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Emergency Department Crowding and Hospital Patient Flow:

Influential Factors and Evidence-Informed Solutions

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Emergency Department Crowding and Hospital Patient Flow: Influential Factors and Strategic Solutions

THESIS FOR DOCTORAL DEGREE (Ph.D.)

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To You – who taught and inspired me to give back. Thank you.

ABSTRACT

Background:

Internationally, one of the biggest challenges in emergency departments is crowding – when demand for emergency care exceeds its capacity in resources and timeliness. Crowding is associated with increased morbidity, mortality, cost and decreased patient and health-care worker satisfaction. Consequently, governments in the United Kingdom, Australia and some Canadian provinces have implemented time targets for emergency department length-of-stay, but have had difficulty achieving them. Although there is much literature on etiology and solutions for emergency department crowding, there is a lack of evidence-informed policy and cost-effectiveness analyses on solutions for reaching targets. Which are the most appropriate interventions for the individual hospital? What factors associated with failing targets should the hospital prioritize?

Objectives:

The objectives of this thesis were to find factors strongly associated with failing to meet emergency department (ED) length-of-stay (LOS) targets and rigorously evaluate ED crowding solutions. The first two objectives were to determine the effectiveness of a supplementary physician-nurse team at triage (MDRNSTAT) on EDLOS, quality of care and its cost-effectiveness from the hospital and patient perspective. The third objective was to determine predictors of target time failure for discharged high acuity patients and intensive care unit (ICU) admissions at Sunnybrook Health Sciences Center (Sunnybrook), an academic tertiary-level hospital in Ontario, Canada. Finally, we compared performance and factors predicting failure of government time targets between 2012 and 2013 at Sunnybrook and between Sunnybrook and Austin Health (Austin), an Australian academic tertiary level hospital.

Methods:

Study I was a pragmatic cluster randomized trial comparing shifts with and without the MDRNSTAT. The primary outcome was emergency department length-of-stay (EDLOS) for non-consulted discharges. Secondary outcomes included EDLOS for patients initially seen by the emergency department, and subsequently consulted and admitted, patients reaching government-mandated thresholds, time to initial physician assessment, left-without being seen rate, time to investigation, and measurement of harm. Study II was a cost-effectiveness evaluation of the MDRNSTAT. Study III was a retrospective, observational study of 2012 Sunnybrook Hospital (Canada) emergency department data using multivariable logistic regression. The main outcome measure was failure to reach government EDLOS targets for high acuity discharges and ICU emergency admissions. Study IV was a retrospective, observational study of 2012, 2013 Sunnybrook Hospital (Canada) and 2012 Austin Health (Australia) administrative data using descriptive statistics and multivariable logistic regression. The main outcome measure was reaching ED time targets by subgroup: admissions, low and high acuity discharges. Secondary outcomes for Study III and IV were predicting failure of government targets and a select group of hospital factors.

Results:

For Study I, the MDRNSTAT decreased discharged, non-consulted, high acuity patients EDLOS by 34 minutes [CI: 16 to 52]. For discharged, non-consulted, low acuity patients, EDLOS decreased by 52 minutes [CI: 38 to 65]. Physician initial assessment duration (PIAD) decreased by 53 minutes [CI: 48 to 57]. The MDRNSTAT-associated shifts' left-without-being-seen rate was 1.5% versus 2.2% for the control (p=0.06). No patients returned to the emergency department after being discharged by the MDRNSTAT at triage. From Study II, the added cost of the MDRNSTAT was $3,597.27 [$1729.47 to ∞] per additional patient-seen, $75.37 [$67.99-$105.30] per physician-initial-assessment hour saved and $112.99 [$74.68 – $251.43] per EDLOS hour saved. From the hospital perspective, the cost-benefit ratio was 38.63 [18.96 to ∞] and net present value of -$447,996 [-$435,646 to -$459,900]. For patients, the cost-benefit ratio for satisfaction was 2.8 [2.3-4.6].

For Study III, factors predicting EDLOS target failure for Sunnybrook's discharged high acuity patients were: having PIAD>2hrs (OR 5.63 [5.22-6.06]), consultation request (OR 10.23 [9.38-11.14]), a MRI (OR 19.33 [12.94-28.87]), CT (OR 4.24 [3.92-4.59]), or US (OR 3.47 [3.13-3.83]). For ICU admissions, factors predicting EDLOS target failure were: bed request duration (BRD)>6hrs (OR 364.27 [43.20-3071.30]) and access block (AB)>1hr (OR 217.27 [30.62-1541.63]). For discharged low acuity patients, factors predicting failure for the 4hr target were: PIAD> 2hrs (OR 15.80 [13.35-18.71]), consultation (OR 20.98 [14.10-31.22]), TnI (OR 13.37 [6.30-28.37]), MRI (OR 31.68 [6.03-166.54]), or CT (OR 16.48 [10.07-26.98]). Study IV found that the Australian hospital, Austin Health, succeeded for all targets except for low acuity discharges. Sunnybrook failed all time targets. For low acuity discharges, Austin factors for failing government targets were PIAD>2 hrs (OR 11.62 [10.40-12.99]), consultation (OR 6.99 [5.83-8.38]) and CT (OR 7.16 [5.19-8.66]). For high acuity discharges, Austin factors were evening shift (OR 4.09 [3.40-4.93]), consultation (OR 8.82 [7.62-10.21) and MRI (OR 8.16 [3.07-21.70]). For admissions, Austin factors were AB>1hr (OR 57.35 [39.31-83.67]) and BRD>6hrs (OR 46.07 [33.23-63.88]). Comparing 2012 to 2013 at Sunnybrook, the factors for failing targets remained similar for admissions, low and high acuity discharges.

<u>Conclusions:</u>

The MDRNSTAT reduced delays and left-without-being-seen rate without increased return visits or jeopardizing urgent care of severely ill patients; however, it was not a cost-effective daytime strategy at Sunnybrook. The MDRNSTAT would be more feasible during time periods with higher access block, such as the afternoon to late evening. Sunnybrook factors predicting failure of government targets for high acuity discharges and ICU admissions were hospital-controlled. The Australian hospital out-performed the Canadian hospital on government time targets. Factors predicting failure of government targets remained consistent over time in the same hospital but were different between hospitals. Irrespective of time and location, factors most associated with target failure were hospital-controlled. Therefore, hospitals should individualize their approach to shortening EDLOS by analyzing its patient population and resource demands.

<u>Study I Trial registration number:</u> NCT00991471 ClinicalTrials.gov

LIST OF SCIENTIFIC PAPERS

I. Cheng I, Lee J, Mittmann N, Tyberg J, Ramagnano S, Kiss A, Schull M, Kerr F and Zwarenstein M: Implementing wait-time reductions under Ontario government benchmarks (Pay-for-Results): a Cluster Randomized Trial of the Effect of a Physician-Nurse Supplementary Triage Assistance team (MDRNSTAT) on emergency department patient wait times. *BMC Emergency Medicine* 2013 13:17.

II. Cheng I, Castren M, Kiss A, Zwarenstein M, Brommels M and Mittmann N: Cost-effectiveness of a Physician-Nurse Supplementary Triage Assessment Team at an Academic Tertiary Care Emergency Department. *Canadian Journal of Emergency Medicine* 2016; 18(3): 191-204.

III. Cheng I, Schull M, Castren M, Kiss A, Brommels M and Zwarenstein M: Retrospective Observational Study: Factors Associated with Failure of Emergency Wait-Time Targets for High Acuity Discharges and Intensive Care Unit Admissions *Canadian Journal* of *Emergency Medicine* (submitted)

IV. Cheng I, Taylor D, Castren M, Kiss A, Brommels M, Yeoh M, Schull M and Zwarenstein M: Retrospective Observational Study: Success of Reaching Government Emergency Department Time Targets between a Canadian and Australian Academic Tertiary Level Hospital (manuscript)

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LIST OF ABBREVIATIONS

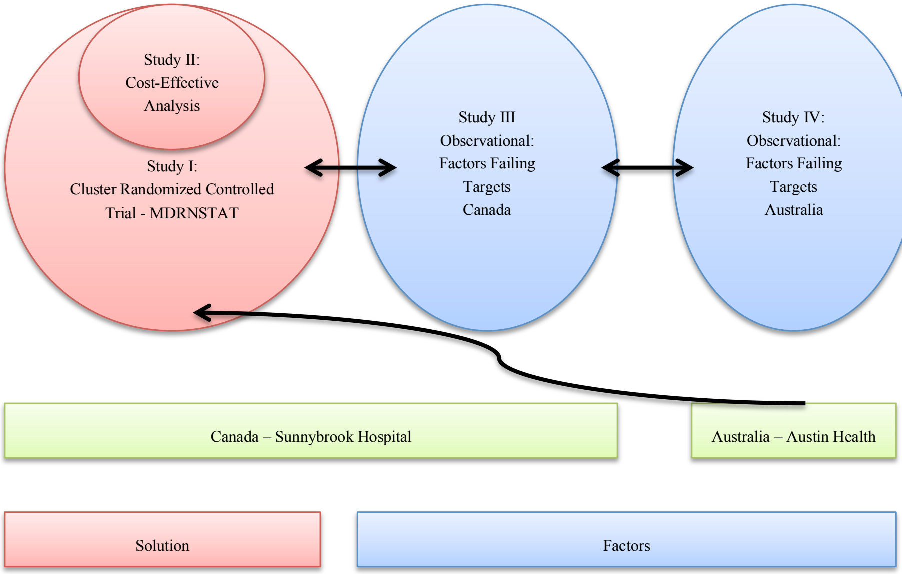
AB	Access Block
Austin	Austin Health
ATS	Australasian Triage Score
BRD	Bed Request Duration
CT	Computer Tomography
CTAS	Canadian Triage Acuity Scale
EDLOS	Emergency Department Length of Stay
EDWIN	Emergency Department Work Index
EP	Emergency Physician
ICER	Incremental Cost Effectiveness Ratio
ICMED	International Crowding Measure in Emergency Departments
ICU	Intensive Care Unit
LWBS	Left without being seen
MDRNSTAT	Physician Nurse Supplementary Team at Triage
MOHLTC	Ontario Ministry of Health and Long Term Care
MRI	Magnetic Resonance Imaging
NEAT	National Emergency Access Target
NEDOCS	National Emergency Department Overcrowding Study
PIA	Physician Initial Assessment
PIAD	Physician Initial Assessment Duration
QALY	Quality Adjusted Life Years
Sunnybrook	Sunnybrook Health Sciences Center
TOMX	% Emergency Department Stretchers Occupied by Admits
TnI	Troponin I – Cardiac enzyme to detect myocardial damage
US	Ultrasound

1 INTRODUCTION

Chapter 1 provides the organization of the thesis. A definition of emergency medicine, crowding and its significance are outlined. A literature review of the etiology, solutions to crowding and its relationship to patient flow is provided. Finally, the research context and summary will be presented – outlining the motivation behind the research, its relevance and implications.

1.1 ORGANIZATION

Chapter 1 introduces the thesis' research context, defines emergency medicine, crowding and its significance with a literature review on its etiology and solutions. Chapter 2 outlines goals and objectives. Chapter 3 provides the setting and methods for the four studies. The thesis begins with a cluster, randomized-control trial of a physician nurse supplementary team at triage (MDRNSTAT), subsequent cost-effective analysis, the 2012 observational cohort study of emergency department visits at Sunnybrook and ends with a comparative study with Sunnybrook in 2013, and Austin Health, in Australia.



The first three studies occurred in Toronto, Ontario, Canada and the last study was in Melbourne, Victoria, Australia. Chapter 4 summarizes the results. Chapter 5, the discussion, describes the insights, implications, and limitations of the research. Chapter 6 is the conclusion. Chapter 7 provides the practical application and future directions.

1.2 EMERGENCY MEDICINE: DEFINITION

"Emergency medicine is the medical specialty dedicated to the diagnosis and treatment of unforeseen illness or injury….It [sic] is not defined by location, but may be practiced in a variety of setting including hospital-based and freestanding emergency departments (EDs), urgent care clinics, observation medicine units, emergency medical response vehicles, at disaster sites, or via telemedicine."[1]

1.3 EMERGENCY DEPARTMENT CROWDING: DEFINITION AND SIGNIFICANCE

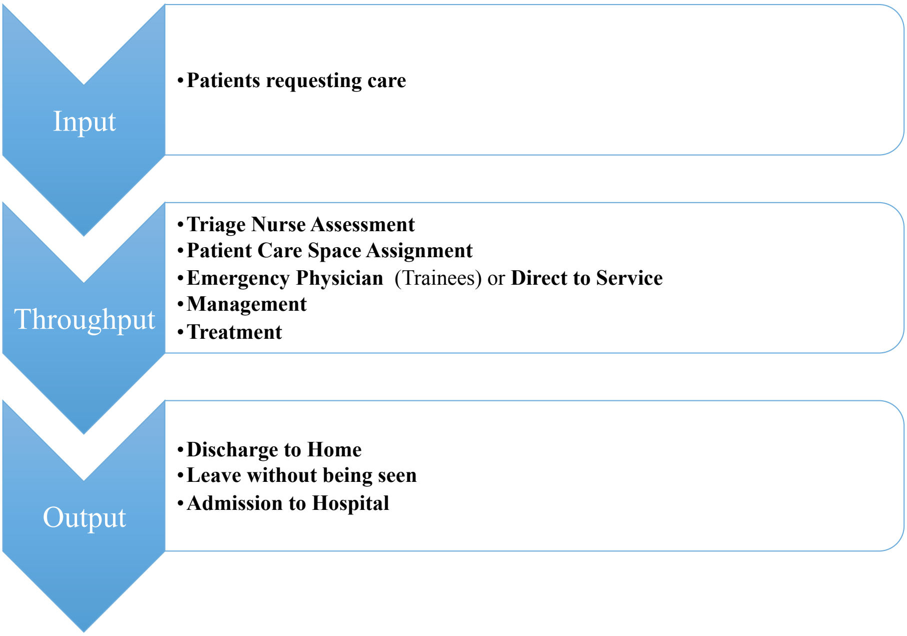
Emergency department (ED) crowding occurs when the demand for emergency services exceeds the ability to provide care in a reasonable amount of time[2]. In 2002, the American College of Emergency Physicians defined crowding as: "A situation in which the identified need for emergency services outstrips available resources in the ED. This situation occurs in hospital EDs when there are more patients than staffed ED treatment beds and wait times exceed a reasonable period. Crowding typically involves patients being monitored in nontreatment areas (eg, hallways) and awaiting ED treatment beds or inpatient beds. Crowding may also involve an inability to appropriately triage patients, with large numbers of patients in the ED waiting area of any triage assessment category"[3].
As a specialty, emergency medicine is relatively young. It has only been in existence since the late 1970's[4] and has grown internationally since this time. In Canada, emergency medicine specialization was established in 1977[5]. Despite emergency medicine being a new specialty, crowding manifested just after one decade. ED crowding was on the cover of *Time* magazine in 1990[6] and the Ontario government was proposing solutions to crowding in 1998[7].

Emergency department crowding is a significant public health issue[8, 9]. Irrespective of the health care system: two-tier, single payer or private, ED crowding is an international problem[6, 8, 10–17]. According to the literature, crowding is associated with increased patient morbidity and mortality[8, 9, 14, 15, 17–20], decreased patient satisfaction [8, 18–25], violence[6], decreased physician productivity and efficiency[6], increased disability, medical errors[14], treatment delays[6, 11, 14, 16] hospital length-of-stay[23, 26–28] and associated costs[27, 29, 30]. In Canada, it was estimated that $51 million dollars were spent on patients in 2005–2006 admitted through emergency departments (EDs) and waiting for a hospital bed[31]. A study published in 2010 concluded that ED admission delays greater than 12 hours increased inpatient LOS at an annual additional cost of $2.1 million dollars[29]. Hence, ED crowding impacts governments[32, 33] insurers[30], hospitals, health care workers[17], physician trainee education[6], ambulance services[14] and patients[18]. Of note, the evidence supporting the ill effects of crowding is based on systematic reviews of observational studies. There have been multi-center[20] and large population database studies[18] correlating mortality with ED crowding, however, recent studies have been questioning the association once patient case-mix is taken into account[34].

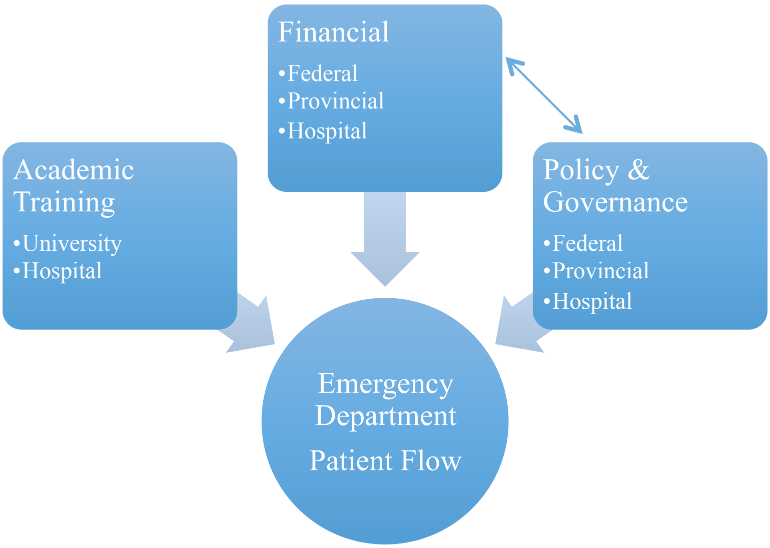
Currently, there is no common measure of crowding[11, 35] but there are a few models, such as Emergency Department Work Index (EDWIN)[36], International Crowding Measure in Emergency Departments (ICMED)[37], or National Emergency Department Overcrowding Study (NEDOCS)[38]. These models were based on consensus documents summarizing factors that constitute crowding, such as ambulance diversion, ED workload, length-of-stay (LOS) of admitted patients in the ED, leave without being seen (LWBS) patients with urgent triage codes, times before patients were seen by a physician and occupancy rate of ED stretchers and hospital[39, 40]. However, these measures are inadequate because they do not reflect the imbalance between workload and resources that occur during crowding[39]. A surrogate for crowding is prolonged EDLOS, (i.e. greater than six hours), because of its association with mortality and readmissions[15, 18]. Consequently, governments in Australia, Canada and United Kingdom have EDLOS targets[10, 41].

1.4 EMERGENCY DEPARTMENT CROWDING: ETIOLOGY

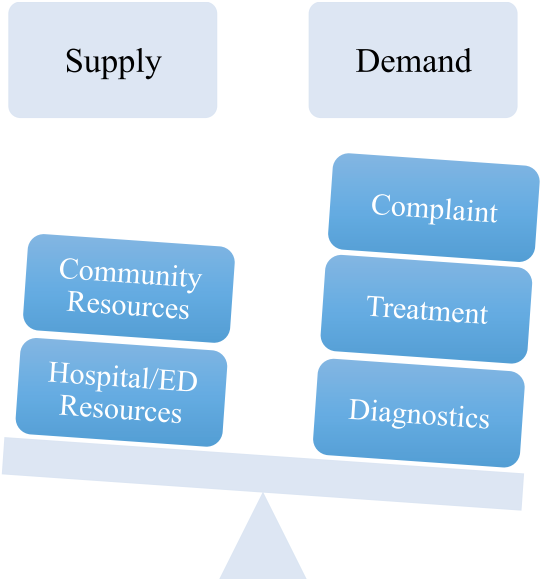
The cause of emergency crowding is multifactorial, but the main contributor is an output factor, access block. To understand the etiology of crowding, it is useful to visualize a patient's journey through the emergency department as an input-throughput and output process[3, 42]:



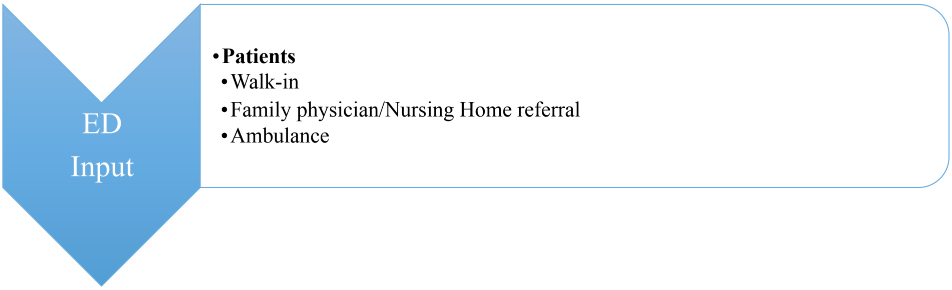
An additional crowding factor is the effect of systems[6, 11, 12], such as the financing, policy, technology and academic training programs, on emergency department care:



Crowding can also be viewed as a mismatch between supply and demand[6, 8, 10] where factors are community, hospital, emergency or patient-related[39]:

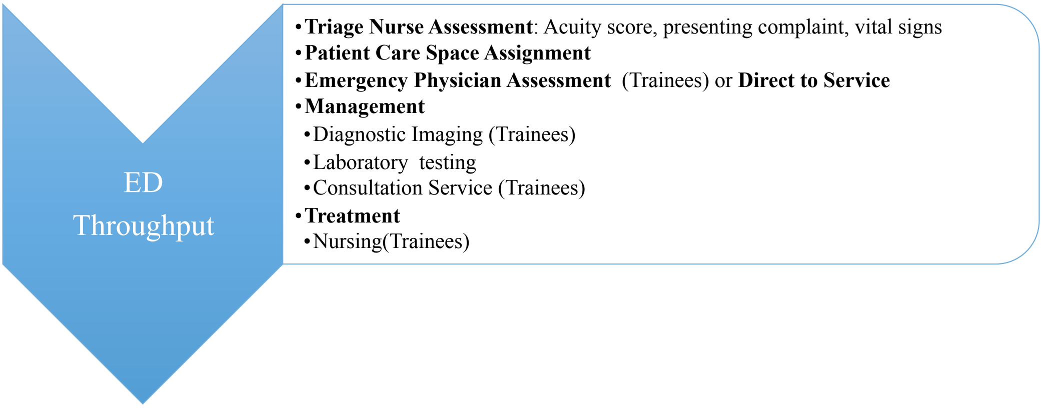


1.4.1 Demand (Input) Factors



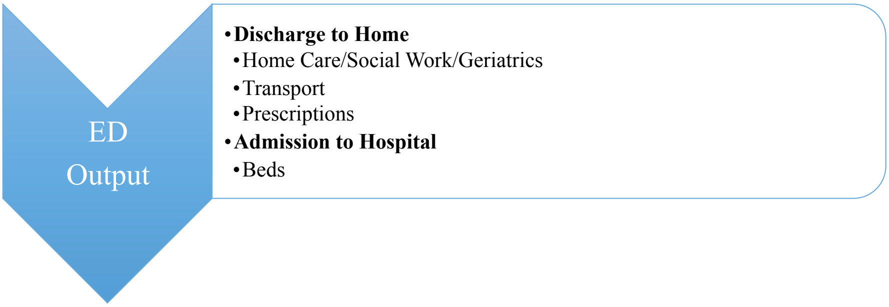
The demand for emergency care has been increasing. Patients are having higher expectations and reliance on professional health care[43]. Patient volumes to emergency departments are on the rise[6, 43]. In Australia, ED presentations increased by 3.4% every year between 2010-11 and 2014-15 [44]. Not only are patient volumes increasing, but also patient complexity and acuity[6, 45] - measured by age, urgency (triage code), discharge diagnosis, and disposition[39]. Nursing home patients older than 65yo require more ambulance services, admissions, investigations, and have longer EDLOS than their non-nursing-home counterpart[46]. In the United States, it was thought that the non-insured contributed significantly to increased demand for emergency services[3], however, Fee et al, found this was not supported[47]. Unpredictable surges of newly arriving ambulances and ambulatory patients[39] can contribute to crowding as can ambulance diversion from a nearby ED[39].

1.4.2 Throughput (Supply) Factors



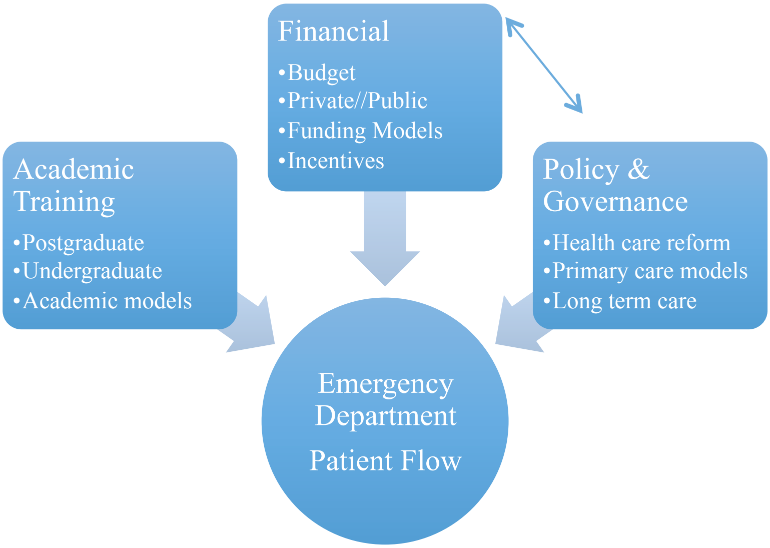
The literature supports a variety of throughput factors associated with crowding: shortages in emergency nursing, physician staffing, consulting, trainee and physical space[6]. Design limitations of the emergency department[39] and ancillary services, such as administrative, social work and geriatric teams effect patient flow[6, 39]. Prolonged consultation turnaround times[39, 48] and the recent requirements for electronic charting and computerized order entry prolong EDLOS[6, 49]. The rising reliance and demand for high technology, such as cross-sectional imaging (computed tomography (CT)) and blood tests (serial troponin I (TnI) increase throughput time[10, 45] - more than treatment and procedures[14, 50]. Lack of off-hours diagnostic imaging, such as ultrasound[39], or delays in imaging[6, 51] are additional contributors. Other factors include physician variations in decision-making, diagnostic testing use, and speed of seeing patients. Finally, patients with language or cultural barriers[6, 52] can increase the time they are in the department.

1.4.3 Output (Supply) Factors



A major contributor, and in some systems the main one, is access block: the inability to access hospital beds for ED admissions due to high hospital occupancy[2, 12, 14, 15, 39, 45, 53–58]. The Australasian College for Emergency Medicine defines access block as "the situation where patients are unable to gain access to appropriate hospital beds within a reasonable amount of time, no greater than 8 hours"[14]. In larger emergency departments, greater than 40% of staff time is consumed by taking care of admitted, access-blocked patients rather than seeing new patients[14]. The shortage of acute care beds, restricting hospital bed sharing by different services[39], bed occupancy with alternate level care (i.e. nursing home) patients[39], excessive inpatient length-of-stay and discharging only on weekdays increase hospital occupancy. Larger hospitals, catchment areas, admission rates and hospital occupancy are associated with access block[59].

1.4.4 Systems Factors



According to the World Health Organization, a health system "consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health[60]." The Input-Throughput-Output model for ED crowding is influenced by the health care system. Crowding can be perceived as a problem of a system[3, 6, 11, 61] that lacks accountability, provides ineffective care, waste, or is overused[12]. The financial framework of the health system can promote crowding[62]. For example, Mitka describes the model where elective patients are more profitable to a hospital than those arriving through the emergency department. Hence, the hospital will reserve beds for elective patients than emergency patients because they are more financially lucrative[62]. The consequence is the emergency department is left to be crowded. Another example is the avoidance of an expensive admission by "intensive therapy" in the emergency department[6, 45]. By managing the patient in the emergency department, the hospital saves money. Another example is the educational framework of academic teaching centers[63]. Because it is mandatory for academic centers to educate physician trainees to become independent practitioners, patients have to see the medical student, resident and then consultant before management is complete. This increases the patient's EDLOS. A disconnect between the ED team members, or hospital services[43] can lead to disjointed, and inefficient care. Hospitals may not be able to discharge their inpatients because of community factors. There may be limited access to home care, alternate level care beds[39]. For emergency patients, difficulties arranging follow up care can result in a hospital admission[6]. These are all systems issues.

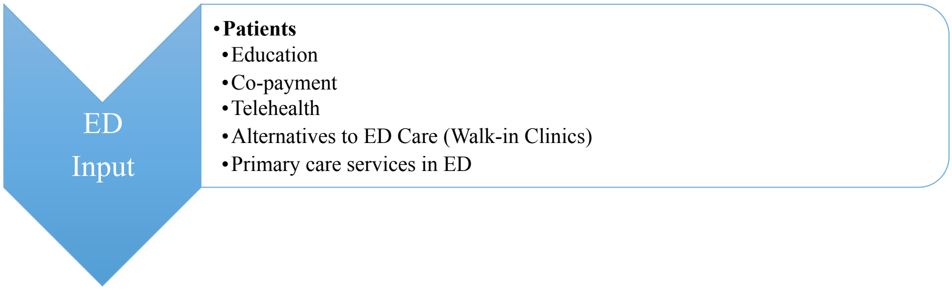
The literature outlining the etiology behind emergency department crowding is mainly low quality, such as commentaries, surveys and consensus meetings. However, there are also systematic reviews and comprehensive observational studies of large databases, such as the National Hospital Ambulatory Medical Care Survey in the USA[45, 47, 51, 52]. Although this improves the quality of evidence, findings from large databases limit the application to individual hospitals. Given the many causes of ED crowding, which factor an individual hospital should prioritize remains uncertain.

1.5 EMERGENCY DEPARTMENT CROWDING: SOLUTIONS

Presently, the multifactorial problem of crowding has no common solution[11, 43]. There are many proposed solutions; however, the literature lacks robust evidence[11, 43, 64], such as randomized control trials or associated economic analyses[65], to determine if resources are used effectively and accountably[12]. Additionally, there are few qualitative analyses on why or how an intervention worked[11]. Finally, knowledge transfer between hospitals and health care systems are challenging given the different infrastructures[11, 39]. It is speculated that crowding solutions will require a systems approach[66, 67] with positivist and relativist thinking[68].

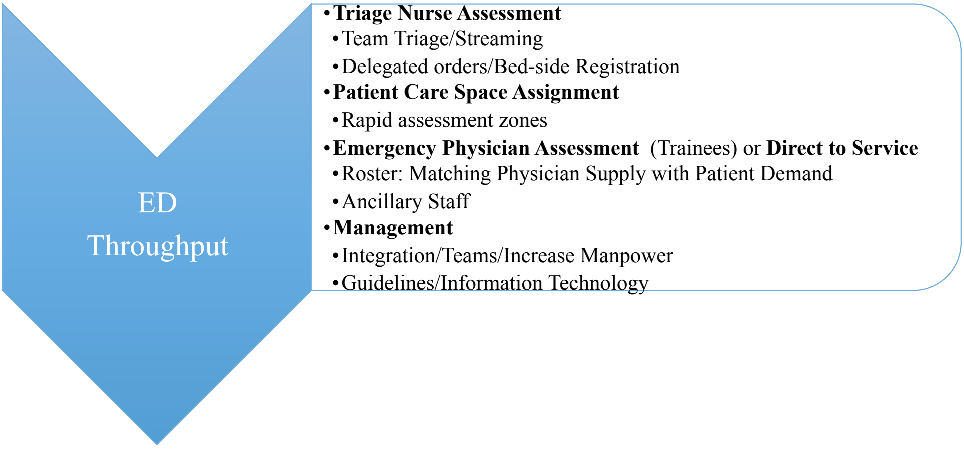
Summarized below are proposed solutions from the literature with a brief commentary on methodology and quality:

1.5.1 Input (Demand) Solutions



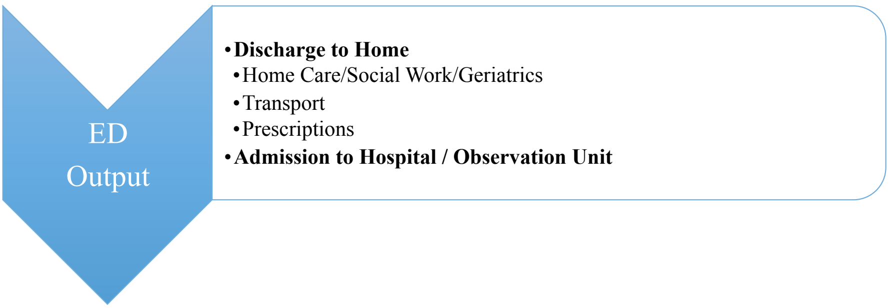
Strategies to decrease patient demand include injury and prevention programs, (especially chronic illness) [11], patient education, managed care, or hospital financial incentives[69]. Patient financial disincentives, such as co-payment, gatekeeping by telephone triage[70] or general practitioner referral to the ED[11, 43] are strategies to discourage ED use. However, telephone advice lines have not shown to decreased ED attendance, but have increased ambulance demand[70, 71]. This strategy has to be used thoughtfully because it assumes that patients are using the emergency department inappropriately and triage is accurate. A recent American study found that 4.4% of triaged non-urgent visits were eventually admitted with 0.7% to the intensive care unit[72]. Other alternatives to the ED are self-care, walk-in clinics[11, 43] or extended paramedic services[43, 70]. There is little evidence to support the effectiveness of primary care services in the ED[73]. The literature providing input solutions was mainly observational studies and reviews, with small numbers of randomized controlled-trials. The overall quality of the evidence was low[11, 69, 73].

1.5.2 Throughput (Demand) Solutions



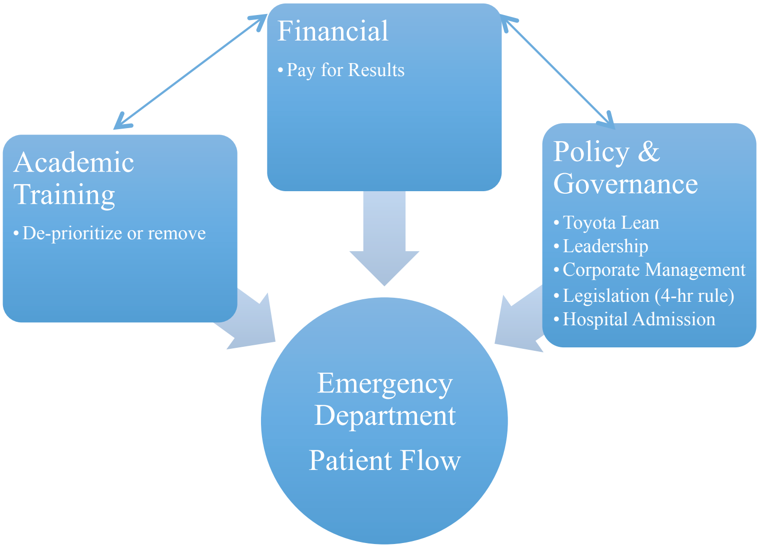
Emergency department solutions can be organized into triage, registration and management (ex. diagnostics, consultation). Triage can be made more efficient with physician or team triage[42, 43, 74], prehospital data transmission [42], streaming [43, 75–77], two-track triage[42], clinical guidelines[42] or delegated orders for triage nurses[14, 78]. EDLOS may be shortened with bedside registration[42, 79] or providing a patient kiosk at triage such that patients can enter information on their own[42]. Rostering physician staffing to patient demand[80], adding accessory staff, such as nurse practitioners, physician assistants, or scribes[42, 70] and teamwork strategies[81] are manpower solutions to expedite patient care. Plant design or tracking methods include flexible partitioning between low and high acuity areas[42, 82], rapid assessment zones[83] or using radiofrequency identification technology to obtain an overview of equipment and open room location[42]. Other throughput solutions include faster access to diagnostics[42, 84–87], improved integration with radiology[58] consultants[11, 88], consultation guidelines[42], daily emailing performance metrics to consultation services[48] and computerized consultation[89]. Although many throughput solutions were in the literature, they were mainly systematic reviews of evidence with average methodology, such as observational pre-post studies or expert consensus. However, there were a few randomized-controlled trials for team triage[90].

1.5.3 Output (Supply) Solutions



The main goal of hospital solutions is to mitigate access block. They can be divided into the process of admission, systems management and discharge. Admission strategies include hospital admission before diagnostics or treatment are completed, full capacity protocols, such as hallway admissions*[42] (Vicellio principle[11]), predictive analytics[91], observation units[43], express admission units[92] or medical assessment units[70, 93]. Systems management in the hospital include improvement of inpatient bed use[42], increased intensive care unit beds[94, 95], elective surgical schedule smoothing[42] and increased aged care and mental health facilities for discharges[14]. Finally, suggested discharge strategies are coordinated discharge planning service[39], early inpatient discharges[42], inpatient discharge units[42] or a designated physician responsible for management of acute overcrowding[39]. The evidence for these output solutions lacks scientific rigor of the randomized-controlled trial and has mainly been from expert consensus, review articles or pre-post observational studies.

1.5.4 Systems Solutions:



The systems approach can be at the hospital, provincial or national level. From the hospital level, integrated care[34, 96], corporate management[97, 98], effective leadership promoting teamwork[99] or lean methodology[11, 100] are proposed strategies. Here, leaders co-ordinate an organized effort to tackle crowding by efficiently integrating all the different systems, such as funding, policies and manpower. However, a large Ontario database study proved that lean had limited gains with shortening EDLOS[101].

From a provincial/state or national level, governments in Canada, Australia and the United Kingdom have implemented financial incentive strategies to decrease wait times. Despite the high cost, gains have been mixed with unintended consequences[43, 102–104]. Introduced in 2004, the United Kingdom implemented the four-hour rule after investing £150 million over three years to improve emergency departments[32]. The government's goal was to have 98% of patients discharged from the ED within four hours of arrival. This rule was the: "Target and Terror regime… forcing [sic] organizations to divert … professional, largely value-driven staff away from 'doing the right thing' toward achieving externally imposed goals instead[43]." Post implementation, the United Kingdom emergency reached targets, but it was found that more patients, mainly elderly, were discharged within the 20 minutes of the four-hour target[102]. An investigation of the MidStaffordshire Trust attributed increased patient mortality

* Admissions who are placed in hospital ward hallway while waiting for hospital bed availability

to the four-hour policy[105]. Other unintended consequences included junior doctor intimidation, bullying, compromised trainee education[106], lack of input from allied health, increased hospital admissions or readmissions, modest benefits in patient outcomes, incomplete patient care, increased nursing and ward workload, inaccurate data that did not necessarily reflect quality of care, and increased ED presentations compared to seeing GP[8, 11, 14, 32, 107]. It was considered that the 98% threshold was overzealous. By 2011, the policy was made less stringent with more quality measures[32].

In Ontario, Canada, the Pay-for-Results[64, 83, 108] strategy was implemented by 2009. Vermeulen determined that the program provided modest EDLOS improvement without causing harm[108]. The study's editorial challenged the conclusion because Pay-for-Results did not lead to best practices or focus on the system bottlenecks, such as hospital operations[64, 109]. However, the study was not designed to determine this. A small qualitative study found that reaching time-targets were prioritized over trainee education and detracted from patient-centered care[32, 110].

A country's healthcare system can influence EDLOS. For example, Denmark's emergency departments do not have access block. Compared to other countries where most unexpected admissions are through the emergency department, 80% of Danish admissions are through the general practitioner or consultant specialist. Patients are instructed to contact their general practitioner first rather than going directly to the ED. Consequently, patient diagnostics and management occur during the hospital admission rather than the emergency department. Hospital occupancy is very high[10].

The literature outlining systems solutions were mainly narratives, consensus documents, systemic reviews of low quality evidence, qualitative and pre-post observational studies. However, there were a few high quality multi-center or large database observational studies[101, 102, 108].

In summary, many input-throughput-output-system solutions decrease EDLOS are in the literature. However, it remains unclear on which solution is the most effective, economical or appropriate for an individual hospital. Additionally, there is a lack of guidance on context for different solutions and qualitative measures to increase usability[103].

1.6 BACKGROUND

The physician-triage model has been at Austin Health (Melbourne, Australia) since 1998. While on sabbatical in 2007, the author was introduced to this model. At the same time, Ontario began to develop its Pay-for-Results program to shorten emergency department wait times[83]. After acquiring funding in 2009, the model was studied at Sunnybrook Hospital. Physician triage was modified to a Physician(**MD**)-Nurse(**RN**) **S**upplementary **T**eam **A**t **T**riage (MDRNSTAT). The intention was to use the gold standard methods uncommonly performed in health services research: the cluster randomized control trial and economic analyses.

While completing Study I and II, the absence of statistically determined factors associated with target failure at Sunnybrook became evident. Although there was a large amount of literature determining factors that increase EDLOS, it was unknown to what degree they could be generalized to the hospital[3]. Inferential statistics, specifically logistic or linear regression analyses, could be applied to Sunnybrook ED data[35]. If factors strongly associated with failing targets could be determined, hospital operations could prioritize crowding solutions. This became Study III. Could Sunnybrook factors associated with target failure remain consistent over time? If so, predictive analytics could be used. Would a hospital with a different health care system, such as Austin Health, have the same model as Sunnybrook?

It was hypothesized that hospitals, like patients, are unique. Each hospital would have its own "footprint" of factors determining their EDLOS. Factors would likely be consistent within the institution, but would be different when compared to another hospital. This became Study IV.

2 GOALS AND OBJECTIVES

Chapter 2 outlines the goals and objectives of this thesis - to scientifically evaluate emergency department crowding solutions and to find factors associated with failure of government targets by:

1) Determining the impact and limitations of adding six and a half hours of a MDRNSTAT on EDLOS among non-consulted, discharged patients seen by the emergency physician.

2) Determining if the MDRNSTAT was economically efficient from the perspective of a publicly funded hospital and the perspective of the patient.

3) Determining government target failure for discharged high acuity patients and intensive care unit (ICU) admissions at Sunnybrook Health Sciences Center (Sunnybrook), an academic tertiary-level hospital in Ontario, Canada.

4) Comparing government time target performance and identifying factors associated with failure between 2012 and 2013 at Sunnybrook and between Sunnybrook and Austin Health (Austin), an Australian academic tertiary level hospital.

3 SETTING AND METHODS

Chapter 3 describes the settings and interventions for the four studies. Emergency departments at two different hospitals were studied – Canada and Australia. The first study evaluated an Australian intervention to decrease emergency wait-times at Sunnybrook Hospital in Canada. The second study was a cost-effective analysis of this intervention. The third observational study determined predictors of failing government time targets for high acuity discharges and admissions at Sunnybrook hospital in 2012. The fourth study was an extension of the third study. It examined if the third study's findings were replicable at Sunnybrook in 2013 and at Austin Health, an Australian hospital, in 2012 for all admissions, high and low acuity discharges.

3.1 SETTING

Studies I, II and III took place at Sunnybrook, an academic tertiary level hospital, in Toronto, Ontario, Canada. In 2015, Sunnybrook had 1359 beds with 321 reserved for emergency admissions[111]. This adult hospital is a trauma, regional stroke, interventional cardiology, neurosurgical and oncology center. Study I and II took place from October 2009 to April 2010. Sunnybrook ED received 45,000 patient visits with a hospital admission rate of 22%. The third and fourth study occurred in 2012 and 2013, respectively. Sunnybrook ED volumes increased from 57,208 (22.3% admissions) to 58,109 (21.3% admissions). Sunnybrook is linked to a rehabilitation hospital, St. John's Rehabilitation; however, direct admissions from the ED are not possible. The Canadian health care system is universal with almost no private hospitals. Study IV occurred at Austin Health, a public hospital in Melbourne, Victoria, Australia. In 2015, this academic tertiary level hospital and its network had 714 beds reserved for emergency admissions. This pediatric-adult institution is an oncology, liver transplant, spinal cord, mental health, and rehabilitation center. In 2012, there were 71,747 visits with a hospital admission rate of 24.2%. Austin had an eight-bed observation unit. Beside the emergency department, there was an after-hours general practitioner clinic to which patients could be re-directed by the triage nurse. Additionally, Austin admissions, specifically geriatrics, could be transferred to Heidelberg Repatriation Hospital. The Mercy, a private gynecological and obstetrics hospital, shares the same building as Austin Health.

3.2 ONTARIO - PAY FOR RESULTS

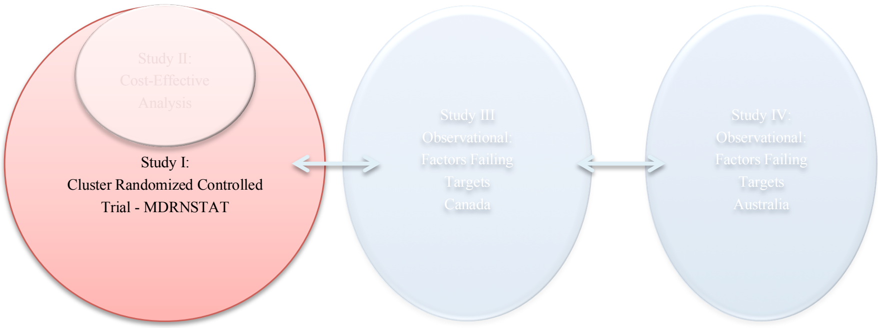
The province of Ontario (population: 13.3 million (c. 2011) [112]) has 163 emergency departments with 5.25 million visits per year [33]. In November 2007, the Ontario Ministry of Health and Long-Term Care (MOHLTC) began to develop policy to reduce EDLOS for specific hospitals. Provincial targets, public reporting, and other initiatives, including a Pay-for Results program with financial incentives, were implemented[33, 83, 113]. Sunnybrook was one of the selected hospitals.

In 2009, the Ontario Pay-for-Results program started. The MOHLTC divided the emergency population into three groups: hospital admissions, low and high acuity discharges. Low acuity was defined as patients triaged between four to five through the Canadian Triage Acuity Score (CTAS) system[114]. High acuity patients were between one and three. By group, the 2009 target was to have ten percent improvement in the proportion of patients achieving the ideal time threshold from the previous year. The endpoint would occur when ≥90% of all ED patients reached ideal thresholds. For admissions, low and high acuity discharges the ideal EDLOS thresholds were ≤eight, ≤ four and ≤eight hours, respectively.

In 2008, 28% of Sunnybrook's hospital admissions, 65% low and 61% high acuity discharges had EDLOS ≤eight, ≤four and ≤eight hours, respectively. Consequently, the 2009 Pay-for-Results target was to have ≥38% of admitted and ≥71% of discharged high acuity patients with EDLOS ≤ eight hours. For discharged low acuity patients, the target was to have ≥75% of patients with an EDLOS ≤ four hours. Additionally, the 90th percentile target for physician initial assessment (PIA) time was set at 5:24, with the future goal of reaching the ideal target of 3:48 [33].

By 2012, the MOHLTC changed the targets. The ideal target was to have the 90th%EDLOS of discharged low acuity, discharged high acuity and admissions to be four, eight and 25 hours, respectively.

3.3 DESIGN-INTERVENTION



Study I was a cluster, randomized-control trial comparing the MDRNSTAT with nurse-triage only over 26 weeks (October 1, 2009-April 1, 2010). Clusters were all emergency department patients arriving between 8:00-14:30. Control cluster patients were triaged by a standard nurse for acuity scoring, registered, and assigned an ED stretcher (Figure 3-1 - light blue arrows). Patients would stay in the waiting room if there were no patient care space available. Upon receiving an assessment space, the regular emergency physician would assess, investigate, manage and provide a disposition for the patient. The intervention was the MDRNSTAT. The team would be added to the usual care at triage (Figure 3-1- bold red arrows). Ambulatory and ambulance patients could be seen by the MDRNSTAT. After being assigned an acuity score by the standard triage nurse, the MDRNSTAT physician would assess the patient assessment a room behind the triage bay. Orders would be initiated without waiting for a stretcher in the ED. The MDRNSTAT nurse completed laboratory and treatment requests whilst diagnostic imaging would follow through radiology orders. The MDRNSTAT nurse could perform triage or emergency care. The MDRNSTAT physician could request consults and potentially discharge the patient. Non-discharged patients were directed to go back into the waiting room to wait for a stretcher where the usual emergency physician would take over care. Patients would bypass the MDRNSTAT if an ED stretcher were immediately available where they could see the usual emergency physician.

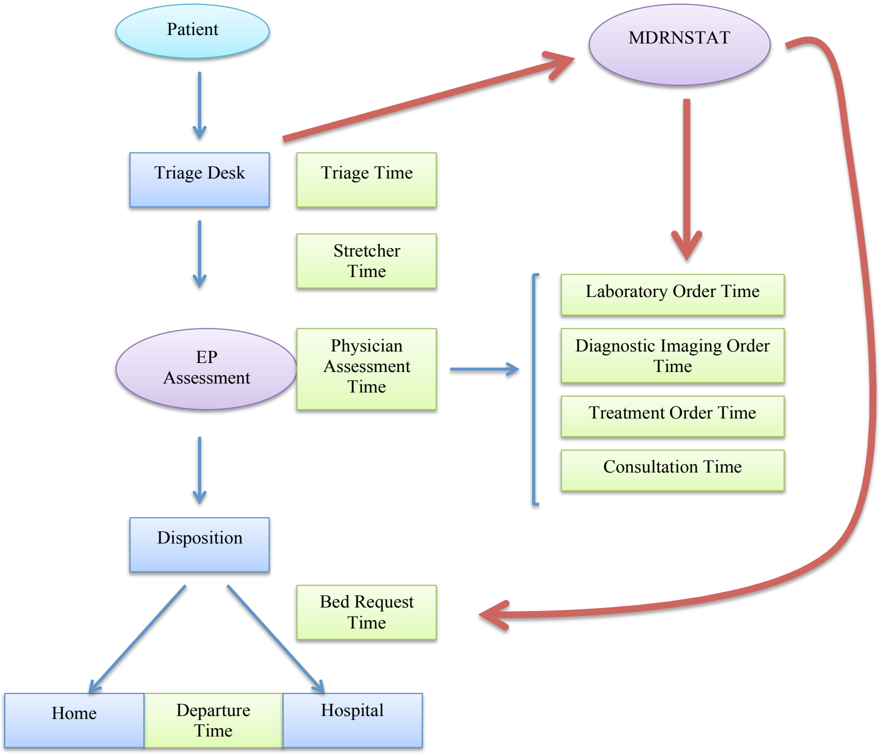


Figure 3-1: MDRNSTAT and Patient Flow

In order to prepare for the predictable 11:00 surge of ED patients, those arriving from 8:00 to 14:30 were included. The rationale was to prevent queuing rather than reacting to increased wait-times. Given budget and recruitment concerns, the study occurred on weekdays. We excluded critically ill (CTAS 1) because they require immediate resuscitation (i.e. cardiac arrest or penetrating chest trauma). Any delays for MDRNSTAT assessment at triage would be unethical and harmful. At Sunnybrook, admitting services (i.e. oncology) would direct patients to come to the ED for admission. Because these patients are seen directly by the admitting service and not the emergency physician, they were also excluded from the study.

Randomization was completed before study initiation using a computer-generated algorithm. The ED shift was the unit of allocation (or cluster). Two control days between intervention days were ensured to minimize any carryover of MDRNSTAT effects. There were 65 MDRNSTAT shifts divided amongst 14 physicians and 14 nurses. There were 66 nurse-triage alone (control) shifts.

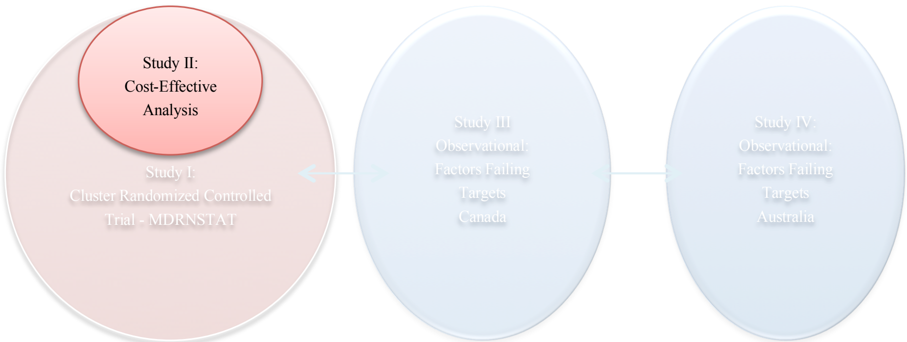
Physicians and nurses voluntarily signed up for the MDRNSTAT shifts in addition to the regularly scheduled ED shifts. Consequently, one physician and one nurse were added to the three physicians and 15-19 nurses typically working each dayshift. Regularly scheduled emergency physicians were instructed to not work at triage. Blinding of the staff to the MDRNSTAT could not be possible; however patients were unaware of the team because its schedule was not publicized. Primary outcome measurements, the time recordings, were not influenced since they were automatically collected by the computerized patient-tracking emergency department information system.

The administrative databases, Electronic Patient Record and Emergency Department Information Systems, provided time data, CTAS levels, and patient disposition. Electronic Patient Records collected diagnostic imaging and laboratory times data. The Emergency Department Information System collected the rest.

Study I's primary outcome measure was the median EDLOS for discharged (non-admitted) patients directly seen by the MDRNSTAT or usual emergency physicians with no consultation ("non-consulted"). The reason is that emergency department interventions could not influence consultation duration or hospital bed availability for admissions. In accordance to the provincial guidelines, EDLOS was defined as the interval between triage and ED discharge time. EDLOS was grouped according to patient acuity, disposition and consultation.

Secondary outcome measures were physician-initial assessment duration (triage time to emergency physician assessment), EDLOS for patients seen by the emergency physician and referred for consultation/admission or left-without-being-seen, percentage of CTAS 3-5 patients who were seen within the Ontario's Pay for Results wait-time target thresholds, and left-without-being-seen rate, a widely used measure of safety and satisfaction[15, 16, 115, 116]. Laboratory, diagnostic imaging, consultation and bed request order time were additional secondary outcome measures.

Unintended harm was measured by searching the database for patients who returned to Sunnybrook within 48 hours after being triaged by the MDRNSTAT. The patient charts were reviewed for a management change, admission or death. Management change was defined if there were a difference in diagnosis or treatment between the first and second visit. Time parameters or external hospital data could be collected for patients who left-without-being-seen. All outcome measures were determined a priori.



Study II was the cost-effective analysis of the MDRNSTAT. Costs and revenue analysis was performed from the hospital and patient perspective. Given the short time horizon with concrete costs, revenue and outcome measures, a decision-analysis and extrapolation model was used. The province of Ontario has a universal, publicly funded, government-run insurance system. From the hospital perspective, costs were personnel and diagnostics. The MOHLTC determines physician and nurse hourly rates and diagnostic imaging fees. Capital costs, such as the physical plant, food, medication and cost transfers, were unchanged between the control and intervention groups. Therefore, they were not included in the analysis. Costs and revenues were calculated in 2009 dollars ($1.00 CAD=0.87 USD, 2009[117]).

With respect to the emergency department, the Alternate Funding Agreement, Global Funding Program, and Pay-for-Results programs collectively determined hospital revenue. The Alternate Funding Agreement funds Ontario's emergency departments prospectively by using the prior years' patient-volume seen and case-mix resulting in a lump sum value for individual hospitals' emergency physician salaries. If the actual patient volume exceeded what is distributed, reconciliation payments for the current year are reimbursed to the hospital. Therefore, decreasing the LWBS rate will increase the Alternate Funding Agreement Revenue. The Global Funding Program provides hospital revenue through a fee-for-service model based on the Ontario Schedule of Benefits[118]. For this program, the physician bills a fee service code and 38% of its value is flowed back to the physician. If the physician sees more patients, ED revenue increases to the physician and the hospital. The Pay-for-Results program provides financial incentives to hospital able to reach specified time threshold indicators. In 2009, if the hospital reached its 90th percentile PIA time target, it would be rewarded $100,000. If acuity-based EDLOS targets for discharged and admitted patients are reached, the hospital would be receive $748,000. Since effectiveness outcomes were in the range of hours, discounting was not required.

Study II was specifically a cost-effective[119] and cost-benefit analysis[120], in contrast to a cost-utility analysis[121]. Effectiveness outcomes were three different intermediate outcomes: 1) additional number of patients seen 2) total hours PIA time saved and 3) EDLOS hours saved.

From the hospital perspective, two comparative economic evaluations were done: 1) incremental cost-effectiveness analysis and 2) incremental cost-benefit analysis. Direct cost and revenue generation by the MDRNSTAT was determined for 2009. By extrapolating the reference study data to 2009, revenue from the Alternate Funding Agreement, Global Funding Program, and reaching Pay-for-Results thresholds was calculated. The difference between the cost and revenue was the net value. By dividing the net value over three different outcome measures: additional patients seen, PIA-hours saved, and EDLOS-hours saved, incremental cost-effectiveness ratios were determined. By dividing the cost of the MDRNSTAT by the revenue generated, an incremental cost-benefit ratio was calculated. Net present value was the cost subtracted from the revenue.

From the patient perspective, patient dissatisfaction is positively correlated to LWBS rates and increased PIA times[116, 122]. A numeric estimation of patient satisfaction was estimated by calculating the PIA time saved, and additional patient seen between the intervention and control groups. For the cost-benefit analysis, there is no Canadian data for willingness-to-pay[123] values to decrease ED wait-times. An alternative, the human capital approach,[123] was used. Here, wait-times are the opportunity cost of lost wages, irrespective of employment status. The 2009 Canadian minimum wage was the financial surrogate for valuing patient wait-times. The 2012 hourly wage was $24.38[124]. Given 1.9% annual inflation, the 2009 hourly rate was estimated to be $23.02. The value for patient satisfaction was calculated by multiplying PIA-time-saved with hourly wage and additional-patients-seen by daily wage. The cost-benefit ratio was determined by dividing the gross MDRNSTAT cost by the patient satisfaction value.

From the staff perspective, three non-MDRNSTAT emergency physicians, three non-MDRNSTAT nurses, the MDRNSTAT physician and nurse completed a survey at the end of each intervention shift. The survey (Appendix I) asked whether or not the MDRNSTAT provided better patient quality of care, benefited patient flow, contributed to teamwork and collegiality or improved personal efficiently. A 7-point Likert scale, ranging 1 (strongly disagree) to 7 (strongly agree) was used.

From the hospital perspective, a univariate sensitivity analysis was performed to determine the most cost-efficient working hours. Variables changed were the MDRNSTAT working time period and salary. Study data was extrapolated to corresponding patient volumes and LWBS rates between (Figure 3-2): 16:00 and 24:00 (8 hours), 12:00 to 06:00 (18 hours) and 12:00 to 24:00 (12 hours).

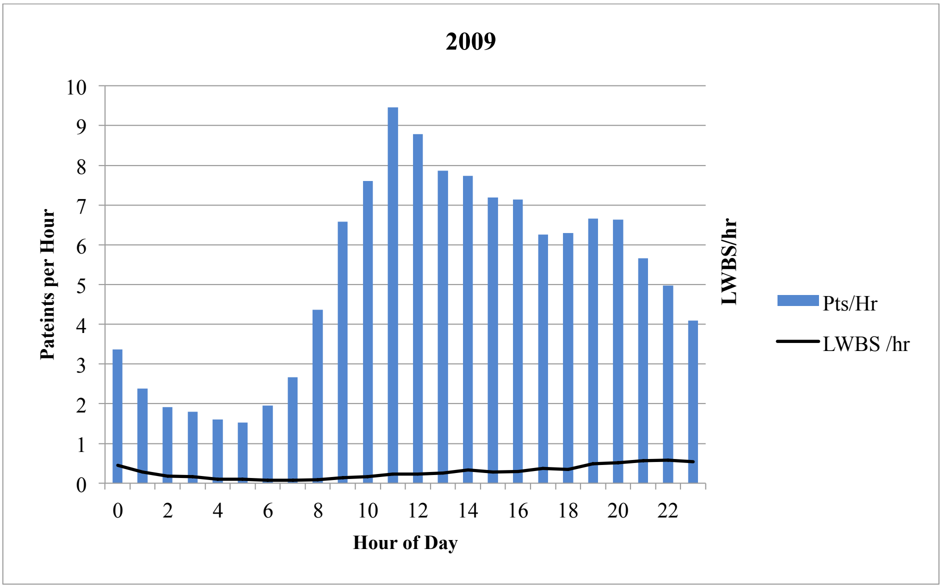
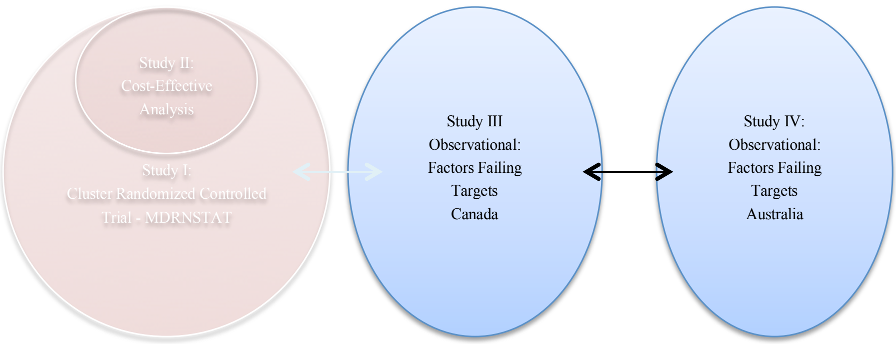


Figure 3-2 Patient arrivals and left-without-being seen (LWBS) rate by hour of day starting from midnight from January 1- December 31, 2009. The 2009 LWBS rate was 6.2%.

MDRNSTAT salary was decreased from $180/hr to $100/hr. In 2009, the LWBS rate was 6.2%.

From the patient perspective, the willingness-to-pay values were changed to a Dutch study's[125] valuation of wait-times for non-emergent orthopedic assessment or non-palliative radiotherapy.



Study III and IV were retrospective, single center, observational studies. Study III's population was Sunnybrook ED patients from January 1 to December 31, 2012. For Study IV populations included 2013 Sunnybrook and 2012 Austin Health ED patients. Sunnybrook data was retrieved from four administrative databases: Electronic Patient Registry, Emergency Department Information Systems, Emergency Department Stretcher and Hospital Occupancy Tables. Austin Health data was retrieved from Medtrak and Occupancy tables.

Emergency registration, physicians, nurses and decision support enter data for each patient encounter. Demographics, acuity, time stamps (i.e. triage, physician initial assessment, bed request and discharge time), arrival model, diagnostic interventions (imaging, laboratory), disposition and occupancy were collected. Emergency registration, physicians, nurses and decision support enter data for each patient encounter. All patient visits were included, irrespective if multiple visits were from the same patient at different times.

Using Stata (Version 13.1, StatCorp, College Station, TX), administrative data was checked for duplicated registrations, missing data points and inaccurate times (ex negative durations). Duplicated registrations of the same patient visit were removed. For missing and discrepant data points, chart reviews were performed (IC). If the information was found, the data point was changed manually. If the data was still missing post chart review, it was excluded. All other data entries were included. Descriptive statistics were determined for selected variables.

Figure 3-3 outlines the durations of: emergency department length-of-stay (EDLOS), physician initial assessment duration (PIAD), bed request duration (BRD), and access block (AB). Access block was defined as the duration waiting for the ward bed.

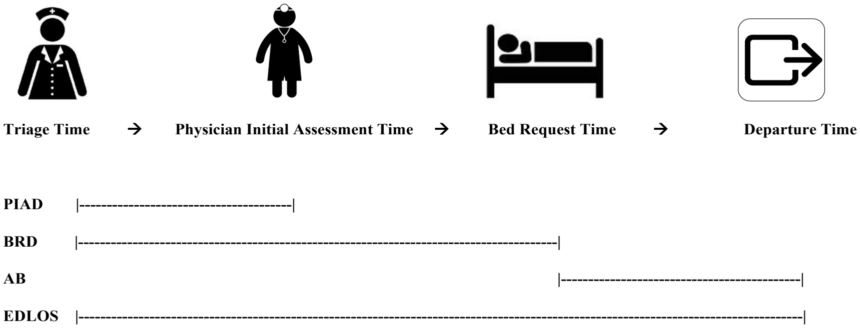


Figure 3-3 Physician Initial Assessment Duration (PIAD), Bed Request Duration (BRD), Access Block (AB), Emergency Department Length-of-Stay (EDLOS)

Patients were grouped into the following government classifications to remain consistent with ED time targets for admissions, high and low acuity discharges.

Group
Discharged low acuity (Acuity 4 and 5)**
Discharged high acuity (Acuity 1 to 3)**
a. Hospital Admissions b. Observation Unit Admissions (Austin Health only)
a. Left-without being seen b. Re-directed to General Practitioner Clinic (Austin Health only)
Died

** CTAS: Canadian Triage Acuity Scale [114], ATS: Australasian Triage Score [126]

The Canadian Triage Acuity Scale (CTAS)[114] and Australasian Triage Score (ATS)[126] define acuity. Both scores define one as highest acuity, requiring immediate physician management. Lowest acuity is five. For Study III, discharged high acuity patients were discharges with acuity score between one and three. Intensive care unit (ICU) admissions were defined as hospital admissions under the ICU service. Because Austin had an observation unit and after-hours general practitioner clinic, there were two additional subcategories for admissions and left-without-being-seen for Study IV.

Predictor factors for failing government targets were selected through literature searches, expert clinical consensus and availability in the collected data[6, 10, 14, 39, 58, 127]. Hospital-uncontrolled factors were patient factors, such as demographics, acuity, ambulance arrival, shift, weekday/weekend, ED attendances by hour or day. Hospital-controlled factors were resources, such as diagnostics, hospital occupancy or consultations and physician initial assessment time.

Study III's primary outcome was predicting failure of MOHLTC targets for discharged high acuity patients and ICU admissions. Study IV's primary outcome was reaching time targets for Sunnybrook Health Sciences Center (Canada) and Austin Health (Australia) by admissions, low and high acuity discharges. The secondary outcome was predicting target failure for both hospitals by the same groups for both studies. The secondary outcome was predicting EDLOS target failure for all Sunnybrook admissions, and low acuity discharges in 2012. From 2010-11, the ideal EDLOS target was to have 90% of the low acuity discharges, high acuity discharges, and admissions ≤ four, ≤ eight and ≤ eight hours, respectively. By 2012, the MOHLTC changed to a 90th percentile EDLOS value of four, eight and 25 hours. Both targets were used in the analyses.

3.4 SAMPLE SIZE AND STATISTICAL ANALYSIS

For Study I**,** it was determined that a sample size of 50 clusters (shifts) per group, with 32 patients per cluster, would have greater than 90% power to detect a difference of 30 minutes between the group medians. Thirty minutes was clinically significant because previous literature determined its association with decreased 7-day mortality, re-admission of discharged patients[18] and left-without-being seen rate[116]. Additionally, the MOHLTC's target was a 10% reduction of Sunnybrook's baseline physician initial assessment of 324 minutes – equaling 30 minutes [128]. We used a standard deviation of 70 minutes, intra-cluster correlation of 0.1[129] with a two-sided t-test and a significance level of 0.05.

Analyses were done by cluster (shifts), control versus treatment, adjusting for the clusters in which the patients appeared. Consequently, there were 66 control clusters (3163 visits) and 65 intervention clusters (3137 visits). Visits were not treated as independent observations for analysis purposes. The number of clusters was increased to 65 to compensate for the variable number of visits per cluster.

Descriptive statistics were calculated for selected variables. Categorical measures were summarized with counts and percentages. The primary outcome, EDLOS, and secondary measures were summarized as medians. Outcomes were log transformed, and the mean group differences of EP's, MDRNSTAT, combination of the two and the control group were compared using linear models adjusting for the correlation among observation taken from the same cluster (shift). Using 1000 bootstrap simulations, confidence intervals for medians were determined. The 95th confidence interval used the 2.5th and 97.5th percentile, respectively. If there were variables with no events, such as rate of harm, a one-sided 95% confidence interval using the Hanley estimate of 3/n[130] (where n is the total sample size of interest) was used. Statistical analyses were done using SAS Version 9.1 (SAS Institutet, Cary, NC, USA).

For Study II, the first study's results were extrapolated to staffing the MDRNSTAT from 08:00 to 15:00. The 2009 calendar year ED patient volume was 45,405 patients. During this daytime period, 19,120 patients (42.1% of annual volume) with 2.0% LWBS rate were seen. The reference study's non-consulted, discharged CTAS 2-3 and CTAS 4-5 proportions were projected to the corresponding 7 hours. Analysis also included patient arrivals, LWBS rate, PIA-time and EDLOS by hour of arrival.

Additional patients seen were determined by extrapolating the LWBS-rate difference between the intervention and control. Two-sample, two-sided tests of proportions were carried out and 95% confidence intervals were calculated around estimates.

For total EDLOS- or PIA-time-saved, only statistically significant differences between MDRNSTAT and control were used. We kept the intervention LWBS rate at 1.5% and multiplied the corresponding patient volumes by their respective time differences. These were determined using the total EDLOS time or PIA time saved between the control and intervention groups. Because these durations were non-parametric, median differences and their associated confidence intervals were determined by the Hodges-Lehmann estimation method. This involves an analysis of all differences between two groups with derivation of a median difference and its associated 95% confidence interval.

Cost-effective analyses and patient flow graphs were performed on Microsoft Excel (Version 14.4.1, Microsoft Corporation, Redmond, WA). The hourly cost-effective analyses and sensitivity graphs were produced on Stata (Version 13.1, StatCorp, College Station, TX).

For Study III and IV, descriptive statistics and the 90^{th}%EDLOS government target were determined and stratified by admissions, high and low acuity discharges, For multiple logistic regression, EDLOS was made binary: EDLOS ≤ four, ≤ eight and ≤ eight hours for discharged low acuity, high acuity and admissions, respectively.

Prior to determining logistic regression models, factors were examined by two-by-two tables with odds ratios, Woolf approximation for confidence interval and standard deviation calculations. Using a forced entry, stepwise backwards method with the lowest Akiake's information criterion for best fit, most appropriate model was chosen. To control for heteroskedacity, models were run robust. Odds ratios were provided with their 95% confidence intervals. All statistical analyses were performed with Stata

By varying the combination of the top three factors associated with failure of targets, a descriptive, stepwise table of mean EDLOS +/- standard deviation and 90^{th} %EDLOS was created for discharged high acuity patients and Sunnybrook ICU admissions.

3.5 ETHICS APPROVAL

The Sunnybrook Hospital Research Ethics Board gave approval for the randomized control trial, cost-effective analysis and two observational studies. Formal informed consent for patients was waived for Study I. Austin Health Human Research Ethics Committee granted approval for the Australian observational study.

4 RESULTS

Chapter 4 summarizes the results of the four studies.

4.1 MDRNSTAT: CLUSTER RANDOMIZATION (I)

For Study I, there were 17,034 weekday emergency department visits: 8531 were randomized to the intervention (MDRNSTAT and Emergency Physician) and 8503 to control. There were 3163 control visits (66 clusters) and 3137 intervention visits (65 clusters) after excluding patients arriving outside 8:00-14:30, critically ill, or "directs." The subgroups of the intervention cluster were those patients who were only seen by the MDRNSTAT or the emergency physician (EP). From the intervention cluster, 750 (24%) patients waiting for an ED stretcher were initially seen by the MDNRSTAT. The regularly scheduled emergency physician (EP) solely managed the remaining 2387 patients (Figure 4-1).

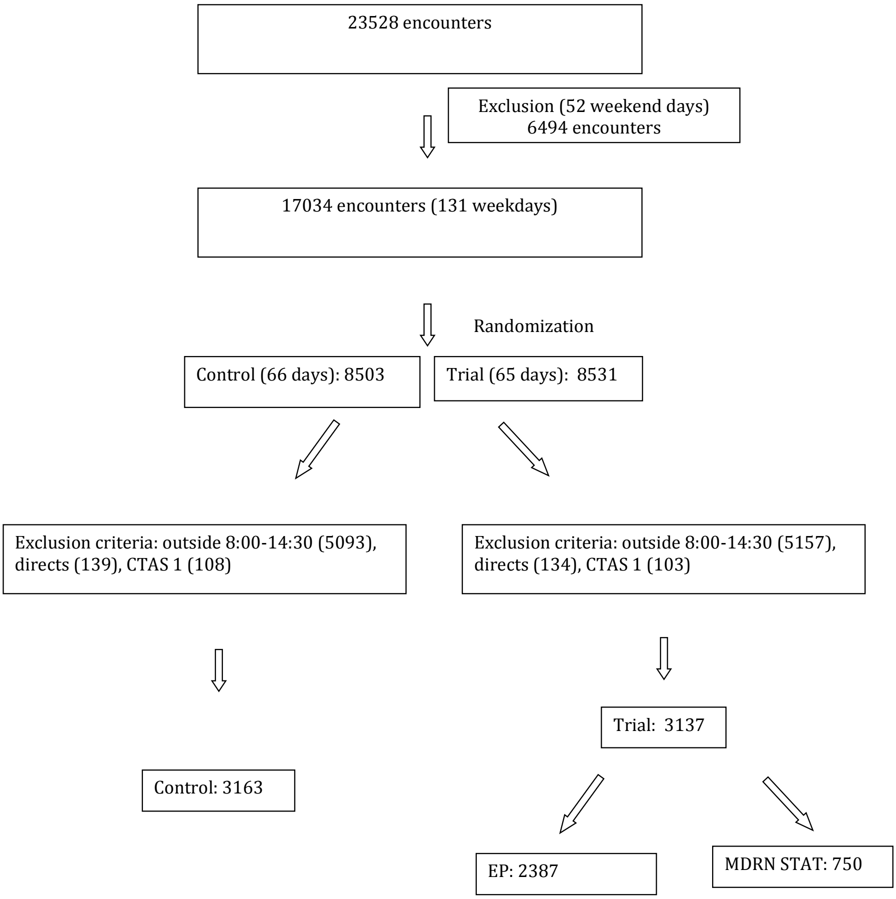


Figure 4-1 Randomization and encounter allocation with associated inclusion and exclusion criteria

With respect to baseline characteristics of sex, age and CTAS, the two study groups were similar (Table 4-1). Between the control and intervention groups, the proportion of discharged patients was the same (79.1%).

	Control Days		**Trial Days**						
			EP		**MDRNSTAT**		**Intervention (EP+MDRNSTAT)**		***p***
	No.	%	No.	%	No.	%	No.	%	
No. of Patients (randomization)	8503	36.1					8531	36.3	
No. of Patients (8:00-14:30)	3163	37.2	2387		750		3137	36.8	*0.58*
Visits/shift	47.9						48.3		
No. of Clusters (Shifts)	66						65		
No. of Patients seen after 8:00 arriving before 8:00	331	31.2	295		78		373	32.5	*0.55*
Sex (Male)	1389	43.9					1362	43.4	*0.71*
Age (mean)	56yo		56yo		54 yo		56yo		
CTAS 1 (of 8:00-14:30)	108	2.9	97		6		103	3.1	*0.84*
CTAS 2-3 (of 8:00-14:30)	2489	78.7	1828	76.6	615	82	2443	77.9	*0.45*
CTAS 4-5 (of 8:00-14:30)	674	21.3	559	23.4	135	18	694	22.1	*0.45*
Directs (of 8:00-14:30)	139	4.1	117		17		134	4	*0.85*
Admits (of 8:00-14:30)	586	18.5	451	18.9	154	20.5	605	19.3	*0.44*
Discharges (of 8:00-14:30)	2503	79.1					2482	79.1	*0.99*
No. of CT/Study Discharges	280	11.2					295	11.9	*0.44*
No. of CT/Study Admissions	160	27.3					163	26.9	*0.89*
No. of CT/Study Discharges & Admissions	440	14.2					458	14.8	*0.51*

Table 4-1 Characteristics of MDRNSTAT Trial and Control Clusters from October 2009-April 2010 (EP=Emergency Physician, MDRNSTAT=Physician-Nurse Supplementary Team at Triage)

4.2 INTERVENTION (MDRNSTAT AND EP) AND PRIMARY OUTCOMES (I)

The intervention cluster improved the primary outcome: EDLOS was significantly reduced by 24' for discharged, non-consulted higher acuity patients (CTAS 2-3) (p=.005) but was not significant for the lower acuity patients (CTAS4-5). The MDRNSTAT subgroup significantly reduced the discharged non-consulted lower acuity EDLOS by 56' (p<.0001)(Table 4-2).

4.3 INTERVENTION (MDRNSTAT AND EP) AND SECONDARY OUTCOMES (I)

With respect to secondary outcomes for discharged non-consulted high acuity patients, the intervention cluster achieved its 10% improvement target, and almost reached the ideal threshold of 90% (89.1% reached Pay for Results EDLOS target of ≤ eight hours). For discharged, non-consulted low acuity patients, the intervention also reached the 10% improvement threshold. The intervention did not exceed the ideal target (83.3%), but the MDNRSTAT did (92.1%).

There was no significant difference between the intervention and control for admitted or discharged patients requiring a consultation.

The intervention had a 90th percentile physician initial assessment (PIA) time of 3:31 and achieved a decrease of 26' when compared to control. The MDRNSTAT had a 90th percentile PIA time of 1:08 with a decrease of 56'. The ideal provincial 90th percentile PIA time threshold is 3:48. In 2007-8, Sunnybrook hospital's 90th percentile PIA time was 5:42.

The MDRNSTAT and intervention reduced the left-without-being-seen-rate (Table 4-2).

	Control	Trial		
		EP	MDRNSTAT	Intervention (EP+MDRNSTAT)
Discharges LOS – Not Consulted				
CTAS 2-3 *n*	1547	1156	379	1535
LOS (95$^{t\%}$ CI)	4:29 (4:19-4:38)	4:07 (3:59-4:18) *p=.01, k=0.1*	4:01 (3:43-4:16) *p=.03, k=0.1*	4:05 (3:58-4:15) *p=.005, k=0.1*
Pay for Results Threshold (71%)	86.0%	89.1% *p=.02*	89.2% *p=.13*	89.1% *p=.01*
CTAS 4-5 *n*	614	497	126	623
LOS (95$^{\%}$ CI)	2:06 (2:02-2:14)	2:08 (2:01-2:21) *p=0.74*	1:10 (0:58-1:19) *p<.0001, k=0.1*	1:55 (1:48-2:05) *p=.12*
Pay for Results Threshold (75%)	84.4%	81.1% *p=.17*	92.1% *p=.04*	83.3% *p=.67*
Discharges LOS - Consulted				
CTAS 2-3 *n*	305	205	81	286
LOS	7:19	7:06 *p=0.5*	6:25 *p=0.1*	6:48 p=.27
Pay for Results Threshold (71%)	57.0%	61.5% *p=.37*	64.2% *p=.30*	62.2% *p=.23*
CTAS 4-5 *n*	37	32	6	38
LOS	4:57	4:40 *p=.71*	4:19 *p=.95*	4:40 *p=.73*
Pay for Results Threshold (75%)	40.5%	34.4% *p=.78*	50% *p=1.0*	36.8% *p=.93*
Admissions LOS				
Admissions *n*	586	451	154	605
LOS	12:03	11:41 *p=0.24*	11:20 *p=0.1*	11:36 *p=.21*
Pay for Results Threshold (38%)	21.3%	22.6% *p=.67*	25.3% *p=0.34*	23.3% *p=0.34*
Physician Initial Assessment Duration				
n	3092/3163	2341/2387	750	3091/3137
Pay for Results 90th percentile (3:48) (95th CI)	4:25 (4:11–4:36)	3:57 (3:47-4:08)	1:08 (1:01-1:14)	3:31 (3:22-3:42)
Median PIA (95th CI)	1:21 (1:18-1:25)	1:13 (1:10-1:16) *p=.0005*	0:25 (0:23-0:26) *p<.0001*	0:55 (0:53-0:58) *p<.0001*
LWBS				
LWBS *n*	69/3163	44/2387	4/750	48/3137
Percentage	2.2%	1.9% *p=0.43*	0.53% *p=.001*	1.5% *p=.06*
Mortality				
Deaths *n*	5/3163	2/2387	0/750	2/3137
Percentage	0.16%	0.08% *p=.71*	0% *p=.59*	0.06% *p=.45*

Table 4-2 Discharged EDLOS (Consulted and Non-Consulted), Admission EDLOS, Physician Initial Assessment, LWBS and Mortality

Legend:

CTAS: Canadian Triage Acuity Scale
CI: Confidence interval
LOS: Length of Stay
EP: Emergency Physician
MDRNSTAT: Physician-Nurse Supplementary Team at Triage
PIA: Physician Initial Assessment
LWBS: Left without Being Seen

For diagnostic imaging and consultations, the intervention and MDRNSTAT subgroup had shorter ordering times for discharges. For admissions, only diagnostic imaging ordering times were shortened by the intervention and MDRNSTAT. Only the MDRNSTAT was able to reduce bed request time for admissions (Table 4-3).

	Control	**Trial**		
		EP	**MDRNSTAT**	**Combined (EP+MDRNSTAT)**
Discharges:				
n	2503	1890	592	2482
% Bloodwork (BW) Request	37.0%	32.9%	43.8%	35.5%
% Imaging (DI) Request	51.0%	45.8%	61.8%	49.6%
% Discharged	79.1%	79.2%	78.9%	79.1%
% Consulted	13.7%	12.5%	14.7%	13.1%
Median Times:				
Bloodwork Request Time	1:47	1:42	1:02	1:32
Imaging Request Time (95% CI)	2:16 (2:08-2:24)	1:56 (1:48-2:04) *p=.0025*	0:51 (0:43-0:57) *p<.0001*	1:38 (1:32-1:46) *p<.0001*
Consult Request Time	3:20	2:59 *p=.08*	2:40 *p=.02*	2:54 *p=.01*
Admissions:				
n	586	451	154	605
% Bloodwork (BW) Request	80.9%	83.4%	79.2%	82.3%
% Imaging (DI) Request	84.5%	83.8%	88.3%	85.0%
% Admitted	18.5%	18.9%	20.5%	19.3%
Median Times:				
Bloodwork Request Time	1:38	1:51	1:07	1:39
Imaging Request Time	2:41	2:43 *p=.87*	1:05 *p<.0001*	2:11 *p=.0027*
Consult Request Time (95% CI)	3:57 (3:44-4:08)	3:49 (3:37-4:10) *p=.80*	3:36 (3:16-4:02) *p=0.17*	3:46 (3:36-4:03) *p=.36*
Bed Request Time	7:41	7:30 *p=.50*	7:01 *p=.02*	7:19 *p=.19*
Wait for Bed Time	2:58	3:14	2:59	3:10

Table 4-3 Bloodwork, Diagnostic Imaging, and Consultation Request Times for Discharge and Admissions; Bed Request and Wait for Bed Times for Admissions

Legend:

BW: Bloodwork
CT: Computer Tomography Scan
CI: Confidence interval
DI: Diagnostic Imaging

The MDRNSTAT discharged 26.1% (196/750) of patients from triage. Only 3 of these patients returned to the ED within 48 hours. None of these patients died or required admission. Chart review found the same discharge diagnosis between the first and second visit: staple reassessment, urinary tract infection and social concern. All three patients were discharged on the second visit with no change in management or treatment. None met our definition of harm. The Hanley[130] 95% CI estimate was 0-1.53%.

4.4 COST-EFFECTIVENESS OF MDRNSTAT (II)

To prepare for the cost-effective analysis of the MDRNSTAT, Study I's outcome differences were determined (Table 4-4):

Outcome		**Intervention (EP +MDRNSTAT)**		**Control**
n		3137		3163
Resource Utilization				
Bloodwork Request		44.7%		45.3%
Diagnostic Imaging Request		56.5%		57.4%
Consultations		18.6%		19.7%
Admissions		19.3%		18.5%
Pay-for-Results Targets				
90th% Physician Initial Assessment Time (hrs:min, <=3:48)		3:31		4:25
Discharged CTAS 2-3 P4R target (<=8hr, 71%)		84.9%		81.3%
Discharged CTAS 4-5 P4R target (<=4hr, 75%)		80.6%		81.9%
Admission P4R target (<=8hr, 38%)		23.3%		21.3%
Time		**EP**	**MDRNSTAT**	**Control**
n		2387	750	3163
Physician Initial Assessment Time		1:13	0:25	1:21
Difference (minutes) from Control [95% CI]		-7 [-3 to -10]	-53 [-48 to -57]	
Discharged CTAS 2-3 EDLOS (hrs:min)	Consulted	7:06	6:25	7:19
	Difference (minutes) from Control [95% CI]	-35 [-73 to 3]	-52 [-106 to 2]	
	Non-consulted	4:07	4:01	4:29
	Difference (minutes) from Control [95% CI]	-19 [-7 to -31]	-34 [-52 to -16]	
Discharged CTAS 4-5 EDLOS (hrs:min)	Consulted	4:40	4:19	4:57
	Difference (minutes) from Control [95% CI]	7 [-65 to 78]	-18 [-188 to 153]	
	Non-consulted	2:08	1:10	2:06
	Difference (minutes) from Control [95% CI]	3 [-7 to 13]	-52 [-65 to -38]	
Admissions EDLOS		11:41	11:20	12:03
Difference (minutes) from Control [95% CI]		-16 [-63 to 32]	-38 [-102 to 26]	
Discharge Processes:				
Labwork Request Time		1:42	1:02	1:47
Difference (minutes) from Control [95% CI]		-3 [-12 to 6]	-32 [-44 to -21]	
Diagnostic Imaging Request Time		1:56	0:51	2:16
Difference (minutes) from Control [95% CI]		-18 [-27 to -9]	-67 [-79 to -55]	
Consult Request Time		2:59	2:24	3:20
Difference (minutes) from Control [95% CI]		-14 [-34 to 6]	-55 [-82 to -27]	
Admission Processes:				
Labwork Request Time		1:51	1:07	1:38
Difference (minutes) from Control [95% CI]		4 [-9 to 16]	-20 [-37 to -3]	
Diagnostic Imaging Request Time		2:43	1:05	2:41
Difference (minutes) from Control [95% CI]		-10 [-26 to 6]	-87 [-109 to -64]	
Consult Request Time		3:49	3:36	3:57
Difference (minutes) from Control [95% CI]		-5 [-24 to 15]	-23 [-48 to 3]	
Bed Request Time		7:30	7:01	7:41
Difference (minutes) from Control [95% CI]		-8 [-34 to 7]	-29 [-66 to 7]	
LWBS rate		1.8%	0.5%	2.2%
Difference (%) from Control [95% CI]		-0.3% [-0.4 to 1.0]	-1.6% [-0.9 to -2.4]	
LWBS rate		1.5%		2.2%
Difference (%) from Control [95% CI]		-0.7% [0 to -1.3%]		

Table 4-4 Difference outcomes of randomized cluster control trial of MDRNSTAT

Legend:

CTAS: Canadian Triage Acuity Scale
P4R: Pay for Results
EDLOS: Emergency Department Length of Stay
LWBS: Left Without Being Seen

Table 4-5 outlines the cost and hospital revenue of the MDRNSTAT compared to the control group. By decreasing the number of LWBS patients though government funding programs, revenue was achieved.

	MDRNSTAT Hrly Rate	MDRNSTAT Annual Cost	Revenue			
			AFP	GFP	PIA	NPV
8am-3pm (Base)	$180/hr $100/hr	$459,900 $255,500	$10,354	$1,550	$0	$447,996 $243,596
4pm-midnight	$180/hr $100/hr	$525,600 $292,000	$70,651	$10,513	$0	$444,436 $210,836
Noon-6am (18hrs)	$180/hr $100/hr	$1,182,600 $657,000	$177,364	$26,392	$100,000	$878,845 $353,245
Noon-midnight	$180/hr $100/hr	$788,400 $438,000	$177,364	$26,392	$100,000	$484,645 $134,245

Table 4-5 Cost and Revenue of the MDRNSTAT compared to Control: Base Study and Sensitivity Analysis. Base Study is from 8am to 3pm with MDRNSTAT salary of $180/hr.

Legend:

AFA: Alternate Funding Agreement
GFP: Global Funding Premium
P4R: Pay for Results
PIA: Physician Initial Assessment Time
EDLOS: Emergency Department Length of Stay
NPV: Net Present Value (NPV=Cost–Revenue)

From the hospital perspective, Table 4-6 outlines the intermediate effectiveness outcomes – increased number of patients seen, PIA time, and EDLOS.

	Patient Volume	LWBS %	Intervention (MDRNSTAT) vs. Control		
			Patients Seen Difference	PIA Hrs Difference	EDLOS Hrs Difference
8am-3pm (Base)	19,120	2.2%	125 [0-252]	6,102 [4,368-6,764]	4,070 [1,829-6,158]
4pm-midnight	17,410	6.4%	845 [770-919]	5,556 [3,977-6,159]	3,706 [1,666-5,607]
Noon-6am (18hrs)	33,527	6.2%	2,120 [1,925-2,315]	10,700 [7,659-11,861]	7,137 [3,207-10,798]
Noon-midnight	28,934	6.2%	2,120 [1,925-2,315]	9,234 [6,632-10,236]	6,160 [2,768-9,319]

Table 4-6 Hospital Perspective: Intermediate Effectiveness Outcomes between Intervention and Control: Base and Sensitivity Analysis. Base analysis is 8am to 3pm. Sensitivity analysis uses extrapolated outcomes from 4pm-midnight, noon-6am, noon-midnight and by hour of arrival.

Legend:

LWBS: Left Without Being Seen
PIA: Physician Initial Assessment Time
EDLOS: Emergency Department Length of Stay
CTAS: Canadian Triage Acuity Scale

The intervention cost $3597.27 [CI: $1729.47 to ∞] per additional-patient-seen from 8am-3pm (Figure 4-2). Keeping the LWBS constant at 1.5%, the intervention cost $75.37/PIA-hour-saved [CI: $67.99-$105.30] (Figure 4-3) and $112.99/EDLOS-hr-saved [CI: $74.68 - $251.43] (Figure 4-4). The hospital CBR was 38.6 [CI: 19.0 to ∞].

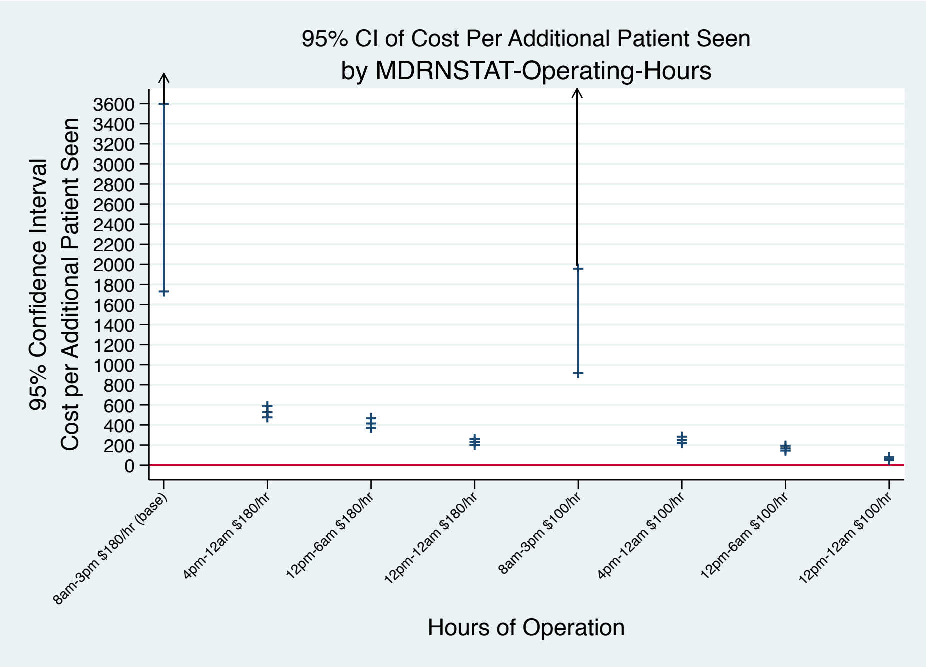


Figure 4-2 plots the 95% confidence interval of the cost per additional patient seen by MDRNSTAT operating hours of: 8am to 3pm (base), 4pm to 12am, 12pm to 6am the following day, and 12pm to midnight at salary rates of $180/hr and $100/hr

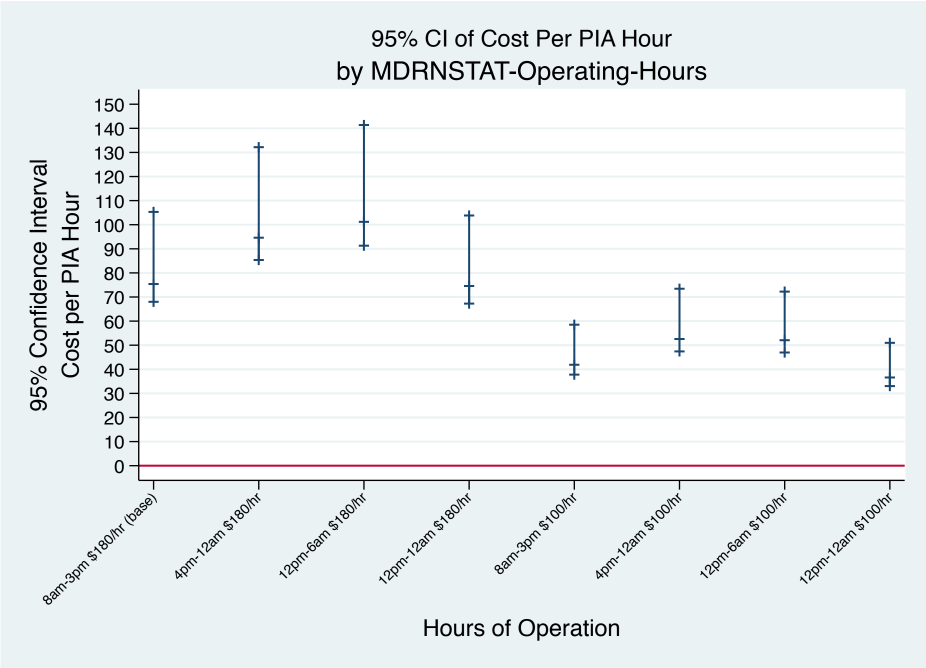


Figure 4-3 plots the 95% confidence interval of the cost per physician-initial-assessment (PIA)-hour saved by MDRNSTAT operating hours of: 8am to 3pm (base), 4pm to 12am, 12pm to 6am the following day, and 12pm to midnight at salary rates of $180/hr and $100/hr

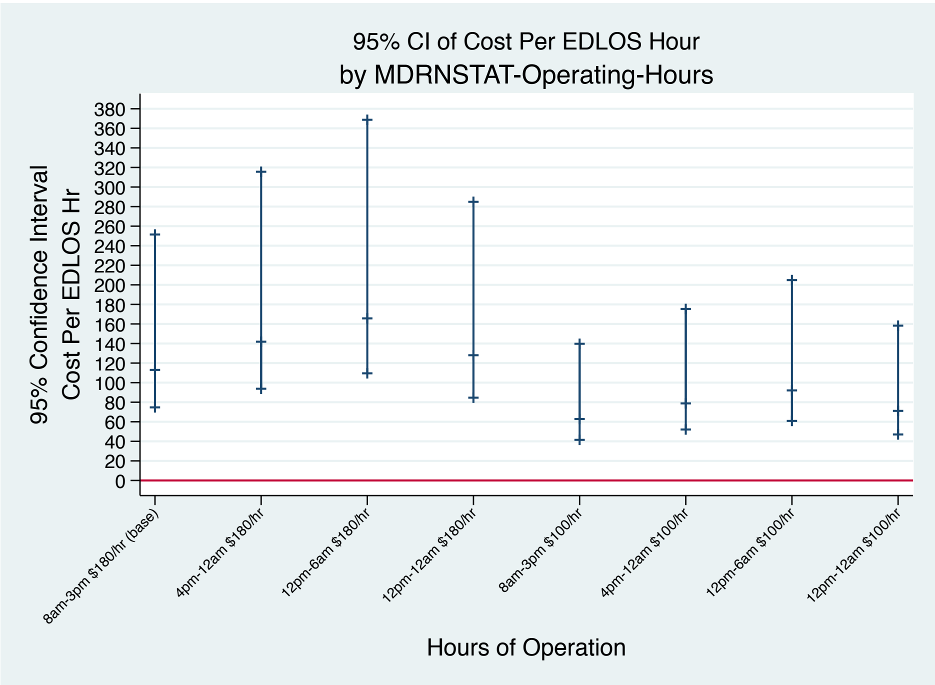


Figure 4-4 plots the 95% confidence interval of the cost per EDLOS-hour saved by MDRNSTAT operating hours of: 8am to 3pm (base), 4pm to 12am, 12pm to 6am the following day, and 12pm to midnight at salary rates of $180/hr and $100/hr

Table 4-7 provides the cost-effective analysis by hour of arrival. From 7pm to midnight the intervention was less than $510 per additional-patient seen. Between noon and 2am, the cost per PIA-hr saved was less than $100.00. For EDLOS, the cost per hour saved remained less than $120 for noon to 7pm and 11pm to 1am.

Hour of Arrival	Pts/ Hr	LWBS/ Hr	PIA Time Median (hrs)	CTAS23 EDLOS Median (hrs)	CTAS45 EDLOS Median (hrs)	Cost/ Pt Seen	Cost per PIA hr Saved	Cost per EDLOS hr Saved
0	3.5	0.36	2.1	5.5	4.1	$485.34 [$458.35-515.06]	$51.51 [$49.33-53.35]	$73.49 [$65.44-85.27]
1	2.5	0.28	2.1	5.7	3.5	$654.43 [$622.09-689.82]	$76.46 [$73.05-79.35]	$87.23 [$78.84-99.13]
2	2.0	0.17	2.2	5.3	3.7	$1194.92 [$1120.49-1279.06]	$86.89 [$83.29-89.93]	$141.54 [$123.56-169.38]
3	2.1	0.18	1.7	5.1	4.2	$1090.46 [$1023.61-1165.80]	$149.86 [$138.89-159.73]	$163.08 [$140.53-199.28]
4	1.7	0.17	1.7	5.2	4.9	$1161.08 [$1098.69-1230.35]	$171.61 [$159.78-182.16]	$167.05 [$145.79-199.95]
5	1.5	0.08	1.6	4.8	4.2	$3378.94 [$2983.80-3890.46]	$226.17 [$207.28-243.54]	$283.78 [$234.69-371.34]
6	1.9	0.05	2.1	5.2	3.7	$7579.95 [$5630.51-11542.37]	$90.89 [$86.99-94.19]	$153.76 [$133.90-184.42]
7	2.6	0.03	1.5	4.5	2.8	NS	$146.07 [$132.32-159.01]	$275.37 [$198.75-484.28]
8	4.4	0.06	0.9	3.7	1.9	NS	NS	NS
9	6.7	0.04	0.8	3.5	1.7	NS	NS	NS
10	7.7	0.07	0.9	3.9	1.8	NS	NS	NS
11	9.7	0.15	1.2	4.0	2.1	NS	$108.02 [$84.19-138.77]	NS
12	9.6	0.23	1.7	4.5	2.6	$2146.63 [$1387.99-4492.61]	$28.63 [$26.68-30.37]	$77.93 [$56.15-137.49]
13	8.1	0.30	2.0	4.6	2.7	$917.42 [$751.01-1165.32]	$23.67 [$22.53-24.65]	$73.88 [$57.15-109.78]
14	8.2	0.26	2.2	5.0	2.7	$1248.71 [$968.35-1729.64]	$20.17 [$19.32-20.89]	$47.66 [$39.87-60.90]
15	7.7	0.28	2.1	5.0	2.7	$1029.88 [$836.02-1325.59]	$23.60 [$22.51-24.52]	$46.71 [$39.59-58.43]
16	7.1	0.25	1.9	4.8	2.9	$1170.64 [$948.07-1513.86]	$30.88 [$29.21-32.34]	$71.75 [$57.99-97.58]
17	6.9	0.32	1.9	4.9	2.9	$758.94 [$653.47-898.97]	$30.98 [$29.34-32.39]	$63.45 [$52.20-83.61]
18	6.7	0.25	1.8	4.5	3.0	$1127.75 [$926.81-1426.97]	$34.09 [$32.15-35.79]	$110.13 [$80.52-187.23]
19	6.8	0.41	1.9	4.7	2.6	$500.19 [$447.70-563.89]	$31.13 [$29.42-32.51]	$79.78 [$62.63-114.99]
20	6.9	0.43	1.9	4.2	2.7	$453.16 [$407.34-508.15]	$31.68 [$29.99-33.14]	$557.57 [$494.44-616.60]
21	5.8	0.41	1.9	4.0	2.6	$473.23 [$431.32-522.38]	$37.03 [$35.08-38.70]	$735.83 [$644.80-822.97]
22	5.1	0.39	1.8	4.3	2.3	$476.77 [$439.77-519.27]	$53.29 [$48.89-56.28]	$958.25 [$810.83-1109.56]
23	4.0	0.36	1.8	5.2	2.8	$508.50 [$475.74-545.26]	$64.61 [$60.74-68.00]	$74.44 [$64.56-89.94]

Table 4-7 Cost-Effective Analysis by Hour of Arrival

Table 4-8 summarizes patient satisfaction. The MDRNSTAT subgroup decreased the time waiting to see a physician by 6102 hours and saved 996 hours of opportunity cost for 124 LWBS patients. Using the LWBS rate of 1.5% with a Canadian minimum wage of $23.02 as a surrogate for patient satisfaction, the CBR was 2.8 [2.3 to 4.6] (Figure 4-5).

	MDRNSTAT Cost	Satisfaction (MDRNSTAT vs. Control)			
		LWBS & PIA Hours Saved [95% CI]	Valuation per Hour	Total Valuation [95% CI]	NPV [95% CI]
8am-3pm (Base)	$459,900	7098 [4368-8779]	$23.02	$163,408 [$100,542-$202,095]	-$296,492 [-$257,805 to -$359.358]
			$45.83	$325,324 [$200,167-$402,346]	$-134,576 [-$57,544 to -$259,733]
4pm-midnight	$525,600	12,313 [10,136-13,514]	$23.02	$283,452 [$233,320-$311,095]	$-242,148 [-$214,505 to -$292,280]
			$45.83	$564,318 [$464,512-$619,352]	$38,718 [-$61,088 to $93,752]
Noon-6am (18hrs)	$1,182,600	27,662 [23,060-30,383]	$23.02	$636,784 [$530,847-$699,413]	-$545,816 [-$483,187 to -$651,753]
			$45.83	$1,267,759 [$1,056,852-$1,392,446]	$85,159 [-$125,748 to $209,846]
Noon-midnight	$788,400	26,196 [28,758-22,033]	$23.02	$603,040 [$507,205-$662,010]	-$185,360 [-$126,390 to -$281,195]
			$45.83	$1,200,578 [$1,317,980-$1,009,782]	$412,178 [$221,382 to $529,580]

Table 4-8 Patient Perspective – Satisfaction. Satisfaction analysis values time saved by seeing physician faster and decreasing left-without-being–seen rate. Base analysis is from 8am to 3pm.

Legend:
MDRNSTAT: Physician-Nurse Supplementary Team at Triage
LWBS: Left without Being Seen
PIA: Physician Initial Assessment
NPV: Net Present Value

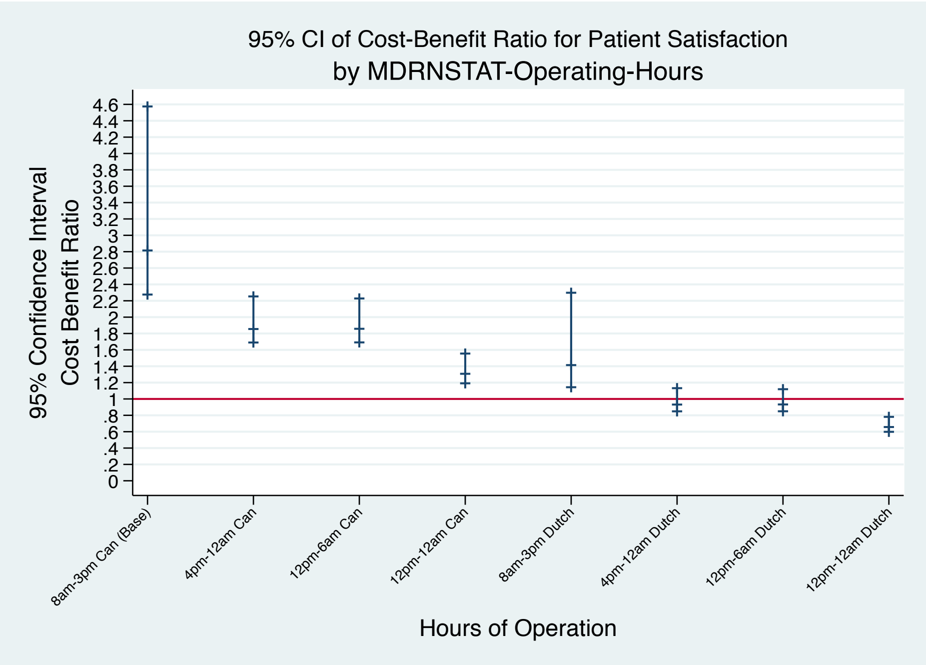


Figure 4-5 plots the 95% confidence interval of the cost-benefit ratio for patient satisfaction by MDRNSTAT operating hours of: 8am to 3pm (base), 4pm to 12am, 12pm to 6am the following day, and 12pm to midnight at salary rates fo $180/hr. Can-Canadian minimum wage ($23.02), Dutch-Dutch valuation of waiting time for treatment ($45.83)

The MDRNSTAT, and non-MDRNSTAT emergency physicians and nurses completed 162 and 551 surveys, respectively. Compliance was 99.7%. Staff agreed that the MDRNSTAT provided better patient quality of care, benefited patient flow and improved personal efficiency. Staff strongly agreed that the MDRNSTAT contributed to teamwork and collegiality.

4.5 COST-EFFECTIVENESS OF MDRNSTAT: SENSITIVITY ANALYSIS (II)

Study II results were extrapolated to three different time periods: 4pm to midnight, noon to 6am, noon to midnight. Each period had different LWBS rates and PIA times. During the 4pm to midnight shifts, the LWBS rate was 6.4%. Keeping the intervention LWBS rate at 1.5%, the cost per additional-patient-seen was $526.20 [$475.61-$586.63], $94.59/PIA-hour-saved [$85.34-$132.16], $141.81/EDLOS-hour-saved [$93.74 - $315.57] and the CBR was 6.5 [6.0-7.1]. The patient satisfaction CBR was 1.8 [1.7-2.2] (Figures 4-2 to 4-5).

From noon to 6am the following day (18 hours), Sunnybrook emergency department exceeded the ideal Pay-for-Performance PIA target of 3:48. LWBS rates progressively exceeded 2.4% by noon, and peaked at 13% by midnight, and dropped to 3.6% by 5am (Figure 3-2). Annual LWBS rate was 6.2%. Assuming that MDRNSTAT working from noon to 6am would achieve the Pay-for-Performance PIA target and decrease the annual LWBS rate to 1.5%, the intervention would cost $414.50 per additional-patient-seen [$371.47-466.22], $101.18/PIA-hour-saved [$91.28-$141.36] and $165.69/EDLOS-hour-saved [$109.52-$368.70]. Hospital CBR was 3.9 [3.7-4.1]. Patient satisfaction CBR was 1.9 [1.7-2.2] (Figures 4-2 to 4-5).

It was hypothesized that the MDRNSTAT working from noon to midnight could achieve the same outcomes as working from noon to 6am. If so, the intervention would cost $228.58 per additional-patient-seen [$201.21-$261.46], $74.55/PIA-hour-saved [$67.25-$103.81], and $129.39/EDLOS-hour-saved [$84.60-$284.82]. Hospital CBR was 2.6 [2.4-2.8]. Patient satisfaction CBR was 1.3 [1.2-1.6] (Figures 4-2 to 4-5).

From the hospital perspective, analyses were replicated with a salary of $100/hr. Sensitivity analysis for cost per additional patient seen, PIA hour saved, EDLOS-hour saved and CBR is summarized in figures 4-2 to 4-4. For patient satisfaction, the Dutch value treatment waiting-time at €30.10 per hour ($45.83Cdn)[125] resulting with a CBR<1 from 12pm to midnight. Sensitivity analysis is provided in Table 4-8 and Figure 4-5.

4.6 SUNNYBROOK HOSPITAL (2012-2013) AND AUSTIN HEALTH (2012) (III AND IV)

For Study III, there were 57,208 Sunnybrook emergency patient visits from January 1 to December 31, 2012. The median age was 53 with more female visits than male. Greater than 85% of patients was high acuity (CTAS one to three). The emergency department received 23% of patients by ambulance. About 5.5% of patients were "direct to service." These patients bypassed the emergency physician and were directly seen by specialty teams, such as trauma, stroke or an admitting service (oncology). Consultation and admission rates were 26.5% and 22.3%, respectively. However, only 21.9% went to the hospital ward because some admissions remained in the ED, improved and were eventually discharged. There were 11.5% discharged low acuity patients, 62.7% discharged high acuity patients. Computed tomography scans and troponins were ordered on 20.4% and 22.6% of patients, respectively. Sunnybrook hospital ward bed capacity for acute admissions decreased from 351 to 341 beds. The average hospital occupancy was 97.6%. There were 36 emergency department stretchers. The daily average occupancy level of emergency stretchers with admitted patients was 51.8% (Table 4-9).

For Study IV, Sunnybrook patient volume increased in 2013. The number of discharged high acuity patients increased and hospital admissions decreased. The proportion and number of patients who were initially admissions, but eventually discharged from the emergency department increased. Demographics, resource use and occupancies were similar for both years. Austin Health had 14,539 more visits than Sunnybrook in 2012. Patients were younger with lower acuity. There were more males, pediatrics, ambulance arrivals and higher consultation rate. Compared to Sunnybrook, Austin tripled the number of low acuity discharges, had 54% of high acuity discharges and 38% more admissions. The Austin re-directed 2.7% of emergency patients to the general practitioner clinic and had a higher left-without-being-seen rate. Austin and Sunnybrook LWBS population's median EDLOS was 1.5 hours [IQR: 0.5 – 2.8] and 3.0 hours [IQR: 1.6 – 4.5], respectively, with a 90^{th}%EDLOS of 4.2 and 6.0 hours, respectively. Austin's observation unit admitted 10.8% of the emergency patients. Sunnybrook did not have a general practitioner clinic or observation unit. Austin Health had doubled the number of Sunnybrook hospital beds for acute admissions and had lower hospital occupancy. The Austin's ward admission rate was higher. Sunnybrook had admissions discharged from the emergency department while waiting for a ward bed. Austin did not. X-ray ordering rates were similar. CT, ultrasound, MRI and troponin I rates were lower at the Austin (Table 4-9).

Less than 1% and 0.01% of Sunnybrook and Austin data points were missing, duplicated or discrepant, respectively.

Descriptor	Sunnybrook Canada 2012	Sunnybrook Canada 2013	Austin Health Australia 2012
Visits	57,208	58,109	71,747
Age	53 [IQR: 34 – 72]	54 [IQR: 35-72]	44 [IQR: 22-68]
Pediatric population (Age≤18yo)	5.7% (3,287)	5.5% (3,194)	21.0% (15,067)
Elderly population (Age≥65)	34.1% (19,492)	34.6% (20,091)	28.4% (20,351)
Female	54.8% (31,346)	55.0% (31,937)	48.4% (34,746)
Male	45.2% (25,852)	45.0% (26,172)	51.6% (37,000)
Acuity (CTAS or ATS)			
Highest Acuity (CTAS or ATS 1)	4.6% (2,620)	4.4% (2,552)	0.7% (475)
High Acuity (CTAS or ATS 1-3)	87.7% (50,183)	88.4% (51,371)	56.3% (40,380)
Low Acuity (CTAS or ATS 4-5)	12.3% (7,025)	11.6% (6,738)	43.7% (31,3667)
Direct to Consult Service (bypass ED Physician)	5.5% (3,168)	5.5% (3,198)	n/a
Arrive by Ambulance	23.0% (13,140)	22.9% (13,322)	29.2% (20,948)
All-Comers Consultation Rate	26.5% (15,169)	27.0% (15,708)	39.2% (28,128)
Consultations by Emergency Physician	26.1% (14,959)	26.7% (15,514)	39.2% (28,128)
Diagnostic Imaging			
Total Number of XR's ordered	31,341	32,220	
Total Number of Patients with XR	40.7% (23,294)	41.0% (23,810)	40.1% (28,761)
Total Number of CT's ordered	18,847	20,582	
Total Number of Patients with CT	20.4% (11,657)	21.4% (12,427)	12.5% (8,974)
Total Number of US ordered	5,848	6,001	
Total Number of Patients with US	7.2% (4,148)	7.4% (4,290)	2.8% (1,992)
Total Number of MRI ordered	471	510	
Total Number of Patients with MRI	0.8% (457)	0.8% (477)	0.2% (147)
Total Number of Nuclear Imaging ordered	59	51	
Total Number of Patients with Nuclear Imaging	0.1%(57)	0.1%(49)	
Total Number of Troponins	22.6% (12,949)	22.1% (12,869)	4.4% (3,185)
Discharges	73.8% (42,239)	75.0% (43,607)	56.0% (40,175)
All-Comers Admission Rate	22.3% (12757/57208)	22.1% (12,854/51371)	35.0% (25,100)
Admissions discharged from the ED	1.8% (224/12757)	3.9% (484/12370)	n/a
Admissions Short Stay Unit	n/a	n/a	10.8% (7,730)
Admissions Hospital	21.9% (12533/57208)	21.3% (12,370)	24.2% (17,370)
Directs Admission Rate	67.1% (2125/3168)	69.1% (2,209/3198)	n/a
Ambulance Arrival Admission Rate	47.4% (5941/13140)	44.5% (5934/13322)	60.3% (12,634/20984)
Deaths	0.2% (131)	0.2% (104)	0.1% (83)
Deaths who arrived by ambulance	93.9% (123/131)	94.2%(98/104)	95.2%(79/83)
Left Without Being Seen	3.6% (2,081)	3.5% (2,028)	6.3% (4,481)
Redirect to General Practitioner Clinic	n/a	n/a	2.7% (1,908)
Emergency Department Stretchers	36	36	32
Short Stay Unit Stretchers	0	0	8
% ED Stretcher Occupied by Admits per Day			
Average	51.8%	52.0%	n/a
Minimum	19.1%	21.2%	
Maximum	82.6%	88.8%	
Number of Hospital Beds			
Jan 1- Jan 16	351	341	714
Jan 16-April 29	349		
April 30-July 31	346		
Aug 1-Sept 7	344		
Sept 8-Sept 17	346		
Sept 18-Dec 31	341		
Hospital Occupancy			
Average	97.6%	96.8%	87.6%
Minimum	80.6%	80.1%	58.3%
Maximum	113.4%	109.7%	100%

Table 4-9 Emergency Patients from Sunnybrook Hospital (2012,2013) and Austin Health (2012) - Demographics, Acuity, Resource Consumption, Disposition

Legend:

CTAS: Canadian Triage Acuity Scale
ATS: Australasian Triage Scale
XR: X-ray
US: Ultrasound
CT: Computed Tomography
MRI: Magnetic Resonance Imaging
TOMX: Percentage ED Stretcher Occupied by Admits per Day

4.7 SUNNYBROOK HOSPITAL AND AUSTIN HEALTH: REACHING ONTARIO GOVERNMENT TARGETS (IV)

In 2012 and 2013, Sunnybrook failed the 2009 and 2012 Ontario government targets for physician initial assessment duration (PIAD) and EDLOS. For 2009 targets, only Austin Health's high acuity discharges were successful; however, it succeeded for all 2012 ideal targets except for low acuity discharges (Table 4-10).

	Sunnybrook 2012			**Sunnybrook 2013**			**Austin Health 2012**		
N	55224			56198			66163		
50%PIAD (hrs)	1.7			1.8			0.2		
90%PIAD* (hrs)	4.9			4.5			1.7		
% PIAD>2hrs	45.9%			44.6%			6.3%		
	Discharges		Admits	Discharges		Admits	Discharges		Admits
	Low Acuity	High Acuity		Low Acuity	High Acuity		Low Acuity	High Acuity	
N	6573	35890	12533	6291	37316	12370	20786	19389	17370
50%EDLOS (hrs)	2.6	4.8	11.6	2.8	4.8	11.2	2.5	3.5	6.4
90%EDLOS (hrs)*	5.4	9.7	26.9	5.6	12.3	26.7	5.6	6.7	13.3
%≤ (2009 Target)**	77.4%	82.4%	27.7%	76.4%	82.2%	29.0%	76.4%	94.3%	67.6%

Table 4-10 2012 and 2013 Sunnybrook Hospital and 2012 Austin Health: Reaching Ontario Government Ideal 2011 and 2012 Time Targets: Physician Initial Assessment Duration (PIAD) and Emergency Department Length-of-Stay (EDLOS)

*2012 Ideal Time targets:
90^{th}%PIAD≤3.6hrs
90^{th}%EDLOS: Discharged Low Acuity EDLOS≤4hrs, Discharged High Acuity EDLOS≤8hrs, Admissions≤25hrs

**2009 Ideal Time Targets:
90% of Discharged Low Acuity EDLOS≤4hrs, Discharged High Acuity ≤8hrs, Admissions≤8hrs

4.8 FACTORS PREDICTING FAILURE OF ONTARIO GOVERNMENT TARGETS (III AND IV)

4.8.1 High Acuity Discharges (III and IV)

For 2012 Sunnybrook discharged high acuity patients (III), the factors most associated with predicting of failing to meet the eight-hour time target were having a physician initial assessment duration greater than two hours (PIAD>2hrs), or undergoing one of the following in the ED: a MRI, consultation, CT scan and ultrasound. Factors less strongly associated with failing to meet the eight-hour target included arrival by ambulance, being direct-to-service, being seen on an evening shift, nightshift, receiving an x-ray, troponin I, increasing daily volume, increasing age, and increasing emergency department stretcher occupancy with admissions. For 2013, factors and rankings were similar. Compared to Sunnybrook, Austin factors (IV) were similar except for evening shift, but rankings and odds ratios were different (Table 4-11).

	Sunnybrook 2012 Discharged High Acuity (n=35890)	**Sunnybrook 2013 Discharged High Acuity (n=37272)**	**Austin Health 2012 Discharged High Acuity (n=19389)**
Variable	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**
Magnetic Resonance Imaging (Yes vs. No)	19.33 [12.94-28.87]	11.63 [7.69-17.59]	8.16 [3.07-21.70]
Consultation (Yes vs. No)	10.23 [9.38-11.14]	10.78 [9.94-11.70]	8.82 [7.62-10.21]
PIA>2hrs (Yes vs. No)	5.63 [5.22-6.06]	4.28 [3.98-4.61]	3.89 [3.13-4.85]
Computed Tomography (Yes vs. No)	4.24 [3.92-4.59]	4.88 [4.52-5.28]	3.01 [2.52-3.59]
Ultrasound (Yes vs. No)	3.47 [3.13-3.83]	3.33 [3.00-3.70]	3.87 [2.77-5.42]
Shift: Day	Reference	Reference	Reference
Evening	1.23 [1.14-1.32]	1.31 [1.22-1.41]	4.09 [3.40-4.93]
Night	2.15 [1.96-2.35]	2.59 [2.37-2.84]	3.44 [2.62-4.51]
X-Ray (Yes vs. No)	1.70 [1.58-1.82]	1.81 [1.69-1.93]	1.64 [1.42-1.88]
Troponin (Yes vs. No)	1.66 [1.54-1.79]	1.56 [1.45-1.68]	NS
Ambulance Arrival vs. Non-Ambulance Arrival	1.58 [1.45-1.72]	1.82 [1.68-1.98]	1.53 [1.32-1.78]
Direct vs Nondirect	1.38 [1.11-1.72]	1.43 [1.15-1.79]	n/a
Male vs Female	1.01 [1.01-1.01]	0.91 [0.85-0.97]	0.79 [0.69-0.91]
Patient Arrival per Hour (per patient)	NS	-	0.97 [0.95-0.99]
TOMX (% ED Stretchers Occupied by Admissions)	1.01 [1.00-1.01]	1.02 [1.01-1.02]	n/a
Age (Year)	1.01 [1.01-1.01]	1.01 [1.01-1.01]	NS
Weekday vs Weekend	NS	NS	NS
Daily Volume (per patient)	1.01 [1.01-1.01]	1.01 [1.01-1.01]	
Hospital Occupancy (Percent)	NS	-	

Table 4-11 Emergency Patients from Sunnybrook Hospital (2012,2013) and Austin Health (2012) - Multivariate Analysis: Odds Ratios of Reaching EDLOS Targets for Discharged High Acuity Patients: PIA – Emergency Physician Initial Assessment Time, TOMX- Percentage ED Stretcher Occupied by Admits per Day

The crude odds ratio for Austin's high acuity discharges reaching targets over Sunnybrook was 3.52 [3.30-3.77].

Table 4-12 outlines the stepwise effect of PIAD>2hrs, CT scan and consultation on EDLOS. If all three factors were absent, government target (90^{th}%EDLOS≤8hrs) was reached irrespective of hospital. Irrespective of year, adding one of the top three factors would fail targets at Sunnybrook. Austin required at least two of these factors. The volume of patients having one factor was greater at Sunnybrook. For both hospitals, less than three percent of high acuity discharges had all three factors. For this subgroup, the 2012 and 2013 Sunnybrook 90^{th}%EDLOS exceeded 20 hours and 2012 Austin exceeded 12 hours.

	Sunnybrook 2012 Discharged High Acuity (n=35890)	**Sunnybrook 2013 Discharged High Acuity (n=37272)**	**Austin Health 2012 Discharged High Acuity (n=19389)**
	Number (% of Total) EDLOS (mean +/- SD) 90^{th} % EDLOS		
All comers	35890 (100%) 5.5 +/- 4.0 hrs 9.7 hrs	37315 (100%) 5.7 +/- 4.4 hrs 9.9 hrs	19389 (100%) 3.9 +/- 2.4 hrs 6.9 hrs
No Consultation No Computed Tomography No Magnetic Resonance Imaging PIA<=2hrs	13959 (38.9%) 3.3+/- 2.1 hrs 6.0 hrs	14043 (37.6%) 3.4 +/- 2.1 hrs 6.0 hrs	14775 (76.2%) 3.3+/- 1.9 hrs 5.6 hrs
No Consultation No Computed Tomography PIA<=2hrs	14016 (39.1%) 3.4 +/- 2.1 hrs 6.0 hrs	14101 (37.8%) 3.4 +/- 2.1 hrs 6.1 hrs	14793 (76.3%) 3.3 +/- 1.9 hrs 5.6 hrs
No Consultation No Computed Tomography PIA>=2hrs	12804 (35.7%) 5.9 +/- 2.6 hrs 9.2 hrs	13058 (35.0%) 5.7 +/- 2.4 hrs 8.7 hrs	767 (4.0%) 5.5 +/- 1.8 hrs 7.8 hrs
No Consultation Computed Tomography PIA<=2hrs	2328 (6.5%) 5.9 +/- 2.5 hrs 9.0 hrs	2525 (6.8%) 6.1 +/- 2.9hrs 9.3 hrs	1309 (6.8%) 5.3 +/- 2.1 hrs 7.8 hrs
No Consultation Computed Tomography PIA>=2hrs	2375 (6.6%) 8.4 +/- 3.0 hrs 12.2 hrs	2448 (6.6%) 8.5 +/- 3.2hrs 12.5 hrs	57 (0.3%) 7.6 +/- 1.8 hrs 9.7 hrs
Consultation No Computed Tomography PIA<=2hrs	1779 (5.0%) 7.5 +/- 6.5 hrs 12.5 hrs	1996 (5.3%) 8.1 +/- 7.2 hrs 14.0 hrs	1833 (9.5%) 5.9 +/- 3.3 hrs 10.3 hrs
Consultation No Computed Tomography PIA>2hrs	1296 (3.6%) 10.4 +/- 6.6 hrs 17.1 hrs	1514 (4.1%) 11.2 +/- 8.7 hrs 18.4 hrs	115 (0.6%) 8.3 +/- 3.4 hrs 12.8 hrs
Consultation CT PIA<=2hrs	727 (2.0%) 10.5 +/- 9.2 hrs 16.4 hrs	876 (2.3%) 10.2 +/- 6.9 hrs 16.8 hrs	476 (2.5%) 7.0 +/- 3.2 hrs 11.4 hrs
Consultation Computed Tomography PIA>2hrs	565 (1.6%) 13.9 +/- 6.0 hrs 21.7 hrs	754 (2.0%) 14.0 +/- 7.9 hrs 22.0 hrs	39 (0.2%) 9.2 +/- 2.8 hrs 12.8 hrs
Consultation Computed Tomography Magnetic Resonance Imaging PIA>2hrs	25 (0.1%) 18.4 +/- 8.6 hrs 33.0 hrs	33 (0.1%) 16.3 +/- 6.4 hrs 25.7 hrs	0 (0%) - -

Table 4-12 Emergency Patients from Sunnybrook Hospital (2012, 2013) and Austin Health (2012) - Effect of High Odds-Ratio on Mean and 90th%EDLOS for Discharged High Acuity Emergency Department Patients (CTAS1-3)

Legend:
CTAS: Canadian Triage Acuity Score
PIA: Emergency Physician Initial Assessment Time

4.8.2 Admissions (III and IV)

For 2012 Sunnybrook admissions, factors most associated with failure of meeting the eight hour time target were bed request duration greater than six hours and access block greater than one hour. Other variables with lower odds ratios were arriving by ambulance, being seen on a nightshift, PIAD>2hrs, receiving a troponin I, x-ray, CT scan, consultation, increasing hospital occupancy, increasing emergency department stretcher occupancy with admissions and increasing age. For 2013, the Sunnybrook factor rankings were similar but odds ratios were not exactly the same. Austin factors were similar (Table 4-13). The crude odds ratio for the Austin's admissions reaching targets over Sunnybrook was 7.76 [7.39-8.14].

	Sunnybrook 2012 Ward Admissions (n=12509)*	**Sunnybrook 2012 ICU Admissions (n=752)**	**Sunnybrook 2013 Ward Admissions (n=12337)***	**Austin Health 2012 Ward Admissions (n=16901)***
Variable	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**	**OR EDLOS>8hrs vs EDLOS ≤8hrs [95% CI]**	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**	**OR EDLOS>8hrs vs EDLOS≤8hrs [95% CI]**
Bed Request Duration > 6hrs	45.30 [37.75-54.36]	364.27 [43.20-3071.30]	44.43 [37.22-53.04]	46.07 [33.23-63.88]
Access Block Duration > 1hr	22.39 [18.67-26.87]	217.27 [30.62-1541.63]	16.81 [14.20-19.91]	57.35 [39.31-83.67]
Shift: Day	Reference	NS	Reference	Reference
Evening	NS	NS	NS	4.28 [3.93-4.65]
Night	1.97 [1.64-2.36]	1.88 [1.03-3.44]	1.69 [1.35-2.12]	2.93 [2.62-3.29]
Computed Tomography (Yes vs. No)	1.61 [1.42-1.82]	NS	1.35 [1.19-1.52]	1.99 [1.82-2.16]
Consultation (Yes vs. No)	1.88 [1.63-2.18]	NS	1.80 [1.56-2.08]	Collinear
PIA>2hrs (Yes vs. No)	1.42 [1.23-1.63]	NS	1.52 [1.32-1.72]	4.24 [3.50-5.13]
Troponin (Yes vs. No)	1.30 [1.13-1.48]	NS	1.56 [1.38-1.76]	1.62 [1.40-1.86]
X-Ray (Yes vs. No)	1.17 [1.03-1.32]	0.63 [0.40-0.98]	1.26 [1.11-1.42]	1.49 [1.37-1.62]
Hospital Occupancy (Percent)	1.04 [1.03-1.06]	NS	1.04 [1.02-1.06]	1.04 [1.03-1.05]
TOMX (% ED Stretchers Occupied by Admissions)	1.01 [1.01-1.02]	1.02 [1.01-1.04]	1.02 [1.01-1.02]	n/a
Age (Year)	1.00 [1.00-1.01]	NS	NS	1.01 [1.00-1.01]
Ultrasound (Yes vs. No)	NS	NS	NS	1.91 [1.63-2.24]
Magnetic Resonance Imaging (Yes vs. No)	NS	NS	NS	1.78 [1.11-2.86]
Ambulance Arrival vs. Non-Ambulance Arrival	1.16 [1.02-1.32]	NS	1.22 [1.08-1.38]	1.11 [1.02-1.21]
Direct vs Nondirect	NS	NS	NS	n/a
Male vs Female	NS	NS	0.83 [0.74-0.93]	0.91 [0.84-0.98]
Patient Arrival per Hour (per patient)	NS	1.02 [1.00-1.03]	0.98 [0.96-1.00]	NS
Weekday vs Weekend	NS	NS	NS	0.50 [0.42-0.59]
Daily Volume (per patient)	NS	NS	1.00 [1.00-1.01]	1.00 [1.00-1.01]
CTAS 1	NS	0.47 [0.30-0.74]	NS	0.36 [0.26-0.50]

Table 4-13 Emergency Patients from Sunnybrook Hospital (2012, 2013) and Austin Health (2012) - Multivariate Analysis: Odds Ratios of Reaching EDLOS Time Targets for Ward Admissions: PIA – Emergency Physician Initial Assessment Time, TOMX- Percentage ED Stretcher Occupied by Admits per Day

*Dayshift Reference omitted – so sample size is smaller than admission volume

4.8.3 2012 Sunnybrook ICU Admissions (III)

Factors most associated with failure of meeting the eight-hour time target were bed request duration greater than six hours and access block greater than one hour. Factors weakly associated with failure were being seen on a nightshift, patient arrival per hour and percentage emergency stretchers occupied by admissions per day. Having an acuity score of one and having an x-ray were variables predicting target achievement (Table 4-13).

The 90th% EDLOS for Sunnybrook ICU admissions was 28.8 hours, exceeding the MOHLTC target of 25 hours. There were three different possibilities to be admitted to the ICU: 1) zero-consult, 2) one-consult, or 3) two-consult. The zero consult ICU admission was from the "direct" population: Because Sunnybrook is a regional trauma and stroke center, teams led by trauma leaders or neurologists "directly" see these critically ill patients in the ED and admit them to ICU with no consultation through the ED. The one-consult ICU admission is referred to the ICU after being assessed by the emergency physician, seen by the ICU service in the ED and possibly accepted for admission. For the two-consult ICU admission, the emergency physician initially refers to a non-ICU service. The consult occurs in the ED. The service decides the patient is too ill for a ward bed and referred to ICU. The second ICU consult occurs in the ED and usually accepted for admission. Zero, single and two-consultation was 20.0%, 38.4% and 41.6% of ICU admissions, respectively.

Irrespective of the number of consultations, ICU admissions reached MOHLTC targets if bed request duration ≤ six hours, physician initial assessment duration ≤ two hours and access block ≤ one hour. Less than 12% of ICU admissions fulfilled the criteria and had a 90th%EDLOS of 5.8 hours. Eleven percent of ICU admissions had all three factors with a 90th%EDLOS of 37.9 hours. For the two-consultation subgroup, the 90th%EDLOS increased to 41.5 hours (Table 4-14).

ICU Admissions	Number (%)				PIAD (mean +/- SD) (hrs)				90th % PIAD (hrs)			
	No Cons	One Cons	Two Cons	All	No Cons	One Cons	Two Cons	All	No Cons	One Cons	Two Cons	All
% CTAS1	88.4%	55.3%	38.5%	50.9%	-	-	-	-	-	-	-	-
% PIAD> 2hr	12.8%	10.3%	25.6%	16.8%	-	-	-	-	-	-	-	-
	147	282	305	743	0.8 +/-1 .0	0.8 +/-1 .0	1.5 +/-1.7	1.1 +/-1.4	2.2	1.9	3.6	2.7
	Number (%)				EDLOS (mean +/- SD) (hrs)				90th % EDLOS (hrs)			
PIA < 2 hrs BRD < 6 hrs AB < 1hr	16 10.9%	52 18.4%	19 6.2%	88 11.8%	2.8 +/- 1.5	3.2 +/- 1.5	3.6 +/- 1.4	3.2 +/- 1.5	5.1	5.8	5.8	5.8
PIA < 2hrs BRD < 6hrs AB > 1hr	97 66.0%	150 53.2%	90 29.5%	342 46.0%	13.0 +/- 8.0	10.2 +/- 6.6	14.1 +/- 10.3	12.0 +/- 8.3	24.9	19.6	26.9	23.0
PIA <2hrs BRD> 6hrs AB > 1hr	14 9.5%	48 17.0%	106 34.8%	169 22.7%	18.7 +/- 7.9	20.0 +/- 12.3	21.8 +/- 11.5	21.0 +/- 11.5	28.8	35.7	33.6	33.4
PIA > 2hrs BRD < 6 hrs AB > 1hr	17 11.6%	3 1.1%	5 1.6%	27 3.6%	14.8 +/- 10.5	11.2 +/- 9.3	17.7 +/- 11.8	13.0 +/- 9.3	31.3	23.6	32.0	30.8
PIA > 2hrs BRD >6 hrs AB > 1hr	0 0%	20 7.1%	62 20.3%	82 11.0%	-	19.9 +/- 9.8	23.8 +/- 11.7	22.9 +/- 11.4	-	33.9	41.5	37.9
All	147	282	305	743	12.5 +/- 8.7	11.2 +/- 9.3	17.7 +/- 11.8	14.1 +/- 10.7	25.3	23.6	32.0	28.8

Table 4-14 Effect of High Odds-Ratio Factors on Mean adn 90th%EDLOS for ICU-Admitted Sunnybrook Emergency Department Patients in 2012: PIAD – Emergency Physician Initial Assessment, BRD – Bed Request Duration, AB – Access to Ward Bed, Cons – Consult

No Consult – Directs to ICU ex. Trauma
One Consult – Through Emergency Physician to ICU
Two Consult – Through Emergency Physician to Non-ICU Service and re-Consulted to ICU
All – All ICU Admissions

4.8.4 Discharged Low Acuity Patients (III and IV)

The 2012 Sunnybrook factors most strongly associated with failing the four-hour time target for discharged low acuity patients were PIAD>2hrs, receiving a consultation, MRI, CT scan, troponin I or ultrasound. Other factors with lower odds ratios included night shift, ambulance arrival, receiving an x-ray, additional patient arrival per hour, increasing emergency stretcher occupancy with admitted patients, increasing patient age and weekends. In 2013, Sunnybrook factors and rankings were similar but odds ratios were not the same. Receiving a MRI was not significant. Austin factors were similar but with different rankings and odds ratios (Table 4-15). The crude odds ratio for the Austin's low acuity discharges reaching targets over Sunnybrook was not significant 0.95 [0.89-1.01].

	Sunnybrook 2012 Discharged Low Acuity (n=6573)	**Sunnybrook 2013 Discharged Low Acuity (n=6270)**	**Austin Health 2012 Discharged Low Acuity (n=20786)**
	Odds Ratios (OR)		
Variable	**OR EDLOS>4hrs vs EDLOS≤4hrs [95% CI]**	**OR EDLOS>4hrs vs EDLOS≤4hrs [95% CI]**	**OR EDLOS>4hrs vs EDLOS≤4hrs [95% CI]**
Magnetic Resonance Imaging (Yes vs. No)	31.68 [6.03-166.54]	NS	4.71 [2.22-10.00]
Consultation (Yes vs. No)	20.98 [14.10-31.22]	22.43 [14.75-34.10]	6.99 [5.83-8.38]
Computed Tomography (Yes vs. No)	16.48 [10.07-26.98]	17.35 [10.93-27.54]	7.16 [5.92-8.66]
PIA>2hrs (Yes vs. No)	15.80 [13.35-18.71]	11.68 [9.98-13.68]	11.62 [10.40-12.99]
Troponin (Yes vs. No)	13.37 [6.30-28.37]	5.94 [3.18-11.10]	2.93 [1.98-4.34]
Ultrasound (Yes vs. No)	7.61 [5.25-11.04]	6.51 [4.33-9.79]	4.51 [3.55-5.74]
Shift: Day	Reference	Reference	Reference
Evening	NS	NS	1.61 [1.48-1.75]
Night	2.83 [2.13-3.77]	2.51 [1.87-3.36]	2.39 [2.08-2.75]
Ambulance Arrival vs. Non-Ambulance Arrival	2.04 [1.51-2.77]	2.71 [1.95-3.76]	1.99 [1.78-2.22]
Male vs Female	NS	NS	0.80 [0.74-0.86]
X-Ray (Yes vs. No)	1.89 [1.62-2.20]	2.03 [1.75-2.36]	1.79 [1.65-1.94]
Patient Arrival per Hour (per patient)	1.03 [1.00-1.06]	1.03 [1.01-1.06]	1.02 [1.00-1.03]
TOMX (% ED Stretchers Occupied by Admissions)	1.01 [1.01-1.02]	1.01 [1.01-1.02]	n/a
Age (Year)	1.01 [1.01-1.01]	1.01 [1.00-1.01]	1.01 [1.01-1.01]
Direct vs Nondirect	NS	NS	n/a
Weekday vs Weekend	0.83 [0.71-0.99]	0.71 [0.60-0.84]	NS
Daily Volume (per patient)	NS	1.01 [1.01-1.02]	NS
Hospital Occupancy (Percent)	NS	NS	1.02 [1.01-1.02]

Table 4-15 Emergency Patients from Sunnybrook Hospital (2012, 2013) and Austin Health (2012) - Multivariate Analysis: Odds Ratios of Reaching EDLOS Time Targets for Discharged Low Acuity Patients: PIA – Emergency Physician Initial Assessment Time, TOMX- Percentage ED Stretcher Occupied by Admits per Day

5 DISCUSSION

Chapter 5 summarizes the main conclusions of the four studies. The process and findings provide potential approaches to prolonged EDLOS. More questions and future directions on provision of evidence-informed efficiency emergency medical care are presented.

Emergency department crowding is one of the most relevant international public health issues today. It is a quality improvement problem requiring multiple stakeholder involvement. Crowding is a significant cause of increased patient morbidity, mortality, patient dissatisfaction and health care spending. There are many potential solutions, but which ones are most effective? Which solutions give the most value for Sunnybrook? Austin Health? Can government targets be reached with general interventions, or should they be individualized?

Because of the complexities, unknowns and resource allocation practicalities in health care, the quality improvement community declared the need for increased scientific rigor and funding for its research more than a decade ago[131–133]. The increasing demands for health care and limited resources have necessitated quality improvement initiatives and subsequent evaluations to be evidence-informed[132, 134].

Study I used the research gold standard, a cluster, randomized control trial. The MDRNSTAT significantly reduced EDLOS for non-consulted, discharged patients: 53% of the trial population. The team significantly reduced physician initial assessment time, decision-making time and decreased patient delays by ordering investigations (laboratory, diagnostic imaging) and management (consultations) sooner. Since wait times to disposition were reduced, the left-without-being seen rates declined and patient throughput increased. Harm was not detected for patients discharged by the MDRNSTAT at triage. There was high satisfaction with the team amongst the staff.

However, the limitation of the MDRNSTAT was its inability to address hospital-controlled bottlenecks[135]. Since patients' EDLOS relied largely on factors external to the ED (i.e. consultations, access block) the gains with shortened physician initial assessment and request times were negated by the time required to complete these requests by non-ED hospital staff. The MDRNSTAT did not benefit EDLOS for admissions or consulted discharged patients. This was the sicker proportion of the ED population. Other limitations of this single-center study was its generalizability, limited hours of operation (weekdays, 8:00-14:30), potential measurement bias and inability to ascertain if the benefit was from extra staffing as opposed to having the team being placed at triage. To address these limitations, a multi-center randomized cluster control trial, with expanded hours of operation and comparison with an additional physician-nurse team in the ED would be recommended. Additionally, the study only examined Sunnybrook's database for harm. Patients returning to a different hospital, or dying outside of Sunnybrook would have been missed. With these findings, the MDRNSTAT could not yet be recommended.

Since the MDRNSTAT decreased EDLOS for only half the study population, the next step was to determine if the MDRNSTAT was cost-effective (Study II). At $180/hr, the hospital could spend $500,000 or $1 million per year depending if the team worked 7 or 18 hours per day, respectively. The team was least cost-effective from 8am to 3pm and most cost-effective working 12pm to midnight. However, this 12-hour time period would cost the hospital almost $800,000/yr. Could the hospital spend this money more effectively on other factors to improve EDLOS? Waiting to see a physician greater than two hours is a factor associated with failing government targets for low and high acuity discharges, however, access block and cross-sectional imaging are more influential. Decreasing access block benefits admissions, whereas the MDRNSTAT benefits the non-consulted, less sick, discharges. The additional concern was the MDRNSTAT "compensat(ing)[sic] for deficiencies in the larger organization by subordinating its own needs and priorities[136]." Consequently, prioritizing funding efforts to more influential factors, such as access block, would be more cost-efficient for Sunnybrook. However, for hospitals with low admission rates, an observation unit, lower physician salaries, acuity and rates of cross-sectional imaging, the physician-triage model could be feasible.

A limitation of this study was EDLOS being an intermediate outcome. EDLOS is the most pragmatic quality metric for emergency care; however, it is not ideal for economic analyses. Health economists prefer cost-utility rather than cost-effectiveness analyses. EDLOS does not perfectly measure patient or staff satisfaction, morbidity or mortality[137]. For economic analyses, the cost-utility outcome is Quality Adjusted Life Years or utility measures, such as willingness-to-pay or patient satisfaction. However, mortality is a rare outcome in the emergency department population, so the practicality of using Quality Adjusted Life Years is limited. Currently, there are no standardized measurements of emergency patient satisfaction. For the sensitivity analysis, the assumption that the MDRNSTAT working from noon to midnight would achieve an annual 1.5% LWBS rate could be questioned. However, the high LWBS rates from midnight to 6 am were likely from the noon to midnight patient volume backlog being cleared after midnight. If the MDRNSTAT efficiently managed patient flow from noon to midnight, backlog would be eliminated and the 1.5% LWBS rate would be preserved. To verify this, the study could be repeated with the MDRNSTAT working noon to midnight. Sunnybrook's funding model, a government-run public insurance plan with unique funding models, may not be generalizable to other hospitals. However, any hospital using a case-mix, volume-based, fee-for-service, or pay-for-performance funding schemes may find this analysis useful. A multicenter study, with different funding models and a MDRNSTAT working during the hours of high patient flow, could be performed. Despite these limitations, this is the first study to investigate the cost-effectiveness of the MDRNSTAT.

At this point, the research changed direction: to provide better understanding of why Sunnybrook failed government targets and why the Austin performed better - an essential first step for quality improvement[132].

Study III determined factors associated with failing Ontario government EDLOS targets at Sunnybrook. For discharges, including high acuity, factors strongly associated with failing to meet ED LOS targets were potentially modifiable at the physician/hospital-level: the use of advanced diagnostic imaging (CT, MRI, US), TnI, waiting to see an emergency physician more than 2 hours, and requesting consultations. For admissions, including ICU, factors were also hospital-controlled: bed request and access block duration.

The ability of any single hospital to mitigate these factors will vary[138]. Because Sunnybrook is a regional trauma, stroke, neurosurgical and oncology center with an elderly patient population, more hospital resources are required to care of its complex, high acuity ED population and high admission rate, more than three times the average for Ontario[139].

These findings are concordant with a small, retrospective chart review in 1999[140] and a comprehensive 2006-8 study of the American National Hospital Ambulatory Medical Survey by Kocher et al[50]. However, the American study had limited generalizability to individual hospitals because of institutional differences, such as patient case-mix and policy. Consequently, Kocher recommended that each hospital examine its patient population to determine bottlenecks for quality improvement. With Study III, multiple factors outlined in the literature[50, 53, 88, 140–142] have been incorporated and applied to Sunnybrook.

With this evidence, the limitations of the MDRNSTAT were realized and crowding solutions can be tailored to Sunnybrook's population. For example, CT and US imaging volume can be decreased by best-practice guidelines or team approach[143–145]. Eliminating oral contrast speeds up abdominal CT scans and shortens EDLOS[86]. Consultation processes and EDLOS can be shortened by a computer management system[89], dedicated emergency consultation teams[145, 146] or communicating daily performance metrics[48]. Physician-triage can shorten PIAD and EDLOS for non-consulted discharges[74, 90, 147]. In some settings, point of care TnI or stat laboratory can shorten EDLOS[87, 148–151]. Access block can be reduced by early hospital discharges[152], streaming[77], full capacity protocols[153, 154] and medical assessment units[155].

The largest contributing factor for Sunnybrook ICU and all admissions was access block[2, 12, 14, 39, 45, 53–58]. In 2012, hospital bed capacity for acute admissions decreased by ten beds with average hospital occupancy of 97.6%. Sunnybrook ICU had 58 beds with almost 100% occupancy. More than 50% of Sunnybrook's 36 emergency stretchers were occupied by admissions. The unintended consequence is multiple management pathways for admissions, including the critically ill. The associated prolonged EDLOS results in higher mortality, longer inpatient length of stay and higher cost[156, 157]. Consequently, solutions for admissions to reach government targets include examining and balancing the supply-demand for hospital beds and resources by collaborating with other units (ex. ICU transition beds), other hospitals (ex. ICU transfers), the government (ex. value based funding) and delivering best practice (appropriate investigations and disposition) with appropriate cost awareness.

Study III's strength was its large sample size with few missing data points. There were limitations. Data entry into the administrative databases is by the health care workers (physicians, nurses, trainees) and administrative staff. User error, such as entering wrong time values, could compromise database accuracy. A solution is to use radiofrequency identification technology, where time stamps are automatically collected during the patient's physician encounter, departure or admission. It was a deliberate choice to focus on a Sunnybrook such that a model for tailored solutions to crowding at one site could be determined. The consequence was, by design, limited generalizability. The model did not include all factors that could affect EDLOS, such as medical student supervision[158] or staffing. Finally, we did not include variables such as elective surgery[159] or family physician access[160] given that these were not modifiable by ED operations.

In Study IV, Austin Health was successful on reaching Ontario targets for PIAD, EDLOS for high acuity discharges and admissions, but not low acuity discharges. Sunnybrook failed all targets. Austin's overall population was different from Sunnybrook. Austin patients were younger with lower acuity. Austin's higher admission rate suggests that patients admitted to hospital would, at Sunnybrook, have their investigation and management completed in the emergency department and subsequently discharged.

Austin's short PIAD and shorter EDLOS for high acuity discharges could be explained by physician-triage[161], the licensed junior doctor workforce (Australian trainees), lower high acuity volume and faster turnover in the emergency department. Australian trainees are more numerous because training programs are by individual hospitals (and overseen by specialty colleges), whereas, Canadian programs are by university or city. Additionally, Australian trainees are licensed, whereas Canadian trainees are not. Because the ratio of licensed physicians per patient is higher at the Austin, there are more independent physicians who can assess, manage and discharge than Sunnybrook. Because Austin patients are younger with lower complexity, they have less time-consuming tests. This results in a shorter EDLOS[127]. Additionally, there is an observation unit where government thresholds do not apply. More complex patients requiring time–consuming diagnostics or short-term management can be placed here before anticipated discharge. This not only explains Austin's achievement of government targets for high acuity discharges, but also contributes to faster ED care space turnover and shortened PIAD. Austin's left-without-being-seen rate almost doubled that of Sunnybrook's; however, their median EDLOS was short and half of Sunnybrook. Austin's patients left under two hours – suggesting that there were other healthcare options or lower tolerance for waiting.

Despite a higher hospital admission rate, the Austin was able to halve the EDLOS of Sunnybrook admissions. Compared to Sunnybrook, the Austin could have reached targets by shortening bed request duration and access block: At Sunnybrook, bed requests occur after the consulting service sees the patient in the ED and accepts the patient for admission. Admission orders are written in the ED before the patient can enter the ward. In contrast, Austin's bed requests are made by the emergency physician/trainee[109]. It is not necessary to have the consulting service see the patient in the ED as Austin admissions are usually accepted through telephone consultation. Admission orders can be completed on the ward. The number hospital beds could explain Austin's lower access block. The Austin has twice the number of Sunnybrook's acute hospital beds, lower hospital occupancy and private hospital access. High hospital occupancy and access block are the reasons why Sunnybrook admissions are being discharged from the emergency department. It is unlikely that Sunnybrook can obtain more beds, an observation unit, more diagnostic resources or access to private hospitals. The financial infrastructure for Victorian observation units[1] does not exist in Ontario. Sunnybrook may need to consider innovative outpatient solutions to manage patient demand for hospital resources.

The Austin ordered fewer advanced imaging and troponin I tests than Sunnybrook. However, volumes may be underestimated because these tests could have been done through the observation unit or admission. Austin's pediatric population would require less CT's and troponins. Because the Mercy Hospital, specializing in women's health, shares the same building as the Austin and has its own ED, a higher proportion of males would attend the Austin. Obstetrical and gynecological ultrasound requests would likely be lower. The Austin is not a regional trauma center where multiple CT's are often required for trauma patient management. For troponin I testing, volume could have been underestimated because the Austin had an ED point-of-care machine. Its troponin I results were not recorded into the administrative database.

In 2011, Australia introduced its National Emergency Access Target (NEAT) [41] where 90% of all triage categories were to achieve an EDLOS ≤ four hours[162]. Since its introduction, some Australian hospitals have introduced a streaming model[77] with a senior physician at triage organizing patients into pathways, such as admission, discharge, observation unit or further diagnostics in the main department. This model has been associated with shortened EDLOS and increased admissions[77]. The pursuit of NEAT has resulted in some unintended inpatient consequences: referrals with presumed diagnoses[106], increased inter-unit transfers, prolonged LOS[163] and younger inpatient population[162] with very short admissions and low mortality. If Sunnybrook operations were to adopt this model, it would have to examine if it has similar financial, manpower and infrastructure as Australian hospitals and consider if the unintended inpatient consequences were acceptable.

Between 2012 and 2013 at Sunnybrook, the demographics and factors affecting EDLOS in the high and low acuity discharges and admissions were generally unchanged in ranking and minimally changed with respect to regression coefficients and odds ratios. Therefore, predictive analytics has potential to guide implementation strategy to shorten EDLOS at Sunnybrook.

For Sunnybrook and the Austin, the most influential factors affecting discharged EDLOS were hospital controlled: diagnostics (advancing imaging or TnI), and manpower (consultation by specialty services or physician initial assessment time). Improved staffing matching patient demand could be a potential solution for both hospitals with focus on the evening shift for the Austin. For both hospitals, engaging all the stakeholders on integrating the patients' diagnostics and consultations would be a high-impact solution[164].

With respect to limitations, Study IV would benefit from qualitative research and examination of the different health care systems. The explanation for why Austin Health is more successful than Sunnybrook on reaching targets is speculative. A qualitative study on why tests are ordered, or how decisions are made would be useful. It could be argued that a fair comparison between Sunnybrook and the Austin could not be made because the emergency populations and contexts were different. This, however, is one of the goals of this study – that solutions for EDLOS should be tailored to a hospital's ED population. Sunnybrook triage scoring may be different from the Austin affecting the high and low acuity discharge volume. Finally, the introduction of NEAT could have driven the shorter Austin EDLOS.

6 CONCLUSIONS

1) The MDRNSTAT shortened EDLOS among non-consulted, discharged patients seen by the emergency physician without an increase in harm.

2) From the perspective of a publicly funded hospital, the MDRNSTAT was not a cost-effective daytime strategy, but more feasible during times of high volumes, such as afternoon to late evening.

3) At Sunnybrook hospital, the factors most strongly associated with government target failure for discharged high acuity patients were hospital resources: waiting to see a physician greater than two hours, receiving a consult and CT scan. For ICU admissions, the major factors were also hospital controlled: bed request duration and access block.

4) The factors predicting failure of government targets between 2012 and 2013 at Sunnybrook Hospital were similar and predictable. Austin Health, an Australian hospital, was more successful on reaching targets than Sunnybrook. Factors predicting failure were not similar between both hospitals. However, the emergency populations between the two hospitals are different. It is speculated that this contributes to target performance.

Like Simpson's paradox and hospital standardized mortality ratios[165], it is important to provide a description of patients being treated at the hospital when comparing time targets for EDLOS. When creating pay-for-results models, policy makers need to keep this in mind. The current models rely on acuity triage scales to determine EDLOS. However, there is little evidence that these scales can predict EDLOS or resource consumption. By focusing only on a time target, there is potential for hospitals with lower acuity populations requiring few resources to be rewarded financially at the expense of hospitals with higher acuity populations needing more resources. Unintended consequences, such as "destructive goal pursuit[102, 166]", altered relationships between physicians/patients[104] or deterioration in quality of patient care can result[105].

A hospital's ability to achieve time targets is likely contingent on their patient population, infrastructure, financial support, leaders and external policy. It is also important to examine if prolonged EDLOS is a surrogate for patient complexity with high resource demand or system inefficiencies. Similar to findings by Gabayan[34] and Pitts[127], these studies suggest that Sunnybrook's prolonged EDLOS is from its patient complexity and associated throughput processes for diagnostics and management. Sunnybrook patients are older, have higher acuity and require more hospital resources. We found that the MDRNSTAT was not the single, optimal, cost-effective solution for Sunnybrook. This makes sense because the MDRNSTAT can only address only part of the throughput factors of prolonged EDLOS. We need to focus on those factors with highest impact, which happen to be hospital-controlled throughput factors. Improving the process of acquiring cross-sectional imaging, consultations and beds for admissions could inadvertently speed up the access to the emergency physician. This requires an integrated approach between the hospital systems with a budget, leadership and manpower to support it.

Although the MDRNSTAT research was not positive, its outcomes were practical and useful. We have saved the hospital the opportunity cost of implementing a MDRNSTAT. The research also illuminated that we did not know the main factors associated with prolonged EDLOS at Sunnybrook and if they are different from other hospitals. By determining these factors, a tailored, evidence-informed strategy can be built to manage EDLOS at Sunnybrook and Austin Health.

7 FUTURE DIRECTIONS

The next steps are to provide practical application of the research to Sunnybrook and other hospitals. These research findings have been presented to local policy makers to reinforce the fact that ED crowding is a systems issue. Providing real-time data analytics to Sunnybrook Quality Improvement Plan is essential to have evidence-informed decisions. Evaluation of interventions needs to ensure that reaching time targets is not at the expense of quality of care with unintended costs. The entire hospital and system need to be involved in order to decrease ED crowding. Currently, our quality improvement plan is focusing on the high impact factors influencing EDLOS. The strategy is to improve the integration between diagnostic imaging, consultation services and the emergency department. The hospital has increased resources for emergency diagnostic imaging and creating policy and information technology solutions to streamline consultations. Therefore, the goal is to use knowledge translation for change management. For example, the factors for prolonged ICU admissions were presented to leadership. Consequently, Sunnybrook added four more transitional beds between the emergency department and intensive care unit.

Other future studies would include more detailed examination on how prolonged EDLOS contributes to increased morbidity and mortality [18 28]. Could EDLOS be a confounder for patient complexity with associated higher resource use, but poorer outcomes? Could a patient complexity measurement for EDLOS be determined? Which portion of EDLOS harms and benefits patients? How much can EDLOS be decreased before patients are harmed? If time targets are limited as quality indicators, what are more appropriate or additional ED quality indicators? Can an emergency patient satisfaction score be developed for cost-utility analyses?

For admissions, research is required to differentiate which part of access block compromises quality of care. Is management in the emergency department suboptimal to ward management? Or is it the boarding – leading to delays in definitive care, deconditioning or sleep deprivation[109]? In addition to access block, research needs to be done on “diagnostic-management” block – the diagnostic and management bottlenecks during emergency patients’ EDLOS.

Other future directions are to approach the problem of EDLOS from a relativist, systems [167] or design thinking [168] approach - working with stakeholders, such as patients, leadership, government, policy makers and health care workers to find innovative solutions. This approach would complement the positivist, empirical approach of medical research. Routinely doing cost-effectiveness or cost utility analyses of different interventions to shorten EDLOS would aid in choosing the most efficient intervention. Having robust and accurate data gives the greatest chance of implementing a quality improvement intervention that is effective and beneficial [14, 133]. The power of using registries [169, 170], and more comprehensive databases [171] can provide more complete data that can provide evidence-informed solutions. With this framework, interventions can be tailored to the context of the individual hospital.

Because the scope of prolonged ED wait-times is international [15], there is immense opportunity for collaboration across nations. Examining the health funding structure differences between Australia and Canada and the cost-effectiveness of its crowding strategies can lead to shared international solutions. Each country’s emergency system has implemented different strategies to improve ED wait-times. We can learn from one another by sharing our experiences and working together.

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APPENDIX I

<u>MDRNSTAT</u>

Dear Colleague:

Below is a survey on the addition of the MDRNSTAT to our emergency department. Filling out this form is entirely voluntary. Please do not provide any identifying information on the survey. All information will be anonymous. Thank you!

1. The assignment of CTAS scores are beneficial in patient flow

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

2. The role of a MDT (physician at triage) is beneficial in patient flow

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

3. The role of a RNT (part of the MDRN STAT) is beneficial in patient flow

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

4. The MDRN STAT provides a patient with better quality of care

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

5. The MDRN STAT is a in a position of medicolegal risk

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

Comments about your shift today:

Clinical Care Leader, Zone Emergency Physician, Triage Nurse

Dear Colleague:

Below is a survey on the addition of the MDRN STAT to our emergency department. Filling out this form is entirely voluntary. Please do not provide any identifying information on the survey. All information will be anonymous. Thank you!

1. The assignment of CTAS scores are beneficial in patient flow

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

2. The role of a MDRN STAT is beneficial in patient flow

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

3. The MDRN STAT provides a patient with better quality of care

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

4. The MDRN STAT decreased my efficiency in the ED

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

5. The MDRN STAT contributes to teamwork and collegiality in the ED

1	2	3	4	5	6	7
Strongly Disagree		Somewhat Disagree		Somewhat Agree		Strongly Agree

Comments about your shift today: