2022-05-09

National Surgical Quality Improvement Program: A Scoping Review of the Literature and Real-World Application Among Radical Cystectomy Patients

Mardinger, Cynthia

UNIVERSITY OF CALGARY

National Surgical Quality Improvement Program: A Scoping Review of the Literature and Real-World Application Among Radical Cystectomy Patients

by

Cynthia Mardinger

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN MEDICAL SCIENCES

CALGARY, ALBERTA

MAY, 2022

Preface

This thesis is original, unpublished, independent work by the author, Dr. Cynthia Mardinger. Dr. Mardinger is the primary author and has made the most substantial contribution to this thesis and wrote the manuscript in consultation with the members of the supervisory committee.

Dr. John Kortbeek and Dr. Eric Hyndman conceived of the presented idea and co-supervised the project. Dr. Dean Yergens developed the literature reference management program Synthesis, with which this project would not have been possible. Dr. Dean Yergens also assisted with the scoping review of the NSQIP literature and designed the heat map figure to help visualize and identify publication patterns. Alexander Drover assisted as a second reviewer of the scoping review. Dr. Chel Hee Lee assisted with the study design and statistical analyses of the radical cystectomy pathway project. Dr. Mary Brindle, Dr. Frankie Fraulin, and Dr. Lea Austen aided in interpreting the results and commented on the manuscript.

Acknowledgements

The serendipitous conception of this project was born in March 2019 when Dr. John Kortbeek, Dr. Eric Hyndman and I met Dr. Dean Yergens for coffee, who introduced us to Synthesis – a literature reference management program he had custom written. We were fascinated by Synthesis and its ability to automate parts of the research process. I was very lucky to have the opportunity to utilize the unique software and apply it to conduct a scoping review of the NSQIP literature. To complement this research, I was also given the opportunity to work with NSQIP data firsthand while evaluating the use of a clinical pathway among patients undergoing radical cystectomy for bladder cancer.

First and foremost, I would like to express my sincere gratitude and appreciation to my co-supervisors Dr. John Kortbeek and Dr. Eric Hydman for their continuous support throughout my Master's degree and research, for their patience, motivation, and immense knowledge. Most of all, I am fully indebted to Dr. Kortbeek for his substantial mentorship, understanding, and encouragement. Without him this project truly would not have been possible; thank you for believing in me and pushing me farther than I thought I could go.

I would also like to express thanks to Dr. Dean Yergens and Dr. Chel Hee Lee, who both supported me immensely with the methodology of this project. Thank you for the many friendly one-on-one Zoom meetings, for your patience, and sense of humour. To the rest of my committee, Dr. Mary Brindle, Dr. Lea Austen, and Dr. Frankie Fraulin, I am extremely grateful for your assistance and suggestions throughout my thesis project. Finally, I would like to thank Renee Duckworth for helping me obtain access and assisting me with the NSQIP data.

Table of Contents

List of Tables

List of Figures

Chapter I: Introduction

THESIS DESCRIPTION

Change is fundamental to the success of any improvement effort. However, not all changes result in improvement. Changes that result in improvement are those that produce visible, positive differences, in comparison to historical efforts, and have a lasting impact. The five central principles of improvement include: 1) understanding why there is a need for improvement, 2) having a way to measure if improvement has occurred, 3) developing a change that is expected to lead to improvement, 4) testing the change to determine if it is a good idea before any attempts to implement it, and 5) implementing the change so that it is permanent. [1]

The Model for Improvement (MFI) is a framework based on these principles and is the most common approach to improvement in health care. [2] Quality improvement (QI) teams using the MFI framework begin by asking three fundamental questions: "*What are we trying to accomplish? How will we know that a change is an improvement? What changes can we make that will result in improvement?*" Once a change has been developed, the Plan-Do-Study-Act (PDSA) Cycle can then be used to plan to test the change (Plan), carry out the test (Do), learn from the test (Study), and determine if any modifications need to be made to the test (Act) before the change is permanently implemented. [1].

QI in health care is focused on evaluating systems and teamwork rather than individual practitioners. QI in health care also values peer review, recognizes fallibility, and views errors as learning opportunities. QI uses measurement and data to determine how effective processes are at achieving desired outcomes in order to ensure stable and predictable results while reducing variability. [2] There are several components to ensure a QI initiative is successful. First, it is important to develop the proper infrastructure, including a committed team with strong

motivation, teamwork, and leadership. Second, it is critical to collect rigorous clinical data that are measurable and reliable. Quantitative measures are necessary to test changes and determine if changes lead to improvement. QI teams should also consider the use of tools and strategies that have been developed and adapted to help accelerate improvement efforts (e.g., protocols, order sets, etc.). [3] Finally, recognizing the influence of local contextual factors across health care system levels when designing a QI initiative is crucial to ensure that changes implemented produce effective improvements and can be replicated in other settings. [4]

In 2001, the Institute of Medicine (IOM) issued a report outlining six dimensions of quality we should aim to improve in health care, including: safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity. [5] Patient safety incidents are the third leading cause of death in Canada and episodes of unintended harm occur in the Canadian health care system every minute. [6] Given that nearly two thirds of hospital adverse events are associated with surgical care [7], many QI initiatives exist to try to improve surgical safety.

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a QI initiative that was designed to collect reliable, prospective, and longitudinal data to identify performance gaps and provide reliable feedback on the safety and effectiveness of surgical interventions. NSQIP is a nationally validated, risk-adjusted, outcomes-based program that includes over 700 participating hospitals from 11 different countries. [8] It provides demographic information, medical comorbidities, and 30-day morbidity and mortality risk-adjusted outcomes data for all major surgical procedures. These data permit hospitals to gauge the quality of their surgical programs and implement targeted quality improvement programs to reduce preventable complications.

Unsurprisingly, there has been a growing number of academic publications related to NSQIP. However, little is known about the breadth of research being conducted and the topics of articles being published with the use of NSQIP data. Current systematic and scoping reviews are almost completely limited to specific patient populations, surgical specialties, and procedures within the NSQIP literature. [9-13] As such, the first manuscript within this thesis was a scoping review of the NSQIP literature. A scoping review was chosen as a valid approach given its ability to address the entire range of material within the literature – an objective that could not have been met by a systematic review.

While the first manuscript emphasizes the role of NSQIP data within QI, the second manuscript of this thesis explores the integration of NSQIP data into a QI initiative. More specifically, we examined the effect of a multimodal clinical pathway on radical cystectomy outcomes using NSQIP data collected at a single tertiary urban hospital within our university setting.

Radical cystectomy following neoadjuvant chemotherapy is standard of care for patients with muscle invasive and recurrent high risk noninvasive bladder cancer. (12, 13) It is a complex procedure associated with a high risk of morbidity and mortality. (14, 15) Clinical pathways such as enhanced recovery after surgery (ERAS) protocols were introduced in the 1990s to accelerate recovery and reduce morbidity after major surgery. (16) Such pathways have been shown to improve postoperative outcomes, such as reducing length of stay and improving complication rates compared to standard care. (17) (18, 19)

RESEARCH AIMS AND OBJECTIVES

This thesis project consists of two manuscripts: 1) a scoping review of the NSQIP literature, and 2) an investigation of the effect of a multimodal clinical pathway on radical cystectomy outcomes.

The aim of the first manuscript was to describe the scope of research published on NSQIP. The objectives were to: 1) describe and quantify the growth of the NSQIP literature, 2) describe the extent, range, and nature of published NSQIP research activity, and 3) to describe the contribution to the NSQIP literature by surgical specialty.

The aim of the second manuscript was to apply the use of NSQIP data firsthand by investigating the effect of a multimodal clinical pathway on radical cystectomy outcomes at a participating NSQIP site within our institution. The objectives were to: 1) describe the demographic and perioperative characteristics of patients undergoing radical cystectomy for bladder cancer, and 2) investigate the effect of a multimodal clinical pathway on the complication rate and mortality among patients undergoing radical cystectomy for bladder cancer.

RATIONALE

The first manuscript within this thesis describes the type of research being conducted and the topics currently published within the NSQIP literature. The results of this review will provide experts with more information on how NSQIP is being used to improve surgical safety and will also help identify any gaps in the literature. The broader goal of this study is to identify

opportunities for future interventions aimed to improve surgical safety, which may guide future organizational strategies and/or health care policy.

The second manuscript within this thesis will provide an example of how NSQIP data can be used to evaluate an intervention at a single participating hospital. More importantly, however, it may support justification for implementing a clinical pathway more broadly to decrease complications and mortality among patients undergoing radical cystectomy for bladder cancer.

ETHICAL CONSIDERATIONS

This research study falls under the scope of a quality improvement project, which has received ethics approval by the Conjoint Health Research Ethics Board of the University of Calgary.

Chapter II: Background Literature

PATIENT SAFETY

One of the principal ethical responsibilities of health care providers, facilities, and systems is to first 'do no harm'. While the provision of health care is not completely devoid of risk, patient safety must be prioritized by ensuring that the benefits of medical interventions outweigh any potential risks. Patient safety incidents are the third leading cause of death in Canada and unintended harm occurs in a Canadian health care context every minute. [6] A recent systematic review reported that approximately one in every 150 patients admitted to the hospital die as a result of an adverse event and nearly two thirds of events are associated with surgical care. [7] The Canadian Adverse Events Study estimated that the average annual incidence rate of adverse events during admission is 7.5% and over two thirds of these events are deemed preventable. [14]

The most common types of adverse events are operative (e.g., postoperative bleeding, reoperations), medication- or drug/fluid-related (e.g., medication errors, allergic reactions), and health care-acquired infections (e.g., central venous catheter infections, urinary tract infections). [15,16] Although the majority of adverse events were temporary and of minimal consequence, 7.0% of patients suffered a permanent disability and 7.4% of events were fatal. [7]

Adverse events exert not only a burden on patients and their families through temporary or permanent disability but also exert a significant resource burden on the health care system and society more broadly. Depending on the severity, adverse events can lead to additional medical investigations, treatments, prolonged hospital stays, and readmissions. According to the Canadian Institute for Health Information (CIHI), the average cost of a standard hospital stay was $6,162 in 2018-2019. [17] On average, adverse events prolong hospital stays by 10.2 days [18],

with perioperative events resulting in extended hospital stays by 16 days, [19] and hospital-acquired sepsis by up to 30 days. [20]

The health sector already represents a high proportion of provincial and territorial expenditures. In 2015, Canadians spent nearly $65 billion on hospital care, making it the largest category of health spending. [21] Adverse events account for 12 to 16% of hospital expenditures, corresponding to $7.8 to $10.4 billion annually. [22,23] In contrast, only 6.9% of hospital expenditures were spent on the functioning of operating rooms and 4.4% on emergency services in Canada in 2018-2019. [17] The authors of the CIHI estimated the economic burden of adverse events in Canada was $685 million in 2014-2015. [24] Adverse events are predominantly attributable to organizations and systems rather than the negligence of one member of the patient care team. [25] Therefore, developing an institutional culture conducive to quality and safety is critical and addressing such a system-wide problem calls for a much larger response. Reducing preventable adverse events therefore provides an opportunity to build capacity in the health care system through reallocation of funds.

While patient safety has been studied for decades, [26,27] it has garnered more attention in recent years. In the 21st century, the National Academy of Medicine, Agency for Healthcare Research and Quality, The Joint Commission, and the National Quality Forum, among others started a quality improvement (QI) 'movement' in efforts to improve patient safety. [28] These organizations developed aims, goals, quality indicators, clinical practice guidelines, committees, and task forces aimed to improve outcomes, processes, and structure within health care.

SURGICAL SAFETY

Surgery has been an essential component of health care worldwide for over a century. It has been estimated that approximately 11% of the overall global burden of disease can be treated by surgery. [29] According to the World Health Organization (WHO), 63 million people each year undergo surgery for traumatic injuries, 10 million for pregnancy-related complications, and 31 million to treat malignancies. However, surgery is invasive and therefore carries an inherent risk for patients. The WHO reports that the crude mortality rate following major surgery is approximately 0.5% to 5% and up to 25% of all patients experience postoperative complications, accounting for 13% of the world's total disability-adjusted life years (DALYs). As previously noted, two thirds of all in-hospital adverse events are associated with surgical care [7] and, incidentally, two thirds of all adverse events are deemed preventable. [14] Given the disproportionate number of adverse events associated with surgery, several organizations have acknowledged the need to transform the surgical component of the health care system and increase the importance of surgical safety.

As part of the QI movement, the Surgical Quality Officer (SQO) was identified by the American College of Surgeons as a critical role in all hospitals providing surgical care to help foster institutional cultures focused on quality, safety, and high reliability. [28] The SQO is responsible for QI programs within surgical departments and promotes the cooperation and collaboration among surgical disciplines and with non-surgical disciplines. The SQO is also in charge of identifying and addressing system errors or barriers inhibiting the delivery of optimal patient care. Among many responsibilities, the SQO provides leadership in quality and safety, informs themselves on best practices and QI principles, and integrates these findings within the existing institutional governance structure. [28]

Targets and strategies for SQOs are developed using many educational programs, including the programs and tools produced by the WHO. The WHO developed a core set of safety standards in their Global Patient Safety Challenge called: "Safe Surgery Saves Lives." [30] Four major areas of improvement in surgical safety were identified by several groups of international experts after reviewing relevant literature and drawing on the experiences of surgeons around the world. The four areas identified were: 1) surgical site infection prevention, 2) safe anesthesia, 3) safe surgical teams, and 4) measurement of surgical services. [30] Prevention of SSIs includes hand washing, appropriate use of antibiotics, antiseptic skin preparation, atraumatic wound care, instrument decontamination, and sterility. Safe anesthesia consists of the presence of a trained anesthetist, a medication and anesthesia machine safety checklist, as well as ongoing temperature, blood pressure, and pulse oximetry heart rate monitoring. Teamwork is central to ensuring any system involving multiple people functions safely and effectively. Safe surgical teams involve good communication, clinical skills, and situational awareness. Teams should follow a surgical safety checklist to ensure safety standards are met. Measurement of surgical services includes peer review, quality assurance, and monitoring outcomes.

The 2008 WHO Surgical Safety Checklist is a tool that was developed in response to the second global patient safety "Safe Surgery Saves Lives" challenge. The aim of the checklist was to improve communication among surgical teams and to decrease errors and adverse events. Several early pilot studies showed dramatic improvement in outcomes, such as a 47% reduction in mortality and 36% reduction in complications. [31-33] A more recent systematic review and meta-analysis from 2018 demonstrated that surgical safety checklists continue to be associated with reduced mortality and complications. [34] The production of the WHO surgical safety checklist demonstrates how a QI initiative can lead to improved outcomes.

SURGICAL QUALITY IMPROVEMENT

The most widely recognized surgical databases in the United States include the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), [35] the National Inpatient Sample (NIS), [36] and the National Cancer Database (NCDB). [37] Although these surgical databases are all used to monitor outcomes, NSQIP differentiates itself from these other databases in that it is specifically designed for QI research and to understand clinical outcomes. In contrast, the NIS was designed using data that was collected primarily for reimbursement purposes and is interested in cost utilization. [36] While the NCDB was started for similar reasons to NSQIP, it solely pertains to the treatment and outcomes of malignant neoplastic diseases. [37] It is important to consider the purpose behind the creation of a database, as this substantially influences sampling procedures, patient populations, and collected variables.

THE NATIONAL SURGICAL QUALITY IMPROVEMENT PROGRAM

The ACS NSQIP is a nationally validated outcomes-based program which aims to measure and improve the quality of surgical care. It was originally created as a QI initiative for the Veteran's Healthcare Administration (VA) in the 1980s. Given the substantial reduction in morbidity and mortality seen within the VA using the data provide by NSQIP, the program expanded to include private-sector medical centers by 2003. [35] NSQIP now consists primarily of North American academic and community hospitals, with as many as 722 participating sites in 2018. [8] There are NSQIP hospitals in 49 of the 50 states and across over an additional 100 hospitals in 11 countries, including Canada.

Features of NSQIP include risk-adjusted outcomes, audited clinical data collection to ensure data reliability, 30-day postoperative tracking, team engagement and best practice

recommendations. Each site has an assigned and trained surgical clinical reviewer (SCR) who is responsible for capturing data using a combination of automated data collection, medical chart reviews, and direct patient contact, if necessary. [8] The SCR must follow the ACS-validated random sampling strategy and use standardized variable definitions provided by NSQIP for data collection. [38] NSQIP includes all major procedures as determined by Current Procedure Terminology (CPT) codes. Eligible procedures are then sampled by either capturing all the cases at an entire participating site or by systematically including cases using a rotating 8-day schedule. [38] Routine data audits have demonstrated an inter-rater reliability of 98%. [8]

NSQIP data are collected from the patients' medical chart and include demographic information, medical comorbidities, and 30-day morbidity and mortality outcomes for all major inpatient and outpatient surgical procedures. [8] Patient records have been demonstrated to be more reliable for identifying risk factors in comparison to claims-based data provided by other databases. [39-42]

In addition, NSQIP data can be risk-adjusted using the ACS surgical risk calculator (SRC) to predict outcomes for each patient based on their individual characteristics. [8] The SRC utilizes data from the over 4.3 million operations in the ACS NSQIP database and is publicly accessible online. [43,44] Data reported by NSQIP are also case-mix-adjusted to account for the complexity of operations performed so all surgical centers can equally calibrate their results against each other's. [8] For example, a designated center of excellence with high procedure volume may take on more complex surgical cases in comparison to centers that perform straightforward procedures and might inherently have higher complication rates. Finally, data are based on 30-day patient outcomes to provide a more complete picture, since post-discharge

complications are common and strongly predict readmission. [45] Although these data are not reported, participating sites can follow patients longer than 30 days.

Participating hospitals continuously submit data through the ACS website, which is a HIPAA-compliant, secure, web-based platform accessible through participant use data files (PUFs) 24 hours a day. [8] A surgeon is assigned to lead and oversee NSQIP-related initiatives at each participating hospital. Blinded, risk-adjusted reports are provided to all participating hospitals to benchmark performance and identify areas of improvement.

A 2009 study which included 118 NSQIP hospitals reported that the program had helped prevent approximately 250 to 500 complications per year among each hospital. [46] Furthermore, 80% of hospitals saw a significant decrease in their complication rates and two thirds saw a decrease in their mortality rates. A 2015 study with an eight-year follow-up period demonstrated similar outcomes. [47] By identifying areas of low performance, NSQIP provides the opportunity for participating hospitals to develop and implement QI interventions aimed to reduce adverse events and improve patient outcomes. Taking into account the considerable cost of adverse events, such interventions can enable cost savings in the millions of dollars. [8,48] For example, a recent economic evaluation in Alberta, Canada reported that the net cost-savings of participating in NSQIP were $8.8 million after subtracting the costs associated with NSQIP and its interventions. The return-on-investment ratio was estimated at 4.3, meaning for every dollar invested in NSQIP would bring $4.30 in returns. [49]

Given its many reported benefits and the increasing adoption of NSQIP, it is not surprising that there has been a growing number of academic publications related to NSQIP. While most publications measure QI interventions at specific sites or within surgical specialties utilizing NSQIP-derived data, several studies also investigate the reliability of the publicly

accessible SRC. Despite the growing number of publications, there is limited collated information as to the type of research being conducted and the topics of articles being published.

Systematic and scoping reviews reporting on specific patient populations, surgical specialties, and procedures within the NSQIP literature have been published. [9-13] However, little is known about the entire breadth of surgical interventions and perioperative outcomes being reported. The first aim of this thesis was to provide a scoping review of the NSQIP literature, including the growth of the literature, the extent, range, and nature of NSQIP research activity, as well as the contribution from each surgical specialty.

NSQIP AT A PARTICIPATING HOSPITAL

The second aim of this thesis was to demonstrate firsthand the application of NSQIP data and how it can be used to investigate a QI intervention. More specifically, the second manuscript within this thesis investigated the effect of a multimodal clinical pathway on radical cystectomy outcomes at a participating NSQIP site within our institution. Radical cystectomy represents a significant challenge in the surgical community. In effort to try to reduce morbidity and mortality associated with radical cystectomy, a tertiary urban hospital and regional centre for Urology was selected as one of the five acute care facilities within our institutions' province to adopt NSQIP as part of a pilot study in 2015.

RADICAL CYSTECTOMY

Bladder cancer is the ninth most common cancer worldwide and according to Bladder Cancer Canada, it is the fifth most common cancer in Canada. [50] Bladder cancer is the second most common urological malignancy following prostate cancer and 90% of all bladder cancers

are diagnosed as urothelial carcinoma. Although the majority are superficial at the time of diagnosis, between 20% and 40% of patients present with invasive disease. [51] Radical cystectomy with neoadjuvant chemotherapy is standard of care for patients with muscle invasive and recurrent high-risk noninvasive bladder cancer. [52,53] It is considered one of the most morbid urological procedures and involves removal of the bladder, pelvic lymph node dissection, and urinary diversion. [51] In men, radical cystectomy includes removal of the prostate and seminal vesicles. In women, the uterus, ovaries, and part of the vagina are also removed. Given the complexity of the procedure, radical cystectomy is associated with a high risk of morbidity and mortality. [54,55] Patients with bladder cancer are often also of advanced age with multiple comorbidities, placing them at increased risk for perioperative complications. [56,57]

Despite advancements in technology, surgical technique, equipment, and anesthesia, a review of the literature reveals that perioperative outcomes following radical cystectomy have remained relatively unchanged over the past decade. Complications rates are still reported in as many as 64% of cases [54,58-60] and include blood transfusion, infection, and venous thromboembolism (VTE). A significant proportion of these complications occur after discharge, including nearly half of all VTE cases. [59] One in four patients who undergo radical cystectomy for bladder cancer have been found to be readmitted [54,57,61] and approximately 5% of all patients require reoperation within 30 days of discharge. [62-64] Given the high morbidity associated with radical cystectomy, actionable targets for improvement must be identified and tailored interventions should be implemented to better optimize patient outcomes.

SURGICAL PATHWAYS

Multidisciplinary, fast-track surgery and enhanced recovery after surgery (ERAS) protocols were first introduced in the 1990s for colorectal surgery to accelerate recovery and reduce morbidity associated with surgery using standardized, evidence-based perioperative care. [65] These clinical pathways are multimodal and include a wide range of items from preoperative medical optimization, intraoperative management, and postoperative care elements. The key tenets include early feeding, minimizing intravenous fluids, and avoidance of preoperative bowel preparation, nasogastric tubes or narcotic analgesics. [66] Another key tenet within ERAS is auditing and feedback to ensure that policies and procedures are always being updated and improved based on new evidence.

Studies have demonstrated how clinical pathways have the ability to decrease postoperative complication rates, readmission rates, shorten LOS, and enable cost savings. [67] For example, ERAS protocols for colorectal surgery have been shown to decrease complications by 50% and LOS by 2.5 days. [68] Given the substantial improvement seen in perioperative outcomes, it is no surprise that ERAS has since been adopted in other surgical specialties, such as gynecology, thoracic, vascular, pediatric, and orthopedic surgery. [69] Although there has been less uptake in urology, bladder cancer patients have been identified as ideal candidates for a clinical pathway since there is significant potential to reduce complications. A recent study identified how the application of ERAS to cystectomy does not currently have a high level of evidence for decreasing morbidity and mortality. [70] Therefore, the ERAS Society has since acknowledged the complexity and high morbidity associated with cystectomy and has provided a comprehensive specialty-specific pathway based on available evidence. [71] In fact, a recent systematic review and meta-analysis comparing 13 studies demonstrated that ERAS after cystectomy reduced LOS,

postoperative complications, and readmission rates compared to standard care. [72,73] A 2019 review summarizing the items included in the most current radical cystectomy protocols agreed that ERAS improved LOS. [73] However, the authors reported that most studies showed no benefit in complication and readmission rates.

Herein, we will investigate the effect of a clinical pathway on the complication rates and mortality among patients undergoing radical cystectomy for bladder cancer at a participating NSQIP site within our institution.

Chapter III: Manuscripts

Manuscript I:

A Scoping Review of the NSQIP Literature

Cynthia Mardinger, Alexander Drover, Eric Hyndman, Mary Brindle, Frankie Fraulin, Lea Austen, John Kortbeek, Dean Yergens

ABSTRACT

Introduction: The National Surgical Quality Improvement Program (NSQIP) is a validated database designed to measure risk-adjusted 30-day surgical outcomes for national and international benchmarking. De-identified, anonymized datasets can be abstracted from submitting NSQIP hospitals. The purpose of this scoping review is to describe the breadth of studies in the NSQIP literature.

Methods: A comprehensive electronic literature search was performed using PubMed, MEDLINE, Web of Knowledge and Scopus to capture all NSQIP articles published between January 1, 2000 and December 31, 2020. Two reviewers independently reviewed articles to determine their relevance using predefined inclusion criteria. Articles were included if they were about NSQIP or used NSQIP data. References were imported into a literature review application, Synthesis®, to semi-automate data management. Extracted data included the domain of surgery, study type, and year of publication.

Results: Of the 4,661 NSQIP articles included, 77.9% were published within the last 5 years. Outcomes (46.7%) and Association (41.7%) were the most common types of NSQIP-related articles. The most common surgical domains of NSQIP articles were general surgery and orthopedic surgery, representing 35.7% and 24.0% of the articles, respectively. Overall, 52 (1.1%) articles could not be categorized.

Conclusion: This scoping review provides an overview of the diversity of articles in the NSQIP literature. Mapping the NSQIP database identified areas where systematic reviews might be feasible or relevant and identified opportunities for future research.

INTRODUCTION

Surgery is an essential component of health care. It has been estimated that approximately 11% of the overall global burden of disease is treatable by surgery. [1] However, surgery is invasive and therefore carries inherent risks for patients. The World Health Organization (WHO) reported that the crude mortality rate following major surgery is approximately 0.5% to 5% and up to 25% of all patients experience postoperative complications, accounting for approximately 13% of the world's total disability-adjusted life years (DALYs). [2] With the continued rise in trauma, cancer, and cardiovascular disease, the impact of surgical care is expected to continue to grow. [2] Therefore, developing an institutional culture of surgical safety and quality improvement is critical.

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a nationally validated, risk-adjusted, outcomes-based program with more than 700 participating hospitals from 11 different countries. [3] NSQIP data are collected from the patients' medical charts and include demographic information, medical comorbidities, and 30-day morbidity and mortality risk-adjusted outcomes for all major inpatient and outpatient surgical procedures. Data entry is performed by trained qualified personnel using a standard data dictionary and definitions. NSQIP data provided to sites can be risk-adjusted using the ACS surgical risk calculator (SRC). The SRC is a publicly accessible prediction tool that was developed using data from over 4.3 million operations captured by the NSQIP database. The calculator has excellent predictive performance and can provide a prediction of likelihood of an outcome or complication based on individual patients' preoperative data. [4,5] Finally, data reported by NSQIP are also case-mix-adjusted to account for the complexity of operations performed, which allows surgical centers to equally calibrate their results against each other. [3]

Given the significant benefits and increased adoption of NSQIP, there has been a growing number of academic publications related to NSQIP. While most publications measure quality improvement interventions at specific sites or within surgical specialties utilizing NSQIP-derived data, several studies also investigate the reliability of the SRC. Despite the growing number of publications, there is limited collated information as to the type of research being conducted and the topics of articles being published. Some systematic and scoping reviews have reported on specific patient populations, surgical specialties, and procedures within the NSQIP literature. [6-10] However, little is known about the entire breadth of research being conducted and the types of articles being published within the NSQIP literature. This study aims to describe the growth of the NSQIP literature, describe the nature of NSQIP research activity by study type, and identify the relative contribution to the NSQIP literature by surgical specialty using an automated literature review application called Synthesis.

METHODS

Study Selection

This scoping review was completed based on the five-stage scoping review framework described by Arksey and O'Malley 2005. [11] A search was performed on February 11, 2021. Relevant studies were identified through a query of four electronic databases: PubMed, MEDLINE, Web of Knowledge and Scopus. All articles in the English language with "NSQIP" OR "National Surgical Quality Improvement Program" in the title or abstract published between January 1, 2005, and December 31, 2020, were included. This interval was chosen because NSQIP Participant Use Files (PUFs) were only made available to participating hospitals as of 2005. References were imported into Synthesis, and duplicates were excluded. The following

references were also excluded: conferences, commentary (e.g., letters, corrections, editorials, discussions), books and book chapters. References that met the screening criteria were manually reviewed to eliminate all the narratives, commentaries, or duplicates that were not excluded in the initial screening.

Two reviewers (C.M. and A.D.) independently reviewed the titles and abstracts to determine their relevance to the study (Figure 1). Reviewers were blinded to each other's selections. Articles were included if they were specific to a statistical analysis of NSQIP data. Disagreements on eligibility were referred to a third reviewer (D.W.Y.) for arbitration.

The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist [12] was applied to the current scoping review and can be found in the Appendices (Supplemental Content 3). However, many items on the checklist could not be feasibly addressed due to the large volume of included sources of evidence in this study. The authors received no funding to support this scoping review.

Synthesis

Synthesis is a Java-based literature reference management program that was developed by D.W.Y. [13] and uses the open-source Apache Lucene's text search abilities. [14] Keywords or phrases can be searched within an entire database of imported references using Boolean queries, similar to the "find" command in commercially available word processors. Finally, Synthesis can use a text definition file based upon keywords or phrases, Boolean operators, wildcards, and proximity searching to tag every reference that meets the user-defined criteria.

Data Management

While traditional scoping reviews are generally a qualitative process, the use of Synthesis software is a novel approach as it allowed for a quantitative analysis.

All relevant articles were imported into Synthesis. Data charting was done independently by CM. Articles were catalogued into different categories based on words and phrases in the article title. Words and phrases were identified within the titles using Boolean operators, wildcards, and proximity searches. These words and phrases were then subjectively grouped into main categories. A statement for each category was constructed to enable Synthesis to automatically identify and tag each article with descriptive labels according to category. Statements consisted of a string of commonly occurring words, phrases, and basic algorithms, which were managed using a dynamic Word Cloud. This was an iterative process, which involved deciding which words or phrases should be included in each category.

Two broader themes were identified based on the constructed categories. These included: Surgical Specialty and Study Type. It should be highlighted that articles could be catalogued within more than one category. For example, multidisciplinary articles were labeled with each relevant surgical specialty and therefore fell into several categories. Titles for which the algorithm produced no category were labeled as ‘Unknown’.

The initial Word Cloud for Surgical Specialty was built using Current Procedure Terminology (CPT) codes. Surgical Specialty categories were constructed based on surgical specialties common in American and Canadian Surgery programs. Anesthesia was also included as a separate non-surgical category. The main categories were: General Surgery, Otolaryngology and Head and Neck Surgery, Orthopedic Surgery, Plastic Surgery, Pediatric Surgery, Vascular Surgery, Thoracic Surgery, Cardiac Surgery, Oro-Maxillofacial Surgery, Transplant Surgery,

Urology, Surgical Oncology, Obstetrics and Gynecology, Neurosurgery, Dentistry, and Podiatry. Ophthalmology was not included as it is the only specialty that is not captured by NSQIP.

The categories within Surgical Specialty were defined based on a variety of associated keywords/concepts mostly related to surgical procedure or anatomy. For example, 'General Surgery' consisted of derivatives of the following keywords: general surgery, colorectal, hepatic, and cholecystectomy. It should be noted that journal names often include the surgical specialty relevant to each article. Therefore, an exception was made where journal names were also searched based on Surgical Specialty categories. A list of the main categories and examples of their associated sub-categories can be found in Table 1.

Manuscript I: Table 1. Category Definition Examples for Surgical Specialty

Main Category	**Category Definitions Examples**
Cardiac Surgery	Cardiac Surgery, valve replacement, pacemaker, coronary artery bypass…
General Surgery	General Surgery, bariatric, mastectomy, colorectal…
Otolaryngology and Head and Neck Surgery	Otolaryngology, rhinology, tracheostomy, glossectomy…
Orthopedic Surgery	Orthopedic, fusion, meniscectomy, joint replacement…
Plastic Surgery	Plastic, aesthetic, craniofacial, breast reconstruction, tissue transfer…
Pediatric Surgery	Pediatric, adolescent, children, neonatal…
Vascular Surgery	Vascular, abdominal aortic aneurysm, infrainguinal bypass, endovascular…
Thoracic Surgery	Thoracic, diaphragmatic, thoracoscopy, pleurectomy…
Podiatry	Podiatry
Dentistry	Dentistry
Oro-Maxillofacial Surgery	Maxillofacial
Transplant Surgery	Transplant
Urology	Urology, cystectomy, nephrectomy, prostatectomy…
Surgical Oncology	Cancer, metastatic, chemotherapy, neoplasm…
Obstetrics and Gynecology	Gynecology, oophorectomy, colpopexy, hysterectomy…
Neurosurgery	Neurosurgery, craniotomy, ventricular shunt, temporal lobectomy…
Anesthesia	Anesthesia, analgesia
Unknown	No categories identified

Study Type categories were initially defined using previously published ontology. [13] The categories found to be transferrable to the current study included: Association, Characteristics, Estimates, Surveillance, Risk, Utilization, Implementation, Prediction, Methodology, Evaluation. Additional relevant categories were developed using the previously described approach, which included: Education, Economics, Outcomes, and Adverse Events. Like the Surgical Specialty categories, each of the Study Type categories were defined based on a variety of associated keywords/concepts. For example, the Utilization main category consisted of derivatives of some the following keywords: utilization, usage, services, and access. A list of the main categories and their associated sub-categories can be found in Table 2.

Manuscript I: Table 2. Category Definition Examples for Study Type

Main Category	**Category Definition Examples**
Association	Association, Relationship, Differences, Comparison, Correlation, Disparities, Effect…
Characteristics	Characteristics, Determinants, Burden, Classification, Descriptive…
Estimates	Estimates, Prevalence, Incidence, Occurrence…
Surveillance	Surveillance, Trends, Pattern, Update, Screening…
Risk	Risk, Frailty Index, Score…
Utilization	Utilization, Usage, Access, Services, Treatment…
Implementation	Implementation, Application, Planning, Management…
Prediction	Prediction
Methodology	Methodology, Algorithm, Derive, Design, Develop…
Evaluation	Evaluation, Validation, Accuracy, Reliability, Impact…
Education	Education, Training, Curriculum, Learning…
Economics	Compensation, Reimbursement, Payment, Billing, Cost…
Outcomes	Outcomes, Mortality, Morbidity, Readmission, Length of Stay, Reoperation, Discharge…
Adverse Events	Adverse, Complications, Infections…
Unknown	No categories identified

Data Analysis

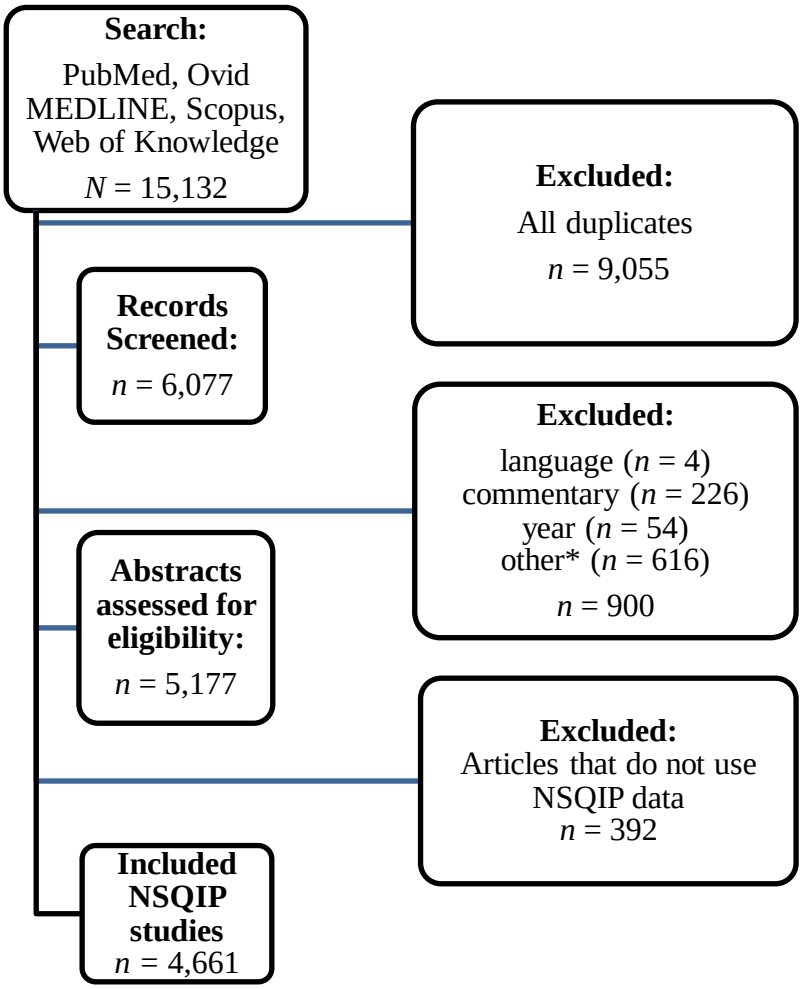
Synthesis was used to quantify the frequency of each of the main categories within the Surgical Specialty and Study Type themes. The total number of NSQIP articles were identified per year between 2005 and 2020 to describe the growth of the NSQIP literature. A heat map was created to visualize and identify Study Type publication patterns by Surgical Specialty.

RESULTS

Study Selection

An electronic search was conducted on February 11, 2021, which produced a total of 15,132 articles using PubMed, MEDLINE, Web of Knowledge and Scopus (Figure 1). A total of 6,077 remained once duplicates were removed. An additional 900 articles were excluded because studies were performed out of the target years, did not contain NSQIP in the title or abstract, or were not in the English language. All letters, editorials, commentaries, books, or book chapters were removed. Articles were then screened in the title and abstract to determine their relevance to the study. A total of 4,661 articles were deemed eligible for this scoping review. The interrater reliability for screening titles and abstracts was near perfect with a Cohen's κ of 0.84.

Manuscript I: Figure 1. Flow Diagram

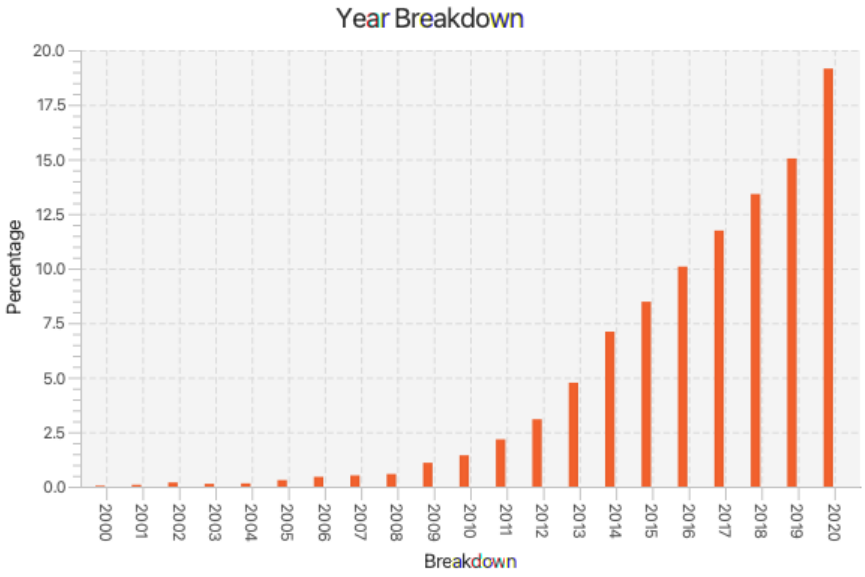


Other*: missing abstract, no NSQIP in title or abstract, conference abstracts, erratum, commentary, books or book chapters

Study Characteristics

Of the 4,661 articles, 77.9% (3,631 articles) were published within the last five years and 893 (19%) were published in 2020 alone (2015-2020; Figure 2). Overall, 52 (1.1%) of articles could not be categorized based on either Study Type or Surgical Specialty.

Manuscript I: Figure 2. Distribution of NSIP articles per year.



The most common Surgical Specialty reported within published NSQIP articles were ‘General Surgery’ (35.7%, *n* = 1,666) and ‘Orthopedic Surgery’ (24.0%, *n* = 1,120) (Table 3). The next most common were ‘Surgical Oncology’ (12.0%, *n* = 560) and ‘Vascular Surgery’ (8.1%, *n* = 378). The next natural grouping of specialties based on percentages consisted of ‘Pediatric Surgery’ (6.2%, *n* = 290), ‘Plastic Surgery’ (6.1%, *n* = 286), ‘Otolaryngology and Head and Neck Surgery’ (5.5%, *n* = 255), ‘Neurosurgery’ (5.2%, *n* = 243), ‘Urology’ (4.9%, *n* = 228), ‘Obstetrics and Gynecology’ (4.1%, *n* = 190), ‘Anesthesia’ (3.7%, *n* = 172), and ‘Thoracic Surgery’ (2.3%, *n* = 109). There were very few articles related to ‘Cardiac Surgery’ (0.6%, *n* = 28), ‘Oro-Maxillofacial Surgery’ (0.2%, *n* = 7), and ‘Transplant Surgery’ (0.1%, *n* = 6). There were no articles published in ‘Podiatry’, or ‘Dentistry’. Overall, there was no relevant Surgical Specialty identified in 509 articles (10.9%). Nearly 30% (1,244) of all articles were multidisciplinary and were labelled with two or more specialties.

Manuscript I: Table 3. Number of Articles Published by Surgical Specialty Category

Surgical Specialty	**Articles Published (%)**
Cardiac Surgery	28 (0.6%)
General Surgery	1666 (35.7%)
Otolaryngology and Head and Neck Surgery	255 (5.5%)
Orthopedic Surgery	1120 (24.0%)
Plastic Surgery	286 (6.1%)
Pediatric Surgery	290 (6.2%)
Vascular Surgery	378 (8.1%)
Thoracic Surgery	109 (2.3%)
Podiatry	0 (0.0%)
Dentistry	0 (0.0%)
Oro-Maxillofacial Surgery	7 (0.2%)
Transplant Surgery	6 (0.1%)
Urology	228 (4.9%)
Surgical Oncology	560 (12.0%)
Obstetrics and Gynecology	190 (4.1%)
Neurosurgery	243 (5.2%)
Anesthesia	172 (3.7%)
Unknown	508 (10.9%)

* Articles may fall under more than one category.

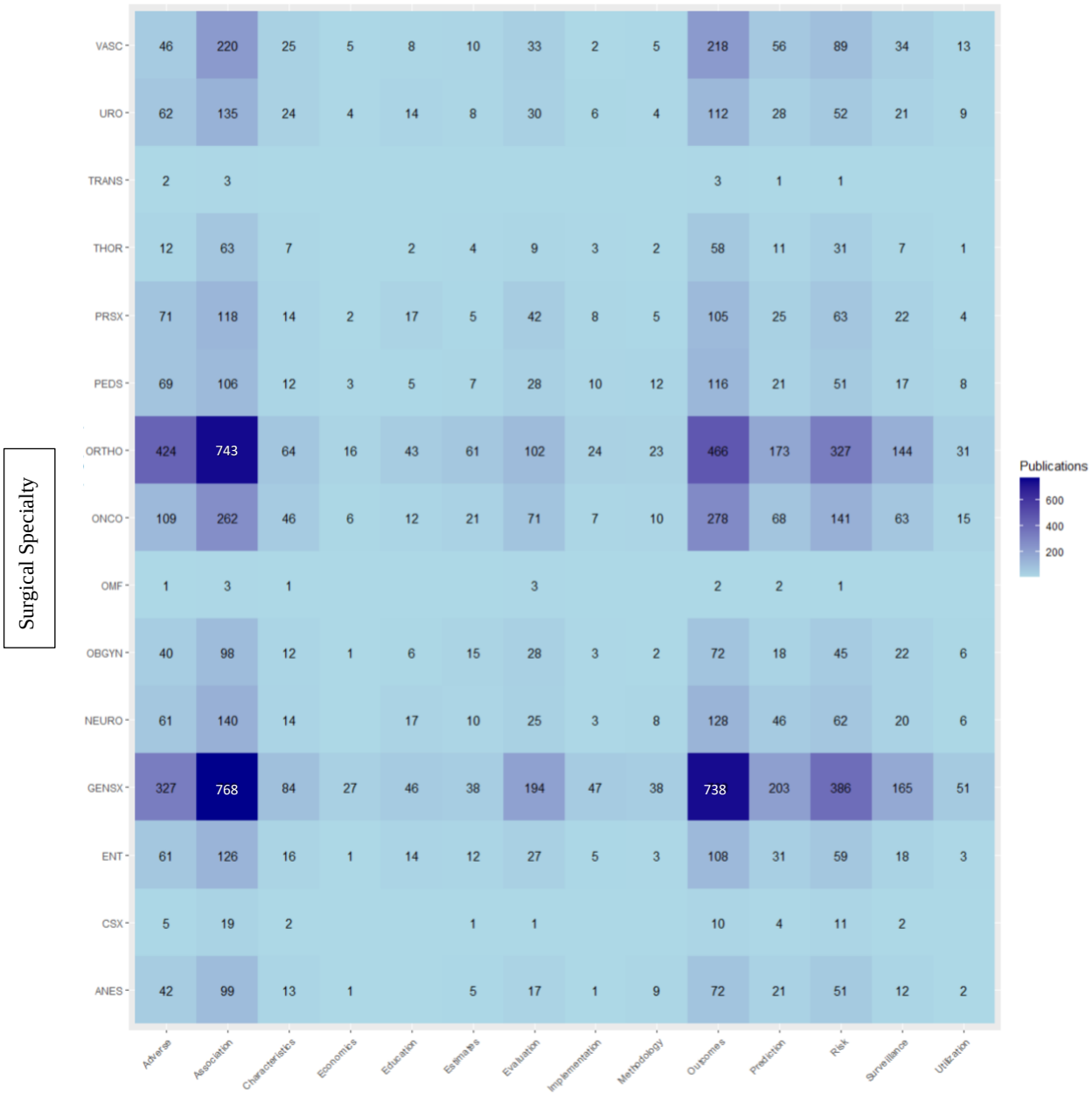
The most common Study Type of published NSQIP articles were based on ‘Outcomes’ (46.7%, *n* = 2,179) and ‘Association’ (41.7%, *n* = 1,944) (Table 4). The next most common were on ‘Adverse Events’ (32.5%, *n* = 1,515) and ‘Risk’ (25.3%, *n* = 1,177). The next natural grouping of Study Types based on percentages consisted of ‘Prediction’ (13.0%, *n* = 606), ‘Evaluation’ (11.8%, *n* = 548), ‘Characteristics’ (11.4%, *n* = 533), and ‘Surveillance’ (8.7%, *n* = 407). There were few articles relating to ‘Education’ (4.5%, *n* = 208), ‘Estimates’ (3.6%, *n* = 167), ‘Methodology’ (2.7%, *n* = 128), ‘Utilization’ (2.6%, *n* = 122), ‘Implementation’ (2.3%, *n* = 107), and ‘Economics’ (1.8%, *n* = 82). Overall, the Study Type was ‘Unknown’ in 375 articles (8.0%). Within ‘General Surgery’ articles, the most common Study Type was ‘Association’, followed by ‘Outcomes’, ‘Adverse Events’, and ‘Risk’ (Figure 3). Within Orthopedic Surgery, the most common Study Type was ‘Association’, followed by ‘Adverse Events’, ‘Outcomes’, and ‘Risk’ (Figure 3). Of the 4,286 labeled articles, 2,936 (68.5%) fell under two or more Study Types.

Manuscript I: Table 4. Number of Articles Published by Study Type Category

Study Type	**Articles Published (%)**
Association	1944 (41.7%)
Characteristics	533 (11.4%)
Estimates	167 (3.6%)
Surveillance	407 (8.7%)
Risk	1177 (25.3%)
Utilization	122 (2.6%)
Implementation	107 (2.3%)
Prediction	606 (13.0%)
Methodology	128 (2.7%)
Evaluation	548 (11.8%)
Education	208 (4.5%)
Economics	82 (1.8%)
Outcomes	2179 (46.7%)
Adverse Events	1515 (32.5%)
Unknown	375 (8.0%)

* Articles may fall under more than one category.

Manuscript I: Figure 3. Distribution NSQIP Publications Study Type by Surgical Specialty.



DISCUSSION

This scoping review identified that a total of 4,661 NSQIP articles were published between 2005 and 2020, and that 19% of all articles were published in 2020. Overall, 78% of these articles were published within the last five years, which demonstrates an upward trend in the volume of NSQIP literature and reflects that the number of publications utilizing NSQIP-derived data is rapidly growing. This finding may also suggest that NSQIP is being more widely adopted by hospitals and surgical specialties to benchmark performance and that the data being collected by these centers are being used to identify areas of improvement.

Highlighting areas of low performance can provide participating hospitals the opportunity to develop quality improvement initiatives, which can reduce adverse events and improve patient outcomes. For example, a 2009 study which included 118 NSQIP hospitals found that 80% of participating sites reported a decrease in complication rates and two thirds saw a significant decrease in mortality after the adoption of NSQIP. [15] NSQIP has continued to evolve and there are now similar versions of the database, such as the Trauma Quality Improvement Program (TQIP) and NSQIP-Pediatric, which were not included in the current scoping review. Other widely recognized databases used to monitor surgical outcomes include the National Inpatient Sample (NIS) [16] and the National Cancer Database (NCDB). [17] However, an advantage unique to NSQIP is that it was specifically designed with the intention to be used for quality improvement and the data are collected from patient medical charts. In contrast, the NIS database was designed for reimbursement purposes and data are based on insurance claims. [16] It is important to consider the purpose behind the creation of a database, as this influences sampling procedures, patient populations, and collected variables. Studies have shown that administrative and claims-based data are limited, inconsistent, and subject to misinterpretation when used for quality

improvement. [18] For example, a study comparing NSQIP data to administrative and claims data found that NSQIP identified 61% more complications, including 97% more surgical site infections. [19] Although the NCDB data are collected from patient charts, the data only concern malignant neoplastic diseases and are not as broad as NSQIP. [17]

In this scoping review, General Surgery and Orthopedic Surgery were found to be the most published Surgical Specialty within the NSQIP literature, representing 35.7% and 24.0% of the articles, respectively. These findings are not surprising, as General Surgery and Orthopedic Surgery are among the largest surgical specialty groups. General Surgery also arguably developed NSQIP, as well as other QI databases such as TQIP, NSQIP-Pediatric, and the NCDB. [3] The American Academy of Orthopedic Surgeons (AAOS) has also strongly emphasized the importance of optimizing patient care with clinical practice guidelines. [3] Therefore, several QI initiatives and registries have been developed for the specialty, with a focus on joint replacements, spine surgery, and trauma.

While this scoping review also found several other surgical specialties have been actively involved in quality improvement initiatives using NSQIP, very few articles were related to Cardiac Surgery, Oro-Maxillofacial Surgery, and Transplant Surgery, and none were published by Podiatry or Dentistry. While the underlying reasons are unknown, the fewer number of publications may relate to the smaller number of surgeons in these specialties, compared to General Surgery and Orthopedic Surgery. Similar to Ophthalmology, it is also possible that these specialties may participate in QI initiatives outside of NSQIP, as the clinical outcomes captured by NSQIP may not be relevant indicators of quality for certain specialties. The NSQIP database focuses on traditional clinical measures of surgical quality, such as mortality, postoperative complications, length of stay, and readmission rates. These data are objective, easily accessible,

quantifiable, and can be interpreted by both patients and physicians. However, it is important to recognize that surgery has become exceedingly safe, and many surgeries are now performed on an outpatient basis with fewer complications requiring readmission or inpatient care. Many surgeries are also performed for improvement in symptoms, such as function, quality of life, and pain relief. Consequently, several of the quality indicators relevant to these procedures rely on different methods, such as patient-reported outcomes, which are currently not captured by NSQIP. Therefore, NSQIP may be of wider use if its outcome measures were tailored by specialty or procedure.

In this scoping review, Outcomes (46.7%) and Association (41.7%) were the most common Study Types found in the NSQIP literature. These findings are as expected, since NSQIP was designed with the intention of exploring associations between different risk factors and adverse events to improve surgical outcomes. Other Study Types, such as Education and Economics, were identified, demonstrating other unique applications of NSQIP.

An inherent limitation of performing a scoping review is the overlap among articles. As previously described, nearly 30% of all articles were multidisciplinary (i.e., were labeled by two or more surgical specialties) and nearly 70% of all articles fell under two or more study types. While potential overlap is to be expected in a scoping review, it is important to highlight its potential limitations with interpretation. Future studies may consider quantifying Study Type and Surgical Specialty over years in proportionality to provide a trend rather than a cumulative count. It would also be important to evaluate the precision of Synthesis in labeling Study Types based on words found in the title alone. Due to the subjective nature of the decisions made regarding category groupings, the authors shared category definitions in the Supplemental Content to be transparent about any potentially subjective decisions that were made regarding data analysis.

Despite potential subjectivity, existing definitions are easily modifiable. The definitions used in this study have been included in the Supplemental Content 1 and 2 for readers to understand the position of authors and determine any potential bias in reporting and recommendations. Finally, it is important to note that some articles could not be categorized based on their title alone. For example, the title: "O'Surgery case log data, where art thou?" by Patel et al [23] does not identify a Surgical Specialty or Study Type and cannot be categorized. In a similar fashion, 52 (1.1%) of all articles remained unknown.

Despite the growing number of NSQIP-related publications, there is limited collated information as to the type of research being conducted and the topics of articles being published. This scoping review offers insight into over 4,000 published articles while describing a novel approach using text data mining to categorize surgical quality improvement topics based on academic publication titles. A scoping review was chosen as a valid approach for our study given its ability to address the entire range of material within the existing NSQIP literature – an objective that could not have been met by a systematic review. A systematic review provides an answer to a well-defined question by selecting and critically appraising research through the extraction and analysis of data from articles included in the review. A scoping review is similar to a systematic review in that they follow a structured process. However, they are performed for different reasons. Scoping reviews are typically used to identify types of available evidence in a given field, examine how research is being conducted on a certain topic, and can be used to identify knowledge gaps. In comparison to a systematic review, a scoping review does not assess the quality of studies included and focuses on breadth rather than the depth in the summary of findings. Pre-existing systematic and scoping reviews on the NSQIP literature have been limited to a much narrower focus, such as specific patient populations, surgical specialties, and

procedures within NSQIP. [6-10] Although this scoping review does not capture findings in as much detail as a systematic review, the use of Synthesis allowed for the interpretation of large volumes of data and has produced a much larger review than has been feasible in the past, allowing for a more complete picture of the existing NSQIP literature. It is important to note that this study did not include grey literature. However, most grey literature involves commentary (e.g., letters, discussions, etc.) and therefore would not have met the study inclusion criteria.

In addition to describing the scope of the published literature, this study has allowed us to identify gaps in the surgical quality and safety literature that could be addressed within and across specialties. As previously mentioned, this study identified a paucity of articles on Implementation, Utilization, Estimates, Education, and Economics. Although NSQIP is primarily used to report adverse events and outcomes, future studies should maximize its use by conducting other study types. For example, NSQIP can be used to evaluate the effects of implementing an intervention, utilizing new techniques or devices, or can help estimate cost effectiveness. The findings from this study also suggest a need for greater engagement from Transplant Surgery, Oro-Maxillofacial Surgery, and Cardiac Surgery with NSQIP data.

Most notably, our study highlights the usefulness of Synthesis and demonstrates how it can facilitate the undertaking of large scoping reviews by semi-automating data management. The topic definitions described in the current study may be applied to other surgical databases, such as the NIS and NCDB, to perform similar analyses. This may quickly and efficiently help identify areas of focus for large quality and safety and other health care research organizations.

Similar to Synthesis, several software tools have been developed to facilitate title and abstract screening. These tools all vary based on style, scope, and cost. The most popular software tools in the world of systematic reviews within healthcare research include Rayyan

(http://rayyan.qcri.org/) and Covidence (https://www.covidence.org/). [20-22] Similar to Synthesis, these tools can identify and remove duplicates, support multiple projects, as well as have include and exclude options. [21] While Rayyan does not support data extraction, Covidence does. Similar to Synthesis, both tools also search citations, categorize and label references, and blind screeners to the decisions of others. Future studies should consider conducting a feature analysis to evaluate how Synthesis compares to these commonly used software applications. Nonetheless, the application of Synthesis and similar software tools are vast, as it can allow investigators the advantage of searching large databases for definitions, cataloguing articles, and performing a quantitative analysis. This in turn can help quality and safety organizations quickly and efficiently identify gaps within any desired body of literature.

CONCLUSION

Since its inception at the beginning of the 21st century NSQIP has been widely used to examine outcomes and support quality improvement in surgery. The current scoping review provides a novel approach using data text mining for categorizing NSQIP article topics based on the titles of academic publications. This study categorized the NSQIP literature according to Surgical Specialty and Study Types, for which topic definitions could be applied to other surgical databases. General Surgery and Orthopedic Surgery were found to be the most common surgical specialties within the NSQIP literature. Outcomes and Association were the most common Study Type, which is expected given this is the premise behind NSQIP. This study identified very few articles published on Transplant Surgery, Cardiac Surgery, and Oro-Maxillofacial Surgery. Future studies should aim to increase the involvement and representation by these specialties. Furthermore, very few articles were published on ‘Implementation’,

‘Utilization’, ‘Estimates’, ‘Education’, or ‘Economics’. Future studies should maximize the use of NSQIP by conducting other study types. Finally, the results of this study demonstrate how Synthesis can be applied more broadly to scoping reviews to identify gaps more quickly and efficiently within any desired body of literature.

REFERENCES

1. Debas H, R G, C M, A. T. *Surgery. Disease control priorities in developing countries. .* Jamison D, ed. ed. Oxford University Press; 2006.

2. Organization. WH. WHO guidelines for safe surgery 2009: safe surgery saves lives. *Geneva: World Health Organization*. 2009;

3. American College of Surgeons. ACS National Surgical Quality Improvement Program (ACS NSQIP). Accessed March 13, 2021. https://www.facs.org/quality-programs/acs-nsqip

4. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *Journal of the American College of Surgeons*. 2013;217(5):833-842. e3.

5. American College of Surgeons. The ACS NSQIP Surgical Risk Calculator. Accessed March 13, 2021. https://riskcalculator.facs.org/RiskCalculator/

6. Marjoua Y, Xiao R, Waites C, Yang BW, Harris MB, Schoenfeld AJ. A systematic review of spinal research conducted using the National Surgical Quality Improvement Program. *The Spine Journal*. 2017;17(1):88-95.

7. Yolcu Y, Wahood W, Alvi MA, Kerezoudis P, Habermann EB, Bydon M. Reporting Methodology of Neurosurgical Studies Utilizing the American College of Surgeons-National Surgical Quality Improvement Program Database: A Systematic Review and Critical Appraisal. *Neurosurgery*. 2020;86(1):46-60.

8. Mahmoud S, Dong Y, Loloi J, Gruson KI. Are perioperative complications and clinical outcomes following reverse shoulder arthroplasty adversely affected by obesity?: a systematic review. Elsevier; 2020:

9. Ornaghi PI, Afferi L, Antonelli A, et al. Frailty impact on postoperative complications and early mortality rates in patients undergoing radical cystectomy for bladder cancer: a systematic review. *Arab Journal of Urology*. 2020:1-15.

10. Bernatz JT, Anderson PA. Thirty-day readmission rates in spine surgery: systematic review and meta-analysis. *Neurosurgical focus*. 2015;39(4):E7.

11. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International journal of social research methodology*. 2005;8(1):19-32.

12. Peters M, Godfrey C, McInerney P, Soares CB, Khalil H, Parker D. Methodology for JBI scoping reviews. *The Joanna Briggs Institute Reviewers Manual 2015*. Joanna Briggs Institute; 2015:3-24.

13. Yergens DW, Dutton DJ, Fiest KM. Automated Identification of National Health Survey Research Topics in the Academic Literature. *Studies in health technology and informatics*. 2017;235:211-215.

14. Ritchie J, Spencer L, Bryman A, Burgess R. Qualitative data analysis for applied policy research. *Analyzing qualitative data*. 1994;173:194.

15. Hall BL, Hamilton BH, Richards K, Bilimoria KY, Cohen ME, Ko CY. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals. *Annals of surgery*. 2009;250(3):363-376.

16. Houchens R, Ross D, Elixhauser A, Jiang J. Nationwide inpatient sample (NIS) redesign final report. *HCUP Methods Ser Rep*. 2014;4

17. American College of Surgeons. National Cancer Database. Accessed March 13, 2021. https://www.facs.org/Quality-Programs/Cancer/NCDB

18. Iezzoni LI. Assessing quality using administrative data. *Annals of internal medicine*. 1997;127(8_Part_2):666-674.

19. Steinberg SM, Popa MR, Michalek JA, Bethel MJ, Ellison EC. Comparison of risk adjustment methodologies in surgical quality improvement. *Surgery*. 2008;144(4):662-669.

20. Couban R. Covidence and Rayyan. *Journal of the Canadian Health Libraries Association/Journal de l'Association des bibliothèques de la santé du Canada*. 2016;37(3)

21. Harrison H, Griffin SJ, Kuhn I, Usher-Smith JA. Software tools to support title and abstract screening for systematic reviews in healthcare: an evaluation. *BMC medical research methodology*. 2020;20(1):1-12.

22. McKeown S, Mir ZM. Considerations for conducting systematic reviews: evaluating the performance of different methods for de-duplicating references. *Systematic reviews*. 2021;10(1):1-8.

23. Patel MB, Guillamondegui OD, Ott MM, Palmiter KA, May AK. O'surgery case log data, where art thou? *Journal of the American College of Surgeons*. 2012;215(3):427-431.

BRIDGE TO MANUSCRIPT II

Health care organizations traditionally functioned in silos, with each discipline acting independently of each other. Before modern communication technologies, many surgeons worked in isolation without sharing practice and technical details with each other. [28] Since surgeons were viewed as autonomous professionals, individual surgeons were often blamed for adverse outcomes and were subjected to corrective action. [28] This approach distracted from any serious attempts to understand the underlying factors that can lead to such adverse outcomes.

The National Surgical Quality Improvement Program (NSQIP) is a collaborative attempt to identify and address system errors and other factors inhibiting the delivery of optimal patient care. NSQIP permits surgeons around the world to share important information about advances in surgical care and is part of the collective commitment to foster a culture focused on quality, safety, and high reliability. Understanding the investigations that have come from NSQIP further allows leaders in the QI movement, such as surgical chairs and SQOs, to further develop and refine quality and safety programs in their departments.

As previously identified in the scoping review of the NSQIP literature in Manuscript I, only 4.9% of all articles were related to Urology. While the underlying reason for fewer publications is unknown, Manuscript II of this thesis adds to the current to body of urological content within the NSQIP literature. The manuscript also aims to demonstrate firsthand the application of NSQIP data and how it can be used to investigate a quality improvement intervention. More specifically, the second manuscript within this thesis investigated the effect of a multimodal clinical pathway on radical cystectomy outcomes at a participating NSQIP site within our institution.

Manuscript II:

Implementation of a Clinical Pathway for Radical Cystectomy – A NSQIP Analysis

Cynthia Mardinger, Chel Hee Lee, Mary Brindle, Frankie Fraulin, Lea Austen, John Kortbeek, Eric Hyndman

ABSTRACT

Background: Radical cystectomy (RC) is standard of care for bladder cancer that is muscle-invasive or recurrent and refractory to treatment. Despite a high risk of morbidity and mortality, adverse events associated with RC have remained relatively unchanged for almost a decade.

Objective: This study investigates the effect of a multimodal clinical pathway on morbidity and mortality among RC patients.

Methods: Our institution adopted the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) in 2015 and a multimodal clinical pathway for RC was implemented in February 2016 to reduce adverse surgical events. The NSQIP database (2015-2019) was queried for RC cases at our institution. Demographic characteristics, medical comorbidities, and intraoperative characteristics were collected to establish a baseline. Primary outcomes included 30-day procedure related complications and mortality. Stepwise generalized linear regression models were used to study all outcomes of interest.

Results: Two hundred and sixty patients (35 pre-pathway and 225 post-pathway) were included. Implementing a clinical pathway was associated with decreased operative time by 33 minutes (267 ± 79.7 minutes vs. 234 ± 62.0 minutes, $p<0.01$), decreased length of stay by four days (10.20 $\pm$ 6.72 days vs. 14.20 $\pm$ 8.40 days, $p < 0.01$), and a 57% reduction in the risk of postoperative complications (B -0.85; 95%CI -1.65, -0.05; $p<0.05$). Complications included infections, excessive blood loss requiring blood transfusions, pulmonary embolism, deep vein thrombosis, respiratory failure requiring unplanned intubation, renal failure, cerebrovascular

accidents, cardiac arrest, among several others. There were no significant differences in 30-day readmission, reoperation, or mortality rates.

Conclusion: This study demonstrates how a multimodal clinical pathway significantly improves LOS and complications among RC patients. Although quality improvement has traditionally focused on postoperative interventions, clinical pathways that include preoperative medical optimization and intraoperative management can synergistically reduce morbidity associated with major surgery.

INTRODUCTION

Radical cystectomy with neoadjuvant chemotherapy is standard of care for patients with muscle invasive bladder cancer. [1,2] It is considered one of the most morbid urological procedures and has been associated with a high risk of morbidity and mortality. [3,4] Despite advancements in technology, surgical technique, and anesthesia, perioperative outcomes following radical cystectomy have remained relatively unchanged over the past decade. Complications are still reported in as many as 64% of cases [3,5-7] including bleeding, infection, and venous thromboembolism with a significant proportion occurring after discharge. [6] One in four patients who undergo radical cystectomy for bladder cancer are readmitted [3,8,9] and approximately 5% of all patients require reoperation within 30 days of discharge. [10-12] Given the high morbidity associated with radical cystectomy, several initiatives have been implemented to better optimize surgical care.

Clinical pathways such as enhanced recovery after surgery (ERAS) protocols were first introduced in the 1990s to accelerate recovery and reduce morbidity associated with colorectal surgery by using standardized, evidence-based perioperative care. [13] Protocols such as ERAS have since been implemented for other major surgeries, including radical cystectomy. [14] A recent meta-analysis reported that ERAS protocols decreased length of stay, postoperative complications, and rates of readmission in patients who underwent radical cystectomy for bladder cancer. [15]

Given the high risk associated with radical cystectomy, actionable targets for improvement must be identified and tailored interventions must be implemented to optimize surgical care. The National Surgical Quality Improvement Program (NSQIP), an outcomes-based program, is an initiative which was designed to measure and improve the quality of surgical care.

This study investigated the effect of a multimodal clinical pathway on the complication rate and mortality among patients undergoing radical cystectomy for bladder cancer using NSQIP data collected at our institution.

METHODS

Study Population

A tertiary urban hospital and regional centre for Urology was selected as one of the five acute care facilities within a provincial health authority to adopt NSQIP as part of a pilot study in 2015. Data from this centre were prospectively collected using NSQIP between January 1, 2015 and December 31, 2019. Two-hundred and sixty-three consecutive patients aged $\geq$ 18 years undergoing radical cystectomy for bladder cancer were identified. A multimodal clinical pathway was implemented in February 2016 and included preoperative, intraoperative, and postoperative items. Patients who underwent radical cystectomy before February 2016 were defined as the "pre-pathway" group, and those who underwent radical cystectomy after February 2016 were defined as the "post-pathway" group. Patients missing all data (n = 2) and those with complications present at the time of surgery (n = 1) were removed from the dataset. The remaining 260 patients were used in the final analysis of this study.

This study was evaluated by our institutional ethics review board, the Health Research Ethics Board of Alberta, who identified this study as quality improvement study. Studies from the NSQIP database are considered exempt by the institutional review board.

Clinical Pathway

All patients undergoing radical cystectomy at our institution followed a multimodal clinical pathway that was developed locally by a multiprofessional stakeholder team following ERAS principles. [14] This clinical pathway contained preoperative, intraoperative, as well as postoperative elements (See Supplemental Content 5 in the Appendices for full details).

Preoperative

Each patient attended a preoperative anesthesia consult and received education and counseling, including ostomy teaching. Patients were referred to internal medicine to optimize common medical conditions and met with a dietitian for malnutrition screening and dietary counseling. Preoperative carbohydrate loading was encouraged to maintain muscle and lean body mass, decrease thirst, and insulin resistance. [16] Patients were permitted to have solid food up to six hours and liquids up to two hours before surgery. [17] Oral mechanical bowel preparation was safely omitted [18,19] and long-acting sedating pre-anesthesia medications such as benzodiazepines were avoided. [16] All patients received subcutaneous heparin during surgery and enoxaparin the day of surgery as thromboprophylaxis unless there was an increased bleeding risk, given the risk of deep vein thrombosis post-cystectomy. [20]

Intraoperative

All patients received antimicrobial prophylaxis and standard general anesthesia using short-acting anesthetic agents intraoperatively. Multimodal opioid-sparing analgesia was used as baseline treatment. Adequate lung ventilation was maintained to reduce the risk of barotrauma and hypoxia. Normal body temperature was maintained to prevent hypothermia. Intravenous

fluids were minimized to reduce possible ileus and other complications, such as increased blood loss. [21,22] However, sufficient fluid was given to minimize postoperative nausea and vomiting. Surgical approach was based on surgeon and patient preferences. Sequential compression devices (SCD) were used to further reduce the risk of thrombosis. [16]

Postoperative

Early oral diet and early ambulation were encouraged. Vital signs were taken routinely. Oxygen saturation was maintained above 90% and incentive spirometry was encouraged. Fluid intake and output was monitored to maintain a urine output above 30ml per hour with conditional bolus orders if the output was unsatisfactory. Patients received intravenous cefazolin preoperatively and subcutaneous enoxaparin daily. SCDs were discontinued when the patient was mobilizing well. Oral acetaminophen and gabapentin were used as baseline analgesia. Patients received daily oral pantoprazole and ranitidine and antiemetics were administered as needed. Patients received daily docusate sodium, sennosides, and alvimopan until the patient had a bowel movement. Home medications were resumed, and diabetic patients were started on a low-volume insulin protocol. Dressings were removed and patients were assessed by an enterostomal therapist (ET) on day one. Drains were removed by day three, and stents and staples were removed on day seven.

Discharge and Follow-Up

A physician assistant (PA) met each patient in the preoperative period, assisted in the operating room, followed patients on the unit daily, and acted as a liaison and point of contact for nursing staff and families. Discharge planning was discussed daily. Teaching documents were

reviewed with patients and their families, and logistics for patient departure were finalized on postoperative day seven. Patients received follow-up by the PA by phone at two weeks, three months, six months, and nine months postoperatively. Patients met with an ET and the PA on postoperative day 22 for postoperative review.

Data Collection

Data were prospectively collected between January 1, 2015, and December 31, 2019, using the ACS-NSQIP Participant Use Data File (PUF). Patients who underwent radical cystectomy for bladder cancer were included using Current Procedural Terminology (CPT) codes for radical cystectomy (51595, 51590, 51596, 51597). Data were extracted through a combination of both automated data collection as well as trained surgical clinical reviewers. Although NSQIP is the source of data used in this analysis, NSQIP has not reviewed the methodology of this study and is not responsible for its content.

Variables

Patient demographics and preoperative medical comorbidities included: age, body mass index (BMI), gender, diabetic status (insulin dependent vs non-insulin dependent vs none), smoking history, dyspnea, functional status (independent vs partially dependent), ventilator dependence, chronic obstructive pulmonary disease (COPD), ascites $\leq$ 30 days prior to surgery, congestive heart failure $\leq$ 30 days prior to surgery, hypertension on medication(s), acute renal failure, disseminated cancer, steroid use, greater than 10% weight loss within six months prior to surgery, bleeding disorder, blood transfusion $\leq$ 72 hours prior to surgery, and sepsis $\leq$ 48 hours prior to surgery. Intraoperative variables that were evaluated included operative time, number of

concurrent procedures, urgency, and American Society of Anesthesiologists' classification (ASA class). Postoperative variables included length of stay (LOS), discharge destination, as well as complications, readmission, reoperation, and death within 30 days.

Complications included: wound disruption, infectious complications (superficial incisional infection, deep incisional infection, organ/space infection, C. difficile, urinary tract infection, sepsis, pneumonia) septic shock, respiratory distress requiring unplanned intubation, pulmonary embolism, ventilator requirements >48 hours, progressive renal insufficiency, acute renal failure, cerebrovascular accident, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis (DVT) requiring therapy, end of life/withdrawal of care, bleeding requiring transfusions $\leq$ 72 hours of surgery. Criteria for each characteristic are defined in the 2019 NSQIP User's Guide. [23] No information about tumor stage or grade was available.

Outcomes

The primary outcomes were complication rate and mortality. Complications were measured as a composite variable, where patients with one or more postoperative complications were counted. A composite outcome measure was chosen as a method to reduce the granularity of the analysis, since there are several complications captured by NSQIP. Mortality was measured as a death within 30 days of surgery. Secondary outcomes included all other NSQIP variables.

Statistical Analysis

Descriptive statistics were reported as means with standard deviations for continuous variables and percentages for categorical variables. Student's *t*-tests and Wilcoxon Rank-Sum tests were used to analyze continuous variables. Chi-square tests were used to analyze categorical variables. Fisher's exact tests were used when cells had a frequency less than five. [24]

Generalized linear regression models were used to study all outcomes of interest. A negative binomial regression model was performed for LOS and logistic (i.e., binomial) regression models were performed for mortality, complications, readmission, and reoperation rates. A negative binomial regression was used for LOS because it is used to model count data as opposed to binary data. Predictors were screened by univariate regression analysis and were considered for further model development if $p < 0.2$. A fixed value of 0.2 was arbitrarily used as a threshold. Model selection was done with a stepwise approach in order to choose a subset of predictor variables which result in the best performing model. The model with the lowest Akaike Information Criterion (AIC) was selected as the most reasonable model for multivariate regression analysis. [25-27]

Statistical analyses were performed using R version 4.0.1 (R Foundation, Vienna, Austria). *P* values < 0.05 were considered statistically significant. Relevant assumption testing was undertaken prior to conducting each analysis.

Attrition

Of the pre-pathway group, one patient (2.9%) had missing data and one patient (2.9%) did not complete the 30-day postoperative follow-up period. Of the post-pathway group, six

patients (2.7%) had missing data and 19 patients (7.3%) did not complete the 30-day postoperative follow-up period.

RESULTS

Overview

Two hundred sixty patients who underwent radical cystectomy for bladder cancer at our institution were included. Thirty-five patients who underwent cystectomy prior to the implementation of a clinical pathway and were compared with 225 patients who underwent radical cystectomy after the implementation of a clinical pathway.

Demographic Characteristics and Medical Comorbidities

Most patients were functionally independent (98.1%), male (76.5%), and had a mean age of 69 years old (Table 1). The average BMI was 28.0 ± 6.4. Fifty-three (20.4%) patients were diabetic and 62 (23.8%) smoked. Although 15 (5.8%) of patients were dyspneic at baseline, none were ventilator dependent and 11 (4.2%) had a history of severe COPD. No patients were found to have ascites, congestive heart failure, or were on dialysis. However, over half (55.8%) of patients required medications for hypertension. Very few patients had acute renal failure (0.4%), were on steroids (1.9%), had recent significant weight loss (1.5%), or a bleeding disorder (1.5%). One (0.4%) patient had a transfusion within 72 hours leading up to surgery and one (0.4%) patient was septic within 48 hours leading up to surgery.

Of note, patients in the pre-pathway group were found to have more disseminated cancer (17.1% vs. 1.8%, $p = 0.001$) and a higher average BMI (29.3 ± 4.5 vs. 27.8 ± 6.6, $p = 0.05$)

compared with the post-pathway group. Otherwise, both groups had a similar frequency of preoperative medical comorbidities.

Manuscript II: Table 1. Demographic Characteristics and Medical Comorbidities

	Pre-pathway (*n* = 35)	**Post-pathway** (*n* = 225)	**Total** (*n* = 260)	***P* value**
Age (mean ± SD)	69.0 ± 9.0	69.2 ± 10.6	69.2 ± 10.4	0.76
BMI (mean ± SD)	29.3 ± 4.5	27.8 ± 6.6	28.0 ± 6.4	0.05
Gender (%)				1.00
Male	27 (77.1%)	172 (76.4%)	199 (76.5%)	
Diabetic status (%)				0.57
Insulin dependent	2 (5.7%)	13 (5.8%)	15 (5.8%)	
Non-insulin dependent	7 (20.0%)	31 (13.8%)	38 (14.6%)	
None	26 (74.3%)	181 (80.4%)	207 (79.6%)	
Smoking status (%)				0.95
Yes	9 (25.7%)	53 (23.6%)	62 (23.8%)	
No	26 (74.3%)	172 (76.4%)	198 (76.2%)	
Dyspnea (%)				0.08
None	31 (88.6%)	214 (95.1%)	245 (94.2%)	
Moderate exertion	3 (8.6%)	11 (4.9%)	14 (5.4%)	
At rest	1 (2.9%)	0 (0.0%)	1 (0.4%)	
Functional health status (%)				1.00
Independent	35 (100.0%)	220 (97.8%)	255 (98.1%)	
Partially dependent	0 (0.0%)	5 (2.2%)	5 (1.9%)	
Ventilator dependent (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
History of severe COPD (%)	0 (0.0%)	11 (4.9%)	11 (4.2%)	0.37
Ascites ≤ 30 days prior to surgery (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Congestive heart failure ≤ 30 days prior to surgery (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Hypertension requiring medication (%)	20 (57.1%)	125 (55.6%)	145 (55.8%)	1.00
Acute renal failure (%)	0 (0.0%)	1 (0.4%)	1 (0.4%)	1.00
Dialysis (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Disseminated cancer (%)	6 (17.1%)	4 (1.8%)	10 (3.8%)	0.001
Steroid/immunosuppressant use for chronic condition (%)	1 (2.9%)	4 (1.8%)	5 (1.9%)	0.52
>10% loss of body weight in the last 6 months prior to surgery (%)	1 (2.9%)	3 (1.3%)	4 (1.5%)	0.44
Bleeding disorder (%)	1 (2.9%)	3 (1.3%)	4 (1.5%)	0.44
Transfusion ≤ 72 hours prior to surgery (%)	0 (0.0%)	1 (0.4%)	1 (0.4%)	1.00
Sepsis ≤ 48 hours prior to surgery (%)	1 (2.9%)	0 (0.0%)	1 (0.4%)	0.14

Intraoperative Characteristics

Overall, the mean operative time was 239.0 $\pm$ 65.5 minutes. The mean average operative time was shorter by 33 minutes in the post-pathway group ($p < 0.01$) (Table 2). Most procedures were elective (98.1%) and only six patients (2.3%) underwent concurrent procedures. Most patients were of ASA classification 2 (49.6%) or 3 (46.9%).

Manuscript II: Table 2. Intraoperative Characteristics

	Pre-pathway (*n* = 35)	**Post-pathway** (*n* = 225)	**Total** (*n* = 260)	***P* value**
Operative duration (mean minutes ± SD)	267 ± 79.7	234 ± 62.0	239 ± 65.5	0.007
Concurrent procedures (%)	1 (2.9%)	5 (2.2%)	6 (2.3%)	0.59
Urgency (%)				1.00
Elective	33 (94.3%)	222 (98.7%)	255 (98.1%)	
Emergent	2 (5.7%)	3 (1.33%)	5 (1.9%)	
ASA Classification (%)				1.00
1	0 (0.0%)	6 (2.7%)	6 (2.3%)	
2	18 (51.4%)	111 (49.3%)	129 (49.6%)	
3	17 (48.6%)	105(46.7%)	122 (46.9%)	
4	0 (0.0%)	3 (1.3%)	3 (1.2%)	

30-Day Postoperative Complications

Postoperative complications for the subgroup analysis are displayed in Table 3. Postoperative laboratory investigations were also compared between groups (See Supplemental Content 4 in the Appendices for full details). Nearly half (48.6%) of patients in the pre-pathway group developed a complication compared with 30.0% of patients in the post-pathway group (p <0.02). However, the types of complications did not differ between groups. Overall, the most common complications were blood loss requiring transfusion (29.0%), with a mean average of 2.0 ± 1.0 units of blood transfused within 72 hours of surgery, followed by urinary tract infections (19.9%), and sepsis or septic shock (13.1%).

Using multivariate logistic regression, a clinical pathway was found to be associated with a 57% reduction in the risk of postoperative complications (B -0.85; 95%CI -1.65, -0.05; p<0.05) (Table 4). Patients with an abnormal hematocrit were found to have nearly a threefold increase in the odds of developing a postoperative complication (B 1.07; 95%CI 0.48, 1.66; p<0.05). Patients with an ASA classification $\geq$ 3 also had 52% increase in the risk of postoperative complications (B -0.74; 95%CI -1.32, -0.15; p=0.01).

Manuscript II: Table 3. Postoperative Outcomes

	Pre-pathway (*n* = 35)	**Post-pathway** (*n* = 225)	**Total** (*n* = 260)	***P* value**
Length of stay (mean ± SD)	14.2 ± 8.4	10.2 ± 6.7	10.7 ± 7.1	<0.001
Discharge destination (%)				0.70
Home	33 (94.3%)	206 (91.2%)	239 (91.9%)	
Rehabilitation	0 (0.0%)	1 (0.4%)	1 (0.4%)	
Separate acute care	1 (2.9%)	4 (1.8%)	5 (1.9%)	
Deceased	1 (2.9%)	6 (2.7%)	7 (2.7%)	
Death within 30 days (%)	1 (2.9%)	5 (2.2%)	6 (2.3%)	0.58
Readmission within 30 days (%)	9 (25.7%)	41 (18.2%)	50 (19.2%)	0.45
Readmissions related to principal procedure	9 (100.0%)	38 (92.7%)	47 (94.0%)	0.28
Unplanned reoperations within 30 days (%)	0 (0.0%)	12 (5.3%)	12 (4.6%)	0.38
≥ 1 postoperative complication	17 (48.6%)	61 (27.1%)	78 (30.0%)	0.02
Complications				
Wound disruption (%)	1 (2.9%)	10 (4.4%)	11 (4.2%)	1.00
Infection (%)				
Superficial incisional infection	1 (2.9%)	9 (4.0%)	10 (3.8%)	1.00
Deep incisional infection	1 (2.9%)	2 (0.9%)	3 (1.2%)	0.35
Organ/space infection	0 (0.0%)	7 (3.1%)	7 (2.7%)	0.60
C. difficile	0 (0.0%)	4 (1.8%)	4 (1.5%)	1.00
Urinary tract infection	3 (8.6%)	29 (12.9%)	32 (12.3%)	0.78
Sepsis	4 (11.4%)	14 (6.2%)	18 (6.9%)	0.28
Pneumonia	2 (5.7%)	5 (2.2%)	7 (2.7%)	0.24
Septic shock (%)	0 (0.0%)	4 (1.8%)	4 (1.5%)	1.00
Unplanned intubation (%)	0 (0.0%)	3 (1.3%)	3 (1.2%)	1.00
Pulmonary embolism (%)	2 (5.7%)	2 (0.9%)	4 (1.5%)	0.09
Ventilation required > 48 hours (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Progressive renal insufficiency (%)	0 (0.0%)	2 (0.9%)	2 (0.8%)	1.00
Acute renal failure (%)	1 (2.9%)	1 (0.4%)	2 (0.8%)	0.25
Cerebrovascular accident (%)	0 (0.0%)	1 (0.4%)	1 (0.4%)	1.00
Cardiac arrest requiring CPR (%)	0 (0.0%)	2 (0.9%)	2 (0.8%)	1.00
Myocardial infarction (%)	1 (2.9%)	2 (0.9%)	3 (1.2%)	0.35
Deep vein thrombosis requiring therapy (%)	2 (5.7%)	3 (1.3%)	5 (1.9%)	0.14
End of life/withdrawal of care (%)	0 (0.0%)	6 (2.7%)	6 (2.3%)	-
Transfusion ≤ 72hrs of surgery (%)	10 (28.6%)	40 (17.8%)	50 (19.2%)	0.20
Total blood transfused (units)				0.36
0	25 (71.4%)	185 (82.2%)	210 (80.8%)	
1	3 (8.6%)	14 (6.2%)	17 (6.5%)	
2	4 (11.4%)	17 (7.6%)	21 (8.1%)	
3	1 (2.9%)	4 (1.8%)	5 (1.9%)	
4	2 (5.7%)	5 (2.2%)	7 (2.7%)	

Manuscript II: Table 4. Modeling Postoperative Complications Using Multivariate Logistic Regression

	Parameter Estimate (B)	**Standard Error for B**	**OR**	**95% CI**	***P* value**
Intercept	-0.20	0.42	0.82	-1.02, 0.63	0.64
Pathway	-0.85	0.41	0.43	-1.65, -0.05	0.04
Hematocrit (abnormal)	1.07	0.30	2.92	0.48, 1.66	<0.05
ASA Classification $\geq$ 3	-0.74	0.30	0.48	-1.32, -0.15	0.01

30-Day Mortality

One (2.9%) patient in the pre-pathway group died within 30 days of surgery in comparison to five (2.2%) patients in the post-pathway group (Table 3). However, there were no differences in the risk of mortality based on participation in the clinical pathway (Fisher's exact test $p = 0.81$). Age 75 years or greater, abnormal serum sodium, and operative duration of four hours or longer were associated with an increased likelihood of mortality within 30 days of surgery (Table 5).

Manuscript II: Table 5. Modeling Mortality Using Multivariate Logistic Regression

	Parameter Estimate (B)	**Standard Error for B**	**OR**	**95% CI**	***P* value**
Intercept	-4.84	0.75	0.01	-6.30, -3.38	>0.05
Age (≥ 75 years)	1.56	0.66	4.76	0.27, 2.85	0.02
Serum sodium (abnormal)	2.04	0.72	7.69	0.62, 3.46	<0.05
Operative duration ≥ 4 hours	1.45	0.67	4.26	0.15, 2.76	0.03

Length of Stay

Most patients (91.9%) were discharged home as opposed to those sent to rehabilitation, a separate acute care, or deceased. The average mean length of stay (LOS) was 10.7 ± 7.1 days (Table 3). However, LOS was shorter by four days among the post-pathway group compared with the pre-pathway group (10.2 ± 6.7 days vs. 14.2 ± 8.4 days, $p < 0.01$).

A multivariate negative binomial regression estimated that participation in a clinical pathway was independently associated with a decrease in length of stay (B -0.30; 95%CI -0.49, -0.11; p=0.02) (Table 6). Age 75 years or greater, abnormal WBC, and blood transfusions were associated with an increased likelihood of prolonging LOS.

Manuscript II: Table 6. Modeling Length of Stay Using Multivariate Negative Binomial Regression

	Parameter Estimate (B)	**Standard Error for B**	**OR**	**95% CI**	***P* value**
Intercept	2.46	0.10	11.70	2.27, 2.65	<0.05
Pathway	-0.30	0.10	0.74	-0.49, -0.11	<0.05
Age (≥ 75 years)	0.16	0.07	1.17	0.02, 0.30	0.03
White blood cell count (abnormal)	0.19	0.09	1.21	0.02, 0.37	0.03
Total blood transfused (≥ 1unit)	0.26	0.08	1.30	0.09, 0.42	<0.05

30-Day Readmission

Overall, 19.2% of patients experienced a readmission within 30 days of surgery and 94.0% of these readmissions were related to the principal procedure (Table 3). However, there were no estimated differences in the likelihood of readmission based on participation in the clinical pathway (OR 0.66; 95%CI 0.29, 1.59; p=0.45). However, patients with a history of severe COPD had over a five-fold increase in likelihood of readmission (B 1.71; 95%CI 0.48, 2.95; p<0.05) (Table 7).

Manuscript II: Table 7. Modeling Readmission Using Multivariate Logistic Regression

	Parameter Estimate (B)	**Standard Error for B**	**OR**	**95% CI**	***P* value**
Intercept	-1.53	0.17	0.22	-1.86, -1.20	<0.05
History of severe COPD	1.71	0.63	5.53	0.48, 2.95	<0.05

30-Day Reoperation

Twelve (4.6%) patients in the post-pathway group underwent reoperation within 30 days in comparison to zero (0.0%) patients in the pre-pathway group (Table 3). There was no difference in reoperation based on participation in the clinical pathway (Fisher's exact test $p = 0.17$).

DISCUSSION

This study evaluated the effect of a multimodal clinical pathway on morbidity and mortality among patients undergoing radical cystectomy for bladder cancer. Our analysis identified 260 patients who underwent radical cystectomy between 2015 to 2019 using the ACS NSQIP database. Most patients were functionally independent males with a mean age of 69 years. Although more patients in the pre-pathway group had disseminated cancer compared with the post-pathway group, both groups had similar preoperative medical comorbidities. Overall, the average operative time was 240 minutes. The operative time of patients in the post-pathway group was significantly shorter than the pre-pathway group by 33 minutes. Prolonged operative time has been associated with worse outcomes, such as increased complications. [28,29] Our study findings suggest that a clinical pathway can help reduce surgical times, thereby improving quality of care and perioperative outcomes.

Our findings show that the mean length of stay (LOS) decreased by four days after the implementation of a clinical pathway. These findings are consistent with prior studies looking at enhanced recovery pathways. [30-35] Although clinical pathways may encourage an earlier hospital discharge, one of the major criticisms is that early discharge may increase the risk of the rate of readmission. However, our findings suggest that implementing a clinical pathway did not affect the rate of readmission. Prior studies on enhanced recovery pathways in surgery also report no differences in readmission compared to standard perioperative care. [30,36]

We identified several independent predictors associated with increased LOS, including age 75 years or greater, abnormal WBC, and blood transfusions. Our study also identified that age and blood transfusions were also associated with increased likelihood of 30-day mortality. Older age has been associated with adverse events among radical cystectomy patients.[37] Since

patients of greater age with comorbid conditions and poor physiologic reserves are increasingly being offered surgery, several studies have suggested the importance of assessing he functional capacity or cardiopulmonary fitness of patients prior to undergoing major non-cardiac surgery, such as radical cystectomy.[37-39] Preoperative cardiopulmonary exercise testing may be a useful adjunct to enhanced recovery protocols such as the one used in the current study and have possible prognostic value in urological surgery. This is the first study to our knowledge that identified WBC as a predictor associated with increased LOS. However, both WBC and LOS were identified as a predictor of readmission in a previous study. [40] WBC is used as a clinical marker for infection, which may suggest the need for identifying and treating postoperative infections prior to discharge. Blood transfusions have been previously described as predictors of postoperative complications in patients who underwent radical cystectomy. [7,41] These findings highlight the importance of a multi-phase pathway and suggest that actionable targets still exist to improve perioperative management. Strategies aimed to decrease the need for blood transfusion is also necessary to improve the current clinical pathway.

Our complication rate of 30.0% was lower than reported by other groups. However, the most common complications were the need for blood transfusions, urinary tract infections (UTIs), and sepsis or septic shock, which are consistent with previous studies. [6,36] Our study findings suggest that implementing a clinical pathway for radical cystectomy was associated with a 57% reduction in the risk of postoperative complications. Future clinical pathways could consider a change in perioperative antibiotics in effort to decrease the rate of UTIs in this population. For example, a study among patients undergoing radical cystectomy reported a significant improvement in postoperative infections after a change in prophylactic antibiotics was made from cefoxitin to ampicillin-subactam, gentamicin, and fluconazole.[42]

Readmission rates described in previous studies vary between 19.7% and 28.5%, which is consistent with our rate of 19.2%. [7,43-47] Very few studies have demonstrated the importance of each independent risk factor with readmission in the radical cystectomy population. Although the clinical pathway was not associated with readmission, we identified that patients with a history of COPD had a five-fold increase in likelihood of needing readmission. A study by Reese et al [48] also found that COPD was a risk factor for reoperation and patients who underwent reoperation were at higher risk for readmission. These findings suggest that identifying and optimizing treatment in patients with COPD is an important step in the preoperative phase of the clinical pathway to help reduce reoperation and readmission rates.

Implementing a clinical pathway was not associated with reoperation or death within 30 days of surgery. However, it is important to note that postoperative complications can consequently lead to such events. Similarly, complications can also lead to increased LOS. For example, hospital-acquired sepsis can extend hospital stay by as much as 30 days. [49] The current literature has also suggested that timing of complications is an important consideration. A study by Lavallée et al. [6] reported that 16% of complications occurred after discharge from hospital, including 46% of thromboembolic events. This further supports the need for close postoperative follow-up in the clinical pathway. Our clinical pathway includes follow-up by a physician assistant at two weeks, three months, six months, and nine months postoperatively.

Other interesting findings identified in the current study was the increased likelihood of complications among patients with an abnormal hematocrit or an ASA classification ≥ 3, as well as the increased likelihood of mortality among patients with an abnormal serum sodium or operative duration of four hours or longer. While hematocrit may be a surrogate marker of blood loss, serum electrolytes such as sodium should be monitored throughout the perioperative

process and should be included in the current protocol. Continued refinement in surgical techniques should also be considered to decrease blood loss and limit operative time.

Our data add to the growing body of literature with other institutions which have implemented multimodal clinical pathways. Most clinical pathways aim to reduce LOS by optimizing gastrointestinal recovery and reducing the risk of infection or thromboembolic events. Our protocol aims to decrease postoperative ileus by preoperative carbohydrate loading, using opioid-sparing analgesia, as well as encouraging early oral diet and the use of laxatives postoperatively. Thromboembolic events are decreased by using thromboprophylaxis and encouraging ambulation as early as eight hours after surgery. As the implementation of clinical pathways continues to gain traction for radical cystectomy cases, further research is needed to elucidate the elements of the care pathway that are most beneficial.

This study has several strengths worth noting. The NSQIP is a rigorous, nationally validated database that collects data prospectively by a trained surgical clinical reviewer. Although the data are still subject to a small degree of misclassification, the program uses predefined outcomes that have been shown to be highly accurate. [50] Therefore, there is less potential for selection and measurement bias.

Limitations of this study include its non-randomized design and the small sample size of the pre-pathway group. This is in part because the pathway was started just shortly after our institution was selected to participate in NSQIP. Future studies could consider including pre-NSQIP patients to have a more balanced comparison between groups. Finally, it is possible that patients in this study had complications or were readmitted outside our institution and therefore were not captured in the results of this study.

An inherent limitation of using NSQIP is that data are collected within a 30-day postoperative window. Therefore, some complications post-discharge may not have been captured. Another limitation of NSQIP is that some preoperative variables important for bladder cancer are not available, such as tumor stage and previous non-surgical treatments. Future studies should consider collection of these variables, as these may be important risk factors for adverse events.

CONCLUSION

In summary, this study demonstrates how a multimodal clinical pathway among patients undergoing radical cystectomy for bladder cancer can lead to a shorter length of stay and significantly decrease postoperative complications. The findings from this study help elucidate ways to improve the current clinical pathway, including assessing preoperative physiologic fitness, optimizing patients with severe COPD or electrolyte disturbances, emphasizing the need to limit blood transfusion, as well as reducing operative duration. Understanding the relationship between patients who undergo radical cystectomy for bladder cancer and the reasons for increased LOS, complications, readmissions, reoperation, and death is important to guide preoperative counseling, operative planning, and risk-stratification. The findings from this study should be disseminated to key stakeholders to further improve the pathway and study it further, as such multidisciplinary and multi-phase clinical pathways can help reduce morbidity and improve patient outcomes.

REFERENCES

1. Witjes JA, Lebret T, Compérat EM, et al. Updated 2016 EAU guidelines on muscle-invasive and metastatic bladder cancer. *European urology*. 2017;71(3):462-475.

2. Babjuk M, Böhle A, Burger M, et al. EAU guidelines on non–muscle-invasive urothelial carcinoma of the bladder: update 2016. *European urology*. 2017;71(3):447-461.

3. Shabsigh A, Korets R, Vora KC, et al. Defining early morbidity of radical cystectomy for patients with bladder cancer using a standardized reporting methodology. *European urology*. 2009;55(1):164-176.

4. Shariat SF, Karakiewicz PI, Palapattu GS, et al. Outcomes of radical cystectomy for transitional cell carcinoma of the bladder: a contemporary series from the Bladder Cancer Research Consortium. *The Journal of urology*. 2006;176(6):2414-2422.

5. Lawrentschuk N, Colombo R, Hakenberg OW, et al. Prevention and management of complications following radical cystectomy for bladder cancer. *European urology*. 2010;57(6):983-1001.

6. Lavallée LT, Schramm D, Witiuk K, et al. Peri-operative morbidity associated with radical cystectomy in a multicenter database of community and academic hospitals. *PloS one*. 2014;9(10):e111281.

7. Berger I, Xia L, Wirtalla C, Dowzicky P, Guzzo TJ, Kelz RR. 30-day readmission after radical cystectomy: Identifying targets for improvement using the phases of surgical care. *Canadian Urological Association Journal*. 2019;13(7):E190.

8. Altobelli E, Buscarini M, Gill HS, Skinner EC. Readmission rate and causes at 90-day after radical cystectomy in patients on early recovery after surgery protocol. *Bladder Cancer*. 2017;3(1):51-56.

9. Skolarus TA, Jacobs BL, Schroeck FR, et al. Understanding hospital readmission intensity after radical cystectomy. *The Journal of urology*. 2015;193(5):1500-1506.

10. Lyon TD, Boorjian SA, Shah PH, et al. Comprehensive characterization of perioperative reoperation following radical cystectomy. Elsevier; 2019:292. e11-292. e17.

11. Patel HD, Ball MW, Cohen JE, Kates M, Pierorazio PM, Allaf ME. Morbidity of urologic surgical procedures: an analysis of rates, risk factors, and outcomes. *Urology*. 2015;85(3):552-560.

12. Hussein AA, Hashmi Z, Dibaj S, et al. Reoperations following robot-assisted radical cystectomy: a decade of experience. *The Journal of urology*. 2016;195(5):1368-1376.

13. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *British journal of anaesthesia*. 1997;78(5):606-617.

14. Cerantola Y, Valerio M, Persson B, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS®) society recommendations. *Clinical nutrition*. 2013;32(6):879-887.

15. Tyson MD, Chang SS. Enhanced Recovery Pathways Versus Standard Care After Cystectomy: A Meta-analysis of the Effect on Perioperative Outcomes. *European Urology*. 2016;70(6):995-1003. doi:10.1016/j.eururo.2016.05.031

16. Nygren J, Thacker J, Carli F, et al. Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Clinical nutrition*. 2012;31(6):801-816.

17. Smith I, Kranke P, Murat I, et al. Perioperative fasting in adults and children: guidelines from the European Society of Anaesthesiology. *European Journal of Anaesthesiology| EJA*. 2011;28(8):556-569.

18. Xu R, Zhao X, Zhong Z, Zhang L. No advantage is gained by preoperative bowel preparation in radical cystectomy and ileal conduit: a randomized controlled trial of 86 patients. *International urology and nephrology*. 2010;42(4):947-950.

19. Tabibi A, Simforoosh N, Basiri A, Ezzatnejad M, Abdi H, Farrokhi F. Bowel preparation versus no preparation before ileal urinary diversion. *Urology*. 2007;70(4):654-658.

20. Novotny V, Hakenberg OW, Wiessner D, et al. Perioperative complications of radical cystectomy in a contemporary series. *European urology*. 2007;51(2):397-402.

21. Maffezzini M, Campodonico F, Capponi G, Manuputty E, Gerbi G. Fast-track surgery and technical nuances to reduce complications after radical cystectomy and intestinal urinary diversion with the modified Indiana pouch. *Surgical oncology*. 2012;21(3):191-195.

22. Giglio M, Marucci M, Testini M, Brienza N. Goal-directed haemodynamic therapy and gastrointestinal complications in major surgery: a meta-analysis of randomized controlled trials. *British journal of anaesthesia*. 2009;103(5):637-646.

23. American College of Surgeons. User Guide for the 2019 ACS NSQIP Participant Use Data File (PUF). Accessed March 13, 2021. https://www.facs.org/-/media/files/quality-programs/nsqip/nsqip_puf_userguide_2019.ashx

24. McDonald JH. *Handbook of biological statistics*. vol 2. sparky house publishing Baltimore, MD; 2009.

25. Bozdogan H. Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. *Psychometrika*. 1987;52(3):345-370.

26. Akaike H. A new look at the Bayes procedure. *Biometrika*. 1978;65(1):53-59.

27. Sakamoto Y, Ishiguro M, Kitagawa G. Akaike information criterion statistics. *Dordrecht, The Netherlands: D Reidel*. 1986;81(10.5555):26853.

28. Daley BJ, Cecil W, Clarke PC, Cofer JB, Guillamondegui OD. How slow is too slow? Correlation of operative time to complications: an analysis from the Tennessee Surgical Quality Collaborative. *Journal of the American College of Surgeons*. 2015;220(4):550-558.

29. Procter LD, Davenport DL, Bernard AC, Zwischenberger JB. General surgical operative duration is associated with increased risk-adjusted infectious complication rates and length of hospital stay. *Journal of the American College of Surgeons*. 2010;210(1):60-65. e2.

30. Lemanu D, Singh P, Stowers M, Hill A. A systematic review to assess cost effectiveness of enhanced recovery after surgery programmes in colorectal surgery. *Colorectal Disease*. 2014;16(5):338-346.

31. Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. *The Lancet*. 2003;362(9399):1921-1928.

32. Kehlet H. Fast-track colonic surgery: status and perspectives. *Rectal Cancer Treatment*. 2005:8-13.

33. Kehlet H. Fast-track colorectal surgery. *The Lancet*. 2008;371(9615):791-793.

34. Zargar-Shoshtari K, Connolly AB, Israel LH, Hill AG. Fast-track surgery may reduce complications following major colonic surgery. *Diseases of the colon & rectum*. 2008;51(11):1633-1640.

35. Varadhan KK, Neal KR, Dejong CH, Fearon KC, Ljungqvist O, Lobo DN. The enhanced recovery after surgery (ERAS) pathway for patients undergoing major elective open colorectal surgery: a meta-analysis of randomized controlled trials. *Clinical nutrition*. 2010;29(4):434-440.

36. Brockman JA, Vetter J, Peck V, Strope SA. Effect of a radical cystectomy care pathway on postoperative length of stay and outcomes. *Urology*. 2018;116:125-130.

37. Shea C, Khawaja AR, Sofi K, Nabi G. Association of metabolic equivalent of task (MET) score in length of stay in hospital following radical cystectomy with urinary diversion: a multi-institutional study. *International urology and nephrology*. 2021;53(7):1305-1310.

38. Tolchard S, Angell J, Pyke M, et al. Cardiopulmonary reserve as determined by cardiopulmonary exercise testing correlates with length of stay and predicts complications after radical cystectomy. *BJU international*. 2015;115(4):554-561.

39. Chesnut GT, Tin AL, Sjoberg DD, et al. Electronic rapid fitness assessment identifies factors associated with adverse early postoperative outcomes following radical cystectomy. *The Journal of urology*. 2021;205(2):400-406.

40. McIntosh AG, Li T, Ito T, et al. WBC associates with readmission following cystectomy. *Bladder Cancer*. 2017;3(2):95-103.

41. Yu J, Hong B, Park J-Y, Hwang J-H, Kim Y-K. Impact of prognostic nutritional index on postoperative pulmonary complications in radical cystectomy: a propensity score-matched analysis. *Annals of Surgical Oncology*. 2021;28(3):1859-1869.

42. Pariser JJ, Anderson BB, Pearce SM, et al. The effect of broader, directed antimicrobial prophylaxis including fungal coverage on perioperative infectious complications after radical cystectomy. Elsevier; 2016:121. e9-121. e14.

43. Stimson C, Chang SS, Barocas DA, et al. Early and late perioperative outcomes following radical cystectomy: 90-day readmissions, morbidity and mortality in a contemporary series. *The Journal of urology*. 2010;184(4):1296-1300.

44. Hu M, Jacobs BL, Montgomery JS, et al. Sharpening the focus on causes and timing of readmission after radical cystectomy for bladder cancer. *Cancer*. 2014;120(9):1409-1416.

45. Pak JS, Lascano D, Kabat DH, et al. Patterns of care for readmission after radical cystectomy in New York State and the effect of care fragmentation. Elsevier; 2015:426. e13-426. e19.

46. Leow JJ, Gandaglia G, Sood A, et al. Readmissions after major urologic cancer surgery. *The Canadian journal of urology*. 2014;21(6):7537-7546.

47. Lorentz CA, Gilbert K, Alemozaffar M, Patil D, Filson CP. Risk of readmission after uncomplicated hospitalization after radical cystectomy. *Clinical genitourinary cancer*. 2018;16(4):e705-e710.

48. Reese SW, Ji E, Paciotti M, et al. Risk factors and reasons for reoperation after radical cystectomy. Elsevier; 2020:269-277.

49. Pirson M, Leclercq P, Jackson T, Leclercq M, Garrino M, Sion C. Financial consequences of hospital-acquired bacteraemia in three Belgian hospitals in 2003 and 2004. *Journal of Hospital Infection*. 2008;68(1):9-16.

50. American College of Surgeons. ACS National Surgical Quality Improvement Program (ACS NSQIP).

Chapter IV: Conclusion

Establishing QI programs within existing institutional governance structures of surgical organizations is critical to help foster a culture focused on safety and optimize the delivery of health care. With over 700 participating sites from 11 countries, including Canada, and 49 of the 50 states, [8] NSQIP provides surgical organizations around the world an opportunity to participate and collaborate in this culture by identifying factors that lead to adverse outcomes and sharing advancements aimed to address them.

All participating NSQIP hospitals continuously submit data through the ACS website and are provided reports to benchmark performance and identify areas of improvement. NSQIP data are nationally validated, based on standard definitions, and are collected by a trained surgical clinical reviewer using a random sampling strategy. The data capture 30-day morbidity and mortality outcomes of all major surgical procedures with the intent to be used for quality improvement. [34] Furthermore, the data have been audited and demonstrate an inter-rater reliability of 98%. [8] NSQIP is viewed as an objective measure of quality and safety and is part of a collective commitment to foster a culture focused on quality, safety, and reliability. To further illustrate this commitment, the ACS website provides public access to data from over 4.3 million operations in the NSQIP database through the surgical risk calculator. [8,39,40]

The overall purpose of this thesis was to demonstrate how NSQIP is being used to identify and address system errors and share important information about advances in surgical care. Given the increasing adoption of NSQIP, it is no surprise that the scoping review within this thesis identified 4,661 NSQIP articles published between 2005 and 2020, with 78% of these articles published just within the past five years. Given the increasing growth in the literature, it is important to understand the extent, range, and nature of NSQIP research activity, including the

contributions from each surgical specialty. Pre-existing systematic and scoping reviews report on specific patient populations, surgical specialties, and procedures within NSQIP. [9-13] However, this scoping review was the first to our knowledge that provides a description of the broad scope of how NSQIP is being used to improve the quality of surgical care.

Perhaps most interesting was the novel approach of using Synthesis, a literature reference management program that allows text data mining to categorize topics based on academic publication titles. Although this review did not capture findings in as much detail as a systematic review, the use of Synthesis allowed for interpretation of large volumes of data and produced a much larger review than has been feasible in the past. The implications of this technology are extraordinary, as it facilitates the rapid undertaking of large scoping reviews by semi-automating data management. Such an approach may be applied to other databases in the future to perform similar analyses or to compound the current data to provide an even larger picture of QI initiatives within surgery.

Within this scoping review, 'General Surgery' and 'Orthopedic Surgery' were identified as the most published surgical specialties in the NSQIP literature. These findings are not surprising, as General Surgery arguably developed NSQIP, as well as other QI databases such as the Trauma Quality Improvement Program (TQIP), NSQIP-Pediatric, and the National Cancer Database (NCDB). [8] Furthermore, the American Academy of Orthopedic Surgeons (AAOS) has strongly emphasized the importance of optimizing patient care with clinical practice guidelines. [8] Therefore, several QI initiatives and registries have been developed for the specialty, with a focus on joint replacements, spine surgery, and trauma. While the underlying reasons for fewer publications identified in certain specialties – such as Cardiac Surgery, Oro-Maxillofacial Surgery, and Transplant Surgery – are unknown, it is important to consider that these other

specialties may participate in QI initiatives outside of NSQIP. This thesis only increases exposure to NSQIP as a QI initiative and may encourage additional sites to explore the advantages of participation. For example, this scoping review demonstrated that 'Outcomes' and 'Association' were the most common study types, however, other study types, such as Education and Economics, were identified, demonstrating some of the many unique applications of NSQIP.

Many publications within the NSQIP literature measure quality improvement interventions at specific sites or within surgical specialties utilizing NSQIP-derived data. Therefore, the second manuscript within this thesis aimed to demonstrate firsthand the application of NSQIP data and how it can be used to investigate a quality improvement intervention. More specifically, the second manuscript investigated the effect of a multimodal clinical pathway on radical cystectomy outcomes at a participating NSQIP site within our institution. Our study findings identified that operative time was shorter by 33 minutes and length of stay was reduced by four days, and complications were reduced after the implementation of a clinical pathway without affecting the rate of readmission. Furthermore, this study identified several independent factors associated with length of stay and readmission among the radical cystectomy population. These findings not only highlighted the benefits of a clinical pathway but also suggest that NSQIP can be utilized to identify actionable targets to optimize perioperative management within specific populations.

Identifying the underlying factors that lead to adverse surgical outcomes is not only important to guide preoperative counseling, operative planning, and risk-stratification but can also inform future interventions aimed to optimize patient care. The data from these studies are then interpreted by professional organizations and inform clinical practice guideline development

and dissemination. Clinical practice guidelines are then subject to continual review and updates, as they are used to establish performance benchmarks and implement QI programs. [8]

Ultimately, QI initiatives such as NSQIP allow advancements in surgical care and are part of the collective commitment to foster a culture focused on quality and safety. The ultimate result will be a health care environment where surgical patients are provided with safe and optimal outcomes.

Bibliography

1. Langley GJ, Moen RD, Nolan KM, Nolan TW, Norman CL, Provost LP. *The improvement guide: a practical approach to enhancing organizational performance*. John Wiley & Sons; 2009.

2. Agency for Healthcare Research and Quality. Module 4. Approaches to Quality Improvement. Content last reviewed May 2013. Rockville, MD.

3. Institute for Healthcare Improvement. How to Improve. 2022.

4. Coles E, Wells M, Maxwell M, et al. The influence of contextual factors on healthcare quality improvement initiatives: what works, for whom and in what setting? Protocol for a realist review. *Systematic reviews*. 2017;6(1):1-10.

5. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. The National Academies Press; 2001:360.

6. Patient Safety Institute. Why does Canada need a National Quality and Patient Safety Framework for Health Services?. Accessed December 28, 2020. https://www.patientsafetyinstitute.ca/en/toolsResources/Canadian-Quality-and-Patient-Safety-Framework-for-Health-and-Social-Services/Pages/default.aspx

7. de Vries EN, Ramrattan MA, Smorenburg SM, Gouma DJ, Boermeester MA. The incidence and nature of in-hospital adverse events: a systematic review. *BMJ Quality & Safety*. 2008;17(3):216-223.

8. American College of Surgeons. ACS National Surgical Quality Improvement Program (ACS NSQIP). Accessed March 13, 2021. https://www.facs.org/quality-programs/acs-nsqip

9. Marjoua Y, Xiao R, Waites C, Yang BW, Harris MB, Schoenfeld AJ. A systematic review of spinal research conducted using the National Surgical Quality Improvement Program. *The Spine Journal*. 2017;17(1):88-95.

10. Yolcu Y, Wahood W, Alvi MA, Kerezoudis P, Habermann EB, Bydon M. Reporting Methodology of Neurosurgical Studies Utilizing the American College of Surgeons-National Surgical Quality Improvement Program Database: A Systematic Review and Critical Appraisal. *Neurosurgery*. 2020;86(1):46-60.

11. Mahmoud S, Dong Y, Loloi J, Gruson KI. Are perioperative complications and clinical outcomes following reverse shoulder arthroplasty adversely affected by obesity?: a systematic review. Elsevier; 2020:

12. Ornaghi PI, Afferi L, Antonelli A, et al. Frailty impact on postoperative complications and early mortality rates in patients undergoing radical cystectomy for bladder cancer: a systematic review. *Arab Journal of Urology*. 2020:1-15.

13. Bernatz JT, Anderson PA. Thirty-day readmission rates in spine surgery: systematic review and meta-analysis. *Neurosurgical focus*. 2015;39(4):E7.

14. Baker GR, Norton PG, Flintoft V, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. *Cmaj*. 2004;170(11):1678-1686.

15. Schwendimann R, Blatter C, Dhaini S, Simon M, Ausserhofer D. The occurrence, types, consequences and preventability of in-hospital adverse events–a scoping review. *BMC health services research*. 2018;18(1):1-13.

16. Van Den Bos J, Rustagi K, Gray T, Halford M, Ziemkiewicz E, Shreve J. The $17.1 billion problem: the annual cost of measurable medical errors. *Health Affairs*. 2011;30(4):596-603.

17. Canadian Institute for Health Information. *What are hospitals spending on?* [infographic]. CIHI.

18. Hoonhout LH, de Bruijne MC, Wagner C, et al. Direct medical costs of adverse events in Dutch hospitals. *BMC health services research*. 2009;9(1):27.

19. Zerey M, Paton BL, Lincourt AE, Gersin KS, Kercher KW, Heniford BT. The burden of Clostridium difficile in surgical patients in the United States. *Surgical infections*. 2007;8(6):557-566.

20. Pirson M, Leclercq P, Jackson T, Leclercq M, Garrino M, Sion C. Financial consequences of hospital-acquired bacteraemia in three Belgian hospitals in 2003 and 2004. *Journal of Hospital Infection*. 2008;68(1):9-16.

21. Canadian Institute for Health Information. National health expenditure trends, 1975 to 2015. *Nat Inst Health Info Rep*. 2015;36:423-5.

22. Jackson T. One dollar in seven: Scoping the Economics of Patient Safety. *The Canadian Safety Institute*. 2009;

23. Analysis HP. *Analysis of hospital-acquired diagnoses and their effect on case complexity and resource use – Final report, Australian Commission on Safety and Quality in Health Care*. 2013. Accessed Dec 28, 2020. https://www.safetyandquality.gov.au/sites/default/files/migrated/Analysis-of-hospital-acquired-diagnoses-and-their-effect-on-case-complexity-and-resource-use-Dec-2013.pdf

24. Canadian Institute for Health Information. Measuring patient harm in Canadian hospitals. *What can be done to improve Patient Safety*. 2016;

25. Francis R. *Report of the Mid Staffordshire NHS Foundation Trust public inquiry: executive summary*. vol 947. The Stationery Office; 2013.

26. Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The quality in Australian health care study. *Medical journal of Australia*. 1995;163(9):458-471.

27. Donaldson MS, Corrigan JM, Kohn LT. *To err is human: building a safer health system*. vol 6. National Academies Press; 2000.

28. Hoyt DB, Ko CY, Jones RS. *Optimal resources for surgical quality and safety*. American College of Surgeons; 2017.

29. Debas H, R G, C M, A. T. *Surgery. Disease control priorities in developing countries.* . Jamison D, ed. ed. Oxford University Press; 2006.

30. World Health Organization. WHO guidelines for safe surgery 2009: safe surgery saves lives. *Geneva: World Health Organization*. 2009;

31. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *New England journal of medicine*. 2009;360(5):491-499.

32. de Vries EN, Prins HA, Crolla RM, et al. Effect of a comprehensive surgical safety system on patient outcomes. *New England Journal of Medicine*. 2010;363(20):1928-1937.

33. Birkmeyer JD. Strategies for improving surgical quality—checklists and beyond. Mass Medical Soc; 2010. p. 1963-1965.

34. Abbott T, Ahmad T, Phull M, et al. The surgical safety checklist and patient outcomes after surgery: a prospective observational cohort study, systematic review and meta-analysis. *British journal of anaesthesia*. 2018;120(1):146-155.

35. Khuri SF, Daley J, Henderson W, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. *Annals of surgery*. 1998;228(4):491.

36. Houchens R, Ross D, Elixhauser A, Jiang J. Nationwide inpatient sample (NIS) redesign final report. *HCUP Methods Ser Rep*. 2014;4

37. American College of Surgeons. National Cancer Database. Accessed March 13, 2021. https://www.facs.org/Quality-Programs/Cancer/NCDB

38. American College of Surgeons. User Guide for the 2019 ACS NSQIP Participant Use Data File (PUF). Accessed March 13, 2021. https://www.facs.org/-/media/files/quality-programs/nsqip/nsqip_puf_userguide_2019.ashx

39. Pugely AJ, Martin CT, Harwood J, Ong KL, Bozic KJ, Callaghan JJ. Database and registry research in orthopaedic surgery: part 2: clinical registry data. *JBJS*. 2015;97(21):1799-1808.

40. Pugely AJ, Martin CT, Harwood J, Ong KL, Bozic KJ, Callaghan JJ. Database and registry research in orthopaedic surgery: part I: claims-based data. *JBJS*. 2015;97(15):1278-1287.

41. Weiss A, Anderson JE, Chang DC. Comparing the national surgical quality improvement program with the nationwide inpatient sample database. *JAMA surgery*. 2015;150(8):815-816.

42. Somani S, Di Capua J, Kim JS, et al. Comparing national inpatient sample and national surgical quality improvement program: an independent risk factor analysis for risk stratification in anterior cervical discectomy and fusion. *Spine*. 2017;42(8):565-572.

43. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *Journal of the American College of Surgeons*. 2013;217(5):833-842. e3.

44. American College of Surgeons. The ACS NSQIP Surgical Risk Calculator. Accessed March 13, 2021. https://riskcalculator.facs.org/RiskCalculator/

45. Morris MS, Deierhoi RJ, Richman JS, Altom LK, Hawn MT. The relationship between timing of surgical complications and hospital readmission. *JAMA surgery*. 2014;149(4):348-354.

46. Hall BL, Hamilton BH, Richards K, Bilimoria KY, Cohen ME, Ko CY. Does surgical quality improve in the American College of Surgeons National Surgical Quality Improvement Program: an evaluation of all participating hospitals. *Annals of surgery*. 2009;250(3):363-376.

47. Cohen ME, Liu Y, Ko CY, Hall BL. Improved surgical outcomes for ACS NSQIP hospitals over time. *Annals of surgery*. 2016;263(2):267-273.

48. Guillamondegui OD, Gunter OL, Hines L, et al. Using the national surgical quality improvement program and the Tennessee surgical quality collaborative to improve surgical outcomes. *Journal of the American College of Surgeons*. 2012;214(4):709-714.

49. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2019. *CA: a cancer journal for clinicians*. 2019;69(1):7-34.

50. Stein JP, Lieskovsky G, Cote R, et al. Radical cystectomy in the treatment of invasive bladder cancer: long-term results in 1,054 patients. *Journal of clinical oncology*. 2001;19(3):666-675.

51. Witjes JA, Lebret T, Compérat EM, et al. Updated 2016 EAU guidelines on muscle-invasive and metastatic bladder cancer. *European urology*. 2017;71(3):462-475.

52. Babjuk M, Böhle A, Burger M, et al. EAU guidelines on non–muscle-invasive urothelial carcinoma of the bladder: update 2016. *European urology*. 2017;71(3):447-461.

53. Shabsigh A, Korets R, Vora KC, et al. Defining early morbidity of radical cystectomy for patients with bladder cancer using a standardized reporting methodology. *European urology*. 2009;55(1):164-176.

54. Shariat SF, Karakiewicz PI, Palapattu GS, et al. Outcomes of radical cystectomy for transitional cell carcinoma of the bladder: a contemporary series from the Bladder Cancer Research Consortium. *The Journal of urology*. 2006;176(6):2414-2422.

55. Boorjian SA, Kim SP, Tollefson MK, et al. Comparative performance of comorbidity indices for estimating perioperative and 5-year all cause mortality following radical cystectomy for bladder cancer. *The Journal of urology*. 2013;190(1):55-60.

56. Altobelli E, Buscarini M, Gill HS, Skinner EC. Readmission rate and causes at 90-day after radical cystectomy in patients on early recovery after surgery protocol. *Bladder Cancer*. 2017;3(1):51-56.

57. Lawrentschuk N, Colombo R, Hakenberg OW, et al. Prevention and management of complications following radical cystectomy for bladder cancer. *European urology*. 2010;57(6):983-1001.

58. Lavallée LT, Schramm D, Witiuk K, et al. Peri-operative morbidity associated with radical cystectomy in a multicenter database of community and academic hospitals. *PloS one*. 2014;9(10):e111281.

59. Berger I, Xia L, Wirtalla C, Dowzicky P, Guzzo TJ, Kelz RR. 30-day readmission after radical cystectomy: Identifying targets for improvement using the phases of surgical care. *Canadian Urological Association Journal*. 2019;13(7):E190.

60. Skolarus TA, Jacobs BL, Schroeck FR, et al. Understanding hospital readmission intensity after radical cystectomy. *The Journal of urology*. 2015;193(5):1500-1506.

61. Lyon TD, Boorjian SA, Shah PH, et al. Comprehensive characterization of perioperative reoperation following radical cystectomy. Elsevier; 2019:292. e11-292. e17.

62. Patel HD, Ball MW, Cohen JE, Kates M, Pierorazio PM, Allaf ME. Morbidity of urologic surgical procedures: an analysis of rates, risk factors, and outcomes. *Urology*. 2015;85(3):552-560.

63. Hussein AA, Hashmi Z, Dibaj S, et al. Reoperations following robot-assisted radical cystectomy: a decade of experience. *The Journal of urology*. 2016;195(5):1368-1376.

64. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *British journal of anaesthesia*. 1997;78(5):606-617.

65. Hayman A. Enhanced Recovery After Surgery in Community Hospitals. 2018;

66. Lemanu D, Singh P, Stowers M, Hill A. A systematic review to assess cost effectiveness of enhanced recovery after surgery programmes in colorectal surgery. *Colorectal Disease*. 2014;16(5):338-346.

67. Varadhan KK, Neal KR, Dejong CH, Fearon KC, Ljungqvist O, Lobo DN. The enhanced recovery after surgery (ERAS) pathway for patients undergoing major elective open colorectal surgery: a meta-analysis of randomized controlled trials. *Clinical nutrition*. 2010;29(4):434-440.

68. Ansari D, Gianotti L, Schröder J, Andersson R. Fast-track surgery: procedure-specific aspects and future direction. *Langenbeck's archives of surgery*. 2013;398(1):29-37.

69. Azhar RA, Bochner B, Catto J, et al. Enhanced recovery after urological surgery: a contemporary systematic review of outcomes, key elements, and research needs. *European urology*. 2016;70(1):176-187.

70. Cerantola Y, Valerio M, Persson B, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS®) society recommendations. *Clinical nutrition*. 2013;32(6):879-887.

71. Tyson MD, Chang SS. Enhanced Recovery Pathways Versus Standard Care After Cystectomy: A Meta-analysis of the Effect on Perioperative Outcomes. *European Urology*. 2016;70(6):995-1003. doi:10.1016/j.eururo.2016.05.031

72. Pozo C, Shariat SF, D'Andrea D, Fajkovic H, Abufaraj M. Enhanced Recovery after Radical Cystectomy. *Current Opinion in Urology*. 2019;29(3):227-238.

Appendices

Supplemental Content 1. Manuscript I: Category Definitions for Surgical Specialty

Main Category	Category Definitions
Cardiac Surgery	((title:"cardiac surgery") AND NOT (title:"non-cardiac surgery")) OR journal:cardiology OR journal:cardiothoracic OR ((title:"Cardiac surgery") AND NOT (title:"non-cardiac surgery")) OR title:Pericardiotom* OR title:Cardiotom* OR title:Valvotom* OR title:"valve replacement" OR title:"valve surgery" OR title:"valve surgeries" OR title:"valve repair" OR title:pacemaker OR title:"Coronary artery bypass" OR title:"coronary venous graft"
General Surgery	title:"General Surgery" OR title:"general surgeries" OR title:"general surgical" OR title:"general surgeon" OR title:"general and vascular surgery" OR title:"general and thoracic" OR journal:"General Surgery" OR title:gastrointestinal OR journal:gastrointestinal OR journal:colon OR journal:rectum OR journal:"general and vascular surgery" OR journal:"general and thoracic" OR title:adrenal OR title:adrenalectom* OR title:Appendix OR title:Appendectom* OR title:appendiceal OR title:Appendicitis OR title:bariatric OR title:"weight loss surgery" OR title:"sleeve gastrectomy" OR title:"Roux-en-Y" OR title:"gastric bypass" OR title:"bowel resection" OR title:colon* OR title:colotom* OR title:enterostom* OR title:enterotom* OR title:colorectal OR title:colectom* OR title:ostom* OR title:proctocolectom* OR title:proctocol-ectomy OR title:ileocolic OR title:ileo-colic OR title:"small bowel" OR title:enterotom* OR title:enterostom* OR title:ileostom* OR title:ileo* OR title:ileal OR title:jejun* OR title:jejunostom* OR title:gastroduodenal OR title:duode* OR title:intestinal OR title:Breast OR title:Mastectom* OR title:mammaplast* OR title:lumpectom* OR title:postmastectomy OR title:colon* OR title:colotom* OR title:enterostom* OR title:enterotom* OR title:colorectal OR title:colectom* OR title:colostomy OR title:ostom* OR title:proctocolectom* OR title:"proctocol-ectomy" OR title:ileocolic OR title:"ileo-colic" OR ((title:diverticulectomy) AND NOT (title:"urethral diverticulectomy" OR title:"Zenker’s diverticulectomy")) OR

	((title:diverticulum) AND NOT (title:"hypopharyngeal diverticulum")) OR title:gastric OR title:gastrectom* OR title:"peptic ulcer surgery" OR title:esophagogastrostom* OR title:gastrostom* OR title:vagotomy OR title:gastroduodenal OR title:fundoplication OR title:gastroesophageal OR title:gastrointestinal OR title:"intra-abdominal" OR title:gastroenterological OR title:hernia* OR title:hernioplast* OR title:herniorrhaphy OR title:herniotom* OR title:"Bile duct" OR title:pancrea* OR title:whipple* OR title:Gallbladder OR title:Cholecyst* OR title:hepatic OR title:hepatectom* OR title:posthepatectom* OR title:hepato* OR title:hepaticojejunostom* OR title:HPB OR title:"liver tumor" OR title:"liver tumors" OR title:"liver cancer" OR title:"liver resection" OR title:"liver resections" OR title:"liver surgery" OR title:"liver metastasis" OR title:"liver metastases" OR title:"liver, pancreatic, and colorectal surgery" OR title:Puestow OR title:cholangiocarcinoma OR ((title:liver) AND NOT (title:"liver function" OR title:"liver disease" OR title:"liver failure")) OR title:lymphadenectomy OR title:"lymph node" OR title:"lymph nodes" OR title:colorectal OR title:rectal OR title:Proctectom* OR title:proctocolectom* OR title: "proctocol-ectomy" OR title:ileoanal OR title:anal OR title:anorectal OR title:recto* OR ((title:"anastomosis") AND NOT (title:"arteriovenous anastomosis")) OR title:"small bowel" OR title:enterotom* OR title:enterostom* OR title:ileostom* OR title:ileo* OR title:ileal OR title:jejun* OR title:jejunostom* OR title:gastroduodenal OR title:duode* OR title:spleen OR title:"splenic flexure" OR title:splenectom* OR title:trauma OR journal:trauma OR title:laparotom* OR title:enterolysis OR title:abdominoperineal OR title:"abdominal surgical operations" OR title:"abdominal surgery" OR title:"abdominal operations" OR title:"thoracoabdominal operation" OR title:abdominopelvic OR title:"pelvic surgery" OR title:colitis OR title:IBD OR title:"inflammatory bowel disease" OR title:"inflammatory bowel diseases" OR title:crohn* OR title:diverticulitis OR title:"diverticular disease" OR title:hirschsprung* OR title:"abdominal wall reconstruction" OR title:hartmann* OR title:pringle OR title:"sigmoid volvulus" OR title:"heller myotomy" OR title:"peptic ulcer

	disease" OR title:"peptic ulcers" OR title:omentoplasty OR title:RYGB OR title:foregut OR title:"metabolic/diabetes surgery" OR title:"endocrine surgery" OR title:pyloromyotomy OR title:"gallstone ileus" OR title:perianal OR title:biliary OR title:"anastomotic leak" OR title:cholangiography OR title:"enterocutaneous fistulas" OR title:"bowel obstruction" OR title:stoma OR title:"component separation" OR title:gastroschisis
Otolaryngology and Head and Neck Surgery	title:Otolaryngolog* OR journal:Otolaryngolog* OR journal:laryngoscope OR journal:otology OR journal:rhinology OR journal:laryngology OR journal:ORL OR title:Laryng* OR title:"head and neck" OR title:pharyng* OR title:"branchial cleft cyst" OR title:esophag* OR title:esophagogastrostom* OR title:esophagectom* OR title:Glossectom* OR title:tongue OR title:"oral cavity" OR title:"choanal atresia" OR title:hypopharyngeal OR title:"neck dissection" OR title:thyroid* OR title:thyroid OR title:"thyroglossal duct cyst" OR title:tracheostomy OR title:hyperparathyroid* OR title:parathyroid* OR title:goiter OR title:hemithyroidectomy
Orthopedic Surgery	title:orthop* OR journal:orthop* OR journal:spine OR title:amputation* OR title:arthro* OR title:THA OR title:TKA OR title:extremity OR title:extremities OR title:extensor OR title:forearm OR title:limb OR title:elbow OR title:wrist OR title:ankle OR title:fusion OR title:fusions OR title:refusion OR title:arthrodesis OR title:"distal radius fracture" OR title:"distal radius fractures" OR title:"fracture of the hip" OR title:"hip fracture" OR title:"hip fractures" OR title:"ankle fracture" OR title:"ankle fractures" OR title:"humerus fracture" OR title:"humerus fractures" OR title:"compression fracture" OR title:"compression fractures" OR title: "femoral neck fracture" OR title: "femoral neck fractures" OR title: "odontoid fracture" OR title:"odontoid fractures" OR title: "femoral shaft fracture" OR title:"femur fractures" OR title:"trimalleolar fractures" OR title:"bimalleolar fractures" OR title:"pilon fractures" OR title:"Hip/pelvis fractures" OR title:"intertrochanteric fractures" OR title:"C2 fractures" OR title:"knee fractures" OR title:"proximal ulna fractures" OR title:"malleolar fractures" OR title:"humeral fractures" OR title:"tibia fractures" OR title:"tibial plateau fractures" OR

	title:"tibial shaft fractures" OR title:"humeral shaft fractures" OR title:"pelvic/acetabular fractures" OR title:"clavicular fractures" OR title:clavicle OR journal:"shoulder and elbow surgery" OR title:hip OR title:Hemiarthroplast* OR title:THA OR title:"pelvic osteotomy" OR title:knee OR title:meniscectomy OR title:ACL OR title:PCL OR title:"anterior cruciate ligament reconstruction" OR title:"posterior cruciate ligament reconstruction" OR title:patellofemoral OR title:TKA OR title:lumbar OR title:spine OR ((title:spinal) AND NOT (title:"spinal anesthesia" OR title:"spinal and general anesthesia" OR title:"spinal versus general anesthesia")) OR title:kyphoplast* OR title:vertebroplast* OR title:discectom* OR title:laminectom* OR title:ACDF OR title:vertebral OR title:disc OR title:microdiscectomy OR title:"degenerative cervical myelopathy" OR title:"open reduction" OR title:ORIF OR title:"latarjet-bristow" OR title:shoulder OR title:"bankart" OR title:"rotator cuff" OR title:spinopelvic OR title:"joint replacement" OR title:achilles OR title:"femoral neck" OR title:"above-knee" OR title:"through-knee" OR title:scoliosis
Plastic Surgery	title:plastic OR title:oncoplastic OR journal:plastic OR journal:aesthetic OR title:craniofacial OR journal:craniofacial OR title:"breast reconstruction" OR title:"chest reconstruction" OR title:gynecomastia OR title:uvulopalatopharyngoplasty OR ((title:cleft) AND NOT (title:"branchial cleft cyst")) OR title:contour* OR title:flap* OR title:"tissue transfer" OR title:"free tissue" OR title:"free-tissue" OR title:"free flap" OR title:microsurg* OR title:microvascular OR title:autologous OR title:panniculectomy OR title:craniosynostosis OR title:"surgical repair of pressure ulcers" OR title:"surgically managed pressure ulcers" title:syndactyly OR title:polydactyly OR ((title:hand*) AND NOT (title:"hand-assisted")) OR title:"ligament reconstruction and tendon interposition" OR title:"hidradenitis suppurativa" OR title:otoplasty OR title:"mandibular fracture" OR title:"mandibular fractures" OR title:"facial fracture" OR title:"hand fractures"

Pediatric Surgery	title:pediatric* OR title:paediatric OR journal:pediatric* OR title:adolescen* OR title:children* OR journal:children OR title:neonatal OR journal:neonatal OR journal:perinatology OR title:infant*
Vascular Surgery	title:vascular OR title:endovascular OR title:revascularization OR journal:vascular OR journal:endovascular OR journal:revascularization OR title:EVAR OR title:"abdominal aortic aneurysm" OR title:"abdominal aortic aneurysms" OR title:"aortic abdominal aneurysm" OR title:"aortic abdominal aneurysms" OR title:"aortic abdominal aneurysm" OR title:"thoracoabdominal aortic aneurysm" OR title:"thoracoabdominal aortic aneurysms" OR title:"thoracoabdominal aneurysm" OR title:"thoracoabdominal aneurysms" OR title:"aortic aneurysm" OR title:"aortic aneurysms" OR title:"aortoiliac aneurysm" OR title:"aortoiliac aneurysms" OR title:"aorto-iliac aneurysm" OR title:"aortic repair" OR title:"abdominal aortic dissection repair" OR title:"aortic surgery" OR title:Arteriovenostom* OR title:"arteriovenous fistula" OR title:"arteriovenous anastomosis" OR title:Carotid OR title:Endarterectom* OR title:endarterectomies OR title:Thromboendarterectom* OR title:"femoropopliteal bypass" OR title:"femoral-popliteal bypass" OR title:"bypass leg surgery" OR title:"infrainguinal bypass" OR title:"infrainguinal arterial bypass" OR title:revascular* OR title:"peritoneal dialysis catheter placement" OR title:"upper extremity bypass"
Thoracic Surgery	title:thoracic OR journal:cardiothoracic OR journal:thoracic OR title:diaphragmatic OR title:diaphragm OR title:thoracic OR title:thoracotom* OR title:pleurectom* OR title:lung OR title:"pulmonary resection" OR ((title:lobectomy) AND NOT (title:"temporal lobectomy")) OR title:pneumonectom* OR title:thymectomy OR title:transhiatal OR title:diversion OR (title:divert AND NOT title:diverticul*) OR title:"congenital pulmonary airway malformations" OR title:"congenital lung malformations" OR title:"congenital pulmonary lesions" OR title:thoracoscopic OR title:thoracoscopy OR title:VATS
Oro-Maxillofacial Surgery	title:maxillofacial OR journal:maxillofacial
Transplant Surgery	title:transplant* OR journal:transplant*

Urology	title:urolog* OR journal:urolog* OR journal:endourology OR title:cystectom* OR title:bladder OR title:Nephrostom* OR title:Pyelotom* OR title:nephrectom* OR title:nephroureterectom* OR title:pyeloplast* OR ((title:renal) AND NOT (title:"renal disease" OR title:"renal function" OR title:"renal failure" OR title:"renal dysfunction")) OR ((title:kidney) AND NOT (title:"kidney disease" OR title:"kidney function" OR title:"kidney failure" OR title:"kidney injury" OR title:"kidney transplantation")) OR title:penile OR title:penectomy OR title:prostate OR title:Prostatectom* OR title:"benign prostatic hyperplasia procedures" OR title:"benign prostatic hyperplasia surgery" OR title:"benign prostatic enlargement surgery" OR title:testicular OR title:orchiectomy OR title:"urethral diverticulectomy" OR title:cystourethroscopy OR title:vesicovaginal OR title:hypospadias OR title:"TURBT" OR "title:transurethral resection"
Surgical Oncology	title:onco* OR journal:onco* OR title:cancer* OR journal:cancer* OR title:onc* OR title:tumor* OR title:tumour* OR title:metastatic OR title:metastas* OR title:chemoradiation OR title:chemotherapy OR title:radiotherapy OR title:radiation OR title:malignancy OR title:neoplasm OR title:melanoma OR title:carcinoma OR title:sarcoma OR title:HIPEC OR title:cytoreductive
Obstetrics and Gynecology	title:gynecology OR title:gynaecological OR title:gynecologic OR journal:gynecology OR journal:gynecologic OR title:urogynecology OR title:urogynecologic OR journal:urogynecology OR title:endometrial OR title:ovarian OR title:oophorectomy OR title:hysterotomy OR title:hysterectomy OR title:uterine OR title:"cervical cancer" OR title:"cervical malignancy" OR title:myomectomy OR title:vaginal OR title:"apical prolapse surgery" OR title:"uterovaginal prolapse" OR title:"pelvic organ prolapse" OR title:"uterovaginal prolapse" OR title:sacrocolpopexy OR title:"pelvic floor" OR title:colpopexy OR title:debulk* OR (title:sling AND NOT title:"male sling") OR title:"pelvic reconstructive surgery"
Neurosurgery	title:neurosurgery OR title:neurosurgical OR journal:neurosurg* OR title:Craniotomy OR title:craniotomies OR title:"cranial surgery" OR title:"temporal lobectomy" OR

	title:Craniectom* OR title:intracranial OR (title:cranial AND NOT (title:"cranial nerve")) OR title:"brain tumour resection" OR title:"deep brain stimulation" OR title:"brain tumor surgery" OR title:"cerebrovascular surgery" OR title:pituitary OR title:"skull base" OR title:"cranial surgery" OR title:cranioplasty OR title:"surgery for cerebellar hemorrhage" OR title:"ventricular shunt" OR title:schwannoma OR title:"transsphenoidal surgery" OR title:electrocorticography OR title:"epilepsy surgery" OR title:"pineal surgery" OR title:"vertebral fracture" OR title:"vertebral fractures"
Anesthesia	title:anesthe* OR title:anaesthe* OR journal:anesthe* OR journal:anaesthe* OR title:analgesia
Unknown	No definition
Podiatry	None identified
Dentistry	None identified

Supplemental Content 2. Manuscript I: Category Definitions for Study Type

Main Category	Category Definitions
Association	title:associat* OR (title:associations AND title:between) OR title:relation* OR title:differences OR title:compar* OR title:variation* OR title:correlat* OR title:dispar* OR title:after OR title:effect OR title:following
Characteristics	title:characterist* OR title:epidemiology OR title:determinants OR title:consump* OR title:burden OR title:profile OR title:classif* OR title:descriptive OR title:determinant* OR title:frail* OR title:"advanced age" OR title:geriatric* OR title:septuagenarian* OR title:octogenarian* OR title:elderly OR title:older OR title:"oldest old" OR title:nonagenarian* OR title:"65 years" OR title:"nursing home" OR title:obesity OR title:obese OR title:superobese OR title:overweight OR title:"body mass index" OR title:BMI OR title:weight
Estimates	title:prevalence OR title:incidence OR title:estimates OR title:occurrence* OR title:adjust*
Surveillance	title:surveillance OR title:trends OR title:increas* OR title:decreas* OR title:chang* OR title:pattern* OR title:updat* OR title:screening OR title:rate
Risk	title:risk* OR title:"risk-scoring" OR title:"risk index" OR title:"risk model" OR title:"risk assessment tool" OR title:"risk assessment model" OR title:"risk stratification" OR title:"risk score" OR title:"risk-scoring" OR title:"risk factor" OR title:"risk factors" OR title:"risk-stratified" OR title:"risk calculator" OR title:"frailty index" OR title:scoring OR title:score* OR title:"surgical apgar score"
Utilization	title:utilization OR title:usage OR title:access OR title:services OR title:treatment
Implementation	title:implement* OR title:application OR title:planning OR title:manag* OR title:recommend*
Prediction	title:predict*
Methodology	title:method* OR title:algorithm* OR title:deriv* OR title:design* OR title:develop*
Evaluation	title:evaluat* OR title:valid* OR title:accur* OR title:reliab* title:impact* OR title:adherence
Education	title:training OR title:teach* OR title:resident* OR title:student* OR title:fellow* OR title:intern OR title:trainee* OR title:educat* OR title:"attending surgeons" OR title:learning OR title:curriculum OR title:academic OR title:certification OR title:QITI

Economics	title:compensate* OR title:reimburs* OR title:fee OR title:pay* OR title:financ* OR title:economic OR title:bill* OR title:cost* OR title:expenditur*
Outcomes	title:outcomes OR title:mortality OR title:death* OR title:moribund OR title:morbidity OR title:readm* OR title:stay OR title:reop* OR title:revision OR title:"return to the operating room" OR title:"repeated operation" OR title:discharge OR title:post-discharge OR title:predischarge OR title:postdischarge OR title:"transfer" OR title:"non-home discharge" OR title:"postacute care" OR title:"post-acute care" OR title:"rehabilitation"
Adverse Events	title:adverse OR title:complication* OR title:infection* OR title:transfus* OR title:"venous thromboembolism" OR title:"venous thrombosis" OR title:"venous thromboses" OR title:"venous thrombi" OR title:"deep vein thrombosis" OR title:"deep vein thromboses" OR title:thrombosis OR title:thromboses OR title:DVT OR title:VTE OR title:thromboembolic
Unknown	No definition

Supplemental Content 3. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	25
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	25
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	26-27, 46
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	27
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	N/A
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	27
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	27
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	27
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	28, 35

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	28-34
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	95-103
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	28-34
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	35
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	N/A
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	N/A
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	34, 36-42
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	43-45
Limitations	20	Discuss the limitations of the scoping review process.	45-49

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	45-49
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	28

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

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

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

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

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

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

Supplemental Content 4. Manuscript II: Postoperative Laboratory Investigations

	Pre-pathway (*n* = 35)	**Post-pathway** (*n* = 225)	**Total** (*n* = 260)	***P* value**
Serum sodium (mmol/L)	139 ± 2.5	139 ± 3.0	139 ± 2.9	0.63
Abnormal value	1 (2.9%)	18 (8.0%)	19 (7.3%)	0.48
Serum creatinine (umol/L)	106 ± 36.7	101 ± 49.0	101 ± 47.5	0.14
Abnormal value	7 (20.0%)	46 (20.4%)	53 (20.4%)	1.00
Albumin (g/dL)	3.9 ± 0.4	10.4 ± 13.0	9.7 ± 12.5	0.72
Abnormal value	9 (25.7%)	82.0 (36.4%)	91.0 (35.0%)	0.30
Total bilirubin (umol/L)	0.4 ± 0.3	1.9 ± 3.2	1.7 ± 3.0	0.11
Abnormal value	11 (31.4%)	76 (33.8%)	87 (33.5%)	0.94
Aspartate aminotransferase (U/L)	20.5 ± 3.5	30.1 ± 23.3	29.4 ± 22.5	0.41
Abnormal value	2 (5.7%)	24 (10.7%)	26 (10.0%)	0.55
Alkaline phosphate (U/L)	73.1 ± 36.3	86.5 ± 42.7	84.9 ± 42.0	0.45
Abnormal value	10 (28.6%)	74.0 (32.9%)	84.0 (32.3%)	0.75
White blood cell count (x10*9/L)	7.9 ± 3.3	7.9 ± 3.0	7.9 ± 3.0	0.88
Abnormal value	7 (20.0%)	33 (14.7%)	40 (15.4%)	0.53
Hematocrit (L/L)	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.12
Abnormal value	14 (4.0%)	72 (32.0%)	86 (33.1%)	0.53
Platelet count (x10*9/L)	245 ± 86.8	264 ± 95.8	261 ± 94.8	0.31
Abnormal value	8 (22.9%)	57 (25.3%)	65 (25.0%)	0.99
INR	1.04 ± 0.1	1.1 ± 0.3	1.1 ± 0.3	0.99
Abnormal value	3 (8.6%)	23 (10.2%)	26 (10.0%)	0.74
PTT (seconds)	33.0 ± 6.6	32.1 ±8.3	32.2 ± 8.1	0.17
Abnormal value	8 (22.9%)	31 (13.8%)	39 (15.0%)	0.02

Supplemental Content 5. Manuscript II: Clinical Pathway Details

Preoperative

All patients undergoing radical cystectomy at our institution followed the ERAS protocol prior to surgery. (62) Patients attended a preoperative anesthesia consult assessment and received preoperative education and counseling. Preoperative education is addressed as an ERAS item as it has been shown to reduce anxiety, improve wound healing, and decrease complications. (70, 71) Preoperative ostomy teaching by an enterostomal therapist (ET) is also emphasized, as ostomies are known to independently increase the risk of delayed discharge. (71)

Patients were subsequently referred to internal medicine if additional diagnostics were required and underwent optimization of common medical conditions, such as hypertension, anemia, and diabetes. Patients met with a dietitian for malnutrition screening and dietary counseling. Preoperative carbohydrate loading was encouraged to maintain muscle and lean body mass, decrease thirst, and insulin resistance. (72) Patients were permitted to have solid food up to six hours and liquids up to two hours before surgery. (73) Oral mechanical bowel preparation was safely omitted (74, 75) and long-acting sedating pre-anesthesia medications such as benzodiazepines were avoided. (72) There is an estimated 5% risk of clinically significant deep vein thrombosis post-cystectomy. (76) Therefore, all patients received thromboprophylaxis. Sequential compression devices (SCD) were also used to further reduce the risk. (72)

Intraoperative

All patients received antimicrobial prophylaxis and standard general anesthesia using short-acting anesthetic agents intraoperatively. Multimodal opioid-sparing analgesia was used to for baseline treatment. Adequate lung ventilation was maintained to reduce the risk of

barotrauma and hypoxia. Normal body temperature was maintained to prevent hypothermia. Intravenous fluids were minimized to reduce possible ileus and other complications, such as increased blood loss. (77, 78) However, sufficient fluid was given to minimize postoperative nausea and vomiting. The surgical approach was based on surgeon and patient preference.

Postoperative

Diet

Early oral diet was encouraged. Patients received maintenance intravenous Ringers Lactate until clear fluids could be tolerated orally. Clear fluids were advanced to full fluids on postoperative day one. A postsurgical transition diet was started on postoperative day two with diet supplementation (I.e., Ensure-plus 90ml) five times daily. A regular diet was encouraged by postoperative day three. Patients were encouraged to chew gum for 30 minutes three times daily until discharge.

Activity

Physiotherapy was consulted to assist patients with early ambulation. Patients were encouraged to stand at bedside and ambulate five meters within eight hours of surgery. Other goals included: 1) to be up in a chair for a total of six hours on postoperative day one and eight hours on postoperative day two, and 2) to ambulate four times daily, from postoperative day one until discharge.

Vitals

Vital signs were taken routinely. Oxygen saturation was maintained above 90% and patients were encouraged to use an incentive spirometer hourly. Patients were weighed daily for the first three consecutive days.

Investigations, Ins and Outs

For the first three consecutive days, patients underwent a complete blood count (CBC) and extended electrolyte panel. Ins and outs were monitored every two hours to maintain a urine output above 30ml per hour. Conditional bolus orders (I.e., Ringers Lactate 500ml per hour infused over one hour) were activated if the urine output was unsatisfactory for two consecutive hours. A physician was notified when the patient required more than three boluses.

Medications

All patients received intravenous cefazolin preoperatively as antimicrobial prophylaxis. Patients received subcutaneous heparin at surgery and continued to receive subcutaneous enoxaparin daily for thromboprophylaxis. SCDs were discontinued when the patient was mobilizing well.

The health care team targeted a pain score less than four and a nausea score less than two. Oral acetaminophen and gabapentin were used as baseline analgesia. A non-steroidal anti-inflammatory drug (NSAID), either intravenous ketorolac or oral ibuprofen, was also used in addition if the patient had adequate renal function (I.e., a glomerular filtration rate greater than 50). Oral or subcutaneous morphine could also be administered if the baseline analgesia was inadequate. Postoperative antiemetics were administered as needed, including intravenous or oral ondansetron, oral dimenhydrinate, and/or metoclopramide (intravenous, oral, or intramuscular).

Patients received daily docusate sodium, sennosides, and alvimopan for postsurgical bowel recovery. Liquid lactulose or a glycerin suppository could also be given. These were initiated on postoperative day one and continued until the patient had a bowel movement.

Home medications were resumed. Diabetic patients were started on a low-volume insulin protocol. Daily oral pantoprazole and ranitidine were also administered.

Drains and Dressings

Dressings were removed and patients were assessed by an ET on postoperative day one. Incisions were monitored daily. Stents were flushed with normal saline every day starting on postoperative day one. The Jackson Pratt drain was reprimed every shift and as needed. Drains were removed by postoperative day three, if indicated. Stents and staples were removed on postoperative day seven.

Disposition and Follow-Up

A single physician assistant (PA) met each patient in the preoperative period, assisted in the operating room, followed patients on the unit daily, and acted as a liaise and point of contact for nursing staff and families. Discharge planning was discussed daily with the patient to ensure adequate supports were arranged. Teaching documents were reviewed with patients and their families, and logistics for patient departure were finalized on postoperative day seven.

Patients received follow-up by the PA by phone at two weeks, three months, six months, and nine months postoperatively. Patients met with an ET and the PA on postoperative day 22 for postoperative review.