Factors Related to Emergency Surgery Wait Times in British Columbia

by

Jaclyn Sing
BN, University of Calgary, 2013

A Project Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

in the Department of Health Information Science

Supervisory Committee

Factors Related to Emergency Surgery Wait Times in British Columbia

by

Jaclyn Sing
BN, University of Calgary, 2013

Supervisory Committee

Dr. Scott Macdonald (School of Health Information Science)
Supervisor

Dr. Francis Lau (School of Health Information Science)
Departmental Member

Abstract

Dr. Scott Macdonald (School of Health Information Science)
Supervisor
Dr. Francis Lau (School of Health Information Science)
Departmental Member

Objective: The purpose of this project was to assess the relationships between emergency surgery wait times in British Columbia (BC) and characteristics of the patient's hospital admission.

Background: The BC Ministry of Health has historically focused on elective surgery wait times. Various clinical decision support tools have been proposed for optimizing emergency wait times; however, little is known about how long patients are waiting for emergency surgery. This project sought to uncover how long patients wait for emergency surgery in BC and to identify whether wait times can be shortened using health information technology such as clinical decision support.

Methods: The research design was a retrospective cohort study. Secondary data from the Discharge Abstract Database (DAD) was statistically examined to identify factors associated with longer wait times. Patients included in this study must have received surgery during an urgent admission between April 1, 2012 – March 31, 2017 for hip fracture repair, appendectomy or cholecystectomy.

Results. When comparing mean wait times by procedure, the results of the one-way ANOVA indicated mean wait times varied significantly between procedures (appendectomy = 13 hours, hip fracture repair = 33 hours, cholecystectomy = 53 hours). In addition, wait times were significantly increased for patients with older age, afterhours admission or admission to hospitals with a trauma level 1 or 2 designation and transplant services. A subsequent analysis to assess which factors impacted wait times was done on a per-procedure basis. Factors affecting appendectomy was compared against a *24 hour benchmark*, while hip fracture repair and cholecystectomy were compared against a *48 hour benchmark.* Mean wait times for hip fracture repair and appendectomy were within the benchmarks; however, mean wait times for cholecystectomy were greater than the benchmark. In a multivariate analysis, older age had the strongest effect. Older age significantly increased the risk of surgical delay (OR 3.066, 95% CI 2.553 – 3.682, $p<.001$).

Conclusion: All though surgical wait times varied significantly based on a number of factors, these variations may be strongly related to other prioritization variables not included in the DAD. For this project, patient age was the strongest factor related to surgical delay. Age is not a factor that can improved by implementing clinical decision support. Further research is needed to determine if clinical decision support can be used to reduce emergency surgery wait times in BC.

Table of Contents

List of Tables

List of Figures

Acknowledgements

I am deeply grateful for all the support I have received on this journey. I'd like to start this report by thanking the following people:

Jessica Galo and the staff at Population Data BC for enabling students like me to access data through the Student Data Access Request without which this project would not have been possible.

Dr. Scott Macdonald whose supervision and expert guidance have been invaluable through this project.

My family who have supported me and shaped my love of learning.

Darek Stiller for the gift of perfect kindness.

All inferences, opinions, and conclusions drawn in this report are those of the author's, and do not reflect the opinions or policies of the Data Steward(s).

Introduction

Certain types of emergency surgeries can be subject to prolonged wait times. The purpose of this project was to assess the relationships between emergency surgery wait times in British Columbia (BC) and characteristics of the patient's hospital admission. This report is divided into two sections. The first section offers an overview of the current guidelines for emergency surgery wait times and presents some clinical decision support systems available for scheduling emergency surgeries. The second section analyses the current state of emergency surgery wait times in BC using Discharge Abstract Database (DAD) data. The report concludes by offering a commentary on whether clinical decision support for scheduling emergency surgery is warranted in BC.

Background & Literature Summary

In this section, optimal and accepted wait times for emergency surgery are described, then an overview of decision support and the relationship between time of surgery and patient outcomes are examined. Finally, the current state of emergency surgery wait times in BC is reviewed in relation to the issues raised above.

The definition of surgical delay is not consistent in the literature. Some studies define surgical delay as a wait greater than an absolute number of hours such as 12 or 24 hours (Ong, Guang, & Yang, 2015). Many researchers use 48 hours as the indicator of surgical delay (Bohm, Loucks, Wittmeier, Lix, & Oppenheimer, 2015; Fantini et al., 2011; Kristiansen, Kristensen, Nørgård, Mainz, & Johnsen, 2016; Moja et al., 2012). Other studies define surgical delay relative to the priority selected by the patient's surgeon. For example, for McIsaac et al. (2017), each emergency case was assigned a priority target by a surgeon (A < 45 min; B < 2 h; C < 4 h; D < 8 h; E < 24 h) and surgical delay was defined as any wait longer than the target.

Across Canada there is a lack of standardization for prioritizing adult patients for emergency surgery. In 2004, Canadian Premiers met at the First Minister's Meeting and prioritized the work of establishing pediatric access targets for surgery. Since then, Alberta has led a national effort to develop the Pediatric Canadian Access Targets (PCATS) which has resulted in a single code set for prioritizing pediatric surgery (Wright, Menaker, & Canadian Paediatric Surgical Wait Times Study Group, 2011). The PCATS code set includes a subset of codes for emergency surgeries for wait times of less than 1 day. For adults, the equivalent standardization has not been done. Indeed, for adults awaiting emergency surgery the only national benchmark is the *48 hour* hip facture benchmark (Bohm, Loucks, Wittmeier, Lix, & Oppenheimer, 2015).

Due to the lack of a standardization on acceptable wait times for emergency surgery, adults waiting for surgery are prioritized at their surgeon's discretion using the hospital's internal prioritization levels, for example less than 12, 24 or 48 hours. The research that does exist for emergency surgery wait times generally considers each surgical procedure rather than the patient's diagnosis. In addition, procedures are assigned wait times in isolation, rather than in relation to other surgical procedures. Some examples of research on acceptable emergency surgery wait times include research on hip fracture repair, cholecystectomy and appendectomy.

Hip Fracture Repair

In Canada, the Canadian Institute for Health Information (CIHI) uses the *48 hour benchmark* as the indication for excessive wait time for hip fracture repair (Canadian Institute of Health Information, 2018). This benchmark is supported by research in Canada which suggests that hip fracture repair within 48 hours is associated with shorter length of stay and decreased mortality (Bohm et al., 2015). The benchmark is also supported by international research that suggests surgical delay over 48 hours is associated with an increased risk of death and pressure sores (Moja et al., 2012). The benchmark chosen for hip fracture repair in this project was 48 hours.

Cholecystectomy

While there is no benchmark for cholecystectomy wait times in Canada, there has been research on the optimal wait time for gall bladder removal during acute cholecystitis. Historically, physicians have managed patients with acute cholecystitis conservatively by prescribing antibiotics and performing surgery only when the inflammation decreased; however, recent evidence shows early surgery is beneficial (Blohm et al., 2017; Gurusamy, Davidson, Gluud, & Davidson, 2013). The research is still divided on the optimal wait time for emergency cholecystectomy. On the one hand, a recent Cochrane Systematic Review concluded that surgery within 7 days of admission was associated with decreased length of stay, quicker return to work and no increased risk of bile duct injury (Gurusamy et al., 2013). However, Blohm et al. (2017) suggests surgery within 1-2 days is protective against bile duct injury, invasive surgery and 30 and 90-day mortality. The *48 hour benchmark* is also supported by Aboulian et al. (2010) and Falor et al. (2012). For this project, 48 hours was chosen as the benchmark for cholecystectomy.

Appendectomy

Similar to patients waiting for cholecystectomy, there is currently no national benchmark for appendectomy. Some research on acceptable appendectomy wait times shows minimal evidence that early appendectomy is beneficial (Cheng et al., 2017). A recent Cochrane review by Cheng et al. (2017) found that the evidence is low and inconclusive on whether early access to surgery improves patient outcomes. This is counter to the systematic review done by van Dijk, van Dijk, Dijkgraaf, & Boermeester (2018) which suggested appendectomy can be safely delayed for 24 hours, while the impact of a delay longer than 24 hours not known. This research is also supported by the United Kingdom National Surgical Research Collaborative & Bhangu (2014) who suggested appendectomy should be performed within 24 hours and found that surgery between 24 -48 hours was associated with increased risk of surgical site infection and 30-day adverse events. More research is needed to establish a benchmark for emergency appendectomy. For this project, the *24 hour benchmark* was used for emergency appendectomy.

Understanding Surgical Delay

Emergency surgery wait times can be attributed to a variety of variables. Some factors that affect patient wait times include the patient's fitness for surgery, the type of surgery needed and the recommended treatment guidelines. These factors, while having a significant impact on wait times, were out of scope for this project. Instead this project focused on understanding which factors related to operational resources and hospital capacity were related to surgical delay.

Lack of operating room availability was identified by Vidán et al. (2011) as a key factor in surgical delay of hip fracture repairs. If the surgery occurs during regular business hours, patients waiting for emergency surgery can take priority over elective surgery patients for operating room resources such as operating room time, staff and post anesthesia care. Most emergency surgery patients also require a postoperative hospital bed which may not be available due to elective surgery slates, overflowing emergency rooms and patients waiting in hospital for long term care. In a study based in Australia, lack of postoperative bed was the most common reason for delayed discharge from the post anesthesia care unit (Cowie & Corcoran, 2012).

The time that the patient was admitted to hospital may also have an impact on the timeliness of emergency surgery. In a study based in Demark, the time of hospital admission was related to surgical delay (Kristiansen et al., 2016). Patients who were admitted during the weekend off-hours were associated with increased surgical delay and had a higher 30 day mortality rate (Kristiansen et al., 2016). Day of admission was also reported by Ricci, Brandt, McAndrew, & Gardner (2015) as a factor for surgical delay of hip fracture repairs. This project examined if patients in BC, like Denmark, were more likely to experience surgical delay if admitted on the weekends and during off hours.

While the definition of surgical delay and the acceptable wait times are not consistent across the research, the research on the impact of surgical delay suggests that delay has a negative impact on patient outcomes. Surgical delay is associated with a greater risk of mortality, increased length of stay and higher costs (Kristiansen et al., 2016; McIsaac et al., 2017; Ong et al., 2015). For some types of surgery, delay is also associated with increased risk of surgical complications and invasive surgery (Blohm et al., 2017).

McIsaac et al. (2017) studied the impact of the on mortality, length of stay and costs. The study, based in Ottawa, Ontario, followed patients who received emergency surgery to identify if there was a relationship between delayed surgery and patient outcomes. The results of the matched observational cohort study suggested that surgical delay was associated with greater mortality (OR 1.50 95% CI 1.30 – 1.93), increased length of stay (incident ratio 1.07 95% CI 1.10 – 1.11) and higher total cost (incident ratio 1.06 95% CI 1.01 – 1.11). A similar study has not been conducted in BC. This research project provides a first step towards a similar study in BC. A further study focusing on patient outcomes is needed.

Clinical Decision Support for Emergency Surgery

Shortliffe (1987) described clinical decision support as "a medical decision-support system is any computer program designed to help health professionals make clinical decisions" (p. 61). Early clinical decision support was designed like "Greek oracles" where clinicians gathered in formation and entered it into the clinical decision support, which then provided the answer (Middleton, Sittig, & Wright, 2016). However, this type of clinical decision support was not well accepted and as a result the design decision support has shifted to point of care alerts and suggestions that are incorporated into providers workflow (Middleton et al. 2016). Recently, Beeler, Bates, & Hug (2014) described clinical decision support as having two key characteristics. First clinical decision support systems "link patient data with an electronic knowledge base in order to improve decision-making" and second "computerized physician order entry (CPOE) is a requirement to set up electronic [clinical decision support]" (Beeler et al., 2014, p. 7). Under this definition, clinical decision support includes a large range of alerts, reminders and workflow support.

Some examples of clinical decision support in the perioperative space include programs for prioritizing patients for elective surgery and optimizing surgical schedules. After conducting a mini literature review, it's clear there are several tools for operating room scheduling (Ferrand, Magazine, & Rao, 2014; Heydari & Soudi, 2016; Lamiri, Xie, Dolgui, & Grimaud, 2006; Zonderland, Boucherie, Litvak, & Vleggeert-Lankamp, 2010).

1) Ferrand et. al. (2014) compared the flexibility in operating room schedules and demonstrated how partially flexible schedules can decrease emergency surgery wait times. This study showed how clinical decision support can be used to structure operating room schedules to increase capacity for emergency surgeries.

2) Heydari & Soudi (2015) presented a two-stage stochastic programming model for emergency surgery scheduling. Their study suggested clinical decision support can be used to optimize operating room schedules for robustness and stability, thereby improving emergency surgery access to the OR.

3) Lamari et. al. (2008) presented a stochastic programming model for elective surgeries, followed by a Monte Carlo simulation. This model showed how clinical decision support can be used to balance costs between emergency and elective surgery.

4) Zonderland et. al. (2010) explored how a decision support tool based on the Markov decision process can be used for emergency surgery scheduling. This study showed how clinical decision support can be used to optimize the hospital's scheduling policy and can be used to alert the scheduler when it is optimal to cancel elective surgeries to accommodate semi urgent cases. The above studies demonstrate how clinical decision support can be used to improve emergency scheduling. At the time of writing this paper, the author was not aware of these tools being used in BC.

Current State of Emergency Surgery in BC

In BC while elective surgeries are scheduled using surgical block scheduling (Santibáñez, Begen, & Atkins, 2007), emergency operations are scheduled without decision support systems. Instead emergency surgeries are scheduled using a paper list and a first in-first out methodology. The BC provincial government is currently focusing on elective surgery wait times. Specifically, the BC government is focusing on improving wait times for elective hip, knee and dental procedures (BC Government, 2018).

This elective surgery policy focus has led to very limited information being available for emergency surgery wait times. Indeed, the only publicly available data on BC emergency surgery wait times is the CIHI report for hip fracture wait times in BC shows that approximately 86 % of patients receive hip fracture repair within 48 hours (Canadian Institute of Health Information, 2017). CIHI calculates patient wait time from the time the patient enters the emergency department, to the time that surgery starts (Canadian Institute of Health Information, 2018). The methodology used by CIHI to calculate wait times was also used to calculate patient wait times in this project.

Other than hip fracture repair wait times, at this time little is known about emergency surgery wait times in BC or the effectiveness of operating room scheduling to enable emergency surgeries to be completed in a timely fashion. This research project aimed to fill in the picture of emergency surgery wait times in BC. Using retrospective data, we explored how long patients in BC waited for emergency surgery and if clinical decision support can be used to support operating room scheduling of emergency surgeries in BC health authorities.

Project Methodology

Research Objectives

The overarching aim of this research project was to examine emergency surgery wait times for patients in BC and determine if there were specific hospital or admission characteristics that are associated with extended patient wait times. The key objectives of this project were to:

1) Examine the length of time patients waited for non-life-threatening emergency surgery in BC, and
2) Determine if hospital or admission characteristics were statistically related to surgery wait times.

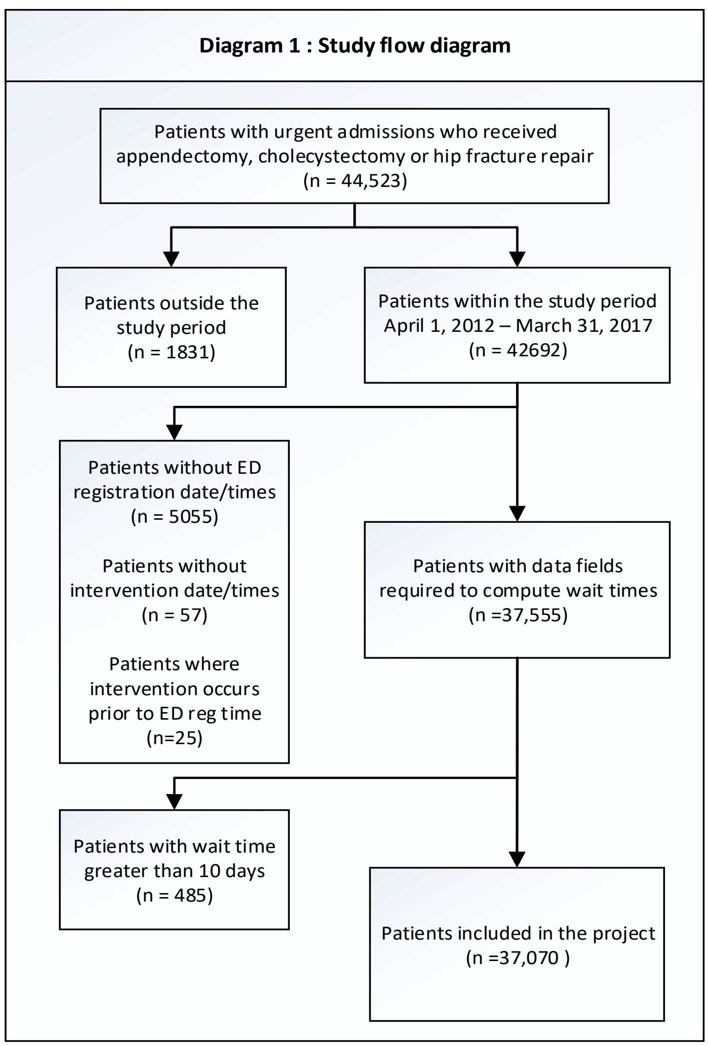
Research Design

This study was a retrospective cohort design. The observational study design allowed the researcher to analyze a single set of data for patient wait times. The cohort design was chosen as it includes the dimension of time, which is the focus of this research (Laake, Benestad, & Olsen, 2007). This design allows the researcher to follow the patients over the hospital admission and measure the key points of emergency admission time and surgery start time. This study focused on patients who received appendectomy, cholecystectomy or hip fracture repair. These three surgeries were chosen as they are common procedures that are performed in both large hospitals and small community hospitals. In addition, the procedures are not immediately life threatening.

Sample

The sample included all patients who were admitted for emergency surgery in the last 5 years for 3 specific procedures. To be included in the project, a patient must have received one of the specified non-life-threatening emergency surgeries in a BC public health care facility and have an urgent admission between April 1, 2012 - March 31, 2017. The 3 procedures are determined by the Canadian Classification of Health Interventions (CCI) code in any position: Appendectomy -1.NV.89.^^ , Cholecystectomy - 1.OD.89.^^ , Hip fracture repair - 1.VA.74.^^

Prior to beginning the data analysis, any rows of data that did not contain the urgent admission for appendectomy, cholecystectomy and hip fracture repair were removed. The resulting data contained rows for all urgent admissions in the date range. The process is described in Diagram 1 below.



Of the 44,523 urgent cases provided by Population Data BC, 1831 cases were removed to make the cohort 5 fiscal years (April 1, 2012 - March 31, 2017). An additional 5,055 cases were removed as they did not contain Emergency Department(ED) registration dates/time and 57 cases were removed as they did not include an intervention date/time. Without these date/time fields, patient wait time could not be calculated. In addition, 25 cases were removed as the intervention time was reported as starting prior to the ED registration time and 485 cases were removed where wait time was greater than 10 days. The final number of cases included in the study was 37,070.

Measures

The DAD data requested from Population Data BC included data fields associated with the patient's demographics, the type of emergency surgery and the admission and surgery start time. Table 1 contains a brief description of the primary data fields.

Table 1: Primary Data Fields

MEASURE	DESCRIPTION	FORMAT	TYPE
Age	The approximate age of the patient was calculated by subtracting the year the patient was born, from the year the surgery occurred in years.	Continuous	Independent
Gender	Assigned in DAD data as male (M), female (F) or unknown (U).	Categorical (3 groups)	Independent
Intervention	The intervention represents the type of surgery the patient received. Represented by CCI Code: Appendectomy -1.NV.89.^^ Cholecystectomy - 1.OD.89.^^ Hip fracture repair - 1.VA.74.^^	Categorical (4 groups)	Independent
ED Registration Date/Time	The time the patient was registered in ED. This time indicates the start of the wait time. The field was reported as dd:mm:yy HH:mm:ss	Date	Dependent
Intervention Start Date/Time	The time the patient entered the operating room. This time indicates the end of the wait time. The field was reported as dd:mm:yy HH:mm:ss	Date	Dependent
Wait time	This calculated field describes the length of time between the ED registration and the intervention. The wait time reported as dd:mm:yy HH:mm:ss	Date	Dependent

Hospital Type: Solid Organ Transplant	A computed field from the hospital number. There are 2 groups: Hospital that perform solid organ transplant (T) Hospitals that do not perform transplant (N)	Categorical (2 groups)	Independent
Hospital Type: Surgical Obstetrics	A computed field from the hospital number. There are 2 groups: Hospital that perform c-sections (C) Hospitals that do not perform c-sections (N)	Categorical (2 groups)	Independent
Hospital Type: Trauma Centers	A computed field from the hospital number. There are 2 groups: Hospital that are trauma level 1 or 2 (T) Hospitals that are not trauma level 1 or 2 (N)	Categorical (2 groups)	Independent
Admission Time	A calculated field from the ED registration. There are 3 groups: Weekday (D) (Monday – Friday 0900- 1700) Weekend (W) (Saturday & Sunday 0900 -1700) After hours (E) (any day after 1700)	Categorical (3 groups)	Independent

Setting

The project took place in BC. BC has a population of over 4.6 million people (Statistics Canada, 2017). From 2011 – 2016 BC had a population growth of 5.6% (Statistics Canada, 2017). In addition to the population growth, the population is also aging. Indeed in 2016 the number of people over 65 years old exceeded the number of children under 15 years old (Statistics Canada, 2017). As the baby boomers continue to age, Canada expects to see an increase health care demand as increased health care costs are associated with increased age (Alemayehu & Warner, 2004; Canadian Institute of Health Information, 2011). The setting for this project was all hospitals in BC that preform emergency surgeries and submit DAD data to CIHI. This wide setting was chosen to obtain an accurate representation of emergency surgery provincially.

Data Handling and Collection

The research project used de-identified DAD data. The DAD is a standardized data set that contains patient and admission characteristics for acute care hospitalization in Canada. A data extract was requested directly from Population Data BC for secondary data analysis. A subset of patient information was requested from Population Data BC including patient characteristics, emergency department registration date/time, intervention start date/time, and a record of all interventions performed. No patient identifying fields were requested, with the exception of birth year which was used to calculate the patient's age. Hospital groupings were created using information from Provincial Health Services. A complete summary is in Appendix A.

The retrieved data was entered into the statistics program IBM SPSS version 25 in order to complete some basic statistics. The data for this research project was stored in the Population Data BC's secure research environment (SRE) and followed Population Data BC's data standard rules including: no attempt was made to re-identify the patients, no data linkages were performed and only summary results were exported from the SRE.

Limitations and Data Measurement Issues

There were two measurement issues associated with the surgery wait time calculation. The first issue was the data point used to calculate the start of the wait time. The wait time was calculated from ED registration date/time. McIsaac et al. (2017) cautions that calculating wait time from admission time is a limitation of many surgical wait time studies as time of admission does not necessarily coincide with the decision for surgery. Indeed "inpatient work-up is often required to determine the risks and potential benefits of surgery" (McIsaac et al, 2017, p. E905). The second limitation was the data point used to calculate the end of the wait time. The end of the wait time was calculated from the patient's entry into the operating room. The patient's entry into the operating room, does not coincide with the start of the surgery. Prior to beginning surgery patients must be safely anesthetized, positioned, and prepped before surgeon can begin.

Despite the drawbacks outlined above, these data points were chosen for two reasons. Firstly, this method is consistent with the method that CIHI uses to report on hip fractures on the public website (Canadian Institute of Health Information, 2018). Secondly, this wait time is reflective of the patient's perspective and aligns with a patient-centered focus of care.

In addition to the data measurement issues, there were also several limitations to this research project based on the research design. This project did not account for patients' admitting diagnosis, severity of condition or health. In addition, the sample is limited to only 3 emergency procedures and the scope of the project does not include patient outcomes. These elements were scoped out in order to limit the size of the research project, but further studies should include more robust analysis of different procedures and evaluate patient outcomes such as length of stay and post-operative complications. In addition, future studies should consider using benchmarks based on admitting diagnosis rather than procedure, as a patient may receive a procedure for several different diagnosis which reflect different levels of patient acuity.

Ethics Approval

This project was approved by the University of Victoria Human Research Ethics Board (Appendix B). The project involved the secondary use of de-identified DAD data and was therefore classified as having minimal risk. An amendment was filed to update the cohort dates and clarify population cohort as requested by Population Data BC. In addition to approval from the University of Victoria, the data access request was approved by the Ministry of Health's data stewards. In preparation for this project, the student completed the TCPS2: CORE training (Appendix C).

Results

Demographics

Patient demographics were analyzed to ensure consistency across the 5 years of data and build confidence in using this data to make decisions on future clinical needs. Across 2012 -2017 there were 37,070 urgent admissions that resulted in appendectomy, cholecystectomy or hip fracture repair (n = 37,070). The number of admissions gradually increased from 7,025 to 7,757 emergency procedures per year. The average patient age was 47.21 years old and the proportion of male to female patients was consistent with the mean proportion of 45.5% male to 54.5% female. Patient demographics were generally consistent across the 5 years of data. A complete summary of the demographics is in Table 2 below.

Table 2: Patient Demographics and Distribution by Year

	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	Total
Procedure (#, %)	7,025 (18.95)	7,355 (19.84)	7,354 (19.83)	7,579 (20.44)	7,757 (20.92)	37,070
Appendectomy	4,086 (58.2)	4,036 (54.9)	4,062 (55.2)	4,249 (56.1)	4,363 (56.2)	20,796 (56.1)
Cholecystectomy	2,065 (29.4)	2,213 (30.1)	2,182 (29.7)	2,370 (31.3)	2,381 (30.7)	11,211 (30.2)
Hip Fracture Repair	874 (12.4)	1,106 (15)	1,110 (15.1)	9,60 (12.7)	1,031 (13.1)	5,063 (13.7)
Mean age (years)	46.07	47.33	47.82	47.29	47.47	47.21
Sex (#, %)						
Male	3,144 (44.8)	3,331 (45.3)	3,313 (45.1)	3,539 (46.7)	3,531 (45.5)	16,585 (45.5)
Female	3,881 (55.2)	4,022 (54.7)	4,040 (54.9)	4,039 (53.3)	4,425 (54.5)	20,207 (54.5)
Unknown	Small cell size	Small cell size	Small cell size	Small cell size	Small cell size	5

Objective #1: Descriptive Results of Patient Wait Times by Procedure

For the first objective of examining the length of time patients wait for non-life-threatening emergency surgery in BC, wait time was calculated from the ED registration date and time to the intervention start date and time for each patient. The emergency surgery wait time calculation was:

Wait time = (Intervention start date & time) - (ED registration date & time).

The mean wait times were compared between procedures using one-way ANOVA to assess if there was a major difference in wait times across the different procedures. Patients waiting for appendectomy had the shortest mean wait time of 13 hours and 15 minutes, while patients waiting for cholecystectomy had the longest mean wait time of 52 hours and 48 minutes. Table 3 below shows the mean wait times by procedure. Since Levene's statistic was significant (p <.001) (meaning the variance between the means are significantly different from each other), Brown-Forsythe test was used to show the mean times were significantly different across procedures (p<.001). As well, using post hoc tests, Games Howell was significant (p <0.001) for every comparison.

Table 3: One Way ANOVA Comparison of Mean Wait Time by Procedure			
	Mean Wait Time	**N**	**P-value[1]**
All Procedures	**27.84 hours**	**37,070**	**<.001**
Appendectomy	13.25 hours	20,796	
Cholecystectomy	52.79 hours	11,211	
Hip Fracture Repair	32.58 hours	5,063	

1 Levene's p<.001, p-value base on equal variances not assumed

Objective #2 Results: What Factors are Related to Wait Times?

To examine if hospital or admission characteristics including age, admission type or hospital type were statistically related to surgery wait time, mean wait times were calculated using one-way ANOVA and independent t-tests. The key findings include: mean wait time was significantly increased for the older age group, afterhours admission, trauma level 1 or 2 designation and transplant services. A full description of the analysis preformed is described in the section below.

Assessing Significant Difference in Wait Times by Age

To assess for significant differences between mean wait times by age group, the mean wait times were assessed using ANOVA. Mean wait times between the 3 sub-groups are reported in Table 4 below.

Table 4: One Way ANOVA Comparison of Mean Wait Time by Age Sub-Group			
Group	**Mean Wait Time**	**N**	**P-value[1]**
Pediatrics (0-17 years)	11.37 hours	4,148	<.001
Adults (18- 65 years)	25.92 hours	23,851	
Older adults (66+ years)	40.44 hours	9,071	

1 Levene's p<.001, p-value base on equal variances not assumed

Levene's statistic was significant (p<.001) and Brown-Forsythe test showed the mean times were significantly different across age sub groups (p<.001). Games-Howell post hoc tests were also significant (p<.001) for every comparison.

Assessing Significant Difference in Wait Times by Admission Time

To assess for significant difference between wait times by admission time, the mean wait times were assessed using one-way ANOVA. Mean wait times for the 3 groups (Weekday, Weekend Day, After Hours) are described in Table 5 below.

Table 5: One Way ANOVA Comparison of Mean Wait Time by Admission Time

Group	Mean Wait Time	N	P-value[1]
Week Day (M-F; 0900 - 1700)	26.35 hours	13,410	<.001
Weekend (S-Su; 0900 - 1700)	24.71 hours	4,666	
After Hours (M-Su; 1701 - 0859)	29.68 hours	18,994	

1 Levene's p<.001, p-value base on equal variances not assumed

Levene's statistic was significant (p<.001) and Brown-Forsythe was also significant (p<.001), therefore the wait times are significantly different between admission times. Using Games Howell, the mean wait times for each group were significantly different (p<.05) between each group of admission time. Thus, the After Hours mean wait time is significantly longer than the other 2 admission groups

Assessing Significant Difference in Wait Time by Hospital Type

Procedures that typically take priority on the emergency wait list include trauma, cesarean sections and transplants. To assess for significant difference between wait times in hospitals that offer these services, mean wait times were compared between hospital type using separate independent-samples T-tests. The following groups were compared:

1) Trauma Level 1 &2 hospitals versus all other hospitals
2) Perinatal hospitals versus hospitals without perinatal services
3) Transplant hospitals versus hospitals without transplant services.

1) Trauma hospitals: for the independent-samples T-tests comparing wait times between trauma hospitals vs non-trauma hospitals Levene's Test for Equality of variance was significant (p<.001) and the p-value for equal variance not assumed was also significant (p<.001). Patients awaiting the 3 emergency procedures in a trauma hospital waited longer than patients in a community hospital by approximately 5 hours.

Table 6: T-Test Comparison of Mean Wait Time by Trauma Hospital Type

Group	Mean Wait Time	N (n=37,070)	P-value[1]
Trauma Hospitals	31.61 hours	11,475	<.001
Non-trauma hospitals	26.16 hours	25,595	

1 Levene's p<.001, p-value base on equal variances not assumed

2) Perinatal Hospitals: for the independent-samples T-tests comparing wait times between perinatal hospitals versus non-perinatal hospitals Levene's Test for Equality of variance was significant (p<.001) and the p-value for equal variance not assumed was also significant (p<.001). Patients awaiting the 3 emergency procedures in a hospital that did not offer perinatal services waited longer by approximately 4 hours.

Table 7: T-Test Comparison of Mean Wait Time by Perinatal Hospital Type

Group	Mean Wait Time	N (n=37,070)	P-value[1]
Perinatal Hospitals	27.12 hours	31,196	<.001
Non-Perinatal Hospitals	31.70 hours	5,874	

1 Levene's p<.001, p-value base on equal variances not assumed

3) Transplant hospitals: for the independent-samples T-tests comparing wait times between transplant hospitals vs non-transplant hospitals Levene's Test for Equality of variance was significant (p<.001) and the p-value for equal variance not assumed was also significant (p<.001). Patients awaiting the 3 emergency procedures in a hospital that offered solid organ transplant waited longer than patients in a hospital without transplant services by approximately 4 hours.

Table 8: T-Test Comparison of Mean Wait Time by Transplant Hospital Type

Group	Mean Wait Time	N (n=37,070)	P-value[1]
Transplant Hospitals	31.87 hours	4,614	<.001
Non-Transplant Hospitals	27.27 hours	32,456	

1 Levene's p<.001, p-value base on equal variances not assumed

Assessing Risk Factors for Surgical Delay

The final analysis of the factors affecting emergency surgery wait times was completed using multivariate logistic regression. Multivariate logistic regression was chosen to identify which factors were most strongly related to surgical delay as patient wait times are impacted by many interrelated factors. Odds ratios were computed to assess which admission characteristics were associated with increased risk of surgical delay. Because mean wait times were significantly different based on the procedure, logistic regression was used to evaluate risk factors on a per procedure basis. In addition, the literature supports different wait time benchmarks per procedure. These benchmarks were used to define surgical delay. For appendectomy the benchmark for acceptable wait was 24 hours. For cholecystectomy and hip fracture repair the benchmark was 48 hours. Odds ratios were calculated the following variables: patient age, admission time, and admission to trauma, transplant or perinatal hospital.

Dependent Variable

Wait time was dichotomized in order to calculate odds ratios. For appendectomy the dependent variable was the *24 hour* bench mark. The two categories included:

- Within 24 Hours: patients who received surgery within 24 hours of ED admission
- Surgical Delay: patients who waited greater than 24 hours after ED admission.

For cholecystectomy and hip fracture repair the dependent variable was the *48 hour benchmark.* The two categories included:

- Within 48 Hours: patients who received surgery within 48 hours of ED admission
- Surgical Delay: patients who waited greater than 48 hours after ED admission.\

These variables were entered as the dependent variable for the logistic regression.

Independent Variables:

In order to assess the associations between the variables, the independent variables were first transformed into the following categorical variables:

1) Age was grouped into 3 categories:
    a. Pediatric (0 - 17 years)
    b. Adults (18 - 65 years)
    c. Older adults (66 years and older).
2) Admission Time was grouped into 3 categories
    a. Weekday admissions: Monday to Friday 0900-1700
    b. Weekend admissions: Saturday and Sunday 0900-1700
    c. After hours admissions: Monday to Sunday 1701 – 0859
3) Trauma Hospitals were categorized as:
    a. Trauma level 1 & 2 hospitals
    b. Hospitals not designated as level 1 or 2 trauma
4) Perinatal Hospitals were categorized as:
    a. Perinatal Hospitals
    b. Hospitals without perinatal services
5) Transplant Hospitals were categorized as:
    a. Transplant Hospitals
    b. Hospitals without transplant services

Odds ratios for each of the 3 procedures are reported in relation to their benchmarks in Table 9 – 11 below.

Table 9: Odds Ratios for Appendectomy 24 Hour Benchmark			
Variable	**OR**	**95 % CI**	**Sig**
Age: reference group: Pediatric			
Adult	1.611	1.393 – 1.862	<.001
Older adult	3.066	2.553 – 3.682	<.001
Admission Time: reference group Weekday			
Weekend	.997	.850 – 1.169	.966
After Hours	1.069	.963 – 1.187	.208
Trauma Hospital	1.221	1.096 – 1.360	.<.001
Transplant Hospital	1.232	1.047 – 1.450	.012
Perinatal Hospital	.754	.647 - .879	<.001

Table 10: Odds Ratios for Cholecystectomy 48 Hour Benchmark			
Variable	**OR**	**95 % CI**	**Sig**
Age: reference group: Pediatric			
Adult	.805	.507 – 1.277	.357
Older adult	1.224	.769 – 1.948	.394
Admission Time: reference group Weekday			
Weekend	.944	.830 – 1.300	.379
After Hours	1.012	.931 – 1.100	.777
Trauma Hospital	1.406	1.283 – 1.542	<.001
Transplant Hospital	1.259	1.062 – 1.491	.008
Perinatal Hospital	.853	.735 - .990	.036

Table 11: Odds Ratios for Hip Fracture Repair 48 Hour Benchmark			
Variable	**OR**	**95 % CI**	**Sig**
Age: reference group: Pediatric			
Adult	.708	.243 – 2.062	.527
Older adult	1.502	.526 – 4.289	.448
Admission Time: reference group Weekday			
Weekend	.863	.673 – 1.108	.249
After Hours	.984	.834 – 1.163	.854
Trauma Hospital	1.124	.935 – 1.1351	.214
Transplant Hospital	.881	.661 -1.174	.386
Perinatal Hospital	1.124	.831 – 1.520	.449

The risk factors associated with surgical delay varied by procedure group. For appendectomy, using the *24 hour benchmark*, the factors that had significant effect on surgical delay included age and admission to either trauma or perinatal hospital. Age was the most significant factor impacting wait time with Older Age being associated with the greatest increased risk of delay (OR 3.066, 95% CI 2.553 – 3.682, p<.001). Admission to a hospital with trauma level 1 or 2 certification was associated with a slight increased risk for surgical delay (OR 1.221, 95% CI 1.096 – 1.360, p<.001). While admission to a hospital with perinatal services was protective of surgical delay (OR.754, 95% CI .647 -.879, $p<.001$).

For gallbladder removal when using the *48 hour benchmark*, the only factor that had significant effect on surgical delay was admission to a trauma hospital. Admission to a hospital with trauma level 1 or 2 designation was associated with a slight increased risk for surgical delay (OR 1.406, 95% CI 1.283 – 1.542, $p<.001$). For hip fracture repair when using the *48 hour benchmark*, none of the factors had significant effect on surgical delay.

Discussion

The average age and sex distribution of patients for this research project was 47.21 years and 45% male to 55% female. This is slightly different than the average age and sex distribution reported by Faryniuk & Hochman (2013) whose study on a similar patient population reported mean age ranged from 45.5 – 50.8 and closer to a 50-50 split between male and female. However, these differences could be explained by the fact that this project used hip fracture repair while Faryniuk & Hochman (2013) used small bowel obstruction. Faryniuk & Hochman (2013) all also had a much smaller sample size (n = 346 patients). For patients who received hip fracture repair in this project, the average was 77 years old, the highest of all interventions, and the distribution between male and female for hip fracture repair was 65.4 % female to 34.6% male which was the highest ratio of female to male by procedure. A repeat study using small bowel instead of hip fracture could be used to confirm this hypothesis.

There was a significant difference for mean wait times between procedure groups. This is consistent with the literature which suggests different benchmarks for each procedure. For appendectomy and hip fracture repair, the mean wait times were within the suggested benchmarks; however, for cholecystectomy the mean wait time was 4 hours over the benchmark, which suggests there is room for improvement. Further studies are needed to examine a more comprehensive number and variety of procedures.

Another significant result was that mean wait times increased with age. The mean wait times for the pediatric group was 13 hours while the older adult group was 34 hours. Some possible explanations include the more extensive medical work up and longer preoperative stabilization required for older adults with multiple comorbidities. Further research is needed to account for factors such as pre-operative diagnosis as well as medical comorbidities.

The impact of admission time on mean wait time was significantly different between the three groups ($p<.05$). Mean wait times ranged from 24 to 29 hours. The difference in mean wait time was less than 5 hours. The significance can be partially explained by the large sample (n=37,070). Weekend admissions were associated with shortest wait times. This is somewhat congruent with Kristiansen et al. (2016) who found that off-hours admission had the lower risk of surgical delay when compared to on-hours admission. However, Kristiansen et al. (2016) specifically identified weekday evening and night shifts as associated with decreased risk of surgical delay, rather than weekend day admissions. Kristiansen et al. (2016) suspected that because outpatient and elective surgeries are limited to week days, admission during off-hours may result in greater access to organizational services. Further research is required to confirm this speculation.

The impact of hospital type on mean wait time was conflicting. While admission to hospitals that perform solid organ transplant and trauma surgeries had a longer mean wait times, admission to perinatal hospitals had a shorter mean wait times. This result is counter to the hypothesis but could be explained by the fact that hospitals without perinatal services do not have anesthesiologist available and therefore must wait for staff to arrive before surgery begins.

The strongest factor associated with surgical delay across all procedure types in this project was older age for patients awaiting appendectomy. Older age was associated with highest risk of surgical delay (OR 3.066, 95% CI 2.553 – 3.682, $p<.001$). Admission to trauma hospital was also associated with surgical delay; however, it had a small effect size.

In addition, admission to a perinatal hospital was protective of surgical delay, but it also had a small effect size.

The two main limitations of this project were related to the wait time calculation and the scope of the project. The first limitation was the data points used for the wait time calculation. For this project, wait time begins at the time of ED registration and ends at intervention start time, which CIHI defines as the "date and time when the patient enters a physical area (intervention location) to have a service(s)/intervention (s) initiated" (Canadian Institute of Health Information, 2015, p. 8). Beginning the wait time at ED registration results in an extended wait time and includes time that the hospital cannot reduce as it is not aware of the need for surgery. Ending the wait time calculation with the intervention start time under represents the patient wait time as the patient may require extensive preparation inside the operating room prior to the actual skin cut or surgery start time. Future studies using the surgery decision time and the skin cut time would be more accurate; however, these data elements are not collected in the DAD and would need to be linked from another data source.

The second limitation of this project is the small scope. Only 3 procedures were included in this project. In order to generalize the findings to other procedures, more procedures should be included in future studies. In addition, this project does not include information on the patients' medical conditions, comorbidities or postoperative outcomes. Further studies that consider wait time bench marks in relation to patients' admitting diagnoses are needed as patient diagnoses and comorbidities may impact acceptable wait times.

Based on the findings of this project, there is not a strong argument for recommending clinical decision support. The mean wait times and risk factors assessed in this project do not create a strong case for implementing clinical decision support. Mean wait times for appendectomy and hip fracture repair were within the recommended benchmarks. Furthermore, the most significant factor related to surgical delay was age. This is not a factor that any of the decision support tools examined in the literature review section considers. Further research is needed to build a case for clinical decision support in BC. In order to perform a comprehensive assessment, future research should include additional procedures, admitting diagnosis and patient outcomes. Ideally the study would calculate wait time from surgery decision time to skin cut time in order to capture the most accurate patient wait time.

Conclusion

Certain types of emergency surgeries can be subject to prolonged wait times. Clinical decision support is available for emergency surgery scheduling, but at this time it is not used in BC. This research project used 5 years of DAD to present the mean wait times for 3 emergency procedures in BC and assess the impact of age, admission time, and hospital type on surgical delay. While clinical decision support is available for use, the mean wait times and risk factors assessed in this project do not create a strong case for implementing a decision support tool. Mean wait times for appendectomy and hip fracture repair were within the recommended benchmarks and the most significant risk factor for surgical delay was age, rather than hospital or admission characteristics. Further research is needed to build a case for clinical decision support for scheduling emergency surgery in BC.

Literature Cited

Aboulian, A., Chan, T., Yaghoubian, A., Kaji, A. H., Putnam, B., Neville, A., de Virgilio, C. (2010). Early Cholecystectomy Safely Decreases Hospital Stay in Patients With Mild Gallstone Pancreatitis. *Annals of Surgery*, *251*(4), 615–619. https://doi.org/10.1097/SLA.0b013e3181c38f1f

Alemayehu, B., & Warner, K. E. (2004). The lifetime distribution of health care costs. *Health Services Research*, *39*(3), 627–642. https://doi.org/10.1111/j.1475-6773.2004.00248.x

BC Government. (2018). New strategy will help more people get the surgeries they need faster | BC Gov News. Retrieved from https://news.gov.bc.ca/releases/2018PREM0010-000460

Beeler, P., Bates, D., & Hug, B. (2014). Clinical decision support systems. *Swiss Medical Weekly*, *144*, w14073. https://doi.org/10.4414/smw.2014.14073

Blohm, M., Österberg, J., Sandblom, G., Lundell, L., Hedberg, M., & Enochsson, L. (2017). The Sooner, the Better? The Importance of Optimal Timing of Cholecystectomy in Acute Cholecystitis: Data from the National Swedish Registry for Gallstone Surgery, GallRiks. *Journal of Gastrointestinal Surgery*, *21*(1), 33–40. https://doi.org/10.1007/s11605-016-3223-y

Bohm, E., Loucks, L., Wittmeier, K., Lix, L. M., & Oppenheimer, L. (2015). Reduced time to surgery improves mortality and length of stay following hip fracture: results from an intervention study in a Canadian health authority. *Canadian Journal of Surgery, 58*(4), 257–263. https://doi.org/10.1503/CJS.017714

British Columbia Ministry of Health. (2017): Consolidation File (MSP Registration & Demographics & Geodata). V2. Population Data BC. Data Extract. MOH (2017). Retrieved from http://www.popdata.bc.ca/data

Canadian Institute of Health Information. (2011). *A Focus on Seniors and Aging*. Retrieved from https://secure.cihi.ca/free_products/HCIC_2011_seniors_report_en.pdf

Canadian Institute of Health Information. (2015). *DAD Data Elements 2015 -2016.* Retrieved from www.cihi.ca

Canadian Institute for Health Information. (2017): Discharge Abstract Database (Hospital Separations). V2. Population Data BC. Data Extract. MOH (2011 - 2017). Retrieved from http://www.popdata.bc.ca/data

Canadian Institute of Health Information. (2018). *Wait Times for Priority Procedures in Canada, 2018: Technical Notes*. Retrieved from www.cihi.ca

Canadian Institute of Health Information. (2018). *Wait Times for Priority Procedures in Canada, 2018: Technical Notes*. Retrieved from www.cihi.ca

Cheng, Y., Xiong, X., Lu, J., Wu, S., Zhou, R., & Cheng, N. (2017). Early versus delayed appendicectomy for appendiceal phlegmon or abscess. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD011670.pub2

Cowie, B., & Corcoran, P. (2012). Postanesthesia Care Unit Discharge Delay for Nonclinical Reasons. *Journal of PeriAnesthesia Nursing*, *27*(6), 393–398. https://doi.org/10.1016/j.jopan.2012.05.013

Falor, A. E., de Virgilio, C., Stabile, B. E., Kaji, A. H., Caton, A., Kokubun, B. A., Saltzman, D. J. (2012). Early Laparoscopic Cholecystectomy for Mild Gallstone Pancreatitis. *Archives of Surgery*, *147*(11), 1031. https://doi.org/10.1001/archsurg.2012.1473

Fantini, M. P., Fabbri, G., Laus, M., Carretta, E., Mimmi, S., Franchino, G., Rucci, P. (2011). Determinants of surgical delay for hip fracture. *The Surgeon*, *9*(3), 130–134. https://doi.org/10.1016/J.SURGE.2010.11.031

Faryniuk, A. M., & Hochman, D. J. (2013). Effect of an acute care surgical service on the timeliness of care. *Canadian Journal of Surgery*, *56*(3), 187–191. https://doi.org/10.1503/cjs.022911

Ferrand, Y. B., Magazine, M. J., & Rao, U. S. (2014). Partially Flexible Operating Rooms for Elective and Emergency Surgeries. *Decision Sciences*, *45*(5), 819–847. https://doi.org/10.1111/deci.12096

Gurusamy, K. S., Davidson, C., Gluud, C., & Davidson, B. R. (2013). Early versus delayed laparoscopic cholecystectomy for people with acute cholecystitis. *Cochrane Database of Systematic Reviews*, (6). https://doi.org/10.1002/14651858.CD005440.pub3

Heydari, M., & Soudi, A. (2016). Predictive / Reactive Planning and Scheduling of a Surgical Suite with Emergency Patient Arrival. *Journal of Medical Systems*, *40*(1), 30. https://doi.org/10.1007/s10916-015-0385-1

Kristiansen, N. S., Kristensen, P. K., Nørgård, B. M., Mainz, J., & Johnsen, S. P. (2016). Off-hours admission and quality of hip fracture care: a nationwide cohort study of performance measures and 30-day mortality. *International Journal for Quality in Health Care*, *28*(3), 324–331. https://doi.org/10.1093/intqhc/mzw037

Laake, P., Benestad, H. B., & Olsen, B. R. (2007). *Research methodology in the medical and biological sciences*. Retrieved from https://ebookcentral.proquest.com/lib/uvic/detail.action?docID=317017.

Lamiri, M., Xie, X., Dolgui, A., & Grimaud, F. (2006). A stochastic model for operating room planning with elective and emergency demand for surgery. https://doi.org/10.1016/j.ejor.2006.02.057

McIsaac, D. I., Abdulla, K., Yang, H., Sundaresan, S., Doering, P., Vaswani, S. G., … Forster, A. J. (2017). Association of delay of urgent or emergency surgery with mortality and use of health care resources: a propensity score-matched observational cohort study. *Canadian Medical Association Journal*, *189*(27), E905–E912. https://doi.org/10.1503/cmaj.160576

Medical Management Consulting. (2009). *Operational Review Section 2 Vernon Jubilee Hospital*. Retrieved from https://www.interiorhealth.ca/AboutUs/Accountability /Documents/VJH-Report-Section2-OperationalReview.pdf

Middleton, B., Sittig, D. F., & Wright, A. (2016). Clinical Decision Support: a 25 Year Retrospective and a 25 Year Vision. *Yearbook of Medical Informatics*, *25*(S 01), S103–S116. https://doi.org/10.15265/IYS-2016-s034

Moja, L., Piatti, A., Pecoraro, V., Ricci, C., Virgili, G., Salanti, G., Banfi, G. (2012). Timing Matters in Hip Fracture Surgery: Patients Operated within 48 Hours Have Better Outcomes. A Meta-Analysis and Meta-Regression of over 190,000 Patients. *PLoS ONE*, *7*(10), e46175. https://doi.org/10.1371/journal.pone.0046175

Ong, M., Guang, T. Y., & Yang, T. K. (2015). Impact of surgical delay on outcomes in elderly patients undergoing emergency surgery: A single center experience. *World Journal of Gastrointestinal Surgery*, *7*(9), 208–213. https://doi.org/10.4240/ wjgs.v7.i9.208

Perinatal Services BC. (n.d.). Facility-Level Indicator Data. Retrieved from http://www.perinatal servicesbc.ca/

Ricci, W. M., Brandt, A., McAndrew, C., & Gardner, M. J. (2015). Factors Affecting Delay to Surgery and Length of Stay for Patients With Hip Fracture. *Journal of Orthopaedic Trauma*, *29*(3), e109–e114. https://doi.org/10.1097/BOT.0000000000000221

Santibáñez, P., Begen, M., & Atkins, D. (2007). Surgical block scheduling in a system of hospitals: an application to resource and wait list management in a British Columbia health authority. *Health Care Management Science*, *10*(3), 269–282. https://doi.org/10.1007/s10729-007-9019-6

Shortliffe, E. H. (1987). Computer Programs to Support Clinical Decision Making. *JAMA: The Journal of the American Medical Association*, *258*(1), 61. https://doi.org/10.1001/jama.1987.03400010065029

Transplant BC. (2017). *Quick Facts on Organ Donation and Transplant in BC 2017.* Retrieved from www.transplant.bc.ca/documents/BCT017_FactSheet_2018.pdf

Trauma Service BC. (2014). *Trauma Services BC A program of the Provincial Health Services Authority Executive Summary-2014 Stereotactic radiosurgery for int*. Retrieved from http://www.phsa.ca/our-services-site/Documents/TSBC Executive Summary - 2014.pdf

United Kingdom National Surgical Research Collaborative, & Bhangu, A. (2014). Safety of short, in-hospital delays before surgery for acute appendicitis: multicentre cohort study, systematic review, and meta-analysis. *Annals of Surgery*, *259*(5), 894–903. https://doi.org/10.1097/SLA.0000000000000492

van Dijk, S. T., van Dijk, A. H., Dijkgraaf, M. G., & Boermeester, M. A. (2018). Meta-analysis of in-hospital delay before surgery as a risk factor for complications in patients with acute appendicitis. *British Journal of Surgery*, *105*(8), 933–945. https://doi.org/10.1002/bjs.10873

Vidán, M. T., Sánchez, E., Gracia, Y., Marañón, E., Vaquero, J., & Serra, J. A. (2011). Causes and Effects of Surgical Delay in Patients With Hip Fracture. *Annals of Internal Medicine*, *155*(4), 226. https://doi.org/10.7326/0003-4819-155-4-201108160-00006

Zonderland, M. E., Boucherie, R. J., Litvak, N., & Vleggeert-Lankamp, C. L. A. M. (2010). Planning and scheduling of semi-urgent surgeries. *Health Care Management Science*, *13*(3), 256–267. https://doi.org/10.1007/s10729-010-9127-6

Appendix A. Specialty Hospitals

The data for hospitals performing specialty services was retrieved from Provincial Heath Service Authority program areas.

- The hospitals performing C-sections was collected from Perinatal BC,
- The hospitals performing solid organ transplants was collected from BC transplant,
- The hospitals trauma designation was collected from Trauma ServiceBC.

Hospitals that perform C sections (Perinatal Services BC, n.d.)

FHA	Abbotsford
FHA	Burnaby
FHA	Chilliwack
FHA	Langley
FHA	Peace Arch
FHA	Ridge Meadows
FHA	Royal Columbian
FHA	Surrey Memorial
IHA	Cariboo Memorial
IHA	100 mile House
IHA	Creston Valley Hospital
IHA	East Kootenay Regional
IHA	Elk Valley Hospital
IHA	Golden and District
IHA	Kelowna
IHA	Kootenay Boundary
IHA	Kootenay Lake
IHA	Lillooet
IHA	Penticton
IHA	Queen Victoria Yes
IHA	Royal Inland Hospital
IHA	Shuswap Lake

IHA	Vernon Jubilee
NHA	Buckley Valley
NHA	Dawson Creek
NHA	Fort St John
NHA	Kitimat
NHA	Mills Memorial
NHA	Prince Rupert
NHA	St John
NHA	UNBC
PHSA	BC Women's Hospital
VCHA	LGH
VCHA	Powell River
VCHA	Richmond
VCHA	Sechelt
VCHA	Squamish
VCHA	St. Paul's
VIHA	Campbell River
VIHA	Cowichan
VIHA	Nanaimo
VIHA	St. Josephs
VIHA	Vic General
VIHA	West Coast General

Hospitals that perform solid organ transplant (Transplant BC, 2017)

- BC Children's
- St. Paul's Hospital
- Vancouver General Hospital

Hospitals with Trauma level 1 (Trauma Service BC, 2014)

- Vancouver General Hospital
- Royal Columbian Hospital
- BC Children's Hospital

Hospitals with Trauma level 2 (Trauma Service BC, 2014)

- Victoria General & Royal Jubilee Hospitals
- Royal Inland Hospital
- Kelowna General Hospital

Appendix B. University of Victoria Ethics Approval and Modification

University of Victoria | Office of Research Services | Human Research Ethics Board
Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR:	**Jaclyn Sing**	**ETHICS PROTOCOL NUMBER:** Minimal Risk - Chair/Vice-chair	**18-183**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	14-May-18
UVic DEPARTMENT:	**HEIS**	APPROVED ON:	14-May-18
		APPROVAL EXPIRY DATE:	13-May-19

PROJECT TITLE: **BC Emergency Surgery Wait Times**

RESEARCH TEAM MEMBER Primary Investigator & Supervisor: Scott Macdonald

DECLARED PROJECT FUNDING: **None**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Rachael Scarth

Dr. Rachael Scarth
Associate Vice-President Research Operations

18-183 Sing, Jaclyn

Certificate Issued On: 14-May-18

University of Victoria

Office of Research Services | Human Research Ethics Board
Michael Williams Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | ethics@uvic.ca | uvic.ca/research |

Modification of an Approved Protocol

PRINCIPAL INVESTIGATOR:	**Jaclyn Sing**	**ETHICS PROTOCOL NUMBER:** Minimal Risk - Chair/Vice-chair	**18-183**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	14-May-18
UVic DEPARTMENT:	**HEIS**	MODIFIED ON:	08-Jun-18
SUPERVISOR:	**Dr. Scott Macdonald**	APPROVAL EXPIRY DATE:	13-May-19

PROJECT TITLE **BC Emergency Surgery Wait Times**

RESEARCH TEAM MEMBER Primary Investigator & Supervisor: Scott Macdonald (UVic)

DECLARED PROJECT FUNDING: **None**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

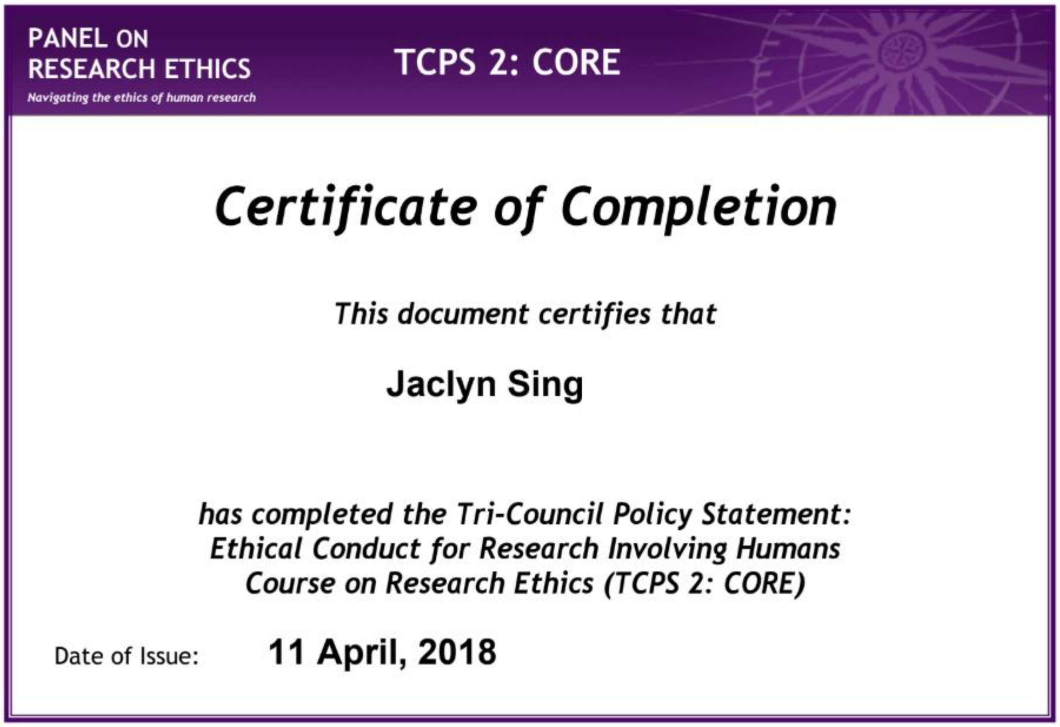
Rachael Scarth

Dr. Rachael Scarth
Associate Vice-President Research Operations

18-183 Sing, Jaclyn

Certificate Issued On: 08-Jun-18

Appendix C. TCPS 2 CORE Certificate



PANEL ON
RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Jaclyn Sing

*has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)*

Date of Issue: **11 April, 2018**