BRINGING PHYSICIAN ASSISTANTS TO CANADIAN PEDIATRIC EMERGENCY DEPARTMENTS

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

The Faculty of Graduate Studies

(Population and Public Health)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

January 2013

Abstract

Background and objectives: Pediatric emergency department (PED) utilization has increased, resulting in long waiting times for children and families. Extending PED physician coverage as a solution may not be cost effective or sustainable. Physician assistants (PAs), clinicians with roles tailored to assist physicians, have skills best suited to provide care in high volume and low complexity environments. As a large proportion of PED visits are for non-emergent problems, PAs are an alternative solution to increasing PED demand given constrained healthcare resources. Despite the growing acceptance of PAs, there are few studies evaluating their roles or cost-effeciency in PEDs. We assessed PA acceptance by Canadian healthcare users and providers, and estimated the impact of PAs on patient flow compared to extending physician coverage.

Methods: The range and frequency of clinical complaints managed at a tertiary care PED was ascertained from an administrative database. Surveys of Canadian PED physicians defined a clinical scope of practice for PAs and estimated the proportion of PED visits a PA could manage, with varying degrees of physician supervision. Healthcare users were surveyed regarding their willingness to receive PA care. A discrete event simulation model of a PED was built to assess the impact of extending physician coverage versus adding PAs at equal incremental cost to the system, on waiting time, length of stay (LOS) and rate of patients leaving without being seen (LWBS).

Results and interpretation: Provided that their waiting time was shortened, Canadians were willing to have their children receive care from PAs for minor injuries and non-emergent ailments. Although few Canadian PED physicians were familiar with PAs, most supported the concept of PA utilization for a large proportion of non-emergent visits. However, physicians wanted to remain directly involved thereby limiting PA autonomy. The simulation found important reductions in waiting time, LOS and LWBS rates for both scenarios: the extended physician model benefited all acuity levels, while the PA model with restricted PA autonomy favoured only highest acuity

patients. Increasing the level of PA autonomy was critical in broadening the impact of PAs to all acuity levels.

Preface

The work presented in this dissertation was designed, implemented, analyzed, written and disseminated by Quynh Doan. All study projects conducted as part of this dissertation received ethics approval from the Children's & Women's Health Center (Vancouver, British Columbia) Research Review Committee and the University of British Columbia Behavioural Research Ethics Board under certificates: H09-01535, CW10-0085 / H10-00795, CW10-0106 / H10-01133, CW10-0325 / H10-03070, H10-01449. All subjects enrolled in these studies provided informed consent.

Chapter 2:

A portion of chapter 2 has been published. [Quynh Doan], Vikram Sabhaney, Niranjan Kissoon, Sam Sheps, and Joel Singer (2012). The role and impact of the physician assistant in the emergency department: a systematic review. Emergency Medicine Australasia 23(1): 7-15. Quynh Doan designed the systematic review and search strategy, reviewed all relevant articles and wrote most of the manuscript. Vikram Sabhaney, was the second reviewer and all other co-authors reviewed and revised the manuscript.

Chapter 3:

A version of chapter 3 has been submitted for publication through two manuscripts. The first manuscript was published. [Quynh Doan], Vikram Sabhaney, Niranjan Kissoon, David Johnson, Hubert Wong, Sam Sheps, and Joel Singer. The role of physician assistants in a pediatric emergency department. A center review and survey. Pediatric Emergency Care. 2012 Aug; 28(8): 783-788. Quynh Doan designed and implemented the study protocol and subsequently wrote the manuscript. Vikram Sabhaney assisted in the database review and data extraction. All other co-authors reviewed and revised the manuscript.

The second manuscript was submitted and is currently undergoing peer review for publication. [Quynh Doan], Shalea Piteau, Sam Sheps, Joel Singer, Hubert Wong,

David Johnson, and Niranjan Kissoon. The Role of Physician Assistants in Pediatric Emergency Medicine: The Physician's View. Quynh Doan designed and conducted the study and authored the manuscript. All co-authors reviewed and revised the manuscript.

Chapter 4:

A version of chapter 4 has been submitted for publication through two manuscripts, one has been published. [Quynh Doan], Roderick S. Hooker, Hubert Wong, Joel Singer, Sam Sheps, Niranjan Kissoon, and David Johnson. Canadians' willingness to receive care by physician assistants. Canadian Family Physician. 2012 Aug; 58:e459-466. Quynh Doan adapted Hooker's study design and conducted the study and subsequently wrote the manuscript. All co-authors reviewed and revised the manuscript.

The second manuscript was accepted for publication in the Canadian Journal of Emergency Medicine in December 2011. [Quynh Doan], Sam Sheps, Hubert Wong, Joel Singer, David Johnson, and Niranjan Kissoon. Parents' willingness to consider having their child receive care by physician assistants in a pediatric emergency department. CJEM accepted Dec 2011. Quynh Doan designed and conducted the study and subsequently wrote the manuscript. All co-authors reviewed and revised the manuscript.

Chapter 5:

A version of chapter 5 has been submitted to a peer review journal and is currently undergoing review. [Quynh Doan], Steven Shechter, Sam Sheps, Joel Singer, David Johnson, Hubert Wong, and Niranjan Kissoon. Impact of physician assistants on patient flow in a pediatric emergency department: a discrete event simulation model. Quynh Doan designed and conducted the study and subsequently wrote the manuscript. All co-authors reviewed and revised the manuscript.

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List of abbreviations

AAP	American Academy of Pediatrics
BCCH	British Columbia Children's Hospital
CI	Confidence intervals
CTAS	Canadian Triage and Acuity Scale
ED	Emergency department
ICD 10	International Statistical Classification of Diseases and Related Health Problems 10th revision
LOS	Length of stay
LWBS	Left without being seen
min	Minutes
NP	Nurse practitioner
PA	Physician assistant
PED	Pediatric emergency department
PHSA	Provincial Health Services Authority
SD	Standard deviation

Acknowledgments

Firstly, I would like to express my gratitude to Dr. Joel Singer, my supervisor for his guidance, patience and support throughout my training. I also am grateful to Drs. Niranjan Kissoon and David Johnson, along with Dr. Singer, for their mentorship and extensive commitment to my training through the Canadian Child Health Clinician Scientist Program (CCHCSP), without which completing my graduate studies would have been extremely difficult. By the same token, my thanks are extended to Dr. Norman Rosenblum, Primary Investigator, CCHCSP and the Department of Pediatrics, University of Toronto for inspiring and facilitating my completion of graduate studies as a clinician, and the opportunity to pursue a career as a clinician scientist.

I would also like to thank the remainder members of my supervising committee, Dr. Sam Sheps, Dr. Hubert Wong, and Dr. Steven Shechter for their constant vigilance and steering throughout my studies, driving me to aim for excellence in learning and achievement every step of the way. In addition, I want to recognize the support and guidance that Dr. Roderick S Hooker provided me, from the moment I approached him with my interests in the role of physician assistants in the Canadian healthcare system.

None of the studies included in this dissertation could have been completed without the help of my numerous research assistants and student volunteers, and to them, I am deeply grateful.

Lastly but not least, I am indebted to my husband Sebastien Do and my children Tam and Thien, for their unconditional support in my decision to return to school and believing that I could still succeed in doing so.

Dedication

I dedicate this work to my parents Huong and Chinh Doan.

With love, admiration, and gratitude.

Chapter 1. Problem overview and study goals

1.1 Emergency department overcrowding: general principles

Emergency department (ED) overcrowding is a growing concern faced by most healthcare users visiting hospitals in North America.[1] In a Canadian survey of general ED directors, approximately 2/3 identified overcrowding in their ED as a severe problem.[2] This problem is believed to be the result of converging and competing factors. Conceptually, ED overcrowding is the result of input (volume and acuity of patients coming to the ED), throughput (ED resources availability and efficiency), and output (timely disposition of ED patients stable enough to be either discharged or transferred to definitive treatment area) factors.[3,4]

1.1.1 Input factors

Over time, there has been a steady increase in demand. In the USA, since the late 1950s, the total number of ED visits across the nation has increased by 600%, with about 30 million pediatric visits to the ED in 2000.[5] During this rise in ED use, a large number of EDs in the US was closed down,[6] presumably due to budget reductions and liability issues.[7] Not only have general EDs been experiencing increasing numbers of visits, the acuity and severity illness of patients has also risen. In a large urban ED in Canada, between 2001 and 2007, an analysis showed that the proportion of emergent cases had doubled, from 8 to 16% while the proportion of semi-urgent and non-urgent cases had dropped from 42.4% to 28.8% and from 9.4& to 4.3% respectively.[8]

1.1.2 Output factors

A rise in acuity of ED patient visits would lead to increased proportion of patients being admitted from the ED and consequently, higher demands on inpatient beds. This increase in demand has coincided with a reduction in supply; in-patient hospital beds were reduced by 40% from 1995 to 2000 in Canada and by 39% in the US between 1981 and 1999. [9,10]

Patients who need to be admitted to hospital for ongoing care but cannot access an inpatient bed immediately are boarded in the ED until such time an inpatient bed is available. Boarding admitted patients in ED consumes resources such as bed space, monitoring, along with nursing and physician attention. As a consequence, these resources are not available to manage newly arrived patients in the ED. This results in access block. ED boarding is considered a key determinant of ED overcrowding.[11] ED boarding is also correlated with ED waiting time and ambulance diversion.[12] Ambulance diversion occurs when an ED is unable to accept new patients and ambulances are re-routed to another medical facility. This in turn results in delayed access to care for the transported patients and may negatively affect their outcome.[13] Ambulance diversion is therefore an ED's reaction to overcrowding and should be considered an additional negative outcome in the ED overcrowding phenomenon.

1.1.3 Throughput factors

Throughput factors in the ED overcrowding problem are factors related to how patients are managed in the ED, and may include ED specific processes. The most important throughput factors are ED resource shortages, including both human (physician and nurses) and material (beds and space). Throughput factors also include ED process inefficiency such as low value added process (e.g. duplication of information gathering), long waits to retrieve past medical information from health records, and difficulty accessing specific resources (eg. radiological tests) that are not readily available after business hours. Solutions to patient flow issues including implementation of electronic health records and facilitation of patient information access have produced mixed results. Gains in information access may be offset by delays when clinicians are forced to use cumbersome or unfamiliar documentation systems.[14,15] Finally, the use of ineffective treatments and investigative modalities also have a detrimental effect on throughput in EDs.

Many studies have explored strategies to improve ED efficiency by addressing input, throughput and output factors. Efforts to decrease ED utilization by either redirecting flow of patients to other healthcare facilities or by providing education to users with non-emergent problems to seek alternative care venues in the future, have reported conflicting results and have been only modestly effective as a mean to reduce ED use or overcrowding.[13] Other forms of ED use deterrents such as user fees in the ED and screening patients out of the ED may be unsafe and lack evidence to support their practice.[16]

Increasing ED capacity such as extending physician coverage, adding short stay or observation medical units and emphasizing in-patient hospital bed access has been shown to be successful in improving measures of ED crowding,[13] but these strategies require significant financial investments which must compete with other priorities for constrained resources. Indeed, there is little evidence that ED service delivery changes and re-organization effectively impacts patients' length of stay (LOS) in the ED unless additional resources are also allocated. There is however some evidence supporting specific strategies. They range from the introduction of simple innovations to more complex operational changes to the system. The use of point of care testing, the rapid performance of laboratory investigations at the bedside, can accelerate the decision-making and improve system efficiency[17]. Another focused strategy involves the use of nurse specialists in the ED to address problems requiring expertise, such as medical devices (feeding tubes, vascular indwelling catheters) or wound care. Similarly, protocols and programs to avoid hospital admissions (eg. community services to provide home care support for chronic ailments, or observation and short stay units) where patients who would otherwise need an admission, are given time for their condition to improve or to organize appropriate home care are more feasible than increasing in-patient bed capacity in relieving ED crowding.[16]

Reorganizing specific ED operations such as implementation of a fast track system or a dedicated low acuity treatment area, staffed by dedicated clinicians such as physicians, nurse practitioners (NP) or physician assistants (PA), to

manage patients triaged to a low acuity levels, is also an option. Although studies assessing this option suffer from methodological weaknesses, they have consistently shown that managing low acuity patients in a separate area (with dedicated staffing while maintaining access to the main ED if needed) is cost efficient, safe, and ultimately results in shorter LOS and higher satisfaction for low acuity patients.[18] Strategies aimed at reducing boarding in the ED can also reduce ED waiting time and length of stay.[19,20] However, these reorganizational initiatives have had only modest to moderate success as individual interventions since their combined effects remain unpredictable, they are expensive, require ongoing monitoring and evaluation, and their impact over the longer term has yet to be demonstrated.[21] Moreover, their success in reducing wait times may paradoxically encourage an increase in ED visits for non-acute concerns that would otherwise be more properly managed in a primary care setting.[18]

1.2 Approach to pediatric emergency department specific problems

Pediatric EDs (PEDs) have also experienced problems with overcrowding and suffer from poor patient flow issues[22] with resulting decreases in quality of care (e.g. delay receiving essential treatment for specific acute clinical conditions[23-25]) and are also faced with unique challenges. For example, the most frequent determinant of ED overcrowding in adult EDs is the proportion of admitted patients occupying an ED bed,[26] but this problem is not common in PEDs. A survey of Canadian PED directors and nursing staff suggests that prolonged waiting time is related to the volume of patients arriving at a PED relative to the capacity to manage them.[27]

PEDs treat a relatively higher proportion of non-urgent and low complexity cases (35-70%), and have lower patient admission rates than general EDs.[28-31] Although the level of acuity of problems managed in PED may be lower than in general EDs,[28,32] parents have a low threshold for perceiving that their child needs to be assessed by a physician, regardless of the time of day or night; therefore high emergency visit volumes and input factors are significant in PED

crowding[33]. Attempts at addressing these issues and reducing PED utilization through gatekeeping by primary care provider screening prior to PED admission, education and improved access to primary care services have been met with conflicting results, not unlike the experience in general EDs.[34-37]

The inability to manage large volume of patients in a timely fashion correlates with the proportion of patients who leave before being seen by a physician[27]. Some of these patients and families (0.2 to 7.6% off all PED visits[38,39]) choose to leave the PED without having being assessed medically, presumably a result of having to wait longer than they deem acceptable. Although patients who leave the PED without being seen are usually triaged to low acuity levels, some may have unsuspected conditions leading to preventable poor outcomes.[38,39]

Research on crowding specific to PEDs is still in its early stage, and published reports are scarce. Research on PED crowding has been mainly focused on defining the magnitude of the problem. Although unpublished communications between PED physicians across Canada acknowledge that PED volumes are rising, there are no published reports of this phenomenon.[28] As we recognize the subtle but important differences in the challenges faced by PEDs, the impetus on reducing boarding of admitted patients in the PED may not be as relevant as in general EDs. The consensus is that the focus should be placed on input and throughput factors, by efficiently managing large volumes of patients with low acuity medical problems while addressing those with higher acuity in a timely fashion.[27]

1.2.1 Input factors

Input factors affecting PEDs and drivers of utilization of PED by families, are closely related to parents' abilities to navigate the healthcare system and overall accessibility to adequate care for children elsewhere in the system. Accessing healthcare services for children with acute problems is often challenging because of issues described below.

Lack of access to family physicians and limited hours of operation

An important factor that contributes to PED utilization is difficulty in accessing family physicians. Although the number of physicians registered with the College of Physicians of British Columbia has increased to 5673 active general practitioners,[40] recent surveys report that approximately 15% of British Columbians are without a family doctor.[41,42] These statistics are similar at the national level, where approximately 4.1 million Canadians are without a family doctor, among whom 64% use walk in clinics and 12% use emergency departments (ED) as their usual source of healthcare.[43]

In addition to rare emergency pediatric health events, PEDs are used by families who cannot be seen by a family doctor for an acute but non-urgent problem, or for after office hour access to healthcare for their children.[44-47]

Family physician level of training in pediatrics

The practice of referring children to the PED by a primary care physician (family physician or a physician working in a walk-in facility) for reassurance or a second opinion is another factor influencing PED utilization. This practice is highly variable and related to the primary physician's level of comfort with pediatric problems, which in turn is related to the extent of pediatric medicine exposure during their training.

At the University of British Columbia Family Medicine residency program exposure to children in primary care rotations is not extensive: a family medicine resident was only required to spend two months in a dedicated pediatric training environment over the training period. More recently, following the Triple C Competency-based Curriculum[a] adopted by the College of Family Physicians of Canada, the period of training in pediatrics for family medicine residents no longer will be a set duration, but based on competency. This means that the amount of pediatric training a family medicine resident receives

[a] The Triple C Competency-based Curriculum is a new and enhanced approach to resident training which makes use of contextual teaching to help residents assimilate competencies while evaluating trainees with regard to their readiness to begin their family medicine practice.

will be based on performance evaluations using pre-defined dimensions of competencies[48]. There will no longer be a standardized amount of pediatric exposure for family medicine residents (e.g. 2 months).

How this will affect family physician's comfort level with sick children is yet unknown, but it could have the effect of increasing referrals to pediatricians and PEDs, aggravating the overcrowding problem.

Access to a pediatrician

In British Columbia, pediatric medicine is a clinical specialty and a consulting service. Although some pediatricians choose to practice primary care, and are compensated at the same rate as family doctors, these are the exception and are not widely accessible. Family doctors are the main provider of primary care for children, and only refer children to a pediatrician for occasional consultation when the child's condition is thought to require pediatric expertise. Following assessment, investigation, subspecialty consultation, diagnosis, and management, care of the child is normally returned to the family physician. Further visits to the pediatrician whether for the same (after a six months period) or a new problem, requires a new referral by the family doctor.

Which health conditions need pediatric consultation varies widely and is influenced by a number of factors including the severity and duration of the child's symptoms, the child's past medical history, the presence of underlying chronic conditions, and local clinical culture and practice. However, a referral is more likely to be sought if the family doctor is uneasy caring for children (given their training or their familiarity with the child) and the family's desire for pediatric consultation driving the referral. The need for expert knowledge, skills and experience or the need for in depth counselling, may also dictate a pediatric consultation. Although a few pediatricians accommodate urgent consultations on the same day if requested directly (via telephone), most have a waiting list and clinically non-urgent consultations may be delayed for months. Parents as well as physicians (office based or those working in a walk in clinic) may consider the PED a means to access pediatric and pediatric subspecialty

consultations or for a second opinion, when it cannot be arranged in the community within a time frame deemed acceptable.[49,50]

1.2.2 Throughput factors

In an effort to address management efficiency to decrease PED wait times, many strategies similar to those undertaken in general EDs as noted above, have been trialed in PEDs. These include;

System organization and process re-engineering

Nurse initiated therapy targeting specific clinical conditions where evidence based clinical pathways exist, such as asthma exacerbation or mild to moderate dehydration from gastroenteritis, [51,52] have resulted in reductions of LOS for patients afflicted with these conditions, but their effect on flow and efficiency in the PED for other patients overall, has not been addressed. For example, whether the observed improvement in the timeliness of care for a subpopulation of PED users comes at the detriment of others, particularly if the nurse initiated therapy is adding to the nursing workload without additional coverage has not been measured.

Although scarce, evaluations of fast track areas to address minor injuries and medical complaints in PEDs, are consistent with those in general ED. There is evidence suggesting that managing children with low acuity problems in a dedicated fast track area, with separation of resources from the main PED area is cost effective and may reduce ED LOS for children with health concerns triaged to a low acuity level.[53,54]

Personnel composition

If imbalances continue to grow between demand (PED utilization) and PED capacity, and reducing demand is not effective or potentially unsafe, increasing capacity to improve throughput may become unavoidable.

Hiring and retaining more PED nursing staff and extending emergency pediatricians coverage are often the main approaches used in response to patient volume increases. If additional funding is available however, there is an

opportunity to explore novel uses of increased funding to address the problem. Extending coverage by pediatric emergency physicians to manage increasing PED volumes of largely non-emergent needs is neither necessary nor cost effective. Thus an alternative solution is to use non-physician clinicians such as NPs and or PAs.

NPs are advanced practice registered nurses who have completed graduate-level education following their basic nursing training. They are trained by nurse educators in the nursing model, expanding their scope of practice to provide individualized comprehensive care of primary, acute and chronic illness care. The first NP training program was introduced in 1967, and by 1972, the implementation of the expanded role for the nursing practice was prioritized. However, in the mid 1980s, due to a perceived oversupply of physicians, lack of funding and support from both medical and nursing program, most Canadian NP training programs disappeared. In the mid 1990s, the Council of Ontario University Programs in Nursing introduced a new NP training program, which spearheaded a renewed interest in NP training program and enrolment.[55]

Despite this initial challenge, a small number of NPs continued to provide primary care in northern stations and community health centers through the 1980s and 1990s and were valued for their contribution in health prevention promotion and community based care. There are currently over 3000 NPs in Canada and NPs are legislated to practice in all Canadian provinces and territories. They can assess, evaluate and treat patients independently of physicians, prioritizing prevention, wellness, patient education and advocacy. NPs often run clinics in areas with clinical needs unmet by physicians whether geographical or functional.[56]

PAs are clinicians with roles tailored to assist physicians. They can help with specific procedural tasks such as wound closure or fracture immobilization, but they also assess and provide care to a range of primary health needs. In the PED setting, PAs could then free the PED physician to manage children with high acuity and medically complex health complaints, or to teach medical

trainees[57]. PAs are trained in the medical model, often by physicians, and learn along side medical trainees on clinical rotations. PA practice is always linked to a supervising physician and in Canada, the medical management and liability is shared between the PA and supervising physician. In Canada, PA education consists of either a 2 year specialized program (Canadian Medical Services School of Physician Assistants), following 2 years in a university program (McMaster University or The Consortium of PA Education: University of Toronto, Northern Ontario School of Medicine and The Michener Institute for Applied Health Sciences) or a 2 year masters degree program following an undergraduate degree (University of Manitoba). As such, the scope of practice of PAs is narrower than that of physicians, but their compensation rate is also lower than that of physicians.

The Canadian military has trained and has had good experiences with PAs since the 1960s (approximately 130 Forces PAs currently provide high quality medical care to Canadian troops at home, at sea, and abroad).[58] As of 2012, PAs have yet to be licensed by all provinces, although there is growing interest in Canada. Manitoba was the first province to legislate PAs in 1999, later amended in 2009 and where PAs' contribution to Canadian healthcare is most established. Ontario followed in 2006, with pilot projects to include PAs to their health care system. Most recently the Colleges of Physicians and Surgeons of New Brunswick (2009) and Alberta (2010) announced licensing of PAs under their regulations.[59]

There is significant overlapping between PAs and NPs' skills and abilities, which may allow them to perform comparable tasks in certain clinical environments. PAs and NPs, however, are trained in two different models and philosophies, which can affect the clinical positions they choose to pursue and their compatibility with certain working environments.

I chose to focus my work on exploration and evaluation of the role and impact of PAs in PEDs for a number of reasons. Firstly, though PAs are early in the introduction to the non-military Canadian healthcare system, their rate of

incorporation is rapid. Personal communications with Mr. Ian Jones, past president of the Canadian Association of PAs informs me that all PAs trainees in Canada are employed upon graduation. Consequently a systematic exploration of their potential benefits and limitations focusing on PED issues seem necessary and timely.

In addition, a policy statement by the American Academy of Pediatrics (AAP) on the pediatric workforce views the inclusion of non-physician clinicians to pediatric health care as beneficial when taking a team based approach, where the pediatrician or pediatric subspecialist acts as a team leader and supervisor for non-physician clinicians, and assumes overall responsibility for the pediatric patient[60]. As the ability of NPs and PAs to manage all level of complexity of care independently has yet to be evaluated and documented, the AAP opposes their independent practice and prescriptive authority.

While both NPs and PAs may practice collaboratively with physicians, there are fundamental differences between NPs and PAs with regards to their legislation and intended scope of practice. PAs may only practice under the supervision of a physician, by design. NPs are licensed to practice independently. Although the interpretation of the degree of physician direct involvement required when supervising may vary, at the BC College of Physicians' level, independent practitioners such as NPs do not practice under the supervision of physicians. Physicians may oversee medical trainees and PAs, direct or delegate medical act to them, then review and sign their patient charts, ultimately sharing liability. Due to NP's independent licensing, superintending clinical decisions or inspecting records of patient seen by NPs by physicians is not an accepted practice. NPs may consult a physician, at which point the medical responsibility is shared, but this occurs strictly at the NP's own discretion.

The AAP's position on the necessary supervision by pediatricians for the delivery of pediatric healthcare may seem conservative for certain situations, but in the high risk context of the PED, where there is a wide rage of acuity in

patient presentations, large volume of visits and short interaction times, the supervision of clinical care to children by an emergency pediatrician, even when triaged to a low acuity level, is not unreasonable. For this reason, I believe that PAs may be more suitable to assist in the management of patient flow in PED overcrowding, while maintaining safe level of care in the PED under the supervision of an emergency pediatrician.

1.3 Goals

The following chapters of this dissertation address various aspects regarding the use of PAs in PEDs as a potential approach to managing PED overcrowding. The first objective was to reviews the published literature on PAs and their work in EDs, in order to establish a rationale for their potential introduction to Canadian PEDs. The second objective was to define a role and scope of practice for PAs in PEDs, through an assessment of PED utilization and physician surveys. The third objective was to explore the acceptance of PAs by healthcare users and their willingness to receive acute care from PAs. The last objective was to incorporate elements ascertained from the previous studies to estimate the impact of PAs on PED patient flow relative to extending PED physician coverage using discrete event simulation model of patient flow in a PED. In closing, I reflected on how knowledge gained through this work will help guide the BC Ministry of Health, and other authorities, in their planning for licensing and introducing PAs to the Canadian healthcare system.

Chapter 2. Physician assistants in emergency departments[b]

2.1 Objectives

The objective of this systematic review was to gather and review evidence for the role of PAs in the ED, their impact on ED efficiency and patient satisfaction, as well as evaluate PAs as a potential resource to relieve ED overcrowding.

2.2 Methods

Criteria for considering studies for this review

The intervention studied in this review is the use of PAs in an emergency department setting and the outcomes of interest included: prevalence of PAs in EDs, PA roles and responsibilities, quality of care (performance comparisons between physicians and PA), changes in patient flow, changes in cost as a result of PA presence in the ED of an emergency department visit, patient satisfaction with PA care in the ED and emergency physician satisfaction and attitudes towards PAs. Participants involved were either hospital personnel (doctors, nurses, residents), patients who received care from PAs in an emergency department setting or PAs working in the emergency department.

Search strategy for identification of studies

I performed a systematic search of English and French literature on PAs using the following electronic databases: MEDLINE (1950 to July 2009), EMBASE (1980 to July 2009), Database of Abstracts of Reviews of Effects (DARE) (2nd Quarter 2009), Cochrane Database of Systematic Reviews (2nd Quarter 2009), Cochrane Central Register of Systematic Reviews (2nd Quarter 2009) and C Cumulated Index to Nursing and Allied Health Literature (CINHAL) (1982 to July 2009).

[b] [Quynh Doan], Vikram Sabhaney, Niranjan Kissoon, Sam Sheps, and Joel Singer (2012). The role and impact of the physician assistant in the emergency department: a systematic review. Emergency Medicine Australasia 23(1): 7-15.

I also consulted topic experts to identify sources of unpublished data. The search strategy used for Medline Ovid is displayed in Table 1. With librarian support, the terms were translated for the other electronic databases.

Table 1 Search strategy with title count for Medline 1950 to July 2009.

Medline Ovid	Search terms	# Titles
1	Physician Assistants/	3 391
2	((pediatric or paediatric or physician$ or doctor$) adj2 (assistant? or extender?)).tw.	2 110
3	medical care practitioner?.tw.	10
4	physician$ associate.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	49
5	midlevel provider.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	7
6	non-physician provider.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	3
7	feldsher?.tw.	461
8	manpower.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	13594
9	or/1-8	18 005
10	exp Emergency Service, Hospital/	34 244
11	Emergency Medicine/	7 685
12	((emergenc$ or trauma) adj (medicine or department? or room? or visit? or care or service? or hospital? or centre? or center?)).tw.	52 111
13	fast track.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	1 039
14	acute care.mp. [mp=title, original title, abstract, name of substance word, subject heading word]	8 466
15	or/ 10-14	78 846
16	9 and 15	367
17	Animals/	4 438 535
18	Humans/	10 869 055
19	17 not (17 and 18)	3 319 969
20	16 not 19	367

Two independent reviewers assessed studies for relevance, using titles and abstracts (see *Criteria for considering studies for this review)*. Both reviewers had to agree a study met inclusion criteria to be included. Level of agreement between reviewers was assessed using Kappa Statistics. Differences were resolved by consensus. The references of all selected papers were screened for relevant titles and were tracked forward using the Cited Reference Search feature in Web of Science.

Once a study was included, it was assessed independently by two reviewers using the "Quality Assessment Tool for Quantitative Studies Method" developed by Thomas. This tool has been found to be suitable for use in a systematic review of non-randomized studies.[61,62] Standardized data extraction forms were used to collect and compare outcome measures between included studies.

2.3 Search results

The electronic search yielded 712 original titles. After excluding articles that either did not involve PAs in the ED or were an editorial, we identified 66 articles that met inclusion criteria. There was good agreement in the selected articles between the two reviewers with a Kappa score of 0.83.

Overall, the methodological quality of included studies was weak to moderate with very few studies scoring strong. For many articles, which were descriptive in nature, the quality assessment tool did not apply well, as the tool is meant to evaluate experimental studies. Most studies were cross sectional surveys or observational in nature (retrospective cohorts). Experimental designs were limited to uncontrolled pre and post PA introduction comparisons.

Many of the papers we found were anecdotal reviews of individual centers' experience in using PAs, or commentaries and personal opinions on the use of PAs, which we excluded from this review.

2.4 Prevalence of PAs in EDs

Eight articles addressing the use of PAs in EDs were included in my review. These consist of surveys published between 1992 and 2008. All originated from the USA and pertains to EDs in America. National surveys of general EDs (including both pediatric and rural EDs) reported that 13-18% of surveyed EDs used some non-physician health care providers (mostly PAs although some used nurse practitioners (NPs).[63-65] A smaller survey of EDs in Louisiana, found only 4% used PAs.[66] In contrast, studies focused on US academic EDs, that employed managed care to limit costs to insurers, reported between 65 and 68% used PAs.[67–69]

Many EDs that employ PAs, use them in fast track units (FT), where PAs manage patients with low level acuity health concerns. While over half of EDs using PAs have a FT unit, PAs are used exclusively in FT only in 18.5% of EDs[70] and the rest use PAs for a wider range of patient acuity levels. The average response rate to these surveys was 79% ranging from 56% to 96%. The quality scores for these studies were predominantly moderate, with the main weakness being inadequate description of the survey sample.

2.5 PAs roles and task assignments in EDs

The range of tasks assigned to PAs and their scope of practice in EDs was described in seventeen articles. The first paper was published in 1973 and described the use of military corpsmen PAs to suture lacerations in a pediatric emergency department.[71]

Typical duties of a PA in an ED include taking histories and performing physical examinations, evaluating laboratory data, instituting treatment, admitting patients, communicating with consultant services and performing procedures.[72–74] In addition to traditional ED roles, innovative PA positions such as the patient navigator have been created.[75] These PAs liaise between the ED and primary care physicians, follow up investigations and attend bed allocation meetings, resulting in improved patient flow through the ED. Another

unique role of PAs is as a part of a transition team caring for admitted patients while still in the ED.[76, 77]

Based on chart reviews, studies have suggested that a PA can manage 53-62% of all ED patients in collaboration with the ED physician, with variable degrees of autonomy.[78,79] These two articles date from the 1970s however, and the pattern of ED users may have changed in the last few decades. Most patients evaluated by PAs are younger with non-urgent conditions and are less likely to require admission (8 vs. 14%) than those managed by ED physicians.[80,81] Common conditions managed and procedures performed by PAs are summarized in Table 2. [73,80-84]

Table 2: Common clinical conditions and procedures managed by PAs as described from retrospective chart and database reviews.

Clinical conditions commonly managed by PA	Diagnostic & therapeutic procedures performed by PAs
Uncomplicated open wounds	Intravenous insertion
Musculoskeletal injuries	Nasogastric tube
Abdominal pain	Foley catheter placement
Head injury	Lumbar punctures
Otitis media	Intubation
Upper respiratory illnesses (bronchitis, pharyngitis)	Abscess drainage
Chest pain	Arterial lines and central venous line insertions
Headaches	Chest tube placement
Skin rash	Peritoneal lavage
	Soft tissue injury and wound care
	Wound suturing

More recently, PAs have been trained to use bedside ultrasonography for focused assessment with sonography for trauma (FAST) and visualization for minor procedures.[85] PAs performing procedures such as blood drawing and intravenous cannulation, and clinical duties, including clerical work and answering telephone calls, have reduced time the physicians spend performing

these tasks, allowing them more time to supervise trainees, consult with colleagues and care for sicker patients.[86]

These were all descriptive studies, some were chart or database reviews of what PAs actually did in the ED, some were based on expert opinions of what PAs should do in the ED.

2.6 Quality of care

Thirteen papers evaluated the quality of care provided by PAs in the ED by comparing PAs' performance of medical evaluation with those of ED physicians. These are grouped into four task categories.

2.6.1 Clinical decision and management

Table 3 summarizes the studies reporting performance related to clinical decision making and management.[86-92] All six studies were retrospective in nature, although most were moderate to strong in methodological quality. The exception to this was the Kozlowski study,[91] where there was risk of misclassification. In this study, the data surrounding analgesia prescription and health care providers in relation to patients' pain score was self-reported days after the ED visit. This data was not verified for accuracy against available health records data.

Though there were some statistical differences in the practice patterns between physicians and PAs, such as rates of test ordering (PAs ordered more throat cultures for pharyngitis and fewer blood cultures for febrile children), these were not compared to accepted standards of practice, nor were details around all clinical scenarios available to permit judgement. Moreover, no studies addressed whether these differences had any impact on the patients' outcome.

Table 3. Comparison of clinical decision and patient management in the ED

Study	Methods and outcome measures	Results
Hirshberg 1997[87]	Cross sectional survey of management of 5 hypothetical clinical cases. This is a comparison between management by primary care providers, ED physicians and PAs.	**Cystitis:** similar management patterns between ED physicians and PA. **Asthma:** PAs frequently reported using subcutaneous epinephrine and arterial blood gas, while no physicians reported using these. These interventions are not part of common asthma management guidelines. **Pharyngitis:** PAs more commonly requested rapid Strep tests (75% VS 20% p<0.0001) and complete blood count (33% V 5% p=0.008) than ED physicians. While complete blood count is not routinely recommended in the management of pharyngitis, the use of rapid Strep test is. **1 year old child with febrile viral symptoms:** PA reported requesting blood cultures less often than ED physicians (18 VS 50% p=0.008). There is no evidence supporting the routine use of blood cultures in the management of febrile children of this age. **Back strain**: PA reported requesting lumbar spine imaging more frequently than ED physicians (51 VS 15% p=0.008). Clinical information surrounding this hypothetical scenario was not available, preventing reflection on recommended practice.
Currey 1980[88]	Retrospective chart review, comparing guideline adherence for 2 ED clinical conditions.	**Pharyngitis:** Using results of throat swabs, PAs' diagnosis was confirmed 67.4% of the time, and ED physicians' diagnosis was confirmed 42.2% of the time (p<0.05) **Ankle trauma:** Both PA and ED physicians diagnosis were accurate >90% of the time. No significant difference was observed.
Roumie 2005[89]	Cross sectional survey of antibiotic prescription patterns for outpatient visits (including ED)	Antibiotic prescription patterns in the ED for PA and physicians were comparable.

Table 3 continued: Comparison of clinical decision and patient management in the ED

Study	Methods and outcome measures	Results
Kozlowski 2002[91]	Retrospective cohort of patients who were investigated with radiography at an ED for isolated lower extremity, comparing analgesia provision patterns. Surveys were conducted days following ED discharge and were dependent on patients' recall. Responses related to type of practitioner encounter and prescription, were not validated against health records.	ED physicians gave a significantly larger proportion of patients' analgesia (29% vs. 10%) and provided a prescription on discharge more frequently (44% vs. 21%). Of note, pain scores were reported by patients, days after the fact, data about analgesics provision and type of practitioner encounters was not verified using chart.
Ritsema 2007[92]	Retrospective cohort study of patients with long bone fractures coming to the ED comparing the quality of pain management amongst care providers.	Rates of receiving any analgesia was not associated with practitioner seen, however narcotic analgesic was significantly associated with having been seen by a PA (OR 2.05 95%CI 1.24-3.39).

2.6.2 Procedure performance

Table 4 summarizes four studies, which compared PAs and physicians' skills at performing procedures. The results suggest that outcomes of procedures conducted by PAs are comparable to that of physicians. The methodological quality of these studies was moderate to strong. Limitations included retrospective nature of the studies, with the exception of the two Singer's studies,[93,94] comparing the rates of wound infections and cosmetic appearances between wounds repaired by physicians and PAs, which were prospective, but provider assignments were not random and it is possible that challenging wounds were more frequently assigned to physicians.

Table 4. Comparison of procedure performances between physicians and PAs

Study	Methods and outcome measures	Results
Singer 1995[93]	Prospective cohort study comparing wound care practice and rate of wound infections amongst more junior providers* (medical students and junior residents) and experienced practitioners** (ED physicians, senior residents and PAs). Wound care was assigned in a non-randomized fashion, resulting in more experienced providers caring for facial wounds more frequently.	Junior providers* used pressure irrigation (42% vs. 26%, p<0.0001) and antibiotic ointment (74% vs. 59, p=0.0003) significantly more frequently then experienced providers**. They also performed deep sutures less often (17% vs. 28%, p=0.0007). Wound infection rates were not significantly different amongst care practitioners (PAs 3.6%, attending physicians 5.6%).
Singer 1996[94]	Retrospective review of a wound care registry comparing short term cosmetic appearance resulting from wound care performed by junior providers and more experienced practitioners (ED physicians, senior residents and PAs).	Proportion of repairs, which achieved the maximal cosmetic score, was higher in experienced practitioners as compared to junior practitioners (68% vs. 52%, p=0.016).
Kaups 1998[95]	Retrospective chart review examining the outcomes of intracranial pressure monitor placement by neurosurgeons, nurse practitioners and PAs.	There was no significant difference amongst various providers in rates of minor complications. No major complications were observed in either group.
Bevis 2008[96]	Retrospective chart review examining the outcomes of patients undergoing tube thoracostomy by trauma surgeons, advanced nurse practitioners and PAs.	There was no significant difference in the rate of adverse outcomes when comparing MDs and other providers. The quality of tube placement was only significantly different for tubes extending caudad, as this occurred in 11% of placements by a surgeon as compared to 21% of placements by other providers.

2.6.3 Patient outcomes

I found no study of outcomes of patients treated by PAs in the ED, but identified two studies of trauma services for which the studied patient population was likely in-patients but the initial care may have started in the ED. Rudy et al[97] compared the outcomes of patients treated by 14 NPs/PAs versus 16 resident physicians over a one-month period from two academic centers. They found no significant differences but were not able to control/adjust for important differences (e.g. age and level of acuity) in patient characteristics between the two groups.

A retrospective chart review at a large hospital compared patient outcomes treated by three different in-house trauma teams: 1) general surgery residents and staff surgeons vs. 2) trauma surgeons vs. 3) trauma surgeons with PAs.

The patients treated by Group 3, resulted in significant lower adjusted odds ratio for mortality and shorter length of stay (LOS) (decreased by less than half a day).[98] These trauma teams were implemented in sequence over three distinctive study periods (1999-2002, 2002-2005 and 2005-2006). Although analyses were adjusted for patient characteristics (demographics and injury severity), other variables pertaining to patient management (staffing policies in addition to having PAs on service, or clinical practice guidelines and their use which may have changed over time) were not taken into account. Although these studies were not sufficiently powered to determine equivalence, they suggest that patients' outcomes were not negatively affected by the implementation of PA on trauma services.

2.6.4 History taking and documentation

A prospective observational study assessed the completeness of medical records, specifically documentation of "cause of injury" data, amongst physicians, PAs and NPs, residents and medical students working in an ED.[99] Health care providers' documentation was compared to that of research assistants trained to document a comprehensive history ("gold standard"). There was significant loss of information across all health care providers at the history taking stage (they only elicited 68% of all pertinent information retrieved by the research assistant) and at the documentation stage (only 67% of information was documented); however the key finding was that there were no significant differences in amount of loss of information between physicians, PAs and NPs.

2.7 Impact on patient flow and cost.

Four papers reported the results of primary studies regarding the effect of PA on ED system outcomes. The most recent study (2009) reports the outcome of introducing PAs and NPs as additional providers in six EDs in Ontario, Canada.[100] The proportion of patient visits meeting waiting time benchmark by acuity level using the Canadian Triage and Acuity Scale (CTAS) and LOS were compared during a two-week period before and after PAs were introduced to

the ED. The waiting time benchmarks as recommended by the CTAS tools are: CTAS 1: immediate assessment, CTAS 2: less than 15 minutes, CTAS 3: less than 30 minutes, CTAS 4: less than 60 minutes and CTAS 5: less than 120 minutes.

After adjustments for hospital site, time of day and patient acuity level, the odds of achieving the waiting time benchmarks were 1.9 [95%CI 1.6-2.4] for patients visiting the ED after PA implementation compared to the pre-implementation period. The average ED LOS when a PA was present was 9% shorter than before PAs were introduced (304.2 minutes down to 277.2 minutes). ED patient volume varies greatly over time, and patient volume can affect ED patient flow, thus the very short study period limits our ability to interpret and generalize the PA impact over a longer time period.

In another study in the US, implementing a fast track unit staffed by a PA (previously working alongside a physician in a single track ED) and a technician resulted in a reduction in LOS (from 127 to 53 minutes on average), among patients triaged to a low acuity level. Patient satisfaction was significantly higher among these patients after PA implementation; only 36% of patients were willing to wait longer to see a physician.[101] No cost analyses were performed, although 2.0 full time equivalents of a technician were added to the system to help staff the fast track unit.

A retrospective review of urgent care clinic charts revealed that PAs took slightly more time (total length of visit 82 vs. 75 minutes) to assess and treat patients, than physicians, while PAs' total charges per visit was slightly lower ($159 vs. $164).[102] The breadth of clinical conditions seen by both providers was similar, but there was a significant difference in the demographics of patients seen (PA saw fewer pediatric patients than physicians). In addition, the work shifts evaluated in the study were different: mornings for PA, and evenings for physicians. The effect of ED volume surges and access to resources (ancillary investigations or specialist consultations) is likely different between these scheduled shifts, but were not discussed.

A rural ED staffed by either rotating physicians or PAs for its overnight coverage found that the net cost to the organization, of using physicians (net loss of US $50) was higher than that of using PAs (to a gain of US $260 dollars) per overnight shift, due to increased billings by PAs, compared to the cost of their employment.[103] However this study's applicability to Canadian EDs is limited, because reimbursement arrangements are different in a single payer system.

These four studies did not control for important confounders such as patient characteristics, ED volumes and access to ancillary services at times when PAs were providing care that may have affected patient flow. Available cost estimates only weakly support using PAs to reduce costs.

2.8 Acceptance

There were four articles studying the attitudes of physicians toward the use of PAs in the ED and their opinions regarding PA skills and aptitudes.

In a survey of American ED physicians' opinion of PAs US (N=960 with 29% response rate) where 91% of respondents had worked with a PA, found that ED physicians were confident in PAs' overall performance.[104] PAs' performance was rated highest for patient education (3.9 out of 5), history and physical examination (4 out of 5) while diagnosis (3.5 out of 5) and clinical management (3.6 out of 5) was rated slightly lower. Respondents also rated PAs overall utility, cost effectiveness and capability in the ED at 5.2 out of 7. Physicians however commented that PAs did not have enough educational training in emergency medicine topics.

Two studies surveyed non-ED physicians regarding their opinion on PAs working in the ED. A US survey from 1972,[105] found that most physicians, almost 40 years ago, felt that PAs were able to take a good medical history and provide patient care relevant to the ED. The other survey was addressed to primary care physicians[106] of whom 78.5% had previously worked with PAs.[100] 80% of respondents felt that PAs are competent to handle routine care, but did

not feel that ED coverage was a priority when it comes to PAs' scope of practice.

Larkin et al[107] undertook a cross-sectional survey of senior ED residents acting as patients using case-based scenarios. There was a preference to be treated by moonlighting senior ED residents, followed by PAs, and then NPs; the willingness to be treated by a PA decreased as the severity of the clinical scenario increased (44.3% dropping to 0.8%). In the scenario of being the parent of a young child, the willingness to receive care by a PA was to 38.3%. If a physician were also to evaluate them, however, 83.7% of respondents were willing to see a PA as an initial step. The overall responses suggest that physicians find the use of PAs in the ED acceptable.

Only two articles evaluated patient satisfaction with PA care in the ED. A survey of ED patients where PAs manage low acuity patients found high satisfaction with the care provided by PAs (mean patient satisfaction score: 93 out of 100)[108]. Another study, surveying trauma patients cared for by PAs, found that 85% were very satisfied with the care they received.[109] While both studies reported high patient satisfaction with the care provided by PAs, they also had low response rates (11% and 25% respectively).

2.9 Conclusions

PAs have commonly been used in EDs in the US, where they provide quality of care that is comparable to that of physicians, albeit within their narrower scope of practice. PAs working in EDs have been shown to have high patient satisfaction ratings, and other health care providers generally accept them. This suggests that PAs, with their less extensive training and skills, could provide satisfactory care to large numbers of children with low acuity problems, as a less costly alternative to hiring more pediatric sub-specialists.

However, the literature on PAs in PEDs is limited. Although almost 20% of PEDs in the US use PAs, there are no published reports of PAs' impact, or guidelines to ensure their safe and standard use in the PED.

Chapter 3. Role definition for physician assistants in a pediatric emergency department

Current practice in the US, Ontario, Alberta, and Manitoba dictates that PAs work under the supervision of a physician. While the degree of supervision (physician directly reviews and assesses all patients or just reviews the documentation) is often open to interpretation and to physician-PA preferences and negotiated roles and responsibilities, all patients managed by PAs in PEDs will ultimately remain the responsibility of the attending emergency pediatrician. Therefore, assessing acceptability of PAs by pediatric emergency physicians is essential if PA introduction to Canadian PED is to be considered. The differences in care patterns and funding mechanisms between the US and Canada raise the question of whether PAs will be accepted in Canada to the same extent as the US. An initial step is the need to gather opinions of Canadian PED physicians on the appropriate level of involvement and degree of supervision PAs should require with non-emergent common clinical conditions managed in a PED.

3.1 Administrative review of pediatric emergency department utilization: study objectives

The first of the following two studies reviews all visits to a Canadian PED to outline the clinical conditions currently treated by PED physicians and to describe how frequently they are managed in the PED, how long they stay in the department, and how often they require hospital admission. This information is then used to survey the opinions of a group of clinicians including invited PAs and physicians at one Canadian PED to determine which conditions they consider suitable for assessments by PAs, the level of therapeutic involvement PAs should have, and to estimate the proportion of the total PED volume that PAs could potentially manage.

3.1.1 Methods

Pediatric ED utilization characterization

I reviewed the British Columbia Children's Hospital (BCCH, Vancouver, British Columbia, Canada) PED administrative database (2007) provided by the Provincial Health Service Authority (PHSA) decision support services to define patient visits' characteristics. BCCH is the only pediatric tertiary care hospital and referral center in the province of British Columbia.

The PED at BCCH and most PEDs in Canada use the pediatric Canadian triage and acuity scale (CTAS)[110] to triage children visiting the PED. There is good inter-rater agreement for assignment of triage level using the pediatric CTAS tool and it has been validated by two Canadian multicenter studies, demonstrating good correlation between CTAS levels and markers of severity, patient outcome and PED resource utilization.[111,112]

It was decided *a priori* that since patients triaged to the highest acuity levels, or CTAS levels 1 (need resuscitation) and 2 (need emergent care) are required to be seen by a physician with the highest priority, in our setting, the direct contribution of PAs to these patients would be limited. All CTAS 1 and 2 visits were therefore excluded from detailed analyses.

For the remainder of the ED visits (CTAS 3: urgent, CTAS 4: semi urgent, and CTAS 5: non-urgent), two investigators independently assigned each visit an International Statistical Classification of Diseases and Related Health Problems 10th revision code (ICD 10), an international standard diagnostic classification commonly used for epidemiological, clinical, or administrative purposes, which most closely reflected the patient's presenting complaint. The presenting complaint consisted of a 1-10 word description of the reason for the PED visit as provided by the patients' family and entered by the triage nurse upon arrival to the ED. For the few visits with missing presenting complaint entries, the discharge diagnosis was used to assign the ICD 10 code. The reason for coming to the PED was used when available rather than the

discharge diagnosis because the decision to involve a PA in a case occurs at the initial encounters, before a final diagnosis is made.

To assess agreement, both investigators coded an overlapping 15% of the database. Individual codes were collapsed into related common clinical categories. For example, ICD 10 codes S 40-99, coding for a variety of specific upper and lower limb injuries and T 10-13, coding for non-specific upper and lower limb injuries, were collapsed in to “Extremity injuries”.

For each of these clinical categories, I reported total visits for the year, mean PED total LOS in minutes, mean waiting time to be seen by the physician after arrival to the PED in minutes, rate of admission to the hospital, and proportion of patients leaving without being seen by a physician (LWBS), presumably for waiting longer than they feel is warranted to see a physician.

Clinical categories selection for PA involvement in PEDs.

An invitation to participate in this study was sent to all physicians working regularly at the BCCH PED, as well as to a convenience sample of PAs living or working in the North West Pacific region (British Columbia, Canada and Washington, USA) introduced to us by the president of the Canadian Association of PAs in 2006.

A single meeting was held where five invited PAs introduced themselves to the participating BCCH PED physicians. Among the invited PAs, there was a PA training program director and a recent PA graduate who discussed the breadth of the PA training program in the US, and two PAs practicing in the US (Washington state), who described the scope of their practice. One of them worked in a general ED and the other worked in an urgent care clinic, both had treated a large volume of children. Lastly, a retired Canadian military PA and past president of the Canadian Association of PAs shared his experience and the current status of PA practice in Canada. Participants were encouraged to discuss unresolved questions about PA scope of practice in the US, and share their experience during an open forum and through one on one exchange after the presentation session.

The PAs' introduction was followed by a presentation of the results of the database review: the various non-emergent clinical conditions with their characteristics, and utilization patterns.

A survey form summarizing the clinical categories with their characteristics was emailed to all participants following the meeting. For each clinical category, participants were asked to choose whether PAs should: 1) not be involved in managing these cases at all, 2) manage these cases with direct physician supervision, in other words, the PA sees the patients, initiates investigations and treatment, then a physician reviews the patient with the PA prior to final patient disposition, or 3) manage the case without direct physician involvement, where the PED physician only reviews and signs off the charts on PA managed patients, including situations after the patient has left the PED.

There is no precedent for, or standard accepted minimal proportion of, participants' agreement on a condition to determine appropriateness for management by PAs. It was therefore arbitrarily defined *a priori* and conservatively that clinical conditions with ≤15% of respondents selecting "no PA involvement" would be considered appropriate for PA management in defining the scope of practice for PAs in PED.

I used descriptive statistics to summarize the data; proportions and averaged time durations are presented with 95% confidence intervals. I used the chi-square test to compare differences in admission rates and analyses of variance to compare differences in averaged waiting time and LOS between ED visits for conditions selected for different level of PA involvement.

3.1.2 Results

The BCCH ED received 38,721 visits in 2007, of which 0.4% were triaged to CTAS level 1 (requires resuscitation), 8.8% to CTAS level 2 (needs emergent care), 35.9% to CTAS level 3 (urgent), 52.6% to CTAS level 4 (semi-urgent) and 2.3% to CTAS level 5 (non-urgent). Of the 35,169 visits triaged to CTAS Level 3-5, we had enough information on 35,077 visits to categorize them using the ICD 10 codes, into 56 main clinical categories and one additional category consisting of scheduled return visits for intravenous therapy as an outpatient through the PED, which is an established service provided at BCCH ED, for a total of 57 categories.

There was 90% agreement between the two reviewers' coding. Disagreement consisted of minor variations in the choice of ICD10 subcategory detailed coding. When the visits were collapsed into the 57 clinical categories, there was 100% agreement between the two reviewers.

There was missing information for several data points. The presenting complaint was missing in 6% of cases, which required using the patient's discharge diagnosis to categorize the visit. The least consistently recorded data point was the time of physician assessment; hence the waiting time variable was frequently missing. The rate of missing waiting time was highly variable between the 57 clinical categories, ranging from 9% to 77%. The clinical categories with the most missing waiting times were those involving pediatric subspecialties, such as liver and kidney related complaints.

Absolute number of visits, averaged ED total LOS, waiting time, admission rate, proportion of visits for which the patient left without being seen by a physician for each of these 57 categories are presented in table 5.

Table 5: PED clinical categories and visit characteristics.

Clinical presentation categories	N	Mean LOS mins (95% CI)		Mean waiting time mins (95% CI)		Admission rate (95% CI)	
Bug bites	115	100	(89, 110)	62	(55, 70)	0	(0.00, 0.03)
Ear pain or discharge	1017	109	(104, 113)	73	(70, 76)	0	(0.00, 0.01)
Hives & rash	1185	129	(124, 135)	79	(76, 82)	0.01	(0.00, 0.02)
Burns	115	130	(116, 144)	71	(62, 80)	0.03	(0.01, 0.09)
Oral/dental disease	214	133	(121, 145)	69	(63, 75)	0.04	(0.02, 0.07)
Recheck (out patient intravenous treatment)	1988	134	(129, 139)	65	(63, 67)	0.01	(0.01, 0.01)
Post-procedural complication	71	134	(113, 154)	76	(64, 88)	0.06	(0.02, 0.14)
Eye complaints	660	136	(128, 143)	78	(74, 81)	0.02	(0.01, 0.03)
Viral eruptions	269	138	(126, 149)	78	(72, 83)	0.03	(0.01, 0.06)
Epistaxis	167	141	(125, 157)	78	(69, 86)	0.03	(0.01, 0.07)
Minor head injuries	2411	141	(137, 145)	81	(79, 83)	0.03	(0.02, 0.04)
Back injuries	77	143	(127, 160)	87	(75, 98)	0.06	(0.02, 0.15)
Male genito-urinary	284	143	(131, 156)	73	(68, 79)	0.03	(0.01, 0.06)
Animal bites	80	144	(123, 166)	78	(64, 91)	0.03	(0.00, 0.09)
Voiding dysfunction	339	152	(142, 163)	81	(75, 86)	0.03	(0.01, 0.05)
Motor vehicle collision/pedestrian strike	95	154	(134, 174)	76	(66, 86)	0.08	(0.04, 0.16)
Hernia	78	156	(134, 179)	68	(60, 75)	0.14	(0.07, 0.24)
Crying	345	156	(145,166)	83	(76, 89)	0.01	(0.00, 0.03)
Multi-site injuries	23	159	(127, 192)	69	(55, 83)	0.13	(0.03, 0.34)
Acute upper respiratory tract infection	4769	160	(156, 163)	83	(82, 85)	0.01	(0.01, 0.02)
Extremity Injuries	4152	160	(156, 164)	76	(74, 77)	0.03	(0.03, 0.04)
Foreign body removal	449	161	(148, 175)	77	(72, 82)	0.06	(0.04, 0.08)
Fall	74	166	(122, 210)	81	(70, 91)	0	(0.00, 0.05)
Allergic reactions	269	167	(153, 180)	73	(68, 78)	0.03	(0.01, 0.06)
Chest/abdominal Injury	90	168	(144, 191)	79	(70, 89)	0.16	(0.09, 0.25)
Neoplasm (undifferentiated masses)	156	174	(156, 191)	82	(74, 90)	0.38	(0.30, 0.46)
Device malfunction (cast/tubes/lines)	458	175	(159, 192)	72	(67, 78)	0.08	(0.06, 0.11)
Soft tissue infection	779	181	(172, 191)	80	(77, 84)	0.13	(0.11, 0.16)
Female genito-urinary	72	182	(140, 224)	81	(62, 100)	0.13	(0.06, 0.22)
Chest pain	180	182	(167, 197)	81	(73, 88)	0.01	(0.00, 0.04)
Assault	73	184	(156, 212)	72	(58, 86)	0.04	(0.01, 0.12)
Upper gastro-intestinal (reflux like)	140	185	(167, 203)	89	(81, 98)	0.08	(0.04, 0.14)
Vomiting/diarrhea	3611	188	(183, 192)	87	(85, 89)	0.04	(0.04, 0.05)
Liver disease	28	194	(141, 247)	42	(26, 59)	0.73	(0.52, 0.88)
Feeding issues	117	197	(174, 221)	96	(85, 106)	0.11	(0.06, 0.18)
MSK & rheumalologic (joint and limb)	641	200	(189, 211)	78	(74, 82)	0.13	(0.10, 0.16)
Acute lower GI (no-specific abdominal pain)	2079	200	(193, 207)	83	(81, 86)	0.13	(0.12, 0.15)
Lower airway complaints (respiratory distress)	2733	203	(197, 209)	88	(85, 90)	0.10	(0.09, 0.11)
GI bleed	250	211	(196, 226)	89	(83, 96)	0.15	(0.11, 0.20)
Neonatal jaundice	117	212	(194, 231)	91	(81, 101)	0.14	(0.08, 0.22)
Cardiac symptoms	75	220	(189, 252)	77	(65, 90)	0.34	(0.23, 0.46)
Non-infectious upper resp. symptoms	52	221	(182, 260)	87	(73, 100)	0.38	(0.25, 0.53)
Dizzy-Faint	187	221	(205, 238)	94	(85, 103)	0.04	(0.02, 0.08)
Chronic lower GI (eg.Inflammatory Bowel Disease)	52	228	(185, 270)	88	(66, 111)	0.67	(0.53, 0.80)
Medical drug Ingestion	52	229	(189, 269)	71	(58, 83)	0.21	(0.11, 0.35)
Episodic (headaches, seizure disorders)	965	233	(224, 242)	88	(85, 92)	0.20	(0.18, 0.23)
Bone diseases	63	234	(195, 274)	71	(60, 83)	0.34	(0.28, 0.56)
Focal neurological abnormality	141	236	(212, 259)	91	(82, 100)	0.31	(0.24, 0.30)
Severe bacterial infection (undifferentiated fever)	1053	238	(229, 248)	88	(85, 91)	0.19	(0.16, 0.21)
Hematology	151	241	(218, 265)	79	(69, 90)	0.42	(0.34, 0.50)
Non-medical ingestions (recreational)	130	246	(216, 276)	79	(67, 90)	0.13	(0.13, 0.20)
Metabolic/endocrinologic	175	249	(218, 280)	88	(78, 98)	0.34	(0.27, 0.41)
Renal	74	261	(215, 306)	91	(79, 102)	0.46	(0.34, 0.68)
Acute life threatening event (blue spell)	45	270	(206, 334)	81	(67, 96)	0.61	(0.45, 0.75)
Psych/mental health complaint	428	276	(258, 293)	107	(98,115)	0.32	(0.28, 0.37)
Known asthmatics in exacerbation	632	276	(262, 291)	90	(85, 95)	0.11	(0.09, 0.14)
Immuno-deficiency related complaints	32	309	(221, 398)	79	(59, 100)	0.28	(0.14, 0.47)

A total of 22 health care professionals participated in this project: 13 of 17 invited Pediatric Emergency trained physicians working at BCCH (two had previously worked with PAs outside Canada), four pediatric emergency sub-specialty clinical fellows and five PAs. Of these, 21 returned a completed survey, with a 95% response rate. At least 85% of respondents felt that it was appropriate for PAs to be involved in the care of patients coming to the ED for 30 of 57 non-emergent clinical conditions presented. These represented 82% of ED visits that are triaged to CTAS 3-5, or 74% of the total PED annual volume. In addition, of these, three clinical conditions were found by 80% of respondents to be appropriate for PA management without direct physician supervision.

Table 6. PED clinical categories selected as appropriate for PA management

Clinical presentation	N	PA without direct supervision: proportion of respondents (95% CI)	PA with direct supervision: proportion of respondents (95% CI)	No PA involvement: proportion of respondents (95% CI)
Bug bites	115	0.86 (0.65, 0.97)	0.14 (0.03, 0.36)	0.00 (0.00, 0.16)
Ear pain or discharge	1017	0.86 (0.65, 0.97)	0.14 (0.03, 0.36)	0.00 (0.00, 0.16)
Acute URTI	4769	0.81 (0.58, 0.95)	0.19 (0.05, 0.42)	0.00 (0.00, 0.16)
Epistaxis	167	0.76 (0.53, 0.92)	0.24 (0.08, 0.47)	0.00 (0.00, 0.16)
Hives & rash	1185	0.76 (0.53, 0.92)	0.24 (0.08, 0.47)	0.00 (0.00, 0.16)
Vomiting/diarrhea	3611	0.62 (0.38, 0.82)	0.38 (0.18, 0.62)	0.00 (0.00, 0.16)
Animal bites	80	0.57 (0.34, 0.78)	0.43 (0.22, 0.66)	0.00 (0.00, 0.16)
Foreign body removal	449	0.48 (0.26, 0.70)	0.52 (0.30, 0.74)	0.00 (0.00, 0.16)
Oral/dental disease	214	0.48 (0.26, 0.70)	0.52 (0.30, 0.74)	0.00 (0.00, 0.16)
Burns	115	0.43 (0.22, 0.66)	0.57 (0.34, 0.78)	0.00 (0.00, 0.16)
Allergic reactions	269	0.33 (0.15, 0.57)	0.67 (0.43, 0.85)	0.00 (0.00, 0.16)
Extremity injuries	4152	0.29 (0.11, 0.52)	0.71 (0.48, 0.89)	0.00 (0.00, 0.16)
Fall	74	0.14 (0.03, 0.36)	0.86 (0.65, 0.97)	0.00 (0.00, 0.16)
Recheck (out patient IV treatment)	1988	0.62 (0.38, 0.82)	0.33 (0.15, 0.57)	0.05 (0.00, 0.24)
Viral eruptions	269	0.62 (0.38, 0.82)	0.33 (0.15, 0.57)	0.05 (0.00, 0.24)
Dizzy-faint	187	0.43 (0.22, 0.66)	0.52 (0.30, 0.74)	0.05 (0.00, 0.24)
Non-infectious upper resp. symptoms	52	0.38 (0.18, 0.62)	0.57 (0.34, 0.78)	0.05 (0.00, 0.24)
Feeding issues	117	0.29 (0.11, 0.52)	0.67 (0.43, 0.85)	0.05 (0.00, 0.24)
Non-medical ingestions	130	0.19 (0.05, 0.42)	0.76 (0.53, 0.92)	0.05 (0.00, 0.24)
Back injuries	77	0.43 (0.22, 0.66)	0.48 (0.26, 0.70)	0.10 (0.01, 0.3)
Upper GI (GERD like)	140	0.33 (0.15, 0.57)	0.57 (0.34, 0.78)	0.10 (0.01, 0.3)
Voiding dysfunction	339	0.29 (0.11, 0.52)	0.62 (0.38, 0.82)	0.10 (0.01, 0.3)
Device malfunction (cast/tubes/lines)	458	0.19 (0.05, 0.42)	0.71 (0.48, 0.89)	0.10 (0.01, 0.3)
Acute lower GI (abdominal pain)	2079	0.19 (0.05, 0.42)	0.67 (0.43, 0.85)	0.14 (0.03, 0.36)
Eye complaints	660	0.19 (0.05, 0.42)	0.67 (0.43, 0.85)	0.14 (0.03, 0.36)
Hernia	78	0.19 (0.05, 0.42)	0.67 (0.43, 0.85)	0.14 (0.03, 0.36)

Table 6 continued. PED clinical categories selected as appropriate for PA management

Clinical presentation	N	PA without direct supervision: proportion of respondents (95% CI)	PA with direct supervision: proportion of respondents (95% CI)	No PA involvement: proportion of respondents (95% CI)
Lower airway complaints (respiratory distress)	2733	0.19 (0.05, 0.42)	0.67 (0.43, 0.85)	0.14 (0.03, 0.36)
Minor head injuries	2411	0.19 (0.05, 0.42)	0.67 (0.43, 0.85)	0.14 (0.03, 0.36)
Female GU	72	0.14 (0.03, 0.36)	0.71 (0.48, 0.89)	0.14 (0.03, 0.36)
MSK & rheum (joint and limb)	641	0.10 (0.01, 0.3)	0.76 (0.53, 0.92)	0.14 (0.03, 0.36)

Table 7. PED clinical categories not selected as appropriate for PA management

Clinical presentation	N	PA without direct supervision: proportion of respondents (95% CI)	PA with direct supervision: proportion of respondents (95% CI)	No PA involvement: proportion of respondents (95% CI)
Chronic lower GI (IBD, congenital)	52	0.24 (0.08, 0.47)	0.57 (0.34, 0.78)	0.19 (0.05, 0.42)
Crying	345	0.24 (0.08, 0.47)	0.57 (0.34, 0.78)	0.19 (0.05, 0.42)
Episodic (headaches, seizure disorders)	965	0.19 (0.05, 0.42)	0.62 (0.38, 0.82)	0.19 (0.05, 0.42)
Soft tissue infection	779	0.48 (0.26, 0.70)	0.29 (0.11, 0.52)	0.24 (0.08, 0.47)
Known asthmatics in exacerbation	632	0.24 (0.08, 0.47)	0.52 (0.30, 0.74)	0.24 (0.08, 0.47)
Neonatal jaundice	117	0.24 (0.08, 0.47)	0.52 (0.30, 0.74)	0.24 (0.08, 0.47)
Psych/mental health complaint	428	0.24 (0.08, 0.47)	0.52 (0.30, 0.74)	0.24 (0.08, 0.47)
Bone diseases	63	0.05 (0.00, 0.24)	0.71 (0.48, 0.89)	0.24 (0.08, 0.47)
Chest pain	180	0.05 (0.00, 0.24)	0.71 (0.48, 0.89)	0.24 (0.08, 0.47)
Post-procedural complication	71	0.24 (0.08, 0.47)	0.48 (0.26, 0.70)	0.29 (0.11, 0.52)
Medical drug Ingestion	52	0.10 (0.01, 0.3)	0.62 (0.38, 0.82)	0.29 (0.11, 0.52)
Renal	74	0.05 (0.00, 0.24)	0.67 (0.43, 0.85)	0.29 (0.11, 0.52)
Male GU	284	0.19 (0.05, 0.42)	0.48 (0.26, 0.70)	0.33 (0.15, 0.57)
Chest/abdominal injury	90	0.05 (0.00, 0.24)	0.62 (0.38, 0.82)	0.33 (0.15, 0.57)
MVC/pedestrian strike	95	0.05 (0.00, 0.24)	0.62 (0.38, 0.82)	0.33 (0.15, 0.57)
Assault	73	0.10 (0.01, 0.3)	0.52 (0.30, 0.74)	0.38 (0.18, 0.62)
Severe bacterial infection (undifferentiated fever)	1053	0.10 (0.01, 0.3)	0.52 (0.30, 0.74)	0.38 (0.18, 0.62)
Metabolic/endocrinologic	175	0.10 (0.01, 0.3)	0.38 (0.18, 0.62)	0.52 (0.30, 0.74)
GI bleed	250	0.00 (0.00, 0.16)	0.48 (0.26, 0.70)	0.52 (0.30, 0.74)
Liver disease	28	0.05 (0.00, 0.24)	0.38 (0.18, 0.62)	0.57 (0.34, 0.78)
Multi trauma	23	0.00 (0.00, 0.16)	0.43 (0.22, 0.66)	0.57 (0.34, 0.78)
Cardiac symptoms	75	0.10 (0.01, 0.3)	0.29 (0.11, 0.52)	0.62 (0.38, 0.82)
Hematology	151	0.05 (0.00, 0.24)	0.33 (0.15, 0.57)	0.62 (0.38, 0.82)
Focal neurological abnormality	141	0.00 (0.00, 0.16)	0.38 (0.18, 0.62)	0.62 (0.38, 0.82)
ALTE	45	0.00 (0.00, 0.16)	0.33 (0.15, 0.57)	0.67 (0.43, 0.85)
Neoplasm (undifferentiated masses)	156	0.00 (0.00, 0.16)	0.33 (0.15, 0.57)	0.67 (0.43, 0.85)
Immuno-deficiency related	32	0.10 (0.01, 0.3)	0.19 (0.05, 0.42)	0.71 (0.48, 0.89)

The average LOS in the ED, waiting time, and admission rates were statistically different ($p < 0.001$) between clinical conditions that were deemed appropriate and not appropriate for PA involvement. However, only differences in average LOS in the ED and admission rates were clinically meaningful as there was minimal difference in wait time among the groups. The conditions not selected for PA management had longer mean LOS and higher admission rate than those selected for PA management.

Table 8. Mean LOS, waiting time and admission rates comparisons between clinical categories by selected level of PA involvement.

	No PA involvement N=27 conditions 6,429 visits	PA involvement with MD direct supervision N= 30 conditions 22,746 visits	PA management without direct MD supervision N= 3 conditions 5,901 visits	p (value)
Mean LOS in min (95%CI)	219 (215, 223)	169 (167, 170)	123 (86,160)	<0.001
Mean waiting time in min (95%CI)	85 (83, 87)	80 (79, 81)	73 (61,85)	<0.001
Mean admission rate (95%CI)	0.190 (0.184, 0.203)	0.053 (0.051, 0.057)	0.011 (0,009, 0.015)	<0.001

3.1.3 Discussion

We conducted this study because of the paucity of information on PAs' potential contribution to pediatric emergency care. A large proportion of pediatric ED visits are for low acuity clinical problems and these could potentially be managed by PAs. Despite the fact that PAs have been providing care for children in EDs in the US for many years,[64] the systematic review (Chapter 2) of PAs in EDs found no articles specifically defining the role of, or type of patients seen by, PAs in a pediatric ED. This study's results suggest that a large proportion of visits to a tertiary care center Pediatric ED may be appropriate for management by PAs because of low acuity or complexity of conditions. Over 85% of respondents agreed that PAs could care for more than half of the presenting conditions. These health conditions were common reasons for visiting the ED and were responsible for approximately three quarters of all pediatric ED visits. Furthermore, the group felt that a PA could

manage 15% of all pediatric ED visits (or 21% of CTAS 4 or 5 visits) without direct clinical supervision by an ED physician.

The high rate of acceptance of PAs in this survey is consistent with the general literature on PAs working in general EDs.[104] This study reflects the opinions of pediatric ED physicians and PAs working in acute care settings, and not observations of actual PAs' scope of practice in pediatric EDs. Despite a high response rate, those surveyed represent a small group relative to the number of pediatric ED physicians and clinical trainees across Canada. Furthermore, the physicians who participated in the study were all from the same pediatric ED (BCCH), and this may represent a relatively homogenous group compared to the opinion of those who work in pediatric EDs across Canada. The database of ED visits was also from only one pediatric institution in Canada.

In addition, inherent to all retrospective reviews of administrative database, missing data and potentially inaccurate entries may have introduced errors in diagnostic classification and influenced the indicators of healthcare utilization and system performance. However, a random sample of data was independently reviewed by both reviewers and resulted in perfect agreement in clinical category assignment. There were varying proportions of missing waiting time data by clinical category, those with the highest rate of missing waiting time were those primarily managed by pediatric subspecialties (rather than emergency pediatricians), such as complaints of liver, kidney and neurological diseases. Clinical categories with highest rates of missing waiting time data were also less frequently selected for PA management. Although surveyed subjects were presented with the rate of missing waiting data associated with clinical categories, we suspect that the reluctance to involve PAs with these clinical categories is due to the potential complexity or acuity associated with these conditions rather than the high rate of missing waiting time.

This study suggests that PAs could play an important role in pediatric EDs by relieving emergency pediatricians from personally attending to a sizable

proportion of ED visits. This could potentially reduce wait times, permitting PED physicians to play a supervisory role in low acuity cases and provide more time to manage higher complexity cases.

3.2 National survey of pediatric emergency physician on physician assistants' scope of practice: study objectives

The previous study demonstrated that a large proportion of visits to a tertiary care center PED for relatively low acuity clinical conditions, requiring limited medical treatment (low admission rates and during which patients/families spent more time waiting than receiving care), may be amenable to management by PAs. Due to the small sample size and anticipated practice variation in Canada, the degree of physician acceptability of PAs needs to be validated with a larger survey including physicians from a wider range of ED centers in Canada. This national survey was undertaken to verify the range of clinical conditions Canadian emergency pediatricians consider appropriate for PA management and the degree of supervision PAs should require in the PED.

3.2.1 Methods

This cross sectional pan-Canadian survey targeted physicians practicing pediatric emergency medicine in Canada, potential supervisors of PAs in PEDs. All physicians registered in the Pediatric Emergency Research Canada (PERC) network database were invited to participate. This database is maintained for academic purposes under the direction of the PERC executive. It contains contact information for 297 physicians, capturing approximately 70% of physicians practicing pediatric emergency medicine regularly in Canada. The PERC executives reviewed and approved this study protocol and questionnaire forms before we received access to the physician registry.

Using a modified Dillman survey methodology,[113] a standardized email was sent to the database registrants informing them of the nature of the study (background, along with a short description of PAs, their training in Canada, and experience in the US healthcare system), rationale, objectives and their rights associated with their decision to participate or decline as study subjects.

Within 24 hours, a follow up email from Active Campaign Survey connected all study subjects to the online questionnaire. A scheduled reminder email was sent only to non-responders. The survey schedule and reminder was sent two weeks, one month, two months, and two and a half months following the original invitation. Finally, a hard copy mail out survey was sent at 3 months post initial survey deployment.

Communication with individuals to solicit their participation was done with standardized emails. Although participation status was tracked using unique links, there was no attempt to identify individual participants for any other reasons nor were they contacted outside of the original study participation invitation and three reminder emails. Once data entry and validation were complete, the unique responder tracking identification was removed to prevent further linkages. Completion of the survey was taken as the respondent's consent to participate. No financial incentives for survey completion were offered.

Three types of information were collected: demographics, familiarity with PAs, and PA clinical roles in PED determination. Demographic information included respondents' age, the number of years they have practiced pediatric emergency medicine, the size of the ED center in which they practice expressed as average annual visits, and their method of remuneration (fee for service billing, fixed annual salaries, or on service contract and paid by the shift or by the hour).

Respondents' familiarity with PAs was explored by recording their awareness of PAs as clinicians having heard or read about them, previous clinical work experience with PAs (whether in training or employed graduated PAs), previous involvement in educating PAs or in policy work surrounding the legislation of PAs.

Respondents were asked what degree of PA involvement they felt was appropriate for each clinical condition with which they were presented. The three response options for degree of PA involvement were: (1) none: PAs

should not be involved in the care of a child with this condition, (2) PAs can manage the care of a child with this condition but with direct physician supervision and involvement, and (3) PAs can manage the care of a child with this clinical condition without direct physician involvement and indirect supervision only is appropriate (for example, reviewing the chart and co-signing it after patient management is completed and disposition has been decided on).

The previous review of all visits to a tertiary care PED department had identified 57 commonly treated, non-emergent clinical conditions, triaged as pediatric CTAS 3, 4, or 5, which could be managed by PAs. Although the same 57 conditions were used in this study, the label for each condition offered a more explicit description, to ensure clarity. This was deemed necessary because no face-to-face meeting to discuss these conditions preceded this survey, unlike in the previous study. Due to the large number of clinical conditions to assess and concerns about survey length, these 57 clinical conditions were randomly divided into two sets of 28 and 29 conditions, and each respondent was presented with only one of the two sets, chosen at random. The random number generator function in Microsoft Excel was used to select 150 of the 297 subjects to receive the first set of the clinical conditions; the remaining subjects received the second set.

Similar to the previous survey, it was arbitrarily defined *a priori* that: clinical conditions with ≥15% of respondents selecting “no PA involvement” would be considered inappropriate for PA management in defining the scope of practice for PAs in PED. I used descriptive statistics to summarize respondents’ demographic information and familiarity with PAs. For each of the 57 clinical conditions, the proportion of respondents choosing each of the three levels of PA involvement was reported with 95% confidence intervals (CIs). In addition, for each of the respondents, the proportion of clinical conditions for which the respondent selected either “(2) PAs can manage the care of a child with this condition but with direct physician supervision and involvement” or “(3) PAs can manage the care of a child with this clinical condition without direct physician involvement and indirect supervision only is appropriate” was recorded as an

index of physician acceptance of PAs. The role of demographic background and familiarity with PA on physician acceptance of PA was explored by presenting the difference (and 95% CI) between the mean proportion of clinical conditions selected as appropriate for PA involvement (with or without direct physician supervision) for each subgroup and the reference subgroup for each demographic variable or level of PA familiarity.

An estimated sample size of 49 respondents per clinical condition was required to find 85% of respondents selecting “PA management without direct MD involvement”, or alternatively 15% of respondents selecting “no PA involvement” with 95% confidence and precision level of 10%.

3.2.2 Results

A total of 297 physicians were contacted by email and in some cases (non-responders to emails), mailed out surveys. Of these,152 physicians completed the survey, with a response rate of 51.2%. Respondents’ demographic information is presented in table 9.

Ninety-five percent of respondents were between 30 to 60 years of age with the greatest number (38%) between 30-39 years of age. The number of years of working experience in an ED was fairly evenly distributed between less than 5 years to over 15 years. The majority (86%) of respondents work in a dedicated pediatric ED, and in centers with over 40 000 visits annually (76%). Only a minority of respondents (22%) is remunerated by fee for service billing. Most of the respondents had read about or heard of PAs (92%), but only 38% had worked with PAs (trainees or graduates) in a clinical setting, and a smaller number of respondents had more extensive involvement with PAs. The distribution of these characteristics remained similar when the respondents were grouped into the two random sets of clinical conditions they were given to evaluate PAs’ involvement.

Table 9. Survey respondents' demographic information

Characteristics	Categories	Full sample N (%)	Survey 1 respondents N (%)	Survey 2 respondents
Age (years)	<30	3 (2.0)	1 (1.3)	2 (2.6)
	30 to <40	58 (38.2)	34 (44.8)	24 (31.6)
	40 to <50	51 (33.6)	22 (29.0)	29 (38.2)
	50 to <60	35 (23.0)	14 (18.4)	21 (27.6)
	60 and higher	5 (3.3)	5 (6.6)	0 (0)
PED working experience (years)	<5	32 (21.0)	16 (21.1)	16 (21.1)
	5 to <10	46 (30.3)	26 (34.2)	20 (26.3)
	10 to <15	34 (22.4)	15 (19.7)	19 (25.0)
	15 and higher	40 (26.3)	19 (25.0)	21 (27.6)
Type of ED	Dedicated pediatric ED	130 (86.1)	64 (84.2)	67 (88.2)
	General ED	5 (3.3)	3 (4.0)	2 (2.6)
	Both	16 (10.6)	9 (11.9)	7 (9.2)
Average ED annual volume (N visits/year)	<20 000	2 (1.3)	2 (2.6)	0 (0.0)
	20 000 to < 40 000	34 (22.4)	20 (26.3)	14 (18.4)
	40 000 to < 60 000	54 (35.5)	27 (35.5)	27 (35.5)
	60 000 and higher	62 (40.8)	27 (35.5)	35 (45.1)
Type of remuneration	Alternate payment plan or salaried	78 (51.3)	39 (51.3)	39 (51.3)
	Service contract (paid hourly or by shift rate)	38 (25.0)	22 (29.0)	(16 (21.1)
	Fees for services	33 (21.7)	13 (17.1)	20 (26.3)
	Other or combination	3 (2.0)	2 (2.6)	1 (1.32)
Level of familiarity with PA	Has heard of or read about PA before	139 (91.4)	68 (89.5)	71 (93.4)
	Has been involved in formal teaching of PAs outside of clinical shifts	24 (15.8)	11 (14.5)	13 (17.1)
	Has worked with PAs in training on clinical shifts	47 (30.9)	23 (30.3)	24 (31.6)
	Has worked with fully trained PAs on clinical shifts	11 (7.2)	7 (9.2)	4 (5.3)
	Has been directly involved in PAs legislation (policy making) either at the ministry level or through medical associations and colleges	2 (1.3)	0 (0)	2 (2.6)

There were 24 clinical conditions with ≥15% of respondents selecting "no PA involvement" and therefore may not be considered appropriate for PAs in defining the scope of practice for PAs in PED, at least initially. (Table 10) PED physicians were divided between direct and without direct supervision for the remainder of 33 (58%) clinical conditions, among which only one condition, resolved epistaxis, for which over 80% of respondents felt that a PA could manage without direct physician involvement. (Table 11)

Table 10. PED clinical categories not selected as appropriate for PA management (national survey).

Clinical condition	N respondents	PA without direct supervision: Proportion of respondents (95% CI)	PA with direct supervision: Proportion of respondents (95% CI)	No PA involvement: Proportion of respondents (95% CI)
Heart and circulatory complaint (abnormal heart beat and pallor).	76	0.00 (0.00, 0.05)	0.55 (0.43, 0.67)	0.45 (0.33, 0.57)
Focal neurological symptoms.	76	0.00 (0.00, 0.05)	0.57 (0.45, 0.68)	0.43 (0.32, 0.55)
Non-specific masses or lesions	77	0.04 (0.01, 0.11)	0.55 (0.43, 0.66)	0.42 (0.30, 0.53)
Known or suspected liver disease (jaundice outside of neonatal period).	76	0.00 (0.00, 0.05)	0.63 (0.51, 0.75)	0.37 (0.26, 0.49)
Assault (alleged, suspected or threat).	76	0.08 (0.03, 0.16)	0.57 (0.45, 0.68)	0.36 (0.25, 0.47)
Known or suspected immunodeficiency.	77	0.03 (0.00, 0.09)	0.62 (0.51, 0.73)	0.35 (0.25, 0.47)
Blood disorder (anemia, thrombocytopenia or coagulopathy)	77	0.05 (0.01, 0.13)	0.62 (0.51, 0.73)	0.31 (0.21, 0.43)
Metabolic, endocrinologic or nutritional concerns.	77	0.04 (0.01, 0.11)	0.64 (0.52, 0.74)	0.31 (0.21, 0.43)
History of dusky spell (may include apnea or breath holding) which is resolved on presentation.	76	0.01 (0.00, 0.07)	0.70 (0.58, 0.80)	0.29 (0.19, 0.41)
Episodic neurological symptoms such as seizures disorder, febrile seizures and recurrent headaches.	77	0.00 (0.00, 0.09)	0.70 (0.59, 0.80)	0.27 (0.18, 0.39)
Mild to moderate injury to chest or abdomen.	77	0.03 (0.00, 0.09)	0.74 (0.63, 0.83)	0.23 (0,15, 0.34)
Medication ingestion accidental or intentional.	76	0.07 (0.02, 0.15)	0.71 (0.60, 0.81)	0.22 (0.14, 0.33)
Non-specific malaise including dizzy, faint, pallor and fatigue.	76	0.01 (0.00, 0.07)	0.76 (0.65, 0.85)	0.22 (0.14, 0.33)
Involvement in a transport (motor or bicycle) collision.	77	0.10 (0.05, 0.19)	0.66 (0.55, 0.77)	0.22 (0,13, 0.33)
Known renal disease or abnormal urine.	77	0.08 (0.03, 0.16)	0.70 (0.59, 0.80)	0.21 (0.12, 0.32)
Crying in an infant or non-verbal young child	75	0.05 (0.01, 0.13)	0.73 (0.62, 0.83)	0.20 (0.12, 0.31)
Chest pain not otherwise specified without cardiorespiratory compromise.	76	0.12 (0.06, 0.21)	0.68 (0.57, 0.79)	0.20 (0.11, 0.30)
Intoxication (alcohol or recreational drugs).	77	0.14 (0.11, 0.30)	0.66 (0.55, 0.77)	0.19 (0.11, 0.30)
Chronic bowel disorders such as IBD exacerbation.	76	0.07 (0.02, 0.15)	0.76 (0.65, 0.85)	0.17 (0.09, 0.27)
Self-limiting hematemesis or blood per rectum.	75	0.07 (0.02, 0.15)	0.76 (0.66, 0.85)	0.17 (0.01, 0.28)

Table 11. PED clinical categories selected as appropriate for PA management (national survey).

Clinical condition	N respondents	PA without direct supervision: Proportion of respondents (95% CI)	PA with direct supervision: Proportion of respondents (95% CI)	No PA involvement: Proportion of respondents (95% CI)
Non infectious upper respiratory tract complaint (pain NYD or non acute symptoms).	77	0.25 (0.16, 0.36)	0.62 (0.51, 0.73)	0.12 (0.05, 0.21)
Respiratory distress not otherwise specified (bronchiolitis, noisy breathing, possible pneumonia).	76	0.00 (0.00, 0.05)	0.89 (0.80, 0.95)	0.11 (0.05, 0.20)
Non traumatic eye complaints (disease of eye lids, conjunctiva, non specific eye pain or visual changes).	77	0.27 (0.18, 0.39)	0.61 (0.49, 0.72)	0.10 (0.05, 0.19)
Complaints of female genitalia (vulvovaginitis) or menstrual disorder.	77	0.26 (0.17, 0.37)	0.62 (0.51, 0.73)	0.10 (0.05, 0.19)
Cellulitis, adenitis, abscesses.	75	0.23 (0,13, 0.33)	0.67 (0.53, 0.75)	0.09 (0.04, 0.18)
Post procedure or treatment reactions (e.g. post operative concerns or vaccination or medication reaction).	76	0.21 (0.13, 0.32)	0.70 (0.58, 0.80)	0.09 (0.04, 0.18)
Recurrent vomiting/spit up without diarrhea or fever.	76	0.11 (0.05, 0.20)	0.80 (0.69, 0.89)	0.09 (0.04, 0.18)
Non-traumatic musculoskeletal complaints (pain/swelling).	77	0.30 (0.20, 0.41)	0.62 (0.51, 0.73)	0.08 (0.03, 0.16)
Urticaria or pruritic rash	75	0.48 (0.36, 0.60)	0.44 (0.33, 0.56)	0.07 (0.02, 0.15)
Minor back injuries	76	0.37 (0.26, 0.49)	0.55 (0.43, 0.67)	0.07 (0.02, 0.15)
Mild to moderate injury to more than 1 area e.g. ankle and wrist injuries, or laceration to forearm and facial abrasions.	75	0.41 (0.29, 0.52)	0.51 (0.38, 0.61)	0.07 (0.02, 0.15)
Non-traumatic dental or oral mucosal complaint.	77	0.52 (0.40, 0.63)	0.40 (0.29, 0.52)	0.06 (0.02, 0.15)
Rash with viral infection symptoms	77	0.47 (0.35, 0.58)	0.45 (0.34, 0.57)	0.06 (0.02, 0.15)
Non-anaphylactic allergic reaction or suspected allergic reaction.	77	0.39 (0.28, 0.51)	0.53 (0.42, 0.65)	0.06 (0.02, 0.15)
Device (lines, tubes) or cast related concerns (dysfunction) and requests (removal, replacement)	77	0.39 (0.28, 0.51)	0.55 (0.43, 0.66)	0.05 (0.01, 0.13)
Ear pain or discharge	77	0.52 (0.40, 0.63)	0.42 (0.30, 0.53)	0.05 (0.01, 0.13)
Voiding dysfunction or dysuria.	77	0.38 (0.27, 0.49)	0.57 (0.45, 0.68)	0.05 (0.01, 0.13)
Known asthmatic in exacerbation.	77	0.30 (0.20, 0.41)	0.64 (0.52, 0.74)	0.05 (0.01, 0.13)
Scheduled revisits for outpatient intravenous therapy or home observation and reassessment.	77	0.71 (0.60, 0.81)	0.25 (0.16, 0.37)	0.04 (0.01, 0.11)
Mild or suspected injury due to animal bites (dog, cat, hamster...)	77	0.51 (0.39, 0.62)	0.44 (0.33, 0.56)	0.04 (0.01, 0.11)
Fall not otherwise specified.	76	0.24 (0.15, 0.35)	0.72 (0.61, 0.82)	0.04 (0.01, 0.11)

Table 11. Continued. PED clinical categories selected as appropriate for PA management (national survey).

Clinical condition	N respondents	PA without direct supervision: Proportion of respondents (95% CI)	PA with direct supervision: Proportion of respondents (95% CI)	No PA involvement: Proportion of respondents (95% CI)
Insect bites (swelling, itchy, concerns about infection).	77	0.75 (0.64, 0.84)	0.23 (0.14, 0.34)	0.03 (0.00, 0.09)
Foreign body (swallowed, in nose, in ear, in eye lid) without airway compromise	77	0.52 (0.40, 0.63)	0.45 (0.34, 0.57)	0.03 (0.00, 0.09)
Non limb threatening injuries to extremities, including lacerations.	77	0.44 (0.33, 0.56)	0.55 (0.43, 0.66)	0.03 (0.00, 0.09)
Vomiting and diarrhea without bleeding.	76	0.54 (0.42, 0.65)	0.45 (0.33, 0.57)	0.03 (0.00, 0.09)
Fever with cough, rhinorrhea or sore throat.	76	0.54 (0.42, 0.65)	0.45 (0.33, 0.57)	0.03 (0.00, 0.09)
Epistaxis that has resolved on presentation.	77	0.83 (0.73, 0.91)	0.16 (0.08, 0.26)	0.01 (0.00, 0.07)
Burn: includes friction and scald burns.	77	0.53 (0.42, 0.65)	0.45 (0.34, 0.57)	0.01 (0.00, 0.07)
Minor head injuries	77	0.44 (0.33, 0.56)	0.55 (0.43, 0.66)	0.01 (0.00, 0.07)

The proportion of conditions selected as appropriate for PA management ranged from 0% to 100%, with a mean of 85.1% (SD 21). Two (1%) physicians did not want to have PAs involved with any clinical conditions, while 65 (43%) physicians would involve PAs with all of the presented clinical conditions. The mean proportion of clinical conditions selected as appropriate for PA involvement was similar between respondents when grouped by the random set of assigned clinical conditions to evaluate: 84% (95%CI: 79, 89%) in group 1 and 86% (95%CI: 82, 90%) in group 2.

The proportion of conditions physicians selected for PA involvement stratified by their demographic variables is shown in Table 12. The mean proportion of cases selected for PA involvement by respondents working in larger EDs was significantly higher than that by their counterparts working in smaller EDs (87.7-89.1% vs. 74.2%). Although respondents under 30 years of age seemed more conservative in the number of clinical presentations they

selected for PA involvement, the sample size in this category was very small. The mean proportion of conditions selected for PA involvement was similar between number of years of experience worked in a PED, type of ED, and form of remuneration.

Table 12. The influence of respondents' demographic variables on the proportion of conditions selected for PA involvement

Demographic variables	Categories	N	Mean % of clinical conditions selected as appropriate for PA management under direct or indirect MD supervision (SD)	Difference in mean proportion of conditions selected for PA involvement compared to the first category for each variable (95% CI).
Age	<30 years old (ref)	3	72.9 (5.4)	
	30 to <40 years old	58	85.5 (20.6)	12.6 (5.2, 20)
	40 to <50 years old	51	84.0 (22.7)	11.0 (3.1, 18.9)
	50 to <60 years old	34	86.8 (22.7)	13.9 (4.6, 23.2)
	60 years or older	5	83.6 (18.3)	10.6 (-8.4, 29.6)
Number of years worked in PEM	<5 years (ref)	31	87.9 (15.2)	
	5 to < 10 years	46	85.2 (23.4)	-2.7 (-12.2, 6.8)
	10 to < 15 years	34	80.6 (22.4)	-7.3 (-16.9, 2.3)
	15 years or more	40	86.3 (21.1)	-1.4 (-10.2, 7.4)
Remuneration	Service contracts (by the hours or by the shift payment) (ref)	38	78.6 (28.1)	
	Salaried or alternative payment plan	77	88.3 (17.3)	17.3 (-19.5, 0.1)
	Fee for service billing	33	83.8 (19.2)	5.2 (-5.9, 16.3)
	Other or combination	3	93.1 (11,9)	14.5 (-0.1, 29.1)
Type of ED	General ED (ref)	5	73.5 (24.2)	
	Dedicated PEM ED	130	85.1 (21.4)	11.6 (-7.9, 31.1)
	Work at both	16	87.4 (17.4)	13.9 (-5.9, 33.7)
ED size (annual volume)	20000 to <40000 (ref)	36	74.2 (28.9)	
	40000 to <60000	54	89.1 (15.9)	14.9 (4.4, 25.4)
	60000 or more	61	87.7 (17.0)	13.5 (3, 24)

The proportion of conditions physicians selected as appropriate for PA involvement stratified by their familiarity with PAs is shown in table 13. Having worked with PAs (in training or graduated) during clinical shifts was associated with the proportion of conditions selected as appropriate for PA involvement. Although respondents involved with PA legislation had a lower mean proportion of conditions selected for PA management, there were only 2 respondents (1%) who had been involved with PA legislation.

Table 13. The influence of PA familiarity on the proportion of conditions selected as appropriate for PA involvement.

Familiarity with PA	Categories	N (%)	Mean % of clinical conditions selected as appropriate for PA management under direct or indirect MD supervision (SD)	Difference in mean % of clinical conditions selected as appropriate for PA (95% CI)
Have read about PA	No	13 (8.6)	76.3 (29.4)	9.6 (-2.6, 21.8)
	Yes	139 (91.4)	85.9 (19.8)	
Have taught PA outside of clinical shifts	No	128 (84.2)	83.8 (21.9)	8.4 (-0.9, 17.7)
	Yes	24 (15.8)	92.2 (13.0)	
Have worked with PA in training during clinical shifts	No	105 (69.1)	82.2 (21.8)	9.3 (3.8, 14.8)
	Yes	47 (30.9)	91.5 (17.4)	
Have worked with fully trained PA during clinical shifts	No	141 (92.8)	84.7 (21.4)	5.8 (0.2, 11.4)
	Yes	11 (7.2)	90.5 (13.7)	
Have been involved in PA legislation	No	150 (98.7)	85.3 (20.9)	-12.9 (-42.7, 17.0)
	Yes	2 (1.3)	72.4 (20.7)	

3.2.3 Discussion

The intent of this national survey was to explore the opinion of clinically active pediatric emergency physicians on the level of involvement PAs should have with non-emergent conditions commonly seen in a PED. In addition, the sample size of this study allowed for exploration of factors influencing physician's opinion of the magnitude of PAs' participation in pediatric emergency medicine. Findings of this study also corroborate with results of the role delineation survey, where PED physicians felt that PAs could contribute to the care of at least half of the presented clinical conditions with or without direct supervision.

There are no published studies on PAs scope of PED practice to validate the study population's selection of clinical conditions. Instead, informal discussions with PAs practicing in EDs in the US suggest that they manage a much wider range of pediatric ED presentations with little or no direct involvement from the physician than the conditions identified in this survey. It is understood that as a supervising physician and PA team gain experience with each other's practicing style, the degree of autonomy afforded to PAs increases; referred to as negotiated autonomy.[114] It is therefore not surprising to find that survey respondents who have either worked with fully trained PAs or PAs in training selected a greater proportion of cases for PA involvement. That only 7% of respondents had worked with fully trained PAs and less than a third had worked with PA trainees reflects the early stage of PA development in Canada, and likely explains respondents' conservative approach to PAs' involvement in PED.

The observed higher proportion of cases selected for PAs from respondents working in larger centres may be related to higher demands and pressure to manage overcrowding, thus the willingness to accept help provided by PAs.

Although a lower mean proportion of cases selected for PA involvement was found in respondents younger than 30 years old compared to the other groups (encompassing 30 to 60 year old categories), there were only three respondents under 30 years of age (who are likely PED subspecialty clinical trainees). It is surprising that PED work experience did not affect the mean proportion of cases selected for PA involvement, and one could speculate that factors like employment security and competition might account for these findings.

The most important limitation to this study is the restrictive nature of the sample frame. The PERC database comprises PERC members (physicians involved in pediatric emergency research) and other physicians working in a Canadian pediatric ED as identified by PERC members. This database does not include many physicians who treat children in general EDs (less than 5% of

respondents work only at a general ED). Because 85% of all emergent care of children in Canada is delivered in general EDs, these results do not capture the views of the majority of physicians who care for acutely ill and injured children. These results only reflect opinions of physicians who work primarily at tertiary PEDs. The opinion of ED physicians managing children in general community EDs and their level of comfort with PA's involvement in the care of children would likely be different from my findings.

The other limitation is the sample size and response rate. With a 51% response rate, one might assume that the survey topic itself might have affected decision to take on the survey. Alternatively the modest response rate among the physicians in PERC database may be due to survey fatigue. The PERC executives, managing the uptake rates of surveys using its database, reported a drop from about 60% response rates to about 30% in the year prior to my survey for other surveys. A decision was then made to significantly reduce the access to this database and the uptake rate has since come back to about fifty percent. In addition, this survey also had a decline option and an opportunity to express why they did not want to take the survey. Only five subjects clicked on the decline link, two expressed that they were too busy and were asked to participate in too many surveys, and another two no longer practice emergency medicine and did not feel that the topic concerned them.

Furthermore, to reduce the burden to respondents, each was only surveyed on half of the 57 clinical conditions. This cut my sample size for each clinical condition by half. Despite this, the estimated required sample size was met.

In conclusion, these findings suggest that PAs could be involved in a large proportion of pediatric ED patient visits, with reservations about the amount of supervision PAs would require. Cases managed by PAs with most conditions would have to be reviewed and reassessed by a physician, not unlike when a medical trainee is seeing patients in the ED. We can speculate, however, that with time, a PA will develop rapport with the supervising physician, similar to that developed with a subspecialty clinical resident who trains in a department

for two years as opposed to more junior trainees who only rotate through the ED for a one month duration. This in turn may alter the balance between cases needing direct physician interaction and those only requiring indirect physician supervision, which has an important bearing on the overall impact of PAs on PED throughput.

Chapter 4. Emergency department users' willingness to receive care by physician assistants

Canadian healthcare users' acceptance of PAs as a healthcare provider is essential to consider before introducing PAs to our healthcare system, particularly in settings where there is a perception of urgency. No endorsement of PAs would overcome the public's perception if they thought PAs were not acceptable as health care providers. Studies of healthcare users' willingness to be treated by PAs have shown mixed results depending on how the question was posed. In an American study, only 57% were willing to be treated by a PA while a study in Northern Queensland Australia, found that over 99% of respondents were willing to be treated by a PA[115,116]. The following two studies address two questions: "How likely are British Columbians to accept acute care by a PA?" and "Does wait time for PAs versus physicians influence acceptance?".

4.1 Survey of patients' willingness to receive care for minor injuries by physician assistants: study objectives

I surveyed healthcare users to determine their willingness to receive emergency treatment by a PA either for themselves or for their child under various injury and wait-time trade-off scenarios.

4.1.1 Methods

I adapted the protocol used for the survey conducted in Australia[117] as it was also replicated in the Netherlands, in order to compare my result with those obtained in these two countries. Modifications to this protocol were limited to alterations to demographic information questions, to suit the geographical differences. Respondents consisted of mothers accompanying a child to the ED or the general pediatric clinic at BCCH, a tertiary care facility in Vancouver, British Columbia. Patients familiar with PAs (prior experience being treated by PA) were excluded, thus all participants were unaware of PAs and what they do

until they entered the study. Each participant was given a brief description of PA training and scope of practice, as well as that of a general doctor. Females were selected since this was the largest segment of respondents in the pilot study in the US and Australia, thus providing respondent comparisons. Scenarios were selected as common conditions that were easily identifiable by the respondent, and could be readily managed in a family medicine office. An international panel, including doctors in family medicine and researchers, selected the scenarios to be applicable in different countries under different settings (such as urban or remote), and translatable for comparative purposes.

Each participant was presented with one of three injury scenarios randomly selected by means of sealed envelopes: 1) a sprained ankle, 2) a forearm laceration, and 3) a four-year-old child with a forehead laceration. As in previous research, participants were asked to assume the role of the patient in scenario #1 or #2, and the role of the parent in scenario #3 was selected. Participants were asked to choose between receiving care by a physician or by a PA based on a waiting time trade off. The first choice was the option of waiting four hours to be seen by the physician or one hour by a PA. After making that initial time selection, the participants were given a second and third scenario of being seen by a physician in four hours, or being seen by a PA in either 30 minutes or in two hours. The primary outcome measure was the proportion of individuals in each scenario who were willing to be treated by a PA at least for one of the time trade off options offered. The secondary outcome measure was the proportion of individuals who changed their answer when the waiting time to see the PA was varied. I also collected demographic information such as age and ethnic background.

Descriptive statistics were used to summarize participants' demographic characteristics for each of the three scenarios tested, and compared the proportion of individuals favourable to PAs across the scenarios using the Chi Square test. A planned sample size of 77 participants per group was chosen to achieve ±7.5% precision with 90% confidence in the estimate of the proportion

of responses favourable to PAs, derived under the assumption that the true proportion was 80% (a conservative estimate, considering that over 90% of subjects chose to see a PA in the Australian study).

4.1.2 Results

A total of 306 potential participants were approached for this study. Of this group, 29 were familiar with PAs and thus excluded, 41 declined to participate, three had been enrolled in the study once before and four could not provide consent due to language barriers. The participation rate among the 270 eligible respondents was 85% and their average age was 34 years. The vast majority of subjects were recruited while waiting in the PED rather than in the general pediatric clinic. Half (52%) were Caucasian and 40% Asian (see Table 14).

Table 14. Distribution of demographic characteristics of participant for each of the injury scenario group.

	Ankle sprain (%)	Forearm Laceration (%)	Child forehead laceration (%)	Total study population (%)
N (total: 229)	78	75	76	229
Age Mean [95%CI]	34 [32,36]	34 [32,36]	34 [32,37]	34 [33,35]
Recruited in PED (as opposed to the clinic)	69 (88)	64 (85)	71 (93)	204 (89)
Ethnicity				
Asian	34 (44)	21 (28)	37 (49)	92 (40)
Caucasian	38 (49)	46 (61)	34 (45)	118 (52)
First Nations	1 (1)	4 (5)	3 (4)	8 (3)
Hispanic	4 (5)	3 (4)	2 (3)	9 (4)
African	1 (1)	1 (1)	0	2 (1)

There was unanimous selection of PAs (98%) for at least one of the time trade off options regardless of the clinical scenarios presented (Table 15). A slightly lower proportion (96%) favoured the PA in the scenario involving a child. This was observed at each of the time trade off options, but is only statistically significant at the longest wait time for the PA (2 hours for the PA vs. 4 hours for the MD). Across the scenarios, the majority of respondents chose a PA despite the varying waiting time to be seen by a PA.

Table 15. Proportion of participants choosing to be seen by a PA by injury scenario for each time trade off options

	Ankle sprain [95%CI]	Forearm Laceration [95%CI]	Child forehead laceration [95%CI]	P value for difference across scenarios
PA for at least one time trade off option	0.99 [0.93, 1.0]	0.99 [0.93, 1.0]	0.96 [0.89, 0.99]	0.43
PA 2hr VS MD 4hrs	0.86 [0.76, 0.93]	0.85 [0.75, 0.92]	0.67 [0.55, 0.75]	**0.03**
PA 1hr VS MD 4hrs	0.92 [0.84, 0.97]	0.96 [0.89, 0.99]	0.88 [0.79, 0.94]	0.20
PA 30 min VS MD 4hrs	0.99 [0.93, 1.0]	0.99 [0.93, 1.0]	0.96 [0.89, 0.99]	0.43

4.1.3 Discussion

The results of this study suggest that British Columbian mothers seeking care for their child in a tertiary care center previously unaware of PAs would accept the concept of a PA over physician care in exchange for shorter wait times, regardless of the clinical scenario. Respondents overwhelmingly opted for PA care, but were willing to wait longer to see a physician in the case of the injured child scenario compared to the scenarios in which the participant assumed the role of the patient. Although all 3 cases would be categorized as level 4 (semi-urgent) using the CTAS scale, if presenting to the ED, it is possible that respondents perceived the pediatric forehead laceration to be more severe than was intended. In addition, most of the respondents were recruited from the PED waiting room, despite efforts to approach subjects in the general pediatric clinic, due to limited clinic hours and low appointment rates compared to PED visits. Although all three hypothetical scenarios suffered from heavy recruitment from the PED evenly, it is possible that the stress of seeking help for their child in the PED affected respondents of the pediatric injury scenario differently than those responding to the other two hypothetical scenarios. Whether the relative reluctance in having PAs manage the pediatric case is a reflection of perceived acuity of nature of the injury or that parents were willing to wait longer when it involves their child due the pediatric nature of the case requires further exploration.

These findings were consistent with the Australian study,[116] which assessed willingness to be treated by PAs for similar injuries. Minor differences distinguished these two studies. The Australian study varied both the waiting time to see the PA and the waiting time to see the doctor. In addition, all but two out of 225 of their respondents chose to be treated by PAs across all three scenarios and at all time trade offs, hence there was no observed effect from varying the injury scenario or the waiting time reduction.

Though this study suggests acceptance of PAs as healthcare providers among a sample of Canadian women, the choice of using a scenario based survey rather than asking participants' willingness to be treated by PAs for a health complaint for which they presented at the time of enrolment limits the generalizability of my findings to minor injury scenarios. These scenarios, nonetheless, are likely good surrogates for a wide range of minor patient complaints.

In addition, my intent was to shape the study for understanding a Canadian perspective as well as for international comparison. I wanted to be able to compare my results to the studies conducted in Australia and the Netherlands, where the use of PAs is in early stages of development and deployment. While using these scenarios limit the generalizability of my findings to a fuller range of presenting patient complaints, being able to eventually make comparisons to the results from other countries was a priority.

A study of PAs working in Manitoba found similar acceptance of patients for care by PAs.[117] Over 90% of surveyed patients felt that PAs were important team members, and using them was a good idea.

Although PAs are new to healthcare users in Canada, this research suggests that patients report a willingness to receive care by a PA. This finding adds to the nascent body of literature supporting the use of PAs in the Canadian healthcare system.

4.2 Survey of parents' willingness to have their child with non-emergent problems cared for by physician assistants: study objectives

The notion that healthcare users are more averse to a new and unfamiliar type of healthcare provider when it comes to their children is a complex and important topic to explore. On one hand children's health is considered immutable and should be a high medical priority. On the other hand science in general, and medicine in particular, is rapidly changing and so are those who provide that care. This study explores Canadians' acceptance of PA providing care to their child in a PED setting and the minimal amount of waiting time reduction required as the trade-off for not being directly assessed and treated by an emergency pediatrician.

4.2.1 Methods

I conducted a cross sectional survey between July 9th, 2010 and March 15th, 2011, at BCCH ED where approximately 40,000 ED visits occur annually. The survey sample consisted of adults (> 17 years old) seeking care for a child at BCCH PED, triaged to level 3 (urgent), 4 (semi-urgent), or 5 (non-urgent) using the pediatric CTAS. This was based on a previous survey of PED physicians at BCCH, which concluded that three quarters of patient visits triaged as CTAS level 3-5 would be appropriate for PA management with variable degrees of physician supervision.

After written consent, participants were given a brief description of PA training and scope of practice, and told that PAs do not currently work at BCCH PED. They were then asked verbally, using a scripted questionnaire, if PAs were utilized at BCCH PED and could see their child for the problem prompting them to come to the ED, order required tests, provide treatment and give out discharge instructions when their child can safely go home, and only consult the physician if the PA felt that the child's condition warranted it, would they be willing to have their child assessed and treated by a PA: definitely or maybe or never. If the respondent answered yes, they were asked what is the

minimum amount of waiting time reduction would they want to see to make them chose to receive treatment by PAs rather than wait for the doctor.

Demographic information such as patient's age, respondents' relation to the patient, the survey respondent's perception of the child's condition severity (mild, moderate or severe), was also collected using the questionnaire. Presenting complaint, triage CTAS category, whether they had been seen by the physician at the time of enrolment and their actual waiting time to see the physician as a surrogate for the department activity level, were retrieved from the patient's health records.

All data was collected onto a standardized data collection form and entered onto an electronic database (Microsoft Excel 2000 spreadsheet) by a research assistant. I subsequently reviewed the database for data entry accuracy using both the data collection forms and questionnaires, prior to conduct the analyses. (See Appendix 1 for questionnaire and Appendix 2 for the data collection form).

The primary objective was to determine the proportion of subjects who reported willingness to consider having their child seen and treated by a PA and the average waiting time reduction felt necessary for that trade off (with 95% confidence intervals). Survey respondents who selected maybe or definitely they were viewed as "willing to consider". The secondary objective was to explore the association between participants' (or their child's) characteristics and their reported willingness to be managed by a PA.

I used descriptive statistics to summarize participants' demographic characteristics and primary outcome variables. I used bivariate logistic regression analyses (SAS statistical software, version 9.2; SAS Institute Inc., Cary, NC) to assess the individual effect of respondent's perceived severity of their child's illness, child's age, type of presenting complaint, pediatric CTAS triage category and waiting time, on the likelihood of considering PA care as an option. Firth's penalized likelihood method was used to correct for separation (when a sub-category contains no subjects and an odds ratio

cannot be calculated) where present.[118] Assuming the willingness to receive care by PA to 50% (a conservative proportion requiring the largest sample size), the estimated sample size to achieve +/-5% precision with 90% confidence was 270 participants. There was no intention to build a predictive model nor to establish causation, hence multivariate analyses were not conducted.

4.2.2 Results

A total of 320 eligible participants were approached, among whom 28 declined to participate, and 19 were unable to provide informed consent due to language barriers. Of these, 273 participants were enrolled with a participation rate of 85.3%. When asked if they would be willing to have their child seen and treated by a PA and only subsequently by a physician if deemed necessary by the PA, 140 (51.3%) answered definitely, 107 (39.2%) answered maybe and 26 (9.5%) responded no. With the exception of the CTAS distribution and perceived severity of the child's condition, all other characteristics of subjects and their children were comparable between those who were and were not willing to have their child assessed and managed by PAs (Table 16).

Table 16. Primary outcomes and respondents, patients, and visit characteristics

Independent variables (%)	Categories	Not willing to have child managed by PA	Possibly willing to have child managed by PA	Definitely willing to have child managed by PA
Age in years	*Mean (95% CI)*	6.4 (4.6, 8.2)	5.4 (4.6, 6.3)	6.2 (5.5, 7.0)
CTAS (% within CTAS level)	*CTAS3*	18 (17.1)	43 (41.0)	44 (41.9)
	CTAS4	8 (5.4)	61 (41.5)	78 (53.1)
	CTAS5	1 (4.6)	3 (13.6)	18 (81.8)
Actual waiting time in minutes	*Median (Inter quartile)*	94.5 (89.4)	100.9 (63.9)	90.2 (86.9)
Chief complaint by system (% within reported level of willingness to be seen by a PA)	*Musculoskeletal/injury (% of all chief complaint)*	6 (22.2)	25 (23.4)	43 (31.6)
	Infectious (fever)	5 (18.5)	31 (29.0)	30 (22.1)
	Respiratory	5 (18.5)	12 (11.2)	10 (7.4)
	Abdominal/genitourinary	9 (33.3)	26 (24.3)	38 (27.9)
	Neurological	0	10 (9.3)	6 (4.4)
	Cardiovascular	0	0 (0.0)	1 (0.7)
	Dermatological	2 (7.4)	3 (2.8)	11 (7.4)
Respondent's relation to child (% within reported level of willingness to be seen by a PA)	*Mother*	19 (73.1)	70 (65.4)	91 (65.9)
	Father	6 (22.2)	32 (29.9)	41 (29.7)
	other	2 (7.4)	5 (4.5)	8 (5.8)
Respondent's perceived severity of child's condition	*Mild*	2 (7.4)	16 (15.0)	45 (32.6)
	Moderate	17 (63.0)	76 (71.0)	83 (60.1)
	Severe	8 (29.6)	15 (14.0)	12 (8.7)
Status at enrolment	*Not yet seen*	15 (55.7)	63 (58.9)	88 (63.8)
	Already seen by physician	12 (44.4)	44 (41.1)	52 (37.7)

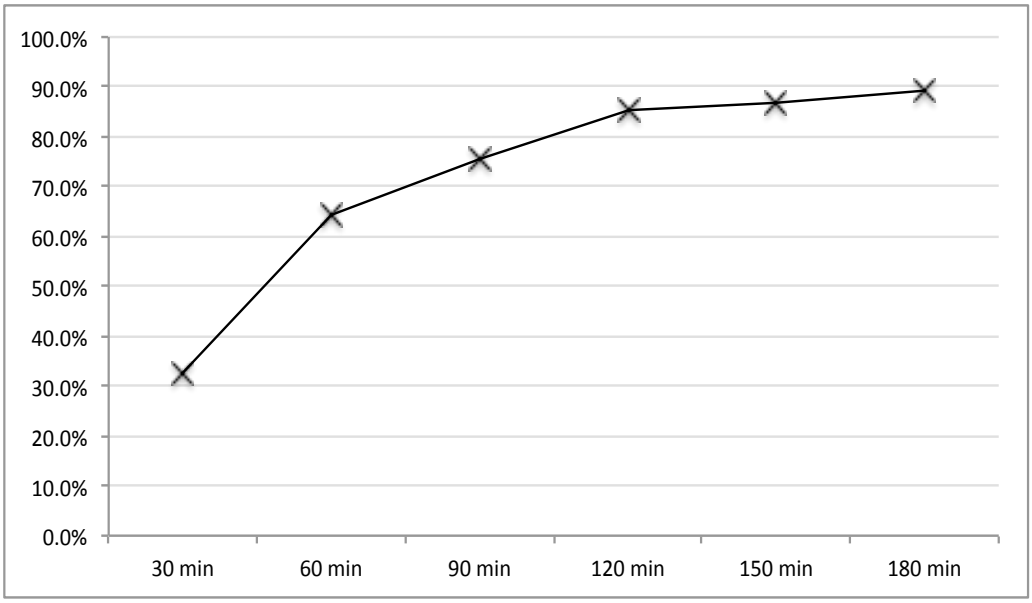
Bivariate analyses confirmed that the odds of accepting care by PAs increased as the respondents' perception of the severity of their child's illnesses decreased. Similarly, the odds of accepting care by PAs increased as the CTAS increased (i.e. from urgent (CTAS 3) to semi-urgent (CTAS 4) and non-urgent (CTAS 5)), but the sample size of CTAS 5 patients was not large enough to reach statistical significance. Other variables such as child's age, presenting complaint, relation between respondent and the child receiving care, and their waiting time to see the physician were not found to be associated with respondent's willingness to have the child treated by a PA. Odds ratios (OR) with their 95% CI for these bivariate analyses are displayed in Table 17.

Table 17. Association between respondent, patient and visit characteristics, and willingness to accept pediatric emergency care treatment by PAs

EFFECT	CATEGORY	ODDS RATIO	95%CI
Age	(continuous variable)	0.98	0.90, 1.07
CTAS (ref: CTAS3)	CTAS4	4.21	1.69, 10.49
	CTAS5	4.44	0.56, 35.22
Waiting time	(continuous variable)	1.00	0.99, 1.00
Chief complaint (ref: musculoskeletal - injury)	Infectious (fever)	1.08	0.31, 3.70
	Respiratory	0.39	0.11, 1.41
	Abdominal/genitourinary	1.39	0.47, 4.11
	Neurological	0.30	0.04, 343.62
	Cardiovascular	3.48	0.36, 8.90
	Dermatological	1.60	0.29, 8.74
Respondent (ref: mother)	father	1.72	0.62, 4.79
	other	1.30	0.16, 10.62
Perceived severity (ref: severe)	moderate	2.94	1.15, 7.76
	mild	9.04	1.80, 45.41
Seen status (ref: not seen)	seen	0.87	0.38,1.97

The average minimal waiting time reduction expected as a trade-off for seeing a PA instead of an emergency pediatrician was 67 minutes (95% CI: 61, 72). The relationship between the proportion of respondents choosing to receive treatment by a PA rather than waiting for the physician and waiting time reduction per 30 minutes time segments are presented in figure 1. Their median actual waiting time was 93 minutes (IQ: 75 minutes).

Figure 1. The relationship between the proportion of respondents choosing to receive treatment by a PA and potential waiting time reduction



4.2.3 Discussion

The results of this study, suggesting that the majority of parents of children seen in the ED for non-emergent causes would be possibly or definitely willing to receive treatment by a PA, provides support for broadening the PED resource mix. It is worth noting however, that although few were unwilling to have their child treated by a PA, most of these respondents' children were in the CTAS 3 triage category. This is consistent with the results from the survey of emergency pediatricians on the type of clinical presentations they think would be appropriate for PAs to manage being predominantly cases normally triaged to CTAS level 4 and 5, and fewer to CTAS level 3. Together, these findings support the limitation on the type of clinical presentations PAs would be involved with, should they be introduced to PEDs.

A similar study set in a general ED, in Vancouver British Columbia, Moser et al found that 72.5% of respondents were willing to be treated by NPs, among which 21% also expected to be seen by a physician in addition to the NP.[119] Among those who were not willing to be treated by an NP, 37.5% would reconsider their options if seeing the NP resulted in a shorter waiting time. Both

studies are limited by the fact that respondents may not have had prior experience with non-physician clinicians and are providing opinion based on a description of the non-physician clinician's scope of practice, and in a hypothetical situation. This study differed in that I investigated parents' willingness to have their child treated by PAs when visiting the pediatric ED for non-emergent complaints, and they determined the attitudes of ED patients toward NPs. Nonetheless, the difference between PAs and NPs may not be important in the eyes of the healthcare users.

PAs and NPs are often compared and, in most contexts, can serve the same role depending on the individual and their flexibility. The main difference is that NPs' scope of practice allows them to be independent health care providers. They often practice in community care settings and function as an alternative to physicians. Although PAs may appear to practice independently, they are in a dependent relationship with a supervising physician and the degree of supervision (from side-by-side work to off-site support through telephone access) is left to the PA-physician relationship and discretion.

The more important differences between these two studies are the population to be treated (adults vs. children). In addition, less than 50% of respondents (101/207) in the Moser study were willing to be treated by the NP without the expectation of also being seen by a physician, while respondents to this survey were instructed that they would only be seen by a physician, if deemed necessary by the PA. Finally, we were able to quantify the magnitude of waiting time reduction valued by respondents as a trade-off for not seeing a physician. A 30 minutes reduction in waiting time was sufficient for a third of respondents, and a 60 minutes reduction for another third, to choose to receive treatment by a PA rather than wait for a physician.

The main limitation of this study is that this was conducted at one center, an academic PED, and my findings may not be generalizable to general EDs where a large proportion of children receive care. While we cannot extrapolate my findings to general EDs with any degree of certainty, it is possible – given

that some parents seek emergency care at children's hospitals expressly to receive subspecialized medical treatment – that the findings underestimate parents' general willingness to have PAs evaluate their children. In addition, although subjects were given opportunities to ask for more detailed information about PAs, and most appeared comfortable answering the questions pertaining to the survey, participants' understanding of PA roles and scope of practice range was not explored.

Education level and socioeconomic background was also not assessed in this study. It is possible that such social factors may affect parent's willingness to have their child receive treatment by PAs despite not having to pay out of pocket for healthcare services. To address this issue, a qualitative study to investigate parental priorities in seeking ED care for their children's non-emergent complaints, and the value they put on the type of healthcare provider versus timeliness of the initial assessment would add understanding to how PAs would be perceived by caregivers of children treated in EDs.

In summary, results from these two studies infer that healthcare users are open to receive medical care by PAs for minor injuries and non-emergent conditions, as a trade off for the convenience of reducing their waiting time. Once PAs have been implemented and healthcare consumers have become familiar with PAs, further exploration of their motivation for acceptance of non-physician clinicians with a qualitative approach, would further complete the picture.

Chapter 5. A forecast of the impact of physician assistants in a pediatric emergency department

5.1 Physician assistants and patient flow in a pediatric emergency department: a discrete event simulation model: study objectives

Using PAs in the ED may be safe and possibly an affordable solution to ED crowding, but whether this is a cost effective strategy has yet to be determined. PA training is shorter and compensation is lower than that of PED physicians, but the concept held by most is that they can only assess and treat a portion of visits (e.g. non-emergent) assessed and treated in a PED, under the supervision of an emergency pediatrician. Civilian PAs are not employed in BC, and as such cannot be directly studied. Instead, I used discrete event simulation modeling (DES) to compare the impact of adding an emergency pediatrician to the PED versus adding a PA on key performance indicators of PED efficiency. I created a computer version of the PED, which operates as a series of ordered events from arrival to disposition from the PED for each patient visiting the PED.

5.2 Methods: Discrete event simulation

The PED is a complex system and the flow of patients through it involves many interventions. From arrival to disposition from the PED, a patient seizes a multitude of resources (staffing or space) that is shared between patients, often between patients at different stages of their PED visits, each with different priorities for seizing the resource. Fluctuations in availability of any of these resources, their utilization, or the volume of PED users competing for them will affect patient flow in the PED. The impact of adding PAs on patient flow in the PED has been evaluated through pre and post intervention studies.[100,101] This approach does not isolate the effect of adding PAs to the PED from system

changes due to other factors, which may have been occurred incidentally during the study period.

As an alternative, time series analysis, with its sequence of data points provide for trending and a more detailed view of system outcome changes through time, including the period surrounding the intervention of interest and not merely a summary of before and after intervention periods.[120] Time series analysis, however does not identify the causative factor responsible for abrupt changes or trends, and should two or more interventions be introduced in a close time frame, they would not be identified nor their separate contribution be isolated.

To compare the effect of adding a PA versus physician coverage to the PED may also be evaluated using cluster randomized controlled trials as they offer the same advantages of randomized controlled trial. Cluster randomized controlled trials however are complex to design and analyze. Moreover, their large sample size requirements to adjust for intra-cluster correlation make them difficult and expensive to conduct.[121]

I chose instead, to use discrete event simulation (DES) to compare the impact of adding PAs to the PED versus increasing physician coverage. DES modeling is a commonly used method in operations research, and is heavily used in healthcare systems to model surgical wait list, optimize operation theatre allocation or scheduling, and to evaluate strategies to improve ED patient flow, forecast ED crowding, and to optimize staffing and scheduling.[122-131]

DES employs a probability-based statistical and logical model of a complex real life system with all its intricate stochastic processes with occurrence of event and durations following set parameters and theoretical distributions.[122] This model portrays changes in events for every entity in the system, precisely at the time it occurs. In other words, a computerized model is built to replicate the series of events forming the operations of a complex real life system. I may then apply changes to this model, targeting certain variables such as specific

resources or demands, while maintaining the rest of the system unaltered other than in response to the imposed changes. DES allows for multiple iterations and exploration of uncertainty. A DES model can be built using general purpose programming languages or using packaged simulation software, which has animation features facilitating visual presentation of the data.

DES allows me to test and analyze outcomes of "what if" scenarios, in a controlled but flexible environment,[123] prior to implementing these changes in the real life system. Observations made from model outcomes provide an overview of what would happen in the real life system and allow for forecast of the direction of potential outcomes and provide an estimate of their magnitude of effect. In addition to circumventing the shortcomings and challenges of evaluating the impact of a change on a system by pre and post studies, time series analyses and cluster randomized controlled trials, DES is particularly advantageous when implementing these changes are financially taxing, time consuming, or potentially dangerous.[124]

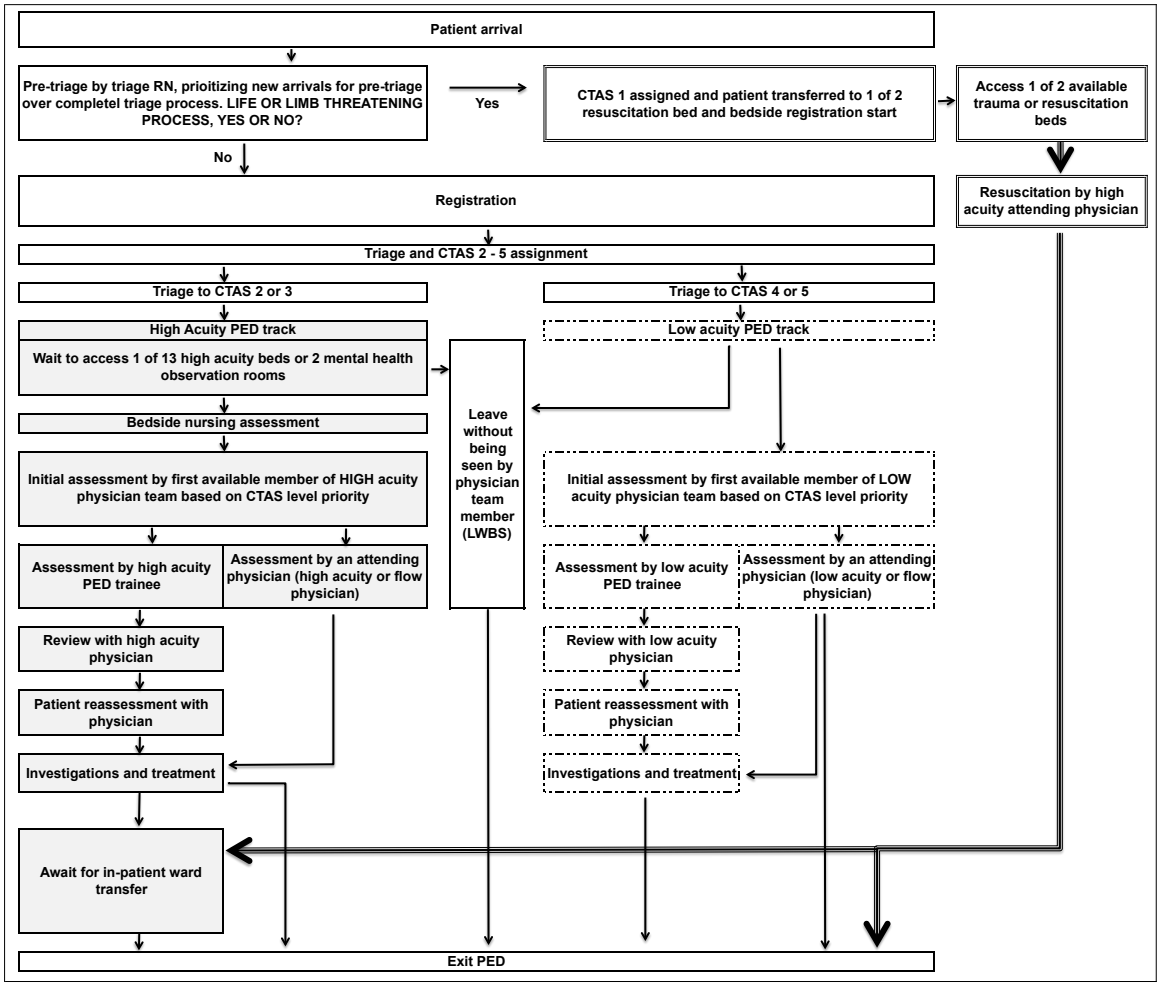
However, DES is not without limitations as it is dependent on the investigator's ability to build a model that sufficiently represents the real life system. This includes accurately and comprehensively reproducing important processes relevant to the system's function as it pertains to the outcomes being studied, yet filtering out processes that complicate the model or are difficult to observe and/or replicate. There is much variability in the observations one can use to build predictive models. Adding many interactions and confounding variables can result in greater uncertainty in a model's predictions. Furthermore, each stochastic process or model component relies on detailed data to adequately reflect its variability. Collecting these data may be challenging and time consuming, or in certain situations, these data may not be readily available and thus assumptions have to be made. For example, PAs are not yet licensed to work in British Columbia; the process time distribution associated with PAs patient assessment in a PED could not be directly observed, and was therefore assumed to mirror that of PED physicians or PED trainees. The

appropriateness of this assumption is discussed in the limitations section of this study.

5.2.1 System description and conceptual model building

A DES model was built based on the PED at British Columbia Children's Hospital (BCCH), the only tertiary care PED in British Columbia, receiving approximately 40 000 visits a year. Information on system layout and operating procedures was collected through consultation with PED staff and direct observations of random patients' flow through the PED from admission to discharge, at BCCH PED. These were displayed visually (Figure 2) and reviewed with the PED chief and nurse manager to ensure accurate representation of patients' course through the PED.

Figure 2. Conceptual model of BCCH PED



The BCCH PED functions as a two track system: a high acuity area, where patients triaged to the pediatric CTAS 1-3 are managed by a team composed of an emergency pediatrician and varying numbers of trainees, and a low acuity area, where patients triaged to CTAS levels 4 and 5 are managed by another team with similar composition as the high acuity area. The low acuity area is open from late morning to late evenings for a total of 14 hours per day. In addition, a third emergency physician (flow physician) is present in the evening seven days a week during the busy season (October to May), and Friday to Sunday only the rest of the year (June to September), to manage patients in either area depending on where the need is highest. This is defined as the area with the longest queue to see a physician, but favouring the high acuity area

when the queue there is longer than five patients, an empirically derived number supported by discussions with PED staff physicians and charge nurses. This flow physician usually manages patients triaged to CTAS level 3 and does not have clinical teaching responsibility for trainees during this shift.

Additional information such as distribution of patient triage levels using the pediatric CTAS, admissions to hospital data, and rate of patients leaving without being seen by a physician (LWBS) was obtained from the Provincial Health Services Authority (PHSA) support services (Table 18). A detailed inventory of resources available BCCH ED and emulated in the model is presented in Table 19.

Table 18. Model patient acuity and arrival rate distributions as obtained from administrative data via PHSA support services.

Patient arrival schedules	Theoretical distribution	Parameter (λ)
Winter-Spring December 1- May 31st.		
Week day (Mon-Fri, 08-1600)	Poisson	6
Week evenings (Mon-Thu 16-2400)	Poisson	8
Week nights (Tue-Fri 00-0800)	Poisson	1.6
Week end day (Sat, Sun and stats 08-1600)	Poisson	6
Week end evening (Fri-Sun 1600-2400)	Poisson	6.8
Week end nights (Sat-Mon 00-0800)	Poisson	2
Summer-Fall (Jun1-Nov30 2010)		
Week day (Mon-Fri, 08-1600)	Poisson	5
Week evenings (Mon-Thu 16-2400)	Poisson	5.8
Week nights (Tue-Fri 00-0800)	Poisson	1.4
Week end day (Sat, Sun and stats 08-1600)	Poisson	5.3
Week end evening (Fri-Sun 1600-2400)	Poisson	6.4
Week end nights (Sat-Mon 00-0800)	Poisson	1.6
CTAS breakdown	**Winter-Spring**	**Summer-Fall**
CTAS1	0.53%	0.75%
CTAS2	11.31%	12.23%
CTAS3	34.91%	33.30%
CTAS4	47.96%	48.34%
CTAS5	5.29%	5.38%
Disposition	**Proportion admitted to inpatient ward**	
CTAS1	65.50%	
CTAS 2	32.70%	
CTAS 3	11.70%	
CTAS 4 and 5	Negligible hence modeled as 0%	

Table 19. PED staff scheduling and resources included in the DES model.

Human resources	**N**	**Schedule**
Registration clerk	1	24 hours/day
Pre-Triage/triage nurse	1	00:00-15:00
	2	15:00-00:00
High acuity track bedside nurses	7	00:00-01:00
	4	01:00-07:00
	7	07:00-24:00
Attending physician high acuity track	1	24 hours/day
Attending physician low acuity track	1	10:00- 01:00
Baseline model flow attending physician	1	18:30-01:00 Oct-May week days
(CTAS levels 2-5)	1	17:30-01:00 Oct-May week ends
	1	18:00-01:00 Jun-Sep week ends only
Junior trainee for high acuity track	Average 1/hour x 24 hours/day	Varying schedule
Junior trainee for low acuity track	Average 1/hour x 14 hours/day	Varying schedule
Senior trainee for high acuity track	Average 1/hour x 7 hours/day	Varying schedule
Senior trainee for low acuity track	Average 1.4/hour x 24 hours/day	Varying schedule
Extended flow attending physician alternative	1	18:00-01:00 Oct-Dec15 week days
scenario 1 model	1	17:00-01:00 Oct-Dec15 week ends
	1	11:00-01:00 Dec15-to Jun15 daily
	1	18:00-01:00 June 15-Sep 30 week ends only
PA for alternative scenario 2 model	1	18:00-12:00 Oct11-May23 daily
	1	15:00-03:00 May 24-Oct 10 daily
PA for sensitivity analysis with overlapping PA	1	14:00-18:00 Oct11-May23 daily
schedules	2	18:00-24:00 Oct11-May23 daily
	1	20:00-02:00 Oct11-May23 daily
	1	16:00-18:00 May 24-Oct 10 daily
	2	18:00-22:00 May 24-Oct 10 daily
	1	22:00-24:00 May 24-Oct 10 daily
Physical resources	**N**	**Types**
PED beds	13	High acuity track
	2	Resuscitation bay
	2	Mental health observation room
	6	Low acuity track cubicles

5.2.2 Data collection and data processing for computerized model building.

Following training with the research coordinator, research assistants were stationed through out the PED, to conduct direct observations. For every process a patient encounters as part of their visit to the PED (described below), a research assistant observed and recorded the duration (beginning and end of process) in minutes using a stopwatch.

Research assistant were on site during selected shifts, including day, evening, and night shifts, as well as a sample of days of the week (Mon-Sun) during all four seasons from July 2010- June 2011.

To ensure data reliability, the research coordinator randomly paired up on shifts with the research assistants and collected data in duplicate alongside research assistants. In addition, prior to data entry, all time values were examined to detect any notable errors, such as entries that were chronologically reversed or instances when a physician would be recorded to initiate a new activity when the prior activity had not been recorded to end yet. In the few instances when such errors occurred, the implicated observations were excluded from analysis. These instances were also discussed with the responsible research assistant. Additional collection shifts were scheduled to ensure sufficient observations were obtained.

Processes for which research assistant conducted direct observation and time stamps were recorded were divided into three main sections.

Section 1: Research assistants stationed at the PED entrance

The first of the observed processes is called pre-triage: a rapid assessment at the time of arrival by a triage nurse to evaluate whether there is imminent threat to the child's life. If there is perceived imminent threat, the child is immediately labeled as CTAS 1 and is transferred to the resuscitation or trauma bay, where a bedside nurse and the high acuity physician meet the child as soon as possible after they are alerted. The registration clerk is also present at the bedside to facilitate registration with an accompanying adult while immediate care is given. The duration of the registration is recorded as the 2nd observed process in this section. If there is no perceived imminent life or limb threatening condition, the child and accompanying adult are directed to the queue at the registration desk. Following registration, the child queues for formal triage by the triage nurse, the third and final observed process occurring in the PED entrance area.

Section 2: Research assistants stationed in the high acuity track area

In the event that the child is triaged to CTAS level 2 or 3, the family is directed to the waiting room and queues for transfer to a bed in the high acuity area. Availability of a bed, is a dependent process. No data was collected for that process. The first observed process in the high acuity track is the bedside nurse assessment. Following this, the child queues for an initial assessment by the first available member of the high acuity physician team, the 2nd observed process in this section. If a trainee does the initial assessment, a case review (process # 3) and reassessment with the emergency pediatrician ensues (process #4) prior to a treatment period in the PED (process #5), encompassing investigations (laboratory and radiological) and medical interventions prior to disposition (process #6). Otherwise, following the initial assessment by the physician (process #2), the patient skips process #3 and #4, receives treatment (process #5), and is then admitted or discharged home (process #6).

A small proportion of these children will be admitted to the hospital, but only after a period of boarding in the PED. This encompasses time waiting for admitting team assessment and transfer to an in-patient bed whether at BCCH or another hospital in the Vancouver lower mainland (process #7). The high acuity bed and cubicle is then cleaned prior to receiving the next child in queue for a high acuity bed, which was the final process observed in this section (process #8).

Section 3: Research assistants stationed in the low acuity track area

In the event that a child is triaged to a CTAS level 4 or 5, the family is directed to wait to have an initial assessment by the first available member of the physician team assigned to the low acuity area, the first observed process in this section. There are only six cubicles and two procedure rooms for patient assessment and treatment in the low acuity area. Room occupation is only for very limited periods due to the lower severity of conditions managed in this area. Patients and their family are usually only placed in one of these cubicles

to undergo assessment by a member of the medical team or when actively undergoing a procedure. When patients are waiting for test results or for further investigations occurring in another part of the hospital, they are directed back to the waiting room. A patient is rarely ever left in the cubicle. Thus, the physician team member is freed to assess the next patient in queue. For this reason, a queue for bed or cubicle in the low acuity PED section was not included in the conceptual model as was the case in the high acuity area. Similar to the high acuity area, however, patients initially assessed by a trainee have their case reviewed (process #2) and reassessed with the attending physician (process #3) prior to undergo a treatment period (process #4) and then disposition (final process).

For each process observed, timed durations were fitted to a theoretical probability distribution, using the input analysis function on ARENA 10.0 Simulation Software (Rockwell Software, Sewickly, PA). (See Table 20) Although all patients are designed to undergo a treatment period (after initial assessment and reviews but before disposition decisions are made), some, particularly those in the low acuity area of the PED, do not require any investigations or procedures. These patients are discharged home immediately after the physician assessment, or, for those patients seen by a trainee, immediately after review and reassessment by the attending physician. These are recorded as having a treatment period duration of 0 minutes and contribute as such, to the theoretical probability distribution fitting.

The number of trainees present on any given shift in the high or low acuity PED area is variable. I used a sample of the 2010 trainee PED schedule to model the presence of senior trainees (fifth year residents in emergency medicine or second year pediatric emergency subspecialty residents) and number of junior trainees (other residents and medical students) in the PED on any given shift.

Table 20. Theoretical probability distributions of PED process durations as obtained from direct observations and data collections.

Observed PED process	N events observed	Service time distribution (parameter) (minutes)
Pre-triage	1563	LOGN(1.63, 1.02)
CTAS1 MD assessment and resuscitation	188	4 + EXPO(54.6)
CTAS1 Nursing monitoring and resuscitation care	76	353 x Beta(0.473, 1.06)
Registration	1518	LOGN(3.93, 1.9)
Triage	1344	ERLA(1.46, 5)
High acuity track bedside nursing assessment	99	25 x BETA(1.19, 2.11)
High acuity initial assessment by junior trainee	263	-0.001 + ERLA(5.45, 3)
High acuity initial assessment by attending staff or senior trainee	221	1 + LOGN(11.8, 10.7)
High acuity case review with attending physician	295	-0.001 + WEIB(6.4, 1.27)
High acuity case reassessment with attending physician	280	-0.001 + EXPO(3.88)
CTAS 2 investigation and treatment time	85	-0.001 + EXPO(176)
CTAS 3 investigation and treatment time	286	-0.001 + GAMM(180, 0.596)
Flow Attending Physician assessment time (CTAS 2-5)	121	ERLA(2.19, 4)
Waiting for transfer to inpatient ward	3367	GAMM(92.1, 1.41)
Final room/bed cleaning	109	2+ LOGN(17.4, 16.2)
Low acuity initial assessment by junior trainee CTAS 4	396	3 + WEIB(12.8, 1.74)
Low acuity initial assessment junior trainee CTAS 5	31	TRIA(1, 6.82, 26)
Low acuity initial assessment by attending staff or senior trainee CTAS 4 & 5	531	1+ ERLA (3.74, 2)
Low acuity case review with attending physician	500	-0.001+ ERLA(2.14, 2)
Low acuity case reassessment with attending physician	467	-0.001+ EXPO(4.48)
CTAS 4 investigation and treatment time	785	-0.001+ 882 x BETA(0.196, 3.87)
CTAS 5 investigation and treatment time	90	-0.001+ WEIB(15.8, 0.491)

In addition to processes described above, the research assistants also documented all physicians' activities which were not directly involved in a patient flow through the PED, such as charting, clinical teaching, communicating with consultants, answering phone calls, or personal breaks, and any activities that precludes the physician seeing the next child waiting in queue. These were labeled as either personal activities (breaks and non PED patient related discussions or paperwork), or PED operations or patient care related activities. Their frequency and duration were recorded in a similar fashion to the direct patient care processes. (Table 21).

Table 21. Theoretical distributions for Physicians other activities' frequencies and durations as obtained from direct observations and data collections.

Other physician activities frequency	N observations	Theoretical distribution (parameter/hour)	Notes
High acuity track physician day time activities during winter -spring season	880	Poisson (11.9)	*14.6%=personal activities
High acuity track physician night time activities during winter -spring season	117	Poisson (6)	*25%=personal activities
High acuity track physician day time activities during summer-fall season	369	Poisson (9.3)	*14.6%=personal activities
High acuity track physician night time activities during summer-fall season	38	Poisson (4)	*25%=personal activities
Low acuity track physician activities during winter-spring season	1265	Poisson (4.8)	* 10:00- 18:00 **17.1%=personal activities
	320	Poisson (8)	* 18:00-22:00 **17.1%=personal activities
	34	Poisson (3.5)	* 22:00-24:00 **17.1%=personal activities
Low acuity track physician activities during summer-fall season	188	Poisson (7.65)	* 10:00- 18:00 **17.1%=personal activities
	30	Poisson (8.1)	* 18:00-22:00 **17.1%=personal activities
	6	Poisson (6.4)	* 22:00-24:00 **17.1%=personal activities
Flow physician "other" clinical activities incidence during winter-spring season	458	Poisson (8.7)	
Flow physician "other" clinical activities incidence during summer-fall season	156	Poisson (6.8)	
Flow physician "other" personal activities incidence (year round)	73	Poisson (1.48)	
Other physician activity duration		**Theoretical distribution (parameter in minutes)**	
Low acuity track physician "other" activities duration	1549	LOGN (6.95, 10.7)	Personal activities
	324	LOGN(4.07, 4.52)	Clinical activities
Flow physician "other" activities duration	542	LOGN(4.29, 4.36)	Clinical activities
	61	45xBETA (0.462, 2.07)	Personal activities
High acuity track physician daytime clinical activities	581	LOGN (6.09, 6.46)	Clinical activities
	141	WEIB (8.95, 1.09)	Personal activities
High acuity track physician night time clinical activities	115	1+ WEIB (3.04, 0.897)	Clinical activities
	40	1+Expo (19.3)	Personal activities

5.2.3 Computerized model building, verification and validation

The computed operational model was built using ARENA 10.0 Simulation based on the conceptual model described above and the time distributions as collected through direct observations. The model was verified by examination of its output for reasonableness, using stress tests to ensure that all modules and software functions used were adequate.[c] Thus I ran the model with overwhelmingly high patient arrival rates, high physician interruption rates, varying acuity level distribution, exaggerating the proportion for each of the CTAS level sequentially. If the model is adequately designed, queues associated with these varied inputs are expected to lengthen but patients reaching the head of the queue will still be processed appropriately until the simulation program reaches maximum allowed number of entity in the system and the simulation run is interrupted due to software limitations rather than model design error. [d]

The baseline model was validated by comparing the averaged total annual visit numbers, waiting time, LOS and LWBS rates from five iterations of one simulated year, to those from 2010 administrative data, provided by the Provincial Health Service Authority (PHSA) decision support services. I opted *a priori* to validate the model comparing outcome measures summaries of only CTAS level 2-5 patients. PED visits triaged to CTAS level 1 are infrequent and when the physician is made aware of a patient being triaged to this level, the priority is to assess, resuscitate and stabilize the child. Physicians, therefore, usually enter the time of physician initial assessment and resuscitation, after

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[c] Stress testing allowed me to see how the model design responded to extraordinary conditions. If a model is adequately designed, it will respond as anticipated even under unrealistically extreme conditions, and the simulation will be terminated due to software capacity limits rather then design malfunction.

[d] Inherent to ARENA simulation software, the number of entities present in a model during any simulation period, is capped at 12 500. This is a reasonable cap for this study as entities in our models are patients, and 12 500 is an unrealistically high number of patients to have at any one time in the PED. When the number of patients in the system reaches this maximal number, the simulation run is interrupted.

the patient has been stabilized or has left the PED resuscitation bay, hence the waiting time as recorded in the administrative database may be inaccurate.

5.2.4 Scenario testing and outcome measures

The first model tested the system performance of the PED with additional emergency pediatrician coverage added to the system. A total of 1450 physician hours/year of PED coverage at the cost of C$307,000 was added to the flow physician schedule. This amount of extra coverage is equivalent to approximately one full-time equivalent clinical PED physician position. This is also the amount of additional coverage the Department of Pediatrics is currently negotiating with the BC Ministry of Health to address recent BCCH PED volume surges. These additional hours were used to provide an extra 6-hour shift each day, during the busiest periods of the year (winter-spring), and busiest hours of the day (afternoon and evening) as recommended by our PED nurse manager and physicians.

The second model tested the PED performance with the addition of a PA. I chose to keep the additional costs equal to the extended physician model (i.e. C$307,000), which buys 5750 hours of PA coverage at C$53.00/hour including benefits (rate obtained from the past president of the Canadian PA Association). These PA hours were spread over the whole year but favouring busiest days of the year (18 hours per day during winter-spring and 12 hours per day during summer-fall) and busiest hours of the day (afternoon and evening).

On reviewing the range of clinical conditions treated at our PED, participating physicians and PAs primarily selected conditions generally triaged to CTAS level 4 and 5 and had identified only three clinical conditions for which over 80% of surveyed physicians and PAs felt did not need direct physician involvement. These three conditions together totalled 5901 PED visits per year, or 21% of all CTAS 4 and 5 visits in a year. Based on these data (derived from Chapter 3), the PAs were set to manage only CTAS level 4 and 5 patients, and

need to have 79% of cases (randomly assigned in the model) reviewed and reassessed by the physician assigned to the low acuity track.

The decision to model PAs work in PED in the low acuity track and the proportion of PA caseload requiring review and reassessment by the physician was chosen based on the outcomes of my survey of BCCH PED physicians and invited PAs. Review and reassessment with the physician duration was modeled to occur before the PA can assess another patient. Similarly to when a junior trainee is the first physician team member to see the patient, the physician is taken out of the available physician team member group for the duration of the review and reassessment with the PA, and cannot be used for any other function.

In this scenario, when a PA is scheduled to work in the PED, the attending physician assigned to the low acuity track may help out in the high acuity side when the queue to be seen by a physician team member is longer there than in the low acuity area, but the model still prioritizes reviews and reassessment in the low acuity side with trainees and PAs. The model was set to compare queues to be assessed by a physician team member and reassign the low acuity physician to either treatment area every 30 minutes. This frequency was empirically selected on the assumption that 30 minutes is the shortest amount of time during which the physician could see a meaningful number of patients and therefore impact flow. Reassigning the physician to the other treatment area more frequently would likely negatively impact the physician's productivity.

As PAs are not working in BCCH PED, their service times could not be observed directly. Based on discussions with PAs working in EDs in Manitoba and Washington, I have arbitrarily assumed that PA initial assessment times follow a similar time distribution as that of physicians, and that the duration of case review and reassessment by PAs with physicians follow the same theoretical distributions as that of trainees, for which data was collected. The schedule for PA coverage almost fully incorporates that of the extended flow physician; both are described in detail in Table 15.

Sensitivity analyses

In addition to the 2 main scenarios described above, I ran additional scenarios to explore the effect of varying: 1) the allocation of physician team member when a PA is on shift 2) the degree of PA autonomy (i.e. the % cases needing physician review), 3) PA schedules, 4) the number of patients a PA can have waiting to review with the attending physician, and 5) PA assessment times.

With regard to the first scenario, the PA was added to the model but the physician assigned to the low acuity area remains there, rather than float to the high acuity area, even when the queue is longer in the high acuity area. With regard to the second scenario, I ran a model for the proportion of PA cases to be reviewed and reassessed with the physician ranging from 100% to 10% of all cases, or in other words, with increasing autonomy. With regard to the third scenario, I varied the PA schedules from the baseline where a maximum of one PA is on shift at any given time versus overlapping schedule for double coverage in the evenings when it is busiest, as described in Table 15. For the fourth scenario, I tested the model with PAs taking longer to do the initial patient assessment than PED physicians in effect mirroring that of the junior trainees. For the fifth scenario, I varied the number of patients a PA could assess in a row before having to review them with a physician, from 0 (in the main PA model) to 2.

Outcome analyses

Each model was run for a simulated year and the averaged outputs of 5 iterations, was used. Descriptive statistics were used to report absolute differences in mean waiting time, LOS in ED and LWBS rates, stratified by pediatric CTAS levels between each of the alternative scenarios and the baseline model, reporting the 95% confidence interval (CI) surrounding the differences, as well as relative differences from baseline.

5.3 Results

5.3.1 Model verification

The model responded as expected to all stress testing. Amplifying the patient arrival rate to a continuous stream of patients with inter-arrival time intervals set shorter than the time it takes to pre-triage, overwhelmed the pre-triaging process. As anticipated, the queue for triage continued to lengthen until the number in queue exceeded the number of patients allowed in the simulation program at any one point in time (12,500) and simulation was terminated. Similarly, increasing the frequency or duration of physician interruptions to extremes, reduced their availability, and resulted in lengthening queues for physician assessments until the simulation was terminated due to accumulation of patients in the queue exceeding the maximum allowed by the software.

Exaggerating the discrepancy in acuity level distribution, making the triage level of patients predominantly CTAS 1 or CTAS 2 resulted in lengthening queues for a high acuity bed as well as for physician assessment, while shifting most of the patients to CTAS 3 level resulted in lengthening only in the queue for physician assessment in the high acuity area. This is reasonable as patients in CTAS 2 level have longer treatment periods, higher admission rates and therefore occupy beds for longer periods than patients in CTAS 3 level. But as physicians were functioning normally, although LOS and waiting time became extremely long and LWBS rates very high, the system did not come to a stand still and the simulation was not prematurely terminated. Shifting most of the patients to either CTAS 4 or CTAS 5 levels raised the queue for physician assessments in the low acuity area, resulting in high LOS, waiting time and LWBS rates, and model integrity was maintained while the simulation progressed to completion.

5.3.2 Model validation

The PED baseline modeled output summaries mirrored those acquired from the administrative database, with the exception of outcome measures from CTAS 1 level patients (Table 19). As expected, due to limitations

associated with collection of the time of assessment by physicians during an active resuscitation, the derived waiting time obtained from the administrative data for CTAS 1 level visits were unrealistically long. Furthermore, I stratified the baseline model outputs by the 2 main seasonal periods winter spring and summer-fall, and found that the number of patients visiting the PED per CTAS level, LWBS rate, waiting time and LOS remained comparable between my model output and the administrative data.

Table 22. Model validation results (model output compared to real PED data from administrative database).

	Baseline model output			*PHSA administrative data*		
CTAS	**Mean N visits/year (%)**	**Mean N visit during winter-spring**	**Mean N visit during summer-fall**	***Mean N visits/year (%)***	***Mean N visit during winter-spring***	***Mean N visit during summer-fall***
1	252	110	141	*252*	*113*	*139*
2	4688	2424	2264	*4646*	*2402*	*2244*
3	13523	7426	6096	*13525*	*7416*	*6109*
4	19074	10218	8856	*19056*	*10188*	*8868*
5	2364	1232	1131	*2362*	*1237*	*1125*
CTAS	**N LWBS[e]**	**Proportion of visits LWBS (95%CI)**		***N LWBS***	***Proportion of visits LWBS (95%CI)***	
1	0	0		0	*0*	
2	0	0		0	*0*	
3	168	1.2% (1.1, 1.4%)		166	*1.2% (1.0, 1.4%)*	
4	592	3.1% (2.8, 3.4%)		594	*3.1% (2.9, 3.4%)*	
5	355	15.0% (13.6, 15.5%)		369	*15.6% (14.2, 17.0%)*	

[e] LWBS: Left without being seen

Table 22 continued. Model validation results (model output compared to real PED data from administrative database).

Baseline model output				*PHSA administrative data*		
CTAS	**Mean LOS[f] min (95%CI)**	**Mean LOS winter-spring (95%CI)**	**Mean LOS summer-fall (95%CI)**	***Mean LOS min (95%CI)***	***Mean LOS* winter-spring *(95%CI)***	***Mean LOS* summer-fall *(95%CI)***
1	226.7 (219.9, 233.4)	235.2 (223.2, 247.3)	219.6 (210.5, 228.7)	*237.8 (213.0, 262.6)*	*282.9 (244.7, 321.1)*	*201.1 (169.7, 232.5)*
2	315.4 (313.5, 317.3)	322.9 (317.4, 328.4)	307.2 (302.0, 312.5)	*315.0 (309.0, 321.0)*	*321.6 (313.3, 330.0)*	*307.9 (299.4, 316.4)*
3	259.2 (255.9, 262.5)	268.1 (261.1, 275.2)	248.4 (245.1,251.7)	*249.2 (246.3, 252.1)*	*257.8 (253.8, 261.8)*	*238.8 (234.6, 242.9)*
4	176.2 (173.7, 178.6)	182.1 (180.1, 184.0)	169.4 (165.7, 173.0)	*170.2 (168.7, 171.7)*	*176.4 (174.3, 178.6)*	*163.0 (160.9, 165.1)*
5	154.8 (150, 159.7)	164.4 (159.5, 169.2)	144.3 (139.2, 149.4)	*144.9 (141.1, 148.7)*	*148.7 (143.7, 153.8)*	*140.6 (135.2, 146.1)*
CTAS	**Mean waiting time (95%CI)**	**Mean waiting time winter-spring (95%CI)**	**Mean waiting time summer-fall (95%CI)**	***Mean waiting time (95%CI)***	***Mean waiting time* winter-spring *(95%CI)***	***Mean waiting time* summer-fall *(95%CI)***
1	11.8 (11.3, 12.3)	13.5 (12.8, 14.3)	10.4 (9.5,11.4)	*52.4 (46.3, 58.6)*	*57.3 (46.4, 68.2)*	*47.9 (41.4, 54.4)*
2	66.9 (65.1, 68.7)	72.4 (69.6, 75.2)	61.1 (59.2, 62.9)	*70.5 (68.7, 72.4)*	*74.1 (71.5, 76.7)*	*66.6 (64.0, 69.3)*
3	114.5 (111.1, 117.9)	122.6 (114.7, 130.5)	104.7 (101.3, 108.1)	*114.6 (113.4, 115.8)*	*123.2 (121.5, 124.9)*	*104.3 (102.7, 106.0)*
4	107.6 (105.0, 110.1)	114.2 (112.0, 116.4)	99.9 (96.5, 103.4)	*106.0 (105.2, 106.9)*	*113.1 (111.9, 114.3)*	*98.1 (96.9, 99.3)*
5	103.9 (99.6,108.2)	114.1 (109.4, 118.8)	92.6 (88.2, 97.1)	*103.9 (101.3, 106.5)*	*110.5 (107.1, 114.0)*	*97.0 (93.3, 100.6)*

5.3.3 Strategy scenario testing

Outputs from the first scenario model with extended flow physician coverage are displayed in Table 23. Extending the flow physician coverage achieved significant reduction in waiting time during the winter-spring seasons across all 5 CTAS levels, with proportionate reduction in LOS during the winter-spring seasons. As expected, there were no significant changes on the outcome measures during the summer-fall seasons, but the effect during the winter-spring was large enough to affect the annual mean waiting time and LOS in most CTAS levels and resulted in a 60% reduction in LWBS rates at the CTAS 3 level and approximately 30% for CTAS levels 4 and 5.

[f] LOS: Length of stay

Outputs from the second scenario model (i.e. the introduction of a PA to the low acuity track, physicians review 79% of the PA caseload, and occasionally sharing the low acuity physician with the high acuity track) are presented in Table 24. This model resulted in meaningful reductions in waiting time only in CTAS levels 1 to 3. The 95% CI on the waiting time reductions observed for CTAS levels 4 and 5 crossed 0, and were clinically negligible. There was also modest increase in LOS in CTAS 4 and 5 patients. Similarly, the relative reduction in LWBS rate is larger for CTAS level 3 visits in the PA model than in the extended flow physician model, but with only modest reduction in LWBS rate among CTAS level 4 and 5 visits. A comparison between the impact of increasing the physician coverage and introducing PAs is summarized in table 25.

Table 23. Model outcome measures summary for first alternative scenario model (extended flow physician coverage) and differences from the baseline model.

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	0.5% (0.3, 0.7%)	0.8% (0.5, 1.0%)	60.00%
4	2.2% (1.9, 2.4%)	1% (0.7, 1.3%)	30.95%
5	11.0% (9.53, 12.47%)	5.0% (2.4, 7.5%)	26.99%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	219.0 (213.2, 224.9)	7.7 (2.4, 12.9)	3.38%
2	293.5 (290.5, 296.4)	21.9 (19.8, 24.0)	6.94%
3	216.4, (211.7, 221.1)	42.8 (39.5, 46.2)	16.53%
4	154.6 (151.0, 158.2)	21.5 (19.0, 24.1)	12.22%
5	133.4 (129.0, 137.8)	21.4 (18.3, 24.5)	13.82%
CTAS	**LOS winter-spring (95%CI)**	**Absolute reduction in LOS during winter-spring in min (95%CI)**	**Relative (%) reduction LOS during winter-spring**
1	213.5 (203.9, 223.0)	21.8 (12.7, 30.8)	9.26%
2	282.2 (281.2, 283.3)	40.6 (37.4, 43.9)	12.59%
3	195.5 (192.9, 198.2)	72.6 (68.2, 77.0)	27.08%
4	146.0 (142.3, 149.6)	36.1 (33.7, 38.5)	19.83%
5	124.6 (120.2, 129.0)	39.8 (36.0, 43.6)	24.21%
CTAS	**LOS summer-fall (95%CI)**	**Absolute reduction in LOS during summer-fall in min (95%CI)**	**Relative (%) reduction LOS during summer-fall**
1	223.4 (215.1, 231.7)	-3.8 (-4.5, -3.2)	-1.72%
2	305.4 (299.4, 311.4)	1.9 (0.35, 3.35)	0.61%
3	241.8 (232.3, 251.4)	6.6 (3.9, 9.3)	2.72%
4	164.8 (160.3, 169.3)	4.5 (2.4, 6.7)	2.75%
5	143.8 (137.8, 149.7)	0.5 (-2.3, 3.3)	0.37%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	8.7 (7.9, 9.6)	3.0 (2.4, 3.7)	25.83%
2	49.9 (47.7, 52.2)	17.0 (15.5, 18.5)	25.39%
3	72.6 (68.4, 76.8)	41.9 (39.2, 44.6)	36.59%
4	86.8 (83.5, 90.1)	20.8 (18.7, 22.9)	19.30%
5	82.7 (78.4, 87.1)	21.2 (18.4, 24.0)	20.38%
CTAS	**waiting time winter-spring (95%CI)**	**Absolute reduction in waiting time during winter-spring in min (95%CI)**	**Relative (%) reduction waiting time during winter-spring**
1	7.1 (5.9, 8.3)	6.5 (5.7, 7.2)	47.71%
2	42.9 (41.6, 44.1)	29.5 (28.3, 30.8)	40.80%
3	52.0 (50.2, 53.7)	70.6 (68.4, 72.9)	57.61%
4	80.1 (76.6, 83.6)	34.1 (32.5, 36.6)	29.83%
5	75.4 (71.0, 79.7)	38.8 (35.2, 42.4)	33.96%
CTAS	**waiting time S summer-fall (95%CI)**	**Absolute reduction in waiting time during summer-fall in min (95%CI)**	**Relative (%) reduction waiting time during summer-fall**
1	10.1 (8.2, 12.0)	0.3 (-0.9, 1.6)	3.30%
2	57.5 (53.1, 61.8)	3.6 (0.8, 6.4)	5.86%
3	97.8 (89.4, 106.2)	6.0 (1.6, 12.2)	6.59%
4	94.7 (90.8, 98.5)	5.3 (2.4, 8.1)	5.26%
5	91.3 (86.3, 96.3)	1.3 (-2.6, 5.3)	1.44%

Table 24. Model outcome measures summary for 2nd alternative scenario model (PA in low acuity PED track) and differences from the baseline model.

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	0.2% (0.02, 0.38%)	1.1% (0.9,1.3%)	84.4%
4	2.5% (2.28, 2.8%)	0.6% (0.2,0.9%)	18.2%
5	14.1% (12.7, 13.6%)	0.9% (-1.2,2.9%)	6.6%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	235.3 (220.5, 250.0)	-8.6 (-18.1,0.9)	-3.8%
2	282.7 (280.8, 284.6))	32.6 (31.1, 34.2)	10.4%
3	200.2 (196.8, 203.7)	59.0 (-56.2, 61.9)	22.8%
4	183.8 (182.1, 185.5)	-7.7 (-9.4, -5.9)	-4.4%
5	169.1 (167.9, 170.2)	-14.2 (-11.3, -17.2)	-9.2%
CTAS	**LOS W/S (95%CI)**	**Absolute reduction in LOS during W/S in min (95%CI)**	**Relative (%) reduction LOS during W/S**
1	241.8 (225.3, 258.2)	-6.5 (-18.5, 5.5)	-2.8%
2	280.8, 277.9, 283.7)	42.1 (38.4, 45.7)	13.0%
3	199.4 (195.6, 203.2)	68.7 (64.0, 73.4)	25.6%
4	185.7 (182.4, 189.0)	-3.6 (-5.9, -1.4)	-2.0%
5	174.7 (173.6, 175.9)	-10.4 (-14.1, -6.6)	-6.3%
CTAS	**LOS S/F (95%CI)**	**Absolute reduction in LOS during S/F in min (95%CI)**	**Relative (%) reduction LOS during S/F**
1	229.5 (214.4, 244.5)	-9.9 (-10.6, -9.2)	-4.5%
2	284.7 (280.6, 288.9)	22.5 (21.4, 23.6)	7.3%
3	102.2 (195.4, 207.0)	47.2 (44.8, 49.6)	10.0%
4	181.7 (178.1, 185.2)	-12.3 (-10.9, -7.2)	-7.3%
5	162.9 (159.3, 166.5)	18 (16.1, 19.9)	12.5%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	7.2 (6.2, 8.2)	4.6 (3.9, 5.3)	38.8%
2	42.2 (40.8, 43.6)	24.7 (23.6, 25.8)	36.9%
3	55.8 (52.1, 59.5)	58.7 (56.3, 61.1)	51.3%
4	99.4 (97.6, 101.2)	8.2 (6.8, 9.6)	7.6%
5	100.9 (98.4, 103.4)	3.0 (1.1, 4.9)	2.9%
CTAS	**Waiting time W/S (95%CI)**	**Absolute reduction in waiting time during W/S in min (95%CI)**	**Relative (%) reduction waiting time during W/S**
1	8.0 (6.2, 9.7)	5.6 (4.5, 6.6)	41.2%
2	43.5 (42.6, 44.4)	28.9 (27.7, 30.1)	39.9%
3	55.8 (51.5, 60.0)	66.8 (63.7, 70.0)	54.5%
4	102.0 (98.9, 105.1)	12.2 (9.8, 14.5)	10.7%
5	106.5 (101.3, 11.7)	7.6 (3.7, 11.6)	6.7%
CTAS	**Waiting time S/F (95%CI)**	**Absolute reduction in waiting time during S/F in min (95%CI)**	**Relative (%) reduction waiting time during S/F**
1	6.6 (5.7, 7.4)	3.9 (3.1, 4.6)	37.0%
2	40.8 (38.8, 42.9)	20.2 (18.6, 21.8)	33.1%
3	55.8 (51.7, 60.0)	48.8 (45.7, 52.0)	46.7%
4	96.3 (92.7, 99.9)	3.6 (0.9, 6.4)	3.7%
5	94.8 (91.7, 98.0)	-2.2 (-5.4, 1.0)	-2.4%

Table 25. Comparison between the impact of increasing the physician coverage and introducing PAs

	Physician model	PA model
CTAS	**Relative reduction in LWBS rate**	
1	NA	NA
2	NA	NA
3	60.0%	84.4%
4	31.0%	18.2%
5	17.0%	6.6%
CTAS	**Relative reduction in LOS**	
1	3.4%	-3.8%
2	6.9%	10.4%
3	16.5%	22.8%
4	12.2%	-4.4%
5	13.8%	-9.2%
CTAS	**Relative reduction in waiting time**	
1	25.8%	38.8%
2	25.4%	36.9%
3	36.6%	51.3%
4	19.3%	7.6%
5	20.4%	2.9%

5.3.4 Sensitivity analyses

Physician resource reallocation

Preventing the low acuity physician from floating between the two areas resulted in moderate improvement in waiting time outcomes in the low acuity area and, predictably, no impact on outcomes in the high acuity area. This is in contrast to the second scenario model with PAs and in which the low acuity physician is reassigned to the high acuity area when that queue is longer than that in the low acuity area, which, as noted above, led to substantial reductions in the waiting time, LOS and LWBS rates for patients in the high acuity area to the detriment of those in the low acuity area. (See Table 26)

Table 26. Model outcome measures summary for model with PAs in low acuity track without allowing low acuity physician to float between treatment areas.

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	1.2% (1.0, 1.3%)	0.07% (-0.2, 0.3)	6.0%
4	2.3% (2.1, 2.6%)	0.8% (0.5, 1.1%)	24.8%
5	12.7% (11.2, 14,2%)	2.4% (0.4, 4.3%)	16.5%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	226.7 (219.0, 234.5)	0.0 (-6.1, 6.0)	0.0%
2	317.5 (315.8, 320.2)	-2.2 (-4.1, -0.2)	-0.7%
3	256.5 (255.3, 257.8)	2.7 (0.6, 4.7)	1.0%
4	169.6 (166.4, 172.8)	6.6 (4.2, 8.9)	3.7%
5	149.2 (146.2, 152.1)	5.7 (2.7, 8.7)	3.7%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	11.6 (11.0, 12.2)	0.2 (-0.3, 0.7)	1.7%
2	65.8 (64.9, 66.7)	1.1 (0.2, 2.1)	1.7%
3	112.8 (111.6, 114.1)	1.7 (0.4, 2.9)	1.5%
4	91.3 (90.1, 92.5)	16.2 (15.1, 17.4)	15.1%
5	88.9 (88.5, 89.3)	15.0 (13.9, 16.2)	14.4%

This suggests that we may be able to achieve a reasonable balance between the impact of adding a PA to benefit both treatment areas, by modifying the conditions under which the low acuity physician's time is allocated between the low and high acuity areas. There are alternatives to sending the low acuity area physician to the high acuity area whenever the queue to see a physician team member is longer in the high acuity area than the lower area. Perhaps, the low acuity physician would only be sent to the high acuity area when the queue there exceeds that of the low acuity area by a set range of number of patients in queue, in order to achieve the desired balance regarding the impact on each of the treatment area.

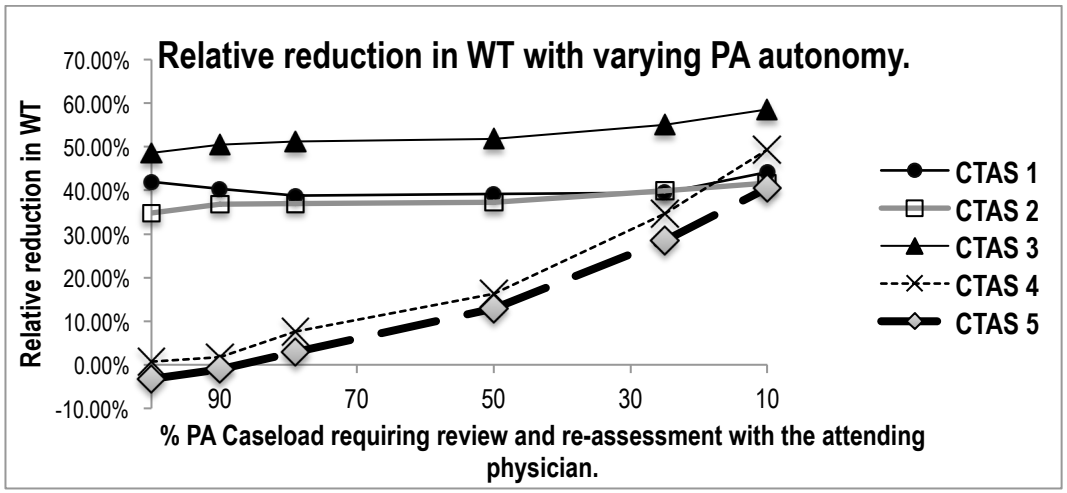
However, comparison of waiting time between models with the low acuity physician being assigned to high acuity area when the queue in the high acuity area is longer in the low acuity area by a range of "N" versus "N+1" is very cumbersome and unlikely to yield precise predictions. This is because

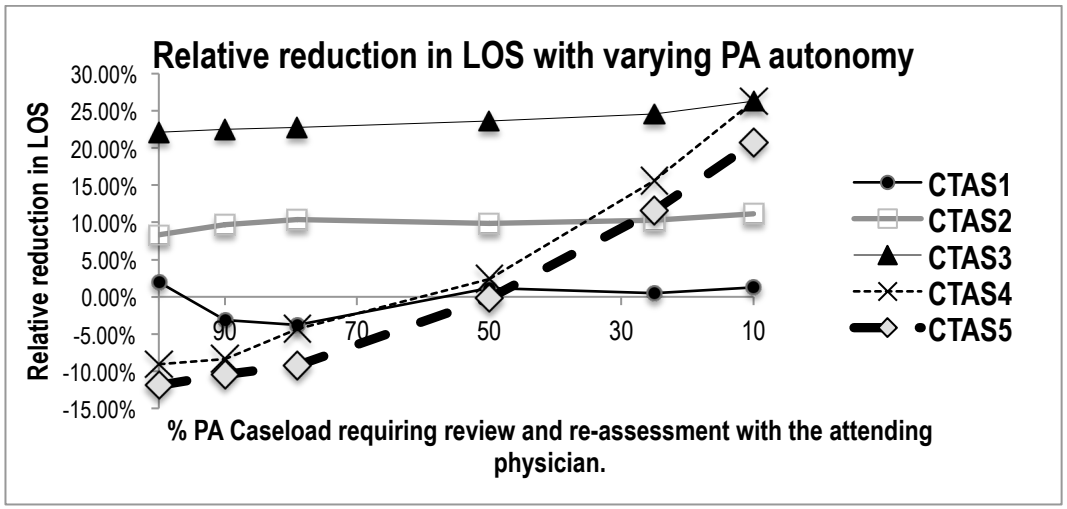
variations in queuing for physician assessment may occur very rapidly, based on the complexity of cases currently being managed, newly arrived patients and staff availability. Moreover, constant monitoring for a specifically determined difference in queue length between the two treatment areas would be time consuming to implement in reality.

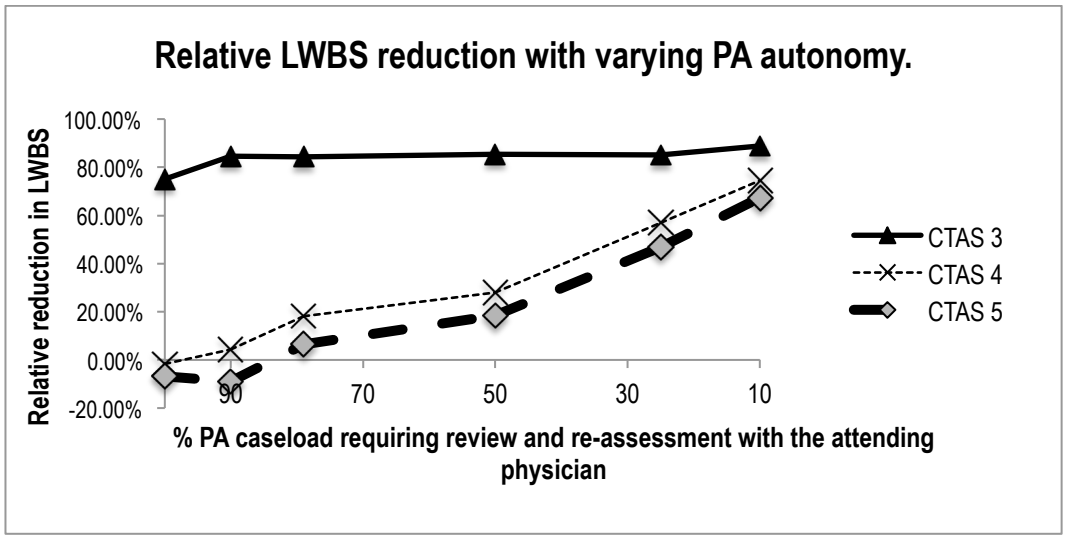
PA autonomy

Increasing PA autonomy or proportion of caseloads PA can assess and manage without direct physician involvement (from reviewing 100% of caseload to 10% with the physician) resulted in consistent and appreciable increase in reduction in mean waiting time, LOS and LWBS rates in CTAS 4 and 5 levels, but little changes to outcomes for CTAS levels 1, 2, and 3 visits. The reductions in waiting time, LOS and LWBS for CTAS 1-3 remained superior to those obtained in the extended flow physician model even if PAs had to have 100% of their caseload reviewed. When the proportion of cases to be reviewed reached 50%, however, the PA model would result in a relative reduction in waiting time for CTAS levels 4 and 5 comparable to the outcomes of the physician model. These are illustrated in Figure 3.

Figure 3. Effect of PA autonomy on relative reduction in waiting time, LOS, and LWBS rate.







Other sensitivity analyses including varying the PA schedules to overlap their shifts (Table 27), lengthening PA's assessment time to mirror that of junior trainees (Table 27), and allowing PAs to assess and accumulate up to 2 cases before having to review and reassess with an attending (Table 28), did not affect the outcome measures when compared to the baseline PA model (2nd alternative strategy model) in a meaningful way.

Table 27. Model outcome measures summary for model with PAs in low acuity track with overlapping schedules to double cover evenings

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	0.3% (0.1, 0.5%)	1.0% (0.7, 1.2%)	76.0%
4	2.7% (2.4, 2.9%)	0.5% (0.1, 0.8%)	14.6%
5	13.9% (12.5, 15.4%)	1.1% (-0.9, 3.1%)	8.4%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	222.0 (217.3, 226.7)	4.5 (-0.2, 9.2)	2.1%
2	292.3 (291.0, 293.5)	30.5 (28.9, 32.1)	7.3%
3	207.8 (202.1, 213.4)	58.2 (56.1, 60.3)	19.8%
4	182.2 (180.1, 184.2)	-13 (-15.6, -10.4)	-3.4%
5	160.8 (157.4, 164.3)	-14.3 (-17.3, -11.3)	-3.9%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	8.2 (7.1, 9.2)	4.9 (4.5, 5.4)	30.7%
2	47.2 (46.6, 47.8)	23.8 (13.2, 34.4)	29.4%
3	64.1 (58.9, 69.2)	57.2 (37.2, 77.2)	44.0%
4	97.3 (95.6, 99.1)	3 (-12.2, 18.2)	9.5%
5	94.6 (91.9, 97.3)	0.6 (-24.6, 25.8)	9.0%

Table 28. Model outcome measures summary for model with PAs in low acuity track but with assessment times as long as trainees

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	0.3% (0.1, 0.4%)	0.9% (0.7, 1.1%)	79.1%
4	2.8% (2.6, 3.1%)	0.3% (-0.1, 0.6%)	8.8%
5	15.1% (13.6, 16.6%)	0.7% (-1.4, 2.7%)	-1.8%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	222.2 (218.0, 226.4)	0.0 (-6.1, 6.0)	2.0%
2	284.9 (282.9, 286.8)	-2.2 (-4.1, -0.2)	9.7%
3	201.0 (199.5, 202.5)	2.7 (0.6, 4.7)	22.5%
4	189.2 (185.6, 192.9)	6.6 (4.2, 8.9)	-7.4%
5	169.1 (167.1, 171.1)	5.7 (2.7, 8.7)	-9.2%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	6.9 (6.5, 7.3)	0.2 (-0.3, 0.7)	41.5%
2	43.1 (42.5, 43.7)	1.1 (0.2, 2.1)	35.6%
3	57.3 (56.2, 58.4)	1.7 (0.4, 2.9)	50.0%
4	104.5 (101.2, 107.9)	16.2 (15.1, 17.4)	2.8%
5	103.3 (100.3, 106.3)	15.0 (13.9, 16.2)	0.6%

Table 29. Model outcome measures summary for model with PAs in low acuity track accumulating 2 patient assessments before they have to wait for a physician and have these cases reviewed before continuing on

CTAS	Proportion LWBS (95%CI)	Absolute difference in % LWBS (95% CI in difference)	Relative (%) reduction
1	0		
2	0		
3	0.2% (0.0, 0.4%)	1.0% (0.8, 1.3%)	83.6%
4	2.3% (2.1, 2.6%)	0.8% (0.4, 1.1%)	24.5%
5	12.6% (11.2, 14.1%)	2.4% (0.4, 4.3%)	15.3%
CTAS	**Overall LOS min (95%CI)**	**Absolute reduction in LOS in min (95%CI)**	**Relative (%) reduction LOS**
1	226.7 (219.0, 234.5)	0.6(-6.7, 7.9)	0.3%
2	317.5 (315.8, 320.2)	32.5(30.8, 34.1)	10.3%
3	256.5 (255.3, 257.8)	62.5(59.9, 65.1)	24.1%
4	169.6 (166.4, 172.8)	-5.9(-7.9, -3.8)	-3.3%
5	149.2 (146.2, 152.1)	-8.8(-11.7, -5.9)	-5.7%
CTAS	**Overall waiting time (95%CI)**	**Absolute reduction in waiting time in min (95%CI)**	**Relative (%) reduction waiting time**
1	11.6 (11.0, 12.2)	5.2(4.7, 5.7)	43.8%
2	65.8 (64.9, 66.7)	24.9(14.3, 35.5)	37.2%
3	112.8 (111.6, 114.1)	60.4(40.4, 80.4)	52.7%
4	91.3 (90.1, 92.5)	15.5(0.3, 30.6)	14.4%
5	88.9 (88.5, 89.3)	13(-12.1, 38.2)	12.5%

5.4 Discussion

I had postulated that PED overcrowding is mainly the results of input and throughput factors, rather than output factors or boarding. The rationale for evaluating the use of PAs as an economically efficient alternative to increasing PED physician coverage is that the later is used at full or near full capacity by the current level of patient in-flow to the PED. In the context of PED physician not being used at full capacity, or lack of space as the cause for poor PED flow, we would not anticipate that increasing the physician capacity would bring meaningful reductions in PED waiting time or LOS for the largest portion of patient population in the PED (CTAS level 3 and 4).

This study shows that an incremental cost of approximately $(C) 300,000 a year, could reduce average waiting time in our PED by 20 to 35% across all 5 CTAS levels visits, if additional physician coverage is provided, or by 35 to 50% for CTAS levels 1-3 visits only (CTAS 4 and 5 unchanged) if PAs are used instead. This is in the context of limiting PAs' ability to manage and discharge children without directly involving the PED physician for only 21% of their caseload, hence very little autonomy.

Sensitivity analyses showed that as PAs' autonomy is increased, visits triaged to CTAS level 4 and 5 also benefit from reduced waiting time and if PAs were to manage and discharge without directly involving a physician for half of their caseload, this patient population would benefit from comparable waiting time reductions to those in the extended physician coverage model, while the patients triaged to CTAS levels 1-3 would experience a greater reduction in waiting time than in the extended physician coverage model. Although the range of cases managed by PAs without directly involving physicians in PEDs is not reported in the literature, discussions with PAs practicing in general EDs with high frequency of pediatric visits in Washington, reveal that on a typical eight-hour shift, a PA may manage approximately thirty patients, of which 30% are children and would involve a physician only twice among all cases they manage.

Sensitivity analyses also showed that flexibility in how physician capacity is used is crucial to maximize efficiency. Fluctuations in patient volume within acuity levels can be very variable and preventing the sharing of physician capacity between the two areas of PED care dampened the impact of adding resource to the system.

PAs are currently practicing in Alberta, Manitoba, New Brunswick and Ontario, in various clinical areas, such as general EDs, primary care practices, and orthopedics surgery, but have yet to be integrated into PEDs. A pilot project in Ontario general EDs, where PAs were involved in and reviewed patients of all CTAS levels with a physician, reported more visits meeting waiting time benchmarks when PAs were on duty.[100] These improvements, however, unlike my findings, were mostly in CTAS levels 4 and 5. It is unclear, how other resources were distributed in that pilot project; whether physicians continued to assess and manage CTAS 4 and 5 level visits at the same pace as before the introduction of PAs, or if they were reassigned to higher acuity patients as in my DES model study was not described.

In addition to major differences between general ED and PED systems and populations such as CTAS levels distribution[132], I modeled the PA to be able to assess, manage and discharge a small proportion of cases without having to involve the physician directly. Although the PA was only involved in management of CTAS 4 or 5 levels patients, the physician dedicated to the low acuity track could be shared between the 2 acuity areas when a PA was on shift. While the high acuity track on occasion benefitted from an extra physician, low acuity track patients who needed to be reviewed by the physician after being seen by trainees or a PA waited in the ED longer. I postulate this to be the main reason why the PA model resulted in important reductions in waiting time, LOS and LWBS for the high acuity levels.

Another patient flow simulation model of our PED was previously built by another group and was published in 2007[131]. This model was built before the

introduction of a flow physician during busy evening shifts, to assist in physician scheduling. I contacted the developer of this model but was advised that the uncertainty surrounding the data populating this model and its complexity rendered it inappropriate to reuse or revise for my purposes. I was therefore directed to build my model from the ground up. In reviewing the report from the previous model, I noted that the performance times for the flow physician were imputed rather than directly observed, with unclear sources for the time distributions and parameters, confirming that re-using this model for my purpose would be inappropriate.

Limitations:

This study is based on a model of BCCH PED, limiting its generalizability to PEDs with a two tracks system and those with similar practice patterns. Although practice pattern variations at this PED, as they relate to assessment times and treatment times, were accounted for by this study's large sample of direct observations and reflected in the choice of theoretical distributions and parameters, findings from this study may not be applicable to other centers where the practice variation pattern and assessment times differ significantly from our center[133].

Since civilian PAs are not yet practicing in BC, direct PA observations (e.g. time to assess patients, etc.) were not possible. I based the assumptions that PA would perform at the same rate as physicians for their assessments and at the same rate as trainees for their review and reassessment duration, on discussions with PAs working in Manitoba and Washington State. Moreover, I could not obtain any data (whether through discussions with PAs or from the literature) regarding the rate of unscheduled return visits to the PED following a visit to the ED where a PA was the main healthcare provider. Unscheduled return ED visits, regardless of the care provider, are however, infrequent, and the causes highly variable due to care provider factors, patient factors, system factors (discussed above), and most are due to disease progression[134]. Therefore, I did not model unscheduled return visit rate in any of the models.

In addition, the very low number of CTAS 1 level visits to this PED prevented me from confidently validating the model for CTAS 1 level visits. In order to validate all outcome measures for CTAS 1 visits, a system for accurate real life data collection are required. Given their low frequency and the high stress level surrounding the management of CTAS level 1 visits, any intervention dependent on clinicians accurately documenting assessment and treatment start times would be difficult to implement. Although there are new technologies available to collect interaction time between patients and healthcare providers without their active involvement, such as passive electronic tracking systems, they are expensive and there is little evidence to suggest their use in PED is cost efficient[135]. Validating all outcome measures for CTAS 1 visits would warrant more extensive work where the intervention is directly targeting the management of CTAS 1 visits and in situations where they are higher in volume, such as in disaster scenarios. In the context of this study, however, where the frequency of CTAS 1 visits is low, and they already have (by definition) the highest priority when it comes to securing PED resources, the impact of any intervention on their waiting time, which is already low, and LWBS rate which is nil, is likely to be clinically insignificant.

Another limitation of this study is its inability to compare costs. Although I explicitly kept human resource costs equal, this model did not address other costs associated with care provided in the PED, which varies with CTAS levels, LOS and frequency of visits or absolute number of patients affected by the reduction in LOS, but may also be different based on care provider, related to ancillary testing (laboratory and radiography) use and their costs. Indeed, few studies compare the overall cost of care between patients managed by PAs as opposed to physicians; only two relating to general EDs were identified by the systematic review in Chapter 2, and they reported conflicting results.

Comprehensive cost comparisons between PAs and emergency pediatricians would also require a broader perspective than that of the PED system such as the societal perspective, and including the differential cost involved in training a PED subspecialist (over ten years post secondary school

for an emergency pediatrician versus a minimum of four years for a PA). Lastly, my simulation model only reflects the impact of PAs on direct clinical care. Effects of introducing PAs to PEDs on medical training programs and physician reimbursement issues remain to be explored.

In conclusion, simulations of a PED comparing outcomes from limited additional physician coverage to widespread presence of PAs found important reduction in waiting time, LOS and LWBS rates for both scenarios. The physician model benefited all 5 CTAS levels. The PA model with constraints on PA autonomy favoured the CTAS 1-3 levels, but given greater autonomy, resulted in waiting time reduction for all 5 CTAS levels and reductions for the high acuity visits superior to those observed in the extended physician coverage model. Further validation of this study's findings with actual implementation of either scenario, detailed cost efficiency analyses and assessments of decision makers regarding priorities in PED service delivery as well as actual (rather than hypothetical as described above) patient satisfaction with PA care are required to guide definitive decisions about the role PAs could play in alleviating PED waiting room crowding and long waiting time. However, this study strongly suggests that using PAs would have a positive impact on waiting time, LOS, and LWBS at a modest additional cost, and likely at a reduced cost.

Chapter 6. Conclusion

PAs have been practicing since 1967 in the US and 1985 in the Canadian military systems. As described in Chapter 2, there is much published about the role PAs may perform in the ED, their acceptability by physicians and patients, with few if any concerns rising about the quality of the care they provide. There is however, little quantitative data surrounding their performance from a cost efficiency point of view, especially as compared to other healthcare providers.

My dissertation work focuses on the potential role for PAs and their anticipated impact on PEDs. Audits of a year's worth of PED visits at BC Children's Hospital PED confirmed that over half of all its visits are of low acuity. Local PED physicians and PAs with ED experience felt that 30 of 57 commonly treated conditions triaged to a CTAS level 3, 4 or 5 (non-emergent), and representing three quarters of all PED visits, could be appropriate for PAs assessment, work up and management. A small proportion of clinical conditions (21%) were felt appropriate for PA management without directly involving PED physicians. This finding was confirmed with a national survey of Canadian physician practicing pediatric emergency medicine, where 32 of the 57 conditions were selected as appropriate for PAs assessment, work up and management but predominantly with direct physician involvement.

Findings from the two surveys among caregivers of children seen at BC Children's Hospital suggest that when confronted with non-emergent health concerns, healthcare users are wiling to receive care by PAs. The second study concerned specifically children seen in the PED for conditions triaged to a low acuity level (CTAS 3, 4, and 5). Caregivers were informed about PAs' background and clinical role, then asked to report their willingness to have a PA evaluate and manage their child. Assuming that the waiting time to be seen by the physician may be longer than that to be seen by a PA, respondents were asked how much waiting time reduction would be required for them to choose to be seen by the PA. This study found that over 90% of respondents would consider having their child seen by a PA, and as the difference in waiting time

to be seen between physicians and PAs increased, so was the reported willingness to be seen by a PA.

Applying a conservative scope of practice for PAs guided by the physician and healthcare users' survey responses, the impact of adding PAs as opposed to increasing physician coverage on patient flow in the PED was compared using DES modeling. Not surprisingly, the addition of manpower to the PED in either form, extending physician coverage by 6 hours a day during the winter spring or adding a PA 12 to 18 hours a day through out the year, resulted in meaningful reduction in waiting time and LWBS rates.

The magnitude and distribution of the flow improvement among the 5 levels of acuity differs significantly, however, between the two models. The predominant reason for this is that while the extended physician only adds physician coverage hours to the baseline model, the PA model not only adds a substantially larger absolute number of hours of manpower to the baseline model than the extended physician model (granted the type of patients being managed by PAs was very conservative), it also redistributes available manpower between high and low acuity track by allowing the physician assigned to the low acuity track to help in the high acuity track.

In choosing which staffing option to implement requires an evaluation of several additional important issues. At the outset, it is important to acknowledge what our priorities are with regard to PED service access. If we agree with the principle that emergency care should be provided to those at highest risk for mortality and morbidity given their presenting clinical condition, then we would chose the solution which yielded best results for those children with higher acuity of illness or injury. This would be best achieved through the PA model, where the addition of funding acquires a large amount of PA time to manage the low acuity track of the PED simultaneously freeing a physician to manage mid to high acuity level patients.

Alternatively, if we agree to the principle of 'first come first served', we would chose the staffing option that benefited the largest number of people possible, in addition to responding differentially by acuity levels. In other words, we recognize that PEDs should also provide access for primary care needs unmet in the community and occasionally cater to users' convenience. This would lead us to prorate the benefits of additional funding to the PED across CTAS level 2-5. While still favouring the highest acuity levels, we would not withhold benefits to the lower acuity levels until the high acuity levels' needs have been completely met. The extended physician coverage model would accomplish this, where the funding buys a modest addition to physician hours during the busiest periods in the PED is used to supplement PED without reassigning existing physician coverage to the high acuity track.

This dilemma is not unique to the PA versus extended physician coverage models, where additional resource is available to allocate. It is also at the heart of the decision between operating a PED with two tracks, including a low acuity treatment area and physician dedicated to manage children with minor illnesses and injuries, such as the baseline PED model, rather than mobilizing this physician and pooling the physician coverage to focus on managing children in order of acuity level in a single tracked PED. Although studies evaluating the impact of introducing a low acuity treatment area show improved cost effectiveness in treating low acuity patients,[18] their impact on the rest of the PED is not established and the decision of operating a single versus two track system rests on administrators' priorities and preferences on this issue.

A second important issue to consider is that while we established that Canadian PED users would accept PAs, this acceptance was tempered by expectations that their waiting time would be reduced. If implementing PAs according to the model primarily benefit children triaged to high acuity levels and those who end up being managed by PAs do not have their waiting time reduced, the result would likely be dissatisfied users, less enthusiasm for PA care, and refusal to be seen by a PA.

It is important to note that these two issues, PED priority setting and patient preferences, conditional to waiting time reduction pose a dilemma only in the context where PA autonomy is restricted by having to review more than 50% of their case loads with the physician. The performance of the second model integrating a PA to the low acuity track of the PED becomes superior to extended physician coverage model and patients triaged to the low acuity track would benefit from waiting time reduction if PAs are only required to review with physicians for half of their caseloads. It is entirely conceivable that experienced PAs having developed good and continuous working relationships with a local group of PED physicians, would have a significantly reduced percentage managed cases reviewed and thus greater overall impact on PED waiting times, LOS and LWBS rates.

Discussions with Ian Jones, past president of the Canadian PA Association, and program director of the University of Manitoba PA Education Program, confirms that such levels of autonomy are realistically reached by PAs in general EDs, albeit after an initial 18 to 24 months period of physician and PA introduction and trust building. In his experience, after PAs are introduced to a general ED, the first 6 months are challenging and perhaps patients throughput is slowed compared to baseline, but a new status quo is generally reached by 12 months. By 18 to 24 months, up to half of all patients visiting the ED are managed and discharged by a PA without having interacted with a physician. The lack of published reports supporting these statements is most likely an artefact of billing practices since PAs are employed in salaried positions, rather than billing fee for service. Thus administrative data includes the physician on all patient encounters even if the physician only retrospectively reviewed a chart after a PA has discharged a patient.

Although my studies of PAs role and impact in PEDs lead us to anticipate a positive and rewarding experience in introducing them to PEDs, reflections on

the introduction of PAs to the Canadian healthcare system are important in forecasting the likelihood of PA joining the workforce in PEDs.

The introduction of PAs to the Canadian health care system outside of the armed forces has been in flux since 1998, when it was first recognized that the role of the military PA needed to be standardized for integration into the civilian system. The Canadian Medical Association recognized PAs as health care professionals in 2003; in the same year the first civilian PA officially began working in the Canadian health care system. In 2010, nearly three hundred PAs were practicing in four Canadian provinces (Manitoba, Ontario, New Brunswick, and Alberta). Despite this history, there are very few peer-reviewed papers on the use of PAs in Canada.[63]

Variations exist across provincial jurisdictions, the process involved in using PAs consists of requests for PA placement in clinical areas of needs as described and initiated by physicians are submitted to health authorities (or equivalent). Once the proposal for a PA with clear scope of practice description is approved and the health ministry grants the funding, a PA is hired into the clinical area. From then on, the PA and supervising physician pair develop through a collaborative working relationship and negotiate the PA's degree of autonomy. Although the degree of PA autonomy is expected to vary over time, PAs remain linked to supervising physicians through their employment.

Personal communication with Canadian PAs suggests that while PAs most commonly work in primary care and emergency medicine, they also assist physicians in anesthesia, critical care, cardiac sciences, internal medicine, oncology, mental health, rehabilitative medicine, general surgery, orthopedic surgery, neurosurgery, plastic surgery, pediatric surgery and pediatric oncology. There are however few articles describing the contribution or impact of PAs in the Canadian non-military health care system.[100,117,136,137]

There may be fewer PAs hired into pediatric medicine and pediatric subspecialties relative to other clinical areas in Canada and the scarcity of

literature reporting PAs involvement in pediatric medicine supports the notion that PAs have yet to be fully integrated to clinical pediatric departments. The limited experience with PAs in pediatric clinical areas may be due to conservatism towards children or simply because the problem of overcrowding and long waiting time have been perceived as less pressing in pediatrics and pediatric subspecialties. The issues with general ED overcrowding and access blocking have indeed been more frequently reported than for PEDs. The paucity of publications related to the PED overcrowding issue does not mean however, that pediatric emergency medicine is immune to workforce concerns, nor justifies excluding children from benefitting from innovative means to efficiently improve access to care.

Although a delay in implementation of effective novel therapeutic modalities and strategies in pediatric emergency medicine may be due to reluctance to expose children to what is perceived as risky and unfamiliar, it is however, heavily related to the significant gap in research conducted in the field of pediatric emergency medicine. The Institute of Medicine Report Emergency Medicine Services for Children identified in 1993, severe gaps in knowledge related to pediatric emergency care services systems (structure, utilization, cost and system outcomes).[138] Although much research has been produced in the last twenty years, the information gap continues to grow in the area of pediatric emergency care efficiency and care provision timeliness. Very little health services research in pediatric emergency medicine, particularly with regard to organization, delivery of services, and cost efficiency is available to contribute to pediatric emergency evidence based practice.[139]

There is however some data concerning the workforce in pediatric emergency medicine in North America. A report by the American Board of Pediatrics on the pediatric workforce warns that, despite a 9% increase in the number of trainees in a pediatric emergency medicine program in 2005, the ratio of practicing physicians in pediatric emergency medicine to children in the 50 US states is low, with a median of 1.4 physician per 100,000 children (IQR:

1.45).[140] Complimenting this is a survey comparing the practice patterns of pediatric emergency physicians and general emergency physicians. Pediatric emergency physicians were more likely to be holding an academic appointment, reported more time spent supervising trainees, teaching, and conducting research. Female physicians reported extended leave from clinical practice occurring in association with childcare issues more frequently. While this was reported evenly in pediatric and general emergency medicine, the ratio of female to male physicians was significantly higher in pediatric emergency medicine (0.8:1) than in general emergency medicine (0.2:1).[141] These observations have important implications for forecasting the pediatric emergency medicine workforce supply, but do not offer a definitive assessment of the pediatric emergency medicine workforce. Further studies are needed to monitor attrition and potential for undersupply of pediatric emergency physicians.

The literature on PAs in PEDs is scarce, and is limited to reports of PAs having worked in that environment.[64] The body of work on PAs in PEDs presented in this dissertation adds to a nascent body of literature concerning overcrowding in PEDs, offering an alternative source for pediatric emergency medicine workforce supply. The early success of the PA programs in a limited number of provinces integrating them to their healthcare system, along with my studies describing a role for PAs in the PED, acceptance by healthcare users and demonstrating that PAs could be cost efficient support the notion that PEDs are primed to benefit significantly from the introduction of PAs in the medium to long term, both with regard to good care for children and efficient use of health care resources.

Bibliography

1. Derlet RW, Richards JR. Overcrowding in the Nation's Emergency Departments : Complex Causes and Disturbing Effects. Annals of Emergency Medicine. 2000;35(1):3-8.
2. Bond K, Ospina MB, Blitz S, et al. Frequency, determinants and impact of overcrowding in emergency departments in Canada: a national survey. Healthcare Quarterly. 2007;10(4):32-40.
3. Derlet RW, Richards JR, Kravitz RL. Frequent Overcrowding in US Emergency Department. Academic Emergency Medicine. 2001;8(2):151-155.
4. Drummond AJ. No room at the inn: overcrowding in Ontario's emergency departments. Canadian Journal of Emergency Medicine. 2002;4(2):91-97.
5. American Academy of Pediatrics. Overcrowding crisis in our nation's emergency departments: is our safety net unraveling? Pediatrics. 2004;114(3):878-88.
6. American College of Emergency Physicians. Emergency medicine statistical profile 2001. Available at http://www.acep.org/content.aspx?id=25234. Accessed May 10, 2012.
7. Hsia RY, Kellermann AL, Shen YC. Factors associated with closures if emergency departments in the United States. JAMA. 2011;305(19): 1978-85.
8. Bullard MJ, Villa-Roel C, Bond K, et al. Tracking Emergency Department Overcrowding in a Tertiary Care Academic Institution. Longwoods Review. 2009;7(2):99-106.
9. Canadian Association of emergency Physician (CAEP) and National Emergency Nurse Affiliation. Joint Position statement on Emergency department overcrowding. CJEM 2001;3(2):82-84.
10. Cowan RM, Trzeciak S. Clinical review: Emergency department overcrowding and the potential impact on the critically ill. Critical care (London, England). 2005;9(3):291-5.
11. American College of Emergency Physician. Definition of Boarded Patient, policy statement. 2011 Available at http://www.acep.org/content.aspx?id=75791. Accessed May 10, 2012.
12. Fatovich D, Nagree Y, Sprivulis P. Access block causes emergency department overcrowding and ambulance diversion in Perth, Western Australia. Emerg.Med.J. 2005;22(5):351-354.
13. Hoot NR, Aronsky D. Systematic review of emergency department crowding: causes, effects, and solutions. Annals of Emergency Medicine. 2008;52(2):126-136.
14. Furukawa MF. Electronic medical records and the efficiency of hospital emergency departments. *Medical care research and review : MCRR*. 2011;68(1):75-95
15. Handel D a, Wears RL, Nathanson L a, Pines JM. Using information technology to improve the quality and safety of emergency care. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine*. 2011;18(6):e45-51.

16. Guo B, Harstall C. Strategies to reduce emergency department overcrowding. Health Technology Assessment Unit. Alberta Heritage Foundation for Medical Research 2006. Available at www.ahfmr.ab.ca. Accessed May 10, 2012.
17. Lee-lewandrowski E, Corboy D, Lewandrowski K, et al. Implementation of a Point-of-Care Satellite Laboratory in the Emergency Department of an Impact on Test Turnaround Time and Patient Emergency Department Length of Stay Setting . Archives of Pathology & Laboratory Medicine. 2003;127(4):456-460.
18. Health Technology Assessment. Emergency department fast-track system. 2003. Alberta Heritage Foundation for Medical Research. Available at www.ahfmr.ab.ca. Accessed May 10, 2012.
19. Dunn R. Reduced access block causes shorter emergency department waiting times: An historical control observational study. Emergency Medicine Australasia. 2003;15(3):232-238.
20. Khare RK, Powell ES, Reinhardt G, Lucenti M. Adding more beds to the emergency department or reducing admitted patient boarding times: which has a more significant influence on emergency department congestion? Annals of emergency medicine. 2009;53(5):575-85.
21. Boyle P, Pineault R, Roberge D. Assessing Quebec's Multi- Component Program to Reduce Room Emergency Overcrowding. Canadian Public Policy. 1992;18(2):189-202.
22. Timm NL, Ho ML, Luria JW. Pediatric emergency department overcrowding and impact on patient flow outcomes. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine. 2008;15(9):832-7.
23. Kennebeck SS, Timm NL, Kurowski EM, Byczkowski TL, Reeves SD. The association of emergency department crowding and time to antibiotics in febrile neonates. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine. 2011;18(12):1380-5.
24. Shenoi R, Ma L, Syblik D, Yusuf S. Emergency department crowding and analgesic delay in pediatric sickle cell pain crises. Pediatric emergency care. 2011;27(10):911-7.
25. Sills MR, Fairclough D, Ranade D, Kahn MG. Emergency department crowding is associated with decreased quality of care for children. Pediatric emergency care. 2011;27(9):837-45.
26. Ospina MB, Bond K, Schull M, et al. Key indicators of overcrowding in Canadian emergency departments: a Delphi study. CJEM Canadian Journal of Emergency Medical Care. 2007;9(5):339-346.
27. Stang AS, McGillivray D, Bhatt M, et al. Markers of overcrowding in a pediatric emergency department. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine. 2010;17(2):151-6.
28. Sinclair D. Emergency department overcrowding – implications for Pediatric Emergency Medicine. Emergency Medicine. 2007;12(6):491-494.
29. Pileggi C, Raffaele G, Angelillo IF. Paediatric utilization of an emergency department in Italy. European journal of public health. 2006;16(5):565-569.

30. Ehrlich NJ, Tasmin F, Safi H, Barnett J, Lasley B. Pilot study of ER utilization at Tulsa hospitals. Journal - Oklahoma State Medical Association. 2004;97(2):64-68.
31. Simon HK, Hirsh D a, Rogers AJ, Massey R, Deguzman M a. Pediatric emergency department overcrowding: electronic medical record for identification of frequent, lower acuity visitors. Can we effectively identify patients for enhanced resource utilization? The Journal of emergency medicine. 2009;36(3):311-6.
32. Bourgeois FT, Shannon MW. Emergency Care for Children in Pediatric and General Emergency Departments. 2007;23(2):94-102.
33. Haltinger KA, Pines JM, Martin ML. The Pediatric Emergency Department: A Substitute for Primary Care? Western Journal of Emergency Medicine. 2006;7(2):24-30.
34. Gadomski AM, Perkis V, Cross S, Stanton B. Diverting Managed Care Medicaid Patients From Pediatric Emergency Department Use. Pediatrics. 1995;95(2):170-178.
35. Franco SM, Mitchell CK, Buzon RM. Primary Care Physician Access and Gatekeeping: A Key to Reducing Emergency Department Use. Clinical Pediatrics. 1997;36(2):63-68.
36. Yoffe SJ, Moore RW, Gibson JO, et al. A Reduction in Emergency Department Use by Children From a Parent Educational Intervention. Family medicine. 2011;43(2):106-111.
37. Chande V, Wyss N, Exum V. Educational Interventions to Alter Pediatric Emergency Department Utilization Patterns. Arch.Pediatr.Adolesc.Med. 1996;150(5).
38. Goldman RD, Macpherson A, Schuh S, Mulligan C, Pirie J. Patients who leave the pediatric emergency department without being seen: a case-control study. CMAJ : Canadian Medical Association journal = journal de l'Association medicale Canadienne. 2005;172(1):39-43.
39. Ng Y, Lewena S. Leaving the paediatric emergency department without being seen: understanding the patient and the risks. Journal of paediatrics and child health. 2012;48(1):10-5.
40. College of Physicians and Surgeons of British Columbia. 2010: Annual report. Strengthening our foundation. 2010. Available at www.cpsbc.ca/files/u6/2010-annual-report.pdf. Accessed May 12, 2012
41. Statistics Canada. Population with a regular medical doctor, by sex, provinces and territories. Canadian Community Heath Survey. 2010. Available at: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/health76b-eng.htm. Accessed May 1, 2012.
42. Gagnon L. Stats Can: 14% of Canadians have no family doctor. CMAJ : Canadian Medical Association journal = journal de l'Association medicale Canadienne. 2004;171(2):124.
43. Canadian Medical Association, College of Family Physicians of Canada, Primary Care Wait Time Partnership. The wait starts here. 2009.

44. Haltinger KA, Pines JM, Martin ML. The Pediatric Emergency Department: A Substitute for Primary Care? Western Journal of Emergency Medicine. 2006;7(2):24-30.
45. Fieldston ES, Alpern ER, Nadel FM, Shea J a, Alessandrini E a. A qualitative assessment of reasons for non-urgent visits to the emergency department: parent and health professional opinions. Pediatric emergency care. 2012;28(3):220-5.
46. Woolfenden S, Ritchie J, Hanson R, Nossar V. Parental use of a paediatric emergency department as an ambulatory care service. Australian and New Zealand journal of public health. 2000;24(2):204-6.
47. Sanmartin C, Ross N. Experiencing difficulties accessing first-contact health services in Canada: Canadians without regular doctors and recent immigrants have difficulties accessing first-contact healthcare services. Reports of difficulties in accessing care vary by age, sex . Healthcare policy = Politiques de santé. 2006;1(2):103-19.
48. Allan T, Brailovsky C, Rainsberry P, et al. Defining competency-based evaluation objectives in family medicine Dimensions of competence and priority topics for assessment Préciser les objectifs de l ' évaluation de la compétence en médecine familiale. Canadian Family Physician. 2011;57(9):331-340.
49. Braunstein J, Abanobi O, Goldhagen J. Parental perception of urgency and utilization of pediatric emergency services. Fam Pract Res J. 1987;6(3):130-137.
50. Salami O, Salvador J, Vega R. Reasons for Non-urgent Pediatric Emergency. Pediatric Emergency Care, PEC. 2012;28(1):43-46.
51. Zemek R, Plint A, Osmond MH, et al. Triage Nurse Initiation of Corticosteroids in Pediatric Asthma Is Associated With Improved Emergency Department Efficiency. Pediatrics. 2012.
52. Doan Q, Chan M, Leung V, Lee E, Kissoon N. The impact of an oral rehydration clinical pathway in a paediatric emergency department. Paediatrics & child health. 2010;15(8):503-7.
53. Simon HK, Ledbetter D a, Wright J. Societal savings by "fast tracking" lower acuity patients in an urban pediatric emergency department. The American journal of emergency medicine. 1997;15(6):551-4.
54. Hampers LC, Cha S, Gutglass DJ, Binns HJ, Krug SE. Fast Track and the Pediatric Emergency Department: Resource Utilization and Patient Outcomes. Academic Emergency Medicine. 1999;6(11):1153-1159.
55. Worster A, Sardo A, C T, Fernandes C, Chemeris E. Understanding the role of nurse practitioners in Canada. Canadian Journal of Rural Medicine. 2005;10(2):89-95.
56. Canadian Nurses Association. NP Canada. Available at: http://www.npcanada.ca/portal/index.php?option=com_frontpage&Itemid=1. Accessed May 4, 2012.
57. Hooker RS. Physician assistants in occupational medicine: how do they compare to occupational physicians?[see comment]. Occupational Medicine (Oxford). 2004;54(3):153-158.

58. Hooker RS, MacDonald K, Patterson R. Physician assistants in the Canadian Forces. Military medicine. 2003;168(11):948-950.
59. Jones IW, Hooker RS. Physician Assistants in Canada: update on health policy initiatives. Canadian Family Physician. 2011;57:83-88.
60. American Academy of Pediatrics, Committee on Pediatric Workforce. Scope of practice issues in the delivery of pediatric health care. Pediatrics. 2003;111(2), 426-35.
61. Effective Public Health Practice Project. Quality assessment tool for quantitative studies. 2010:2-5. Available at: http://www.ephpp.ca/Tools.html. Accessed August 31, 2008.
62. Deeks JJ, Dinnes J, D'Amico R, et al. Evaluating non-randomised intervention studies. Health technology assessment (Winchester, England). 2003;7(27):iii-x, 1-173.
63. Holley JE, Kellermann AL, Andrulis DP. Physician staffing in the emergency departments of public teaching hospitals: a national survey. Annals of Emergency Medicine. 1992;21(1):53-57.
64. Isaacman DJ, Davis HW. Pediatric emergency medicine: state of the art. Pediatrics. 1993;91(3):587-590.
65. Casey MM, Wholey D, Moscovice IS. Rural Emergency Department staffing and participation in emergency certification and training programs. Journal of Rural Health. 2008;24(3):253-262.
66. Waldrop RD, Mandry C, Rios J, Grate I. Emergency medicine practice systems in Louisiana. Southern medical journal. 1998;91(4):354-357.
67. Counselman FL, Schafermeyer RW, Perina DG. Academic departments of emergency medicine: the effects of managed care. Academic Emergency Medicine. 1998;5(11):1095-1100.
68. Counselman FL, Schafermeyer RW, Garcia R, Perina DG. A survey of academic departments of emergency medicine regarding operation and clinical practice. Annals of Emergency Medicine. 2000;36(5):446-450.
69. Stead LG, Boenau I, Skiendzielewski J, Counselman FL. A survey of academic departments of emergency medicine regarding operation and clinical practice: two years later. Academic Emergency Medicine. 2003;10(4):393-396.
70. Ellis GL, Brandt TE. Use of physician extenders and fast tracts in United States Emergency Departments. American Journal of Emergency Medicine. 1997;15(3):229-232.
71. Morse TS. Triage, technicians, and teaching in a children's emergency room. Journal of pediatric surgery. 1973;8(5):701-704.
72. Mikhail J, Millerz W, Wagner J. Midlevel practitioner role evolution in an American College of Surgeons-verified trauma surgery service: the 23-year experience at Hurley Medical Center. Journal of Trauma Nursing. 2009;16(1):33-40.
73. Goldfrank L, Corso T, Squillacote D. The emergency services physician assistant: results of two years' experience. Annals of Emergency Medicine. 1980;9(2):96-99.

74. Papa A, Solheim J. Cutting-edge discussions of management, policy, and program Issues in emergency care. Physicians and physician extenders at triage. JEN: Journal of Emergency Nursing. 2007;33(5):495-496.
75. Anonymous. Patient navigators show the way to faster flow. ED Management. 2007;19(9):104-5.
76. Ganapathy S, Jr FLZ. Coping with a crowded ED: an expanded unique role for midlevel providers. American Journal of Emergency Medicine. 2003;21(2):125-128.
77. Schneider S, Zwemer F, Doniger A, et al. Rochester, New York: a decade of emergency department overcrowding. Academic Emergency Medicine. 2001;8(11):1044-1050.
78. Golomb HM, Herrold SR. An alternative staffing proposal for emergency rooms. Three-year experience in a rural hospital. JAMA. 1974;228(3):329-331.
79. Maxfield RG, Lemire MD, Thomas M, Wansleben O. Utilization of supervised physician's assistants in emergency room coverage in a small rural community hospital. Journal of Trauma-Injury Infection & Critical Care. 1975;15(9):795-799.
80. McCaig LF. Use of PAs and NPs in US hospital emergency departments, 1993-1994. JAAPA: Journal of the American Academy of Physician Assistants. 1998;11(1):38.
81. Hooker RS, Cipher DJ, Cawley JF, Herrmann D, Melson J. Emergency medicine services: interprofessional care trends. Journal of Inter-professional Care. 2008;22(2):167-178.
82. Hachmuth FA, Hootman JM. What impact on PA education? A snapshot of ambulatory care visits involving PAs. JAAPA. 2001;14(12):22; e-24.
83. Currey CJ. PAs and NPs in an emergency room-linked acute care clinic. Physician assistant. 1984;8(12):39.
84. Hooker RS, McCaig L. Emergency department uses of physician assistants and nurse practitioners: a national survey. American Journal of Emergency Medicine. 1996;14(3):245-249.
85. Daymude ML, Mehta S, Gruppo L. Use of emergency bedside ultrasound by emergency medicine physician assistants: a new training concept. Journal of Physician Assistant Education. 2007;18(1):29-33.
86. Law H, Sloan J. Doctor's assistants -- do we need them? Journal of accident & emergency medicine. 1999;16(2):114-116.
87. Hirshberg AJ, Holliman CJ, Wuerz RC, Chapman DM. Case management by physician assistants and primary care physicians vs emergency physicians. Academic Emergency Medicine. 1997;4(11):1046-1052.
88. Currey CJ. Adapting the medical audit to the practice of the military physician's assistant. Military medicine. 1980;145(7(pp 498-503):ate of Pubaton: 1980.
89. Roumie CL, Halasa NB, Edwards KM, et al. Differences in antibiotic prescribing among physicians, residents, and nonphysician clinicians. American Journal of Medicine. 2005;118(6(pp 641-648):ate of Pubaton: Jun 2005.

90. Wiest DR, Spear SJ, Bartfield JM. Empiric treatment of gonorrhea and chlamydia in the ED. American Journal of Emergency Medicine. 2001;19(4):274-275.
91. Kozlowski MJ, Wiater JG, Pasqual RG, et al. Painful discrimination: the differential use of analgesia in isolated lower limb injuries. American Journal of Emergency Medicine. 2002;20(6):502-505.
92. Ritsema TS, Kelen GD, Pronovost PJ, Pham JC. The National Trend in Quality of Emergency Department Pain Management for Long Bone Fractures. Academic Emergency Medicine. 2007;14(2):163-169.
93. Singer AJ, Hollander JE, Cassara G, et al. Level of training, wound care practices, and infection rates. American Journal of Emergency Medicine. 1995;13(3):265-268.
94. Singer AJ, Hollander JE, Valentine SM, Jr HCT, Henry MC. Association of training level and short-term cosmetic appearance of repaired lacerations. Academic Emergency Medicine. 1996;3(4):378-383.
95. Kaups KL, Parks SN, Morris CL. Intracranial pressure monitor placement by midlevel practitioners. Journal of Trauma-Injury Infection & Critical Care. 1998;45(5):884-886.
96. Bevis LC, Berg-Copas GM, Thomas BW, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. American Journal of Critical Care. 2008;17(4):357-363.
97. Rudy EB, Davidson LJ, Daly B, et al. Care activities and outcomes of patients cared for by acute care nurse practitioners, physician assistants, and resident physicians: a comparison. American Journal of Critical Care. 1998;7(4):267-281.
98. Mains C, Scarborough K, Bar-Or R, et al. Staff commitment to trauma care improves mortality and length of stay at a level I trauma center. Journal of Trauma-Injury Infection & Critical Care. 2009;66(5):1315-1320.
99. Schwartz RJ, Boisoneau D, Jacobs LM. The quantity of cause-of-injury information documented on the medical record: an appeal for injury prevention. Academic Emergency Medicine. 1995;2(2):98-103.
100. Ducharme J, Alder RJ, Pelletier C, Murray D, Tepper J. The impact on patient flow after the integration of nurse practitioners and physician assistants in 6 Ontario emergency departments. Canadian Journal of Emergency Medicine. 2009;11(5):455-461.
101. Rodi SW, Grau MV, Orsini CM. Evaluation of a fast track unit: alignment of resources and demand results in improved satisfaction and decreased length of stay for emergency department patients. Quality management in health care. 2006;15(3):163-170.
102. Arnopolin SL, Smithline HA. Patient care by physician assistants and by physicians in an emergency department. JAAPA. 2000;13(12):39-40.
103. Newkirk W. Rural emergency department coverage: comparison of a physician assistant to rotating medical staff members. Journal of the Maine Medical Association. 1980;71(12):375-377.
104. Elliott EP, Erdman K, Waters V, Holcomb JD. Opinions of Texas emergency medicine physicians regarding the use of physician assistants in the

emergency department [corrected] [published erratum appears in J Physician Assist Educ 2008;19(1):4]. Journal of Physician Assistant Education. 2007;18(4):40-43.
105. Borland B, Williams F, Taylor D. A survey of attitudes of physicians on proper use of physician's assistants. Health services reports. 1972;87(5):467-472.
106. Bergeson J, Cash R, Boulger J, Bergeron D. The attitudes of rural Minnesota family physicians toward nurse practitioners and physician assistants. Journal of Rural Health. 1997;13(3):196-205.
107. Larkin GL, Kantor W, Zielinski JJ. Doing unto others? Emergency medicine residents' willingness to be treated by moonlighting residents and non-physician clinicians in the emergency department. Academic Emergency Medicine. 2001;8(9):886-892.
108. Counselman FL, Graffeo CA, Hill JT. Patient satisfaction with physician assistants (PAs) in an ED fast track. American Journal of Emergency Medicine. 2000;18(6):661-665.
109. Nyberg SM, Waswick W, Wynn T, Keuter K. Midlevel providers in a Level I trauma service: experience at Wesley Medical Center. Journal of Trauma-Injury Infection & Critical Care. 2007;63(1):128-134.
110. Warren DW, Jarvis A, Leblanc L, Gravel J. Revisions to the Canadian Triage and Acuity Scale Paediatric Guidelines (Paed CTAS). Canadian Journal of Emergency Medicine. 2008;10(3):224-232.
111. Gravel J, Gouin S, Goldman RD, et al. The Canadian Triage and Acuity Scale for Children: A Prospective Multicenter Evaluation. Annals of emergency medicine. 2012;(C).
112. Gravel J, Fitzpatrick E, Gouin S, et al. Performance of the Canadian Triage and Acuity Scale for children; a multicenter database study. Annals of Emergency Medicine. 2012.
113. Dillman D. Mail and telephone surveys: the total design method. In: Mail and telephone surveys: the total design method. New York: John Wiley & Sons; 1978.
114. Danielsen R, Ballweg R, Vorvick L, Sefcik D. The Preceptor's Handbook for supervising Physician Assistants. Sudbury, MA: Jones & Bartlett Learning; 2012.
115. Larkin GL, Hooker RS. Patient willingness to be seen by physician assistants, nurse practitioners and residens in the ED: Does the presumption of consent have an empirical basis? American journal of bioethics. 2010;10(7):1-10.
116. Hooker RS, Harrison K, Pashen D. Are Australians willing to be treated by a Physician Assistants? Australasian Medical Journa; 2010;3(7):407-413.
117. Bohm ER, Dunbar M, Pitman D, Rhule C, Araneta J. Experience with Physician Assistants in a Canadian Arthoplasty Program. Canadian Journal of Surgery. 2010;53(2):103-108.
118. Firth D. Bias reduction of maximum likelihood estimates. Biometrika. 1993;80(1):27-38.

119. Moser M, Abu-Laban R, Van Beek C. Attitude of emergency department patients with minor problems to being treated by a nurse practitioner. Canadian Journal of Emergency Medicine. 2004;6(4):246-252.
120. Shardell M, Harris AD, El-Kamary SS, et al. Statistical analysis and application of quasi experiments to antimicrobial resistance intervention studies. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America. 2007;45(7):901-7.
121. Elley CR, Chondros P, Kerse NM. Randomised trials – cluster versus individual randomisation. Australian Family Physician. 2004;33(9):759-763.
122. Babulak E, Wang M. Discrete Event Simulations Goti A, ed. 2010:1-10. Available at: http://www.intechopen.com/books/discrete-event-simulations.
123. Jun J, Jacobson S, Swisher J. Application of discrete-event simulation in health care clinics: A survey. Journal of the Operational Research Society. 1999;50(2):109-123.
124. Maria A. Introduction to modeling and simulation. In: Andradóttir S, Healy KJ, Withers DH, Nelson BL, Maria A, eds. Proceedings of the 1997 Winter Simulation Conference. Binghamton, NY; 1997:7-13.
125. Gunal M, Pidd M. Discrete event simulation for performance modelling in health care: a review of the literature. Journal of simulation. 2010;4:42-51.
126. Jacobson SH, Hall SN, Swisher JR. Discrete event simulation of health care systems. In: Patient Flow: Reducing Delay in Healthcare Delivery. International Series in Operations Research & Management Science; 2006:211-252.
127. Komashie A, Mousavi A, Gore J. Using Discrete Event Simulation (DES) to Manage Theatre Operations in Healthcare: An Audit-Based Case Study. In: Tenth International Conference on Computer Modeling and Simulation (uksim 2008). Ieee; 2008:360-365.
128. Sciomachen A, Tanfani E, Testi A. Simulation models for optimal schedules of operating theatres. International Journal of simulation. 2004;6(12):26-34.
129. Duguay C, Chetouane F. Modeling and Improving Emergency Department Systems using Discrete Event Simulation. Simulation. 2007;83(4):311-320.
130. Hoot NR, LeBlanc LJ, Jones I, et al. Forecasting emergency department crowding: a discrete event simulation. Annals of Emergency Medicine. 2008;52(2):116-125.
131. Hung GR, Whitehouse SR, O'Neill C, Gray AP, Kissoon N. Computer modeling of patient flow in a pediatric emergency department using discrete event simulation. Pediatric emergency care. 2007;23(1):5-10.
132. Hing, E., Hall, M. J., & Xu, J. (2008). National Hospital Ambulatory Medical Care Survey: 2006 outpatient department summary. *National health statistics reports*, (4), 1–31. Available at: www.cdc.gov/nchs/data/nhsr/nhsr004.pdf. Accessed June 6, 2012.
133. McCarthy ML, Ding R, Pines JM, et al. Provider variation in fast track treatment time. Medical care. 2012;50(1):43-9.
134. Kelly AM, Chirnside AM, Curry CH. An analysis of unscheduled return visits to an urban emergency department. The New Zealand medical journal. 1993;106(961):334-336.

135. Dobson I, Doan Q, Hung G. A Systematic Review of Patient Tracking Systems for Use in the Pediatric Emergency Department. The Journal of emergency medicine. 2012;(February):1-7.
136. Hamilton GM, Decloe MD. Reviewing the Evidence for Canada's Physician Assistant Initiative. UTMJ. 2011;88(2):88-90.
137. Sigurdson L. Meeting Challenges in the Delivery of Surgical Care : A Financial Analysis of the Role of Physician Assistants. 2006.
138. Institute of Medicine of the National Academies. Emergency Medical Services for children. (Durch J, Lohr K, eds.). Washington D.C.: National Academy Press; 1993.
139. Institute of Medicine of the National Academies. Emergency Care for Children: Growing Pains. (The committee in the future of Emergency Care in the United States Health System, ed.). Washington D.C: The National Academies Press; 2007:245-273.
140. Althouse L, Stockman J. The pediatric workforce: an update on general pediatrics and pediatric subspecialties workforce data from the American Board of Pediatrics. The journal of pediatrics. 2011;159(6):1036-40.
141. Wiley J, Fuchs S, Brotherton S et al. Acomparison of pediatric emergency medicine and general emergency medicine physicians' practice patterns: Results from the future of pediatric education II survey sections project. Pediatric Emergency Care. 2002;18(3):153-8.