Structure, Process, and Outcome in Emergency General Surgery

by

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Abstract

Background:
Dedicated emergency general surgery (EGS) services have been established across North America as a means to bring focus and quality to a large, complex and vulnerable surgical population. The emergence of these services represents a great opportunity to understand and improve emergency surgical care.

Methods:
This research programs applies a health systems structure/process/outcomes framework to the study of EGS services in Canada:
1. Outcome: A systematic review of the effects of an EGS service on patient and non-patient related outcomes
2. Structure: A national cross sectional study of structure and case mix on 14 EGS services
3. Process: Detailed process mapping of a complex EGS condition

Results:
1. Outcomes: Studies found increased daytime and decreased after-hours operating, improved patient transit from ED to OR to home, and decreased length of stay after implementation of an EGS service. The overall trend was higher more diverse case volumes, which improved resident education. Lower complication rates were noticed in the appendicitis and cholecystitis groups.

2. Structure: Canadian EGS services demonstrated variability in service organization and access to operating rooms. However, a national cross sectional study of EGS patients revealed that all services see diverse case mix and high complexity, and routinely make complex judgments about operative and non-operative care.

3. Process: The processes of care for small bowel obstruction (SBO) patients from the time of presentation to the time of follow-up were highly elaborate and variable in terms of duration.

Data visualization strategies were used to identify substantial variability in terms of time to CT scan and time to OR.

Conclusions:

The EGS model has been implemented worldwide, and has demonstrated an improvement in timeliness of care, decreased administrative costs, and improved trainee learning. EGS services are well-established in Canada, and poised to identify new opportunities for improved patient care. Process mapping has been successfully integrated into surgical specialties and provides insight into potential areas of performance improvement in EGS.

Lay Summary

Emergency General Surgery (EGS) includes any general surgery procedure that is not previously booked on an elective slate and includes multiple organs systems. Previously this was covered by the "on-call" surgeon but now has organized into teams of surgeons and residents at larger hospitals. The focus of this thesis is to review the current literature on the impact of ACS services, complete an environmental scan on the current scope of EGS services in Canada and finally, conduct a review of a subset of EGS patients in an effort to find novel ways to introduce quality improvement to our service.

Preface

The work described in this thesis started as a casual conversation about Emergency General Surgery (EGS) patients and how their care could be improved. It grew into talks of uniting EGS surgeons across Canada into a research network, monthly teleconference calls and multiple research projects running through our national group. This manuscript represents the first chapter in the research efforts from the national group, and the specific efforts driven by the group at Vancouver General Hospital.

This dissertation is original work by the author, Dr. K. DeGirolamo.

This thesis contains the work of 4 articles. Three are currently in press (see details below) and one has been accepted to the American Surgeon. The chapter (2.2) on the impact of an EGS service on non-patient related outcomes has been accepted to The American Surgeon with publication date pending. The manuscript title is "Processes of Health Care Delivery, Education and Provider Satisfaction in Acute Care Surgery: A Systematic Review." The primary author, Dr. Kristin DeGirolamo, was responsible for the concept, designing the literature search, reviewing all of the articles and composing the bulk of the manuscript. Co-authors include, Patrick B Murphy[2-], Karan D'Souza[3], Jacques X. Zhang[3], Neil Parry[2,4,5], Elliott Haut[6], W. Robert Leeper[2, 4,5--], Ken Leslie[2], Kelly N Vogt[2], S. Morad Hameed[1,7]

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The chapter (2.1) on the impact of an EGS service on patient related outcomes in currently in press with JACS (Journal of the American College of Surgeons). The manuscript title is "Meta-analysis on the impact of the acute care surgery model of disease specific and patient outcomes in appendicitis and biliary disease". Authors were: Patrick B Murphy[1], Kristin DeGirolamo[2], Theunis Jean Van Zyl[3], Laura Allen[1], Elliott Haut[6], W. Robert Leeper[1,4,5], Ken Leslie[1], Neil Parry[1,4,5], Morad Hameed[2,7], Kelly N Vogt[1,4]

As secondary author Dr. DeGirolamo was responsible for concept, designing the literature search, reviewing all the articles and composing the manuscript. This article has been summarized in section 2.1 and Dr. P Murphy, a co-author, gave permission to report the unpublished data.

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Chapter 3, A Day in the Life of Emergency General Surgery in Canada was a prospective data collection done at 14 hospitals across Canada. Ethics was granted at each of the participating hospital REB and at UBC, UBC CREB Number: H16-01347. The article is currently in press. As primary author, Dr. DeGirolamo was responsible for study design, acting as principle investigator and site lead for VGH. She also did all the data entry, analysis and composed the majority of the manuscript.
Authors were: K DeGirolamo[1], K D'Souza[2], S Apte[3], C Ball[4], S Widder[3], S Mueller[5], L Gillman[6], R Singh[7], R Nenshi-Patel[8], K Khwaja[9], S minor[10], M Hameed[1,2,11].

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Chapter 4, on the project "Processes Mapping as a Framework for Performance Improvement in Emergency General Surgery" is in press with the Canadian Journal of Surgery. Data was provided by Vancouver General Hospital Department of Surgery NSQIP office for the SBO pilot project. The supervising committee for this project consisted of Dr. Morad Hameed (as the Principal Investigator), Drs. Naisan Garraway, Dr. Emilie Joos, Dr. Chad KimSing, and Dr. Patrick McLaughlin as co-investigators.

Under the supervision of the research committee, Dr. DeGirolamo was responsible for formulating the research objectives, study design, obtaining UBC ethics approval, data collection, data analysis and writing the manuscript.

Mr. Markus Zurberg (Department of Clinical Quality and Safety) provided the cohort of SBO patients and education around how NSQIP is used within the department of Surgery.

Ethics approval was obtained from the UBC Clinical Ethics Review Board for the SBO study component of this manuscript. (UBC CREB No. H15-03023).

Authors were Kristin DeGirolamo[1], Karan D'Souza[2], William Hall[3], Emilie Joos[1,2,4], Naisan Garraway[1,2.4], Chad Kim Sing[2,5], Patrick McLaughlin[2,6], and S. Morad Hameed[1,2,4.]

As the primary author, Dr. DeGirolamo was responsible concept, ethics, data collection and manuscript writing.

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List of Abbreviations

VGH	Vancouver General Hospital
UBC	University of British Columbia
ACS NSQIP	American College of Surgeons – National Surgical Quality Improvement Program
EQIP	Emergency Surgery Quality Improvement Program
MRN	Medical Record Number
SSI	Surgical Site Infection
MI	Myocardial Infarction
ACS	Acute Care Surgery
EGS	Emergency General Surgery
OR	Operating Room
SBO	Small Bowel Obstruction
CT	Computed Tomography
JACS	Journal of the American College of Surgeons
NOS	Newcastle Ottawa Scale
EPIQ	Evidence-based Practice for Improving Quality
LOS	Length of Stay

Acknowledgments

For Dr. Alice Mui, a constant support and believer in my research. You have provided a constant support system in the form of last minute accepting me into your master's program, finding funding for my tuition and conferences and encouraging me to participate in multiple local research competitions. Thank you.

For Dr. Morad Hameed, the driver of all of this research. You constantly push me to think more, do more, achieve more and above all be passionately committed to improving the care of patients served by the EGS service at VGH. I will be forever grateful for how your mentorship over the last 2 years has helped me develop my research skills and (hopefully!) set me up for a successful career as an EGS surgeon. Thank you.

Dedication

For Kassem and Hassan, my constant support system and inspiration. This work would not have been possible without Hassan and his dedication to my career. Hassan, you always ask how you can be more helpful, more involved, always asking what I need to do to improve my future plans and never stop putting Kas and I first. I truly did choose an equal partner and am so lucky.

Chapter 1 – Introduction

1.1 Background

In the last decade, many centers providing acute general surgery coverage have transitioned from a traditional 24-hr call model to a dedicated emergency general surgery (EGS) model. Many differing structures of such services have been described. The most common design of a dedicated EGS team is a "surgeon of the week" model where a single surgeon suspends his or her elective practice for 7 days and instead manages a team of house staff and/or ancillary health professionals in the management of emergency and in-patient consults for acutely ill general surgery patients. Typical coverage is 7 am to 5 pm on weekdays and a full weekend of coverage. Week nights are covered by other general surgeon staff with dedicated hand-over and transfer of care each morning to the consultant of the week. Some models include dedicated day-time emergency operative time.[1–3]

The EGS model has many perceived benefits for patient care and disease specific outcomes such as efficient care delivery, shorter time to decision for operation, more day-time operations, reduced peri-operative complications and decreased length of stay.[1,2,4–6] Surgeon satisfaction and resident/fellow learning can also be positively impacted.[7,8] In the United States this model has amalgamated trauma surgery and emergency surgery into one discipline at many centers to coordinate care of complex emergency general surgery patients, but also to account for the increasing non-operative nature of trauma care.[9]

A recent meta-analysis evaluated the literature surrounding patient and disease specific outcomes before and after implementation of an EGS model.[10] This review was, however, limited by strict inclusion criteria and methodological issues. Another systematic review had a broad scope in determining the structural factors of EGS models but similarly a number of important references were not included.[11]

A comprehensive framework for EGS research

Dr. Avedis Donabedian, a Lebanese physician, famously started analyzing health services and quality improvement. The Donabedian model is named after his lifetime of work into evaluating the quality of healthcare in terms of 3 categories: structure, process and outcomes.[12] Structure is evaluated by looking at every context in which care is delivered. This includes buildings, finance and staff. Process is how the care is delivered to patients. Outcomes are any product of this system and include patient related outcomes (ex: morbidity and mortality) and non patient related outcomes (ex: cost efficiency, resident learning, quality improvement projects).[12]

The overall theme for this thesis is the application of the Donabedian model to define the impact of EGS services, characterize EGS patients and systems of care in Canada, and use a representative cohort of EGS patients (small bowel obstruction (SBO)) to test process mapping as a way to identify areas of quality improvement. We will explore the opportunities that these new systems present to elucidate (and therefore improve) the complex processes of emergency surgical care. This dissertation aims to answer the following research questions:

1. How does implementing an EGS service affect appendicitis and cholecystitis outcomes?
2. How does implementing an EGS service affect non-patient related outcomes?
3. What is the current state of EGS services in Canada, with respect to structure and case mix?
4. Do EGS services offer new opportunities to understand and improve the process of emergency surgical care?

1.2. Overall project hypothesis

We hypothesize that EGS services represent a promising health systems approach to a large and complex surgical population, and that, as these services mature, detailed assessments of their structures, processes and outcomes, including process mapping, will lend unprecedented insights about performance improvement.

1.3 Overall project objective

The overall objective of this dissertation is to highlight the complexity of EGS, report on what is already known about the impact of EGS services and apply the methodology of process mapping to a cohort of SBO patients to identify potential areas for quality improvement.

Chapter 2: Outcomes in EGS – Systematic reviews of clinical and non-clinical effects of EGS service implementation

2.1 Meta-analysis of the impact of EGS service implementation on clinical outcomes in appendicitis and cholecystitis

Background

The emergency general surgery (EGS) model was developed to acknowledge the complexity of a traditionally fractured emergency general surgery patient population; however there are variations in the design of EGS service models. Prior to being able to apply more specific quality improvement measures we wanted to first review the literature for effect of EGS services on patient outcomes. This meta-analysis analyzes the impact of different EGS models on the outcomes for appendicitis and biliary disease.

Methods

A joint literature search between Western Ontario and UBC was undertaken to review what the literature has reported on the effects of the implementation of an EGS service. A systematic English language search of major databases was conducted. Two independent reviewers then used the Newcastle Ottawa Scale (NOS) and EPIQ methodology to analyze the effects of an EGS service on patients with cholecystitis and appendicitis.

Results

We found that most papers described the effects of an EGS service on patient outcomes, specifically those patients with appendicitis and biliary disease. The search returned 1827 studies after removal of duplicates, and after applying the inclusion/exclusions criteria 357 articles underwent full text review (see Figure 1). Of the reviewed articles 48 studies were identified as having met inclusion criteria, with reasons for exclusion of the remaining studies

shown in the PRISMA diagram (Figure 1). Of the 48 articles, 25 contained data on outcomes for appendicitis and/or biliary disease, and are outlined in Table 1.

Appendicitis and Biliary Disease Results

The proportion of negative appendectomies was no different after implementation of an EGS model (OR 1.09, 95% CI 0.91,1.31). Perforated or ruptured appendicitis was no different in the Pre-EGS and Post-EGS period (OR 0.85, 95% CI 0.63,1.14).

For both appendicitis and biliary disease there was a significant difference in complication rates, with fewer complications in the Post-EGS period (OR 0.65, 95% CI 0.49,0.86, I^2 = 45%; OR 0.50, 95% CI 0.38, 0.65; I^2 = 2).

The use of a laparoscopic approach was significantly greater in the Post-EGS period (OR 2.59, 95% CI 1.95,3.44; OR 1.4, 95% CI 0.83, 2.37) and there was no difference in the rate of conversion to open (OR 0.6, 95% CI 0.31,1.14; OR 0.74, 95% CI 0.47,1.10). After-hours operating was not statistically different between periods (OR 0.81, 95% CI 0.55, 1.18; OR 0.5, 95% CI 0.16, 1.57).

Length of stay was on average 0.5 days shorter in the Post-EGS period (95% CI -0.81, -0.20) for appendicitis and 0.73 days shorter in the Post-EGS period (95% CI -0.1.36, -0.09) for biliary disease. This effect was reduced, but still significant, to 0.2 days when considering only appendicitis studies with dedicated theater time (95% CI -0.29, -0.03, I^2 = 0%). This finding may initially come off as insignificant, however if you consider the ubiquity of these diseases, these small improvements do contribute a significant amount of cost and system resource savings.

The time to arrival in the OR from the ED was on average 2.6 hours shorter in the Post-EGS period (95% CI -4.41, -0.86) with significant heterogeneity (I^2 = 94%) for appendicitis and 6.95 hours shorter in the Post-EGS period (95% CI -10.25, -3.65) without significant heterogeneity (I^2 = 8%) for biliary disease. Sensitivity analysis including appendicitis with dedicated OR time could not account for this heterogeneity (I^2 = 84%) and did not yield a significant result (-0.85 hours; 95% CI -2.98, 1.29).

All reporting studies for biliary disease demonstrated an increase in the number of patients receiving early definitive care (< 72 hrs) and an increase in the rate of index operative management. This is key in reducing the multiple ER visits that patients with biliary disease likely have before definitive management of their gallbladder disease.

Discussion

The introduction of an EGS model of care appears to be associated with improved outcomes following admission for appendicitis and biliary disease. There is also a clear effect of dedicated daytime ORs within this model of care for appendectomy. The results of our meta-analysis suggest a reduction in complications, length of stay, time to operation and an increased use of laparoscopy and an increase in the early definitive management with cholecystectomy after the addition of an EGS model. Dedicated day-time operating theater access seems to impact the effect size of the studied outcome measures, particularly with respect to afterhours operating in appendicitis with a predictable decrease only in those studies with dedicated daytime ORs. We unexpectedly found an increase in perforated appendicitis in EGS models with dedicated daytime ORs; however, this was not associated with a documented increase in overall complication rate.

Our meta-analysis demonstrates benefits to patients and likely to the healthcare system by transitioning from a traditional general surgery call model to an EGS model of care. Our comprehensive search strategy and transparency provide evidence for surgeons and hospitals to adopt this model of care, particularly a model with dedicated emergency daytime operating time. Our results suggest potential quality indicators that are achievable with an EGS service such as timeliness to operation.

Future studies on EGS models of care should be prospective, both before and after implementation, if possible, and should clearly outline the design of the service and define complications and other outcome measures. Furthermore, while the studies considered in this meta-analysis provide a strong justification for the implementation of dedicated EGS service structures for 2 common EGS diagnoses, the next generation of EGS research should examine the effect of EGS services on more acute, complex and resource intensive EGS conditions, which

often test the limits of modern surgical care, and which may account for the majority of EGS service activity.

Table 1 – Characteristics of included studies

Study	*Year*	*Country*	*Inclusion Criteria*	*Groups*	*N*	*Total Size*	*Age, y, mean +/- SD*	*Male (%)*
Earley[3]	2006	USA	Appendicitis	Pre-EGS Post-EGS	127 167	294	37 ± 15 30 ± 12	62 54
Ekeh[13]	2008	USA	Appendicitis	Pre- EGS Post-EGS	273 279	552	37 ± 17 36 ± 16	52 52
Gandy[14]	2010	Australia	Appendicitis	Pre-EGS Post-EGS	176 226	402	34 ± NR 33 ± NR	47 54
Qureshi[5]	2011	Canada	Appendicitis	Pre-EGS Post-EGS	169 136	305	57 ± 21 57 ± 21	51 49
Poh[15]	2013	Australia	Appendicitis	Pre-EGS Post-EGS	256 283	539	32 ± 1 32 ± 1	45 47
Brockman[16]	2013	Australia	Appendicitis	Pre-EGS Post-EGS	357 351	708	26 ± NR 26 ± NR	58 50
Pillai[17]	2013	New Zealand	Appendicitis	Pre-EGS Post-EGS	875 982	1857	29 (15-100) † 28 (15-88) †	55 54

Table 1 – Characteristics of included studies								
Study	*Year*	*Country*	*Inclusion Criteria*	*Groups*	*N*	*Total Size*	*Age, y, mean +/- SD*	*Male (%)*
Lancashire[18]	2014	Australia	Appendicitis	Pre-EGS Post-EGS	247 30	548	30 ± 15 29 ± 14	47 44
Beardsley[19]	2014	Australia	Appendicitis	Pre-EGS Post-EGS	84 66	150	30 (16-72) † 29 (16-97) †	37 48
Wright[20]	2014	USA	Appendicitis	Pre-EGS Post-EGS	526 345	871	38 ± 17 37 ± 15	54 50
Fu[21]	2014	Taiwan	Appendicitis	Pre-EGS Post-EGS	146 159	305	41 ± 17 44 ± 29	50 55
Suen[22]	2014	Australia	Appendicitis	Pre-EGS Post-EGS	276 399	675	31 ± 14 31 ± 14	56 46
Krouchev[23]	2014	Canada	Appendicitis	Pre-EGS Post-EGS	85 84	169	39 (15) 38 (17)	58 52
Agrawal[24]	2009	UK	Early LC for gallstone disease	Pre-EGS Post-EGS	45 118	163	44 (23-79) † 47 (18-94) †	18 21
Britt[25]	2010	USA	Biliary tract disease with surgery	Pre-EGS Post-EGS	54 132	186	50 ± NR 44 ± NR	37 24

Table 1 – Characteristics of included studies								
Study	*Year*	*Country*	*Inclusion Criteria*	*Groups*	*N*	*Total Size*	*Age, y, mean +/- SD*	*Male (%)*
Lehane[26]	2010	Australia	AC with surgery	Pre-EGS Post-EGS	87 115	202	50 ± 20 47 ± 17	38 30
Lau[27]	2011	USA	AC with surgery	Pre-EGS Post-EGS	81 71	152	47 ± NR 46 ± NR	30 28
Pepingco[28]	2012	Australia	AC	Pre-EGS Post-EGS	114 157	271	44 (14-85) † 45 (14-94) †	28 39
Cubas[29]	2012	USA	Biliary tract disease with surgery	Pre-EGS Post-EGS	51 62	113	38 ± 17 40 ± 19	16 21
Faryniuk[30]	2013	Canada	AC	Pre-EGS Post-EGS	5 48	53	NR NR	NR NR
Stupart[31]	2013	Australia	Cholecystectomy	Pre-EGS Post-EGS	96 101	197	NR NR	NR NR
Lim[32]	2013	Canada	Biliary tract disease with surgery	Pre-EGS Post-EGS	72 172	244	50 ± NR 51 ± NR	51 45

Table 1 – Characteristics of included studies

Study	*Year*	*Country*	*Inclusion Criteria*	*Groups*	*N*	*Total Size*	*Age, y, mean +/- SD*	*Male (%)*
Wanis[7]	2014	Canada	AC	Pre-EGS Post-EGS	55 70	125	47 ± 17 53 ± 17	45 41
O'Mara[33]	2014	USA	Biliary tract disease with surgery	Pre-EGS Post-EGS	178 842	1020	NR NR	NR NR
Michailidou[34]	2014	USA	AC with surgery	Pre-EGS Post-EGS	94 234	328	40 ± 15 38 ± 16	34 23
Cubas[29]	2012	USA	Appendicitis	Pre-EGS Post-EGS	82 93	175	35 ± 17 34 ± 17	43 55
			Biliary tract disease with surgery	Pre-EGS Post-EGS	51 62	113	38 ± 17 40 ± 19	16 21
Stupart[31]	2013	Australia	Appendicitis	Pre-EGS Post-EGS	305 321	626	NR NR	NR NR
			Cholecystectomy	Pre-EGS Post-EGS	96 101	197	NR NR	NR NR
Faryniuk[30]	2013	Canada	Appendicitis	Pre-EGS Post-EGS	35 152	187	NR NR	NR NR
			AC	Pre-EGS Post-EGS	5 48	53	NR NR	NR NR

Table 1 – Characteristics of included studies								
Study	*Year*	*Country*	*Inclusion Criteria*	*Groups*	*N*	*Total Size*	*Age, y, mean +/- SD*	*Male (%)*
Wanis[7]	2014	Canada	Appendicitis	Pre-EGS Post-EGS	142 150	292	37 ± 16 37 ± 18	51 53
			AC	Pre-EGS Post-EGS	55 70	125	47 ± 17 53 ± 17	45 41
O'Mara[33]	2014	USA	Appendicitis	Pre-EGS Post-EGS	196 882	1078	NR NR	NR NR
			Biliary tract disease with surgery	Pre-EGS Post-EGS	178 842	1020	NR NR	NR NR

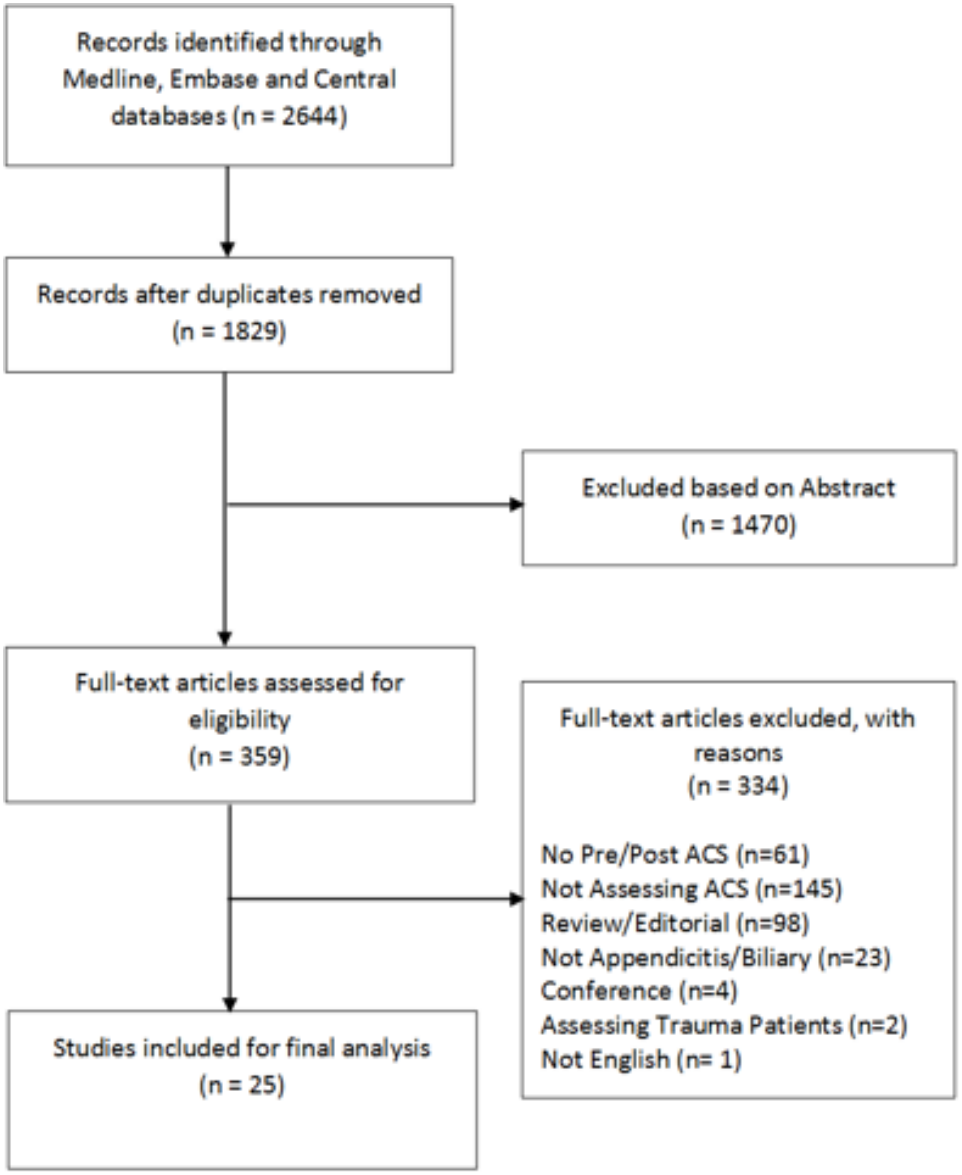
EGS = Emergency General Surgery; NR = Not Reported; †Median (range or IQR)

Table 2 – Design of EGS models in included studies

Study	*Characteristic*									
	Surgeon of the Week	*All Surgeons Participate*	*Consultant Led*	*Trauma*	*House Staff*	*Dedicated OR time*	*Defined Period of Service*	*Handover Protocol*	*Specific Remuneration*	*Quality Measures in Place*
Earley[3]	-	N	Y	Y	Y	-	-	-	-	-
Ekeh[13]	-	N	Y	Y	N	-	-	-	-	-
Gandy[14]	N	-	Y	-	Y	Y	Y	Y	-	-
Qureshi[5]	Y	N	Y	N	Y	N	Y	Y	-	-
Poh[15]	N	-	Y	-	Y	Y	Y	Y	Y	-
Brockman[16]	-	N	Y	-	-	Y	Y	-	-	-
Pillai[17]	N	Y	Y	-	Y	Y	Y	Y	N	Y
Lancashire[18]	-	-	Y	-	Y	-	-	Y	-	-
Beardsley[19]	N	-	Y	Y	Y	Y	Y	-	-	-
Wright[20]	N	Y	Y	Y	Y	-	Y	-	N	-
Fu[21]	-	-	Y	Y	-	N	-	-	-	-
Suen[22]	Y	-	Y	-	-	N	Y	-	-	-
Krouchev[23]	Y	Y	Y	Y	Y	N	Y	Y	N	Y
Agrawal[24]	Y	-	Y	-	-	-	Y	-	-	-

Table 2 – Design of EGS models in included studies										
Study	*Characteristic*									
	Surgeon of the Week	*All Surgeons Participate*	*Consultant Led*	*Trauma*	*House Staff*	*Dedicated OR time*	*Defined Period of Service*	*Handover Protocol*	*Specific Remuneration*	*Quality Measures in Place*
Britt[25]	N	N	Y	-	Y	-	-	-	-	-
Lehane[26]	N	N	Y	-	Y	Y	Y	-	-	-
Lau[27]	-	-	Y	-	Y	N	-	-	-	-
Pepingco[28]	N	-	Y	-	Y	-	Y	-	-	Y
Lim[32]	Y	-	Y	Y	Y	Y	Y	Y	-	-
Michailidou[13]	-	N	Y	Y	Y	-	-	-	-	-
Cubas[29]	N	-	Y	Y	Y	-	Y	-	-	-
Stupart[31]	-	N	Y	-	-	Y	Y	-	-	-
Faryniuk[30]	Y	-	Y	N	-	-	Y	-	-	-
Wanis[7]	Y	-	Y	-	-	-	Y	-	-	-
O'Mara[33]	N	N	Y	N	N	-	Y	Y	Y	-

Figure 1. PRISMA Flowchart of studies included in the review with reason for exclusion



2.2 Systematic review of the impact of EGS service implementation on clinical process and non-clinical outcomes

Background

Upon reviewing the literature around the impact of an EGS service, we noticed a paucity of literature about the processes of delivery of an EGS service, especially in respect to provider satisfaction, systems and resident education. These are key concepts in understanding the true success of an EGS system and help insure staff and hospital administrators believe and support the system.

Methods

The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed for our review (See Figure 2).[35] A comprehensive search of PubMed, MEDLINE, EMBASE and the Cochrane Database of Collected Research was performed with the assistance of a trained medical librarian. The search spanned the period from Jan 1, 2005 to June 1, 2015 to identify all English language publications related to modern models of acute care and emergency surgery service delivery. [36] We kept our search terms and keywords broad (see Appendix 1) to ensure a complete review and narrowed the field to explore the specific themes. All titles and abstracts were reviewed independently by two reviewers (PM, KV). Papers selected for full reviews were analyzed by two reviewers (PM, KD) and consensus used for final inclusion. The reference lists of identified studies and reviews were also examined for potentially relevant studies. Authors of conference abstracts were contacted for further information regarding the study and to obtain results. The authors of identified papers that lacked necessary data for inclusion were contacted for further clarification. This review was registered at Prospero (CRD42015025371).[37]

Study Inclusion

We included studies meeting the following criteria:

1) Studies comparing outcomes under an EGS model [Post-EGS period] to a period of time without an EGS model [Pre-EGS period].
2) Event rate or mean and standard deviation for at least one of the following outcomes of interest: flow efficiency, health economics, and trainee education.

Data Extraction

Data were extracted and paper quality assessed by three independent reviewers (KDG, KDS, JZ) and conflicts resolved by a fourth reviewer (PM). We used a standardized data collection form collecting information on study design, inclusion criteria, population demographics, details of the EGS service and sample size. We recorded inclusion criteria as we were evaluating a large spectrum of non-disease specific outcomes.

Given the non-standardized criteria and units used by institutions, and for ease of interpretation, the delivery and operational system efficiency outcomes were presented as proportional changes from the pre-EGS period, the baseline, as opposed to absolute values. The flow efficiency outcomes examined included: length of stay (LOS), Emergency Department (ED) length of stay, ED to Operating Room (OR) or Surgery time, and surgeries performed outside day time hours. In terms of outcomes on health economics, they have been relatively underreported, therefore all factors were assessed including: case volume, individual and surgeon remuneration, total collections, and productivity or work resource value units. Lastly, impact on trainee education was reported based on survey data on satisfaction and learning opportunity.

Study Quality Assessment

Study quality for observational studies continues to remain a challenge within systematic reviews and meta-analyses. Based on a systematic review of 194 tools for quality assessment and endorsement from the Cochrane Collaboration we chose to use the Newcastle-Ottawa Scale to assess study quality.[38] Quality assessment was completed independently by three reviewers (KDS, KDG, JZ) and discussion with consensus with a fourth for any disagreements (PM). Studies were then assigned a quality rating of 'Good', 'Fair', or 'Poor' based on points in each domain. An important coding understanding with respect to the Newcastle Ottawa score is a lack of statistical

significance between groups for a potential confounder, such as age or sex, is not sufficient for establishing comparability.

The Evidence-Based Practice for Improving Quality (EPIQ) method was also used to grade the quality of included studies based on the level of evidence (1 – Randomized Control Trial to 5 – Studies not directly related to the patient population). Additionally, EPIQ allows for a more subjective overall assessment of the study quality from Good (included most items on the checklist) to Poor (included few items on the checklist).[39]

Results

Our full-text review of 357 papers revealed 22 relevant studies meeting our inclusion criteria. All of the 22 studies were retrospective and varied from two to six stars based on the Newcastle-Ottawa scale (Table 3). For the EPIQ rating 14 of the 22 studies received a rating of Good, and the rest received a rating of Fair (Table 1). The papers originated from North America, Australia, New Zealand and Europe. Themes emerging from this review include: EGS models, hospital flow and efficiency and the economic sustainability, and trainee education.

EGS Models of Service

With no standardized definition of EGS, there is great variability in the literature. Table 4 describes the EGS services that were included in this review. Unfortunately, many of the studies did not adequately describe their services. In general, most were surgeon-led and favoured a "surgeon of the week" model that is common to some trauma and ICU services. In this week, the surgeon suspends his or her elective practice to focus on EGS during the day and shares overnight call responsibilities[30,40,41]Dedicated operating room time was variable among the sites and was reported in 6 studies.[17,31,40-44]

Another popular model is the creation of an Acute Surgical Unit (ASU), most commonly used in Australia.[43,44,45] The ASU is a dedicated ward for acute care surgery patients to be assessed, investigated and treated in a timely manner. The creation of this unit decreased the time to surgery, especially with the addition of a dedicated operating room[43]. The ASU and protected OR time

increased cases performed during the day and no change to after-hours operating. The unit also increased frequency of consultant surgeon case review, improved trainee educational experience, and led to improved communication among surgical staff, which was attributed to effective handover.[45]

Trauma and EGS service models have merged in many US centers due to intrinsic similarities in the nature of the urgent care of multi trauma and emergency general surgery patients, and to improve the operative load of trauma services in an era of increasing non-operative management. The addition of EGS patients to trauma services increases operative volumes of both standard and complex general surgery procedures.[46] This combination improves surgeon satisfaction[4,7] and with protected EGS time, does not impact surgeons' elective services in oncology, minimally invasive and colorectal surgery.[46]

System Performance

Eight papers reported on length of hospital stay[5,6,18,30,44,47,48], five papers described emergency department (ED) length of stay[5,18,30,44,47], six papers reported on the time lapsed between admission to the ED to the OR/ time to surgery[5-7,18,30,40], and five papers reported the percentage of operations performed after-hours[4,7,42,45,49] (Table 5-6).

In the eight papers that described overall hospital length of stay (LOS), four reported a net decrease, but only one analysis reached statistical significance.[47] Decreases in LOS were largely explained by timely assessment by dedicated surgical staff and better access to the OR. Some of these studies further broke down the LOS data into clinically relevant intervals, including time to emergency physician assessment, time to surgical consult request, time to surgical consult, and decision to operate. All four studies that reported on this outcome showed specific and global reductions, which were credited to timely access to dedicated EGS team.[5,18,44,47] The efficiency of EGS services was further demonstrated by five included studies reporting a significant decrease in length of time from admission to the OR. Finally, five articles included in our review described a global reduction in the number of cases outside of daytime hours. [5,30,18,42,31]

Finance

Seven studies reported the financial impact of EGS service implementation on stakeholders. Consistently, EGS service implementation significantly increased the overall and daytime operative case volume by 52% on average.[50,42,51,52] This increase was often attributed to models that created dedicated ORs or hired additional staff. The change from largely night to daytime operating in a study was reported to decrease the individual case remuneration[42]; however, in general the increase in volume and productivity led to an overall positive effect on remuneration. Additionally, although there was a downward trend in overall elective cases, it was small and insignificant.[42,50]

This group of studies also reported significant increases in total collection of revenue by both EGS and elective practices ranging from 11% to 129%.[51-53] Improved collections were often closely related to improved productivity as assessed by work resource value units, a regulated measure encompassing services rendered for the purpose of billing (wRVUs). In three studies the mean wRVU or productivity of EGS surgeons increased by 88%[50,51,53], one study further described the division of EGS surgeons' practice showing that they spent more time on non-operative management of patients after EGS service implementation, potentially due to their complex presentations.[50]

Education and Surgeon Well-Being

Two papers in our review addressed resident education outcomes with the addition of an EGS service. Ahmed et al looked at Accreditation Council for Graduate Medical Education (ACGME) databases to compare resident case numbers before and after the creation of EGS.[54] Residents on a 2 month EGS rotation were able to complete 56% of their ACGME laparoscopic requirements. Many of these operations were cholecystectomies and appendectomies, but also included more complex operations.

Creation of a dedicated EGS service also protects residents on subspecialty rotations by offloading call requirements to residents who are specifically covering EGS.[51] Wood et al demonstrated that residents on subspecialty services covered less call when an EGS service was implemented, increasing resident attendance at academic half day, multidisciplinary rounds, clinics and

independent reading time.[41] Residents surveyed reported an improvement in their work environment despite no change in operating time.[51]

Discussion

This systematic review demonstrated that the EGS model is associated with improved efficiency, increased timeliness and delivery of care, more resident learning opportunities and improved surgeon satisfaction.

A similar meta-analysis from Nagaraja et al.[36] had several differences from our systematic review, including: limiting their search to studies assessing acute appendicitis, acute cholecystitis and small bowel obstructions, excluding papers that met our inclusion criteria[4,50,31,43-46,48,49,51-53] including papers which did not examine outcomes before and after an EGS model was implemented[55]; and not addressing the quality of included studies. A more recent review conducted by Chana et al.[11] excluded key references comparing the EGS model to the traditional care model despite meeting the described inclusion criteria. Additionally, their review limited financial considerations to cost-savings, and did not comment on trainee education or surgeon well-being.

System Performance

The most common metric used to by studies to determine the impact of the EGS model implementation on health system performance was the overall length of stay (LOS). Evaluation of LOS is versatile as it can be used to assess patient care, quality, financial costs to the system. The majority of studies reported a decrease in the hospital LOS. However, statistically insignificant increases in LOS were attributed to a lack of dedicated OR time, slower model adoption and transition, and back-ups in CT diagnoses or lab values.[5,6,48] The trend towards improved efficiency is further supported when the LOS data are stratified into more granular units of time, including, time spent in the emergency department (ED), and time from the ED to the OR. All studies assessing these metrics demonstrated reductions after the EGS model was implemented. Dedicated surgical staffing leads to patients being seen faster, treatment plans being decided on more promptly, patients moving through system more efficiently, and focused and continuous care. This is in stark contrast to the traditional "on call" model, where surgeons taking call add often complex

emergency surgery patients to their existing elective case load and academic/administrative duties. As such, in the older model, these emergent patients would commonly be seen in between cases or clinics, and operations either disrupted elective slates or were booked at the end of day.[6] As overall hospital LOS data depend largely on the entire hospital system, greater reporting of stratified LOS data by key determinants of patient care are needed to effectively assess the impact of the model on the delivery of care. Hence discerning if a metric is impacted by changes attributed to the EGS model or by supporting departments such as pathology and radiology can be determined more conclusively.

Changes in the operational efficiency also impact the scheduling of ORs. In the on-call model, surgeons frequently operated after-hours to accommodate the surgical emergencies or bumped elective cases. Studies implementing the EGS model demonstrated a reduction in after-hours operating.[4,7,42,45,49,] There was also an increase in weekend discharges and therefore patient turnover[18,55], which contributed to the increased operative volume and collections. However, these changes are closely related to the availability of dedicated OR time and a fully-staffed 24/7 EGS team, which require an initial capital investment from the institution.

Finance

Assessing the financial impact of EGS service implementation is multifactorial and requires consideration of systemic and individual factors. From an administrative perspective, studies demonstrated that EGS implementation improves the 'bottom line' and departmental margins due to increased collections from EGS and elective surgeons.[51-53] A considerable rise in the number of cases and physician productivity combined with the savings from reduced LOS and after-hours operating contribute to the increase in collections.[4,42,50-52] Implementation of an EGS model undoubtedly has start-up costs, such as the hiring of new staff or creating dedicated OR time and space; however they have been poorly characterized. Nonetheless, one study reported no increase in total admission costs, a more efficient use of resources, and steady usage of EGS-dedicated ORs with non-emergent cases, suggesting at least a neutral cost-benefit analysis.[18,42]

From the individual surgeon viewpoint, despite the potential for lower reimbursements per case due to increased daytime operating and subsequent reduced compensation from after-hour work, EGS surgeons' productivity/wRVUs and increased caseloads led to an overall increase in

billing.[6,50-53] The trend of increased collections is also seen among elective surgeons at EGS institutions, suggesting the lack of emergency surgical cases did not significantly impact their remuneration.[53] However, despite explicit costs to EGS surgeons, many studies report opportunity costs, including unfavorable call, decreased off-service time to pursue administrative and academic commitments, and lack of manageable lifestyle.[6,51-53] Therefore, health systems should consider implementing and re-structuring their EGS models to either mitigate the intangible costs or economically supplement EGS surgeon salaries.

Lastly, the economic impact on the system wide delivery shows EGS services tend to have a significantly greater proportion of uninsured patients, suggesting a lower socio-economic status or marginalized population demographic.[51,53] Hence, it may suggest the positive impacts of EGS implementation such as timely care, and improved productivity will improve under-served populations care in the long term. Such public health benefits are not limited to a single healthcare model but rather the emergency general surgery population has traditionally received fractured and variable care[56]. Although the results suggest a positive economic impact, due to the variety of models the evaluation of economic impact is still not clear, and more reporting on the costs of implementation is necessary to confirm future viability and sustainability.

Education and Surgeon Well-Being

An EGS service can improve resident education, especially in light of recent work hour restrictions. Ahmed et al. showed that the implementation of an EGS service improved resident exposure to laparoscopic cases while maintaining a diverse mix of cases.[54] Before the EGS service, some cases at major hospitals went uncovered by resident staff, due to the work hour restriction now placed on residents. This created lost learning opportunities, something that the EGS service has the potential to correct. Remarkably in this study, the residents were able to fulfill 60% of their ACGME requirements for basic laparoscopic surgery, without changing the number of residents assigned to the service.[54] A Canadian study also showed that the creation of an EGS service allowed residents to decrease call requirements, allowing them to have more time to participate on sub specialty services.[41]

The majority of papers discussed appendectomies and cholecystectomies as the standard EGS cases, however hernia repairs and other laparoscopic cases are noted to add to the operative case

volumes.[46] Increased operative volume and consults also contributes to an improved case mix which is particularly important for surgical trainees rotating on the EGS services.[45] The availability of the consultant is beneficial to resident and medical student education around ward management and operative skill.[45] General surgery is a diverse specialty, and lack of operative exposure is a fear of many residents. Switching to the EGS model provides a potential solution to this by increasing case volume and variability, improving resident comfort with emergency general surgery patients and fostering interest in this new field.[4]

Limitations

A limitation of this review is the lack of direct comparisons that can be drawn between studies due the heterogenic implementations of the EGS model and the inclusion of diverse disease entities. Resources, administrative and financial support all contribute to variable EGS design. Further, most papers poorly described the EGS service. Therefore, it is challenging to recommend a specific EGS model and indeed the success of EGS services likely depends on local buy-in and adapting to local needs. Another limitation is the retrospective nature of included studies, introducing selection and information biases. Lastly, the EGS model has only been proposed and implemented at sites across North America and Australasia within the past decade. As it continues to be a new area of investigation, our review was limited by the availability of studies published in the literature. Additionally, many of the early studies were conducted with small population groups; hence most of the evidence lacks significant statistical power. We do recognize that a randomized control trial is not practical, however large population based trials may be feasible in the future as more centers adopt this model of care.

Future Directions

Within the body of evidence on the EGS model, our review identified a number of areas that require further investigation. Most of the current literature has used appendicitis and cholecystitis patients as the EGS population; however, there exists a gap in including other operative and non-operative emergency general surgical cases that represent a significant portion of the case mix. Additionally, the EGS surgeons' role in rescuing patients with emergent post-operative

complications should be further investigated.[57] Given that one of the hallmarks of the EGS model is focus and timely consults of potentially surgical patients; there has been no data on patients who have been managed non-operatively. Finally, reporting on the health economics of service implementation, especially on the costs of start-up, impact of surgeon compensation and the role of dedicated daytime OR needs evaluation.

Conclusions

The heterogeneity of EGS models observed in this review, suggests that EGS models are evolving to suit their specific health care environments. Currently, there is a lack of a standardized EGS model and each hospital or region has implemented components based on their needs, resources, and health care system funding and structure. While the differences in the models, along with incomplete descriptions of specific models in some studies, made comparisons challenging, key themes about the impact of EGS service implementation on clinical and educational processes emerged. Initial investments in dedicated operating room (OR) time, hiring of additional staff, devoted on-site surgeon coverage for emergency general surgical conditions, and development of effective handover procedures and trainee education are required for successful service implementation and performance. Such investment may result in greater patient through-put, billings and collections, and surgeon and trainee satisfaction. Furthermore, there is also social return on investment that improves the quality of care for a highly vulnerable patient population.

Table 3. Quality Assessment of Studies using NOS and EPIQ Rating Processes							
First Author	Year	Newcastle-Ottawa Scale Rating				EPIQ Rating[b]	
		Selection	Comparability	Outcome	Rating[a]	LOE[c]	Quality
Anantha[6]	2014	****	-	**	Fair	3	Good
Anantha[42]	2014	****	-	**	Fair	3	Good
Anantha[40]	2014	****	-	**	Fair	3	Good
Eijsvoogel[47]	2014	****	-	**	Fair	3	Fair
Lancashire[18]	2014	****	-	**	Fair	3	Good
Wanis[7]	2014	****	-	**	Fair	3	Good
Faryniuk[30]	2013	****	-	**	Fair	3	Good
Stupart[31]	2013	****	-	**	Fair	3	Good
Sweeting[51]	2013	****	-	**	Fair	3	Good
Ahmed[54]	2012	****	-	**	Fair	3	Good
Hsee[43]	2012	****	-	**	Fair	3	Fair
Miller[53]	2012	*	-	*	Poor	3	Fair
Barnes[50]	2011	***	-	**	Fair	3	Fair
Qureshi[5]	2011	****	-	**	Fair	3	Good
Cox[45]	2010	****	-	**	Fair	3	Fair
von Conrady[44]	2010	****	-	**	Fair	3	Good

Table 3. Quality Assessment of Studies using NOS and EPIQ Rating Processes

First Author	Year	Newcastle-Ottawa Scale Rating				EPIQ Rating[b]	
		Selection	Comparability	Outcome	Rating[a]	LOE[c]	Quality
Wood[41]	2010	***	-	**	Fair	3	Good
Parasyn[4]	2009	****	-	**	Fair	3	Fair
Sorelli[49]	2008	****	-	**	Fair	3	Good
Fitzpatrick[48]	2006	***	-	**	Fair	3	Fair
Austin[46]	2005	****	-	**	Fair	3	Fair
Kaplan[53]	2005	****	-	**	Fair	3	Good

[a] The Newcastle-Ottawa Scale (NOS) rating correlate to the following levels of risk of bias: Good = High risk of bias; Fair = Moderate Risk of Bias; Poor = High Risk of Bias

[b] Evidence-based Practice for Improving Quality (EPIQ) Process

[c] Level of Evidence (LOE) rated on a scale of 1-5 (1 – RCT or meta-analyses of RCTs; 2 – Studies using concurrent controls without true randomization or meta-analyses of such studies; 3 – Studies using retrospective controls; 4 – Studies without a control group; 5 – Studies not directly related to the specific patient/ population)

TABLE 4: Description of Included EGS Models										
First Author	Year	Characteristics of the EGS Models								
		Weekly Surgeon	All Surgeons Participate	Trauma	House Staff	Dedicated OR Time	Defined EGS Period	Handover Protocol	Specific Remuneration	Consultant – Led
Anantha[6]	2014	-	-	-	-	-	-	-	-	-
Anantha[42]	2014	Y	Y	-	Y	Y	Y	-	-	Y
Anantha[40]	2014	Y	Y	-	Y	Y	Y	-	-	Y
Eijsvoogel[47]	2014	-	-	-	-	-	Y	-	-	-
Lancashire[18]	2014	-	-	-	Y	N	-	Y	-	Y
Wanis[7]	2014	Y	-	-	-	-	Y	-	-	Y
Faryniuk[30]	2013	Y	-	-	-	-	-	-	-	Y
Stupart[31]	2013	-	-	Y	-	Y	Y	-	-	Y
Sweeting[51]	2013	N	-	-	-	-	Y	-	Y	-
Ahmed[54]	2012	-	-	-	Y	-	-	-	-	-
Hsee[43]	2012	Y	-	-	Y	Y	Y	Y	-	Y

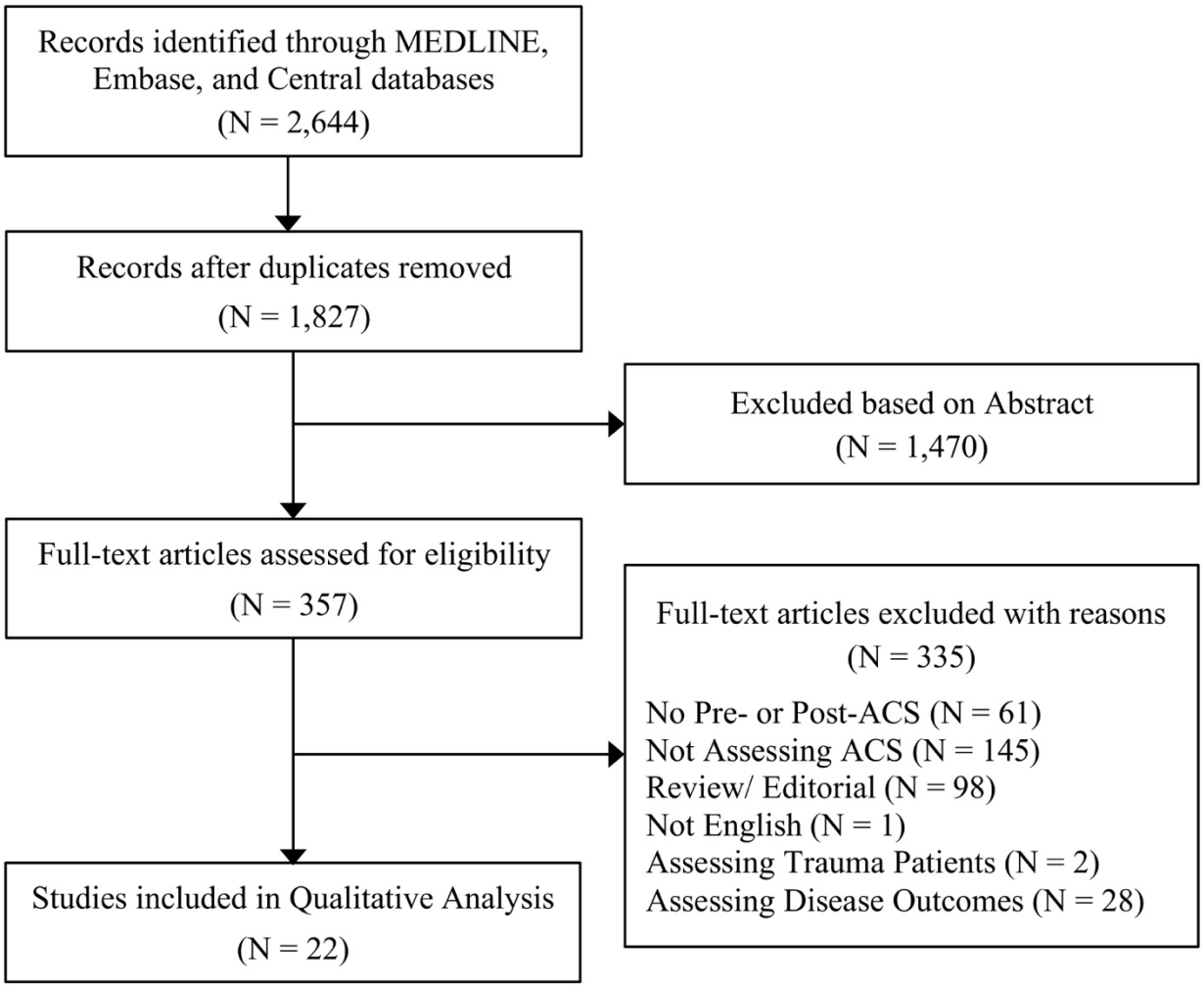
TABLE 4: Description of Included EGS Models										
First Author	Year	Characteristics of the EGS Models								
		Weekly Surgeon	All Surgeons Participate	Trauma	House Staff	Dedicated OR Time	Defined EGS Period	Handover Protocol	Specific Remuneration	Consultant – Led
Miller[53]	2012	-	Y	-	-	-	-	-	-	Y
Barnes[50]	2011	-	-	Y	-	-	Y	-	-	-
Qureshi[5]	2011	Y	N	N	Y	N	Y	Y	-	Y
Cox[45]	2010	Y	Y	-	Y	N	Y	Y	-	Y
von Conrady[44]	2010	-	-	-	Y	Y	Y	Y	-	Y
Wood[41]	2010	Y	Y	N	Y	N	Y	N	-	Y
Parasyn[4]	2009	-	Y	-	Y	Y	Y	Y	-	Y
Sorelli[49]	2008	Y	-	Y	-	-	Y	-	-	Y
Fitzpatrick[48]	2006	-	-	-	-	-	-	-	-	-
Austin[46]	2005	Y	N	N	Y	-	Y	-	-	Y
Kaplan[52]	2005	-	-	N	-	-	-	-	-	-

Table 5. Hospital Delivery Flow Efficiency Outcomes					
Table 6. Overall Hospital Length of Stay (LOS) – reported in days					
First Author	Year	Pre-EGS	Post-EGS	% Change	p-Value
Anantha[6]	2014	10 (6-17.2)[§]	12 (8.5-18.5) [§]	20	0.16
Lancashire[18]	2014	2.94 ± 3.25	2.66 ± 2.92	- 9.52	0.274
Eijsvoogel[47]	2014	4	2	- 50	0.004
Faryniuk[30]	2013	4.03	3.94	- 2.17	0.91
Stupart[31]	2013	3.0 (3.0-4.0) [§]	3.0 (3.0-3.0) [§]	0	1.3
Qureshi[5]	2011	2.06 ± 1.2	2.78 ± 2.22	35.15	0.13
von Conrady[44]	2010	4.2	3	- 28.57	NR
Fitzpatrick[48]	2006	5.75	6.35	10.43	NR
Table 7. Emergency Department (ED) Length of Stay – reported in hours					
First Author	Year	Pre-EGS	Post-EGS	% Change	p-Value
Eijsvoogel[47]	2014	3.6 (2.2-4.9) [§]	3.2 (2.2-4.6) [§]	- 11.11	0.414
Lancashire[18]	2014	9.84 ± 6.48	9.36 ± 5.04	- 4.88	0.385
Qureshi[5]	2011	17	11.8	- 30.59	0.01
Von Conrady[44]	2010	3.17	2.05	- 35.33	NR
Table 8. Time from ED to Operating Room (OR)/ Surgery - reported in hours					
First Author	Year	Pre-EGS	Post-EGS	% Change	p-Value
Anantha[40]	2014	38.4	55.2	43.75	0.40

Table 8. Time from ED to Operating Room (OR)/ Surgery - reported in hours					
First Author	Year	Pre-EGS	Post-EGS	% Change	p-Value
Lancashire[18]	2014	23.14 ± 15.28	21.09 ± 14.58	- 2.53	0.099
Faryniuk[30]	2013	14.175	7.55	- 46.70	0.10
Stupart[31]	2013	19 (18-21) §	18 (17-19) §	- 5.26	0.033
Qureshi[5]	2011	8.2 ± 6.8	7.8 ± 6.28	- 4.87	0.40
All reported pre- and post-EGS outcomes were reported as means and standard deviations, when available, with the exception of fields labelled with §, where outcomes were reported as medians and ranges.					

Table 9. Surgeries Performed During Day-Time Hours – Reported in %				
Study	Year	Pre-EGS	Post-EGS	p-Value
Anantha[42]	2014	11.0	62.0	< 0.0001
Wanis[7]	2014	27.4	40.0	< 0.0001
Cox[45]	2010	57.5	69.9	N/A
Parasyn[4]	2009	64.5	71.7	< 0.0001
Sorelli[49]	2008	57.0	74.0	< 0.0001

Figure 2. Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA)



Chapter 3: Structure of EGS Services: A Day in the Life of Emergency General Surgery in Canada

Introduction

General surgical emergencies are common and can account for 25-50% of a general surgeon's overall workload and 7% of all hospital admissions.[56,58] In 2006, the Institute of Medicine named non-trauma surgical emergencies one of the main stressors on emergency departments in the United States.[59] Patients facing surgical emergencies are often critically ill and have numerous comorbidities, and timely and comprehensive intervention can often prevent devastating, long term complications.[59] Traditionally, on-call surgeons have had to balance emergency surgical care with a busy elective subspecialty services, including rounding on elective patients, seeing clinic patients, and day-time subspecialty operating. Often, surgeons would be expected to continue a subspecialty elective practice the very next day after being on call.

In Canada, there has been a new, grassroots effort to focus and consolidate emergency general surgery (EGS) onto dedicated services. [56,58] EGS services have been implemented with the intent of providing a dedicated, hospital based service specifically for the care of general surgical emergencies.[36,60] This allows comprehensive care to be provided while also creating stronger platforms for quality improvement and resource optimization. Limited data has been reported on the overall case mix of these new EGS services, or about their varied structures, processes or outcomes.[7,30,42] The emergence of EGS systems represents an opportunity to understand and improve processes of care that serve this complex and resource intensive surgical population. More research is needed on the acuity, complexity and diversity of EGS services and systems, and on the roles that these services play in supporting surgical rescue in acute care health systems.

This study attempts to capture a snapshot at a single point in time of the case mix and workflow of a typical day in emergency general surgery across Canada. We hypothesized that Canadian EGS services face highly acute, complex and diverse case mix and that service models have evolved in unique ways in response to their local contexts. Shared insights about case mix and

service delivery will inform the next generation of developments in quality improvement and health system design.

Methods

Study Design

The Canadian Association of General Surgeons formed the Committee on Acute Care Surgery from a group of surgeons providing trauma and EGS care across Canada. The Committee outlined a roadmap for multicenter EGS research, starting with an environmental scan of EGS services across the country. It was felt that such a study would create a strong foundation for future clinical and systems studies in EGS, characterize future participating sites, identify synergies and opportunities for collaboration, help to disseminate best practices, and serve as a gap analysis to identify new research directions. Many members of the Committee are EGS site leaders, which was a strong advantage for study design, institutional review, and data acquisition. The protocol for this cross sectional study was approved by the ethics review board at the study lead site (Vancouver General Hospital) and then at each of the participating hospitals.

Service Structure

A survey of EGS service leaders was used to characterize the different services at each hospital. Site leads were asked to complete an excel sheet to describe key features of their EGS services including: the use of a "surgeon of the week" model, the presence of a dedicated EGS service, the availability of protected operating room time for EGS cases, and the ability to use EGS OR time for elective cases. They were also asked if all general and subspecialty surgeons participated, about the involvement of resident coverage, the inclusion of trauma patients, and the existence of a formalized handover process between surgeons at shift change.

Cross-Sectional Study of Case Mix

Patients seen by EGS services at participating sites on January 10, 2017 formed the study cohort, and the EGS teams on call from 0700 Jan 10, 2017 to 0700 Jan 11, 2017 were briefed about the protocol. Fourteen hospitals across Canada participated. Study personnel embedded on the services, with supervision by site leaders, collected data prospectively.

The following patients were included in the study: those currently admitted to the EGS service, new consults, and any off-service patients being following by the EGS service between the hours of 0700 Jan 10, 2017 to 0700 Jan 11, 2017. Off-service was defined as patients admitted to the hospital but not under the direct care of an EGS surgeon. Trauma patients and patients discharged from the EGS service prior to 0700 Jan 10, 2017 were excluded.

Participating sites collected data using standardized case report forms and a summary sheet (Figure 5&6). Data was collected by study personnel at each site under the supervision of the site lead (co-authors of this paper), and the primary author or the site lead did data entry.

All patients currently admitted to the service and new consults were captured. Patient demographic information such as age, sex, comorbidities and previous operations was collected. All operative and procedural data was collected. Intraoperative and postoperative complications were also collected. Data was verified with the site leads individually, and all perceived discrepancies and questions were resolved in a second round of communication with all sites.

Results

Emergency General Surgery (EGS) services from 14 hospitals across 6 provinces in Canada participated in this study to document service processes, patient demographics, case diversity and management plans over a single 24-hour period (Figure 3).

Service Structure

EGS services nationwide differ in the models employed to structure delivery of care (Table 10). All participating sites had a dedicated service with a "surgeon of the week" model where the surgeon suspends their elective practice to focus on EGS patients during the day while sharing overnight call responsibilities. 71% of sites had protected operating room (OR) time, and of those, 70% were permitted to use protected time for elective cases. In contrast to the United States, where trauma and emergency general surgery are often combined in single services[61,62], only 29% of Canadian sites included trauma patients under their scope. From an educational perspective, 86% of sites have resident coverage and a formal handover process.

Case Mix

On January 10, 2017, a total of 387 patients were seen across the 14 sites. The services were newly consulted to assess 112 patients, and 68% of these patients were ultimately admitted to be primarily managed by the EGS team. In addition to their responsibilities of evaluating new consults and admissions, the teams also rounded on patients previously under the care of their team. These patients varied in acuity, with 13% being cared for in an intensive care unit (ICU) setting and 7% having open abdomens (Table 11). Within the 24-hours, 53 cases were operated on by EGS surgical teams, 53% were completed laparoscopically. When considering all patients on the EGS lists, 48% of cases were operative (Figure 4). Of the operative cases, 45% were laparoscopic with a 3% conversion rate. There was only 1 intraoperative complication across all sites. Of the remaining total non-operative cases, 57% were managed with antibiotic regimens (Table 12).

The mean age was 59.1 ± 4.9, and on average 52% were male. Patients also required complex medical and surgical management due to their past medical histories with 53% of patients having 1-3 co-morbidities, and 37% having greater than 3 comorbid conditions (Table 13). Patients had a wide range of presenting complaints and final diagnoses that demonstrate the breadth of emergency general surgical conditions evaluated and managed by EGS teams. (Table 14). The most common diagnoses were gall bladder disease (17.6%), gastric/intestinal obstructions

(14.3%), and appendiceal disease (7.9%). When evaluating the mean days in hospital since admission, neoplasms, pancreatic disease and intestinal obstruction were the top conditions requiring longer average stays in hospital.

Discussion

EGS services are well established across Canada. This study is a unique snapshot of the complex care that is provided on an average day at 14 hospitals. To our knowledge, this is the first prospective, national study of Canadian EGS services, and, as such, provides a novel look at a large, complex, and resource intensive patient population for which limited reporting exists in the literature .[56,61]

Service Structure

The development of an EGS services in Canada has largely been a grassroots movement to address the growing complexity of acute care surgery by improving access to care, patient outcomes, and safety while enhancing efficient service delivery, surgeon satisfaction and educational opportunities[63]. To accomplish these goals, it is apparent from the variation in models adopted at the 14 participating sites, that hospitals have created services structured to meet objectives set based on their local context. The number of surgeons within a department, diversity in the continuum of learners at a site, proximity of tertiary trauma care, and executive administration and financial support are a few potential factors that can impact the organization of an EGS service. The unpredictable pace of emergency surgery has made protected OR time an important part of delivering timely and safe care, and our data suggests there remains a gap in providing allocated time to emergency general surgeons and autonomy in deciding how unused resources are assigned.

Case Mix and Service Activity

The majority of the studies in the EGS literature have focused on processes and outcomes for appendicitis and cholecystitis, which, while accounting for a significant part of the activity of

EGS services, do not necessarily reflect the breadth, intensity or resource consumption of modern EGS practice. In our national EGS sample, appendicitis and cholecystitis accounted for only 25% of patients, and only 10% of hospital stay. In contrast, cancer accounted for close to 23% of hospital days, and therefore, EGS service activity.

The study confirms that Canadian EGS services are constantly weighing indications for surgery, and often successfully applying non-operative strategies. Nationally, 51% of patients were managed non-operatively, with MGH site having the highest number of non-operative patients. These patients can often require several resource intensive days in hospital yet their care is not well-documented in the EGS literature. Studies such as ours highlight an opportunity for research that aims to understand and improve the processes and outcomes of care for non-operative EGS patients.

The complexity of EGS may, in part, be reflected by the extent of comorbidities and the frequent need for critical care. Some services reported that up to 72% of their patients had greater than 3 comorbidities. The fact that all of these patients had been considered for, or had actually undergone, major emergency operations, is evidence that EGS services routinely face the heavy responsibilities of assessment, diagnosis, resuscitation and preoperative optimization, operative intervention, and postoperative care along fast timelines for extremely vulnerable patients. Furthermore, the number of EGS patients who are cared for in the ICU, an average of 25.4%, demonstrates the critical status of many of these patients. This intersection of aggressive surgical care and extreme patient vulnerability is a daily reality on modern EGS services, and an opportunity for multicenter quality improvement, guideline development, and promotion of best practices. There is an urgent need for the next generation of EGS research to explore this intersection more fully.

Research Network and Future Directions

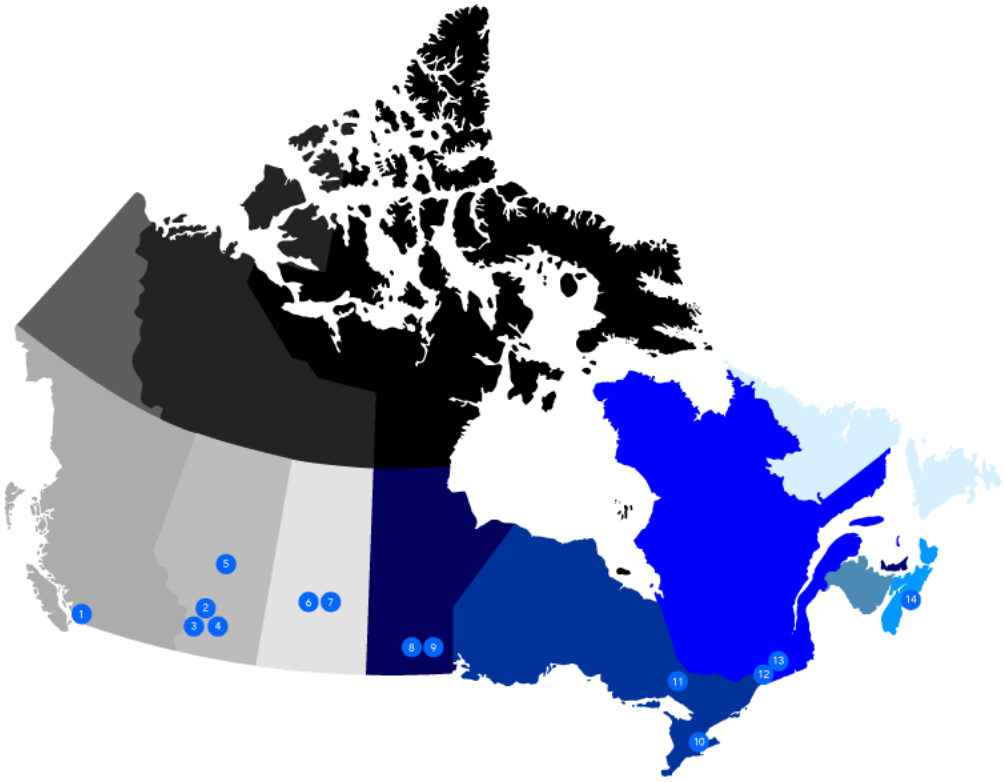
This study was a one-time snapshot of 24-hours of care by EGS services at major Canadian hospitals. It is an observational study that did not capture every hospital with or without a formalized EGS service (mostly due to difficulty in identifying these services and engaging them

in a national study), and therefore could not provide a comprehensive view of Canadian EGS practice. However, despite its methodological limitations, the study was a proof of concept that it is possible to bring emerging EGS services and patient level insights into a national research network. The rapid completion of this study has shown that national collaboration on research protocol development, coordination of multicenter ethics review board applications, development of data sharing agreements, and shared data analysis, interpretation, and reporting, are highly feasible. The implications of a national EGS research network are great. We have seen in this study that EGS patient populations are large, complex, and resource intensive, and that the structures and processes of EGS care are variable. A national EGS research network will be able to share experiences and define best practices, and will serve as a forum to make these experiences and best practices more universal. The network has already defined a research and quality improvement roadmap, with the next series of studies underway. Future studies will focus on processes of care, complex operative care, determinants of complications and mortality, benchmarks of quality, and surgical education in EGS. Ultimately, it is hoped that this work will lead to a national EGS database and research strategy dedicated to analyzing diversity in the Canadian EGS experience, and to optimizing structure, process and outcome of EGS service delivery.

Conclusion

Canadian EGS services are at the center of Canadian acute care. They are busy intake services for extremely vulnerable patients with a spectrum of complex and acutely life threatening conditions including abdominal sepsis, intestinal obstruction and cancer. They optimize perioperative and operative care along the rapid timelines of acutely time dependent surgical illnesses, and, where possible, they often deploy non-operative approaches as well. They act as rescue services, supporting patient care on other services, and very frequently providing care in intensive care units. They are firmly established as a "strategy for general surgery patients left behind".[56] Ongoing national research collaborations will continue to shed light on the structures, processes and outcomes of these important new services, and will identify new opportunities to improve patient care and system performance.

Figure 3: Map of Canada with Site Description



	Site	Location	No. of Acute Care Beds	No. of Patients	ORs in 24 hour period
1	VGH	Vancouver General Hospital, Vancouver, BC	699	48	3
2	FHH	Foothills Medical Centre, Calgary, AB	912	36	9
3	SHC	South Health Campus, Calgary, AB	269	27	2
4	RGH	Rockyview General Hospital, Calgary, AB	500	28	6
5	UAH	University of Alberta Hospital, Edmonton, AB	738	25	4
6	RUH	Royal University Hospital, Saskatoon, SK	344	17	2
7	SPH	St. Paul's Hospital, Saskatoon, SK	214	26	6
8	SBH	St. Boniface Hospital, Winnipeg, MB	398	35	5
9	HSC	Health Sciences Centre, Winnipeg, MB	618	28	2
10	SJHH	St. Joseph's Healthcare Hamilton, Hamilton, ON	326	29	0
11	NBRH	North Bay Regional Health Centre, North Bay, ON	162	18	7
12	RVH	Royal Victoria Hospital, Montreal, QC	517	20	1
13	MGH	Montreal General Hospital, Montreal, QC	479	13	0
14	QEH	Queen Elizabeth II Health Science Centre, Halifax, NS	683	43	6

Table 10: Description of emergency general surgery (EGS) service structures and processes

Hospital Service	Dedicated Service	Surgeon of the Week Model	Protected OR Time	Resident Coverage	Trauma Included	All Surgeons Participate	Formal Handover	Elective Cases in Protected Time
VGH, Vancouver, BC	X	X	X	X		X	X	X
FMC, Calgary, AB	X	X		X		X	X	
SHC, Calgary, AB	X	X	X			X	X	
RGH, Calgary, AB	X	X	X	X		X	X	
UAH, Edmonton, AB	X	X	X	X		X	X	X
RUH, Saskatoon, SK	X	X	X	X	X	X	X	X
SPH, Saskatoon, SK	X	X	X	X		X	X	X
SBH, Winnipeg, MB	X	X	X	X		X	X	
HSC, Winnipeg, MB	X	X		X	X	X	X	
SJHH, Hamilton, ON	X	X	X	X		X	X	
NBRH, North Bay, ON	X	X			X		X	
RVH, Montreal, QC	X	X		X		X	X	
MGH, Montreal, QC	X	X	X	X		X	X	X
QEH, Halifax, NS	X	X	X	X	X	X	X	X

Table 11: Cohorts of emergency general surgery patients by hospital services across Canada

Hospital Service	EGS List	Consults	Admits	ICU Pts. (%)	Open Abdo. (%)	Following w/o Admit (%)
VGH, Vancouver, BC	33	9	7	4 (12.1)	1 (3.0)	4 (12.1)
FHH, Calgary, AB	36	15	11	3 (8.3)	1 (2.8)	1 (2.8)
SHC, Calgary, AB	24	7	5	3 (12.5)	0 (0.0)	3 (12.5)
RGH, Calgary, AB	23	12	9	0 (0.0)	0 (0.0)	7 (30.4)
UAH, Edmonton, AB	10	4	3	6 (60.0)	2 (20.0)	5 (50.0)
RUH, Saskatoon, SK	10	6	3	0 (0.0)	3 (30.0)	1 (10.0)
SPH, Saskatoon, SK	19	10	6	1 (5.3)	0 (0.0)	5 (26.3)
SBH, Winnipeg, MB	35	7	7	0 (0.0)	0 (0.0)	0 (0.0)
HSC, Winnipeg, MB	28	10	8	10 (35.7)	13 (46.4)	3 (10.7)
SJHH, Hamilton, ON	28	4	2	3 (10.7)	0 (0.0)	10 (35.7)
NBRH, North Bay, ON	13	8	6	4 (30.8)	0 (0.0)	5 (38.5)
RVH, Montreal, QC	12	2	1	3 (25.0)	0 (0.0)	0 (0.0)
MGH, Montreal, QC	7	4	2	0 (0.0)	0 (0.0)	1 (14.3)
QEH, Halifax, NS	30	14	6	3 (10.0)	2 (6.7)	7 (23.3)
TOTAL	**308**	**112**	**76**	**40**	**22**	**52**

Table 12: Summary of operative and non-operative management of EGS patients by hospital services across Canada

Hospital Service	Lap. ORs	Open ORs	Total ORs (%)	Converted Cases	Total Non-Op. (%)	Non-Op. Pts. w/ Antibiotics
VGH, Vancouver, BC	8	17	25 (52.1)	1	23 (47.9)	8
FHH, Calgary, AB	10	9	19 (55.9)	0	15 (44.1)	13
SHC, Calgary, AB	8	6	14 (51.9)	0	13 (48.1)	10
RGH, Calgary, AB	13	3	16 (66.7)	1	8 (33.3)	4
UAH, Edmonton, AB	2	13	15 (60.0)	0	10 (40.0)	5
RUH, Saskatoon, SK	4	3	7 (41.2)	0	10 (58.8)	9
SPH, Saskatoon, SK	6	12	18 (69.2)	1	8 (30.8)	5
SBH, Winnipeg, MB	12	7	19 (54.3)	1	16 (45.7)	11
HSC, Winnipeg, MB	4	12	17 (60.7)	0	11 (39.3)	6
SJHH, Hamilton, ON	9	4	13 (44.8)	1	16 (55.2)	10
NBRH, North Bay, ON	1	6	7 (38.9)	0	11 (61.1)	7
RVH, Montreal, QC	4	2	6 (30.0)	0	14 (70.0)	8
MGH, Montreal, QC	0	1	1 (7.7)	0	12 (92.3)	4
QEH, Halifax, NS	7	12	19 (44.2)	0	24 (55.8)	9
TOTAL	**88**	**107**	**196**	**5**	**191**	**109**

Table 13: Age, sex and comorbidities of emergency general surgery patients by hospital

Hospital Service	No. of Patients	Mean Age	Male (%)	>3 Co-Morbidities
VGH, Vancouver, BC	48	62.5	44%	35%
FHH, Calgary, AB	34	58.2	58%	47%
SHC, Calgary, AB	27	56.6	59%	11%
RGH, Calgary, AB	24	59.8	43%	7%
UAH, Edmonton, AB	25	63.5	68%	72%
RUH, Saskatoon, SK	17	50.1	29%	18%
SPH, Saskatoon, SK	26	59.1	46%	23%
SBH, Winnipeg, MB	35	64.1	66%	46%
HSC, Winnipeg, MB	28	51.5	43%	32%
SJHH, Hamilton, ON	29	68.1	66%	72%
NBRH, North Bay, ON	18	58.5	61%	50%
RVH, Montreal, QC	20	57.5	60%	20%
MGH, Montreal, QC	13	62.4	38%	23%
QEH, Halifax, NS	43	56.1	42%	19%

TABLE 14: Case mix and resource utilization as reflected by duration of stay at the time of the study

Final Diagnosis	No. of Cases (%)	Mean Days Since Admission ± SD
Gall Bladder Disease	69 (17.6)	5.3 ± 8.0
Intestinal Obstruction	56 (14.3)	11.9 ± 22.1
Appendiceal Disease	31 (7.9)	4.2 ± 8.0
Neoplasms	25 (6.4)	21.7 ± 41.5
Perforations	23 (5.9)	10.7 ± 11.0
Diverticular Disease	19 (4.8)	8.0 ± 12.0
GI Bleeds	18 (4.6)	8.1 ± 13.9
Hernia Disease	16 (4.1)	4.2 ± 4.0
Skin and Soft Tissue Infections	16 (4.1)	6.1 ± 4.3
Pancreatic Disease	15 (3.8)	15.4 ± 24.6
Other [#]	99 (25.2)	

[#] Includes: Abscesses, Anorectal disease, Breast disease, Sepsis

Figure 4 Bar graph of operative non-operative totals

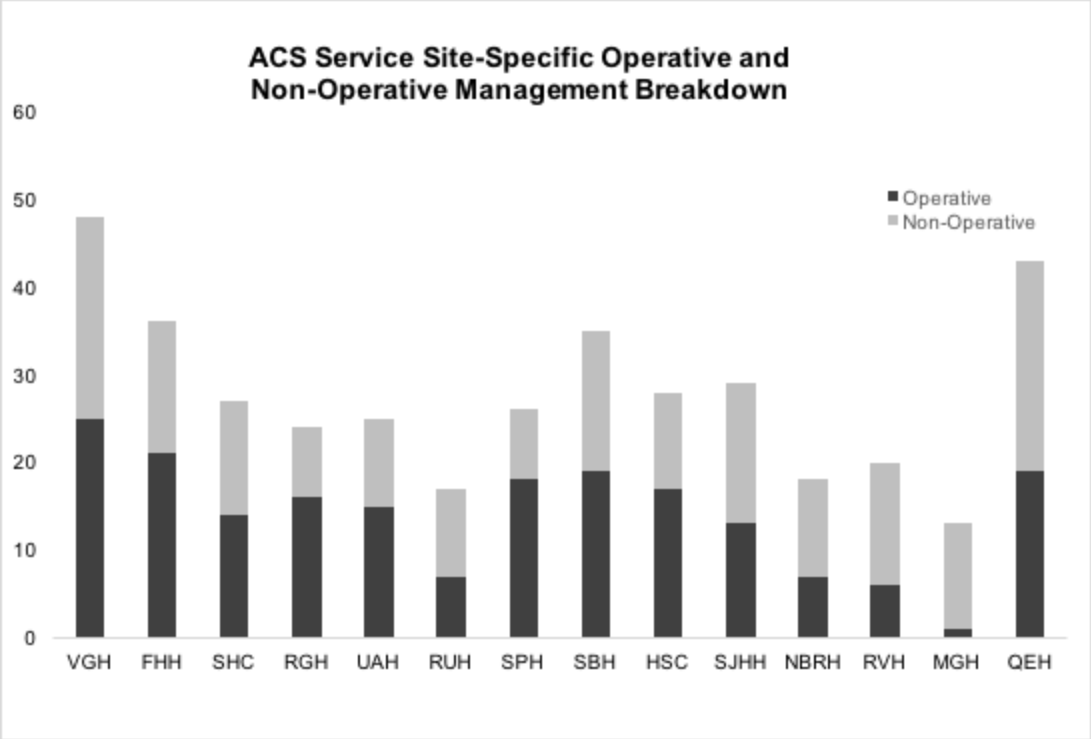


Figure 5: Day in the Life of Acute Care Surgery in Canada Summary Data Collection Form

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A DAY IN THE LIFE OF ACUTE CARE SURGERY IN CANADA

For Final Reviewer ONLY: Please check off your institution, ensure no duplicate forms for patients, fill out any missing fields if possible and REMEMBER to redact patient identifiers prior to faxing to Dr. Hameed at (604) 875-5348.

☐ Vancouver General ☐ Royal Columbian ☐ Eagle Ridge ☐ Victoria Gen. ☐ Foothills ☐ Red Deer Regional
☐ University of Alberta ☐ St. Boniface ☐ Health Sciences Centre ☐ Ottawa ☐ Sunnybrook ☐ Toronto General
☐ St. Michael's ☐ Brampton General ☐ Etobicoke General ☐ McGill University Health Centre
☐ QEII – Halifax Infirmary ☐ SJHH

SUMMARY DATA COLLECTION FORM

Total Number of Consults Seen _____
Total Number of Patients Admitted _____
Total Number of Patients under the Care of the Acute Care Surgery (ACS) Service _____
Total Number of ICU patients the ACS Service is following _____
Total Number of Open Abdomen Patients _____
Total Number of patients the ACS Service is following as Consult ONLY (i.e. Not Admitted under the ACS Service): _____

OPERATIVE DATA:
Total Number of Laparoscopic ORs _____
Total Number of Open ORs _____
Total Procedures Completed _____
Total Intraoperative Complications _____

NON-OPERATIVE DATA:
Total Number of Patients Admitted with Plans for Non Operative Management _____
Total Number of Non Operative Patients admitted for Antibiotic Treatment _____

CASE MIX DATA:
Total Appendicitis Cases _____
Total Cholecystitis Cases _____
Total Pancreatitis Cases _____
Total Intestinal Obstruction Cases _____
Total Upper GI Bleed Cases _____
Total Lower GI Bleed Cases _____
Total Mesenteric Ischemia Cases _____

Figure 6: A Day in the Life of Acute Care Surgery in Canada Patient Demographic Form

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A DAY IN THE LIFE OF ACUTE CARE SURGERY IN CANADA

For Final Reviewer ONLY: Please check off your institution, ensure no duplicate forms for patients, fill out any missing fields if possible and REMEMBER to redact patient identifiers prior to faxing to Dr. Hameed at (604) 875-5348.

☐ Vancouver General ☐ Royal Columbian ☐ Eagle Ridge ☐ Victoria Gen. ☐ Foothills ☐ Red Deer Regional
☐ University of Alberta ☐ St. Boniface ☐ Health Sciences Centre ☐ Ottawa ☐ Sunnybrook ☐ Toronto General
☐ St. Michael's ☐ Brampton General ☐ Etobicoke General ☐ McGill University Health Centre
☐ QEII – Halifax Infirmary ☐ SJHH

PATIENT DEMOGRAPHICS

Age: _____

Gender: □ Male
□ Female
□ Other: _____

Days since admission: _____

Past Medical History/ Co-Morbidities:
□ Diabetes Mellitus
□ Smoking
□ COPD
□ Myocardial Infarction/ Angina
□ TIA/ Stroke
□ Congestive Heart Failure
□ Previous Abdominal Surgery
□ Previous VTE or PE
□ Other: _____

Admitting Diagnosis:
□ Appendicitis
□ Cholecystitis
□ Intestinal Obstruction
□ Mesenteric Ischemia
□ Abdominal Pain
□ Skin and Soft Tissue Infections
□ Other: _____

Final Diagnosis (if different from above)
_____

MANAGEMENT OF PATIENT

Depending on the management of the patient, you may fill both or just one of the sections. Please choose appropriately.

□ NON-OPERATIVE

For the checkboxes that below are ticked, please provide relevant details regarding management

□ Pain Medications or Other Medications
_____
_____

□ Antibiotics
_____

□ Fluids
_____

□ Total Parental Nutrition Ordered

□ Radiological Interventions
_____

□ OPERATIVE

Procedure: _____
Date of Procedure: ___/____/_____
Planned Procedure: ___/____/_____
Operative Management of Patient:
□ Open Abdominal Surgery
□ Laparoscopic Surgery
□ Laparoscopic to Open Conversion
□ Intraoperative Complications (if yes, list below)
_____
_____

□ Post-Operative Complications (if yes, list below)
_____
_____

COURSE OF TREATMENT

Did/ Will this patient be transferred to the Intensive Care Unit during this hospital visit □ Yes □ No

If yes, please answer the following if applicable:

Patient is or will be mechanically ventilated □ Yes □ No
No. of days patient has been in the ICU: _____

Discharge Information:
□ N/A
□ To Home

Which other medical staff were asked to consult on this patient's care (Check more than one if applicable)
□ General Internal Medicine
□ Gastroenterology
□ Oncology
□ Urology
□ Plastics and Reconstructive Surgery
□ Other: _____

Chapter 4: Process Mapping as a Framework for Performance Improvement in Emergency General Surgery

4.1 Background of Process mapping

Emergency general surgery (EGS) conditions are often thought of as being too acute and unpredictable for the development of standardized approaches to QI. However, the surgical literature demonstrates that delays in acute care can cause adverse outcomes and negatively affect the patient and their healthcare experience [64-66] . Effective strategies to measure the process of acute care surgery may open opportunities to improve performance and optimize surgical outcomes in complex and vulnerable surgical populations.

William Edwards Deming revolutionized the manufacturing world and helped to transform Japanese automobile production when he introduced the concept of process mapping.[67] Process mapping employs a technique that breaks down complex events into individual processes, and evaluates how these can be made more efficient. The pioneering work of Dr. Deming is epitomized by understanding and learning to manage variation.[68] Variation exists in all processes and people, as well as the outcomes that are produced in any given system. In his seminal work, he stratifies the concept of variation into common and special causes.[69] Common causes of variance are predictable, expected and natural to the system.[68] Identifying common causes is challenging, however these variables generally do not require change strategies, for example, speed and runtime of electronic health records. Alternatively, special causes are new and unanticipated variables that cause variance, and these causes are defects within the system which necessitate improvement, for example, different physician management strategies to clinical presentations.[68,70]

Process mapping in health care involves following patients through their hospital journey and documenting every interaction they have with the hospital system. The method allows providers to notice the small steps prior to management and discharge, and identify areas of high variation and bottlenecks for future improvement. Insights from process mapping have driven large QI advances in Cardiac, ENT and Orthopedic Surgery.[71-78]

We applied the first three steps of the Six Sigma DMAIC methodology [79], the business world's equivalent to the PDSA cycle, by measuring and analyzing variation in the patient experience of care to quantify acute care service delivery. Ultimately, our study aims to use process mapping to deconstruct the surgical care of patients presenting to emergency general surgery (EGS) services with acute small bowel obstruction (SBO). To our knowledge, process mapping has not yet been applied in evaluating the delivery of Acute Care Surgery services.

4.2 Methods

4.2.1 Study Design

Ethics approval was granted at our tertiary healthcare centre, VGH. The American College of Surgeons (ACS) Emergency General Surgery Quality Improvement Program (EQIP) pilot database was used to identify patients presenting to a single, large teaching hospital over a 1-year period (Mar. 1, 2015, to Mar. 1, 2016), for the non-operative or operative management of SBO.

4.2.2 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were defined by the ACS EQIP pilot. Inclusion criteria was as follows: diagnosis of SBO by a MD, admission to the hospital or observation unit and imaging

consistent with SBO. Patients had to be over the age of 18 years and admitted to the General Surgery EGS Service. Exclusion criteria was SBO occurring within 4 weeks of pelvic surgery, SBO occurring secondary to a ventral, inguinal or femoral hernia, Crohn's disease or SBO occurring in a patient greater than 48 hours after their hospital admission. 4 patients were further excluded from data analysis as upon review of the patient charts as they did not meet NSQIP inclusion criteria.

4.2.3 Data Analysis

Microsoft Excel version 15.18 was used for statistical analysis.

4.3 Results

Small bowel obstruction (SBO) patients at our tertiary Level 1 Trauma Center, Vancouver General Hospital, between March 1, 2015 to April 1, 2016 were stratified into two categories based on their treatment and management. A total of 88 patients were included in our study period, 33 (40%) were managed operatively, while the latter 55 (60%) were managed conservatively. The difference in the mean age between operative and conservative management cohorts (66.3 years ± 17.6 versus 67.5 years ± 17.3; p = 0.747) was not statically significant. Similarly, the comparison between the proportion of males (*n* = 21 males, 57% versus *n* = 29 female, 53%; P = 0.700) and medical comorbidities (see Table 1) were also not significant.

TABLE 15: Patient Demographics for Cohorts of Operative and Conservative Management of Small Bowel Obstruction (SBO) Patients			
Characteristic	Operative Mgmt. (N = 37)	Conservative Mgmt. (N = 55)	p-value
Age, mean ± SD	66.3 ± 17.6	67.5 ± 17.3	0.747
Male, n (%)	21 (56.8%)	29 (52.7%)	0.700
Medical Comorbidities, n (%)	Operative Mgmt. (N = 37)	Conservative Mgmt. (N = 55)	p-value
Diabetes Mellitus	4 (10.8%)	4 (7.3%)	0.562
Hypertension	16 (43.2%)	21 (38.2%)	0.633
Acute Renal Failure	0 (0%)	1 (1.8%)	0.415
Congestive Heart Failure	0 (0%)	0 (0%)	1.000
Ascites	0 (0%)	1 (1.8%)	0.415
COPD	0 (0%)	1 (1.8%)	0.415
Smoker	5 (13.5%)	6 (10.9%)	0.708
Disseminated Cancer	1 (2.7%)	6 (10.9%)	0.148
Steroid Use/ Immunosuppression	3 (8.1%)	3 (5.5%)	0.623

Evaluating the mean process intervals and standard deviations of conservatively managed patients in Table 2 demonstrated an unexpectedly high degree of variation in the time interval of care for patients with SBO. The highest amount of variability was in transferring these patients to the ward after admission to the acute care surgery team (259 ± 257 minutes). There was also a longer time and variability associated with time from emergency physician evaluation and CT scan request (112 ± 171 minutes), which remains the mainstay and gold standard of diagnosis in SBO patients. The interval between being seen by an emergency department physician and a consult being sent to the EGS team also experienced higher times and unpredictability.

TABLE 16: Mean Process Interval Outcomes for Conservative Management of Small Bowel Obstruction (SBO) Patients

Process Interval Measured	N	Time (mean ± SD, min)
Time from arrival to ED to triage	55	11 ± 10
Time from triage to Emerg. MD	55	74 ± 59
Time from Emerg. MD to General Surg. consult initiation	55	198 ± 115
Time from Emerg. MD to CT Request	48	112 ± 171
Time to CT Request to CT Acquisition	49	122 ± 99
Time from General Surg. consult initiation to completion	49	92 ± 79
Time from consult to admission to General Surg. service	49	114 ± 101
Time from admission to General Surg. service to ward	52	259 ± 257
Overall length of stay†	55	83 ± 51

†Reported in hours rather than minutes

Note: Denominator varies slightly due to missing data

The process intervals of the operatively managed patients in Table 3 illustrate similar trends of variability. The period of time between evaluation by the ED physician and request of CT scan (121 ± 153 minutes), and between triage and being seen by an ED physician (74 ± 76 minutes) had higher degrees of variation. In addition, the duration of time required to complete the consult (114 ± 167 minutes), to admit the patient to the EGS service after the consult (165 ± 220 minutes), and to arrive to the OR after booking (442 ± 400 minutes) were also identified as areas in the patient's stay that faced increased standard deviations.

TABLE 17: Mean Process Interval Outcomes for Operative Management of Small Bowel Obstruction (SBO) Patients

Process Interval Measured	N	Time (mean ± SD, min)
Time from arrival to ED to triage	33	10 ± 14
Time from triage to Emerg. MD	33	74 ± 76
Time from Emerg. MD to General Surg. consult initiation	31	203 ± 102
Time from Emerg. MD to CT Request	30	121 ± 153
Time to CT Request to CT Acquisition	30	142 ± 58
Time from General Surg. consult initiation to completion	30	114 ± 167
Time from consult to admission to General Surg. service	30	165 ± 220
Time from admission to General Surg. service to ward	24	232 ± 170
Time from OR booking to arrival to the OR	33	442 ± 400
Time from OR to ward post-operatively	30	445 ± 266
Overall length of stay†	33	455 ± 884

†Reported in hours rather than minutes

Note: Denominator varies slightly due to missing data

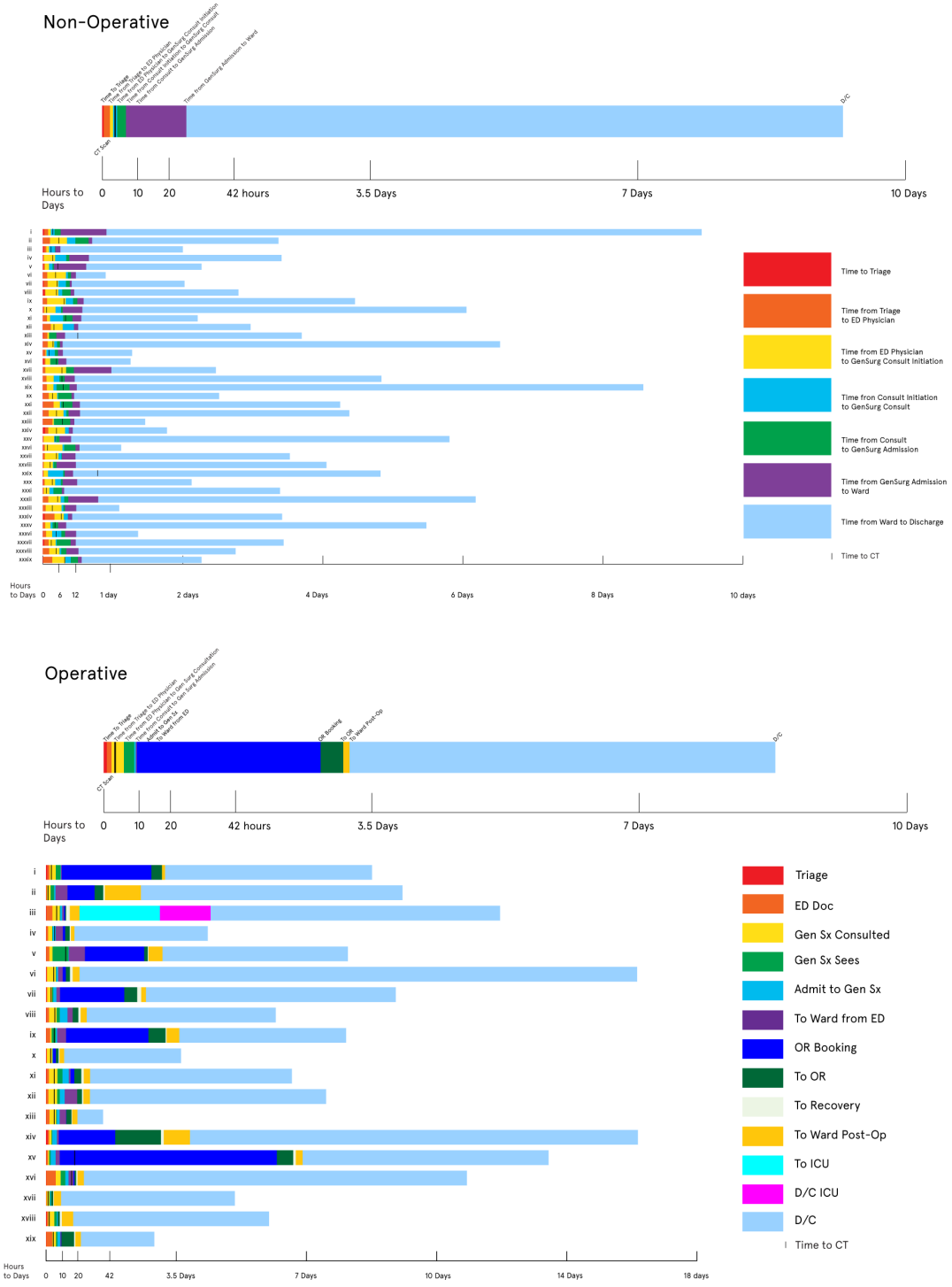
In addition to reviewing the journey of surgical patients through the hospital, we also further stratified the time from OR booking to arrival at the OR to assess the efficiency of the acute care service in meeting expected intervals based on the patient's priority level (Table 4). Patients booked as a E1, our highest priority and meaning they should arrive in the OR within an hour of booking, never arrived at the OR within the expected time limits. The majority of patients were booked as an E2 (arriving at the OR within 8-12 hours of booking) although 69% of these

patients arrived within the expected interval, there was a higher rate of variability and the mean outside the expected 720 minutes (746 ± 893 minutes). Lastly, the EGS service does have protected OR time, and of the cases completed during these times, 80% were within their booked priority levels time expectations.

TABLE 18: Arrival to OR based on Priority Levels in Operative Management of Small Bowel Obstruction (SBO) Patients

Priority Level	N	Time from Booking to Arrival at OR (Mean ± SD, min)	% of Patients Arriving within Expected Interval
E1 (< 60 min from booking)	5	80 ± 17	0.0 %
E2 (< 480-720 min from booking)	32	746 ± 893	68.6%
E3 (< 4,320 min from booking)	4	2,409 ± 1,277	100.0%
Protected Time	5	1,582 ± 2,892	80.0%

Figure 7: Sample Process map



4.4 Discussion

Variation in the clinical setting is unavoidable, and although some variation is expected due to the complexity of cases and individual patient characteristics, there remains differences in productivity, utilization of services and flow.[70] Adding capacity and operating rooms only addresses part of this variation, and a deeper assessment of how patients flow through the system can further assist in identifying obstacles and bottlenecks that can be improved. Length of stay and waiting times have become benchmarks of quantifying clinical outcomes, however, this study further stratifies the overall hospital experience into granular periods of time that represent the steps in the clinical management of SBO patients.

In our study and hospital environment, a source of variation in the operative and conservative management strategies of bowel obstruction patients was during the time in the emergency department. Delays in requesting clinical imaging led to increases in mean time and variability in initiating an EGS team consult. Additionally, these delays also led to downstream effects for the EGS team and their ability to assess the patient and make relevant clinical decisions about management and treatment.

A strategy to improve flow in the emergency department would be to add pre-printed orders (PPO) that summarize the evidence-based steps of the initial workup of a suspected case of a SBO. Using the PPO, the emergency physician would be able to start several treatment options and order imaging and laboratory tests critical to management of bowel obstruction patients prior to general surgery consultation. This could potentially streamline and standardize the initial workup thus improving flow through the department, while providing timely and pertinent clinical information to aid in the acute care surgery team's decision making [80].

Another area of clinical variation was in getting our operatively managed cases to the OR. Although this is a well-established barrier affecting surgeons globally[81], we found that most of the high-priority cases were not getting to the OR in the expected intervals due largely to capacity issues. However, the EGS service at our institution has protected OR time that can be used for urgent cases, and our findings show that this time was being used effectively. The

protected time led to patients receiving their surgeries within the expected interval who may not have if it was not for the dedicated time set aside for the EGS teams. Our sample size for this finding is small, and reflects a need for further data collection and analysis.

The importance of investigating flow and process intervals in patient care is an emerging field in the era of increasing health expenditure and increasing operative and non-operative complexity of patients.[81,82] The EQIP pilot program to collect both operative and non-operative patient outcomes allowed for robust data collection. This is the first time such robust data collection strategies have been applied to non-operative patients who are managed by surgical teams. Although there were initial errors that required correction through detailed chart reviews, the program did extend the realm of patients that can be studied to improve quality and safety. From our experience, we discovered that this data was not difficult to collect and eventually led to insights that build efficiencies in the system.

In the future, another practice that can be adopted to track patient care is the use of an electronic platform to document points of care in the patient's journey through the hospital system. With this platform, the general surgery service could have access to real-time data to monitor metrics and evaluate how new QI interventions are working within our system, while simultaneously flagging new areas for intervention.

4.5 Limitations

A limitation of this study is the retrospective nature of data collection, which led to some missing data when reviewing paper medical records. Additionally, even time stamps recorded on the electronic health record for certain points of care were subject to reporting bias, i.e. the order may be given verbally and then entered in at a later time by the physician, leading to a falsely increased time interval.

Additionally, our results are specific to our site and should not be generalized to other institutions, however the concept could be easily applied to any other system. The population we investigated was specific to one condition and part of a pilot EQIP project at our hospital, resulting in a small sample size, particularly our operative group. Future work will be directed at

larger groups of surgical patients with the hope of minimizing missing data and generating areas of QI and monitoring, the next steps in the RISE process. We hope our work inspires other centres to follow similar methodologies to discover areas of improvement for surgical patients.

4.6 Conclusions

Quality improvement is the new science of healthcare and our patients expect a "culture of safety" from their healthcare providers. As surgeons, this represents an exciting time for us to be leaders in safer patient care. Process mapping is a simple way to evaluate a cohort of patients' journey through the hospital to identify areas for future interventions as well as track the impact of quality improvement projects. Our cohort small bowel obstruction patients are the first group, to our knowledge, to be analyzed using this method and we hope to expand to more emergency general surgery patients in the future.

Chapter 5: Future Directions

All the work described in this thesis is considered just the beginning of research into EGS and quality improvement. The emerging EGS literature has provided powerful evidence that EGS services improve processes and outcomes for selected diagnoses, and that they have non-clinical advantages as well, including enhancing surgical education, improving surgeon job satisfaction, and potentially for improving the cost effectiveness of emergency surgical care. The Day in the Life study showed us that sophisticated EGS systems have blossomed across Canada, and that they care for complex surgical patients with rapidly responsive and comprehensive service structures that have evolved independently to suit local contexts. We have also seen that the case mix of EGS is broad and without well defined metrics of disease severity and outcomes, and that patients face high levels of comorbidity, suggesting that the impact of EGS conditions on health and health care systems is likely larger than might have been previously thought.

These studies have provided us with both an environmental scan of the current state of EGS, and an analysis of gaps in our understanding, and, perhaps, a roadmap for the next generation of EGS research. More detailed studies of the case mix, disease severity, impact of comorbidity, operative and non-operative interventions, patient outcomes (including long term and patient reported outcomes) are needed in order to identify strategies to further consolidate and advance gains made by the early implementation of EGS services. Individual centers will undoubtedly do this, and we have shown that this work can be done on a larger scale, and with more expertise, in a national collaborative. Multicenter initiatives have the advantage of bringing greater methodological expertise to individual studies, and also of creating networks to disseminate research findings and best practices.

One promising avenue for research and quality improvement is to define complex health care processes in microscopic detail, identifying process variations, and targeting these variations with specific refinements. EGS, with varied and complex time dependent processes, with extremely high stakes with respect to patient outcomes and health care costs, is fertile ground for this type of research. With the current data from our SBO process mapping study, surgeons, emergency physicians and radiologists have begun to meet, for the first time, to address

bottlenecks and variations in care through the development of pre-printed orders and clinical practice guidelines. Unconventional ideas, such as having SBO consults initiated by radiology, have begun to emerge from more precise, data-driven insights about process.

In summary, we will define outcome measures for EGS and study them prospectively, we will disseminate service structures for new up and coming services and continue to refine them, and we will use Deming's statistical process control techniques to identify and control variability and quality in highly variable processes.

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Appendix 1. Key Search Terms

"Acute Care Surgery", "Emergency General Surgery", "Acute" OR "Urgent" OR "Emergency" AND "Service" OR "Model" AND "Surgical Procedure" OR "Operation" OR "Surgical Department" OR "General Surgery" OR "Operation", "Team" OR "System" OR "Service" OR "Model" OR "Unit" OR "Ward", "Acute" OR "Urgent" OR "Emergency" AND "Organization models" OR "Organization efficiency", "Emergency" OR "Elective" And "Trauma" OR "Emergency Surgery"