 101 patients with 126 encounters were included. For the sensitivity analysis using imputation, 108 patients with 136 encounters were included.

Table 1 provides a demographic summary of the cohort: one hundred and one (74.2%) of the subjects were male; 123 (90.4) of the subjects were living with an urban address; 80 (58.8 were single). The mean age (SD) at time of SCI was 24.49 (14.3) years. The mean (SD) age at the time of surgery was 43.2 (12.58) years. Ninety (66.2%) of the subjects had traumatic injury, 11 (8.2%) had violence as a cause of SCI. Forty-seven (34.6.%) of the subjects had complete loss of function below the level of spinal cord injury, and 21(15.4%) had incomplete SCI.

Figure 1, Flow Chart of study



There were many unknown types of SCI (n = 72, 54%). Forty-seven (34.5%) had an American Spinal Injury Association (ASIA) classification score of A, meaning complete loss of sensory and motor function (Kirshblum, Burns, Biering-Sorenson, graves, Jha et al., 2011). Twenty four (17.6%) of the subjects had a history of autonomic dysreflexia; 10 (7.3%) had bladder incontinence, and 22 (16.2%) had bowl incontinence. 71(52.2%) of the subjects had a history of spasticity. Twenty (14%) of the subjects had a history of urinary tract infections and 45 (33.1%) had a history of use of chronic pain medications.

With respect to the PI and surgical variables, 136 (100%) had stage 4 PI; 15 (11.0) required surgical revision and mean (SD) length of stay was 9.4 (13.2) days. Thirty-seven (27.2%) of the cases were discharged to the community, while 85 (62.5%) recovered in a rehabilitation facility and 10 (7.3%) were discharged to their home hospitals. Finally, 106 (77.9%) of the cases left hospital receiving antibiotics.

Table 2 displays the number of surgical encounters per patient in this cohort. Of 108 patients, 89 (80.18%) had one encounter; 16 (14.41%) had two encounters, five (4.50%) had three encounters, and one (0.9%) had 4 encounters.

Table 3 displays the type and total number of procedures performed on this cohort of patients. Note that some patients not only had multiple surgeries over time; some patients had multiple procedures (e.g., skin and myocutaneous flaps in the same surgical encounter). The majority of procedures were performed in the ischial area (n=117; 75%), followed by the trochanteric area (n = 25; 16%); followed by the sacral area (n = 14; 9%).

Table 4 displays the mean estimated OHIP billing, OCCI cost and combined OCCI and physician billing per case. The estimated mean total cost (SD) (OCCI and physician billing combined) was $12,960 (SD ±$6,493.48 CAD). This cost includes all charges recorded in the OCCI formula, in addition to the physician billing. All costs were adjusted to the 2015 Canadian dollar.

Covariates (estimate (95% CI) p-value) associated with significantly increased cost per case included length of stay (LOS) (0.06 , 95% CI 0.05, 0.07) $p < 0.001$), discharge to institution other than rehabilitation (0.19, 95% CI 0.08, 0.29, $p < 0.001$), being female (0.11, 95% CI 0.02, 0.20, $p = 0.010$), having bladder incontinence (0.21 95% CI 0.05, 0.36 $p = 0.010$) and those who had a myocutaneous flap (0.11 95% CI 0.03, 0.19, $p = 0.010$). Covariates associated with significantly less cost included discharge disposition to the community (-0.16, 95% CI -0.25, -0.17 $p <0.001$), living in a rural area (-0.14, 95% CI -0.27, -0.04, $p <0.001$) and smoking (-0.07, 95% CI 0.15, - 0.00, $p = 0.055$).

Sensitivity analysis was performed using multiple imputation. A summary of the results is presented in table 6. Additional variables found to be associated with increased cost included those having rheumatological disease (0.12, 95% CI 0.007, 0.26 $p = 0.040$), bowel incontinence (0.13, 95% CI -0.35, -0.08, $p = 0.002$), and having two procedures vs. one (0.15, 95% CI 0.03, 0.27 $p = 0.014$). Additional variables associated with decreased cost included being single (-0.13, 95% CI -0.24, -0.03 $p = 0.1530$), having a skin flap (-0.22, 95% CI -0.35, -0.08 $p = 0.002$), and obesity (-0.18, 95% CI -0.30, -0.05 $p = 0.007$).

DISCUSSION

While there are reports of surgical outcomes in the USA, Canada and other developed countries, literature on hospital case costing for surgical closure of PI in the SCI is scarce worldwide (Ahluwalia, Martin & Mahoney, 2011; Biglari, Buchler, Reitzel, Swing, Gerner, Biglari et al., 2014; Chiu, Liao, Wang, Shih, Ma, Lin, et al., 2017; Diamond, Moghaddas, Kaminski, Grotts, Ferrigno & Schooler, 2016; Keys, Daniali, Warner, & Mathes, 2010; Larson Hudak, Waring, Orr & Simonelic, 2012; Saneem, Au, Wood, Farrokhyar, & Mahoney, 2012). Using Veterans Affairs administrative data, Stroup et al. (2011) reported 12-month health care utilization and cost of SCI persons who developed PI. The mean cost was $100,935 US vs. $27,914 US for those with SCI and no PI. The study found that most of the health care utilization was incurred with hospital admissions. Unfortunately, this study did not specifically examine surgical repair as an intervention. Filius et al. (2013) conducted a retrospective review of 53 cases of surgically treated stage 3 or 4 PI. They estimated average direct hospital costs to be 20,957€. While this study was not specific to SCI persons, the majority (87%) of the cases had SCI as a co-morbidity.

Although attempts were exhaustive to retrieve data on all covariates, many could not be included in the analysis. Education, income, race, PI history post-SCI, and wait times for surgery (access to care) are all important and known social determinants of health (Mikkonen & Raphael, 2011). These covariates could be confounders. Without adjustment

for these covariates, the present results should be interpreted with caution (Birch, Jerrett & Eyles, 2000).

Complete case analysis was the first statistical method employed, followed by Multiple Imputation (MI). The MI results identified more variables that were associated with increased and decreased hospital costs. The MI analysis included the cases that were dismissed by complete case analysis. Therefore, results of the complete case analysis should be interpreted with caution.

Appreciating cost of care and variations in cost may inform who may have ability to intervene with some of the modifiable risk factors. Knowledge of hospital costs can provide those in the Canadian neurotrauma field to advocate for access to surgery as an option. Finally, knowing hospital costs and length of stay may help decision makers to plan and budget for surgical interventions.

With respect to the covariates associated with increased hospital costs, increased LOS and use of myocutaneous flap (higher billing rate) can be simply explained. However, bladder incontinence and being female could not be explained. While these covariates are clinically relevant, the sample size is too small and the LOS is too short to make any hypothesis. Similarly, those covariates associated with less hospital costs (being single, being as smoker, having a skin flap and obesity) presented a conundrum; again, this procedure and hospitalization accounted only for approximately 15% of the entire journey to recovery.

This study has a number of strengths and limitations. This is the first known study on hospital and physician billing for PI surgical closure in a Canadian SCI population. The

data collected from patient records and OCCI data allowed us to include multiple potential cost drivers, which would not necessarily be available in administrative databases.

Limitations include generalization of findings. First, although patients in this cohort were from across the province of Ontario, this historical review was from one hospital in Ontario. Second, while great effort was expended to find all eligible cases, missing or incorrect encounter numbers data precluded inclusion of some subjects in the analysis, which may introduce selection bias. A third limitation is variations in OCCI program versions. These versions have changed over the time horizon of 2002-2015. A fourth limitation included potential practice and/or technology changes over time that could influence hospital costs, thereby, introducing bias to the cost estimates.

A fourth limitation includes the health care payer perspective from which these costs were estimated. In future, studies examining costs from a societal perspective may increase our understanding of costs (Tai, Bae & Le, 2016). Furthermore, hospital costs are merely one portion of the total cost to the health care system. Rehabilitation, community care, emergency room and physician visits associated with this surgery would need to be considered if one were to view the entire encounter of surgical closure of PI in the SCI population. Finally, with our model of care, patients are transferred to rehabilitation centres or back to their community for recovery. Models of care that are more inclusive of the entire recovery process may not be comparable from a cost perspective.

CONCLUSION

The estimated mean, per case hospital costs of SCI patients who underwent surgical reconstruction of pelvic PI is $12,960.00 (SD $6493.40). Multivariate analysis from complete case analysis and from imputed data analysis revealed significant covariates associated with increased cost being increased, including LOS, female gender, discharge disposition to institution other than rehab or community, those who had myocutaneous skin flaps, and those who had more than one procedure. Covariates associated with decreased hospital costs included being single, a current smoker, those with a rural address, having a urinary tract infection, and being obese.

Hospital costs are only one component of the health care journey of PI reconstruction in persons with SCI. While the causal inference cannot be assumed with each of the covariates associated with variations in cost, health care planners/decision makers can examine some of the modifiable covariates and focus on interventions that may result in improved efficiency and clinical outcomes.

Table 1 Characteristics of patient encounters (k=136 encounters)

Variable	Coding	Frequency (%) or Mean (SD)*
Gender	Male	101 (74.2)
Postal code	Rural	17 (12.5)
	Urban	123 (90.4)
Marital status	Single	80 (58.8)
	Married	39 (28.7)
	Divorced	14 (10.2)
	Widowed	<5 (0.7)
Age at time of surgery (years)		43.2 (12.58)*
Age at Spinal cord injury (years)	Assuming '0' is a real age	24.4 (14.3)*
	Assuming '0' is missing	28.0 (11.6)*
Cause of SCI	Trauma	90 (66.2)
	Violent	11 (8.0)
	Non-traumatic	30 (22.0)
Complete/ Incomplete SCI	Complete	47 (34.6)
	Incomplete	21 (15.4)
	Unknown	72 (52.9)
ASIA class	A	47 (34.5)
	Unknown	93 (68.4)
Past medical history		
History of autonomic dysreflexia	No	107 (78.6)
	Yes	24 (17.6)
Bladder Incontinence	No	122 (89.7)
	Yes	10 (7.3)
Bowel Incontinence	No	109 (80.1)
	Yes	22 (16.2)
Spasticity	No	63 (46.3)
	Yes	71 (52.2)
Chronic pain medications	No	81 (59.6)
	Yes	45 (33.1)
Urinary tract infection	No	120 (88.2)
	Yes	20 (14.7)
Pressure injury variables		
Stage of pressure injury	Stage 4	136 (100)
Revision surgery	No	125 (91.9)
	Yes	15 (11.0)
Length of Stay	Days	9.4 (13.2)*
Discharge disposition	Community	37 (27.2)
	Rehab	85 (62.5)

	Other institution	10 (7.3)
Antibiotics at discharge	No Yes	25 (18.3) 106 (77.9)

Table 2, Number of surgical encounters per patient (n = 108 subjects)

Number of surgical encounters	Frequency	Percent	Cumulative frequency	Cumulative percent
1	89	80.18	89	80.18
2	16	14.41	105	94.59
3	<5	4.50	110	99.10
4	<5	0.90	111	100.00

Table 3, Anatomical location and type of surgical flap procedures (K = 156 procedures)

Location	Total	Skin flap	Myocutaneous flap
Ischium	117 (75%)	112 (94.4%)	32 (27.4%)
Trochanter	25 (16%)	16 (64%)	9 (36.0%)
Sacrum	14 (9%)	5 (37.7%)	10 (71.4%)
Total	156 (100%)	133 (85.3%)	58 (37.2%)

Note: Total numbers reflect skin and myocutaneous flaps that could be performed on the same patient

Table 4, Hospitalization adjusted to 2015 Canadian dollars

Variable	N	Mean	Std Dev	Minimum	50th Percentile	Maximum
Estimated OHIP Billing	136	$770.79	275.14	201.40	757.34	2004.79
Estimated OCCI cost	136	$12,189.21	6422.64	4500.78	10644.52	46887.35
Estimated Total cost	136	$12,960.00	6493.48	4702.18	11349.19	48061.59

Table 5, Multivariable analysis of factors associated with total cost (on the log scale) per Complete case analysis n = 101 subjects with k =126 encounters

Variable Comparison	Estimate	Confidence Interval		p-value
Intercept	8.89	8.78	9.00	<0.001
Length of stay (days)	0.06	0.05	0.07	<0.001
Discharge (community)	-0.16	-0.25	-0,07	< 0.001
Discharge (other institution)	0.19	0.08	0.29	<0.001
Rural address	-0.14	-0.23	-0.04	<0.001
Gender (female)	0.11	0.02	0.20	0.010
Presence of bladder incontinence	0.21	0.05	0.36	0.010
Use of myocutaneous flap	0.11	0.03	0.19	0.010
Smoking	-0.07	-0.15	0.00	0.055

Table 6, Sensitivity analysis with Multiple imputation (n = 108 subjects with 136 encounters)

Variable comparison	Estimate	95% CI	P Value
Length of stay (days)	0.06	0.05, 0.07	<0.001
Marital status (single)[1]	-0.13	-0.24, -0.03	0.150
Marital status (divorced/widowed)	0.04	-0.11, 0.19	0.630
Presence of rheumatological disease	0.12	0.01, 0.26	0.040
Presence of bladder incontinence	0.20	0.07, 0.33	0.002
Presence of bowel incontinence	-0.13	-0.35, -0.08	0.040
Presence of urinary tract infection	-0.14	-0.15, -0.03	0.007
Use of skin flap	-0.22	0.03, 0.25	0.002
Discharge to community[2]	-0.06	-0.02, -0.03	0.180
Discharge to other institution[2]	0.14	0.03, 0.25	0.020
Obesity	-0.18	-0.30, -0.05	0.007
Rural address	-0.20	-0.32, 0.09	0.006
Number of procedures 2 vs. 1	0.15	0.03, 0.27	0.014

[1]For marital status, married is the reference
[2]For discharge, rehabilitation is the reference

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CHAPTER THREE

Exploring Validation of Pressure Injury Flap Reconstruction Codes in Ontario Administrative Databases

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Authorship contributions for this paper:

Laura Teague, PhD student conceived the research questions and design and was directly responsible with research ethics board applications/amendments/closure communications, data sharing agreements with the Institute of Clinical Evaluative Sciences, participating in data analysis and writing of the manuscript..

Dr. Susan Jaglal is an ICES scientist who provided methodological guidance, interpretation of the data and reviewed the manuscript.

Andrew Calzavara is an ICES analyst who performed statistical analysis for the combined data for the manuscript.

Dr. Jennifer Voth assisted with obtaining ethical approval and data transfer agreement for ICES.

Dr. Lehana Thabane has been on Ms. Teague's supervisory committee and assumed the

role of Thesis Chair in 2019. Dr. Thabane contributed substantially to the data analysis and interpretation of the data, and reviewed the manuscripts.

Dr. Stephen Birch, a member of the PhD student's thesis committee, provided direct feedback around the design of the research questions. He also reviewed and provided feedback for this chapter.

Dr. Karen E. Campbell was on the PhD student's thesis committee. She reviewed and provided direct feedback around the structure of this chapter

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Key words: *administrative data, codes, algorithms, pressure injury, spinal cord injury, surgical reconstruction*

ABSTRACT

Pressure ulcers, or pressure injuries (PIs) are a common and serious complication of spinal cord injury (SCI). Impaired wound healing in SCI patients contributes to the progression of these ulcers to more severe stages, which are difficult to manage. Best practice guidelines suggest that surgical reconstruction with a flap is an option for chronic stage 4 PIs that have failed to respond to more conservative measures. However, little is known about the epidemiology of surgically reconstructed PIs in SCI patients. Despite efforts to select suitable patients for this procedure, the rate of surgical wound complications is high, and the cost of management is extensive. Thus, it is important to establish a systematic approach to identifying SCI patients with surgically reconstructed PUs to facilitate the study of predictors of sustained wound closure, quantify the cost of surgical reconstruction, and evaluate the efficiency of treatment and recovery.

Objective:

To explore the accuracy of procedure, diagnosis and physician billing code algorithms to identify cases of SCI persons having undergone surgical flap closure of pelvic pressure injuries (PI) in a provincial health administrative database.

Methods:

Hospital medical records with confirmed cases (true positive) were identified using physician-billing records from one plastic surgeon in Toronto, Canada; 108 consecutive

SCI patients with 136 cases of pelvic PI reconstruction procedures were confirmed from review of medical records. Thirty-seven control patients with SCI who were admitted to hospital with PI and no surgery were also confirmed through chart review. These records were used as the reference standard. Ontario Health Insurance Plan (OHIP) billing codes, ICD-10-CA and Canadian Classification of Health Interventions codes (CCI) were recorded for each of the cases and securely transferred to the Institute of Clinical Evaluative Studies (ICES). ICD 10-CA, CCI codes and OHIP billing codes were used to build several algorithms, which were then tested for sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

Results:

The most appropriate algorithm included fee codes combined with diagnostic codes that included any SCI and 'any pressure ulcer'. Inclusion of intervention codes was problematic as there were 329 discrete codes recorded in this cohort of patients. This algorithm displayed a sensitivity of 69.1% (95% confidence interval (95% CI 60, 76.75)); specificity of 97.37% (95% CI 86.19, 99.93); Positive Predictive Value of 98.95% (95% CI 94.77, 97.97); and Negative Predictive Value of 46.84% (95% CI 35.51, 58.40). In other words, 30.9% of all positive cases in this cohort were missed using the algorithm, while 97.37% of all negative cases were identified using the same algorithm.

Conclusion:

Given the complexity of this patient population and the variation and missing

administrative codes, it is likely that retrospective studies using administrative data to identify SCI patients who have undergone PI reconstruction is insufficient to proceed with a population-based study in Ontario. This study emphasizes the importance of evaluating accuracy and completeness of codes in administrative databases in order to reduce the risk of misclassification and subsequent reduction of power and generalizability.

INTRODUCTION

Health care data collected with no specific *a priori* research questions are being increasingly utilized to conduct observational research (Benchimol, et al., 2015). These data, collected from a variety of health care settings and geographical areas, present researchers with opportunities for innovative and efficient research that may inform and improve practice, health care policy and funding (Benchimol et al., 2015; Chuback, Pocobelli & Weiss, 2012).

In Ontario, large administrative databases and registries have been used successfully to conduct several population-based research studies in Ontario (Guilcher et al., 2017; Guilcher et al., 2013; Hwang, Weaver, Aubry, & Hoch, 2011; Munce et al., 2009; Muratov et al., 2017; Tu et al., 2007). However, abstraction studies have shown that diagnostic and procedure codes can vary in completeness and accuracy (Guilcher et al., 2015; Noonan, Thorogood, Fingas, Batcke, Belanger, Kwon et al., 2013; Tu et al., 2007; Widdifield et al., 2014). The accuracy of algorithms for identifying cases with specific diagnoses or procedures is contingent upon features of the database, index condition, variations in coding, the study population, and finally a reference standard for confirming the diagnosis (Chuback, Pocobelli & Weiss, 2012; Decoster et al., 2016; Shrestha et al., 2016).

While population-based studies of this nature in the spinal cord injured (SCI) population in Ontario are being published, there are currently no studies of SCI persons undergoing surgical procedures for pressure injury (PI) closure (Guilcher et al., 2017; Hagen, et al., 2009).

PI flap reconstruction includes surgical debridement and osteotomy (removal of devitalized bone) of the bony prominence if required, followed by reconstruction of the tissues involved (Marchi et al., 2015). The ICD-10 CA codes and CCI procedure codes for these specific diagnoses and hospital procedures are recorded and stored at the Canadian Institute for Health Information (CIHI) and at the Institute for Clinical Evaluative Studies (ICES). The codes for SCI with PI reconstruction have not been explored. Moreover, algorithms of administrative codes used to accurately identify patients undergoing this procedure have not been evaluated. Accordingly, validity and accuracy of administrative codes to identify these patients in administrative databases is a critical first step for this kind of population-based study.

OBJECTIVE

Using confirmed hospital records and administrative databases as a reference standard, the primary objective of this study was to explore the sensitivity, specificity positive predictive value (PPV) and negative predictive value (NPV) of algorithms constructed from administrative codes to identify persons with SCI who underwent surgical flap closure of pelvic pressure injuries in an Ontario tertiary care hospital.

Research Ethics and Privacy Statements

Research ethics approval was obtained at St. Michael's hospital throughout the duration of this study. The need for informed consent was waived by the Research Ethics committee. Research ethics approval was also obtained at the Institute for Clinical Evaluative Studies. A Data Sharing Agreement (DSA) between SMH and ICES was obtained prior to secure data transfer. The data set from this study is held securely in encrypted form at ICES. No identifiable data can be published or shared beyond the approved investigators. Furthermore, DSAs prohibit ICES from making any data set publicly available. The full data set creation plan is available upon request.

The reporting of studies conducted using observational routinely collected health data (RECORD) statement and checklist was used to guide the reporting of this study (Benchimol et al., 2015). The RECORD checklist was designed as an extension of the STROBE statement for observational (cohort) studies, as it addresses the reporting specific

items to observational studies using routinely collected health data (Benchimol et al., 2015).

Setting

St. Michael's Hospital (SMH) is a tertiary/quaternary hospital in Toronto, Ontario, Canada. This hospital is a regional referral centre for persons with SCI requiring PI reconstruction. Ontario is the most populated province in Canada, with approximately 13.6 million residents. The Greater Toronto Area is the most heavily populated region (6.4 million residents) in Ontario and Canada (Statistics Canada, 2016). Ontario provides health care for all residents free at the point of delivery and publicly funded[1].

Design

This was a retrospective, single-center cohort validation study utilizing Ontario's administrative databases, using a convenience sample of confirmed hospital records at St. Michael's Hospital as the reference data. A control group of SCI with PI admitted without having the index procedure was identified and confirmed with two reviewers. The time horizon was from April 1, 2002 to April 1, 2015. The exposure (index procedure) was surgical reconstruction (myocutaneous or fasciocutaneous flap) of pelvic PI.

Outcomes

[1] Government of Canada, 'About Medicare', accessed 28 May, 2020, http://www.canada.ca/en/health-canada/services/canada-health-care-system.html.

The primary objective was to identify diagnostic and procedure codes that are recorded for known encounters of myocutaneous flap closure of PI in persons with SCI at SMH. The secondary objective was to test the validity of diagnostic/procedure code algorithms constructed from known cases and controls of myocutaneous flap closure of PI in persons at SMH and ICES.

Figure 1 provides an overview of the study. The patient records were included if they met the criteria of myocutaneous flap closure for PI in persons living with SCI. Records were excluded if PI surgery was performed on non-SCI persons, or if surgery was performed on SCI persons without PI reconstruction. OHIP number, encounter number and surgery date were recorded for each episode of PI reconstruction surgery. Demographics such as gender, age at time of discharge from hospital, age at time of SCI, level of SCI, cause of SCI, completeness of SCI, rurality, discharge disposition from hospital, PI closed at time of discharge from surgeon, and any revision surgery performed were abstracted. Hospital encounter numbers and surgery dates were confirmed by the Decision support department.

Patients who served as controls were all from patient records at St. Michael's Hospital. The controls included patients with SCI who were admitted to SMH with PI, who did not have a surgical flap closure procedure (n = 38).

Secure transfer of the dataset from SMH to ICES occurred following a data sharing agreement. A password protected/encrypted file was sent through the Axway ST system, operated by ICES. The password for access to the data file was sent to the ICES team via telephone to ensure further security. OHIP numbers were then linked with unique

identifying numbers assigned by ICES, known as ICES key number (IKN). The data and IKN numbers were subsequently sent to the ICES research analyst to begin the process of merging the data sets.

The cohort was then linked to the administrative data to examine how the surgeries were coded and recorded in the hospital database as well as in the ICES database. Table 2 displays the various codes that were expected to be found. The data were prepared for analysis with the following steps. First, imported data were linked to inpatient acute care DAD (discharge abstract database) data to find records with a DAD discharge date within one year of the discharge date recorded in the imported data. If the discharge dates matched, the DAD record was included in the sample; if not, we examined the discrepancy in dates for signs of a typographical error (e.g., day, month, or year differing by one digit). If there was no matching DAD record for the imported record the cases ($N < 6$) were excluded. There were 136 cases of surgical flap closure and 38 controls included in this study.

The matched discharge date was then used as the index discharge date for algorithm development. We examined matched DAD records of the cases to compile a list of possible ICD-10 CA, and CCI codes to use in the PI and surgery algorithm. The same process was used for fee codes of OHIP records within +/- 1 day of the surgery date. Controls were assigned a surgery index date one week prior to discharge. A summary of various ICD 10 CA, CCI and fee codes is available in the Appendix.

From the 21 combinations of fee codes/diagnostic codes and diagnostic codes/intervention codes, the fee code 1 algorithm (FC1) combined with diagnostic codes (Dx5) was chosen. Fee code 1 included billing codes R005 and R560 (see table 3). Fee

code 2 included two additional codes (R073 and R074); these codes were not billed independently of R005 or R560. Dx5 included all stages of pressure injuries as well as codes in the 970-979 series (ulcer of the lower limb). These codes were included as they were also found to be recorded in this cohort of patients and there was concern that the PI codes may not be sensitive enough.

When the intervention codes were reviewed, there were 329 discrete CCI codes; many of which, in consultation with the surgeon, were inappropriate for the type of surgeries performed (Dr. James Mahoney, personal communication, 2017). CCI codes highlighted in each of the intervention code tables in the Appendix were identified by the collaborating surgeon as inappropriate. After discussion with the research team, intervention codes were not included in the final algorithm due to the wide variation and misclassified coding.

A final step was to identify SCI as a diagnosis. There were many issues in identifying SCI, both traumatic (TSCI) and non-traumatic (NTSCI), in all databases. A diagnosis of SCI or para/quadriplegia in DAD was searched for during and prior to the index hospitalization, with look-back to 1988. Subsequently, the National Rehabilitation Reporting System (NRS) was used to identify admissions to rehabilitation up to seven days after the index surgery. Consequently, a number of cases were found that were discharged from PI surgery into rehabilitation and the rehabilitation records confirmed the SCI diagnoses that were not present in the DAD. This increased the sensitivity among the confirmed and control cases from 70% to 83% overall.

Among the TSCI subgroup of patients and looking at the index surgery stay only, only 6% had both TSCI and para/quadriplegia diagnosis. 48% of the group had no mention of either para/quadriplegia or TSCI. 42% had a diagnosis of para/quadriplegia with no TSCI code; 3 % TSCI with no para/quadriplegia diagnosis. In the NTSCI group, para/quadriplegia diagnosis was found in on 27% with the index surgery stay.

To investigate the diagnosis of SCI further, emergency department visits in National Ambulatory Care Reporting System database (NACRS) dating back to the year 2000 for TSCI and 2002 for NTSCI were explored. This improved the sensitivity in this diagnosis of SCI to 84%.

Finally, sensitivities were stratified and computed in the traumatic and non-traumatic groups, as well as the "unknown" causes of SCI. The sensitivities were 76%, 50% and 55% respectively. Combined, the overall mean was 69.1%, with the traumatic group being the largest of the three.

Algorithm derivation and testing

Performance of the algorithms to identify cases of SCI with PI reconstruction surgery with the health administrative data were tested against confirmed cases (true positive) and control (true negative) reference cohorts (see table 5).

Statistical Analysis

Statistical analysis for demographic data were mean, median and frequency (percent). Chi square was employed to compare categorical variables, ANOVA was used for comparing

means, and finally, the Wilcoxon rank-sum test was used to compare medians.

The following characteristics for each procedure and diagnostic code were calculated: sensitivity, specificity, positive and negative predictive values, and 95% confidence intervals. Sensitivity refers to the proportion of confirmed procedure codes and complication diagnostic codes recorded in the patients' charts having a positive DAD recording. Positive predictive value will refer to the proportion of procedure or diagnostic codes in the administrative databases that correspond to the pressure ulcer reconstruction in spinal cord injured persons with procedures recorded in the patient's charts (true positives).

DATA SOURCES

Ontario Health Insurance Plan

The Ontario Health Insurance Plan (OHIP) is an insurance plan for citizens of Canada who live in Ontario. Many aspects of health care are covered under this insurance plan, such as physician visits, hospitalizations, medically necessary diagnostic tests, procedures and treatments. Physician visits are billed to OHIP for most visits/procedures.

Discharge Abstract Database

The Discharge Abstract Database (DAD) contains demographic, administrative and clinical data on inpatient hospital discharges. Facilities in all provinces and territories except Quebec are required to report to the DAD. Quebec acute inpatient records are submitted to CIHI through a different process and are included in the Hospital Morbidity Database (CIHI, 2012).

Home Care Reporting System

The Home Care Reporting System contains demographic, clinical, functional and resource utilization information on clients served by publicly funded home care programs in Canada (CIHI, 2012).

National Ambulatory Care Reporting System

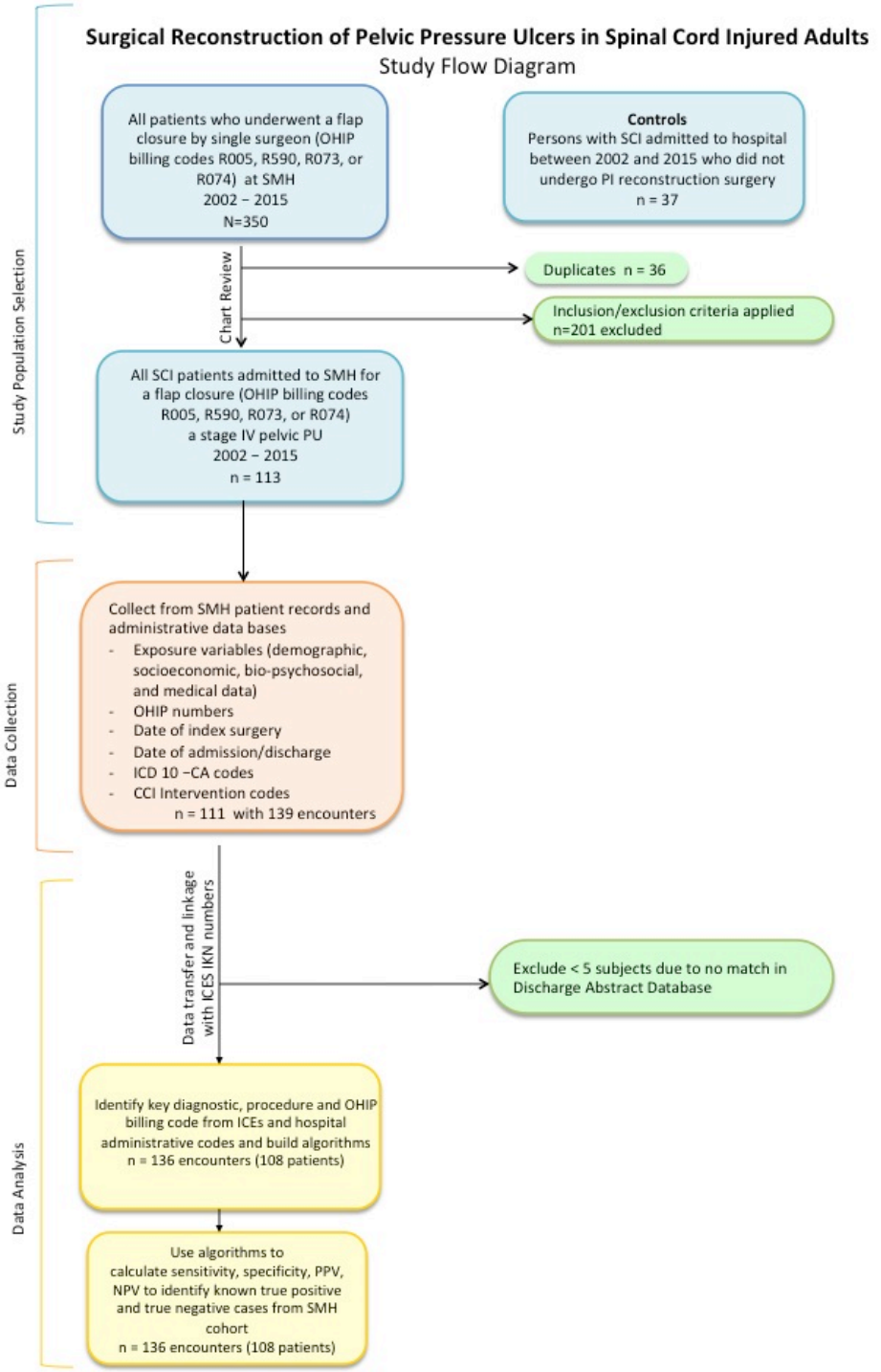
The National Ambulatory Care Reporting System (NACRS) contains data for all hospital-

based and community-based ambulatory care: day surgery, outpatient clinics and emergency departments. Client visit data is collected at the time of service in participating facilities (CIHI, 2012).

National Rehabilitation Reporting System

The National Rehabilitation Reporting System (NRS) contains client data collected from participating adult inpatient rehabilitation facilities and programs across Canada, including specialized facilities and hospital rehabilitation units, programs and designated rehabilitation beds. Rehabilitation facilities send information (clinical data) from a minimum data set to CIHI on a regular basis.
(http://med2020.ca/products/abstracting/nrs/)

Figure 1, Flow chart of study



RESULTS

In total, there were 111 patients with 136 surgical admissions (encounters) and 37 patients. Demographics of the 111 patients are summarized in table 6. Ninety-seven (71.3%) of the patients were male. There was a higher proportion of male encounters in the true positive group than females ($p < 0.004$). The mean age at discharge was 44.32 ($\pm$ 12.85) years. The mean age at time of SCI was 24.09 ($\pm$ 14.30) years. 86 (63.1%) of the patient encounters had traumatic SCI and 30 (22.1%) had non-traumatic SCI. Forty six (69.7%) of the patient encounters had incomplete SCI. One hundred and twenty four (91.9%) of the patients were from an urban address. Eighty three (61%) of the patients were discharged to rehabilitation. There was a higher proportion of patients discharged to rehab in the true positive group ($p = 0.02$). Seventy-five (62%) of the patients had a closed incision at the time of discharge from the plastic surgeon at 3-5 weeks. Thirteen (9.6%) of the surgical encounters required re-operation.

Of the 21 potential algorithms, we chose combination ‘diagnostic code 5 with fee-code 1 ‘any spinal cord’ diagnosis to compute a sensitivity of 69.1%, specificity of 97.37%; PPV of 98.95% and NPV of 46.84%. In other words, 30.9% of the true positives in this cohort were false negatives using the algorithm while 97.37% of the true negatives were identified using the same algorithm. The PPV was high because there were a large number of true positives and very few false positives in this small cohort of patients (see table 7).

DISCUSSION

Prioritizing sensitivity of an algorithm over specificity is important when the goal is identifying all persons with a given characteristic in a population. In other words, sensitivity is the primary consideration when the benefits of identifying more true positives outweigh the negative consequences of including more false positives. This may be important when the goal is: 1) reducing study costs and burdens that will be incurred from using a more accurate measurement tool; 2) enhancing the inclusiveness of an algorithm; or 3) collecting information on a common exposure (Tirschwell & Longstreth, 2002).

There were several issues with both the diagnostic codes (ICD 10 codes) and the intervention codes (CCI codes). For example, the PI diagnosis codes were widely variable and included stage 1 and 2 PIs. Stage 1 and 2 PIs are not an indication for surgical intervention. The use of these codes may reflect the lack of documentation regarding the stage of ulcer. Accordingly, we used any of the PI diagnoses codes. Another issue with the diagnostic codes for PIs was the fact that lower extremity codes in the lower extremity ulcer series (L970-L979) were also found within this cohort. Given that these codes are lower extremity in nature, we may have missed some of our cases if we had left them out of the PI diagnosis. Finally, PIs were also coded as unspecified in a large number of cases. This again may be partly due to documentation in the physician notes and subsequent difficulty from a coding perspective.

Finding SCI diagnostic codes was the most problematic. CIHI-DAD, NACRS and NRS databases were extensively explored to locate SCI codes. None of these data bases

found sufficient numbers. 17 % of the cases were missing a SCI diagnosis. Given that the SCI was the most difficult diagnosis to find, NRS, NACRS databases and ICD 9 codes was explored, looking back as far as 1988. Unfortunately, this did not result in an improvement of the sensitivity. Other combinations of SCI coding, including using traumatic SCI vs. non traumatic SCI, did not improve the sensitivity.

The OHIP billing codes yielded the highest sensitivity and specificity for identifying cases in this cohort. This accuracy may be tied to record keeping/billing from the surgeon. Although there is a training program for coding interventions and diagnosis, the variations in ICD 10 CA coding and CCI coding may be the result of the documentation in patient records as well as interpretation of the records.

Use of health administrative databases can minimize potential recall and non-response biases that are commonly found in survey data. Second, combining the true positive health record data with the administrative data allows researchers to look forwards and backwards to determine cost and health care utilization beyond the hospital sector. Patients lost to follow-up in the hospital charts can be identified and important data such as surrogate economic status and mortality can be included in analyses that would otherwise not be possible with hospital record data only.

In the literature, several validation studies demonstrated high sensitivity and specificity in identifying patient populations using administrative data. Widdifield et al. (2014), used primary care records as a reference standard to identify patients with rheumatoid arthritis (RA). While they concluded that administrative algorithms had achieved a high degree of accuracy, they noted that the variations in sensitivity and

specificity may have been attributed to differences in reference standards (Widdifield et al., 2014). Their final algorithm included a combination of hospitalization code of RA or three physician visits with an RA code over a two-year period and reported a sensitivity of 78 (95% CI 69-88); specificity 100 (95% CI 100, 100); PPV 78% (95% CI 69-88) and NPV of 100 (95% CI 100, 100). This study, however, did not identify any interventions. Furthermore, RA may be less of a complex diagnosis, making documentation and coding easier.

Tu et al. (2016) used family physician records from the electronic medical record administrative linked database (EMRALD) as a reference standard to identify patients with atrial fibrillation in Ontario. The best algorithm computed a sensitivity of 80.7 (95% CI 75.6-86.3), specificity of 99.1 (95% CI 98.9-99.3) and NPV of 99.5 (95% CI 99.3-99.7). They concluded that identification of atrial fibrillation could be done with a reasonable degree of accuracy. This diagnosis appears to be easier to identify than PI or SCI and did not include intervention codes.

Finally, Butt et al. (2014), used primary care records as a reference standard to identify patients with Parkinson's disease. Their best algorithm computed a sensitivity of 70.6 -72.3, specificity of 99.9-99.8, PPV of 79.5-82.8 and NPV of 99.7-99.9 and concluded that administrative database could reliably identify patients with Parkinson's disease with a high degree of accuracy. Given that there are no thresholds for defining 'high degree of accuracy', one might question these conclusions.

This study has a number of strengths and limitations. First, although attempts were made to identify all cases of SCI in persons who underwent surgical closure, there were

missing encounter numbers in the hospital administrative data base; therefore, not allowing us to include them in the study. Fortunately, this did not account for a large proportion of the cohort. When the data were transferred to ICES for analysis, two more cases were found to have no corresponding data in the CIHI-DAD for the index surgery. Second, the algorithms were constructed and tested from one cohort of patients from one surgeon in a single centre in Ontario. Therefore, the algorithms could perform differently in other regions of the province and hence conclusions about accuracy and utility of codes for this cohort of patients may not be generalizable. However, this type of surgery is relatively rare, and the hospital is a tertiary referral centre, receiving referrals to this surgeon for this surgery from across the province. Moreover, given that the search for diagnosis of PI and SCI spanned several databases up to 3 decades, finding these codes would likely be problematic even if this study was to include other sites across the province.

Another limitation is the acknowledgement that this study had a relatively small population of patients over the 13-year period. This illuminates the fact that this type of surgery is relatively rare. If other hospitals have similar or fewer numbers of patients with the same condition undergoing similar surgery, then standardized documentation and coding could be even be more varied. Conditions or procedures with large numbers of patients (e.g. cardiovascular or rheumatological conditions occur in large numbers and in many centres) may have more standardized documentation and coding, which may make administrative data more reliable and useful for epidemiological and health economic research (Tirschwell & Longstreth, 2002; Widdifield et al., 2014).

Finally, due to the characteristics inherent in different administrative data bases (e.g., ICD 10 –CA vs. ICD 10 codes), it would not be prudent to suggest that our findings can be generalized to similar populations in different countries.

CONCLUSION

With the limitations and variations in coding at one large tertiary and provincial referral hospital, Ontario health administrative databases are currently not suitable for identifying and studying SCI patients who have undergone surgical reconstruction of pelvic PIs. The algorithms tested suffer from poor sensitivity and PPV. Proceeding with retrospective reviews in this cohort of patients may lead to case misclassification bias due to underestimating of the procedure/intervention (Chuback, Pocobelli & Weiss, 2012).

This study demonstrates the importance of evaluating the accuracy and completeness of codes and algorithms used to identify patients in administrative data in order to reduce the potential for misclassification, which can lead to reduced power, loss of generalizability, increased risk of other information bias, and costs associated with conducting a study (Benchimol et al., 2015; Chuback, Pocobelli & Weiss, 2012; Schneeweiss, & Avorn, 2005). These findings may inform future research of persons living with SCI who suffer with this common and costly secondary complication (Gelis et al., 2009). Future cohort studies are suggested to be prospective in nature and include standardized documentation of primary and secondary diagnoses. Using templates and mandatory fields in medical records may also decrease error and/or variation in coding practice. Moreover, prospective data collection and perhaps including these patients in an SCI registry would enable important covariates to be accurately documented; thus allowing for comprehensive analysis while reducing the risk of information bias (Guilcher et al., 2015).

Given the burden of pressure injuries in the SCI population, it is important to continue to design studies that can accurately demonstrate the impact of this secondary condition as well as interventions that may have the ability to reduce morbidity and improve quality of life.

Table 1, OHIP billing fee codes and definitions[2]

OHIP Fee code	Definition
R005	Myocutaneous, myogenous or fascia-cutaneous flaps, including gluteus maximus, gracilis, or Sartorius muscles
R590	Bursa excision – trochanter or ischium
R073	Rotations, transpositions, Z-plasties with defect 5.1 to 10 cm average diameter, in areas other than the face, head and neck
R074	Rotations, transpositions, Z-plasties with defect more than 10 cm average diameter in areas other than the face head and neck

[2] Government of Canada (2020, May), *Integumentary System Surgical Procedures*, retrieved from http://www.health.gov.on.ca/en/pro/programs/ohip/sob/physserv/m_skinbr.pdf

Table 2: Summary of codes considered in building algorithms

Encounter or IKN number	Variable/Condition	ICD 9, ICD-10 diagnosis or CCI Procedure Codes	OHIP Surgeon Fee Code
	Excision Myocutaneous flap procedure	1SG80 sequencing 1YS87 sequencing 1SH87 sequencing 1SG80 sequencing	R005, R590, R073, R074
	1) Pressure ulcer diagnosis *2) Ulcer of the lower limb*	L89 sequencing L 970-L975, L 978-9	
	Spinal cord injury diagnoses (traumatic and non-traumatic) from ICD 10	S140, S141, S240, S241, S340 S341, T060, T061, T93	
	Spinal cord injury (traumatic) diagnoses from ICD 9	S127, S327, S328	

Sources:
OHIP Billing codes (Ontario Health Insurance Plan)
Canadian Institute for Health Information (2009);
International Classification of Diseases, Ninth Revision (ICD-9)
International Classification of Diseases, Tenth Revision, Canada (ICD-10 CA)
CCI = Canadian Classification of Health Interventions (CIHI, 2012).
Noonan, Thorogood, Fingas, Batcke, Belanger, Kwon et al., 2013.

Table 3: Algorithm code combinations

Algorithm	Specificity (%)	Sensitivity (%)	NPV (%)	PPV (%)
dx3_fc1	94.74	87.50	67.92	98.35
dx3_fc2	94.74	88.97	70.59	98.37
dx4_fc1	94.74	91.91	76.60	98.43
dx4_fc2	94.74	93.38	80.00	98.45
dx5_fc1	94.74	83.82	62.07	98.28
dx5_fc2	94.74	84.56	63.16	98.29
fc1	94.74	94.85	83.72	98.47
dx1_in1	94.74	76.47	52.94	98.11
dx1_in2	89.47	79.41	54.84	96.43
dx1_in3	100.00	2.94	22.35	100.00
dx2_in1	86.84	78.68	53.23	95.54
dx2_in2	76.32	81.62	53.70	92.50
dx2_in3	100.00	3.68	22.49	100.00
dx3_in1	94.74	82.35	60.00	98.25
dx3_in2	89.47	86.76	65.38	96.72
dx3_in3	100.00	2.94	22.35	100.00
dx3_in4	89.47	91.18	73.91	96.88
dx4_in1	86.84	85.29	62.26	95.87
dx4_in2	76.32	90.44	69.05	93.18
dx4_in3	100.00	3.68	22.49	100.00
dx4_in4	76.32	95.59	82.86	93.53

Legend:
Fc – fee codes from physician billing
Dx – diagnostic codes (ICD 10 CA codes)
In – Intervention codes (CCI codes)
See Appendix for codes included in each of the algorithms in table 3

Table 4: Final administrative algorithm

Final algorithm – Sensitivity test				
Case	**dx5_fc1**	**anysci1**	**Count**	**Percent**
0	0	0	6	15.8
0	0	1	30	78.9
0	1	0	< 6	< 4
0	1	1	< 6	< 4
1	0	0	< 6	< 4
1	0	1	20	14.7
1	1	0	20	14.7
1	1	1	94	69.1

Legend: dx = diagnosis code
fc = fee code
Anysci (TSCI or NTSCI or para/quadriplegia code)
Anysci1 = para/quadriplegia diagnosis for non-trauma included with NTSCI para/quadriplegia diagnosis included with TSCI

Table 5: Methods for computing measures of case identification accuracy

	Reference standard (hospital records)		
Administrative data	SCI + PI + Surgical closure	SCI + PI + no surgery (non-cases)	
	True positive	False positive	Positive Predictive Value (PPV) TP/TP + FP
	False negative	True negative	Negative predictive value (NPV) TN/FN + TN
	Sensitivity = $\frac{TP}{TP+FN}$	Specificity = $\frac{TN}{FP+TN}$	

Table 6: Patient characteristics

		False Negative (n=42)	True Positive (n=94)	Total N=136	p-value
Gender	Male	23 (54.8%)	74 (78.7%)	97 (71.3%)	0.004
	Female	19 (45.2%)	20 (21.3%)	39 (28.7%)	
Age at discharge (years)	Mean ± SD	42.86 ± 13.57	44.81 ± 12.55	44.21 ± 12.85	0.415
	Median (IQR)	41 (33-53)	46 (37-54)	44 (36-54)	0.407
Age at SCI (years)	Mean ± SD	21.47 ± 16.45	25.10 ± 13.33	24.09 ± 14.30	0.198
	Median (IQR)	22 (10-33)	25 (17-32)	24 (17-32)	0.165
Level of SCI	Cervical	7 (16.7%)	27 (28.7%)	34 (25.0%)	0.144
	Thoracic/Lumbar	25 (59.5%)	55 (58.5%)	80 (58.8%)	
	Unknown	10 (23.8%)	12 (12.8%)	22 (16.2%)	
Cause of SCI	Trauma	20 (47.6%)	66 (70.2%)	86 (63.2%)	0.04
	Violent	<=5	5-10	11 (8.1%)	
	Non-trauma	15 (35.7%)	15 (16.0%)	30 (22.1%)	
	Unknown	<=5	<=5	9 (6.6%)	
Completeness of SCI	No	13 (68.4%)	33 (70.2%)	46 (69.7%)	0.886
	Yes	6 (31.6%)	14 (29.8%)	20 (30.3%)	
Rurality	No	35-40	85-90	124 (91.9%)	0.816
	Yes	<=5	5-10	11 (8.1%)	
Discharge disposition	Community	17 (40.5%)	19 (20.2%)	36 (26.5%)	0.02
	Rehab	19 (45.2%)	64 (68.1%)	83 (61.0%)	
	Other institution	<=5	5-10	10 (7.4%)	
	Unknown	<=5	<=5	7 (5.1%)	
PI closed at discharge from surgeon	No	12 (33.3%)	33 (39.3%)	45 (37.5%)	0.537
	Yes	24 (66.7%)	51 (60.7%)	75 (62.5%)	
Revision surgery required	No	39 (92.9%)	82 (87.2%)	121 (89.0%)	0.505
	Yes	<=5	5-10	13 (9.6%)	
	Unknown	<= 5	<=5	<=5	

Note: Demographics of patients that served as controls in this study were not collected.

Table 7, Sensitivity, specificity, PPV and NPV of final algorithm

		Reference Standard (Hospital records)		Predictive Values
		Cases	Non-Cases	
Administrative code algorithm	Positive	94	1	PPV = 98.95% 95% CI (94.27, 99.27)
	Negative	42	37	NPV = 46.84% 95% CI (35.51, 58.40)
		136	38	TOTAL 174
		Sensitivity = 69.1 95% CI (60.3, 76.75)	Specificity = 97.3 95% CI (86.19, 99.93)	

True Positive (TP): Number of known subjects at SMH have SCI with PI and had surgical flap closure and were identified with the identified with the ICD 10 CA and CCI algorithm
False positive (FP): Number of known subjects at SMH with SCI and PI without surgical flap closure but were identified with the ICD 10 CA and CCI algorithm
False negative (FN): Number of known subjects at SMH who SCI with PI and surgical flap closure were not identified with the ICD 10 CA and CCI algorithm
True Negative (TN):
Number of known subjects at SMH with SCI and PI without surgical flap closure who were not identified with the algorithm
Sensitivity: The proportion of people with SCI and PI who did have surgical flap closure procedure.
Specificity: The proportion of people with SCI and PI who did not have the surgical flap closure procedure.
Positive predictive value (PPV): the probability that subjects with SCI and PI identified correctly the ICD 10 CA code algorithm truly had the PI flap closure procedure
Negative predictive value (NPV): the probability that subjects with SCI and PI who did not have surgical flap closure are not identified with the ICD 10 CA code algorithm truly did not have PI flap surgical closure.

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CHAPTER FOUR

Exploring factors associated with complications among persons with spinal cord injury undergoing surgical closure of stage 4 pelvic pressure injuries

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Authorship contributions for this paper:

Laura Teague, PhD student conceived the research questions and design and was directly responsible with research ethics board applications/amendments/closure communications, data sharing agreements with the Institute of Clinical Evaluative Sciences and writing of the manuscripts.

Dr. Gina Browne was the PhD student's Thesis Chair until 2019. She provided guidance, feedback and took the role of Principal Investigator for the Ontario Neurotrauma Foundation grant.

Dr. Susan Jaglal is an ICES scientist who collaborated on the second, third, and fourth manuscripts.

Andrew Calzavara is an ICES analyst who performed statistical analysis for the combined data for the second, third, and fourth manuscripts.

Dr. Jennifer Voth assisted with obtaining ethical approval and data transfer agreement for ICES.

Dr. Lehana Thabane has been on Ms. Teague's supervisory committee and assumed the role of Thesis Chair in 2019. Dr. Thabane contributed substantially to the data analysis and interpretation of the data, and reviewed the manuscripts.

Dr. Stephen Birch, a member of the PhD student's thesis committee, provided direct feedback around the design of the research questions. He also reviewed and provided feedback for this chapter.

Dr. Karen E. Campbell was on the PhD student's thesis committee. She reviewed and provided direct feedback around the structure of this chapter.

Dr. Colleen McGillivray provided feedback with conception of research study and part of the Ontario Neuro Foundation Grant.

Maya Deeb is a medical student who provided data collection and administrative assistance during initiation of the study.

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Keywords: *pressure injury, surgical reconstruction, spinal cord injury, complications, risk factors*

ABSTRACT

This study examined physiological and environmental variables associated with wound complications in persons with spinal cord injury (SCI) who underwent surgical repair of stage 4 pelvic pressure injuries (PI). A cohort of 88 patients with 100 surgeries from one tertiary care hospital in Toronto, Canada were identified. Patient-specific risk and operative variables were obtained from patient records and administrative data. Bivariate and Poisson regression analyses were used to model predictors of open vs. closed wounds, 3–6 weeks following the surgical procedures. Eighty-eight patients having 100 surgical encounters were identified. Thirty-eight percent of the surgical encounters were open at 3–6 weeks post-operatively. Persons receiving 50+ homecare nursing visits in the year prior to the index surgical date had a lower risk of having an open incision at the surgical follow-up clinic visit (incidence rate ratio [IRR] = 0.49; 95% confidence interval [CI] = 0.24, 0.99; p = 0.048). Persons who required surgical revision had an increased risk of having an open incision at the surgical follow-up clinic visit (IRR = 1.89; 95% CI = 1.15, 3.09; p = 0.01). Increased age, northern Ontario residence, and smoking were found to increase the risk of open incision; but were not statistically significant. Being female and having peripheral vascular disease were identified as reducing the risk of having an open incision at the surgical follow-up clinic; but were not statistically significant. Complication rates (incision open at routine surgical follow-up) were found to be 37% in this sample of SCI patients undergoing surgical closure of stage 4 PI. Future prospective studies to mitigate some of the risk factors are warranted.

INTRODUCTION

Spinal cord injury (SCI) is devastating to patients and their families, causing permanent disability, high morbidity and mortality. Beyond the immobility that results from the injury, denervation causes SCI patients to suffer from impaired wound healing and places persons with SCI at higher risk of developing pressure injury (PI) (Houghton, Campbell & CPG Panel, 2013). As a result, PIs are a common and serious secondary health condition in those individuals and come with both economic and medical burdens (Dorsett and Geraghty, 2008; Garber & Rintala, 2003; Hitzig et al., 2008).

The prevalence of PIs in the SCI population exceeds that of the general population and ranges between 8–59% (Chen et al., 2005; Dorsett & Geraghty, 2008; Garber & Rintala, 2003; Saunders et al., 2012). Moreover, PI in the SCI population impairs quality of life, work or school attendance, and community integration (Houghton, Campbell & CPG Panel, 2013). In Canada, the economic burden of PI in SCI persons is significant, but not fully understood. In a small Ontario sample of community-dwelling SCI persons, the estimated mean costs of chronic PI were found to be CA$4,725 per month, or CA$56,700 annually (Chan et al., 2012). In the US study by Brem et al. (2010), the estimated direct health care cost of treating a single stage 4 PI in community and hospital was found to be US$124,327 and US$129,248, respectively. In a systematic review, the cost of PI treatment per patient across different health care settings ranged from 1.71€ to 470.49€ per day (Demarre et al., 2015). In Europe, a review of 52 cases of PI surgical closure in Denmark

by Filius et al. (2013) reported a mean direct cost of 20,957€, with the majority of the cost being associated with hospitalization days.

PIs range in severity from non-blanchable erythema (stage 1) to full-thickness tissue loss (stage 4) (National Injury Ulcer Advisory Panel/European Pressure Ulcer Advisory Panel, 2019). Best practice guidelines suggest that surgical reconstruction with a flap is an option for chronic stage 4 PIs that have failed more conservative approaches to treatment (Ahluwalia, Martin & Mahoney, 2010; Sameem, et al., 2010; Schryvers, Stranc & Nance, 2000; National Pressure Injury Advisory Panel/European Pressure Ulcer Advisory Panel, 2019; Registered Nurses' Association of Ontario, 2016; Health Quality Ontario, 2017). Patients become candidates for surgery after comprehensive assessment. If they can be optimized nutritionally, are free of infection, free of substance use (e.g., cigarettes, alcohol and street drugs), and are willing and able to participate in post-op recovery protocols, patients are offered surgical closure. Patients are assessed in a pre-admission facility for anesthesia purposes. They undergo surgical reconstruction of PI and recover on a therapeutic mattress while in hospital for approximately eight days. A four-to-five-week institutionalization in rehabilitation, or convalescent care with bed rest, is always considered our standard of care. However, some patients choose to recover in their homes, as they have adequate resources and pressure redistribution mattresses to rest on. If the patient's incision remains closed three-to-six weeks after the surgical date, he/she begins a progressive seating program in a rehabilitation centre.

Despite some of the measures employed to choose optimal surgical candidates, a systematic review of the literature and subsequent studies indicates that the complication

rates related to PI surgical flap closure range between 8.9% and 58% (Sameem et al., 2012; Biglari, et al. 2014; Bamba et al., 2017). Furthermore, PI recurrence rates among persons living with SCI, whose PIs were treated through surgical flap closure, ranged from 11% to 29% in cases with post-operative complications, and 6% to 61% in cases without post-operative complications (Guihan et al., 2008; Holmes, Rintala, Garber and Friedman, 2002; Krause and Broderick, 2004; Schryvers, Stranc and Nance, 2000). Reports describing various surgical flap treatments, complication rates, and risk factors for PI recurrence, have identified the importance of structured rehabilitation care in the post-operative phase (Ahluwalia, Martin and Mahoney, 2011; Kruger et al., 2013). The high rate of surgical wound complications and the extensive costs associated with PI management suggest the importance of identifying predictors of wound complications (Ahluwalia, Martin and Mahoney, 2011; Biglari, et al., 2014; Keys et al., 2010; Sameem et al., 2012; Schryvers et al., 2000).

Accordingly, the purpose of this study was to explore factors associated with complications (open incision) of surgically reconstructed stage 4 PIs in SCI patients at three-to-six weeks' follow-up.

METHODS

Research Ethics Board approval was obtained from St. Michael's Hospital in Toronto, Ontario, as well as from the Institute of Clinical Evaluative Sciences (ICES) for the duration of the study. Data were obtained from an original cohort of SCI adult subjects studied to identify costs and health care utilization pre- and post-PI reconstruction and linked using a unique identifier to health administrative data (see figure 1). From the 108 patients with 136 encounters, we excluded 11 (8.1%) encounters who had subsequent surgery within one year. We further excluded 11 (10.2%) with 16 (11.8%) encounters as the outcome was unknown. Finally, we excluded seven (6.5%) patients with seven (5.1%) missing covariates, which included income quintile and HCU in the one-year lookback. In total, 88 patients with 100 encounters were included in this analysis. Gender, age at time of SCI, age at time of surgery, level of SCI, completeness of SCI, rural address, Northern Ontario address, living status, employment status, neighbourhood income quintile, Charlson co-morbidity index, history of autonomic dysreflexia, smoking status, history of peripheral vascular disease, length of stay, revision surgery, discharge disposition and 50+ community nursing visits in the year prior to surgery were recorded. Follow-up was three years from the date of admission for the index surgery.

Data were retrieved from a variety of sources, including:

- Patient records
- Discharge Abstract Database (CIHI-DAD)
- National Ambulatory Care Reporting System (NACRS)

- National Rehabilitation Reporting System (NRS)
- Registered Persons Database (RPDB)
- Homecare Database (HCD)

Statistical analysis was performed using SAS v9. 3, R. Descriptive data (categorical) are expressed in frequencies and percent. Continuous variables are expressed in mean +/- standard deviation (SD) and median with Interquartile range (IQR). Chi-square (x^2) was employed for categorical variables. One-way Analysis of Variance (ANOVA) was employed to compare continuous variables for the mean values. Kruskal-Wallis one-way analysis of variance was employed for continuous, nonparametric values, expressed as median. Generalized estimated equation (GEE) with exchangeable correlation structure was employed to account for repeated subjects. Wilcoxon ranked-sum test was employed to compare visit counts pre-surgery to one-year post surgery. Bivariate and Poisson regression analyses were used to model predictors of open vs. closed incision at three-to-six weeks following the surgical procedure. A risk reduction (RR) >1 indicates that individuals with certain characteristics ulcers had increased risk open incision compared with those with closed incisions.

RESULTS

Seventy-one percent of all surgeries performed were on male patients. The mean age at the time of SCI was 23.31 years (*SD* = 13.47). The mean age at the time of surgery was 43.15 years (*SD* = 12.58). For level of SCI, 23 (23%) were cervical, 59 (59%) were thoraco-lumbar and 18 (18%) were unknown. Completeness of the SCI was recorded for 11% of the subjects; incomplete SCI was 37% and 52% were unknown. Ninety-three percent lived at an urban address and 10% lived at a northern Ontario address. Forty-seven percent lived in homes, 20% lived in apartments, and <5 (8.1%) were in assisted living. Living situation was unknown in 28% of the cohort. Eight percent were employed full time; 24% were receiving disability pension; and 55% had unknown source of income.

Sixty-two percent of the patients had closed incisions and 29% of the patients had an open incision at the three-to-six week follow-up, post index surgery. Significantly more patients in the open incision group were smokers ($p = 0.039$) and had revision surgery. More patients in the group with closed incisions had over 50 nursing visits in the year prior to the index surgery, approaching statistical significance ($p = 0.061$). Table 2 displays the univariate (unadjusted) Robust Poisson Model. This analysis accounts for repeated subjects using GEE with exchangeable correlation structure. Statistically significant variables in the univariate model were employed to build the Poisson regression model.

Table 3 provides a summary of the multivariate analysis using the Poisson Regression Model. Persons receiving 50+ homecare nursing visits in the year prior to the index surgical date had a decreased risk of having an open incision at the surgical follow-up clinic visit

(RR = 0.49; 95% CI = 0.24, .99; p = 0.048). Persons who required surgical revision had an increased risk of having an open incision at the surgical follow-up clinic visit (RR = 1.89; 95% CI = 1.15-3.09; p = 0.01). Increased age, income quintile, northern Ontario residence and smoking were found to increase the risk of open incision; but were not statistically significant. Being female and having peripheral vascular disease were identified as reducing the risk of having an open incision at the surgical follow-up clinic; these risk factors were not statistically significant.

DISCUSSION

In the present study, 37(37%) of the patients experienced complications. Having consistent homecare visits was found to decrease the risk of having an open incision, while a person who required surgical revision had an increased risk of having an open incision at the surgical follow-up clinic visit. Increased age, northern Ontario residence and smoking were found to increase the risk of open incision; but were not statistically significant. Being female and having peripheral vascular disease were identified as reducing the risk of having an open incision at the surgical follow-up clinic; but were statistically insignificant. To our knowledge, this is the first study to look at biophysical and environmental variables at one year prior the surgical procedure.

Interestingly, there were no significant differences in complication rates when comparing recovery location (home with homecare, rehabilitation or other institution). This finding may be due to the small sample size or the intentional decision to send higher risk persons to rehabilitation facilities. Further research is required to explore this phenomenon.

A retrospective study by Kierney et al. (1998) was conducted in the USA to determine PI recurrence rates in 158 patients who underwent surgical flap closure of 268 PIs. This sample included traumatic and non-traumatic SCI persons. The follow-up time was 3.7 years. They reported a recurrence rate of 19% (49/268) over the same site. Analysis of risk factors associated with recurrence were not explored beyond identifying the location and type of surgery and the type of SCI. While the outcomes of that study cannot be

compared to the present study, it is noteworthy that 81% of the patients did not re-ulcerate over the same operative site for a long period of time.

Schryvers et al. (2000) published one of the first reviews of PI reconstruction outcomes in Canada. In their sample size of 168 patients with 598 encounters of stage 4 PIs undergoing reconstruction, the outcomes included suture line dehiscence and revision surgery. They reported that 31% (185/598) had suture line dehiscence with 11% (66/598) requiring revision surgery. They collected socio-demographics and found that 95% (159/168) were spinal cord injured. While no robust statistics were conducted, descriptive statistics were used to suggest that social factors such unemployment, living situation, race (indigenous) and drug use may influence outcomes in addition to surgical technique. Srivasta et al. (2009) conducted a small prospective study of 25 SCI patients with 39 PIs to determine outcomes of PI reconstruction. Four participants (16.6%) had initial complications: wound dehiscence 8.3% (2) and delayed graft healing 8.3% (2). The duration of follow-up was 12 to 21 months (mean = 15.4, ± 7.45 months). Four participants (17.3%) had ulcer recurrence. Given the small sample size, regression analysis to explore risk factors for complications would not have been adequately powered and therefore not useful.

Ahluwalia, Martin, & Mahoney (2010) conducted a retrospective review in Toronto, Canada of stage 3 or 4 PI reconstruction on 78 patients with 104 flap procedures from a consecutive cohort following the surgical reconstruction of a stage 3 or 4 PI between 1997 and 2007. Complications and recurrence rates were examined by PI location and reconstruction method employed to directly compare surgical outcomes. Complications

were defined as any incision that failed to heal immediately postoperatively, including minor dehiscence, infection and flap necrosis. They reported an overall flap complication rate of 16% (17/104) with a wound recurrence rate of 7% (7/104) and concluded that the use of a combination posterior medial thigh fasciocutaneous flap with a biceps femoris muscle flap could be recommended as a first choice in ischial pressure wound reconstruction. No univariate or multivariate analyses were performed. While this review was to evaluate outcomes of flap selection, other variables, such as those that we collected in the administrative database, were not considered as potentially influencing flap outcomes.

Keys et al. (2010) conducted a retrospective review of 135 American veteran patients with SCI who underwent 227 PI flap closure procedures with a primary outcome of recurrence of PI at the operative site. Secondary outcomes included incisional dehiscence and operative revision. Their follow up time was six weeks; it was unclear what the final endpoint was. They reported 88 recurrences of PIs after flap surgery (39%) of 227 operations performed. Thirty-six (16%) had dehiscence necessitating return to the operating room. A glycosylated hemoglobin (A1C) less than 6% and previous same-site flap failure were associated with both dehiscence and recurrence (OR = 2.15 and 3.84; and OR = 6.51 and 3.27). Younger age and albumin less than 3.5 dl were associated with early flap failure (OR = 5.95 and 2.45). Ischial wound location correlated with late recurrence (OR = 4.01). They also reported that patients with multiple risk factors had operative success rates that approached zero. The younger age as a risk factor was in contrast to our study findings. The location of the site of PI (ischial) as a risk factor would be congruent

as this bony prominence would be exposed to highest risk for people sitting in wheelchairs for prolonged periods.

Sameem et al. (2012) conducted a meta-analysis of 55 studies that showed an overall 19% surgical complication rate and a 9% ulcer recurrence rate. Follow-up times ranged from one to 93 months. Site complications including wound infection, hematoma, abscess, surgical wound dehiscence, and ulcer recurrence. This study compared outcomes based on operative techniques only. There were no analyses around risk factors for surgical complication or recurrence rates. While there was heterogeneity in terms of patient populations and time of follow-up, they concluded that PI flap closure is an effective intervention in the context of careful patient selection and optimization during the pre and post-operative periods.

Larson et al. (2012) studied 101 SCI patients with 179 encounters of PI reconstruction. The complication rate was 17.3% (35/179). Suture-line dehiscence, infection and distal flap necrosis were the complications recorded. The mean follow-up period was 436 days. They looked at nutrition (low albumin levels) and positive bone cultures as risk factors for complications and ulcer recurrence but did not find any significant differences among those with and without complications. These findings were aligned with the present study.

Chiu et al. (2016) conducted a similar study with 181 surgical flap encounters between January 2002 and December 2013. Their study compared outcomes between different types of reconstruction procedures. Outcome measures included suture line dehiscence, infection, hematoma, or flap necrosis and PI recurrence. Complication and

recurrence rates for all flaps were 46.5% (84/181) and 16% (29/181) respectively, and there were no statistical differences between the types of flap reconstruction. In multivariate regression analysis, serum albumin of less than 3.0 g/dl, ischial site of surgery, and paraplegia were found to be significant risk factors for wound complications. Unfortunately, this study had 48% (87/181) of the encounters with SCI.

Diamond et al. (2016) performed a retrospective review of 320 patients who underwent PI flap closure in the USA from 2011-2012. This study included all persons with PI; not specific to SCI. Thirty day flap failure rate was found to be 1.9% (n=6); reoperation rate was 4.7% (n=15) and SSI rate was 8% (n= 25) and dehiscence was 4.7% (n=15). The overall 30 day complication rate was 19% (n=61). In their regression analysis, previous steroid use was found to increase the odds of flap failure (OR 15.42, p=0.02). In our study, steroid use was not found to be a significant risk factor.

Bamba et al. (2017) conducted a retrospective chart review of 276 patients who underwent flap reconstruction for a PI between 1997 and 2015. The characteristics of patients were analyzed to determine those who had complications such as PI recurrence, wound dehiscence, and wound infection. The demographics indicated that 82.6% (231/276) of the sample was SCI. They reported an overall complication rate of 58% (162/276). In this sample, multivariate regression analysis ischial PI was found to be the only independent risk factor for both major and minor complications (RR = 2.63; 95% CI = 1.52-4.54; $p < .01$). In our study, location of the reconstruction did not increase risk of open incision.

Gargano and colleagues (2018) conducted a prospective study reviewing 20 sequential patients treated with two types of flap coverage over a 36-month period from 2011 to 2014. Fourteen (70%) were SCI patients. A total of eight (40%) complications were present in the conventional surgical flap operations. While they found no statistical differences between the two groups, the sample size was small and no multivariate analysis was performed.

In a larger, retrospective review of 1,248 patients from 2005-2015 in Utah, USA, Kwok et al. (2018) reported an overall complication rate of 35.0% (437/1248 following PI reconstruction). However, complications included mortality, postoperative blood transfusion, surgical site infection, UTI, sepsis, wound dehiscence, pneumonia, septic shock, ICU stay with ventilation, renal impairment, myocardial infarction, pulmonary embolism, and DVT. The actual reported rate of surgical site infection was 8.09% and wound dehiscence was 4.57%. There were no re-operation encounters reported. These findings are difficult to compare to our study as it was unclear how many of the subjects were spinal cord injured. Needless to say, the surgical site complication rate was significantly lower than in other studies.

The number of SCI patients in Kwok's review was not clear. Surgical wound complications accounted for 12.7% (158/1248) of the 35% complication rate that was reported. On multivariate regression, obesity was independently associated with complications (OR = 11.325; 95% CI = 1.00, 1.74; $p < 0.044$), and flap closure was again associated with fewer complications (OR = 0.71; 95% CI 0.55, 0.91; $p < 0.008$).

Tran et al. (2018) reviewed administrative data on PI reconstruction outcomes from the National Surgical Quality Improvement Project Database (NSQIP) in Boston, USA. Seven hundred fifty-five surgical encounters were reviewed. They reported an overall complication rate of 25% at day 30, post-op. While surgical incisional dehiscence, superficial and deep organ space infection, reoperation and readmission infection accounted for 6.9% (52/755) of the complications rate, they also included bleeding, septic shock, deep vein thrombosis and pulmonary embolism as complications. Moreover, only 28% (210/755) of the sample had SCI as a diagnosis. Consequently, comparing these results with the present study is not feasible.

Finally, Wong et al. (2016) conducted a systematic review of the literature to compare outcomes of reconstructive surgery for closing PIs (stage 2 or above), with no surgery or alternative forms of surgery in any care setting. They found no randomized controlled trials that support or refute the role of reconstructive surgery for PIs. They concluded there is need for more rigorous and robust research in this area.

This study has a number of strengths and limitations. This is the first known study that combines patient records with administrative data to explore factors that may influence outcomes of surgical flap closure of PI in SCI persons. Second, use of retrospective data from patient records and administrative databases vs. survey data may reduce the level of recall and response bias. The nature and size of the sampling (convenience sample from a single centre study, single surgeon and convenience sample in Canada) can therefore limit the generalizability of the findings. Environmental and psychosocial variables such as timely access to surgical consultation, surgical wait times, delays or access to coordinated,

SCI specific health care, mental health, lifestyle choices and high risk behaviours were not available in either the patient records or administrative databases, and could introduce confounding.

CONCLUSION

This Canadian cohort of patients demonstrated a high number of post-operative cases being open at the post-surgery clinic follow-up visit. From our study and through the literature review, complications of surgical flap closure present a formidable challenge. These complications can contribute to delayed wound closure, delayed rehabilitation, reduced quality of life, and continued financial burden on the health care system. Sameem et al. (2012) provide data suggesting no differences in outcomes with type of flap used for PI reconstruction. Significantly more of the patients who received 50+ nursing care visits in the previous year had closed incisions at the surgical follow up visit. Those who were incrementally older, from a northern Ontario residence, and requiring surgical revision, were more likely to have an open incision. Although this is a small sample size, delivery of regular nursing care and increased access to specialized SCI care in rural areas may improve outcomes.

Our data, similar to other studies conducted in developed countries, suggests that not only surgeons but the entire interdisciplinary team need to revisit and collaborate on their risk reduction efforts aimed at mitigating risk. This study identifies numerous risk factors that should be considered when offering flap reconstruction. Prospective studies or studies with data collected through registries specifically designed for SCI patients may identify more complete, relevant and modifiable characteristics, or risk factors that can inform prospective interventional studies within this rare population. Building screen tools and comparing models of delivery of care in persons with SCI undergoing PI reconstruction

are suggested, in order to determine if surgical outcomes can be improved in this complex population of patients.

Figure 1, Flow chart of study

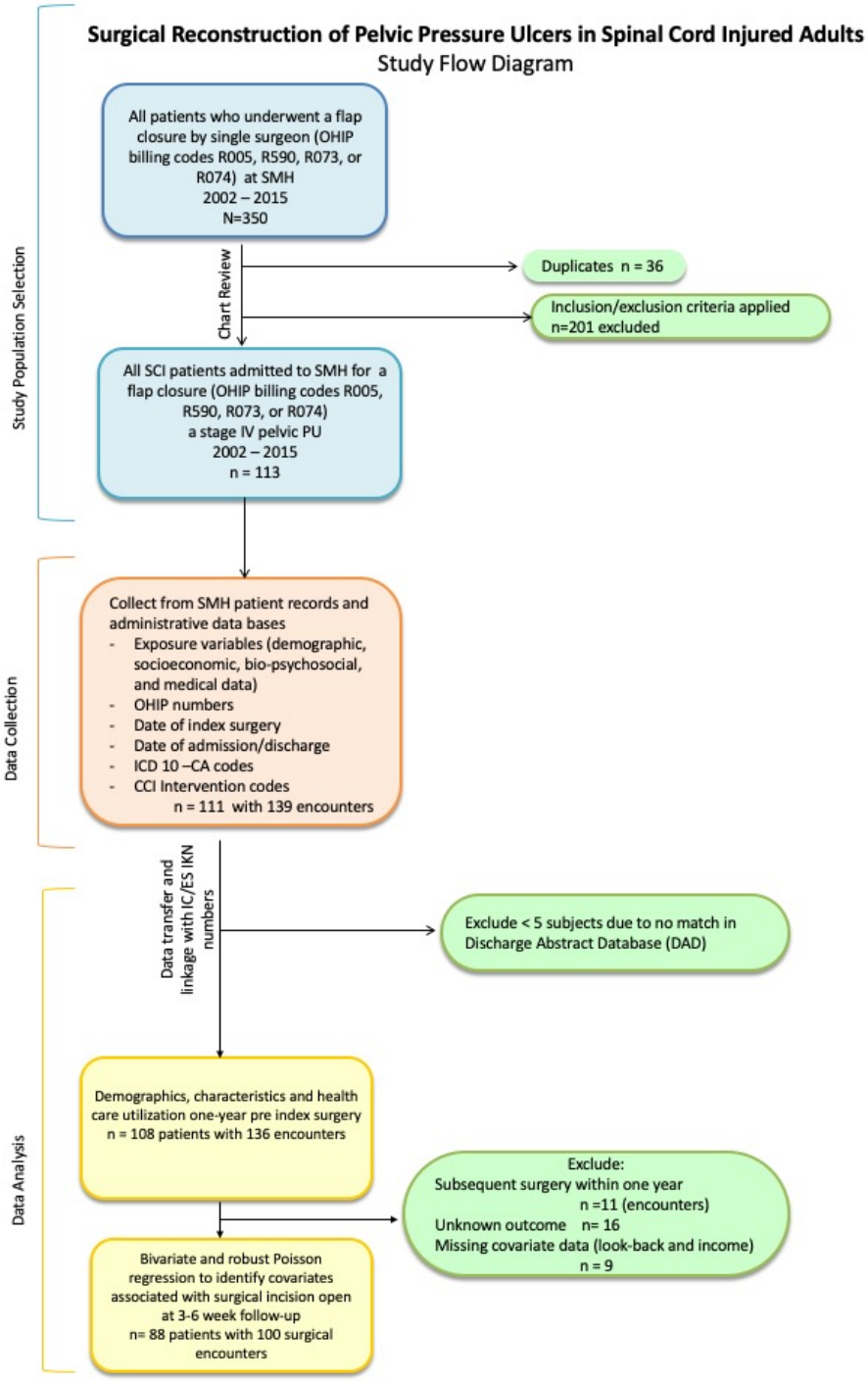

Table 1

Demographics and bivariate analysis of incision closed vs. open

Variable	Incision Closed (*N* = 62)	Incision Open (*N* = 38)	Total (*N* = 100)	*p*
Gender				
Female	20 (32.3%)	9 (23.7%)	29 (29.0%)	0.359
Male	42 (67.7%)	29 (76.3%)	71 (71.0%)	
Age at time of SCI (years)				
Mean ± SD	20.54 ± 10.90	25.14 ± 16.56	23.31 + 13.47	0.104
Median (IQR)	23 (17-28)	25 (17-36)	23 (17-30)	0.206
Age at time of surgery (years)				
Mean ± SD	41.44 ± 11.72	45.95 ± 13.56	43.15 ±12.58	0.082
Median (IQR)	41 (32-51)	47 (38-57)	43 (34-53)	0.10
Level of SCI				
Cervical	15 (24.2%)	8 (21.1%)	23 (23.0%)	0.81
Thoracic/Lumbar	37 (59.7%)	22 (57.9%)	59 (59.0%)	
Unknown	10 (16.1%)	8 (21.1%)	18 (18.0%)	
Completeness of SCI				
Unknown	22 (35.5%)	15 (39.5%)	37 (37.0%)	0.74
Complete	6 (9.7%)	<=5 (13.2%)	11 (11.0%)	
Incomplete	34 (54.8%)	18 (47.4%)	52 (52.0%)	
Lives as Rural Address				
No	59 (95.2%)	34 (89.5%)	93 (93.0%)	0.28
Yes	<=5 (4.8%)	<=5 (10.5%)	7 (7.0%)	
Northern Ontario Address				
Yes	<=5 (4.8%)	7 (18.4%)	10 (10.0%)	0.03
Living Status				
Home	24 (38.7%)	23 (60.5%)	47 (47.0%)	0.06
Apartment	12 (19.4%)	8 (21.1%)	20 (20.0%)	

Assisted living	<=5 (8.1%)	0 (0.0%)	<=5 (5.0%)	
Unknown	21 (33.9%)	7 (18.4%)	28 (28.0%)	
Employment Status	<=5 (6.5%)	<=5 (10.5%)	8 (8.0%)	0.36
Full time	16 (25.8%)	8 (21.1%)	24 (24.0%)	
ODSP	<=5 (1.6%)	0 (0.0%)	<=5 (1.0%)	
WSIB	10 (16.1%)	<=5 (5.3%)	12 (12.0%)	
Unemployed	31 (50.0%)	24 (63.2%)	55 (55.0%)	
Unknown	<=5 (6.5%)	<=5 (10.5%)	8 (8.0%)	0.36
Nearest Census Based Neighbourhood Income Quintile (within CMA/CA)				
1	13 (21.0%)	9 (23.7%)	22 (22.0%)	0.57
2	14 (22.6%)	7 (18.4%)	21 (21.0%)	
3	8 (12.9%)	<=5 (7.9%)	11 (11.0%)	
4	14 (22.6%)	6 (15.8%)	20 (20.0%)	
5	13 (21.0%)	13 (34.2%)	26 (26.0%)	
Charlson Community Index				
0	34 (54.8%)	21 (55.3%)	55 (55.0%)	0.22
1	<=5 (1.6%)	0 (0.0%)	<=5 (1.0%)	
2	27 (43.5%)	14 (36.8%)	41 (41.0%)	
3	0 (0.0%)	<=5 (5.3%)	<=5 (2.0%)	
4	0 (0.0%)	<=5 (2.6%)	<=5 (1.0%)	
History of autonomic dysreflexia				
Unknown	<=5 (8.1%)	<=5 (7.9%)	8 (8.0%)	0.99
No	48 (77.4%)	29 (76.3%)	77 (77.0%)	
Yes	9 (14.5%)	6 (15.8%)	15 (15.0%)	
	<=5 (8.1%)	<=5 (7.9%)	8 (8.0%)	0.99
Current smoker				
Yes	14 (22.6%)	16 (42.1%)	30 (30.0%)	0.04
History of peripheral vascular disease				
No	60 (96.8%)	34 (89.5%)	94 (94.0%)	0.136
Yes	<=5 (3.2%)	<=5 (10.5%)	6 (6.0%)	
Length of stay (days)				
Mean ± SD	7.89 ± 3.08	8.58 ± 6.48	8.15 ± 4.65	0.473

Median (IQR)	8 (6-8)	7 (5-8)	7 (6-8)	0.21
Revision surgery required				
Yes	<=5 (3.2%)	10 (26.3%)	12 (12.0%)	<. 0.01
Discharge Disposition				
Community	13 (21.0%)	15 (39.5%)	28 (28.0%)	0.20
Rehab	44 (71.0%)	20 (52.6%)	64 (64.0%)	
Other institution	<=5 (3.2%)	<=5 (5.3%)	<=5 (4.0%)	
Unknown	<=5 (4.8%)	<=5 (2.6%)	<=5 (4.0%)	
50+ HC nursing visits (year prior)				
Yes	57 (91.9%)	30 (78.9%)	87 (87.0%)	0.06

Note. $N = 97$.

Table 2, *Univariate (unadjusted) Robust Poisson Model*

Variable	IRR	95% CI		*p*
Male gender				
Yes	1.33	0.71	2.41	0.36
Living in a northern residence				
Yes	1.80	1.24	3.15	0.02
Greater than 50 home care nursing visits in year prior				
Yes	0.56	0.34	0.97	0.03
Revision surgery				
Yes	2.66	1.74	3.87	0.00
Disposition to rehabilitation facility				
Rehab	0.59	0.37	0.94	0.03
Peripheral arterial disease				
Yes	1.82	1.05	3.16	0.03
Smoking				
Yes	1.74	1.08	2.79	0.02
Skin flap on anatomical ischium				
Yes	0.6			0.19
Bladder incontinence				
Yes	0.80	0.31	1.98	0.63
Bowel incontinence				
Yes	0.71	0.37	1.55	0.36
Rural residence				

Yes	1.34	0.76	3.04	0.44
Income quintile				
5	1.20	0.78	2.31	0.55
4	0.62	0.62	0.41	0.23
3	0.62	0.12	0.64	0.38
2	0.89	0.28	1.64	0.74
Regional Postal Code				
P-Northern	1.47	0.65	41.6	0.42
M-Toronto	0.67	0.26	1.83	0.43
L-GTHA	0.93	0.37	2.39	0.88
Discharge disposition				
Unknown	0.32	0.10	2.32	0.19
Other institution	0.94	0.36	2.45	0.90
Current consumption of >2 alcoholic drinks/day				
Yes	1.31	0.32	5.35	0.71
Type of anesthesia				
Unknown	1.03	0.51	2.65	0.95
Regional	0.53	0.09	3.09	0.48
Monitored	1.35	0.44	3.98	0.59
Spinal	1.77	0.74	4.07	0.18
Cause of SCI				
Unknown	0.62	0.25	2.12	0.41
Traumatic	0.97	0.57	1.81	0.91
Non-traumatic	0.28	0.04	1.80	0.18
Completeness of SCI				
Complete	0.89	0.54	1.59	0.66
Incomplete	1.19	0.56	2.55	0.66
Positive intraoperative wound culture				
No	1.35	0.43	6.22	0.67
Yes	1.38	0.42	4.60	0.60
Diabetes				
Yes	1.44	0.94	2.58	0.17
Family Support				
Yes	1.35	0.43	4.48	0.62

Hypertension	1.43	0.90	2.54	0.18
SCI Injury Level				
Unknown	1.19	0.61	2.91	0.67
Thoracic/ Lumbar	1.06	0.54	2.08	0.86
Cervical	1.32	?	?	0.40
Marital Status				
Unknown	1.73	0.72	4.01	0.21
Divorced	0.86	0.26	2.75	0.81
Married	0.88	0.48	1.70	0.69
Myocutaneous flap performed in location 1	0.96	0.54	1.59	0.88
Obesity				
Yes	0.63	0.25	2.09	0.41
Osteomyelitis				
Yes	1.32	0.47	3.56	0.59
Osteoporosis				
Yes	0.64	0.11	3.49	0.61
Use of chronic pain meds				
Yes	1.13	0.63	1.96	0.66
History of pneumonia				
Yes	0.87	0.17	4.28	0.86
Renal disease				
Yes	0.71	0.18	2.89	0.64
Help at home				
Yes	0.88	0.46	1.78	0.71
History of spasticity				
Yes	1.44	0.83	2.40	0.17

Note: N = 100.

Table 3

Incidence Rate Ratio of open incision at follow-up in surgical clinic using Poisson regression model

Variable	IRR	95% CI		*p*
Age (per year older)	1.01	0.99	1.03	0.13
Female vs. male	0.86	0.45	1.61	0.63
Income quintile 5 vs. other	1.42	0.83	2.45	0.20
Northern Ontario residence	1.30	0.73	2.30	0.38
Skin flap on anatomical location 1	0.76	0.36	1.63	0.48
50+ homecare nursing visits (year prior)	0.49	0.24	0.99	0.05
Surgical revision needed	1.89	1.16	3.09	0.01
Peripheral vascular disease	0.85	0.39	1.87	0.69
Smoking	1.72	0.91	3.23	0.09

Note: N = 100

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CHAPTER FIVE

Cost and health care utilization in persons with spinal cord injury who have undergone surgical closure of stage 4 pelvic pressure injuries in Ontario, Canada: A descriptive study

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Authorship contributions for this paper:

Laura Teague, PhD student conceived the research questions and design and was directly responsible with research ethics board applications/amendments/closure communications, data sharing agreements with the Institute of Clinical Evaluative Sciences and writing of the manuscripts.

Dr. Gina Browne is the Founder and Director, Health and Social Service Utilization Research Unit and Professor Emeritus, Nursing; Department of Health Research Methods, Evidence, and Impact (formerly the Department of Clinical Epidemiology and Biostatistics) McMaster University, School of Nursing. Dr. Brown was the PhD student's Thesis Chair until 2019. She provided guidance, feedback and took the role of Principal Investigator for the Ontario Neurotrauma Foundation grant.

Dr. Lehana Thabane has been on Ms. Teague's supervisory committee and assumed the

role of Thesis Chair in 2019. Dr. Thabane contributed substantially to the data analysis and interpretation of the data and reviewed the manuscripts.

Dr. Stephen Birch, a member of the PhD student's thesis committee, provided direct feedback around the design of the research questions. He also reviewed and provided feedback for this chapter.

Dr. Colleen McGillivray provided feedback with conception of research study and part of the Ontario Neuro Foundation Grant.

Maya Deeb is a medical student who provided data collection and administrative assistance during initiation of the study.

Dr. James Mahoney supported the PhD student through administrative support throughout Ethics Board portion of the study and was part of the Ontario Neuro Foundation Grant.

Andrew Calzavara is an ICES analyst who performed statistical analysis for the combined data for the second, third, and fourth manuscripts.

Dr. Jennifer Voth assisted with obtaining ethical approval and data transfer agreement for ICES.

Dr. Susan Jaglal is the Toronto Rehabilitation Institute Chair at the University of Toronto in Health Services Research, and an ICES scientist who collaborated on the second, third, and fourth manuscripts.

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Keywords: *pressure injury reconstruction, spinal cord injury, cost, health care utilization*

Background:

Pressure injury (PI) is a common, secondary complication in persons with spinal cord injury SCI. Surgical flap closure can be considered when SCI patients fail to heal PI when conservative best practices have been employed. However, little is known about the short term and long term cost and health care utilization (HCU) of SCI patients with PI who undergo surgical flap closure. Identifying cost and HCU of this procedure within this population of patients is important from a funding, program planning and practice perspective.

Objective:

The purpose of this study was to describe cost and HCU in persons with SCI who have undergone surgical flap closure of pelvic PI, using provincial health administrative data.

Methods:

Seventy-nine patients with 96 confirmed surgical encounters were included in this retrospective cohort study, between April 1, 2003 and April 1, 2013. HCU and costs were recorded for one year, pre-surgery, and annually for three years post-surgery. Socio-demographics were recorded from both the patient records and from linked provincial health administrative databases. This analysis is primarily descriptive.

Results:

In the look-back year, total median physician visits were 15 (first quartile [Q1]- third quartile [Q3]: 10-22), the total median hospitalizations was 0 (0-1), the median acute hospital days was 0 (Q1-Q3:0-5), and total median home care visits were 215 (Q1-Q3:112-357). In the first year post-index surgery, there is a substantial decrease in median home care visits to 54 (Q1-Q3: 8-156). While in some cases these visits were unchanged, and in some cases higher in the first year post surgery, a repeated measures gamma regression model shows that, when comparing total costs in the look-back versus Years 2 and 3, the linear trend is for costs to decrease by approximately $8,034 (2016 CDN $) per year. Comparing Year 2 to Year 3, the trend is a rise in costs $3,879. Most of the differences in HCU were observed in the community care nursing visits, which were reduced by 71% following the surgery.

Summary:

Cost and HCU are high in the first year following surgical repair of PI in SCI persons; similar to the direct health care costs of initial SCI in Canada. However, investment in health care services, total annual cost and HCU in Year 2 and 3 was found to be substantially less when compared to the year prior to the index surgery.

INTRODUCTION

Pressure injuries (PIs) are a common and serious complication of spinal cord injury (SCI) (Hitzig et al., 2008). Impaired wound healing in SCI patients can contribute to the progression of these injuries to more severe stages, which are most often difficult to manage. The treatment of PI is resource intensive and includes local wound care that involves debridement of necrotic tissue, bacterial balance, and dressings that control moisture in the wound bed (RNAO, 2016; Health Quality Ontario, 2017). In Ontario, Canada, persons with SCI and PI are predominantly managed in the community, with skilled home nursing visits. Other health care visits include primary care and specialist assessments, allied health for wheelchair assessments, dietitians, pharmaceutical personnel, and case management.

When conservative best practice fails to achieve wound closure, guidelines suggest that surgical flap closure should be considered for chronic stage 4 PIs (Houghton & Campbell, 2013; RNAO, 2016; NPUAP, 2016, Health Quality Ontario, 2017). Many studies have been published on clinical outcomes of PI reconstruction in the general population as well as in the SCI population (Sameem et al., 2012; Chiu et al., 2016,; Diamond, 2016; Bamba et al., 2017; Kwok et al., 2018; Tran et al 2018). However, little is known about the short term and long term costs and HCU of persons with SCI who have undergone PI reconstruction.

Given that PI in persons with SCI is a lifelong risk, and that surgical complications and PI recurrence in this population are high, it is important to determine the cost and health

care utilization for SCI persons with PI who undergo reconstructive surgery (Chan et al., 2012; Sameem et al 2012, Chan et al., 2018). Appreciating the burden of illness is important, as it may assist decision makers with program planning and budgeting.

More importantly, illuminating the cost and HCU within this population may inspire health care professionals, decision makers, and policy makers to design and study more focused and coordinated approaches to managing these patients in order to improve both financial and clinical outcomes.

To address some of the gaps in the literature, this study aimed to use a convenience sample of hospital records linked to administrative data in order to identify short and long-term cost and health care utilization in persons with SCI who have undergone surgical reconstruction of stage 4 pelvic PI's in Toronto, Ontario.

METHODS

Ethical approval

Research ethics approval was obtained at St. Michael's Hospital (SMH) and ICES throughout the duration of this study. Informed consent was waived by the Research Ethics committee. A Data Sharing Agreement (DSA) between SMH and ICES was obtained prior to secure data transfer. The data set from this study has been held securely in encrypted form at ICES.

Setting

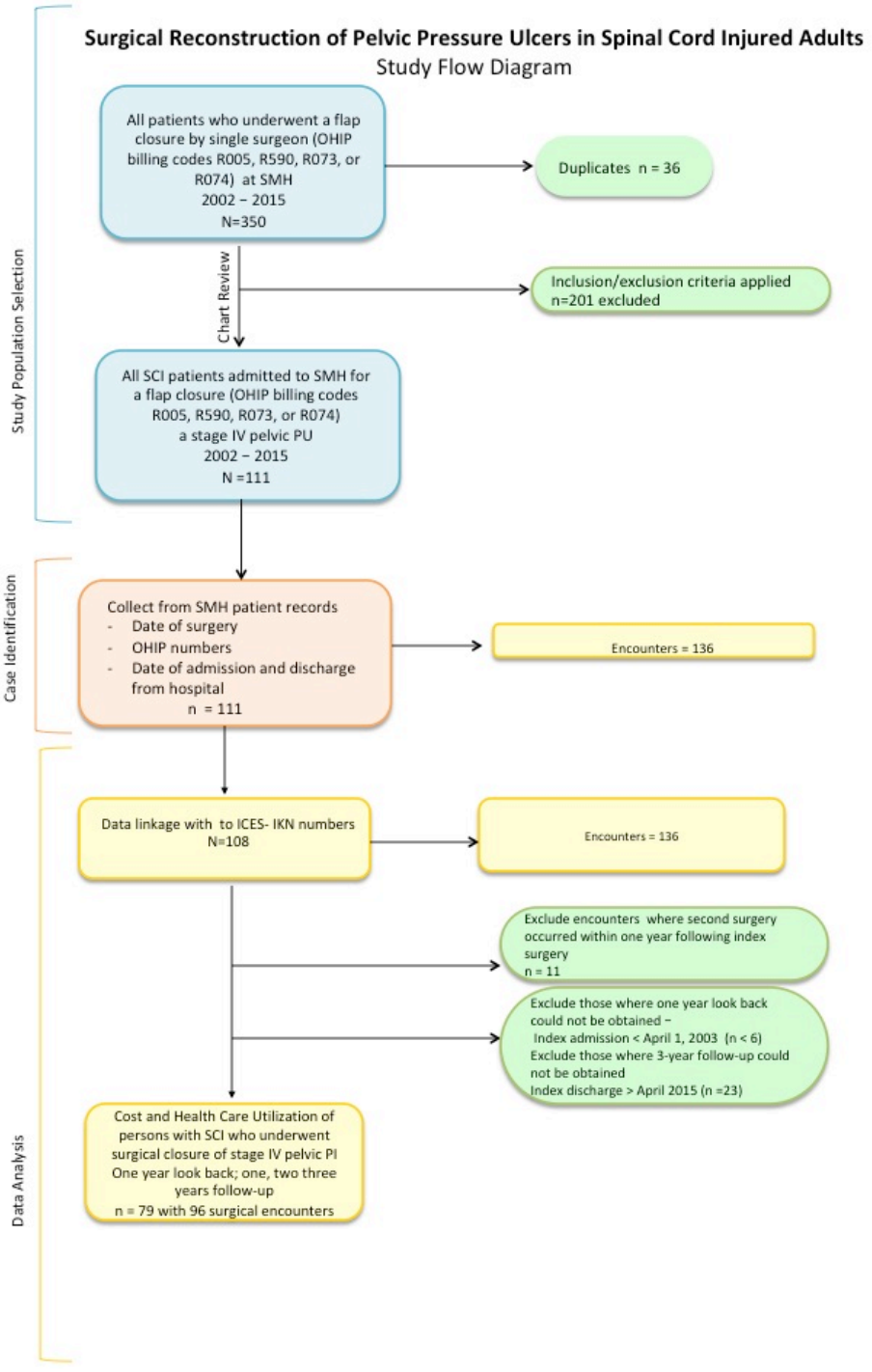
St. Michael's Hospital (SMH) is a tertiary/quaternary hospital in Toronto, Ontario, Canada. This hospital is also a regional referral centre for persons with SCI requiring PI reconstruction. Ontario is the most populated province in Canada, with over 13.45 million residents. The Greater Toronto Area is the most heavily populated region in Ontario and Canada (5,928,040 people). Ontario provides health care that is universal and publicly funded.[3]

The sample consisted of a convenience sample of 79 patients with 96 encounters from April 1, 2003 to April 1, 2013. SCI patients who received pelvic PI reconstruction were identified first by physician billing codes, confirmed with patient records, and then

[3] Statistics Canada, 2016, Census Program, retrieved from https://www12.statcan.gc.ca/census-recensement/index-eng.cfm?MM=1

validated with ICD-10 CA codes. The specific details of how cases of SCI were identified, including the exclusion criteria, can be seen in the flow diagram (Figure 1).

Figure 1, Flow chart of study


Surgical Reconstruction of Pelvic Pressure Ulcers in Spinal Cord Injured Adults
Study Flow Diagram
Study Population Selection
All patients who underwent a flap closure by single surgeon (OHIP billing codes R005, R590, R073, or R074) at SMH
2002 – 2015
N=350
Duplicates n = 36
Chart Review
Inclusion/exclusion criteria applied
n=201 excluded
All SCI patients admitted to SMH for a flap closure (OHIP billing codes R005, R590, R073, or R074)
a stage IV pelvic PU
2002 – 2015
N =111
Case Identification
Collect from SMH patient records
- Date of surgery
- OHIP numbers
- Date of admission and discharge from hospital
n = 111
Encounters = 136
Data linkage with to ICES- IKN numbers
N=108
Encounters = 136
Exclude encounters where second surgery occurred within one year following index surgery
n = 11
Exclude those where one year look back could not be obtained –
Index admission < April 1, 2003 (n < 6)
Exclude those where 3-year follow-up could not be obtained
Index discharge > April 2015 (n =23)
Data Analysis
Cost and Health Care Utilization of persons with SCI who underwent surgical closure of stage IV pelvic PI
One year look back; one, two three years follow-up
n = 79 with 96 surgical encounters

This study used a retrospective cohort design, linking the sample of confirmed cases of PI reconstruction in SCI persons' hospital records with administrative data housed at ICES.

One hundred eleven cases of confirmed SCI injured persons undergoing surgical flap closure of stage 4 PI at SMH were initially considered for the analysis. Following the DSA that was obtained between SMH and ICES for secure data transfer, 108 persons with 136 surgeries from April 1, 2002 to April 1, 2015 were linked to the ICES data. A single encounter is defined as an index surgery with no surgery on the same site within one year following the surgery. Eleven (8.1%) surgical encounters were excluded under this criterion. In order to achieve a one-year look back, cases prior to April 1, 2003 were also excluded from the cohort (n = 6, 5.6%). Finally, to achieve a three-year follow-up, all subjects with index surgery dates later than April 1, 2013 (n = 23, 21.3%) were excluded from the analysis. The total number of persons included in the final analysis were 79, with 96 encounters.

DATA SOURCES

Hospital Records

Demographics and clinical data were collected and included: OHIP number; index surgery date; gender; age at index admission; age at time of SCI; cause of SCI; completeness of SCI; level of SCI; rurality; neighbourhood income quintile; marital status; discharge disposition; American Society of Anaesthesia (ASA) score; history of autonomic dysreflexia; history of spasticity; history of street drug use; and history of urinary tract infection.

The index surgery outcome was binary: 'closed' or 'open' at the time of discharge from the surgeon. By consensus with the surgeon and research team, a closed incision was defined as one with no incisional discharge and with no further wound or incisional care required. The definition of 'open' included any persons who required ongoing wound/incision management, regardless of the severity. These definitions were defined as such, due to the ongoing HCU required with the index operative site, until the incision completely closed. Moreover, active rehabilitation could also be protracted, causing further HCU and cost. These data were then securely transferred to ICES following the DSA.

Registered Persons Database (RPDB)

The Registered Persons Database (RPDB) is a population-based registry that is maintained by the Ministry of Health and Long-Term Care (MOHLTC) in Ontario, Canada. It is used to manage publicly funded health care services that are covered under the Ontario Health

Insurance Plan (OHIP). It houses a listing of the unique health numbers that have been issued to individuals eligible for coverage. The database includes an individual's date of birth, gender, address, date of death (where applicable), and captures changes in eligibility for health insurance coverage. When new RPDB data arrive at ICES, personal identifying information is removed, and each unique health number is converted into an anonymous identifier (IKN). The IKN is a common identifier that is used to link data sources within ICES (eHealth Ontario, 2011).

Discharge Abstract Database (DAD)

The DAD is a national database and contains demographic, administrative and clinical data on inpatient hospital discharges. Facilities in all provinces and territories (except Quebec) are required to report to the DAD (Canadian Institute for Health information, 2016).

Home Care Reporting System (HCRS)

The HCRS contains demographic, clinical, functional and resource utilization information on clients served by publicly funded home care programs in Canada (Canadian Institute for Health information, 2016).

National Ambulatory Care Reporting System (NACRS)

The NACRS contains data for all hospital-based and community-based ambulatory care: day surgery, outpatient clinics and emergency departments. Client visit data is collected

at the time of service in participating facilities (Canadian Institute for Health information, 2016).

National Rehabilitation Reporting System (NRS)

The NRS contains client data collected from participating adult inpatient rehabilitation facilities and programs across Canada, including specialized facilities and hospital rehabilitation units, programs and designated rehabilitation beds (Canadian Institute for Health information, 2016).

Ontario Health Insurance Plan (OHIP)

The OHIP database contains all claims made by physicians (and other health care providers) for insured services provided to residents of the province of Ontario. Nearly 95% of Ontario physicians are paid on a fee-for-service basis and must submit claims to OHIP for reimbursement. Each record in the database represents discrete services provided to a specific person, on a specific visit/day. The record provides the type of service provided, diagnostic information, the individual that provided the service, the individual that received the service, the date that it occurred, associated fee codes, and the total fee paid to that health care provider (Guilcher et al., 2010).

Continuing Care Reporting System (CCRS)

The CCRS is a database that captures administrative, demographic and clinical information on persons in residential and hospital-based continuing care facilities (Canadian Institute for Health information, 2016).

Ontario Drug Benefits (ODB)

The ODB program is used to process medication claims covered under this program. It records all medication prescriptions and their associated cost within this program of coverage for each individual in Ontario.[4]

For comparison purposes, all costs were converted to 2016 CDN $, using the Consumer Price Indices (CPI) for all other health care services included in the analysis. Health system costs were calculated for acute care hospitalization, total physician visits, inpatient rehabilitation, home care visits, complex continuing care, Ontario drug benefits, long term care, and laboratory and non-physician OHIP charges.

From one year prior to admission (look-back year) for an index surgery, through to three years after index surgery discharge, the Ontario Ministry of Health and Long-Term Care pays for all health care facility and community health care services. Indirect costs to the patient and/or family or third-party payers for other non-medically necessary services or services not funded by the Ministry were not included. These indirect costs are not

[4] Government of Ontario, 'Ontario Drug Benefit Monthly Data', last accessed May 29, 2020, https://data.ontario.ca/dataset/ontario-drug-benefit-odb-monthly-data

routinely captured and stored in patient records or administrative databases. The total annual costs were calculated by adding the per-patient case costs in each care setting.

Each inpatient acute care discharge abstract database record includes the resource intensity weight associated with the hospital stay; and the relative amount of hospital resources required to care for a patient. Acute care costs were computed by multiplying the RIW for each inpatient stay by the provincial average cost per weighted case obtained from the MOHLTC financial information management branch (CIHI, 2015; Wodchis et al., 2013).

Cost calculations were estimated from administrative data following recommended guidelines. Hospital and home care costs were based on costs reported to the Ontario government. Primary and specialist physician fees were based on the OHIP fee schedule (OHIP, 2020).

Inpatient rehabilitation costs per weighted case were only available for 2004/05 and were extrapolated to other study years based on the rate of increase in acute hospital case costs. This estimate assumes that changes in rehabilitation hospital costs were the same as changes in acute hospital care costs, which is justified from a financial perspective as most inpatient rehabilitation hospital beds in Ontario are housed within acute hospitals (CADTH, 2015).

Cost weights for CCC were based on the Resident Assessment Instrument-Minimum Data Set Resource Utilization Groups (RUG III) 19, which represents the relative amount of hospital resources required to care for a patient each day. Values were obtained from Statistics Canada CANSIM databases (Wodchis et al., 2013).

Complex Continuing Care (CCC) case cost was calculated by multiplying the RUG-III weight for each patient by the average referent (equivalency) cost per day and multiplying this weighted per day cost by the patient's length of stay. For residents not discharged within a year, we only included costs to 365 days (CADTH, 2015)

Emergency department (ED) costs were calculated by multiplying the number of ED visits by the average cost per ED visit. Physician costs were obtained based on the number of visits by type of visit (identified by the billing code in the OHIP record) and the associated fee code. Home care costs were based on the number of visits by type of service (nursing, personal support, rehabilitation professional by type) multiplied by the average provincial visit costs for each type of service (CADTH, 2015).

ANALYSIS

Descriptive data (categorical) are expressed in frequency and percent. Continuous variables are expressed in mean +/- standard deviation and median with Interquartile range (IQR). Cost data were adjusted to 2016 CDN $ and expressed as median with IQR. Wilcoxon ranked-sum test was employed to compare visit counts pre-surgery to one, two and three years' post-index surgery. All statistical tests were performed at the 5% level of significance and were two-sided (Daniel & Cross, 2014).

Table 1, Patient characteristics at index surgery

Table 1: Patient characteristics at index surgery
N=96 surgerical encounters

Gender	male	72(75%)
	female	24(25%)
Age at index admission	Mean ± SD	43.82 ± 12.78
	Median (IQR)	45 (36-54)
Age at SCI	Mean ± SD	23.46 ± 14.69
	Median (IQR)	23 (17-31)
Length of stay	Mean ± SD	10.84 ± 19.22
	Median (IQR)	7 (6-9)
Cause of spinal cord injury	Traumatic	57 (59.4%)
	Violent	9 (9.4%)
	Non-traumati	22 (22.9%)
	Unknown	8 (8.3%)
Completeness of SCI	Unknown	52 (54.2%)
	Complete	33 (34.4%)
	Incomplete	11 (11.5%)
Level of SCI	Cervical	24 (25.0%)
	Thoracic/Lum	53 (55.2%)
	Unknown	19 (19.8%)
2008 Rurality Index for Ontario	Mean ± SD	5.93 ± 12.58
	Median (IQR)	0 (0-6)
Categorical Rurality Index	40+	<=5 (5.2%)
	<40	91 (94.8%)
StatCan rural neighbourhood		<=5 (1.0%)
	No	91 (94.8%)
	Yes	<=5 (4.2%)
Neighbourhood income quintile		<=5 (3.1%)
	1	21 (21.9%)
	2	19 (19.8%)
	3	14 (14.6%)
	4	18 (18.8%)
	5	21 (21.9%)
Marital status	Single	56 (58.3%)
	Married	28 (29.2%)
	Divorced	8 (8.3%)
	Widowed	<=5 (1.0%)
	Unknown	<=5 (3.1%)
Discharge disposition	Community	21 (21.9%)
	Rehab	60 (62.5%)
	Other institut	8 (8.3%)
	Unknown	7 (7.3%)
Died in first year of follow up		<=5 (1.0%)
Died in second year of follow up		<=5 (2.1%)
Died in third year of follow up		<=5 (3.1%)
ASA score	Mean ± SD	3.06 ± 0.58
	Median (IQR)	3 (3-3)
	.	16 (16.7%)
	1	<=5 (1.0%)
	2	8 (8.3%)
	3	56 (58.3%)
	4	15 (15.6%)
History of autonomic dysreflexia	Unknown	<=5 (3.1%)
	No	75 (78.1%)
	Yes	18 (18.8%)
History of ladder incontinance	Unknown	8 (8.3%)
	No	80 (83.3%)
	Yes	8 (8.3%)
History of bowel incontinence	Unknown	8 (8.3%)
	No	71 (74.0%)
	Yes	17 (17.7%)
History of >2 alcoholic drinks per day	Unknown	<=5 (3.1%)
	No	92 (95.8%)
	Yes	<=5 (1.0%)
Antibiotic use at discharge from hospital	Unknown	6 (6.3%)
	No	18 (18.8%)
	Yes	72 (75.0%)
History of spasticity	Unknown	<=5 (3.1%)
	No	45 (46.9%)
	Yes	48 (50.0%)
History of street drug use	Unknown	<=5 (3.1%)
	No	84 (87.5%)
	Yes	9 (9.4%)
History of UTI	Unknown	83 (86.5%)
	Yes	13 (13.5%)
Postive bone biopsy report	Not perfomed	82 (85.4%)
	No	6 (6.3%)
	Yes	7 (7.3%)
	not perfomed	<=5 (1.0%)
Positive tissue culture	Unknown	8 (8.3%)
	Yes	77 (80.2%)
	No	11 (11.5%)

Table 2 compares the patient encounters who had open incision vs. closed incision at three-to-six week follow-up in the surgical clinic.

Seventy-two (75%) of the patients were male. The mean age at the time of index admission was 43.82 (+/- 12.78) years. The mean age at time of SCI was 23.46 (+/- 14.69) years. The mean LOS was 10.84 (+/-19.22) days. Fifty-seven (59.4%) of the cohort had traumatic SCI. Twenty-four (25%) of the patients had a cervical SCI; 53 (55.2%) had a thoracic or lumbar SCI and 19 (19.8%) were unknown. Ninety-one (94.8%) of the patients had a categorical rurality index > 40; meaning that the majority of the patients were considered to be urban. By region, 76 (79.2%) of the cohort lived in the Toronto or Greater Toronto region. Discharge disposition revealed that 21 (21.9%) were discharged to community, 60 (62.5%) to rehabilitation centres, and 8 (8.31%) to other facilities.

Data on income and education were not available in either data sets; however, neighbourhood income quintiles were available as a socioeconomic surrogate through ICES. There were no significant differences between the open and closed groups in the five income quintiles, ranging from low (1) to high (5).

The Charlson Co-morbidity Index revealed that 91 (94.8%) within the cohort had scores of 0-2. In contrast, American Society of Anesthesia (ASA) risk scores (a global score that measures physical status of patients before surgery) were 3 or 4 in 71 (73.9%) of the patients, indicating patients with severe systemic disease. Less than 5% of the cohort died in Year 1, 2 and 3 following discharge from the index surgery.

Eighteen (18.8%) of the cohort had history of autonomic dysreflexia; 48 (50%) had spasticity; 8 (8.3%) had history of urinary incontinence, 17 (17.7%) had bowel incontinence; 26 (27.1%) were current smokers; 30 (31.3%) were on chronic pain medications and 9 (9.4%) were using street drugs.

PI 'open' vs. PI 'closed' groups were also compared in Table 2. Twenty-nine (30.2%) of the cases were considered open at discharge (three-to-six weeks post-surgery). Fifty six (58.33%) were considered to be closed and 11 (11.45%) were unknown. Only two covariates were found to be significantly different. The first was mean age at time of index surgery. The mean age for those with open incisions was 47.34 (+/- 13.60) years vs. 40.89 (+/-11.55) years ($p = 0.03$). Revision surgery was disproportionately higher in the PI 'open' group compared to the PI 'closed' group ($p < .001$).

Table 2: Patient characteristics, comparing open to closed incisions at follow-up from index surgery
N=79 subjects having 96 surgeries

		Surgical Incision Closed				
		No N=29	Yes N=56	Unknown N=11	TOTAL N=96	P-VALUE
Age at index admission	Mean ± SD	47.34 ± 13.60	40.89 ± 11.55	49.45 ± 13.47	43.82 ± 12.78	0.03
	Median (IQR)	49 (39-57)	41 (31-50)	51 (40-59)	45 (36-54)	0.03
Age at SCI	Mean ± SD	26.43 ± 17.11	20.58 ± 10.64	30.10 ± 22.09	23.46 ± 14.69	0.07
	Median (IQR)	25 (18-37)	23 (17-28)	33 (15-42)	23 (17-31)	0.16
Length of stay	Mean ± SD	9.72 ± 6.84	10.98 ± 23.49	13.09 ± 18.26	10.84 ± 19.22	0.88
	Median (IQR)	7 (6-11)	8 (6-8)	8 (6-9)	7 (6-9)	0.87
Cause of spinal cord injury	Traumatic	18 (62.1%)	32 (57.1%)	7 (63.6%)	57 (59.4%)	0.43
	Violent	<=5 (3.4%)	8 (14.3%)	0 (0.0%)	9 (9.4%)	
	Non-traumatic	7 (24.1%)	11 (19.6%)	<=5 (36.4%)	22 (22.9%)	
	Unknown	<=5 (10.3%)	<=5 (8.9%)	0 (0.0%)	8 (8.3%)	
Completeness of SCI	Unknown	15 (51.7%)	33 (58.9%)	<=5 (36.4%)	52 (54.2%)	0.34
	Complete	12 (41.4%)	17 (30.4%)	<=5 (36.4%)	33 (34.4%)	
	Incomplete	<=5 (6.9%)	6 (10.7%)	<=5 (27.3%)	11 (11.5%)	
Level of SCI	Cervical	6 (20.7%)	12 (21.4%)	6 (54.5%)	24 (25.0%)	0.19
	Thoracic/Lumbar	17 (58.6%)	33 (58.9%)	<=5 (27.3%)	53 (55.2%)	
	Unknown	6 (20.7%)	11 (19.6%)	<=5 (18.2%)	19 (19.8%)	
2008 Rurality Index for Ontario	Mean ± SD	7.59 ± 15.20	5.56 ± 12.21	3.36 ± 4.52	5.93 ± 12.58	0.61
	Median (IQR)	0 (0-5)	0 (0-6)	2 (0-6)	0 (0-6)	0.96
Categorical Rurality Index	40+	<=5 (10.3%)	<=5 (3.6%)	0 (0.0%)	<=5 (5.2%)	0.29
	<40	26 (89.7%)	54 (96.4%)	11 (100.0%)	91 (94.8%)	
Neighbourhood income quintile		<=5 (3.4%)	<=5 (3.6%)	0 (0.0%)	<=5 (3.1%)	0.64
	1	7 (24.1%)	11 (19.6%)	<=5 (27.3%)	21 (21.9%)	
	2	<=5 (13.8%)	13 (23.2%)	<=5 (18.2%)	19 (19.8%)	
	3	<=5 (13.8%)	10 (17.9%)	0 (0.0%)	14 (14.6%)	
	4	<=5 (13.8%)	12 (21.4%)	<=5 (18.2%)	18 (18.8%)	
	5	9 (31.0%)	8 (14.3%)	<=5 (36.4%)	21 (21.9%)	
Marital status	Single	17 (58.6%)	36 (64.3%)	<=5 (27.3%)	56 (58.3%)	0.11
	Married	7 (24.1%)	16 (28.6%)	<=5 (45.5%)	28 (29.2%)	
	Divorced	<=5 (6.9%)	<=5 (5.4%)	<=5 (27.3%)	8 (8.3%)	
	Widowed	<=5 (3.4%)	0 (0.0%)	0 (0.0%)	<=5 (1.0%)	
	Unknown	<=5 (6.9%)	<=5 (1.8%)	0 (0.0%)	<=5 (3.1%)	
Discharge disposition	Community	9 (31.0%)	11 (19.6%)	<=5 (9.1%)	21 (21.9%)	0.13
	Rehab	16 (55.2%)	38 (67.9%)	6 (54.5%)	60 (62.5%)	
	Other institution	<=5 (10.3%)	<=5 (3.6%)	<=5 (27.3%)	8 (8.3%)	
	Unknown	<=5 (3.4%)	<=5 (8.9%)	<=5 (9.1%)	7 (7.3%)	
Died in first year of follow up		0 (0.0%)	<=5 (1.8%)	0 (0.0%)	<=5 (1.0%)	0.70
Died in second year of follow up		0 (0.0%)	<=5 (1.8%)	<=5 (9.1%)	<=5 (2.1%)	0.19
Died in third year of follow up		<=5 (3.4%)	<=5 (1.8%)	<=5 (9.1%)	<=5 (3.1%)	0.44
ASA score	Mean ± SD	3.15 ± 0.46	2.98 ± 0.63	3.20 ± 0.63	3.06 ± 0.58	0.35
	Median (IQR)	3 (3-3)	3 (3-3)	3 (3-4)	3 (3-3)	0.39
	1	0 (0.0%)	<=5 (1.8%)	0 (0.0%)	<=5 (1.0%)	
	2	<=5 (3.4%)	6 (10.7%)	<=5 (9.1%)	8 (8.3%)	
	3	20 (69.0%)	30 (53.6%)	6 (54.5%)	56 (58.3%)	
	4	<=5 (17.2%)	7 (12.5%)	<=5 (27.3%)	15 (15.6%)	
History of autonomic dysreflexia	Unknown	0 (0.0%)	<=5 (5.4%)	0 (0.0%)	<=5 (3.1%)	0.10
	No	24 (82.8%)	45 (80.4%)	6 (54.5%)	75 (78.1%)	
	Yes	<=5 (17.2%)	8 (14.3%)	<=5 (45.5%)	18 (18.8%)	
History of ladder incontinance	Unknown	<=5 (6.9%)	6 (10.7%)	0 (0.0%)	8 (8.3%)	0.58
	No	24 (82.8%)	45 (80.4%)	11 (100.0%)	80 (83.3%)	
	Yes	<=5 (10.3%)	<=5 (8.9%)	0 (0.0%)	8 (8.3%)	
History of bowel incontinence	Unknown	<=5 (10.3%)	<=5 (7.1%)	<=5 (9.1%)	8 (8.3%)	0.96
	No	22 (75.9%)	41 (73.2%)	8 (72.7%)	71 (74.0%)	
	Yes	<=5 (13.8%)	11 (19.6%)	<=5 (18.2%)	17 (17.7%)	
History of >2 alcoholic drinks per day	Unknown	<=5 (3.4%)	<=5 (3.6%)	0 (0.0%)	<=5 (3.1%)	0.60
	No	27 (93.1%)	54 (96.4%)	11 (100.0%)	92 (95.8%)	
	Yes	<=5 (3.4%)	0 (0.0%)	0 (0.0%)	<=5 (1.0%)	
Antibiotic use at discharge from hospital	Unknown	0 (0.0%)	<=5 (7.1%)	<=5 (18.2%)	6 (6.3%)	0.28
	No	6 (20.7%)	11 (19.6%)	<=5 (9.1%)	18 (18.8%)	
	Yes	23 (79.3%)	41 (73.2%)	8 (72.7%)	72 (75.0%)	
History of spasticity	Unknown	0 (0.0%)	<=5 (5.4%)	0 (0.0%)	<=5 (3.1%)	0.27
	No	13 (44.8%)	29 (51.8%)	<=5 (27.3%)	45 (46.9%)	
	Yes	16 (55.2%)	24 (42.9%)	8 (72.7%)	48 (50.0%)	
History of street drug use	Unknown	<=5 (3.4%)	<=5 (3.6%)	0 (0.0%)	<=5 (3.1%)	0.78
	No	25 (86.2%)	48 (85.7%)	11 (100.0%)	84 (87.5%)	
	Yes	<=5 (10.3%)	6 (10.7%)	0 (0.0%)	9 (9.4%)	
History of UTI	Unknown	26 (89.7%)	49 (87.5%)	8 (72.7%)	83 (86.5%)	0.35
	1	<=5 (10.3%)	7 (12.5%)	<=5 (27.3%)	13 (13.5%)	
Postive bone biopsy report	Not perfomed	27 (93.1%)	45 (80.4%)	10 (90.9%)	82 (85.4%)	0.68
	No	<=5 (3.4%)	<=5 (7.1%)	<=5 (9.1%)	6 (6.3%)	
	3	<=5 (3.4%)	6 (10.7%)	0 (0.0%)	7 (7.3%)	
	not perfomed	0 (0.0%)	<=5 (1.8%)	0 (0.0%)	<=5 (1.0%)	
Positive tissue culture	Unknown	<=5 (6.9%)	<=5 (8.9%)	<=5 (9.1%)	8 (8.3%)	0.99
	Yes	24 (82.8%)	44 (78.6%)	9 (81.8%)	77 (80.2%)	
	No	<=5 (10.3%)	7 (12.5%)	<=5 (9.1%)	11 (11.5%)	
Revision surgery during first 6 weeks	No	21 (72.4%)	55 (98.2%)	11 (100.0%)	87 (90.6%)	<.001
	Yes	8 (27.6%)	<=5 (1.8%)	0 (0.0%)	9 (9.4%)	

Data displayed in table 3 are the health care visits by category and include one-year look back and 3 years following discharge from the index surgery for the 96 surgeries. Moreover, the HCU are displayed with PI closure.

Table 3, Health care visits by category

HEALTH CARE PROVIDER	Pre-surgery Count	Percent	Post-surgery Year 1 Count	Percent	Post-surgery Year 2 Count	Percent	Post-surgery Year 3 Count	Percent
NURSING	18,755	74.5	5,506	46.9	5,657	49.7	6,353	49.1
NUTRITION/DIETETIC	59	0.2	23	0.2	16	0.1	21	0.2
PHYSIOTHERAPY	75	0.3	84	0.7	14	0.1	37	0.3
OCCUPATIONAL THERAPY	220	0.9	183	1.6	82	0.7	91	0.7
SOCIAL WORK	66	0.3	51	0.4	32	0.3	16	0.1
CASE MANAGEMENT	50	0.2	64	0.5	52	0.5	60	0.5
PERSONAL AND HOMEMAKI	5,888	23.4	5,830	49.7	5,517	48.5	6,338	49.0
OTHER SERVICES	47	0.2	1	0.0	1	0.0	11	0.1
TOTAL VISITS	**25,160**	**100.0**	**11,742**	**100.0**	**11,371**	**100.0**	**12,927**	**100.0**

The total number of health care visits at the one-year prior to the index surgery (look-back) was 25,160. In the first year post-surgery, the visits dropped to 11,742 in the second year 11,371, and finally in year there to 12,927. The largest number of visits in the look-back year were being community nursing, accounting for 74.5% of all health care visits. In the first second and third years post index surgery, the number of nursing visits ranged from 46.9-49.1% of the total health care visits. Nutrition/dietetic visits were 59(0.2%) of the total visits and reduced to 16-23(0.1-0.2%) in year 1 to 3 post index surgery. Physiotherapy represented 75(0.3%) of the health care visits in the look-back year and increased slightly to 84(0.7%) in post-surgery year 1, but decreased to 14(0.1%) and then increased to 0.3% Occupational therapy accounted for 220(0.9%) in the look- back year followed by183 (1.6%) in year 1, 82 (0.7%) in year 2 and 91(0.7%) in year 3 post-surgery.

Social work visits were initially 66 (0.3%) and decreased from 1-11 visits in the 3 years post-surgery. Case management was relatively constant throughout the four years and ranged from 50-64 visits per year. Personal and homemaking services also remained relatively constant over the 4 years, ranging from 5,517-6,338 visits. These numbers can be explained as people with SCI often require ongoing assistance with personal care and home making.

Table 4 displays the details of mean and median costs, adjusted to 2016 Canadian dollars. The total median cost in the look-back year was $42,012 Canadian (IQR $21,351-$64,279). The total mean number of hospitalizations was 0.47 (SD ± .74). The total mean was 10.73 (SD ± 35.27). The mean cost of hospitalizations was $11,252.95 (SD ± $36,071.12). The mean emergency department (ER) visit count was 1.26 (SD ± 1.69). Unfortunately, data on cost in the ER was not available in the DAD.

General practitioner mean visit count was 11.46 + 19.87 and associated median cost was $282 (IQR 117-728). Specialist visit mean count was 9.70 (SD± 6.58) with a median cost of $2245.78 (SD ± $2238.300). The total physician visit count was 21.16 (SD ± 20.03) with a median cost of $2257 (IQR 1094 - 3678). Inpatient rehab days was 7.47 (SD± 31.58) and the median cost was $4,440.08 (± 19,044.94). Total home care visit count was 262.08 + 228.55 and the total mean cost was $22,157 (IQR 10.983 - 34,686). Median complex continuing care costs were 0 Median Ontario Drug Benefits cost was $419 (IQR 0 - 3287). Median long-term care cost 0 while the laboratory and non-physician OHIP median costs were 54 (IQR 0-204).

In the one-year post surgery, the median total health care costs were found to be $80,040 (IQR 46,398-109,560), which is almost double the cost and HCU in the look-back year. The largest increase in HCU and cost was the inpatient rehabilitation days with a mean of 36.24 (SD +/- 38.58) days and median cost of $30,601 (0-61,751), followed by hospitalization median cost $12,576 (IQR 7,639-28,036), and total median physician cost of $4,707 (IQR 3024-6929). In contrast, the mean number of community nursing visits decreased to 122.31(SD + 199.52) and median cost of $5445 (IQR 1153-12,452).

Figure 2: Total Annual Healthcare Cost over four years

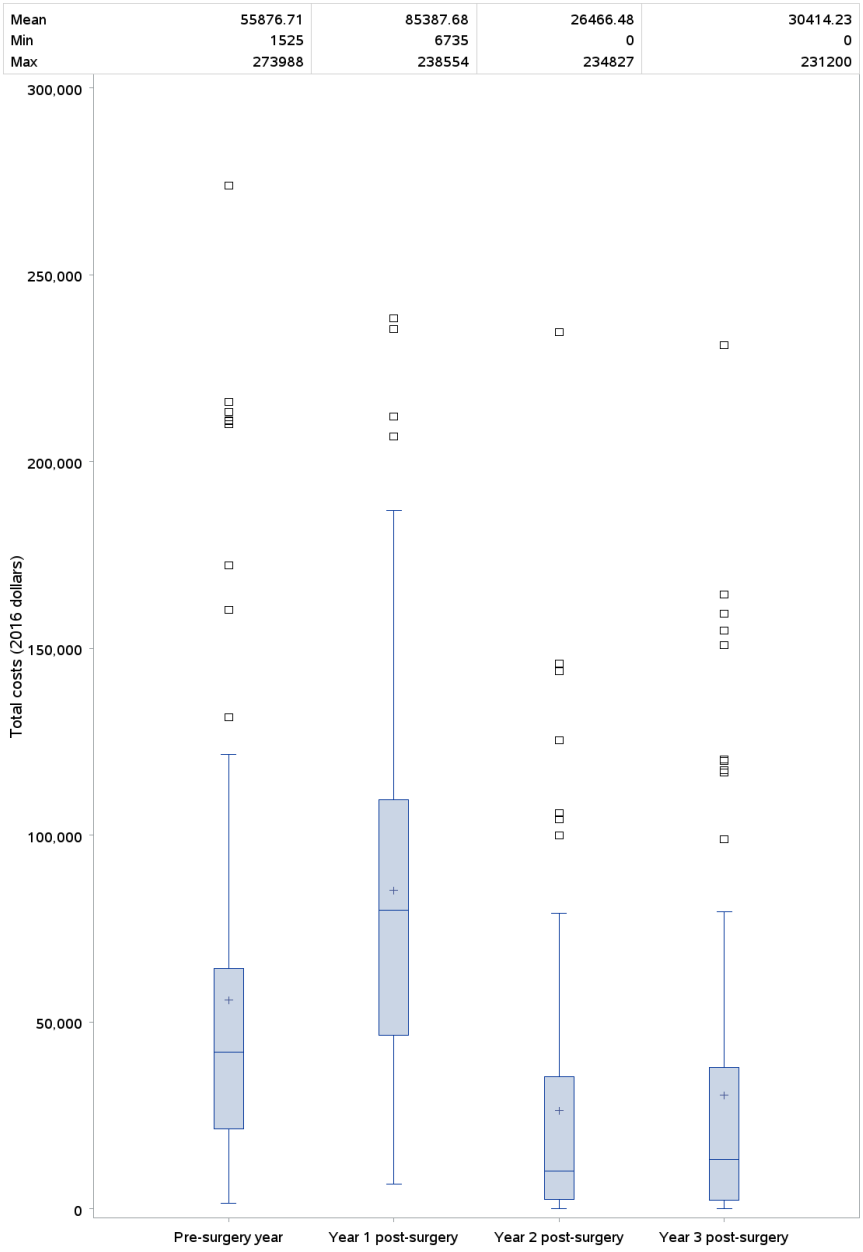


Figure 3 shows the breakdown of combined total costs for each of the four years. The yellow section (home care costs) is highest in the one year look-back. In the first year

post-index surgery, the grey section (rehabilitation facility) accounts for the largest proportion of cost for that year.

Figure 3, Breakdown of combined total cost of healthcare services

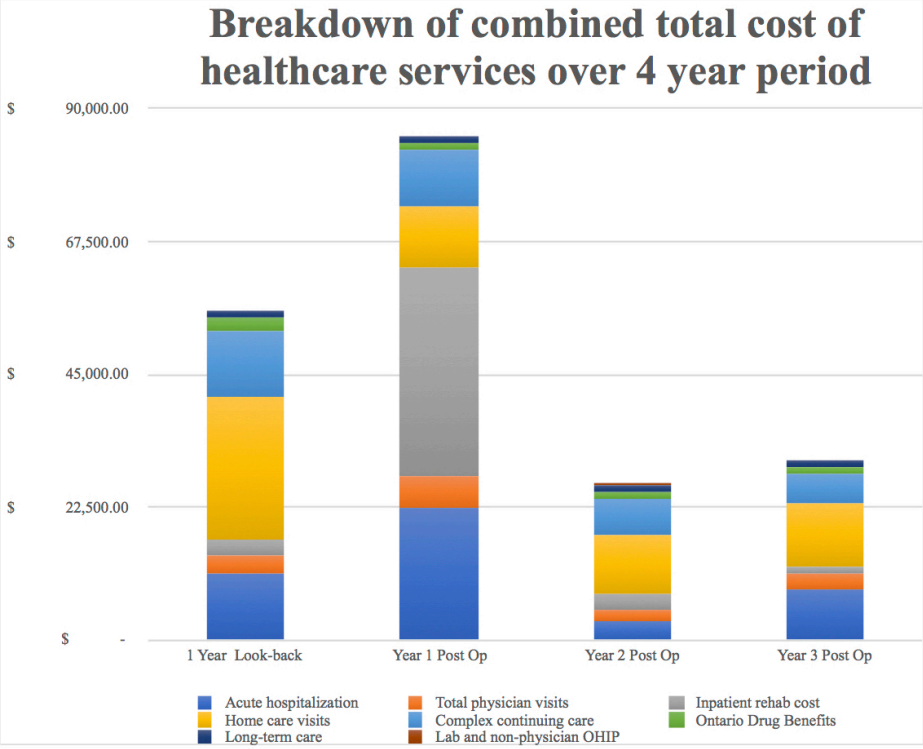


Table 4, Summary of direct health care costs (in Canadian 2016 dollars):

n=96 encounters

Cost		**1 Year Look-back n=96**	**Year 1 Post Op n=96**	**Year 2 Post Op n=96**	**Year 3 Post Op n=96**
Acute hospitalization ($)	Mean ± SD	11,252.95 ± 36,071.12	21,717.05 ± 21,695.84	3,099.39 ± 6,651.75	8,670.96 ± 23,134.56
	Median (IQR)	0 (0-7,844)	12,576 (7,639-28,036)	0 (0-3,377)	0 (0-5,634)
Total physician visit ($)	Mean ± SD	2,848.42 ± 2,502.19	5,621.81 ± 3,404.08	1,989.60 ± 2,198.19	2,438.18 ± 3,528.20
	Median (IQR)	2,257 (1,094-3,678)	4,707 (3,024-6,929)	1,040 (478-2848)	1,390 (386-3,098)
Inpatient rehab cost ($)	Mean ± SD	2,706.85 ± 11,194.82	35,300.76 ± 35,458.68	2,660.10 ± 11,783.43	1,411.31 ± 6,321.13
	Median (IQR)	0 (0-0)	30,601 (0-61,751)	0(0-0)	0(0-0)
Home care visit ($)	Mean ± SD	24,250.98 ± 18,818.97	10,403.62 ± 16,352.81	9,799.73 ± 16,329.36	10,730.38 ± 15,877.28
	Median (IQR)	22,152 (10,983-34,686)	5445 (1,153-12,452)	3,907 (0-13-109)	4,784 (0-16,561)
Complex continuing care ($)	Mean ± SD	11,338.89 ± 40,000.33	9,509.63 ± 33,535.99	6,241.06 ± 29,643.31	4,767.00 ± 21,108.15
	Median (IQR)	0 (0,0)	0(0,0)	0(0-0)	0 (0-0)
Ontario Drug Benefits ($)	Mean ± SD	2,252.14 ± 3,622.81	1,171.00 ± 1,864.02	1,143.82 ± 1,685.25	1,146.34 ± 1,632.13
	Median (IQR)	419 (0-3,287)	325 (0-1,512)	280 (0-1,790)	285 (0-1,763)
Long-term care ($)	Mean ± SD	922.15 ± 6,473.72	1,033.05 ± 6,379.37	1,350.82 ± 7,717.21	1,099.98 ± 7,582.09
	Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0))
Lab and non-physician OHIP	Mean ± SD	246.05 ± 336.43	155.77 ± 260.39	168.26 ± 319.53	140.82 ± 332.71
	Median (IQR)	141 (49-327)	54 (0-204)	88 (2-189)	70 (0-169)
Total costs (2016 $)	Mean ± SD	55,876.71 ± 54,177.61	85,387.68 ± 52,271.94	26,466.48 ± 38,379.06	30,414.23 ± 44,625.33
	Median (IQR)	42,012 (21,351-64,279)	80,041 (46,398-109,560)	10,194 (2,606-35,475)	13,184 (2434-37,890

Compared to the look-back year, the second and third years post-index surgery show substantial reductions in both cost and HCU. In Year 2, the total median cost was $10,194 (IQR 2606-35, 475) and in Year 3, the total median cost was $13,184 (IQR $2,606-35,475). The most significant reduction in cost and HCU was the mean in-patient rehab days, which were below five days in both Year 2 and 3, with a median cost of $ 0 in both years. As expected, the total mean home care visits were reduced to 118.45 (SD +/- 210.01) and 134.66 (SD +/- 211.47) visits in Year 2 and 3 post-surgery respectively. The median total cost was also reduced to $3,907 (IQR 0-13,109) and $4,784 (IQR 0-16,651). When comparing total costs in the look-back versus Years 2 and 3, there is a decrease by approximately $8,034 (CDN) per year.

Table 5 displays the most responsible hospital admission diagnoses with ICD 10 CA codes, frequency and percent of admissions for the one-year look back and one, two and three-years post-index surgery. In the one-year look-back, ‘urinary tract infection’ (UTI) had the highest frequency of admissions (17.8%), but the combined diagnoses of PI accounted for (25.6%), followed by ‘constipation’ and ‘convalescence following surgery’ ($n < 5$).

Table 5 Most responsible diagnoses on hospital admissions over 4 years

Diagnosis	ICD 10 CA Code	Percent of admissions (%)
1 year pre-index surgery		
Urinary tract infection, site not specified	N 390	17.8
Pressure ulcer (any diagnosis)	L893; L892; L899	25.9
Constipation	K 590	4.4
Year 1 post-op		
Pressure ulcer any diagnosis	L891, L892, L893, L894, L899, L97, T813, L984	84.6 %
UTI, site unspecified	N390	5.9
Sepsis, unspecified	A 419	2.0
Other osteomyelitis, pelvic region and thigh	M8685	2.0
Infection following a procedure, not elsewhere classified	T814	2.0
Year 2 post-surgery		
UTI, site unspecified	N390	23.1
Pneumonia	J189	11.5
Any Pressure ulcer	L899	11.5
Year 3 post-surgery		
UTI	N390	15.1
Any Pressure ulcer	L893, L899	11.4
Osteomyelitis pelvic region	M8695	5.7
Cutaneous abscess, furuncle or carbuncle of limb	L024	3.8

In the one-year follow-up, the sum of all admission cases of PI as a primary diagnosis was 105 (84.6%), which accounts for every surgery performed for surgical reconstruction. UTI was the next most responsible admission diagnosis (5.9%), followed by ‘sepsis’ (2.0%); ‘osteomyelitis - pelvic region and thigh’ (2.0%); and ‘other and unspecified intestinal obstruction’ (1.3%). In the first year post-surgery, the numbers of admissions do not correspond to the number of surgical encounters. Patients within the same cohort could have been admitted to hospital for other reasons.

In the Year 2 follow-up, the top three hospital admissions were ‘UTI’ (23.1%), followed by ‘pneumonia’ (11.5%) then ‘decubitus ulcer-pressure area unspecified’ (11.5%). In the Year 3 follow-up, UTI accounted for the most frequent primary hospital diagnosis (11.5%), followed by ‘any PI’ (11.4%); then ‘osteomyelitis’, unspecified, pelvic region and thigh 5.7%); then cutaneous abscess, furuncle and carbuncle of limb (3.8%); finally, ‘other osteomyelitis - pelvic region and thigh’ (3.8%).

DISCUSSION

The objective of this study was to describe the total HCU and total health care cost incurred from the health care payer perspective following surgical repair of stage 4 PI in persons with SCI. This analysis confirms that cost and health care utilization is high in persons with SCI and PI, particularly in the one-year look-back and one year following the reconstruction surgery. This cost is comparable to the direct cost of care estimates in the Canadian SCI population during the first year following SCI (Munce et al., 2013). However, statistically lower cost and health care utilization was observed in Year 2 and 3 following the index surgery.

Data displayed in Table 7 demonstrates that PI remains in the top five primary hospitalization diagnoses in the one-year look back and the three years following the index surgery. However, in follow-up Year 2 and 3, there is a reduction of hospital admissions with PI as a most responsible diagnosis. However, we cannot assume that PI are not an ongoing issue. We do appreciate the fact that PI could be associated with some of the other primary admitting diagnoses, such as osteomyelitis and abscess in the lower limb, or even missed as a diagnosis. Studies of coding PI in our Canadian Discharge Abstract Database (DAD) has been shown to inaccurate and underestimated (Backman et al., 2016; CIHI, 2012; Coomer & McCall, 2013, Ho et al., 2013).

In the one-year look-back, the median costs are similar to the monthly costs of PI in SCI persons living in the Ontario community (Chan et al., 2012). The data presented corroborates the increased cost and HCU required to provide the surgical and rehabilitative

services to achieve closure of PI in this population. As expected, the cost and HCU were substantially increased one year following the index surgery, but cost savings and HCU were realized in Year 2 and 3 following the surgery.

When the cohort was stratified to "open" vs. "closed", there was a substantial reduction in cost and health care utilization. In the "open" group, there were more patients who required revision surgery ($p < 0.001$). This would explain the increase in HCU from a hospitalization and protracted rehabilitation perspective. Interestingly, in the look-back year, the "open" vs. "closed" group had higher median HCU and costs. Given that the demographic data did not show any important differences, there may be other important covariates that could illuminate these findings. For example, although we used Stats Can, rurality index, and neighbourhood quintile as a proxy for socioeconomic status, covariates such as race, income, education, and home situation (e.g., support network, help at home) could not be recorded. These covariates are important social determinants of health and could be considered confounders (Birch, 2002; Raphael, 2009). Another important covariate that could be considered a confounder would be wait time, which could influence the outcome of "closed" vs. "open". In other words, the longer the wait, the more likely a person would be exposed to risk of infection and wound deterioration, thus creating higher risk for complications.

Many studies have explored cost and/or HCU for PI over the past two decades. The data presented in this study adds to the literature on cost and HCU of persons with SCI and PI.

In the US, a study by Brem et al. (2010) estimated the direct health care cost of treating a single stage 4 PI in the community and hospital to be $124,327 and $129,248 US, respectively. Demarre et al. (2015) conducted a systematic review the cost of PI treatment per patient and reported a cost ranging from 1.71€ to 470.49€ per day across different health care settings. The authors noted considerable methodological heterogeneity among the studies, such as type of health economic design, perspective, cost components, as well as health outcomes (Demarre et al., 2015).

In Europe, a review of 52 cases of PI surgical closure in Denmark by Filius et al. (2013) reported a mean direct cost of 20,957€, with the majority of the cost being associated with hospitalization days. These PI costs cannot be compared with the present study as they are not specific to PI reconstruction in the SCI population.

Stroupe et al. (2014), compared HCU and cost of care in US veterans with (n= 1220) and without PI (n= 9737). In the group with PI, the frequency of SCI was greater than 99%. Data collected over a 12-month period showed that veterans with PI had a total mean cost of $73,021 higher than those without PI ($100,935 vs. $27,914 US). They also noted hospitalizations with a significantly greater length of stay. Unfortunately, surgical closure of PI was not included in costs. The costs reported in in the Stroupe et al. (2014) study are significantly higher in than in our present study in the look-back year. Different health care delivery models between Canada and USA may explain some of the cost variation.

Using hard matching and propensity scoring model methods in administrative data, Chan et al. (2018) calculated life-time health care costs on a variety of chronic ulcers,

including 1,470 subjects with PI in Ontario, Canada. Costs were compared to age-matched persons who were admitted to hospital with and without PI. They calculated a lifetime net modeled cost of $98,000 (95% CI $88,300-$109,100). This study included all persons with PI, with and without SCI, and who may or may not have undergone surgical reconstruction. Our study focused on SCI persons who underwent surgical closure and may explain the different costs demonstrated in the Chan study.

STRENGTHS AND LIMITATIONS

This study has a number of strengths and limitations. While this is a retrospective cohort study using a convenience sample from one tertiary care centre, to our knowledge this is the first known study to have described long-term HCU and cost in persons with SCI who have undergone surgical closure of stage 4 pressure injuries in Canada. Second, by confirming the cases through the hospital records and merging the data with ICES, the true positive cases are accurate. A third strength in merging the hospital records with the ICES database is that patients can be followed throughout the healthcare system in Ontario, regardless of their return to the index hospital. This provides a comprehensive look at all services and costs incurred throughout the province of Ontario. Moreover, information such as place/region of residence provides a surrogate for socio-economic status and potential access to SCI speciality services. These are known and important social determinants of health (Raphael, 2009).

Limitations of the study include the convenience sample from one institution in this dataset, impacting generalization of the findings. Secondly, the health care utilization and cost is not specific enough to identify the exact reasons for health care access, unless an ICD or OHIP billing code is recognized for a specific health issue. For example, PI recurrence is possible within the three-year follow-up but may not be coded and billed for as such. Admitting diagnoses can include infection, fever or skin lesion, with no mention of the pressure injury. It would therefore be difficult to attribute some of the ongoing HCU and cost to PI management, as people often have multiple secondary health conditions.

With respect to PI being a primary reason for admission to hospital, we cannot know if the PI is a recurrence at the same site, or if the PI is in a different anatomical location. This makes longitudinal retrospective study more difficult to interpret.

A third limitation of this study is that we reviewed post-operative cases in our dataset; we were unable to compare outcomes of SCI patients undergoing PI surgical reconstruction to those SCI patients with PI who were managed conservatively.

A fourth limitation involves the time horizon for this study. Although patients were able to be followed with administrative data one year prior to and three years' post-index surgery, several of the investigators in this study are aware of the wait-times that were longer than one year prior to the index-surgery.

A fifth and final limitation of this study is the perspective from which the data were derived. To understand the full impact of cost and HCU burden, it would prudent to review costs from a societal perspective, noting patient and caregiver absence from work, and other costs associated with health care, such as travel costs to appointments, and care giving not covered by OHIP. Cost data from a societal perspective is not possible with this.

CONCLUSION

Compared to the look-back year, the largest cost drivers and use of health care services in the first year was found to be the inpatient rehabilitation, followed by hospitalization for the index surgery. The total cost and HCU in this cohort was found to be increased in the first year following the index surgery. However, in Year 2 and 3 post-index surgery, the total cost and HCU was found to be significantly less that the look-back year, with the largest reduction observed being nursing services provided in the home healthcare sector.

While these rehabilitation and hospitalization costs are high in the first year, individuals with SCI who have undergone this extensive surgery require convalescent care and intensive rehabilitation interventions to achieve optimal outcomes. Accordingly, this type of surgery requires significant investment. Munce et al. (2013) caution that reducing LOS in rehabilitation (and subsequent cost savings) could result in unintended consequences such as a reduction of desirable outcomes and an increase in cost and HCU in other sectors.

Future clinical research should be prospective and focus on creative strategies in and throughout the continuum of care. For example, evaluating service models for effectiveness, and cost effectiveness with sustained wound closure as the primary outcome should be explored. Important environmental covariates such as wait time for surgery, availability of rehabilitation services, accessibility to health care focused on SCI, and education status should be included, as these could be confounders with respect to the surgical outcome.

The cost and HCU reported in this study was observed across the continuum of care. These data can provide a foundation for evaluating cost-effectiveness of current and future models of health delivery and interventions that may optimize patient outcomes and use of scarce health care resources.

Conflict of Interest

The authors declare no conflict of interest.

Table 6, Comparison of characteristics of included vs. excluded patients in this cohort

Table 6, Demographics and comparison of excluded to included surgeries					
		Included	Excluded	TOTAL	P-VALUE
		N=96	N=29	N=125	
Age at index admission	Mean ± SD	43.82 ± 12.78	44.90 ± 12.42	44.07 ± 12.66	0.691
	Median (IQR)	45 (36-54)	44 (38-56)	44 (36-54)	0.717
Age at SCI	Mean ± SD	23.46 ± 14.69	23.61 ± 12.51	23.49 ± 14.15	0.961
	Median (IQR)	23 (17-31)	23 (16-33)	23 (17-32)	0.754
Length of stay	Mean ± SD	10.84 ± 19.22	11.24 ± 22.96	10.94 ± 20.05	0.926
	Median (IQR)	7 (6-9)	7 (4-9)	7 (6-9)	0.322
Cause of SCI	Traumatic	57 (59.4%)	19 (65.5%)	76 (60.8%)	0.790
	Violent	9 (9.4%)	<=5	10-15	
	Non-traumatic	22 (22.9%)	(24.1%)	29 (23.2%)	
	Unknown	8 (8.3%)	<=5	5-10	
Completeness of SCI	unknown	52 (54.2%)	13 (44.8%)	65 (52.0%)	0.413
	complete	33 (34.4%)	10 (34.5%)	43 (34.4%)	
	incomplete	11 (11.5%)	6 (20.7%)	17 (13.6%)	
Level of SCI	Cervical	24 (25.0%)	5-10	33 (26.4%)	0.476
	Thoracic/Lumbar	53 (55.2%)	17 (58.6%)	70 (56.0%)	
	Unknown	19 (19.8%)	<=5	20-25	
2008 Rurality Index for Ontario	Mean ± SD	5.93 ± 12.58	10.17 ± 20.93	6.92 ± 14.96	0.182
	Median (IQR)	0 (0-6)	2 (0-8)	0 (0-6)	0.330
Categorical Rurality Index	40+	<=5	<=5	7 (5.6%)	0.729
	<40	90-95	25-30	118 (94.4%)	
StatCan rural neighbourhood		<=5	<= 5	<=5	0.051
	No	91 (94.8%)	24 (82.8%)	115 (92.0%)	
	Yes	<=5	<=5	9 (7.2%)	
Neighbourhood income quintile		<=5 (3.1%)	0 (0.0%)	<=5 (2.4%)	0.701
	1	21 (21.9%)	7 (24.1%)	28 (22.4%)	
	2	19 (19.8%)	<=5 (10.3%)	22 (17.6%)	
	3	14 (14.6%)	<=5 (17.2%)	19 (15.2%)	
	4	18 (18.8%)	<=5 (17.2%)	23 (18.4%)	
	5	21 (21.9%)	9 (31.0%)	30 (24.0%)	
Marital status	1) Single	56 (58.3%)	17 (58.6%)	73 (58.4%)	0.980
	2) Married	28 (29.2%)	8 (27.6%)	36 (28.8%)	

	3) Divorced	8 (8.3%)	<=5 (10.3%)	11 (8.8%)	
	4) Widowed	<=5 (1.0%)	0 (0.0%)	<=5 (0.8%)	
	5) Unknown	<=5 (3.1%)	<=5 (3.4%)	<=5 (3.2%)	
Discharge disposition	1-Community	21 (21.9%)	12 (41.4%)	33 (26.4%)	0.100
	2-Rehab	60 (62.5%)	16 (55.2%)	76 (60.8%)	
	3-Other institution	8 (8.3%)	<=5 (3.4%)	9 (7.2%)	
	4-Unknown	7 (7.3%)	0 (0.0%)	7 (5.6%)	
Died in first year of follow up		<=5 (1.0%)	<=5 (3.4%)	<=5 (1.6%)	0.365
Died in second year of follow up		<=5 (2.1%)	0 (0.0%)	<=5 (1.6%)	0.433
Died in third year of follow up		<=5 (3.1%)	0 (0.0%)	<=5 (2.4%)	0.335
ASA score	Mean ± SD	3.06 ± 0.58	2.86 ± 0.77	3.02 ± 0.63	0.190
	Median (IQR)	3 (3-3)	3 (2-3)	3 (3-3)	0.240
	.	16 (16.7%)	7 (24.1%)	23 (18.4%)	0.354
	1	<=5 (1.0%)	<=5 (3.4%)	<=5 (1.6%)	
	2	8 (8.3%)	<=5 (17.2%)	13 (10.4%)	
	3	56 (58.3%)	12 (41.4%)	68 (54.4%)	
	4	15 (15.6%)	<=5 (13.8%)	19 (15.2%)	
History of autonomic dysreflexia	Unknown	<=5 (3.1%)	6 (20.7%)	9 (7.2%)	0.006
	no	75 (78.1%)	19 (65.5%)	94 (75.2%)	
	yes	18 (18.8%)	<=5 (13.8%)	22 (17.6%)	
History of spasticity	unknown	<=5 (3.1%)	<=5 (6.9%)	<=5 (4.0%)	0.520
	no	45 (46.9%)	11 (37.9%)	56 (44.8%)	
	yes	48 (50.0%)	16 (55.2%)	64 (51.2%)	
History of street drug use	unknown	<=5 (3.1%)	0 (0.0%)	<=5 (2.4%)	0.565
	no	84 (87.5%)	27 (93.1%)	111 (88.8%)	
	yes	9 (9.4%)	<=5 (6.9%)	11 (8.8%)	
History of urinary tract infection	no	83 (86.5%)	23 (79.3%)	106 (84.8%)	0.347
	1	13 (13.5%)	6 (20.7%)	19 (15.2%)	
History of bladder incontinence	unknown	8 (8.3%)	0 (0.0%)	8 (6.4%)	0.165
	no	80 (83.3%)	28 (96.6%)	108 (86.4%)	
	yes	8 (8.3%)	<=5 (3.4%)	9 (7.2%)	
History of bowel in continence	unknown	8 (8.3%)	<=5 (3.4%)	9 (7.2%)	0.558
	no	71 (74.0%)	24 (82.8%)	95 (76.0%)	
	yes	17 (17.7%)	<=5 (13.8%)	21 (16.8%)	
Alcohol >2 drinks per day	unknown	<=5 (3.1%)	0 (0.0%)	<=5 (2.4%)	0.128
	no	92 (95.8%)	27 (93.1%)	119 (95.2%)	
	yes	<=5 (1.0%)	<=5 (6.9%)	<=5 (2.4%)	
Antibiotic use at time of discharge from hospital	unknown	6 (6.3%)	<=5 (3.4%)	7 (5.6%)	0.671

	no	18 (18.8%)	<=5 (13.8%)	22 (17.6%)	
	yes	72 (75.0%)	24 (82.8%)	96 (76.8%)	
Tissue biopsy report	chronic ulcer	82 (85.4%)	21 (72.4%)	103 (82.4%)	0.332
	malignancy	6 (6.3%)	<=5 (13.8%)	10 (8.0%)	
	foreign body	7 (7.3%)	<=5 (13.8%)	11 (8.8%)	
	biopsy not performed	<=5 (1.0%)	0 (0.0%)	<=5 (0.8%)	
Tissue culture positive	no	8 (8.3%)	<=5 (10.3%)	11 (8.8%)	0.430
	yes	77 (80.2%)	25 (86.2%)	102 (81.6%)	
	unknown	11 (11.5%)	<=5 (3.4%)	12 (9.6%)	

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CHAPTER SIX

Conclusion

Pressure injuries (PI) are a common and costly secondary complication in adults living with spinal cord injury (SCI). In hospital, sub-acute, and community sectors, the cost and health care utilization are all substantial in the one year prior to and one year following surgical flap closure procedures.

The purpose of this dissertation was fourfold:

1) To estimate the hospital costs of surgical reconstruction of stage 4 PIs in SCI patients and identify the relationship of biophysical, lifestyle and environmental covariates to cost at discharge from St Michael's Hospital.

2) Using confirmed SMH SCI patients, to explore a standardized method of identifying cases of surgically reconstructed PIs, in the administrative database (ICES) using ICD-10 CA, CCI and OHIP fee codes.

3) To explore risk factors for complications of surgical reconstruction of stage 4 PIs in SMH SCI patients at discharge from SMH wound care follow-up at three-to-six weeks.

4) To estimate the long-term costs and healthcare utilization (HCU) of confirmed SMH SCI patients with a stage 4 pelvic PI who underwent surgical closure, using data from the ICES database.

Table 1 provides a summary of the objectives and key findings. The estimated index-surgery mean hospital costs, including physician fees, was $12,960.00 (SD± 6493.48). Costs are adjusted to 2015 Canadian dollars. This estimate is limited to the small convenience sample of 110 patients and from one institution. Other limitations stem from the span of 13 years in which the costing data were collected. OCCI versions changed several times over that time period. Moreover, practice improvements and changes in technology could influence ability to estimate costs over time. While the cost was adjusted to reflect 2015 Canadian dollars, these findings must be interpreted with caution. This estimate includes not only hospital costs but also physician billings.

Comparing hospital costs for this type of surgery to other regions, provinces or even countries is difficult for many reasons. First, methodologies for obtaining costs outside of the province of Ontario could vary. Second, funding of health care is from a single payer perspective and does not necessarily apply to health care systems globally. Third, the acute phase of surgery in our setting does not include the recovery time during rehabilitation with a progressive seating program. These costs would need to be separated from the surgery and immediate post-operative care with similar length of hospital stay. Despite the known limitations, the findings from these data demonstrate substantial costs and warrant further investigation from a population-based perspective. Furthermore, understanding the costs is helpful for health care resource and program planning.

The second objective was to explore an accurate and valid code algorithm for identifying SCI persons who underwent surgical closure of pelvic PI. Using administrative data to conduct population-based research is desirable for many reasons. First, it offers

larger sample sizes and methodology used to calculate cost, and HCU are based on standardized formulas, reducing variations between institutions (Chubak, Pocobelli & Weiss, 2012). Conducting population-based study without this ease of access to cost is time prohibitive (Maass, Kuske, Lessing & Schrappe, 2015). Another benefit to using administrative data is the ability to capture information on relatively rare disease states and interventions (Chubak, Pocobelli & Weiss, 2012).

As demonstrated in the second research question, accurately identifying patients in the ICES databases was problematic. Variations in intervention coding were the most problematic. These variations led to over 329 intervention codes, many of which were not appropriate to apply to the algorithm. Having reviewed the patient records, the many variations in documentation of similar surgical procedures could explain some of the variations in coding.

Identifying SCI posed formidable challenges. Not only was SCI diagnosis often missing as a diagnosis in the patient records, but also in DAD, NRS and NACRS. The problems with identification of SCI patients through ICD 10 codes has been previously explored by Noonan et al. (2013). Another limitation of this study was the restriction of access to medical records beyond the hospital records. Several connections have been made electronically between hospital systems. Mining some of these databases may have increased access to ICD 10 codes for SCI.

Adding PI and surgical reconstruction procedure codes to the algorithm added more complexity to constructing algorithms. PI diagnosis was also widely variable. The L89 series in the ICD 10 is used to code PI. While all of the subjects would have had stage 4

PI, some of the subjects were recorded as having stage 1 or stage 2 PI. These stages of PI would be inappropriate types of ulcers for reconstruction as they are superficial and would heal within a short period of time with conservative measures (NPUAP, 2016; RNAO, 2016). Most of the PI in coding in this cohort was L899 (decubitus ulcer and pressure area, unspecified). Coding of PI is noted to be problematic in a number of previous studies (Backman, Vanderloo, Miller, Freeman, and Forster, 2016; Coomer and McCall, 2013; Ho, Jiang, Eastwood, Wong, Weaver and Quan, 2017).

The wide variation in the intervention codes and missing or misclassified diagnostic codes that were critical to the algorithm may reflect variations in documentation in the patient records or missing records. For example, patient records prior to 2007 were paper-based. Missing information from these charts could contribute to incomplete or misclassification of codes. Another example is the labelling of surgical procedures on the operative notes. Depending on the surgeon or resident dictating the notes, the labelling the type of surgery was widely variable. This lack of consistency likely contributes to misclassification in the Canadian Case Costing Initiative (CCI) coding. Given that there were over 320 codes, and after debate with it was agreed that the intervention codes should not be used in the final algorithm.

The final algorithm was based on OHIP (physician billing) fee codes rather than intervention codes. While these codes were the most accurate, they are not specific to the PI reconstruction procedures. Consequently, false positives could be included if used in a population-based study. Finally, while using physician fee codes was most helpful, these

codes specifically linked to surgeons are not stored in the ICES database; making it more difficult to conduct population-based studies.

Calculations of sensitivity, specificity, negative predictive value and positive predictive value using the final algorithm were 69.1% (95% CI 60.3, 76.75); 97.3% (95% CI 86.1, 99.3) 98.95% (95% CI 94.27, 99.27) and 46.84% (95% CI 35.51, 58.40) respectively. Although not published, the acceptable threshold for both sensitivity and specificity is greater than 80% (Dr. M. Mamdani, personal communication, 2017). Sensitivity is important when the goal is identification of persons with conditions such as SCI with PI. High sensitivity is also important for minimizing research costs, increasing study inclusiveness for the collection of information on a common exposure (Chubak, Pocobelli and Weiss, 2012).

The study found a high PPV, which is important when identifying a cohort by disease status and ensures that only persons with the condition of interest have been included in the study. However, if this algorithm were to be used for population-based study we could not use intervention codes, due to the wide variation and inaccuracy. Only fee codes which are not specific to surgical flap closure for pelvic pressure injuries were used to build the algorithm. In our own cohort with patient records as a gold standard, 30.9% of the cases were missed (false negatives) in the ICES database. This is problematic as those missed could be systematically different from those found in the administrative database and may not be representative of all persons with SCI and PI who have undergone surgical flap closure (Chubak, Pocobelli & Weiss, 2012). Finally, proceeding with

population-based research without repeating this cohort study in at least one other centre in Ontario may also lead to misclassification bias.

The third objective was to identify risk factors for surgical wound complications within the same cohort. The outcome was binary: closed versus open incision. We did not stratify the outcome to major and minor complications, but did record when revision surgery was performed. The choice of using a binary outcome was based on the health care provision that would be necessary, regardless of the severity of the complication. Thirty eight (38%) of the surgical patient incisions were 'open' and 62 (62%) were 'closed' at the time of surgical follow-up at three-to-six weeks.

Combining data collected from both hospital records and ICES afforded this study look at a broader range of variables to include in the multivariate model. For example, using data from ICES allowed us to look back for one year; this allowed us to look at variables such a number and type of health care visits before and after the surgery, which became a significant risk factor for open versus closed incisions. However, despite being able to access patient records and administrative data, variables such as surgical and rehabilitation wait times, access to specialty SCI care, education obtained, lifestyle choices, actual income, race, and negative behaviours all could confound the findings in the multivariate model. Moreover, for many of the variables, data were missing in over 20% of the subjects and therefore could not be used in the modelling.

Significant factors associated with an open incision at three-to-six weeks follow-up were < 50 nursing visits ($p < 0.05$) in the year pre-index surgery and surgical revision

requirements (p=0.01) within the three-to-six week post-operative period. The number of nursing visits may attest to access to home healthcare services with consistent wound care.

One interesting finding was the gap in age at the time of SCI to the surgical encounter. The mean age at time of the SCI was 21.45 (SD $\pm$ 16.45) years, while the average age at the time of surgical reconstruction was 42.86 (SD $\pm$ 13.57) years. While only a few patients had greater than one surgery for PI reconstruction in this cohort, the majority had only one episode of PI requiring surgery. We were not able to determine PI surgeries from other hospital sites prior to the index surgery as this was beyond the scope of this research. Furthermore, we do not know whether the characteristics of this patient cohort are different from those of other patients with SCI and PI who do not receive surgery.

The final objective was to determine cost and health care utilization for persons with SCI who underwent PI reconstruction. Cost and health care utilization were recorded one year prior to the surgery date and one, two, and three-years post-surgery. Information gleaned from this study was important. First, in the year prior to the surgery, the mean cost of care per patient was related to the majority of the health care utilization being in the form of clinical nursing visits. The study did not observe multiple admissions to hospital or emergency department (ER). These findings are different from the observations found by Chan et al. (2011), who reported the majority of costs being due to ER and hospital admissions.

Chan, Caderette, Wochis, Mittmann & Krahn (2018), conducted a population-based study using administrative data to determine lifetime cost of chronic ulcers requiring

hospitalization in Ontario, Canada. In the cohort of 1,472 patients with PIs, they found that the average lifetime net cost to be $98,500 per patient (95% CI $88,300-$109,100). While these costs appear to be lower than our present study, the sampling included patients with numerous admission diagnoses not specific to SCI, as well as those with PIs of various stages or severities. Our study SCI cohort may reflect higher PI severity and different co-morbidities.

A limitation of this study lies in being able to determine cost and HCU, not just one year prior to the surgery, but for the entire duration of ulceration. In this study, we chose one-year pre-surgery, but it is recognized that some of the patients may in fact have had an ulcer for months or years prior to the one-year pre-surgery time-frame. It is difficult, if not impossible, to look back further within the same cohort, as there would be significant reduction in the number of people in our sample. Moreover, it would also have been difficult to know when a PI was first recorded, as the HCU cannot detect granular, information-specific PI. Review of patient records from homecare would be necessary to determine accuracy of dates, to avoid misclassification bias.

Another observation is the increase of cost and HCU in the first year following the surgery. The increases were observed in hospitalization, rehabilitation stays, and increased allied health visits. These costs and HCU are in keeping with the surgical procedure and recovery, and the rehabilitation necessary to return patients to a seating program. Awareness of both HCU and cost for this period of time is helpful for both health care providers and decision makers around planning and budgeting appropriately. Nonetheless,

significant decreases in cost and HCU were observed in years two and three, following surgical closure, even with the complication rates being what they were.

Given the results of all research questions, suggestions for future research are presented. While retrospective review and use of administrative data not intended for SCI/PI research is somewhat helpful, it is difficult to find patients for population-based research due to the variation and inaccuracy of codes used in this cohort. SCI injury, PI and procedure codes were often missing or inaccurate. Algorithms constructed from diagnosis, intervention and fee codes from our known cohort resulted in a sensitivity of 69.1%; we lost over 30% of our sample. Given the high cost and significant health care utilization in this population, focused research in a prospective manner is suggested.

The Rick Hansen Institute currently has a patient registry established SCI in Canada (Noonan, Kwon, Soril, Fehlings, Hurlbert, Townson, Johnson et al., 2012). The Rick Hansen SCI Registry (RHSCIR) is an organized system for the collection, storage, retrieval, analysis, and dissemination of information on persons who have traumatic SCI. They also collect information on conditions or risk factors that can predispose them to the occurrence of common post-SCI injury health-related events, or prior exposure to substances (or circumstances) known or suspected to cause adverse health effects.

In future, it may be feasible to augment the RHSCIR database with common secondary complications in SCI, such as PI. It would be important to include not only the demographic and physiological information, but also the environmental and psychosocial variables that may be associated with variations in outcomes. For example, duration of the PI, time to referral to a specialized team, access to a specialized team, access to services

that correct issues such as seating, spasticity control, use of pressure relieving devices, and nutrition would all be important. Wait times for surgery and rehabilitation would also be an important independent variable to collect.

Other important variables that could impact outcomes could include treatment plans. Given that surgery is a procedure with risk involved, there may be other treatments available that could be utilized with less resource intensity. For example, electrical stimulation therapy (EST) could be considered prior to surgery, or used during the wait time for surgery. While this therapy has demonstrated increased wound healing in SCI persons with SCI, its use is very limited throughout Ontario (Lala, Spaulding, Burke & Houghton, 2016). EST used prior to surgery could reduce the size of the PI defect and potentially lower the risk of surgical wound complications.

Finally, social and behavioural factors such as income, family and community support systems, race, health care beliefs, high risk behaviours, and variations in personality could all be important independent risk factors that could affect surgical outcomes. Collecting these data in the may provide more insight when examining PI outcomes in this complex population.

Building this database as an adjunct to the Rick Hansen Institute database, or on its own, would require ongoing funding, with human resource available to ensure that critical data elements are being collected, validated and check for completion. Moreover, willingness of health care professionals and patients to participate would also be required.

Prevention of PI in persons with SCI would always be preferred. However, our increasing knowledge about risk factors and development of clinical guidelines for

prevention and interventions to reduce occurrence of PI in persons with SCI have been found to be only minimally effective (Regan, Teasell, Wolfe, Keast, Mortenson & Aubut, 2009). In a recent systematic review of the literature examining behaviour and educational interventions to prevent PI in persons with SCI, no studies were found that support the efficacy of behavioral or educational interventions in this population (Cogan, Blanchard, Garber, Vigen, Carlson & Clark, 2017). Accordingly, it will be important to continue to explore patient-centred and cost-efficient ways to manage SCI persons who develop PI. In cases where surgical closure is being considered, choosing the patients who are good candidates and providing optimal acute and rehabilitation care may bring desirable results for both the patients and the health care system.

This study has highlighted the under-developed research on PI interventions in SCI persons in Canada. The results of this analysis demonstrate the considerable health care costs incurred from the public payer perspective. It also further illuminates the challenges in accurately identifying cases in administrative databases. Nonetheless, this study provides useful information for decision makers assessing the health economic impact of surgical repair of PI in persons with SCI.

Table 1, Summary of objective methods and key findings

Objective	Sample size after inclusion and exclusion criteria applied	Time horizon	Methods	Results
To estimate the hospital costs of surgical reconstruction of stage 4 PIs in SCI patients at and identify the relationship of biophysical, lifestyle and environmental covariates to cost at discharge from SMH.	111 patients with 136 encounters	2002-2015	Generalized Estimated Equation (GEE)	Hospital and OHIP billing costs $12,960.00 (SD± 6493.48). Costs adjusted to 2015 Canadian dollars

To explore standardized a method of identifying cases of surgically reconstructed PIs, in administrative data-bases (ICES, ICD-10 CA, CCI and OHIP fee codes)	108 patients with 136 encounters	2002-2015	Descriptive statistics Sensitivity, Specificity, PPV, NPV	Sensitivity = 69.1 95% CI (60.3, 76.75) Specificity = 97.3 95% CI (86.19, 99.93) NPV = 46.84% 95% CI (35.51, 58.40) PPV = 98.95% 95% CI (94.27, 99.27)
To explore risk factors for complications of surgical reconstruction of stage 4 PIs in SMH SCI patients at discharge from surgical follow-up at 3-6 weeks.	79 patients with 96 encounters	2002-2015	Descriptive statistics Bivariate analysis Poisson regression using GEE	Factors associated with 'open' incision at 3-6 weeks 1) Nursing visits < 50 in the year prior to the index surgery ($p < 0.05$) 2) Revision surgery required within 6 weeks post-index surgery ($p = 0.01$)
To explore cost and HCU of persons with SCI undergoing pelvic PI reconstructive surgery	88 patients with 100 surgical encounters	2003-2013	Descriptive statistics	Median cost of care one-year pre-index surgery $42,012 (IQR $21,352-$64,274) Total number of visits 25, 160 Median cost of care one-year post-index surgery $80,041 (IQR $46,398, 109,560 Total number of visits = 11,742

Costs adjusted to 2016 Canadian dollars				Median cost of care two years post-index surgery $10194,731 (IQR $2,607-$35,475) Median cost of care 3 years post-index surgery $13,184 (IQR $2435-$37,890) Total number of visits = 12,927 Number of nursing visits: Year 1 pre-index surgery 18,755 Year 1 post index surgery 5,506 Year 2 post index surgery 5,657 Year 3 post index surgery 6,553

Note: Costs are adjusted to 2016 Canadian Dollars

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APPENDICES

Appendix 1, a summary of various ICD 10 CA, CCI and fee codes (Chapter 3)

algorithm	specificity (%)	sensitivity (%)	NPV (%)	PPV (%)
dx3_fc1	94.74	87.50	67.92	98.35
dx3_fc2	94.74	88.97	70.59	98.37
dx4_fc1	94.74	91.91	76.60	98.43
dx4_fc2	94.74	93.38	80.00	98.45
dx5_fc1	94.74	83.82	62.07	98.28
dx5_fc2	94.74	84.56	63.16	98.29
fc1	94.74	94.85	83.72	98.47
dx1_in1	94.74	76.47	52.94	98.11
dx1_in2	89.47	79.41	54.84	96.43
dx1_in3	100.00	2.94	22.35	100.00
dx2_in1	86.84	78.68	53.23	95.54
dx2_in2	76.32	81.62	53.70	92.50
dx2_in3	100.00	3.68	22.49	100.00
dx3_in1	94.74	82.35	60.00	98.25
dx3_in2	89.47	86.76	65.38	96.72
dx3_in3	100.00	2.94	22.35	100.00
dx3_in4	89.47	91.18	73.91	96.88
dx4_in1	86.84	85.29	62.26	95.87
dx4_in2	76.32	90.44	69.05	93.18
dx4_in3	100.00	3.68	22.49	100.00
dx4_in4	76.32	95.59	82.86	93.53

Flag name	Code Type	DX type applied	Codes	Code description
DX1	ICD10	('M')	L898	Decubitus [pressure] ulcer, unstageable
DX1	ICD10	('M')	L899	Decubitus ulcer and pressure area, unspecified
DX1	ICD10	('M')	L892	Stage III decubitus [pressure] ulcer
DX1	ICD10	('M')	L891	Stage II decubitus [pressure] ulcer
DX1	ICD10	('M')	L890	Stage I decubitus ulcer and pressure area
DX1	ICD10	('M')	L894	Decubitus ulcer with depth involving bone (Stage 5)
DX1	ICD10	('M')	L895	Decubitus ulcer with joint space involvement (Stage 5)
DX1	ICD10	('M')	L893	Stage IV decubitus [pressure] ulcer

Flag name	Code Type	DX type applied	Codes	Code description
DX2	ICD10	alldx	L894	Decubitus ulcer with depth involving bone (Stage 5)
DX2	ICD10	alldx	L895	Decubitus ulcer with joint space involvement (Stage 5)
DX2	ICD10	alldx	L891	Stage II decubitus [pressure] ulcer
DX2	ICD10	alldx	L898	Decubitus [pressure] ulcer, unstageable
DX2	ICD10	alldx	L893	Stage IV decubitus [pressure] ulcer
DX2	ICD10	alldx	L892	Stage III decubitus [pressure] ulcer
DX2	ICD10	alldx	L890	Stage I decubitus ulcer and pressure area
DX2	ICD10	alldx	L899	Decubitus ulcer and pressure area, unspecified

Flag name	Code Type	DX type applied	Codes	Code description
DX3	ICD10	('M')	L892	Stage III decubitus [pressure] ulcer
DX3	ICD10	('M')	L894	Decubitus ulcer with depth involving bone (Stage 5)
DX3	ICD10	('M')	L899	Decubitus ulcer and pressure area, unspecified
DX3	ICD10	('M')	L895	Decubitus ulcer with joint space involvement (Stage 5)
DX3	ICD10	('M')	L890	Stage I decubitus ulcer and pressure area
DX3	ICD10	('M')	L898	Decubitus [pressure] ulcer, unstageable
DX3	ICD10	('M')	L893	Stage IV decubitus [pressure] ulcer
DX3	ICD10	('M')	L891	Stage II decubitus [pressure] ulcer
DX3	ICD10	('M')	L970	Ulcer of lower limb limited to erythema only [redness] without skin breakdown (Stage 1)
DX3	ICD10	('M')	L973	Ulcer of lower limb with depth involving muscle (Stage 4)
DX3	ICD10	('M')	L975	Ulcer of lower limb with joint space involvement (Stage 5)
DX3	ICD10	('M')	L971	Ulcer of lower limb limited to breakdown of skin (Stage 2)
DX3	ICD10	('M')	L97	Ulcer of lower limb, not elsewhere classified
DX3	ICD10	('M')	L974	Ulcer of lower limb with depth involving bone (Stage 5)
DX3	ICD10	('M')	L978	Ulcer of lower limb with necrosis involving muscle or bone (Stage X)
DX3	ICD10	('M')	L972	Ulcer of lower limb with fat layer exposed (Stage 3)
DX3	ICD10	('M')	L979	Ulcer of lower limb without mention of severity
DX3	ICD10	('M')	L989	Disorder of skin and subcutaneous tissue, unspecified
DX3	ICD10	('M')	L986	Other infiltrative disorders of skin and subcutaneous tissue
DX3	ICD10	('M')	L988	Other specified disorders of skin and subcutaneous tissue
DX3	ICD10	('M')	L984	Chronic ulcer of skin, not elsewhere classified
DX3	ICD10	('M')	L980	Pyogenic granuloma
DX3	ICD10	('M')	L981	Factitial dermatitis
DX3	ICD10	('M')	L985	Mucinosis of skin
DX3	ICD10	('M')	L983	Eosinophilic cellulitis [Wells]
DX3	ICD10	('M')	L982	Febrile neutrophilic dermatosis [Sweet]
DX3	ICD10	('M')	L089	Local infection of skin and subcutaneous tissue, unspecified
DX3	ICD10	('M')	L080	Pyoderma
DX3	ICD10	('M')	L081	Erythrasma
DX3	ICD10	('M')	L088	Other specified local infections of skin and subcutaneous tissue

Flag name	Code Type	DX type applied	Codes	Code description
DX4	ICD10	alldx	L895	Decubitus ulcer with joint space involvement (Stage 5)
DX4	ICD10	alldx	L899	Decubitus ulcer and pressure area, unspecified
DX4	ICD10	alldx	L892	Stage III decubitus [pressure] ulcer
DX4	ICD10	alldx	L898	Decubitus [pressure] ulcer, unstageable
DX4	ICD10	alldx	L894	Decubitus ulcer with depth involving bone (Stage 5)
DX4	ICD10	alldx	L893	Stage IV decubitus [pressure] ulcer
DX4	ICD10	alldx	L890	Stage I decubitus ulcer and pressure area
DX4	ICD10	alldx	L891	Stage II decubitus [pressure] ulcer
DX4	ICD10	alldx	L971	Ulcer of lower limb limited to breakdown of skin (Stage 2)
DX4	ICD10	alldx	L970	Ulcer of lower limb limited to erythema only [redness] without skin breakdown (Stage 1)
DX4	ICD10	alldx	L97	Ulcer of lower limb, not elsewhere classified
DX4	ICD10	alldx	L972	Ulcer of lower limb with fat layer exposed (Stage 3)
DX4	ICD10	alldx	L974	Ulcer of lower limb with depth involving bone (Stage 5)
DX4	ICD10	alldx	L973	Ulcer of lower limb with depth involving muscle (Stage 4)
DX4	ICD10	alldx	L975	Ulcer of lower limb with joint space involvement (Stage 5)
DX4	ICD10	alldx	L979	Ulcer of lower limb without mention of severity
DX4	ICD10	alldx	L978	Ulcer of lower limb with necrosis involving muscle or bone (Stage X)
DX4	ICD10	alldx	L988	Other specified disorders of skin and subcutaneous tissue
DX4	ICD10	alldx	L986	Other infiltrative disorders of skin and subcutaneous tissue
DX4	ICD10	alldx	L985	Mucinosis of skin
DX4	ICD10	alldx	L984	Chronic ulcer of skin, not elsewhere classified
DX4	ICD10	alldx	L983	Eosinophilic cellulitis [Wells]
DX4	ICD10	alldx	L982	Febrile neutrophilic dermatosis [Sweet]
DX4	ICD10	alldx	L981	Factitial dermatitis
DX4	ICD10	alldx	L980	Pyogenic granuloma
DX4	ICD10	alldx	L989	Disorder of skin and subcutaneous tissue, unspecified
DX4	ICD10	alldx	L081	Erythrasma
DX4	ICD10	alldx	L088	Other specified local infections of skin and subcutaneous tissue
DX4	ICD10	alldx	L089	Local infection of skin and subcutaneous tissue, unspecified
DX4	ICD10	alldx	L080	Pyoderma

Flag name	Code Type	DX type applied	Codes	Code description
DX5	ICD10	alldx	L892	Stage III decubitus [pressure] ulcer
DX5	ICD10	alldx	L893	Stage IV decubitus [pressure] ulcer
DX5	ICD10	alldx	L894	Decubitus ulcer with depth involving bone (Stage 5)
DX5	ICD10	alldx	L895	Decubitus ulcer with joint space involvement (Stage 5)
DX5	ICD10	alldx	L898	Decubitus [pressure] ulcer, unstageable
DX5	ICD10	alldx	L899	Decubitus ulcer and pressure area, unspecified
DX5	ICD10	alldx	L975	Ulcer of lower limb with joint space involvement (Stage 5)
DX5	ICD10	alldx	L974	Ulcer of lower limb with depth involving bone (Stage 5)
DX5	ICD10	alldx	L973	Ulcer of lower limb with depth involving muscle (Stage 4)
DX5	ICD10	alldx	L972	Ulcer of lower limb with fat layer exposed (Stage 3)
DX5	ICD10	alldx	L971	Ulcer of lower limb limited to breakdown of skin (Stage 2)
DX5	ICD10	alldx	L970	Ulcer of lower limb limited to erythema only [redness] without skin breakdown (Stage 1)
DX5	ICD10	alldx	L97	Ulcer of lower limb, not elsewhere classified
DX5	ICD10	alldx	L979	Ulcer of lower limb without mention of severity
DX5	ICD10	alldx	L978	Ulcer of lower limb with necrosis involving muscle or bone (Stage X)
DX5	ICD10	alldx	L972	Ulcer of lower limb with fat layer exposed (Stage 3)
DX5	ICD10	alldx	L973	Ulcer of lower limb with depth involving muscle (Stage 4)
DX5	ICD10	alldx	L974	Ulcer of lower limb with depth involving bone (Stage 5)
DX5	ICD10	alldx	L975	Ulcer of lower limb with joint space involvement (Stage 5)
DX5	ICD10	alldx	L978	Ulcer of lower limb with necrosis involving muscle or bone (Stage X)
DX5	ICD10	alldx	L979	Ulcer of lower limb without mention of severity

Flag name created by user	DX/FEEcode/FEESUFF/SPEC/LOCATION	Code	Code Description	Total # claims
FC1	FEECODE	R005	SKIN-MYOCUTAN.FLAP-INCL.CLOS-STERNOMASTOID/TENSOR FASC. LATA	158
FC1	FEECODE	R590	BURSAE-EXC.-TROCHANTERIC BURSA	109

Flag name created by user	DX/FEEcode/FEESUFF/SPEC/LOCATION	Code	Code Description	Total # claims
FC2	FEECODE	R005	SKIN-MYOCUTAN.FLAP-INCL.CLOS-STERNOMASTOID/TENSOR FASC. LATA	158
FC2	FEECODE	R590	BURSAE-EXC.-TROCHANTERIC BURSA	109
FC2	FEECODE	R073	SKIN-FLAPS-ROT/TRANS/ZPLASTY-OTHER AREAS-5.1-10 CM.DIAM.	10
FC2	FEECODE	R074	SKIN-FLAPS/ROTATIONS/TRANSPOSIT/ZPLASTY MORE THAN 10CM DIAM.	16

Flag name	Code Type	Codes	Code description
IN1	CCI	1YS80JAXXK	Repair, skin of abdomen and trunk using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN1	CCI	1YS80JAXXP	Repair, skin of abdomen and trunk using cultured tissue
IN1	CCI	1YS80LAXXB	Repair, skin of abdomen and trunk using split-thickness autograft
IN1	CCI	1YS80LAW4	Repair, skin of abdomen and trunk using open approach and glue (e.g. crazy glue, glustitch)
IN1	CCI	1YS80LA	Repair, skin of abdomen and trunk using apposition technique [suture]
IN1	CCI	1YS80JAFF	Repair, skin of abdomen and trunk using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN1	CCI	1YS80LAXXE	Repair, skin of abdomen and trunk using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN1	CCI	1YS80LAXXA	Repair, skin of abdomen and trunk using full-thickness autograft
IN1	CCI	1YS80LAXXF	Repair, skin of abdomen and trunk using free flap [e.g. fasciocutaneous free flap]
IN1	CCI	1YS87LAAY	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN1	CCI	1YS87LAXXE	Excision partial, skin of abdomen and trunk open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN1	CCI	1YS87LAAGF	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using free flap
IN1	CCI	1YS87LAAG	Excision partial, skin of abdomen and trunk open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN1	CCI	1YS87LAAGA	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using full thickness autograft
IN1	CCI	1YS87LAXXF	Excision partial, skin of abdomen and trunk open [excisional] approach using free flap
IN1	CCI	1YS87LAAYB	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using split thickness autograft
IN1	CCI	1YS87LAAGE	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN1	CCI	1YS87LAAYF	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using free flap
IN1	CCI	1YS87LAAGB	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using split thickness autograft
IN1	CCI	1YS87LAAYE	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN1	CCI	1YS87LA	Excision partial, skin of abdomen and trunk open [excisional] approach with apposition technique (suture, glue) for closure
IN1	CCI	1YS87LAXXA	Excision partial, skin of abdomen and trunk open [excisional] approach using full thickness autograft
IN1	CCI	1YS87LAXXB	Excision partial, skin of abdomen and trunk open [excisional] approach using split thickness autograft
IN1	CCI	1YS87LAAYA	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using full thickness autograft
IN1	CCI	1YS59JADM	Destruction, skin of abdomen and trunk using ruby laser [e.g. for tattoo removal]
IN1	CCI	1YS59JAGX	Destruction, skin of abdomen and trunk using device NEC [electrocautery]
IN1	CCI	1YS59JALV	Destruction, skin of abdomen and trunk using ligature

IN1	CCI	1YS59JAX2	Destruction, skin of abdomen and trunk using cold inducing agent/cryorefrigerant [liquid nitrogen]
IN1	CCI	1YS59JADN	Destruction, skin of abdomen and trunk using argon dye (or tunable dye) laser
IN1	CCI	1YS59JACF	Destruction, skin of abdomen and trunk using mechanical device [sandpaper, wire brush]
IN1	CCI	1YS59JAAD	Destruction, skin of abdomen and trunk using cryoprobe
IN1	CCI	1YS59JADP	Destruction, skin of abdomen and trunk using yellow light (or copper vapor) laser
IN1	CCI	1YS59JAX7	Destruction, skin of abdomen and trunk using chemical cautery agent
IN1	CCI	1YS59JAAL	Destruction, skin of abdomen and trunk using electrolysis device
IN1	CCI	1YS59JAAG	Destruction, skin of abdomen and trunk using laser NEC [e.g. carbon dioxide for ablation]
IN1	CCI	1YV80LAXXE	Repair, skin of leg using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN1	CCI	1YV80LAXXF	Repair, skin of leg using free flap [e.g. fasciocutaneous flap]
IN1	CCI	1YV80LAXXB	Repair, skin of leg using split-thickness autograft
IN1	CCI	1YV80JAXXP	Repair, skin of leg using using cultured tissue
IN1	CCI	1YV80JAXXK	Repair, skin of leg using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN1	CCI	1YV80LA	Repair, skin of leg using apposition technique [suture]
IN1	CCI	1YV80JAFF	Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN1	CCI	1YV80LAXXA	Repair, skin of leg using full-thickness autograft
IN1	CCI	1YV80LAW4	Repair, skin of leg using glue for apposition (e.g crazy glue, glustitch)
IN1	CCI	1YZ80JAXXP	Repair, skin NEC using using cultured tissue
IN1	CCI	1YZ80LAXXF	Repair, skin NEC using open approach and free flap [e.g. microvascular free flap]
IN1	CCI	1YZ80LAW4	Repair, skin NEC using glue for apposition (e.g. crazy glue, glustitch)
IN1	CCI	1YZ80JAFF	Repair, skin NEC using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN1	CCI	1YZ80LAXXE	Repair, skin NEC using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN1	CCI	1YZ80LAXXB	Repair, skin NEC using split-thickness autograft
IN1	CCI	1YZ80LAXXA	Repair, skin NEC using full-thickness autograft
IN1	CCI	1YZ80LA	Repair, skin NEC using apposition technique [suture]
IN1	CCI	1YZ80JAXXK	Repair, skin NEC using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN1	CCI	1SG80LAXXN	Repair, muscles of the back using open approach and synthetic tissue [e.g. mesh, gortex]
IN1	CCI	1SG80LAXXA	Repair, muscles of the back using open approach and autograft [e.g. fascia or skin] (for closure of surgical defect)
IN1	CCI	1SG80LAXXQ	Repair, muscles of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN1	CCI	1SG80LAXXG	Repair, muscles of the back using open approach and pedicled flap [e.g. gluteus maximus flap]
IN1	CCI	1SG80LA	Repair, muscles of the back using open approach and simple appostion [e.g. suturing or 'vest-over-pants' closure]
IN1	CCI	1SG80LAXXE	Repair, muscles of the back using open approach and local [transposition] flap [e.g. rotation plasty, advancement]
IN1	CCI	1SH87LAXXG	Excision partial, soft tissue of the back using open approach and pedicled flap [e.g. gluteus maximus flap] (to close surgical defect)
IN1	CCI	1SH87LAXXE	Excision partial, soft tissue of the back using open approach and local (transposition) flap [e.g. rotation plasty, Z-plasty, advancement flap] (to close surgical defect)
IN1	CCI	1SH87LAXXQ	Excision partial, soft tissue of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (to close surgical defect)
IN1	CCI	1SH87LA	Excision partial, soft tissue of the back using open approach and simple apposition [e.g. suturing] (to close surgical defect)
IN1	CCI	1SH87LAXXA	Excision partial, soft tissue of the back using open approach and autograft [e.g. skin] (to close surgical defect)

IN1	CCI	1SQ87LANWN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using screw, screw with plate
IN1	CCI	1SQ87LAKDK	Excision partial, pelvis using bone homograft using wire, mesh
IN1	CCI	1SQ87LANVA	Excision partial, pelvis using bone autograft using pin, nail
IN1	CCI	1SQ87LANWG	Excision partial, pelvis using pedicled flap using screw, screw with plate
IN1	CCI	1SQ87LANV	Excision partial, pelvis no tissue used [for closure of surgical defect] using pin, nail
IN1	CCI	1SQ87LAPMQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LANVG	Excision partial, pelvis using pedicled flap using pin, nail
IN1	CCI	1SQ87LAKDN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using wire, mesh
IN1	CCI	1SQ87LANWA	Excision partial, pelvis using bone autograft using screw, screw with plate
IN1	CCI	1SQ87LAPMA	Excision partial, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LAKDG	Excision partial, pelvis using pedicled flap using wire, mesh
IN1	CCI	1SQ87LAPMN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LAPMK	Excision partial, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LA	Excision partial, pelvis no tissue used [for closure of surgical defect] with no device used
IN1	CCI	1SQ87LAXXK	Excision partial, pelvis using bone homograft with no device used
IN1	CCI	1SQ87LAPMG	Excision partial, pelvis using pedicled flap using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LAKDQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh
IN1	CCI	1SQ87LANVQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN1	CCI	1SQ87LANWQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using screw, screw with plate
IN1	CCI	1SQ87LANVK	Excision partial, pelvis using bone homograft using pin, nail
IN1	CCI	1SQ87LAXXN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] with no device used
IN1	CCI	1SQ87LANW	Excision partial, pelvis no tissue used [for closure of surgical defect] using screw, screw with plate
IN1	CCI	1SQ87LAXXQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] with no device used
IN1	CCI	1SQ87LANVN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using pin, nail
IN1	CCI	1SQ87LAKDA	Excision partial, pelvis using bone autograft using wire, mesh
IN1	CCI	1SQ87LAKD	Excision partial, pelvis no tissue used [for closure of surgical defect] using wire, mesh
IN1	CCI	1SQ87LANWK	Excision partial, pelvis using bone homograft using screw, screw with plate
IN1	CCI	1SQ87LAXXA	Excision partial, pelvis using bone autograft with no device used
IN1	CCI	1SQ87LAPM	Excision partial, pelvis no tissue used [for closure of surgical defect] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ87LAXXG	Excision partial, pelvis using pedicled flap with no device used
IN1	CCI	1SQ91LAKD	Excision radical, pelvis no tissue used [for closure of defect] using wire, mesh
IN1	CCI	1SQ91LAPMF	Excision radical, pelvis using free flap using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ91LANWA	Excision radical, pelvis using bone autograft using screw, screw with plate
IN1	CCI	1SQ91LAPMN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ91LAKDQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using wire, mesh
IN1	CCI	1SQ91LANWG	Excision radical, pelvis using pedicled flap using screw, screw with plate
IN1	CCI	1SQ91LAPMG	Excision radical, pelvis using pedicled flap using endoprosthesis (to replace hip joint)

IN1	CCI	1SQ91LAPMA	Excision radical, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ91LAKDF	Excision radical, pelvis using free flap using wire, mesh
IN1	CCI	1SQ91LANVQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using pin, nail
IN1	CCI	1SQ91LANWQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using screw, screw with plate
IN1	CCI	1SQ91LAPM	Excision radical, pelvis no tissue used [for closure of defect] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ91LAKDG	Excision radical, pelvis using pedicled flap using wire, mesh
IN1	CCI	1SQ91LANWK	Excision radical, pelvis using bone homograft using screw, screw with plate
IN1	CCI	1SQ91LAKDA	Excision radical, pelvis using bone autograft using wire, mesh
IN1	CCI	1SQ91LANVA	Excision radical, pelvis using bone autograft using pin, nail
IN1	CCI	1SQ91LAKDN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using wire, mesh
IN1	CCI	1SQ91LANWF	Excision radical, pelvis using free flap using screw, screw with plate
IN1	CCI	1SQ91LAXXG	Excision radical, pelvis using pedicled flap with no device used
IN1	CCI	1SQ91LANVN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using pin, nail
IN1	CCI	1SQ91LAXXN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] with no device used
IN1	CCI	1SQ91LANVF	Excision radical, pelvis using free flap using pin, nail
IN1	CCI	1SQ91LANW	Excision radical, pelvis no tissue used [for closure of defect] using screw, screw with plate
IN1	CCI	1SQ91LAPMQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN1	CCI	1SQ91LAXXF	Excision radical, pelvis using free flap with no device used
IN1	CCI	1SQ91LANV	Excision radical, pelvis no tissue used [for closure of defect] using pin, nail
IN1	CCI	1SQ91LANVK	Excision radical, pelvis using bone homograft using pin, nail
IN1	CCI	1SQ91LA	Excision radical, pelvis no tissue used [for closure of defect] with no device used
IN1	CCI	1SQ91LAXXK	Excision radical, pelvis using bone homograft with no device used
IN1	CCI	1SQ91LAKDK	Excision radical, pelvis using bone homograft using wire, mesh
IN1	CCI	1SQ91LANVG	Excision radical, pelvis using pedicled flap using pin, nail
IN1	CCI	1SQ91LAXXQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] with no device used
IN1	CCI	1SQ91LAXXA	Excision radical, pelvis using bone autograft with no device used
IN1	CCI	1SQ91LANWN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using screw, screw with plate
IN1	CCI	1SQ91LAPMK	Excision radical, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN1	CCI	1VC87LALQA	Excision partial, femur with bone autograft using intramedullary nail
IN1	CCI	1VC87LAXXQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] no device used (for closure)
IN1	CCI	1VC87LANVF	Excision partial, femur with free flap [e.g fibular flap] using pin, nail
IN1	CCI	1VC87LANWA	Excision partial, femur with bone autograft using screw, plate and screw
IN1	CCI	1VC87LAXXG	Excision partial, femur with pedicled flap [myocutaneous flap], no device used (for closure)
IN1	CCI	1VC87LAKDG	Excision partial, femur with pedicled flap [myocutaneous flap] using wire, mesh, staple
IN1	CCI	1VC87LAXXK	Excision partial, femur with bone homograft, no device used (for closure)
IN1	CCI	1VC87LAPMK	Excision partial, femur with bone homograft using endoprosthesis [femoral head]
IN1	CCI	1VC87LAPMA	Excision partial, femur with bone autograft using endoprosthesis [femoral head]
IN1	CCI	1VC87LANW	Excision partial, femur no tissue used (for closure of defect) using screw, plate and screw
IN1	CCI	1VC87LANVK	Excision partial, femur with bone homograft using pin, nail

IN1	CCI	1VC87LAPMN	Excision partial, femur with synthetic tissue [bone cement, paste] using endoprosthesis [femoral head]
IN1	CCI	1VC87LAXXA	Excision partial, femur with bone autograft, no device used (for closure)
IN1	CCI	1VC87LALQK	Excision partial, femur with bone homograft using intramedullary nail
IN1	CCI	1VC87LAPMQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis [femoral head]
IN1	CCI	1VC87LANVN	Excision partial, femur with synthetic tissue [bone cement, paste] using pin, nail
IN1	CCI	1VC87LALQ	Excision partial, femur no tissue used (for closure of defect) using intramedullary nail
IN1	CCI	1VC87LALQN	Excision partial, femur with synthetic tissue [bone cement, paste] using intramedullary nail
IN1	CCI	1VC87LANWK	Excision partial, femur with bone homograft using screw, plate and screw
IN1	CCI	1VC87LA	Excision partial, femur no tissue used (for closure of defect), no device used (for closure)
IN1	CCI	1VC87LAKDK	Excision partial, femur with bone homograft using wire, mesh, staple
IN1	CCI	1VC87LANWQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using screw, plate and screw
IN1	CCI	1VC87LALQQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using intramedullary nail
IN1	CCI	1VC87LANVQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN1	CCI	1VC87LAKDN	Excision partial, femur with synthetic tissue [bone cement, paste] using wire, mesh, staple
IN1	CCI	1VC87LAXXN	Excision partial, femur with synthetic tissue [bone cement, paste], no device used (for closure)
IN1	CCI	1VC87LAKDQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh, staple
IN1	CCI	1VC87LANV	Excision partial, femur no tissue used (for closure of defect) using pin, nail
IN1	CCI	1VC87LANVG	Excision partial, femur with pedicled flap [myocutaneous flap] using pin, nail
IN1	CCI	1VC87LANWN	Excision partial, femur with synthetic tissue [bone cement, paste] using screw, plate and screw
IN1	CCI	1VC87LAPMF	Excision partial, femur with free flap [e.g fibular flap] using endoprosthesis [femoral head]
IN1	CCI	1VC87LANWG	Excision partial, femur with pedicled flap [myocutaneous flap] using screw, plate and screw
IN1	CCI	1VC87LAPM	Excision partial, femur no tissue used (for closure of defect) using endoprosthesis [femoral head]
IN1	CCI	1VC87LANWF	Excision partial, femur with free flap [e.g fibular flap] using screw, plate and screw
IN1	CCI	1VC87LALQG	Excision partial, femur with pedicled flap [myocutaneous flap] using intramedullary nail
IN1	CCI	1VC87LAKDF	Excision partial, femur with free flap [e.g fibular flap] using wire, mesh, staple
IN1	CCI	1VC87LAKDA	Excision partial, femur with bone autograft using wire, mesh, staple
IN1	CCI	1VC87LAKD	Excision partial, femur no tissue used (for closure of defect) using wire, mesh, staple
IN1	CCI	1VC87LALQF	Excision partial, femur with free flap [e.g fibular flap] using intramedullary nail
IN1	CCI	1VC87LANVA	Excision partial, femur with bone autograft using pin, nail
IN1	CCI	1VX87LAXXQ	Excision partial, soft tissue of leg using combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN1	CCI	1VX87LAXXF	Excision partial, soft tissue of leg using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN1	CCI	1VX87LAXXA	Excision partial, soft tissue of leg using autograft [e.g. fascia or skin] (for closure of surgical defect)
IN1	CCI	1VX87LA	Excision partial, soft tissue of leg using simple apposition technique [e.g. suture, staple] (for closure of surgical defect)
IN1	CCI	1VX87LAXXE	Excision partial, soft tissue of leg using local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (for closure of defect)

Flag name	Code Type	Codes	Code description
IN2	CCI	1YS80JAXXK	Repair, skin of abdomen and trunk using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN2	CCI	1YS80LAW4	Repair, skin of abdomen and trunk using open approach and glue (e.g. crazy glue, glustitch)
IN2	CCI	1YS80LAXXE	Repair, skin of abdomen and trunk using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN2	CCI	1YS80LAXXA	Repair, skin of abdomen and trunk using full-thickness autograft
IN2	CCI	1YS80LAXXB	Repair, skin of abdomen and trunk using split-thickness autograft
IN2	CCI	1YS80JAFF	Repair, skin of abdomen and trunk using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN2	CCI	1YS80LA	Repair, skin of abdomen and trunk using apposition technique [suture]
IN2	CCI	1YS80LAXXF	Repair, skin of abdomen and trunk using free flap [e.g. fasciocutaneous free flap]
IN2	CCI	1YS80JAXXP	Repair, skin of abdomen and trunk using cultured tissue
IN2	CCI	1YS87LAAYE	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YS87LAXXA	Excision partial, skin of abdomen and trunk open [excisional] approach using full thickness autograft
IN2	CCI	1YS87LAAYF	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using free flap
IN2	CCI	1YS87LA	Excision partial, skin of abdomen and trunk open [excisional] approach with apposition technique (suture, glue) for closure
IN2	CCI	1YS87LAAG	Excision partial, skin of abdomen and trunk open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN2	CCI	1YS87LAXXF	Excision partial, skin of abdomen and trunk open [excisional] approach using free flap
IN2	CCI	1YS87LAXXE	Excision partial, skin of abdomen and trunk open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YS87LAAGE	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YS87LAXXB	Excision partial, skin of abdomen and trunk open [excisional] approach using split thickness autograft
IN2	CCI	1YS87LAAY	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN2	CCI	1YS87LAAYB	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using split thickness autograft
IN2	CCI	1YS87LAAGF	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using free flap
IN2	CCI	1YS87LAAGB	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using split thickness autograft
IN2	CCI	1YS87LAAGA	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using full thickness autograft
IN2	CCI	1YS87LAAYA	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using full thickness autograft
IN2	CCI	1YS59JAGX	Destruction, skin of abdomen and trunk using device NEC [electrocautery]

IN2	CCI	1YS59JAAG	Destruction, skin of abdomen and trunk using laser NEC [e.g. carbon dioxide for ablation]
IN2	CCI	1YS59JALV	Destruction, skin of abdomen and trunk using ligature
IN2	CCI	1YS59JAX2	Destruction, skin of abdomen and trunk using cold inducing agent/cryorefrigerant [liquid nitrogen]
IN2	CCI	1YS59JAX7	Destruction, skin of abdomen and trunk using chemical cautery agent
IN2	CCI	1YS59JADN	Destruction, skin of abdomen and trunk using argon dye (or tunable dye) laser
IN2	CCI	1YS59JADP	Destruction, skin of abdomen and trunk using yellow light (or copper vapor) laser
IN2	CCI	1YS59JACF	Destruction, skin of abdomen and trunk using mechanical device [sandpaper, wire brush]
IN2	CCI	1YS59JADM	Destruction, skin of abdomen and trunk using ruby laser [e.g. for tattoo removal]
IN2	CCI	1YS59JAAL	Destruction, skin of abdomen and trunk using electrolysis device
IN2	CCI	1YS59JAAD	Destruction, skin of abdomen and trunk using cryoprobe
IN2	CCI	1YV59JAX2	Destruction, skin of leg using cold inducing agent/cryorefrigerant [liquid nitrogen]
IN2	CCI	1YV59JACF	Destruction, skin of leg using mechanical device [sandpaper, wire brush]
IN2	CCI	1YV59JAAG	Destruction, skin of leg using laser NEC [e.g. carbon dioxide for ablation]
IN2	CCI	1YV59JADN	Destruction, skin of leg using argon dye (or tunable dye) laser
IN2	CCI	1YV59JAX7	Destruction, skin of leg using chemical cautery agent
IN2	CCI	1YV59JADM	Destruction, skin of leg using ruby laser [e.g. for tattoo removal]
IN2	CCI	1YV59JAAL	Destruction, skin of leg using electrolysis device
IN2	CCI	1YV59JADP	Destruction, skin of leg using yellow light (or copper vapor) laser
IN2	CCI	1YV59JAAD	Destruction, skin of leg using cryoprobe
IN2	CCI	1YV59JAGX	Destruction, skin of leg using device NEC [electrocautery]
IN2	CCI	1YV80LAXXF	Repair, skin of leg using free flap [e.g. fasciocutaneous flap]
IN2	CCI	1YV80JAXXP	Repair, skin of leg using using cultured tissue
IN2	CCI	1YV80LAXXE	Repair, skin of leg using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN2	CCI	1YV80LAXXB	Repair, skin of leg using split-thickness autograft
IN2	CCI	1YV80LAXXA	Repair, skin of leg using full-thickness autograft
IN2	CCI	1YV80JAXXK	Repair, skin of leg using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN2	CCI	1YV80JAFF	Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN2	CCI	1YV80LA	Repair, skin of leg using apposition technique [suture]
IN2	CCI	1YV80LAW4	Repair, skin of leg using glue for apposition (e.g crazy glue, glustitch)
IN2	CCI	1YV87LAXXE	Excision partial, skin of leg open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YV87LAAGE	Excision partial, skin of leg open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YV87LAAYB	Excision partial, skin of leg open [excisional] approach and dermatome using split thickness autograft
IN2	CCI	1YV87LAAYA	Excision partial, skin of leg open [excisional] approach and dermatome using full thickness autograft
IN2	CCI	1YV87LAAYE	Excision partial, skin of leg open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YV87LAXXB	Excision partial, skin of leg open [excisional] approach using split thickness autograft
IN2	CCI	1YV87LAAG	Excision partial, skin of leg open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN2	CCI	1YV87LA	Excision partial, skin of leg open [excisional] approach with apposition technique (suture, glue) for closure
IN2	CCI	1YV87LAXXA	Excision partial, skin of leg open [excisional] approach using full thickness autograft
IN2	CCI	1YV87LAAY	Excision partial, skin of leg open [excisional] approach and dermatome with apposition technique (suture, glue) for closure

IN2	CCI	1YV87LAAGF	Excision partial, skin of leg open [excisional] approach and laser using free flap
IN2	CCI	1YV87LAXXF	Excision partial, skin of leg open [excisional] approach using free flap
IN2	CCI	1YV87LAAGA	Excision partial, skin of leg open [excisional] approach and laser using full thickness autograft
IN2	CCI	1YV87LAAYF	Excision partial, skin of leg open [excisional] approach and dermatome using free flap
IN2	CCI	1YV87LAAGB	Excision partial, skin of leg open [excisional] approach and laser using split thickness autograft
IN2	CCI	1YZ59JAGX	Destruction, skin NEC using device NEC [electrocautery]
IN2	CCI	1YZ59JAX7	Destruction, skin NEC using chemical cautery agent
IN2	CCI	1YZ59JALV	Destruction, skin NEC using ligature
IN2	CCI	1YZ59JAX2	Destruction, skin NEC using cold inducing agent/ cryorefrigerant [liquid nitrogen]
IN2	CCI	1YZ59JADP	Destruction, skin NEC using yellow light (or copper vapor) laser
IN2	CCI	1YZ59JAAL	Destruction, skin NEC using electrolysis device
IN2	CCI	1YZ59JADM	Destruction, skin NEC using ruby laser [e.g. for tattoo removal]
IN2	CCI	1YZ59JAAD	Destruction, skin NEC using cryoprobe
IN2	CCI	1YZ59JACF	Destruction, skin NEC using mechanical device [sandpaper, wire brush]
IN2	CCI	1YZ59JAAG	Destruction, skin NEC using laser NEC [e.g. carbon dioxide for ablation]
IN2	CCI	1YZ59JADN	Destruction, skin NEC using argon dye (or tunable dye) laser
IN2	CCI	1YZ80JAFF	Repair, skin NEC using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN2	CCI	1YZ80LAXXE	Repair, skin NEC using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN2	CCI	1YZ80LA	Repair, skin NEC using apposition technique [suture]
IN2	CCI	1YZ80JAXXK	Repair, skin NEC using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN2	CCI	1YZ80LAW4	Repair, skin NEC using glue for apposition (e.g. crazy glue, glustitch)
IN2	CCI	1YZ80LAXXA	Repair, skin NEC using full-thickness autograft
IN2	CCI	1YZ80LAXXF	Repair, skin NEC using open approach and free flap [e.g. microvascular free flap]
IN2	CCI	1YZ80LAXXB	Repair, skin NEC using split-thickness autograft
IN2	CCI	1YZ80JAXXP	Repair, skin NEC using using cultured tissue
IN2	CCI	1YZ87LAAGB	Excision partial, skin NEC open [excisional] approach and laser using split thickness autograft
IN2	CCI	1YZ87LAAGA	Excision partial, skin NEC open [excisional] approach and laser using full thickness autograft
IN2	CCI	1YZ87LAAG	Excision partial, skin NEC open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN2	CCI	1YZ87LAXXB	Excision partial, skin NEC open [excisional] approach using split thickness autograft
IN2	CCI	1YZ87LAXXF	Excision partial, skin NEC open [excisional] approach using free flap
IN2	CCI	1YZ87LAXXE	Excision partial, skin NEC open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YZ87LAXXA	Excision partial, skin NEC open [excisional] approach using full thickness autograft
IN2	CCI	1YZ87LA	Excision partial, skin NEC open [excisional] approach with apposition technique (suture, glue) for closure
IN2	CCI	1YZ87LAAYF	Excision partial, skin NEC open [excisional] approach and dermatome using free flap
IN2	CCI	1YZ87LAAYB	Excision partial, skin NEC open [excisional] approach and dermatome using split thickness autograft
IN2	CCI	1YZ87LAAYA	Excision partial, skin NEC open [excisional] approach and dermatome using full thickness autograft
IN2	CCI	1YZ87LAAY	Excision partial, skin NEC open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN2	CCI	1YZ87LAAGF	Excision partial, skin NEC open [excisional] approach and laser using free flap

IN2	CCI	1YZ87LAAYE	Excision partial, skin NEC open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1YZ87LAAGE	Excision partial, skin NEC open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN2	CCI	1SG80LAXXG	Repair, muscles of the back using open approach and pedicled flap [e.g. gluteus maximus flap]
IN2	CCI	1SG80LAXXE	Repair, muscles of the back using open approach and local [transposition] flap [e.g. rotation plasty, advancement]
IN2	CCI	1SG80LAXXA	Repair, muscles of the back using open approach and autograft [e.g. fascia or skin] (for closure of surgical defect)
IN2	CCI	1SG80LA	Repair, muscles of the back using open approach and simple appostion [e.g. suturing or 'vest-over-pants' closure]
IN2	CCI	1SG80LAXXN	Repair, muscles of the back using open approach and synthetic tissue [e.g. mesh, gortex]
IN2	CCI	1SG80LAXXQ	Repair, muscles of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN2	CCI	1SG87LAXXE	Excision partial, muscles of the back using local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (for closure of defect)
IN2	CCI	1SG87LAXXF	Excision partial, muscles of the back using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN2	CCI	1SG87LAXXQ	Excision partial, muscles of the back using combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN2	CCI	1SG87LAXXA	Excision partial, muscles of the back using autograft [e.g. fascia or skin] (for closure of surgical defect)
IN2	CCI	1SG87LA	Excision partial, muscles of the back using simple apposition technique [e.g. suture, staple] (for closure of surgical defect)
IN2	CCI	1SH59LA	Destruction, soft tissue of the back using open approach
IN2	CCI	1SH87LAXXA	Excision partial, soft tissue of the back using open approach and autograft [e.g. skin] (to close surgical defect)
IN2	CCI	1SH87LAXXQ	Excision partial, soft tissue of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (to close surgical defect)
IN2	CCI	1SH87LAXXG	Excision partial, soft tissue of the back using open approach and pedicled flap [e.g. gluteus maximus flap] (to close surgical defect)
IN2	CCI	1SH87LAXXE	Excision partial, soft tissue of the back using open approach and local (transposition) flap [e.g. rotation plasty, Z-plasty, advancement flap] (to close surgical defect)
IN2	CCI	1SH87LA	Excision partial, soft tissue of the back using open approach and simple apposition [e.g. suturing] (to close surgical defect)
IN2	CCI	1SQ87LAPMN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LAKD	Excision partial, pelvis no tissue used [for closure of surgical defect] using wire, mesh
IN2	CCI	1SQ87LANVK	Excision partial, pelvis using bone homograft using pin, nail
IN2	CCI	1SQ87LAPMG	Excision partial, pelvis using pedicled flap using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LANVN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using pin, nail
IN2	CCI	1SQ87LAPMA	Excision partial, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LA	Excision partial, pelvis no tissue used [for closure of surgical defect] with no device used
IN2	CCI	1SQ87LAPM	Excision partial, pelvis no tissue used [for closure of surgical defect] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LANWQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using screw, screw with plate

IN2	CCI	1SQ87LANWN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using screw, screw with plate
IN2	CCI	1SQ87LANWK	Excision partial, pelvis using bone homograft using screw, screw with plate
IN2	CCI	1SQ87LANWG	Excision partial, pelvis using pedicled flap using screw, screw with plate
IN2	CCI	1SQ87LANWA	Excision partial, pelvis using bone autograft using screw, screw with plate
IN2	CCI	1SQ87LANW	Excision partial, pelvis no tissue used [for closure of surgical defect] using screw, screw with plate
IN2	CCI	1SQ87LANVQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN2	CCI	1SQ87LANVG	Excision partial, pelvis using pedicled flap using pin, nail
IN2	CCI	1SQ87LANVA	Excision partial, pelvis using bone autograft using pin, nail
IN2	CCI	1SQ87LANV	Excision partial, pelvis no tissue used [for closure of surgical defect] using pin, nail
IN2	CCI	1SQ87LAKDQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh
IN2	CCI	1SQ87LAKDN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using wire, mesh
IN2	CCI	1SQ87LAXXQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] with no device used
IN2	CCI	1SQ87LAPMK	Excision partial, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LAXXN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] with no device used
IN2	CCI	1SQ87LAKDK	Excision partial, pelvis using bone homograft using wire, mesh
IN2	CCI	1SQ87LAXXK	Excision partial, pelvis using bone homograft with no device used
IN2	CCI	1SQ87LAXXG	Excision partial, pelvis using pedicled flap with no device used
IN2	CCI	1SQ87LAKDG	Excision partial, pelvis using pedicled flap using wire, mesh
IN2	CCI	1SQ87LAXXA	Excision partial, pelvis using bone autograft with no device used
IN2	CCI	1SQ87LAPMQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ87LAKDA	Excision partial, pelvis using bone autograft using wire, mesh
IN2	CCI	1SQ91LAXXN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] with no device used
IN2	CCI	1SQ91LANVG	Excision radical, pelvis using pedicled flap using pin, nail
IN2	CCI	1SQ91LAXXK	Excision radical, pelvis using bone homograft with no device used
IN2	CCI	1SQ91LAXXF	Excision radical, pelvis using free flap with no device used
IN2	CCI	1SQ91LAPMQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LAPMN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LAPMG	Excision radical, pelvis using pedicled flap using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LAPMK	Excision radical, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LANVK	Excision radical, pelvis using bone homograft using pin, nail
IN2	CCI	1SQ91LAPMF	Excision radical, pelvis using free flap using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LAPMA	Excision radical, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LAPM	Excision radical, pelvis no tissue used [for closure of defect] using endoprosthesis (to replace hip joint)
IN2	CCI	1SQ91LANVN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using pin, nail
IN2	CCI	1SQ91LANWQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using screw, screw with plate

IN2	CCI	1SQ91LANWN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using screw, screw with plate
IN2	CCI	1SQ91LANVQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using pin, nail
IN2	CCI	1SQ91LAKDF	Excision radical, pelvis using free flap using wire, mesh
IN2	CCI	1SQ91LANWK	Excision radical, pelvis using bone homograft using screw, screw with plate
IN2	CCI	1SQ91LANWG	Excision radical, pelvis using pedicled flap using screw, screw with plate
IN2	CCI	1SQ91LANWF	Excision radical, pelvis using free flap using screw, screw with plate
IN2	CCI	1SQ91LANWA	Excision radical, pelvis using bone autograft using screw, screw with plate
IN2	CCI	1SQ91LANVA	Excision radical, pelvis using bone autograft using pin, nail
IN2	CCI	1SQ91LAXXA	Excision radical, pelvis using bone autograft with no device used
IN2	CCI	1SQ91LAKDK	Excision radical, pelvis using bone homograft using wire, mesh
IN2	CCI	1SQ91LANV	Excision radical, pelvis no tissue used [for closure of defect] using pin, nail
IN2	CCI	1SQ91LAKDQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using wire, mesh
IN2	CCI	1SQ91LAKDN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using wire, mesh
IN2	CCI	1SQ91LAKDG	Excision radical, pelvis using pedicled flap using wire, mesh
IN2	CCI	1SQ91LAKDA	Excision radical, pelvis using bone autograft using wire, mesh
IN2	CCI	1SQ91LAKD	Excision radical, pelvis no tissue used [for closure of defect] using wire, mesh
IN2	CCI	1SQ91LA	Excision radical, pelvis no tissue used [for closure of defect] with no device used
IN2	CCI	1SQ91LANW	Excision radical, pelvis no tissue used [for closure of defect] using screw, screw with plate
IN2	CCI	1SQ91LAXXG	Excision radical, pelvis using pedicled flap with no device used
IN2	CCI	1SQ91LAXXQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] with no device used
IN2	CCI	1SQ91LANVF	Excision radical, pelvis using free flap using pin, nail
IN2	CCI	1VC87LAKDF	Excision partial, femur with free flap [e.g fibular flap] using wire, mesh, staple
IN2	CCI	1VC87LAXXQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] no device used (for closure)
IN2	CCI	1VC87LAXXK	Excision partial, femur with bone homograft, no device used (for closure)
IN2	CCI	1VC87LAXXG	Excision partial, femur with pedicled flap [myocutaneous flap], no device used (for closure)
IN2	CCI	1VC87LAPMQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis [femoral head]
IN2	CCI	1VC87LAPMN	Excision partial, femur with synthetic tissue [bone cement, paste] using endoprosthesis [femoral head]
IN2	CCI	1VC87LAPMK	Excision partial, femur with bone homograft using endoprosthesis [femoral head]
IN2	CCI	1VC87LAPMF	Excision partial, femur with free flap [e.g fibular flap] using endoprosthesis [femoral head]
IN2	CCI	1VC87LANVG	Excision partial, femur with pedicled flap [myocutaneous flap] using pin, nail
IN2	CCI	1VC87LAPMA	Excision partial, femur with bone autograft using endoprosthesis [femoral head]
IN2	CCI	1VC87LAPM	Excision partial, femur no tissue used (for closure of defect) using endoprosthesis [femoral head]
IN2	CCI	1VC87LANWQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using screw, plate and screw
IN2	CCI	1VC87LANVQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN2	CCI	1VC87LANWK	Excision partial, femur with bone homograft using screw, plate and screw

IN2	CCI	1VC87LANWG	Excision partial, femur with pedicled flap [myocutaneous flap] using screw, plate and screw
IN2	CCI	1VC87LANWF	Excision partial, femur with free flap [e.g fibular flap] using screw, plate and screw
IN2	CCI	1VC87LANWA	Excision partial, femur with bone autograft using screw, plate and screw
IN2	CCI	1VC87LANW	Excision partial, femur no tissue used (for closure of defect) using screw, plate and screw
IN2	CCI	1VC87LANVK	Excision partial, femur with bone homograft using pin, nail
IN2	CCI	1VC87LANVN	Excision partial, femur with synthetic tissue [bone cement, paste] using pin, nail
IN2	CCI	1VC87LANVF	Excision partial, femur with free flap [e.g fibular flap] using pin, nail
IN2	CCI	1VC87LANVA	Excision partial, femur with bone autograft using pin, nail
IN2	CCI	1VC87LAXXN	Excision partial, femur with synthetic tissue [bone cement, paste], no device used (for closure)
IN2	CCI	1VC87LANV	Excision partial, femur no tissue used (for closure of defect) using pin, nail
IN2	CCI	1VC87LALQQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using intramedullary nail
IN2	CCI	1VC87LALQN	Excision partial, femur with synthetic tissue [bone cement, paste] using intramedullary nail
IN2	CCI	1VC87LALQK	Excision partial, femur with bone homograft using intramedullary nail
IN2	CCI	1VC87LALQG	Excision partial, femur with pedicled flap [myocutaneous flap] using intramedullary nail
IN2	CCI	1VC87LALQF	Excision partial, femur with free flap [e.g fibular flap] using intramedullary nail
IN2	CCI	1VC87LALQA	Excision partial, femur with bone autograft using intramedullary nail
IN2	CCI	1VC87LALQ	Excision partial, femur no tissue used (for closure of defect) using intramedullary nail
IN2	CCI	1VC87LAKDQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh, staple
IN2	CCI	1VC87LAKDG	Excision partial, femur with pedicled flap [myocutaneous flap] using wire, mesh, staple
IN2	CCI	1VC87LAKDN	Excision partial, femur with synthetic tissue [bone cement, paste] using wire, mesh, staple
IN2	CCI	1VC87LAKDK	Excision partial, femur with bone homograft using wire, mesh, staple
IN2	CCI	1VC87LAKDA	Excision partial, femur with bone autograft using wire, mesh, staple
IN2	CCI	1VC87LAKD	Excision partial, femur no tissue used (for closure of defect) using wire, mesh, staple
IN2	CCI	1VC87LA	Excision partial, femur no tissue used (for closure of defect), no device used (for closure)
IN2	CCI	1VC87LAXXA	Excision partial, femur with bone autograft, no device used (for closure)
IN2	CCI	1VC87LANWN	Excision partial, femur with synthetic tissue [bone cement, paste] using screw, plate and screw
IN2	CCI	1VC91LAXXG	Excision radical, femur using open approach and pedicled flap
IN2	CCI	1VC91LAPNQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPNN	Excision radical, femur with synthetic tissue [e.g. bone cement, paste] using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPNK	Excision radical, femur with bone homograft using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPNG	Excision radical, femur with pedicled flap [myocutaneous flap] using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPNF	Excision radical, femur with free flap [e.g. fibular flap] using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPNA	Excision radical, femur with bone autograft using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPN	Excision radical, femur no tissue used (for closure of defect) using dual component endoprosthesis [distal femur with tibial head]
IN2	CCI	1VC91LAPMQ	Excision radical, femur with combined bone graft and cement or paste using single component endoprosthesis [femoral head]

IN2	CCI	1VC91LAPMN	Excision radical, femur with synthetic tissue [bone cement, paste] using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LAPMK	Excision radical, femur with bone homograft using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LAPMG	Excision radical, femur with pedicled flap [myocutaneous flap] using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LAPMF	Excision radical, femur with free flap [e.g fibular flap] using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LAPMA	Excision radical, femur with bone autograft using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LAPM	Excision radical, femur no tissue used (for closure of defect) using single component endoprosthesis [femoral head]
IN2	CCI	1VC91LANWQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using screw, plate and screw
IN2	CCI	1VC91LANWN	Excision radical, femur with synthetic tissue [bone cement, paste] using screw, plate and screw
IN2	CCI	1VC91LANWK	Excision radical, femur with bone homograft using screw, plate and screw
IN2	CCI	1VC91LANWG	Excision radical, femur with pedicled flap [e.g. rotationplasty] using screw, plate and screw
IN2	CCI	1VC91LANWF	Excision radical, femur with free flap [e.g fibular flap] using screw, plate and screw
IN2	CCI	1VC91LANWA	Excision radical, femur with bone autograft using screw, plate and screw
IN2	CCI	1VC91LANW	Excision radical, femur no tissue used (for closure of defect) using screw, plate and screw
IN2	CCI	1VC91LANVQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using pin, nail
IN2	CCI	1VC91LANVN	Excision radical, femur with synthetic tissue [bone cement, paste] using pin, nail
IN2	CCI	1VC91LANVK	Excision radical, femur with bone homograft using pin, nail
IN2	CCI	1VC91LANVG	Excision radical, femur with pedicled flap [rotationplasty] using pin, nail
IN2	CCI	1VC91LANVF	Excision radical, femur with free flap [e.g fibular flap] using pin, nail
IN2	CCI	1VC91LANVA	Excision radical, femur with bone autograft using pin, nail
IN2	CCI	1VC91LANV	Excision radical, femur no tissue used (for closure of defect) using pin, nail
IN2	CCI	1VC91LALQQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using intramedullary nail
IN2	CCI	1VC91LALQN	Excision radical, femur with synthetic tissue [bone cement, paste] using intramedullary nail
IN2	CCI	1VC91LALQK	Excision radical, femur with bone homograft using intramedullary nail
IN2	CCI	1VC91LALQG	Excision radical, femur with pedicled flap using intramedullary nail
IN2	CCI	1VC91LALQF	Excision radical, femur with free flap [e.g fibular flap] using intramedullary nail
IN2	CCI	1VC91LALQA	Excision radical, femur with bone autograft using intramedullary nail
IN2	CCI	1VC91LALQ	Excision radical, femur no tissue used (for closure of defect) using intramedullary nail
IN2	CCI	1VC91LAKDQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using wire, mesh, staple
IN2	CCI	1VC91LAKDN	Excision radical, femur with synthetic tissue [bone cement, paste] using wire, mesh, staple
IN2	CCI	1VC91LAKDK	Excision radical, femur with bone homograft using wire, mesh, staple
IN2	CCI	1VC91LAKDG	Excision radical, femur with pedicled flap [e.g. rotationplasty] using wire, mesh, staple
IN2	CCI	1VC91LAKDF	Excision radical, femur with free flap [e.g fibular flap] using wire, mesh, staple
IN2	CCI	1VC91LAKDA	Excision radical, femur with bone autograft using wire, mesh, staple
IN2	CCI	1VC91LAKD	Excision radical, femur no tissue used (for closure of defect) using wire, mesh, staple
IN2	CCI	1VC91LA	Excision radical, femur no tissue used (for closure of defect) no fixation device used

IN2	CCI	1VX52LA	Drainage, soft tissue of leg using open (incisional) approach
IN2	CCI	1VX87LA	Excision partial, soft tissue of leg using simple apposition technique [e.g. suture, staple] (for closure of surgical defect)
IN2	CCI	1VX87LAXXQ	Excision partial, soft tissue of leg using combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN2	CCI	1VX87LAXXF	Excision partial, soft tissue of leg using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN2	CCI	1VX87LAXXE	Excision partial, soft tissue of leg using local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (for closure of defect)
IN2	CCI	1VX87LAXXA	Excision partial, soft tissue of leg using autograft [e.g. fascia or skin] (for closure of surgical defect)

Flag name	Code Type	Codes	Code description
IN3	CCI	1EP87LAXXF	Excision partial, muscles of head and neck using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1EQ87LAXXF	Excision partial, soft tissue of head and neck using free flap [e.g. free myocutaneous flap]
IN3	CCI	1FJ80LAXXG	Repair, tongue using pedicled flap [e.g. myocutaneous flap]
IN3	CCI	1GE89LAXXG	Excision total, larynx NEC using open approach and pedicled distant flap (e.g. myocutaneous flap)
IN3	CCI	1GE91LAXXG	Excision radical, larynx NEC using open approach and pedicled distant flap [e.g. myocutaneous flap]
IN3	CCI	1MR91LAXXG	Excision radical, lymphatic vessels of arm using open approach with distant pedicle flap (e.g. myocutaneous flap)
IN3	CCI	1RW91LAXXF	Excision radical, vulva vulvectomy, radical using free distant flap [e.g. myocutaneous or fasciocutaneous]
IN3	CCI	1SG87LAXXF	Excision partial, muscles of the back using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1SY80DAXXF	Repair, muscles of the chest and abdomen endoscopic [laparoscopic] approach using free flap [e.g. free myocutaneous flap]
IN3	CCI	1SY80LAXXF	Repair, muscles of the chest and abdomen open approach using free flap [e.g. free myocutaneous flap]
IN3	CCI	1SY87LAXXF	Excision partial, muscles of the chest and abdomen using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1TF87LAXXF	Excision partial, muscles of the arm [around shoulder] using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1TQ87LAXXF	Excision partial, muscles of the forearm [around elbow] using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1TX87LAXXF	Excision partial, soft tissue of arm NEC using open approach and free flap [e.g. myocutaneous free flap] (to close surgical defect)
IN3	CCI	1UY87LAXXF	Excision partial, soft tissue of the wrist and hand using open approach and free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1VC87LAKDG	Excision partial, femur with pedicled flap [myocutaneous flap] using wire, mesh, staple
IN3	CCI	1VC87LALQG	Excision partial, femur with pedicled flap [myocutaneous flap] using intramedullary nail
IN3	CCI	1VC87LANVG	Excision partial, femur with pedicled flap [myocutaneous flap] using pin, nail
IN3	CCI	1VC87LANWG	Excision partial, femur with pedicled flap [myocutaneous flap] using screw, plate and screw
IN3	CCI	1VC87LAXXG	Excision partial, femur with pedicled flap [myocutaneous flap], no device used (for closure)
IN3	CCI	1VC91LAPMG	Excision radical, femur with pedicled flap [myocutaneous flap] using single component endoprosthesis [femoral head]
IN3	CCI	1VC91LAPNG	Excision radical, femur with pedicled flap [myocutaneous flap] using dual component endoprosthesis [distal femur with tibial head]
IN3	CCI	1VD87LAXXF	Excision partial, muscles of hip and thigh using free flap [e.g. myocutaneous free flap] (for closure of defect)

IN3	CCI	1VQ87LAKDG	Excision partial, tibia and fibula with pedicled flap [e.g. myocutaneous flap] using wire, mesh, staple
IN3	CCI	1VQ87LALQG	Excision partial, tibia and fibula with pedicled flap [e.g. myocutaneous flap] using intramedullary nail
IN3	CCI	1VQ87LANVG	Excision partial, tibia and fibula with pedicled flap [e.g. myocutaneous flap] using pin, nail
IN3	CCI	1VQ87LANWG	Excision partial, tibia and fibula with pedicled flap [e.g. myocutaneous flap] using screw, plate and screw
IN3	CCI	1VQ87LAXXG	Excision partial, tibia and fibula with pedicled flap [e.g. myocutaneous flap], no device used
IN3	CCI	1VR87LAXXF	Excision partial, muscles of lower leg [around knee] using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN3	CCI	1VX87LAXXF	Excision partial, soft tissue of leg using free flap [e.g. myocutaneous free flap] (for closure of defect)

Flag name	Code Type	Codes	Code description
IN4	CCI	1YS80LAXXF	Repair, skin of abdomen and trunk using free flap [e.g. fasciocutaneous free flap]
IN4	CCI	1YS80LAXXE	Repair, skin of abdomen and trunk using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN4	CCI	1YS80LAXXB	Repair, skin of abdomen and trunk using split-thickness autograft
IN4	CCI	1YS80LAXXA	Repair, skin of abdomen and trunk using full-thickness autograft
IN4	CCI	1YS80LAW4	Repair, skin of abdomen and trunk using open approach and glue (e.g. crazy glue, glustitch)
IN4	CCI	1YS80LA	Repair, skin of abdomen and trunk using apposition technique [suture]
IN4	CCI	1YS80JAXXP	Repair, skin of abdomen and trunk using cultured tissue
IN4	CCI	1YS80JAXXK	Repair, skin of abdomen and trunk using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN4	CCI	1YS80JAFF	Repair, skin of abdomen and trunk using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN4	CCI	1SH87LAXXQ	Excision partial, soft tissue of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (to close surgical defect)
IN4	CCI	1SH87LAXXG	Excision partial, soft tissue of the back using open approach and pedicled flap [e.g. gluteus maximus flap] (to close surgical defect)
IN4	CCI	1SH87LAXXE	Excision partial, soft tissue of the back using open approach and local (transposition) flap [e.g. rotation plasty, Z-plasty, advancement flap] (to close surgical defect)
IN4	CCI	1SH87LAXXA	Excision partial, soft tissue of the back using open approach and autograft [e.g. skin] (to close surgical defect)
IN4	CCI	1SH87LA	Excision partial, soft tissue of the back using open approach and simple apposition [e.g. suturing] (to close surgical defect)
IN4	CCI	1YS59JAX7	Destruction, skin of abdomen and trunk using chemical cautery agent
IN4	CCI	1YS59JAX2	Destruction, skin of abdomen and trunk using cold inducing agent/cryorefrigerant [liquid nitrogen]
IN4	CCI	1YS59JALV	Destruction, skin of abdomen and trunk using ligature
IN4	CCI	1YS59JAGX	Destruction, skin of abdomen and trunk using device NEC [electrocautery]
IN4	CCI	1YS59JADP	Destruction, skin of abdomen and trunk using yellow light (or copper vapor) laser
IN4	CCI	1YS59JADN	Destruction, skin of abdomen and trunk using argon dye (or tunable dye) laser
IN4	CCI	1YS59JADM	Destruction, skin of abdomen and trunk using ruby laser [e.g. for tattoo removal]
IN4	CCI	1YS59JACF	Destruction, skin of abdomen and trunk using mechanical device [sandpaper, wire brush]
IN4	CCI	1YS59JAAL	Destruction, skin of abdomen and trunk using electrolysis device
IN4	CCI	1YS59JAAG	Destruction, skin of abdomen and trunk using laser NEC [e.g. carbon dioxide for ablation]
IN4	CCI	1YS59JAAD	Destruction, skin of abdomen and trunk using cryoprobe
IN4	CCI	1SH59LA	Destruction, soft tissue of the back using open approach
IN4	CCI	1YV80LAXXF	Repair, skin of leg using free flap [e.g. fasciocutaneous flap]
IN4	CCI	1YV80LAXXE	Repair, skin of leg using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN4	CCI	1YV80LAXXB	Repair, skin of leg using split-thickness autograft
IN4	CCI	1YV80LAXXA	Repair, skin of leg using full-thickness autograft
IN4	CCI	1YV80LAW4	Repair, skin of leg using glue for apposition (e.g crazy glue, glustitch)
IN4	CCI	1YV80LA	Repair, skin of leg using apposition technique [suture]
IN4	CCI	1YV80JAXXP	Repair, skin of leg using using cultured tissue
IN4	CCI	1YV80JAXXK	Repair, skin of leg using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN4	CCI	1YV80JAFF	Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])

IN4	CCI	1SQ87LAPMK	Excision partial, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ87LAKD	Excision partial, pelvis no tissue used [for closure of surgical defect] using wire, mesh
IN4	CCI	1SQ87LAPMG	Excision partial, pelvis using pedicled flap using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ87LAPMA	Excision partial, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ87LA	Excision partial, pelvis no tissue used [for closure of surgical defect] with no device used
IN4	CCI	1SQ87LAPM	Excision partial, pelvis no tissue used [for closure of surgical defect] using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ87LANWQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using screw, screw with plate
IN4	CCI	1SQ87LANWN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using screw, screw with plate
IN4	CCI	1SQ87LANWK	Excision partial, pelvis using bone homograft using screw, screw with plate
IN4	CCI	1SQ87LANWG	Excision partial, pelvis using pedicled flap using screw, screw with plate
IN4	CCI	1SQ87LANWA	Excision partial, pelvis using bone autograft using screw, screw with plate
IN4	CCI	1SQ87LANW	Excision partial, pelvis no tissue used [for closure of surgical defect] using screw, screw with plate
IN4	CCI	1SQ87LANVQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN4	CCI	1SQ87LANVN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using pin, nail
IN4	CCI	1SQ87LANVK	Excision partial, pelvis using bone homograft using pin, nail
IN4	CCI	1SQ87LANVG	Excision partial, pelvis using pedicled flap using pin, nail
IN4	CCI	1SQ87LANVA	Excision partial, pelvis using bone autograft using pin, nail
IN4	CCI	1SQ87LANV	Excision partial, pelvis no tissue used [for closure of surgical defect] using pin, nail
IN4	CCI	1SQ87LAKDQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh
IN4	CCI	1SQ87LAKDN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using wire, mesh
IN4	CCI	1SQ87LAXXQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] with no device used
IN4	CCI	1SQ87LAXXN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] with no device used
IN4	CCI	1SQ87LAKDK	Excision partial, pelvis using bone homograft using wire, mesh
IN4	CCI	1SQ87LAXXK	Excision partial, pelvis using bone homograft with no device used
IN4	CCI	1SQ87LAKDG	Excision partial, pelvis using pedicled flap using wire, mesh
IN4	CCI	1SQ87LAXXG	Excision partial, pelvis using pedicled flap with no device used
IN4	CCI	1SQ87LAXXA	Excision partial, pelvis using bone autograft with no device used
IN4	CCI	1SQ87LAPMQ	Excision partial, pelvis using combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ87LAKDA	Excision partial, pelvis using bone autograft using wire, mesh
IN4	CCI	1SQ87LAPMN	Excision partial, pelvis using synthetic tissue [e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN4	CCI	1YS87LAXXF	Excision partial, skin of abdomen and trunk open [excisional] approach using free flap
IN4	CCI	1YS87LAXXE	Excision partial, skin of abdomen and trunk open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YS87LAXXB	Excision partial, skin of abdomen and trunk open [excisional] approach using split thickness autograft

IN4	CCI	1YS87LAXXA	Excision partial, skin of abdomen and trunk open [excisional] approach using full thickness autograft
IN4	CCI	1YS87LAAYF	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using free flap
IN4	CCI	1YS87LAAYE	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YS87LAAYB	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using split thickness autograft
IN4	CCI	1YS87LAAYA	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome using full thickness autograft
IN4	CCI	1YS87LAAY	Excision partial, skin of abdomen and trunk open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN4	CCI	1YS87LAAGF	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using free flap
IN4	CCI	1YS87LAAGE	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YS87LAAGB	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using split thickness autograft
IN4	CCI	1YS87LAAGA	Excision partial, skin of abdomen and trunk open [excisional] approach and laser using full thickness autograft
IN4	CCI	1YS87LAAG	Excision partial, skin of abdomen and trunk open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN4	CCI	1YS87LA	Excision partial, skin of abdomen and trunk open [excisional] approach with apposition technique (suture, glue) for closure
IN4	CCI	1VX59LAX7	Destruction, soft tissue of leg using chemical cautery agent
IN4	CCI	1VX59LAGX	Destruction, soft tissue of leg using device NEC
IN4	CCI	1VX59LAAG	Destruction, soft tissue of leg using laser
IN4	CCI	1SG80LAXXN	Repair, muscles of the back using open approach and synthetic tissue [e.g. mesh, gortex]
IN4	CCI	1SG80LAXXG	Repair, muscles of the back using open approach and pedicled flap [e.g. gluteus maximus flap]
IN4	CCI	1SG80LAXXA	Repair, muscles of the back using open approach and autograft [e.g. fascia or skin] (for closure of surgical defect)
IN4	CCI	1SG80LAXXE	Repair, muscles of the back using open approach and local [transposition] flap [e.g. rotation plasty, advancement]
IN4	CCI	1SG80LA	Repair, muscles of the back using open approach and simple appostion [e.g. suturing or 'vest-over-pants' closure]
IN4	CCI	1SG80LAXXQ	Repair, muscles of the back using open approach and combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN4	CCI	1VC87LAXXQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] no device used (for closure)
IN4	CCI	1VC87LAXXA	Excision partial, femur with bone autograft, no device used (for closure)
IN4	CCI	1VC87LAPMQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using endoprosthesis [femoral head]
IN4	CCI	1VC87LAXXN	Excision partial, femur with synthetic tissue [bone cement, paste], no device used (for closure)
IN4	CCI	1VC87LAPMN	Excision partial, femur with synthetic tissue [bone cement, paste] using endoprosthesis [femoral head]

IN4	CCI	1VC87LAPMK	Excision partial, femur with bone homograft using endoprosthesis [femoral head]
IN4	CCI	1VC87LAPMF	Excision partial, femur with free flap [e.g fibular flap] using endoprosthesis [femoral head]
IN4	CCI	1VC87LAPMA	Excision partial, femur with bone autograft using endoprosthesis [femoral head]
IN4	CCI	1VC87LAPM	Excision partial, femur no tissue used (for closure of defect) using endoprosthesis [femoral head]
IN4	CCI	1VC87LANWQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using screw, plate and screw
IN4	CCI	1VC87LANWN	Excision partial, femur with synthetic tissue [bone cement, paste] using screw, plate and screw
IN4	CCI	1VC87LANWK	Excision partial, femur with bone homograft using screw, plate and screw
IN4	CCI	1VC87LANWG	Excision partial, femur with pedicled flap [myocutaneous flap] using screw, plate and screw
IN4	CCI	1VC87LANWF	Excision partial, femur with free flap [e.g fibular flap] using screw, plate and screw
IN4	CCI	1VC87LANWA	Excision partial, femur with bone autograft using screw, plate and screw
IN4	CCI	1VC87LAXXG	Excision partial, femur with pedicled flap [myocutaneous flap], no device used (for closure)
IN4	CCI	1VC87LANW	Excision partial, femur no tissue used (for closure of defect) using screw, plate and screw
IN4	CCI	1VC87LANVQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using pin, nail
IN4	CCI	1VC87LANVN	Excision partial, femur with synthetic tissue [bone cement, paste] using pin, nail
IN4	CCI	1VC87LANVK	Excision partial, femur with bone homograft using pin, nail
IN4	CCI	1VC87LANVG	Excision partial, femur with pedicled flap [myocutaneous flap] using pin, nail
IN4	CCI	1VC87LANVF	Excision partial, femur with free flap [e.g fibular flap] using pin, nail
IN4	CCI	1VC87LANVA	Excision partial, femur with bone autograft using pin, nail
IN4	CCI	1VC87LANV	Excision partial, femur no tissue used (for closure of defect) using pin, nail
IN4	CCI	1VC87LALQQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using intramedullary nail
IN4	CCI	1VC87LALQN	Excision partial, femur with synthetic tissue [bone cement, paste] using intramedullary nail
IN4	CCI	1VC87LALQK	Excision partial, femur with bone homograft using intramedullary nail
IN4	CCI	1VC87LALQG	Excision partial, femur with pedicled flap [myocutaneous flap] using intramedullary nail
IN4	CCI	1VC87LALQF	Excision partial, femur with free flap [e.g fibular flap] using intramedullary nail
IN4	CCI	1VC87LALQA	Excision partial, femur with bone autograft using intramedullary nail
IN4	CCI	1VC87LALQ	Excision partial, femur no tissue used (for closure of defect) using intramedullary nail
IN4	CCI	1VC87LAKDQ	Excision partial, femur with combined sources of tissue [e.g. graft, flap, bone cement] using wire, mesh, staple
IN4	CCI	1VC87LAKDN	Excision partial, femur with synthetic tissue [bone cement, paste] using wire, mesh, staple
IN4	CCI	1VC87LAKDK	Excision partial, femur with bone homograft using wire, mesh, staple
IN4	CCI	1VC87LAKDG	Excision partial, femur with pedicled flap [myocutaneous flap] using wire, mesh, staple
IN4	CCI	1VC87LAKDF	Excision partial, femur with free flap [e.g fibular flap] using wire, mesh, staple
IN4	CCI	1VC87LAKDA	Excision partial, femur with bone autograft using wire, mesh, staple
IN4	CCI	1VC87LAKD	Excision partial, femur no tissue used (for closure of defect) using wire, mesh, staple
IN4	CCI	1VC87LA	Excision partial, femur no tissue used (for closure of defect), no device used (for closure)
IN4	CCI	1VC87LAXXK	Excision partial, femur with bone homograft, no device used (for closure)
IN4	CCI	1SQ91LAXXQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] with no device used
IN4	CCI	1SQ91LAXXN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] with no device used

IN4	CCI	1SQ91LAXXK	Excision radical, pelvis using bone homograft with no device used
IN4	CCI	1SQ91LAXXG	Excision radical, pelvis using pedicled flap with no device used
IN4	CCI	1SQ91LAXXF	Excision radical, pelvis using free flap with no device used
IN4	CCI	1SQ91LAXXA	Excision radical, pelvis using bone autograft with no device used
IN4	CCI	1SQ91LAPMQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPMN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPMK	Excision radical, pelvis using bone homograft using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPMG	Excision radical, pelvis using pedicled flap using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPMF	Excision radical, pelvis using free flap using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPMA	Excision radical, pelvis using bone autograft using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LAPM	Excision radical, pelvis no tissue used [for closure of defect] using endoprosthesis (to replace hip joint)
IN4	CCI	1SQ91LANWQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using screw, screw with plate
IN4	CCI	1SQ91LANWN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using screw, screw with plate
IN4	CCI	1SQ91LANWK	Excision radical, pelvis using bone homograft using screw, screw with plate
IN4	CCI	1SQ91LANWG	Excision radical, pelvis using pedicled flap using screw, screw with plate
IN4	CCI	1SQ91LANWF	Excision radical, pelvis using free flap using screw, screw with plate
IN4	CCI	1SQ91LANWA	Excision radical, pelvis using bone autograft using screw, screw with plate
IN4	CCI	1SQ91LANW	Excision radical, pelvis no tissue used [for closure of defect] using screw, screw with plate
IN4	CCI	1SQ91LANVQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using pin, nail
IN4	CCI	1SQ91LANVN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using pin, nail
IN4	CCI	1SQ91LANVK	Excision radical, pelvis using bone homograft using pin, nail
IN4	CCI	1SQ91LANVG	Excision radical, pelvis using pedicled flap using pin, nail
IN4	CCI	1SQ91LANVF	Excision radical, pelvis using free flap using pin, nail
IN4	CCI	1SQ91LANVA	Excision radical, pelvis using bone autograft using pin, nail
IN4	CCI	1SQ91LANV	Excision radical, pelvis no tissue used [for closure of defect] using pin, nail
IN4	CCI	1SQ91LAKDQ	Excision radical, pelvis using combined sources of tissue[e.g. graft, flap, bone cement] using wire, mesh
IN4	CCI	1SQ91LAKDN	Excision radical, pelvis using synthetic tissue[e.g. bone cement or paste] using wire, mesh
IN4	CCI	1SQ91LAKDK	Excision radical, pelvis using bone homograft using wire, mesh
IN4	CCI	1SQ91LAKDG	Excision radical, pelvis using pedicled flap using wire, mesh
IN4	CCI	1SQ91LAKDF	Excision radical, pelvis using free flap using wire, mesh
IN4	CCI	1SQ91LAKDA	Excision radical, pelvis using bone autograft using wire, mesh
IN4	CCI	1SQ91LAKD	Excision radical, pelvis no tissue used [for closure of defect] using wire, mesh
IN4	CCI	1SQ91LA	Excision radical, pelvis no tissue used [for closure of defect] with no device used
IN4	CCI	1VD80LAXXQ	Repair, muscles of hip and thigh using open approach and combined sources of tissue [e.g. graft/flap, mesh]
IN4	CCI	1VD80LAXXN	Repair, muscles of hip and thigh using open approach and synthetic tissue [e.g. gortex, mesh or Silastic sheath]
IN4	CCI	1VD80LAXXF	Repair, muscles of hip and thigh using open approach and free flap
IN4	CCI	1VD80LAXXE	Repair, muscles of hip and thigh using open approach and local muscle transposition flap [e.g. advancement flap]

IN4	CCI	1VD80LAXXA	Repair, muscles of hip and thigh using open approach and autograft [e.g. fascia, muscle]
IN4	CCI	1VD80LA	Repair, muscles of hip and thigh using open approach and apposition [suture, staple]
IN4	CCI	1YZ80LAXXF	Repair, skin NEC using open approach and free flap [e.g. microvascular free flap]
IN4	CCI	1YZ80LAXXE	Repair, skin NEC using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN4	CCI	1YZ80LAXXB	Repair, skin NEC using split-thickness autograft
IN4	CCI	1YZ80LAXXA	Repair, skin NEC using full-thickness autograft
IN4	CCI	1YZ80LAW4	Repair, skin NEC using glue for apposition (e.g. crazy glue, glustitch)
IN4	CCI	1YZ80LA	Repair, skin NEC using apposition technique [suture]
IN4	CCI	1YZ80JAXXP	Repair, skin NEC using using cultured tissue
IN4	CCI	1YZ80JAXXK	Repair, skin NEC using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN4	CCI	1YZ80JAFF	Repair, skin NEC using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN4	CCI	1VX87LAXXQ	Excision partial, soft tissue of leg using combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN4	CCI	1VX87LAXXF	Excision partial, soft tissue of leg using free flap [e.g. myocutaneous free flap] (for closure of defect)
IN4	CCI	1VX87LAXXE	Excision partial, soft tissue of leg using local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (for closure of defect)
IN4	CCI	1VX87LAXXA	Excision partial, soft tissue of leg using autograft [e.g. fascia or skin] (for closure of surgical defect)
IN4	CCI	1VX87LA	Excision partial, soft tissue of leg using simple apposition technique [e.g. suture, staple] (for closure of surgical defect)
IN4	CCI	1YV80LAXXF	Repair, skin of leg using free flap [e.g. fasciocutaneous flap]
IN4	CCI	1YV80LAXXE	Repair, skin of leg using local flap [e.g. rotation, advancement, transposition, Z-plasty]
IN4	CCI	1YV80LAXXB	Repair, skin of leg using split-thickness autograft
IN4	CCI	1YV80LAXXA	Repair, skin of leg using full-thickness autograft
IN4	CCI	1YV80LAW4	Repair, skin of leg using glue for apposition (e.g crazy glue, glustitch)
IN4	CCI	1YV80LA	Repair, skin of leg using apposition technique [suture]
IN4	CCI	1YV80JAXXP	Repair, skin of leg using using cultured tissue
IN4	CCI	1YV80JAXXK	Repair, skin of leg using homograft (e.g. GRAFTJACKET regenerative tissue matrix)
IN4	CCI	1YV80JAFF	Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])
IN4	CCI	1YV87LAXXF	Excision partial, skin of leg open [excisional] approach using free flap
IN4	CCI	1YV87LAXXE	Excision partial, skin of leg open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YV87LAXXB	Excision partial, skin of leg open [excisional] approach using split thickness autograft
IN4	CCI	1YV87LAXXA	Excision partial, skin of leg open [excisional] approach using full thickness autograft
IN4	CCI	1YV87LAAYF	Excision partial, skin of leg open [excisional] approach and dermatome using free flap
IN4	CCI	1YV87LAAYE	Excision partial, skin of leg open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YV87LAAYB	Excision partial, skin of leg open [excisional] approach and dermatome using split thickness autograft
IN4	CCI	1YV87LAAYA	Excision partial, skin of leg open [excisional] approach and dermatome using full thickness autograft
IN4	CCI	1YV87LAAY	Excision partial, skin of leg open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN4	CCI	1YV87LAAGF	Excision partial, skin of leg open [excisional] approach and laser using free flap
IN4	CCI	1YV87LAAGE	Excision partial, skin of leg open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure

IN4	CCI	1YV87LAAGB	Excision partial, skin of leg open [excisional] approach and laser using split thickness autograft
IN4	CCI	1YV87LAAGA	Excision partial, skin of leg open [excisional] approach and laser using full thickness autograft
IN4	CCI	1YV87LAAG	Excision partial, skin of leg open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN4	CCI	1YV87LA	Excision partial, skin of leg open [excisional] approach with apposition technique (suture, glue) for closure
IN4	CCI	1YZ87LAXXF	Excision partial, skin NEC open [excisional] approach using free flap
IN4	CCI	1YZ87LAXXE	Excision partial, skin NEC open [excisional] approach using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YZ87LAXXB	Excision partial, skin NEC open [excisional] approach using split thickness autograft
IN4	CCI	1YZ87LAXXA	Excision partial, skin NEC open [excisional] approach using full thickness autograft
IN4	CCI	1YZ87LAAYF	Excision partial, skin NEC open [excisional] approach and dermatome using free flap
IN4	CCI	1YZ87LAAYE	Excision partial, skin NEC open [excisional] approach and dermatome using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YZ87LAAYB	Excision partial, skin NEC open [excisional] approach and dermatome using split thickness autograft
IN4	CCI	1YZ87LAAYA	Excision partial, skin NEC open [excisional] approach and dermatome using full thickness autograft
IN4	CCI	1YZ87LAAY	Excision partial, skin NEC open [excisional] approach and dermatome with apposition technique (suture, glue) for closure
IN4	CCI	1YZ87LAAGF	Excision partial, skin NEC open [excisional] approach and laser using free flap
IN4	CCI	1YZ87LAAGE	Excision partial, skin NEC open [excisional] approach and laser using local flap [e.g. rotation, advancement, transposition, Z-plasty] for closure
IN4	CCI	1YZ87LAAGB	Excision partial, skin NEC open [excisional] approach and laser using split thickness autograft
IN4	CCI	1YZ87LAAGA	Excision partial, skin NEC open [excisional] approach and laser using full thickness autograft
IN4	CCI	1YZ87LAAG	Excision partial, skin NEC open [excisional] approach and laser with apposition technique (suture, glue) for closure
IN4	CCI	1YZ87LA	Excision partial, skin NEC open [excisional] approach with apposition technique (suture, glue) for closure
IN4	CCI	1SF87PFXXG	Excision partial, sacrum and coccyx posterior approach using pedicled flap
IN4	CCI	1SF87PFXXE	Excision partial, sacrum and coccyx posterior approach Using local flap
IN4	CCI	1SF87PFXXA	Excision partial, sacrum and coccyx posterior approach Using full thickness graft
IN4	CCI	1SF87PF	Excision partial, sacrum and coccyx posterior approach Without tissue
IN4	CCI	1SF87LNXXG	Excision partial, sacrum and coccyx combined anterior with posterior approach using pedicled flap
IN4	CCI	1SF87LNXXE	Excision partial, sacrum and coccyx combined anterior with posterior approach Using local flap
IN4	CCI	1SF87LNXXA	Excision partial, sacrum and coccyx combined anterior with posterior approach Using full-thickness graft
IN4	CCI	1SF87LN	Excision partial, sacrum and coccyx combined anterior with posterior approach Without tissue
IN4	CCI	1SZ87DA	Excision partial, soft tissue of the chest and abdomen using endoscopic (laparoscopic) approach

IN4	CCI	1SZ87LAXXQ	Excision partial, soft tissue of the chest and abdomen using open approach and combined sources of tissue [e.g. flaps and grafts or mesh with graft/flap] (to close surgical defect)
IN4	CCI	1SZ87LAXXN	Excision partial, soft tissue of the chest and abdomen using open approach and synthetic tissue [e.g. mesh] (to close surgical defect)
IN4	CCI	1SZ87LAXXG	Excision partial, soft tissue of the chest and abdomen using open approach and pedicled flap (to close surgical defect)
IN4	CCI	1SZ87LAXXF	Excision partial, soft tissue of the chest and abdomen using open approach and free flap (to close surgical defect)
IN4	CCI	1SZ87LAXXE	Excision partial, soft tissue of the chest and abdomen using open approach and local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (to close surgical defect)
IN4	CCI	1SZ87LAXXA	Excision partial, soft tissue of the chest and abdomen using open approach and autograft [e.g. fascia or skin] (to close surgical defect)
IN4	CCI	1SZ87LA	Excision partial, soft tissue of the chest and abdomen using open approach and apposition [suture, staple] (to close surgical defect)
IN4	CCI	1VC91LAXXG	Excision radical, femur using open approach and pedicled flap
IN4	CCI	1VC91LAPNQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPNN	Excision radical, femur with synthetic tissue [e.g. bone cement, paste] using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPNK	Excision radical, femur with bone homograft using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPNG	Excision radical, femur with pedicled flap [myocutaneous flap] using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPNF	Excision radical, femur with free flap [e.g. fibular flap] using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPNA	Excision radical, femur with bone autograft using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPN	Excision radical, femur no tissue used (for closure of defect) using dual component endoprosthesis [distal femur with tibial head]
IN4	CCI	1VC91LAPMQ	Excision radical, femur with combined bone graft and cement or paste using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPMN	Excision radical, femur with synthetic tissue [bone cement, paste] using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPMK	Excision radical, femur with bone homograft using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPMG	Excision radical, femur with pedicled flap [myocutaneous flap] using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPMF	Excision radical, femur with free flap [e.g fibular flap] using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPMA	Excision radical, femur with bone autograft using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LAPM	Excision radical, femur no tissue used (for closure of defect) using single component endoprosthesis [femoral head]
IN4	CCI	1VC91LANWQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using screw, plate and screw
IN4	CCI	1VC91LANWN	Excision radical, femur with synthetic tissue [bone cement, paste] using screw, plate and screw
IN4	CCI	1VC91LANWK	Excision radical, femur with bone homograft using screw, plate and screw

IN4	CCI	1VC91LANWG	Excision radical, femur with pedicled flap [e.g. rotationplasty] using screw, plate and screw
IN4	CCI	1VC91LANWF	Excision radical, femur with free flap [e.g fibular flap] using screw, plate and screw
IN4	CCI	1VC91LANWA	Excision radical, femur with bone autograft using screw, plate and screw
IN4	CCI	1VC91LANW	Excision radical, femur no tissue used (for closure of defect) using screw, plate and screw
IN4	CCI	1VC91LANVQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using pin, nail
IN4	CCI	1VC91LANVN	Excision radical, femur with synthetic tissue [bone cement, paste] using pin, nail
IN4	CCI	1VC91LANVK	Excision radical, femur with bone homograft using pin, nail
IN4	CCI	1VC91LANVG	Excision radical, femur with pedicled flap [rotationplasty] using pin, nail
IN4	CCI	1VC91LANVF	Excision radical, femur with free flap [e.g fibular flap] using pin, nail
IN4	CCI	1VC91LANVA	Excision radical, femur with bone autograft using pin, nail
IN4	CCI	1VC91LANV	Excision radical, femur no tissue used (for closure of defect) using pin, nail
IN4	CCI	1VC91LALQQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using intramedullary nail
IN4	CCI	1VC91LALQN	Excision radical, femur with synthetic tissue [bone cement, paste] using intramedullary nail
IN4	CCI	1VC91LALQK	Excision radical, femur with bone homograft using intramedullary nail
IN4	CCI	1VC91LALQG	Excision radical, femur with pedicled flap using intramedullary nail
IN4	CCI	1VC91LALQF	Excision radical, femur with free flap [e.g fibular flap] using intramedullary nail
IN4	CCI	1VC91LALQA	Excision radical, femur with bone autograft using intramedullary nail
IN4	CCI	1VC91LALQ	Excision radical, femur no tissue used (for closure of defect) using intramedullary nail
IN4	CCI	1VC91LAKDQ	Excision radical, femur with combined sources of tissue [e.g. graft, cement/paste] using wire, mesh, staple
IN4	CCI	1VC91LAKDN	Excision radical, femur with synthetic tissue [bone cement, paste] using wire, mesh, staple
IN4	CCI	1VC91LAKDK	Excision radical, femur with bone homograft using wire, mesh, staple
IN4	CCI	1VC91LAKDG	Excision radical, femur with pedicled flap [e.g. rotationplasty] using wire, mesh, staple
IN4	CCI	1VC91LAKDF	Excision radical, femur with free flap [e.g fibular flap] using wire, mesh, staple
IN4	CCI	1VC91LAKDA	Excision radical, femur with bone autograft using wire, mesh, staple
IN4	CCI	1VC91LAKD	Excision radical, femur no tissue used (for closure of defect) using wire, mesh, staple
IN4	CCI	1VC91LA	Excision radical, femur no tissue used (for closure of defect) no fixation device used
IN4	CCI	1TF80LAXXQ	Repair, muscles of the arm [around shoulder] using open approach and combined sources of tissue [e.g. graft/flap, mesh]
IN4	CCI	1TF80LAXXN	Repair, muscles of the arm [around shoulder] using open approach and synthetic tissue [e.g. gortex, mesh, silastic sheath]
IN4	CCI	1TF80LAXXF	Repair, muscles of the arm [around shoulder] using open approach and free flap
IN4	CCI	1TF80LAXXE	Repair, muscles of the arm [around shoulder] using open approach and local transposition flap [e.g. realignment, advancement]
IN4	CCI	1TF80LAXXA	Repair, muscles of the arm [around shoulder] using open approach and autograft [e.g. fascia]
IN4	CCI	1TF80LA	Repair, muscles of the arm [around shoulder] using open approach and simple apposition technique [e.g. suture, staple]
IN4	CCI	1VD87LAXXQ	Excision partial, muscles of hip and thigh using combined sources of tissue [e.g. skin graft with flap] (for closure of defect)
IN4	CCI	1VD87LAXXF	Excision partial, muscles of hip and thigh using free flap [e.g. myocutaneous free flap] (for closure of defect)

IN4	CCI	1VD87LAXXE	Excision partial, muscles of hip and thigh using local transposition flap [e.g. advancement muscle or Z-plasty skin flap] (for closure of defect)
IN4	CCI	1VD87LAXXA	Excision partial, muscles of hip and thigh using autograft [e.g. fascia or skin] (for closure of surgical defect)
IN4	CCI	1VD87LA	Excision partial, muscles of hip and thigh using simple apposition technique [e.g. suture, staple] (for closure of surgical defect)
IN4	CCI	1YV59JAX7	Destruction, skin of leg using chemical cautery agent
IN4	CCI	1YV59JAX2	Destruction, skin of leg using cold inducing agent/cryorefrigerant [liquid nitrogen]
IN4	CCI	1YV59JAGX	Destruction, skin of leg using device NEC [electrocautery]
IN4	CCI	1YV59JADP	Destruction, skin of leg using yellow light (or copper vapor) laser
IN4	CCI	1YV59JADN	Destruction, skin of leg using argon dye (or tunable dye) laser
IN4	CCI	1YV59JADM	Destruction, skin of leg using ruby laser [e.g. for tattoo removal]
IN4	CCI	1YV59JACF	Destruction, skin of leg using mechanical device [sandpaper, wire brush]
IN4	CCI	1YV59JAAL	Destruction, skin of leg using electrolysis device
IN4	CCI	1YV59JAAG	Destruction, skin of leg using laser NEC [e.g. carbon dioxide for ablation]
IN4	CCI	1YV59JAAD	Destruction, skin of leg using cryoprobe
IN4	CCI	1YZ59JAX7	Destruction, skin NEC using chemical cautery agent
IN4	CCI	1YZ59JAX2	Destruction, skin NEC using cold inducing agent/ cryorefrigerant [liquid nitrogen]
IN4	CCI	1YZ59JALV	Destruction, skin NEC using ligature
IN4	CCI	1YZ59JAGX	Destruction, skin NEC using device NEC [electrocautery]
IN4	CCI	1YZ59JADP	Destruction, skin NEC using yellow light (or copper vapor) laser
IN4	CCI	1YZ59JADN	Destruction, skin NEC using argon dye (or tunable dye) laser
IN4	CCI	1YZ59JADM	Destruction, skin NEC using ruby laser [e.g. for tattoo removal]
IN4	CCI	1YZ59JACF	Destruction, skin NEC using mechanical device [sandpaper, wire brush]
IN4	CCI	1YZ59JAAL	Destruction, skin NEC using electrolysis device
IN4	CCI	1YZ59JAAG	Destruction, skin NEC using laser NEC [e.g. carbon dioxide for ablation]
IN4	CCI	1YZ59JAAD	Destruction, skin NEC using cryoprobe

Appendix 2, Spinal Cord Diagnoses

Flag name	Code Type	DX type applied	Codes	Code description
NT1	ICD10	alldx	C701	Malignant neoplasm of spinal meninges
NT1	ICD10	alldx	C720	Malignant neoplasm of spinal cord
NT1	ICD10	alldx	C721	Malignant neoplasm of cauda equina
NT1	ICD10	alldx	D321	Benign neoplasm of spinal meninges
NT1	ICD10	alldx	D334	Benign neoplasm of spinal cord
NT1	ICD10	alldx	D421	Neoplasm of uncertain or unknown behaviour of spinal meninges
NT1	ICD10	alldx	D434	Neoplasm of uncertain or unknown behaviour of spinal cord
NT1	ICD10	alldx	G061	Intraspinal abscess and granuloma
NT1	ICD10	alldx	G120	Infantile spinal muscular atrophy, type I [Werdnig-Hoffman]
NT1	ICD10	alldx	G121	Other inherited spinal muscular atrophy
NT1	ICD10	alldx	G320	Subacute combined degeneration of spinal cord in diseases classified elsewhere
NT1	ICD10	alldx	G373	Acute transverse myelitis in demyelinating disease of central nervous system
NT1	ICD10	alldx	G950	Syringomyelia and syringobulbia
NT1	ICD10	alldx	G951	Vascular myelopathies
NT1	ICD10	alldx	G952	Cord compression, unspecified
NT1	ICD10	alldx	G958	Other specified diseases of spinal cord
NT1	ICD10	alldx	G959	Disease of spinal cord, unspecified
NT1	ICD10	alldx	M4305	Spondylolysis, thoracolumbar region
NT1	ICD10	alldx	M4306	Spondylolysis, lumbar region
NT1	ICD10	alldx	M4308	Spondylolysis, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4301	Spondylolysis, occipito-atlanto-axial region
NT1	ICD10	alldx	M4304	Spondylolysis, thoracic region
NT1	ICD10	alldx	M4307	Spondylolysis, lumbosacral region
NT1	ICD10	alldx	M4309	Spondylolysis, unspecified site
NT1	ICD10	alldx	M4300	Spondylolysis, multiple sites in spine
NT1	ICD10	alldx	M4303	Spondylolysis, cervicothoracic region
NT1	ICD10	alldx	M4302	Spondylolysis, cervical region
NT1	ICD10	alldx	M4316	Spondylolisthesis, lumbar region
NT1	ICD10	alldx	M4319	Spondylolisthesis, unspecified site
NT1	ICD10	alldx	M4317	Spondylolisthesis, lumbosacral region
NT1	ICD10	alldx	M4310	Spondylolisthesis, multiple sites in spine
NT1	ICD10	alldx	M4312	Spondylolisthesis, cervical region
NT1	ICD10	alldx	M4314	Spondylolisthesis, thoracic region
NT1	ICD10	alldx	M4315	Spondylolisthesis, thoracolumbar region

NT1	ICD10	alldx	M4311	Spondylolisthesis, occipito-atlanto-axial region
NT1	ICD10	alldx	M4313	Spondylolisthesis, cervicothoracic region
NT1	ICD10	alldx	M4318	Spondylolisthesis, sacral and sacrococcygeal region
NT1	ICD10	alldx	M45	Ankylosing spondylitis
NT1	ICD10	alldx	M4608	Spinal enthesopathy, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4603	Spinal enthesopathy, cervicothoracic region
NT1	ICD10	alldx	M4606	Spinal enthesopathy, lumbar region
NT1	ICD10	alldx	M4605	Spinal enthesopathy, thoracolumbar region
NT1	ICD10	alldx	M4604	Spinal enthesopathy, thoracic region
NT1	ICD10	alldx	M4602	Spinal enthesopathy, cervical region
NT1	ICD10	alldx	M4609	Spinal enthesopathy, unspecified site
NT1	ICD10	alldx	M4601	Spinal enthesopathy, occipito-atlanto-axial region
NT1	ICD10	alldx	M4600	Spinal enthesopathy, multiple sites in spine
NT1	ICD10	alldx	M4607	Spinal enthesopathy, lumbosacral region
NT1	ICD10	alldx	M461	Sacroiliitis, not elsewhere classified
NT1	ICD10	alldx	M4629	Osteomyelitis of vertebra, unspecified site
NT1	ICD10	alldx	M4628	Osteomyelitis of vertebra, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4622	Osteomyelitis of vertebra, cervical region
NT1	ICD10	alldx	M4620	Osteomyelitis of vertebra, multiple sites in spine
NT1	ICD10	alldx	M4625	Osteomyelitis of vertebra, thoracolumbar region
NT1	ICD10	alldx	M4638	Infection of intervertebral disc (pyogenic), sacral and sacrococcygeal region
NT1	ICD10	alldx	M4637	Infection of intervertebral disc (pyogenic), lumbosacral region
NT1	ICD10	alldx	M4636	Infection of intervertebral disc (pyogenic), lumbar region
NT1	ICD10	alldx	M4634	Infection of intervertebral disc (pyogenic), thoracic region
NT1	ICD10	alldx	M4633	Infection of intervertebral disc (pyogenic), cervicothoracic region
NT1	ICD10	alldx	M4632	Infection of intervertebral disc (pyogenic), cervical region
NT1	ICD10	alldx	M4631	Infection of intervertebral disc (pyogenic), occipito-atlanto-axial region
NT1	ICD10	alldx	M4630	Infection of intervertebral disc (pyogenic), multiple sites in spine
NT1	ICD10	alldx	M4635	Infection of intervertebral disc (pyogenic), thoracolumbar region
NT1	ICD10	alldx	M4639	Infection of intervertebral disc (pyogenic), unspecified site
NT1	ICD10	alldx	M4646	Discitis, unspecified, lumbar region
NT1	ICD10	alldx	M4645	Discitis, unspecified, thoracolumbar region
NT1	ICD10	alldx	M4644	Discitis, unspecified, thoracic region
NT1	ICD10	alldx	M4643	Discitis, unspecified, cervicothoracic region
NT1	ICD10	alldx	M4642	Discitis, unspecified, cervical region
NT1	ICD10	alldx	M4641	Discitis, unspecified, occipito-atlanto-axial region
NT1	ICD10	alldx	M4640	Discitis, unspecified, multiple sites in spine
NT1	ICD10	alldx	M4647	Discitis, unspecified, lumbosacral region
NT1	ICD10	alldx	M4649	Discitis, unspecified, unspecified site

NT1	ICD10	alldx	M4648	Discitis, unspecified, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4655	Other infective spondylopathies, thoracolumbar region
NT1	ICD10	alldx	M4659	Other infective spondylopathies, unspecified site
NT1	ICD10	alldx	M4658	Other infective spondylopathies, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4657	Other infective spondylopathies, lumbosacral region
NT1	ICD10	alldx	M4656	Other infective spondylopathies, lumbar region
NT1	ICD10	alldx	M4654	Other infective spondylopathies, thoracic region
NT1	ICD10	alldx	M4653	Other infective spondylopathies, cervicothoracic region
NT1	ICD10	alldx	M4652	Other infective spondylopathies, cervical region
NT1	ICD10	alldx	M4651	Other infective spondylopathies, occipito-atlanto-axial region
NT1	ICD10	alldx	M4650	Other infective spondylopathies, multiple sites in spine
NT1	ICD10	alldx	M4687	Other specified inflammatory spondylopathies, lumbosacral region
NT1	ICD10	alldx	M4689	Other specified inflammatory spondylopathies, unspecified site
NT1	ICD10	alldx	M4688	Other specified inflammatory spondylopathies, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4686	Other specified inflammatory spondylopathies, lumbar region
NT1	ICD10	alldx	M4685	Other specified inflammatory spondylopathies, thoracolumbar region
NT1	ICD10	alldx	M4684	Other specified inflammatory spondylopathies, thoracic region
NT1	ICD10	alldx	M4683	Other specified inflammatory spondylopathies, cervicothoracic region
NT1	ICD10	alldx	M4682	Other specified inflammatory spondylopathies, cervical region
NT1	ICD10	alldx	M4681	Other specified inflammatory spondylopathies, occipito-atlanto-axial region
NT1	ICD10	alldx	M4680	Other specified inflammatory spondylopathies, multiple sites in spine
NT1	ICD10	alldx	M4719	Other spondylosis with myelopathy, unspecified site
NT1	ICD10	alldx	M4715	Other spondylosis with myelopathy, thoracolumbar region
NT1	ICD10	alldx	M4718	Other spondylosis with myelopathy, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4717	Other spondylosis with myelopathy, lumbosacral region
NT1	ICD10	alldx	M4716	Other spondylosis with myelopathy, lumbar region
NT1	ICD10	alldx	M4714	Other spondylosis with myelopathy, thoracic region
NT1	ICD10	alldx	M4713	Other spondylosis with myelopathy, cervicothoracic region
NT1	ICD10	alldx	M4712	Other spondylosis with myelopathy, cervical region
NT1	ICD10	alldx	M4711	Other spondylosis with myelopathy, occipito-atlanto-axial region
NT1	ICD10	alldx	M4710	Other spondylosis with myelopathy, multiple sites in spine
NT1	ICD10	alldx	M4793	Spondylosis, unspecified, cervicothoracic region
NT1	ICD10	alldx	M4797	Spondylosis, unspecified, lumbosacral region
NT1	ICD10	alldx	M4799	Spondylosis, unspecified, unspecified site
NT1	ICD10	alldx	M4798	Spondylosis, unspecified, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4796	Spondylosis, unspecified, lumbar region
NT1	ICD10	alldx	M4795	Spondylosis, unspecified, thoracolumbar region
NT1	ICD10	alldx	M4794	Spondylosis, unspecified, thoracic region
NT1	ICD10	alldx	M4792	Spondylosis, unspecified, cervical region

NT1	ICD10	alldx	M4791	Spondylosis, unspecified, occipito-atlanto-axial region
NT1	ICD10	alldx	M4790	Spondylosis, unspecified, multiple sites in spine
NT1	ICD10	alldx	M4805	Spinal stenosis, thoracolumbar region
NT1	ICD10	alldx	M4809	Spinal stenosis, unspecified site
NT1	ICD10	alldx	M4808	Spinal stenosis, sacral and sacrococcygeal region
NT1	ICD10	alldx	M4807	Spinal stenosis, lumbosacral region
NT1	ICD10	alldx	M4806	Spinal stenosis, lumbar region
NT1	ICD10	alldx	M4804	Spinal stenosis, thoracic region
NT1	ICD10	alldx	M4803	Spinal stenosis, cervicothoracic region
NT1	ICD10	alldx	M4802	Spinal stenosis, cervical region
NT1	ICD10	alldx	M4801	Spinal stenosis, occipito-atlanto-axial region
NT1	ICD10	alldx	M4800	Spinal stenosis, multiple sites in spine
NT1	ICD10	alldx	Q053	Sacral spina bifida with hydrocephalus
NT1	ICD10	alldx	Q057	Lumbar spina bifida without hydrocephalus
NT1	ICD10	alldx	Q059	Spina bifida, unspecified
NT1	ICD10	alldx	Q058	Sacral spina bifida without hydrocephalus
NT1	ICD10	alldx	Q056	Thoracic spina bifida without hydrocephalus
NT1	ICD10	alldx	Q055	Cervical spina bifida without hydrocephalus
NT1	ICD10	alldx	Q054	Unspecified spina bifida with hydrocephalus
NT1	ICD10	alldx	Q052	Lumbar spina bifida with hydrocephalus
NT1	ICD10	alldx	Q051	Thoracic spina bifida with hydrocephalus
NT1	ICD10	alldx	Q050	Cervical spina bifida with hydrocephalus
NT1	ICD10	alldx	Q069	Congenital malformation of spinal cord, unspecified
NT1	ICD10	alldx	Q064	Hydromyelia
NT1	ICD10	alldx	Q063	Other congenital cauda equina malformations
NT1	ICD10	alldx	Q062	Diastematomyelia
NT1	ICD10	alldx	Q061	Hypoplasia and dysplasia of spinal cord
NT1	ICD10	alldx	Q060	Amyelia
NT1	ICD10	alldx	Q068	Other specified congenital malformations of spinal cord

Flag name	Code Type	DX type applied	Codes	Code description
TRAUM1	ICD9	alldx	7674	SPINAL CORD INJ AT BIRTH
TRAUM1	ICD9	alldx	80670	FX SACRUM-OP/CRD INJ NOS
TRAUM1	ICD9	alldx	80622	T1-T6 FX-CL/ANT CORD SYN
TRAUM1	ICD9	alldx	80626	T7-T12 FX-CL/COM CRD LES
TRAUM1	ICD9	alldx	80638	T7-T12 FX-OP/CEN CRD SYN
TRAUM1	ICD9	alldx	80618	C5-C7 FX-OP/CEN CORD SYN
TRAUM1	ICD9	alldx	80660	FX SACRUM-CL/CRD INJ NOS
TRAUM1	ICD9	alldx	80610	C1-C4 FX-OP/CORD INJ NOS
TRAUM1	ICD9	alldx	8068	VERT FX NOS-CL W CRD INJ
TRAUM1	ICD9	alldx	80605	C5-C7 FX-CL/CORD INJ NOS
TRAUM1	ICD9	alldx	80628	T7-T12 FX-CL/CEN CRD SYN
TRAUM1	ICD9	alldx	80634	T1-T6 FX-OP/CORD INJ NEC
TRAUM1	ICD9	alldx	80617	C5-C7 FX-OP/ANT CORD SYN
TRAUM1	ICD9	alldx	80636	T7-T12 FX-OP/COM CRD LES
TRAUM1	ICD9	alldx	80608	C5-C7 FX-CL/CEN CORD SYN
TRAUM1	ICD9	alldx	8064	CL LUMBAR FX W CORD INJ
TRAUM1	ICD9	alldx	80620	T1-T6 FX-CL/CORD INJ NOS
TRAUM1	ICD9	alldx	80662	FX SACR-CL/CAUDA INJ NEC
TRAUM1	ICD9	alldx	80612	C1-C4 FX-OP/ANT CORD SYN
TRAUM1	ICD9	alldx	80672	FX SACR-OP/CAUDA INJ NEC
TRAUM1	ICD9	alldx	80624	T1-T6 FX-CL/CORD INJ NEC
TRAUM1	ICD9	alldx	80611	C1-C4 FX-OP/COM CORD LES
TRAUM1	ICD9	alldx	80613	C1-C4 FX-OP/CEN CORD SYN
TRAUM1	ICD9	alldx	80627	T7-T12 FX-CL/ANT CRD SYN
TRAUM1	ICD9	alldx	80629	T7-T12 FX-CL/CRD INJ NEC
TRAUM1	ICD9	alldx	80632	T1-T6 FX-OP/ANT CORD SYN
TRAUM1	ICD9	alldx	80631	T1-T6 FX-OP/COM CORD LES
TRAUM1	ICD9	alldx	80637	T7-T12 FX-OP/ANT CRD SYN
TRAUM1	ICD9	alldx	80633	T1-T6 FX-OP/CEN CORD SYN
TRAUM1	ICD9	alldx	80602	C1-C4 FX-CL/ANT CORD SYN
TRAUM1	ICD9	alldx	80607	C5-C7 FX-CL/ANT CORD SYN
TRAUM1	ICD9	alldx	80635	T7-T12 FX-OP/CRD INJ NOS
TRAUM1	ICD9	alldx	80615	C5-C7 FX-OP/CORD INJ NOS
TRAUM1	ICD9	alldx	80603	C1-C4 FX-CL/CEN CORD SYN
TRAUM1	ICD9	alldx	80639	T7-T12 FX-OP/CRD INJ NEC
TRAUM1	ICD9	alldx	80619	C5-C7 FX-OP/CORD INJ NEC

TRAUM1	ICD9	alldx	8065	OPN LUMBAR FX W CORD INJ
TRAUM1	ICD9	alldx	80609	C5-C7 FX-CL/CORD INJ NEC
TRAUM1	ICD9	alldx	80661	FX SACR-CL/CAUDA EQU LES
TRAUM1	ICD9	alldx	80621	T1-T6 FX-CL/COM CORD LES
TRAUM1	ICD9	alldx	80669	FX SACRUM-CL/CRD INJ NEC
TRAUM1	ICD9	alldx	80625	T7-T12 FX-CL/CRD INJ NOS
TRAUM1	ICD9	alldx	80671	FX SACR-OP/CAUDA EQU LES
TRAUM1	ICD9	alldx	80623	T1-T6 FX-CL/CEN CORD SYN
TRAUM1	ICD9	alldx	80679	FX SACRUM-OP/CRD INJ NEC
TRAUM1	ICD9	alldx	80601	C1-C4 FX-CL/COM CORD LES
TRAUM1	ICD9	alldx	8069	VERT FX NOS-OP W CRD INJ
TRAUM1	ICD9	alldx	80604	C1-C4 FX-CL/CORD INJ NEC
TRAUM1	ICD9	alldx	80600	C1-C4 FX-CL/CORD INJ NOS
TRAUM1	ICD9	alldx	80616	C5-C7 FX-OP/COM CORD LES
TRAUM1	ICD9	alldx	80614	C1-C4 FX-OP/CORD INJ NEC
TRAUM1	ICD9	alldx	80606	C5-C7 FX-CL/COM CORD LES
TRAUM1	ICD9	alldx	80630	T1-T6 FX-OP/CORD INJ NOS
TRAUM1	ICD9	alldx	9072	LATE EFF SPINAL CORD INJ
TRAUM1	ICD9	alldx	95207	ANTERIOR CORD SYND/C5-C7
TRAUM1	ICD9	alldx	95206	COMPLETE LES CORD/C5-C7
TRAUM1	ICD9	alldx	95205	C5-C7 SPIN CORD INJ NOS
TRAUM1	ICD9	alldx	95208	CENTRAL CORD SYND/C5-C7
TRAUM1	ICD9	alldx	95204	C1-C4 SPIN CORD INJ NEC
TRAUM1	ICD9	alldx	95203	CENTRAL CORD SYND/C1-C4
TRAUM1	ICD9	alldx	95202	ANTERIOR CORD SYND/C1-C4
TRAUM1	ICD9	alldx	95201	COMPLETE LES CORD/C1-C4
TRAUM1	ICD9	alldx	95200	C1-C4 SPIN CORD INJ NOS
TRAUM1	ICD9	alldx	9528	SPIN CORD INJ-MULT SITE
TRAUM1	ICD9	alldx	9524	CAUDA EQUINA INJURY
TRAUM1	ICD9	alldx	9523	SACRAL SPINAL CORD INJUR
TRAUM1	ICD9	alldx	95219	T7-T12 SPIN CORD INJ NEC
TRAUM1	ICD9	alldx	95218	CENTRAL CORD SYN/T7-T12
TRAUM1	ICD9	alldx	95217	ANTERIOR CORD SYN/T7-T12
TRAUM1	ICD9	alldx	9522	LUMBAR SPINAL CORD INJUR
TRAUM1	ICD9	alldx	95216	COMPLETE LES CORD/T7-T12
TRAUM1	ICD9	alldx	95215	T7-T12 SPIN CORD INJ NOS
TRAUM1	ICD9	alldx	9529	SPINAL CORD INJURY NOS
TRAUM1	ICD9	alldx	95214	T1-T6 SPIN CORD INJ NEC
TRAUM1	ICD9	alldx	95213	CENTRAL CORD SYND/T1-T6

TRAUM1	ICD9	alldx	95212	ANTERIOR CORD SYND/T1-T6
TRAUM1	ICD9	alldx	95211	COMPLETE LES CORD/T1-T6
TRAUM1	ICD9	alldx	95210	T1-T6 SPIN CORD INJ NOS
TRAUM1	ICD9	alldx	95209	C5-C7 SPIN CORD INJ NEC
TRAUM1	ICD10	alldx	S140	Concussion and oedema of cervical spinal cord
TRAUM1	ICD10	alldx	S1413	Posterior cord syndrome of cervical spinal cord
TRAUM1	ICD10	alldx	S1418	Other injuries of cervical spinal cord
TRAUM1	ICD10	alldx	S1410	Complete lesion of cervical spinal cord
TRAUM1	ICD10	alldx	S1411	Central cord lesion of cervical spinal cord
TRAUM1	ICD10	alldx	S1419	Unspecified lesion of cervical spinal cord
TRAUM1	ICD10	alldx	S1412	Anterior cord syndrome of cervical spinal cord
TRAUM1	ICD10	alldx	S240	Concussion and oedema of thoracic spinal cord
TRAUM1	ICD10	alldx	S2410	Complete lesion of thoracic spinal cord
TRAUM1	ICD10	alldx	S2418	Other injuries of thoracic spinal cord
TRAUM1	ICD10	alldx	S2411	Central cord lesion of thoracic spinal cord
TRAUM1	ICD10	alldx	S2413	Posterior cord syndrome of thoracic spinal cord
TRAUM1	ICD10	alldx	S2412	Anterior cord syndrome of thoracic spinal cord
TRAUM1	ICD10	alldx	S2419	Unspecified lesion of thoracic spinal cord
TRAUM1	ICD10	alldx	S340	Concussion and oedema of lumbar spinal cord
TRAUM1	ICD10	alldx	S3418	Other injuries of lumbar spinal cord
TRAUM1	ICD10	alldx	S3411	Central cord lesion of lumbar spinal cord
TRAUM1	ICD10	alldx	S3410	Complete lesion of lumbar spinal cord
TRAUM1	ICD10	alldx	S3412	Anterior cord syndrome of lumbar spinal cord
TRAUM1	ICD10	alldx	S3419	Unspecified lesion of lumbar spinal cord
TRAUM1	ICD10	alldx	S3413	Posterior cord syndrome of lumbar spinal cord
TRAUM1	ICD10	alldx	S3438	Other and unspecified injury of cauda equina
TRAUM1	ICD10	alldx	S3430	Laceration of cauda equina
TRAUM1	ICD10	alldx	T060	Injuries of brain and cranial nerves with injuries of nerves and spinal cord at neck level
TRAUM1	ICD10	alldx	T061	Injuries of nerves and spinal cord involving other multiple body regions
TRAUM1	ICD10	alldx	T913	Sequelae of injury of spinal cord

Flag name	Code Type	DX type applied	Codes	Code description
PLEGIA	ICD10	alldx	G82211	Paraplegia of unspecified type, complete, at cervical level
PLEGIA	ICD10	alldx	G82013	Flaccid paraplegia, complete at lumbar level
PLEGIA	ICD10	alldx	G82193	Spastic paraplegia, unspecified, at the lumbar level
PLEGIA	ICD10	alldx	G82012	Flaccid paraplegia, complete, at thoracic level
PLEGIA	ICD10	alldx	G82192	Spastic paraplegia, unspecified, at the thoracic level
PLEGIA	ICD10	alldx	G82591	Quadriplegia, unspecified type, unspecified, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82191	Spastic paraplegia, unspecified, at the cervical level
PLEGIA	ICD10	alldx	G82590	Quadriplegia, unspecified type, unspecified, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82521	Quadriplegia, unspecified type, incomplete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82123	Spastic paraplegia, incomplete, at the lumbar level
PLEGIA	ICD10	alldx	G82520	Quadriplegia, unspecified type, incomplete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82511	Quadriplegia, unspecified type, complete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82011	Flaccid paraplegia, complete, at cervical level
PLEGIA	ICD10	alldx	G82122	Spastic paraplegia, incomplete, at the thoracic level
PLEGIA	ICD10	alldx	G82510	Quadriplegia, unspecified type, complete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82491	Spastic quadriplegia, unspecified, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82121	Spastic paraplegia, incomplete, at the cervical level
PLEGIA	ICD10	alldx	G82490	Spastic quadriplegia, unspecified, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82421	Spastic quadriplegia, incomplete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82113	Spastic paraplegia, complete, at the lumbar level
PLEGIA	ICD10	alldx	G82420	Spastic quadriplegia, incomplete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82411	Spastic quadriplegia, complete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82112	Spastic paraplegia, complete, at the thoracic level
PLEGIA	ICD10	alldx	G82410	Spastic quadriplegia, complete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82391	Flaccid quadriplegia, unspecified, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82111	Spastic paraplegia, complete, at the cervical level
PLEGIA	ICD10	alldx	G82390	Flaccid quadriplegia, unspecified, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82321	Flaccid quadriplegia, incomplete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82093	Flaccid paraplegia, unspecified, at lumbar level
PLEGIA	ICD10	alldx	G82320	Flaccid quadriplegia, incomplete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82311	Flaccid quadriplegia, complete, at cervical spine level C5 to C7
PLEGIA	ICD10	alldx	G82092	Flaccid paraplegia, unspecified, at thoracic level
PLEGIA	ICD10	alldx	G82310	Flaccid quadriplegia, complete, at cervical spine level C1 to C4
PLEGIA	ICD10	alldx	G82293	Paraplegia of unspecified type, unspecified, at lumbar level
PLEGIA	ICD10	alldx	G82091	Flaccid paraplegia, unspecified, at cervical level
PLEGIA	ICD10	alldx	G82292	Paraplegia of unspecified type, unspecified, at thoracic level
PLEGIA	ICD10	alldx	G82291	Paraplegia of unspecified type, unspecified, at cervical level

PLEGIA	ICD10	alldx	G82023	Flaccid paraplegia, incomplete, at lumbar level
PLEGIA	ICD10	alldx	G82223	Paraplegia of unspecified type, incomplete, at lumbar level
PLEGIA	ICD10	alldx	G82222	Paraplegia of unspecified type, incomplete, at thoracic level
PLEGIA	ICD10	alldx	G82022	Flaccid paraplegia, incomplete, at thoracic level
PLEGIA	ICD10	alldx	G82221	Paraplegia of unspecified type, incomplete, at cervical level
PLEGIA	ICD10	alldx	G82213	Paraplegia of unspecified type, complete, at lumbar level
PLEGIA	ICD10	alldx	G82021	Flaccid paraplegia, incomplete, at cervical level
PLEGIA	ICD10	alldx	G82212	Paraplegia of unspecified type, complete, at thoracic level
PLEGIA	ICD10	alldx	G833	Monoplegia, unspecified
PLEGIA	ICD10	alldx	G8322	Monoplegia of upper limb on unspecified [unilateral] side
PLEGIA	ICD10	alldx	G8321	Monoplegia of upper limb on non-dominant side
PLEGIA	ICD10	alldx	G8320	Monoplegia of upper limb on dominant side
PLEGIA	ICD10	alldx	G831	Monoplegia of lower limb
PLEGIA	ICD10	alldx	G830	Diplegia of upper limbs
PLEGIA	ICD10	alldx	G839	Paralytic syndrome, unspecified
PLEGIA	ICD10	alldx	G838	Other specified paralytic syndromes
PLEGIA	ICD10	alldx	G835	Locked-in state
PLEGIA	ICD10	alldx	G834	Cauda equina syndrome