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Estimating Physician Workload in the Pediatric Emergency Department

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ABSTRACT

Introduction: The goal of this study was to develop a model which included demographic and clinical variables that would enable the prediction of physician workload in a pediatric ED setting.

Methods: This was a prospective time study of pediatric ED physicians. Data collected included patient variables and physician time spent on patient care, educational and administrative activities. Multivariate regression was used to determine which variables had the strongest influence on physician time needed to treat (TNT) pediatric ED patients.

Results: 205 patient visits were studied. Physicians spent 80% of their time on patient care. The strongest predictors of TNT were triage acuity score, ambulance arrival, procedure performed by physician, laboratory test performed, and admission. This model predicted 40% of the variance of TNT.

Conclusions: The model derived in this study could be used by administrators to assist in pediatric ED manpower planning and evaluation of physician efficiency.

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LIST OF ABBREVIATIONS

ED	Emergency department
ACH	Alberta Children's Hospital
CAEP	Canadian Association of Emergency Physicians
CTAS	Canadian Triage and Acuity Score
CIHI	Canadian Institute for Health Information
LOS	Length of stay
ACEP	American College of Emergency Physicians
FTE	Full-time equivalent
TNT	Physician time needed to treat
ln TNT	Natural logarithm of physician time needed to treat

Chapter One: Introduction

In recent years, much attention has been given to emergency department (ED) wait times by patients, the media, physicians, and emergency physician professional organizations.[1,2,3,4,5] The term "ED wait times" has been used to describe a number of distinct, but inter-related patient experiences. After arriving at an ED, patients may experience waits at a number of different phases of their visit. They may wait to be assessed by the triage staff, then wait in the waiting room prior to being taken to a treatment area. Patients may then wait to be assessed by an ED nurse and physician. Subsequent waits might include waiting for tests and consultations and finally waiting for an inpatient bed to be available, should the patient require admission. The factors which contribute to prolonged wait times are complex and likely vary from one ED setting to another. Overall, wait times are influenced by the balance between the demands placed on the staff and facility by patients and the capacity of the staff and facility to meet these demands.

Factors which have consistently been postulated to contribute to prolonged wait times have included patient demographics, insufficient in-patient bed numbers, and insufficient staffing.[6,7,8,9] Although patient demographics and bed numbers are generally beyond the immediate control of ED administrators, staffing decisions are required on a regular basis. It has previously been demonstrated in a study conducted in California by Lambe et al, that the number of ED physicians present at the time a patient visits an ED was a significant contributing factor to the length of time patients waited to be seen by a physician.[6] They concluded through multivariate analysis that the ratio of the number of ED physicians on shift to the number of patients waiting to be seen was a significant factor in the mean wait times to see a physician.[6] An increased physician to patient ratio was associated with shorter waiting times for patients.

ED administrators must assess both the adequacy of current physician staffing as well as forecast future staffing needs. In order to make informed decisions about physician staffing, estimates of present and future physician workload are needed. Unfortunately, despite the fact that physician workload may be a significant factor in patient wait times, there is no universally accepted method for measuring or predicting ED physician workload. Studies designed to quantify ED physician workload have been sparse and those that have been conducted have focused on general ED settings, with predominantly adult patient populations.[10,11,12,13,14,15,16]

The Alberta Children's Hospital (ACH) ED has seen a steady rise over the past five years in both the wait time to first physician assessment and in the total ED length of stay.[17] It is not known if the workload estimates generated in prior studies of general ED settings are generalizable to the pediatric emergency setting. Application of similar methodology in a pediatric ED setting would allow for the estimation of pediatric ED physician workloads.

This study aims to develop a model which includes demographic and clinical variables that will enable the estimation of physician workload in a pediatric emergency setting. Developing methods to accurately quantify and predict physician workload in the pediatric ED will assist in optimizing physician staffing and may ultimately reduce wait times, optimize care and improve outcomes for families and children.

Chapter Two: Background and Literature Review

2.1 Emergency Department Wait Times

Although all of the above mentioned aspects of “wait times” are important, the time delay from patient arrival to the ED to time of physician assessment is a parameter which is monitored closely, as excess delays to see a physician can have significant safety implications for some emergency patients and can negatively effect patient satisfaction with their ED visit.

2.1.1 Wait Time Standards

In the 1990’s The Canadian Association of Emergency Physicians (CAEP) devised and validated a new triage scale for use in Canadian EDs.[18] The Canadian Triage and Acuity Scale (CTAS) is a scoring system which assigns patients at the time of arrival to the ED a score based on the acuity of their injury or illness into one of 5 triage categories. In 2001, a pediatric version of this triage tool, PaedCTAS, was derived from the original scoring system for use with children.[19] These CTAS scales, which have been widely adopted in both general and paediatric EDs, include goals for waiting times to see a physician that are based on patient acuity. These wait time goals to see a physician were not intended by CAEP to be considered the standard of care, as it was recognized early on that these goals would be very difficult to reach given the level of overcrowding in today’s EDs. However, they do allow for more standardized assessments of this element of waiting times.

CTAS 1 (resuscitation) patients have immediate threats to life which require aggressive intervention and should be seen within 5 minutes by a physician. An example of a CTAS I patient would be a patient who arrives in cardiac arrest. CTAS 2 (emergent) patients have potential threats to life or limb function. These patients require rapid medical intervention and should be seen by a physician within 15 minutes of triage. An example would be an asthma patient with shortness of breath and low oxygen saturation levels. CTAS 3 (urgent) patients have conditions which could potentially progress to a serious problem requiring emergency intervention, for example, a patient with vomiting and moderate dehydration. These patients should ideally be seen by a physician within 30 minutes. CTAS 4 (less urgent) patients would benefit from receiving intervention or reassurance within 60-120 minutes and, ideally, should be seen by a physician within 60 minutes. An example would be a patient with a minor laceration requiring closure. CTAS 5 (non-urgent) patients have conditions in which investigations or interventions could be delayed or referred to other areas of the health care system, for example, a cast removal. The goal is to have these patients seen within 120 minutes.[19]

2.1.2 Wait Time to See a Physician Statistics

The Canadian Institute for Health Information (CIHI) recently published a report entitled "Understanding Emergency Department Wait Times" which received a great deal of media attention in Canada.[4] CIHI data from a combination of general and pediatric EDs during the 2003/04 fiscal year in Canada revealed that 87% of CTAS 5 patients were seen by a physician within the 120 minute goal. Only 54% of CTAS 1 patients were seen within the 5 minute goal and 10% of CTAS 1 patients waited longer than 45 minutes to see a physician. The median wait time to be seen by a physician was 51 minutes with 10% of patients waiting longer than 165 minutes.[4]

The mean time to the first physician assessment has been steadily rising at ACH. Wait times to see a physician have risen by 14.1 minutes over the past 5 years to a mean of

94.2 minutes in the 2006/07 fiscal year.[17] At the ACH ED, the mean time to see a physician for the various CTAS levels in 2006/07 was as follows: CTAS 1 (11.8 minutes), CTAS 2 (45.9 minutes), CTAS 3 (93.5 minutes), CTAS 4 (98.7 minutes), and CTAS 5 (87.4 minutes).[17] This data indicates that the ACH ED is unable to meet the CTAS goals for most patients, and sicker patients (CTAS 2 and 3) are waiting an average of 30 minutes longer to be seen by a physician than the goal times established by CAEP.[17,19]

In addition to wait times to see a physician, patient total ED length of stay is also an important indicator of overall departmental efficiency. The mean length of stay (LOS) in Canadian EDs for the 2003/04 year was 128 minutes, with 10% of patients spending greater than 6 hours in the ED.[4] The mean LOS in the ACH ED is currently 186 minutes, higher than the national ED average. The ACH LOS has risen 30 minutes over the past 5 years, from 156 minutes in 2000/2001.[17] Evidence based research aimed at reversing this trend is greatly needed.

2.1.3 Public and Physician Perceptions of Wait Times

Physician groups and patients may differ in their perception of both the causes of prolonged ED wait times and in wait time expectations. The CIHI report on the causes of Canadian ED overcrowding received much media attention.[4] The media focused on a segment of this report which identified that a significant proportion of ED visits were made by people with non-urgent problems. The media inferred from this section of the CIHI report that if people used ED resources more wisely, that the problem of long ED wait times would be mitigated. CAEP strongly opposed this conclusion and suggested that patients with non-urgent problems require minimal nursing and physician time and they do not occupy needed beds for any significant length of time.[2,20] The American College of Emergency Physicians (ACEP) agreed with CAEP's position and has stated that "non-urgent emergency department use simply leads to overcrowding in the waiting room, not overcrowding the emergency department treatment areas".[3] In other words, patients with non-urgent problems do not result in longer waits for those with urgent medical problems as they simply wait in the waiting room. CAEP's position is that congestion within the ED is the result of caring for patients who require investigations and admission. Limited in-patient bed capacity results in prolonged ED stays for these patients and inhibits patient flow through the ED.[20]

Patients who visit the ED may have different expectations of wait times than physician groups. Physician groups are primarily concerned with ensuring that patients with urgent problems are seen in a timely manner.[2] The prognosis for several common serious medical conditions treated in the ED are time sensitive, with earlier treatment interventions resulting in improved patient outcomes. For example, in both adult and pediatric patients with septic shock, a serious condition resulting from bacterial growth in the bloodstream, early intervention has been shown to increase survival rates.[21] Patients presenting with this condition may be difficult to identify at triage as the symptoms and signs can be subtle, particularly in children. Prolonged waits to see a physician could result in delayed diagnosis and initiation of therapy. Treatment of septic shock with fluids and antibiotics within one hour of arrival to an ED has been shown to increase survival.[21] One of the primary goals for physicians working in a ED is to ensure that patients with serious, time sensitive conditions are seen rapidly.

The public is concerned with wait times not just for urgent problems, but also for non-urgent problems. In a cross-sectional telephone survey of 837 patients over 18 years of age who had visited a general ED within the Calgary Health Region during 2002, patients who had higher CTAS scores (lower acuity) at the time of their ED visit, expected shorter waits than those who were more seriously ill at the time of their visit.[22] Over half of all respondents (51.3%) stated their expectation was that patients with non-life threatening medical conditions should be seen by an ED physician in less than one hour. Only 64.4% of respondents felt that the sickest patients should be seen first.[22] There would appear to be a discrepancy between the expectations of patients who visited a Calgary ED and physicians who staff the ED.

A systematic review of factors which influence ED patient satisfaction reported that satisfaction with wait times was one of the most frequently identified factors contributing to overall patient satisfaction. Spaite et al conducted a study of ED patient satisfaction following the implementation of a new departmental process designed to improve wait times in their ED.[23] The study was conducted in an academic general emergency department with a census of 48,000 visits annually. The actual medical care received by patients remained unchanged, but the total wait time from triage to placement in a treatment room decreased from 31 to 4 minutes and the total length of stay decreased from 4 hours, 21 minutes to 2 hours, 55 minutes during the study period. Patient satisfaction evaluations were conducted by an independent institute before and after the new process was put into place and demonstrated dramatic improvements in satisfaction scores.[23] Other studies have demonstrated that it is not the absolute length of wait time that most effects overall satisfaction, but whether the wait time exceeded the patient's expectations. In a telephone survey of 1631 recent visitors to a Chicago hospital ED, patient's whose wait times were less than they expected were more likely to report a positive overall satisfaction rating for the ED visit.[24] In a study conducted in a New Jersey general ED, patients were asked to estimate how long they waited during three time intervals: triage to patient care area, patient care area to physician evaluation, and physician evaluation to disposition. They were then asked to provide values for what they would consider an acceptable wait time for each of the three intervals.[25] Patient satisfaction was found to be related to whether perceived wait times met the patient's acceptable wait time value. Satisfaction was only weakly related to actual wait times.[25] Overall, ED wait times play an important role in the provision of optimal care to critically ill patients and general patient satisfaction with their ED visit.

2.2 Estimating ED Physician Workload

ED physicians perform a variety of duties while on shift. These duties include the provision of patient care, teaching of learners, and external communication duties such as following up on reports of investigations, providing telephone consultation to referring physicians, and taking ambulance patch calls.[11,16]

Previous studies of ED physician workload have commonly adopted one of two methods. The first method involves surveying existing EDs to determine current physician numbers and patient volumes.[12,13,14] These surveys have traditionally measured physician workload by examining patient volumes and the number of full-time equivalent (FTE) physicians staffing an ED. Physician workload is then inferred from manpower estimates which are generally reported as the number of FTE physicians required per 10,000 patient visits. This strategy assumes that all patient visits require approximately the same amount of physician time.

Holley et al conducted a survey of 277 American ED directors and hospital administrators to determine the physician staffing compliments of a wide variety of American EDs.[14] The institutions surveyed included both public and private hospitals and a broad range of ED sizes were represented. No estimate of patient acuity was included in this study. The mean number of visits was 46,900, with a range of 1428 to 236,979 patient visits per year. 86% of EDs surveyed were formally affiliated with a medical school and trained students and 24% had active emergency medicine residency training programs.[14] They concluded that physician staffing varied widely from less than one to greater than 3 FTEs per 10,000 patient visits per year. Staffing levels did not differ significantly between public and private hospitals, or between residency affiliated and non-residency affiliated EDs.[14]

Unfortunately, estimating physician workloads based purely on patient numbers is a very crude estimate and does not take into consideration the large variations between different types of EDs. EDs across Canada differ from one setting to the next. Some EDs are situated within inner city hospitals associated with tertiary care teaching centers, whereas others are rurally located non-teaching centers which attend to the urgent health care needs of smaller populations. Some EDs are Regionl trauma referral centers and others see very little trauma. Most EDs are general and attend to the needs of patients of all ages, however, ten Canadian EDs provide services exclusively for children. All of these pediatric EDs are responsible for educating trainees at multiple levels of training.

In order to make workload estimates more applicable to unique ED settings, some researchers have utilized an alternate method of estimating physician workload which includes not just patient volumes, but patient characteristics and setting factors. A review of the literature revealed 3 such studies of ED physician workload that have adopted this approach.[11,15,16]

Graff et al hypothesized that formulas which included key patient characteristics would more accurately predict physician workload than simple formulas which consider only patient volume.[15] They created a multifactorial formula to predict the number of physician service hours required to treat ED patients. The formula included patient characteristics which were readily available from demographic data: length of stay and intensity of service provided. The intensity of service was inferred from review of internal registries which categorized patients into one of four categories: code care, critical care, observation care, and routine care. Code care patients were those who presented in cardiopulmonary arrest and who died in the ED. Critical care patients were those who were treated in the ED then admitted to the intensive care unit. Observation care patients were those requiring more than 5 hours of observation in the ED, and routine patients included all patients who did not fit into one of the other three categories. Using retrospective data over a 13 year time period, they compared the performance of the newly derived multifactorial formula to a simple volume-based formula in the their ability to predict the actual number of physician service hours needed to care for ED patients. They demonstrated that the multifactorial formula was superior to the simple volume-based formula for predicting physician hours. Predictions made with the multifactorial formula were much more highly correlated with actual physician hours than those made with traditional volume-based formulas (correlation coefficients: 0.96 vs 0.53).[15] An important limitation of this study was that the performance of the formula was assessed on retrospectively acquired data.

A subsequent study, also conducted by Graff et al, utilized a prospective design to test the hypothesis that ED physician service time varied with the type of patient service provided.[16] They conducted a prospective ED physician time study in which 6 ED physicians recorded the time that they spent on various aspects of patient care during 1347 patient visits. The study was conducted in a university-affiliated teaching hospital which sees patients of all ages with an annual census of 45,000 patients. The type of service provided was categorized into 5 groups: those triaged to the low acuity walk-in clinic area of the ED, those requiring laceration repair, those requiring admission to the ED observation unit, those requiring admission to an intensive care unit, and all others who did not fall into one of the other 4 groups (ie. a general ED population group). The average amount of physician service time required per patient was found to be 24 minutes. Walk-in patients required significantly less physician time (mean 10 minutes) and observation and critical care patients more time (56 minutes and 32 minutes) than average. They concluded that certain types of services provided to patients required an amount of physician time that differed significantly from the mean.[16] As such, EDs which differ in the relative proportion of the types of services that they provide may have significantly different physician time needs. A key limitation to this study was that the treating physicians themselves were collecting data on patient characteristics and their time expenditure. The authors reported that accurate data was not able to be collected on

18% of their study population due to excess clinical demands on the physicians being studied.[16]

There has been one Canadian ED physician time study conducted by Innes et al which was designed to estimate emergency physician clinical workload[11]. The goal of the study was to generate a valid mathematical model to objectively estimate ED physician workload in the setting of various measurable patient and setting parameters. The setting of this study was a Vancouver inner city general ED with a predominantly adult patient population. A research assistant shadowed 20 ED physicians throughout their shifts and recorded the time they spent on various activites to the nearest 15 seconds. The research assistant also recorded a large number of clinical, demographic and setting variables. In the first phase of this study, they utilized 314 patient visits to develop a multivariate linear regression model to establish which clinical, demographic, and setting variables had the strongest association with physician time needed to treat ED patients. In the second phase of the study, they utilized an additional 271 patient visits to validate the derived model. The advantage of this study design was that it utilized objective measurement methods of physician time expenditure that were not dependent upon physician self measurement. The authors concluded that ED physician workload was most strongly influenced by 6 key patient variables: triage level (CTAS score), age, arrival by ambulance, number of previous visits, presence of a co-morbid condition, and need for a procedure.[11]

The authors developed a predictive model which was valid in their own setting and suggested that the model required validation in other ED settings.[11] The Vancouver study contained very few younger children and to date, this model has not been validated in a pediatric ED setting. It is possible that the pediatric ED differs significantly from a general ED with respect to predictors of physician clinical workload.

Although this time study methodology is laborious to conduct, it provides some of the most accurate and comprehensive data for assessment of factors that influence physician workload and it has been used successfully in the ED setting elsewhere. In addition to the Vancouver study, several previous studies have used observers to objectively measure the expenditure of time in the performance of duties by nurses and physicians in an ED setting.[26,27,28]

Alternative methods to observer-based time studies for estimating time spent at various activities have been tried. In the Graff et al study in which ED physicians tracked their own time expenditure, physicians had to discontinue data entry 18% of the time due to clinical demands.[16] Further limitations of self-report data were idendified by Burke et al when they compared observer based time study methods to self-report for estimating time spent on work activities. They found that mean activity times were significantly longer using the self-report compared with independent observation.[29] Finally, work-sampling methods where time spent at various activities is estimated based on a number of “snapshots” of work activity taken at various time intervals have been proposed as a less onerous alternative to continuous observation of workers. Unfortunately, when this method was applied to physicians in a hospital setting, the actual time spent on different tasks as assessed by continuous observation differed from the percent of time estimated by work-sampling by 20 percent or more.[30]

Chapter Three: Study Rationale and Objectives

3.1 Study Rationale

The most comprehensive method for estimating pediatric ED physician workload should consider both patient volumes and a model similar to the one described in the Vancouver study which would allow for the prediction of mean time needed to treat patients based on available clinical, demographic and setting variables. Thus, a model to predict pediatric ED physician workload could be derived as follows:

Workload = *patient care time* + teaching time + external communication time + other

Patient care time = Number of patients x mean physician time needed to treat

Where mean physician time needed to treat (TNT) is derived from the following regression model:

TNT = constant + β_1(independent variable 1) + β_2(independent variable 2) + β_3(independent variable 3) +… βn(independent variable n)

Thus, for any given pediatric ED, physician workload could be estimated if the patient volume and mean physician time needed to treat were known and the relative amount of time committed to patient care, teaching and administrative activities could be estimated. It is from this derivation that the specific objectives of this study arise.

3.2 Primary Objective

To determine which demographic and clinical variables most strongly influence physician time needed to treat patients in a pediatric emergency setting.

3.3 Secondary Objective

To determine the proportion of time pediatric ED physicians spend on direct and indirect patient care, teaching, external communication and other activities.

Chapter Four: Selection of Independent Variables for Model

If a model for estimating pediatric ED physician time needed to treat patients is to be developed, a comprehensive set of independent variables must be considered. Three search strategies were utilized to assess potential independent variables for the model generation in this study.

First, a Medline search for studies exploring physician workload was conducted. All factors theorized to be associated with physician workload were explored.

Second, a Medline search of the ED overcrowding literature was conducted to detect factors postulated to contribute to prolonged ED lengths of stay. Although the relationship between physician workload and patient length of stay has not been clearly established, it seems logical that the two may be related.

Third, pediatric emergency physicians at the Alberta Children's Hospital were informally polled to generate additional independent variables that might be unique to the pediatric ED setting. Half of those polled work in both a general ED and pediatric ED setting.

The independent variables identified and considered for inclusion were divided into two groups: patient-specific factors and setting factors.

4.1 Patient-specific Factors

4.1.1 Patient Demographics – Age, Gender, Arrival Time

Patients at the extremes of age are among the highest users of ED services.[31] During the 2003-2004 fiscal year, 48% of all infants under 12 months living in Ontario visited an emergency department.[31] It is not known how specific pediatric age subgroups impact ED throughput, however, Chan found that patient throughput in a general academic emergency department was inversely related to the pediatric volumes.[32] Some ED physicians postulated that infants required more physician time than older patients. Given this possibility and the large utilization of ED services by this age group, patient age was considered an important independent variable to include in the model.

In the Vancouver workload study, female patients were found to require more physician time than male patients.[11] A review of the literature failed to find any data to suggest that patient gender influences physician time in the treatment of pediatric patients. This was therefore considered a low priority variable for this study.

Patient arrival time has been included in previous workload studies. In a CIHI paper addressing patient wait times, time of arrival was stated to be associated with patient length of stay.[4] There was no evidence in the literature to suggest that time of arrival specifically influences physician time required to treat patients, however, it is plausible that fatigue and lack of diagnostic resources at night may independently impact physician treatment times. Pediatric ED physicians did not feel that arrival time strongly influenced the time required to treat patients. This was considered a low priority variable for this study.

4.1.2 Past Medical History

The presence of a significant past medical history was postulated by ED physicians to be an important variable to track. The Vancouver workload study found that patient co-morbidity was a predictor of physician time requirements.[11]

4.1.3 Acuity – CTAS Score, Ambulance Arrival, Source of Referral

Previous studies have demonstrated that low acuity patients form a relatively small part of the emergency department workload.[33] One of the most dramatic trends in the patient demographics at the ACH ED has been the steady rise in patient acuity.[17] Five years ago, 34.0% of patient visits were categorized as CTAS 1, 2, or 3 (higher acuity patients). During the past year, 60.8% of patients were CTAS 1, 2, or 3. This dramatic rise in the number of urgent and emergent patients puts a significant strain on the ED as they require more medical attention and they have significantly longer ED stays.[17]

A previous study has demonstrated that the number of ambulance arrivals was directly related to patient throughput in the ED.[32] In the Vancouver workload study, patients arriving via ambulance required more physician time to manage.[11] It is not known if this is true in the pediatric setting.

Emergency patients can access the ED either by self referral or by being referred from another physician. Patients referred in from other physicians have been “pre-screened” and may be more unwell than those who self refer. It is postulated that these patients might require increased physician time to treat.

4.1.4 Need for Procedures, Laboratory Tests, Radiographs, and Specialist Consultations

The Vancouver workload study found that the need for a procedure was one of the most powerful independent predictors of physician workload.[11] In the ACH ED, 14.4% of patients required a procedure to be performed by a physician.[17] Although it has not been formally studied in a pediatric ED setting, the need for a procedure, such as a fracture reduction or suturing of a wound, is likely to contribute to a longer physician time requirements. Pediatric ED physicians all agreed that the need for a laboratory test or radiograph was also likely to increase the length of physician time needed to treat. In the ACH ED, 22.4% of patients required a laboratory test.[17] The Vancouver workload study did not include this variable, however a study conducted by Hampers et al demonstrated that increased use of tests was associated with increased length of stay in a pediatric ED.[34] This increased length of stay and the time needed to review tests may impact physician time needed to treat.

Patients with more complex or puzzling medical conditions sometimes require subspecialist consultation during their ED stay. These consultations are requested by the treating ED physician and can be conducted either over the telephone or in person. Although consultations are not common, they can involve lengthy conversations regarding recommended treatment plans. At times, due to delays in consultations, patients can also have prolonged lengths of stay. As such, the pediatric ED physicians felt this variable should be included.

Sprivulus derived an ED patient complexity measure in a general ED patient population which included the number of procedures, investigations and consultations required for each patient.[35] He determined that this patient complexity measure increased in magnitude with increasing patient age, and suggested that patient age could be used as a proxy measure for patient complexity. This study was conducted with a largely adult population and the relationship found between procedures, investigations and consultations and patient complexity may not be generalizable to a pediatric ED setting.[35] As such, age alone was not felt to be a reliable proxy measure for pediatric patient complexity and procedures, investigations and consultations were considered as important potential independent variables.

4.1.5 Disposition

It has been previously demonstrated in the general ED setting that the number of admissions is inversely related to patient throughput in the ED.[32] The admission of a pediatric patient generally involves a lengthy discussion with the family and one or more telephone discussions with the admitting service. In addition, admitted patients have longer ED lengths of stay than do discharged patients (5.9 hours versus 2.9 hours in the ACH ED)[17] and generally require closer medical supervision with frequent physician reassessments. Thus, the need for admission may be an important independent variable in physician time needed to treat.

4.1.6 Language Barriers

Between 1991 and 2001, it is estimated that Canada welcomed 1,830,680 new immigrants; 6.2% of Canada's total population. Many large urban centers have even higher proportions of recent immigrants. At the time of the 2001 Canadian census, 17% of Torontonians and 16.5% of Vancouverites had immigrated to Canada within the preceding 10 years. Calgary census data suggests that 7.3% of the population were recent immigrants.[36]

The immigrant population poses unique challenges to Canada's EDs. Most notably, there can be significant language barriers. In the 2001 census, 17.6% of Canada's population and 19% of Calgary's population described their mother tongue as neither French nor English. (Toronto 39.0%, Vancouver 36.9%)[36]

Woloshin et al postulated that language barriers may result in incomplete medical histories which may prompt physicians to order more laboratory and radiographic tests to increase the probability of a correct diagnosis.[37] Hampers et al conducted a study at an urban pediatric emergency department to determine if a language barrier between a family and the ED physician was associated with a difference in diagnostic testing rates and length of stay in the ED.[38] Significant language barriers were present in 8.5% of their patient visits. Multi-variate analysis demonstrated that the presence of a physician-family language barrier was associated with a higher rate of resource utilization ($38 more in test charges) and a longer length of stay (20 minutes).[38] In a retrospective age-matched cohort study conducted in the Hospital for Sick Children ED in Toronto, Goldman et al determined that families with language barriers had significantly longer lengths of stay in the ED than English speaking families.[39] Others have tried to explore whether language barriers specifically increase the amount of physician time needed to treat a patient. One physician time study in a non-emergency setting was unable to demonstrate a difference in the amount of time that physicians spent with English-speaking versus non-English speaking adult patients.[40] It is not clear if the results of this study can be extrapolated to a pediatric emergency setting where the consequences of a communication barrier might result in a significant adverse outcome for a child. The potential for such an adverse outcome may result in increased physician time expenditure to optimize communication with families. Surveyed pediatric ED physicians all agreed that language barriers in their work setting resulted in prolonged physician time requirements.

4.2 Setting Factors

4.2.1 Trainees in the ED

The ACH ED supports a broad spectrum of educational activities for all levels of medical education. At the postgraduate level, 110-120 University of Calgary residents rotate through the ED each year. These include primarily junior residents from a broad range of training programs and a smaller proportion of senior residents in paediatrics and emergency medicine. During the 2005/06 academic year, pediatric ED physicians provided direct clinical supervision for 9856 resident shift-hours.[41] Previous time in motion studies conducted at the Alberta Children's hospital have estimated that the presence of a learner reduces physician efficiency by approximately 20%.[42] In a study of general internal medicine outpatient clinics, the presence of a medical student resulted in a prolongation of the clinic by 32.3 minutes per half day clinic.[43] Thus, the presence of a learner may be an important independent variable in this study.

The impact of a learner in the ED setting, and the impact on patient flow, is not well understood. The CIHI wait times report stated that teaching hospitals (those who teach medical students and residents) have longer wait times to see a physician than non-teaching hospitals.[4] However, this association was not demonstrated to be causal as this was a cross sectional study.[4] A study undertaken by Lammers et al examined the effect of a newly established emergency medicine residency training program on ED patient length of stay.[44] They found that the introduction of emergency medicine residents to the ED was associated with an increased patient length of stay. However, a second study revealed that the presence of residents in an ED resulted in shorter ED lengths of stay for admitted patients.[45] Overall, the impact of learners on ED physician workload is unclear. Understanding the impact of learners on physician workload is particularly important in the pediatric ED setting, as the number of learners in a pediatric ED is often proportionally larger than in a general ED. This is due to the fact that there is generally only one pediatric ED affiliated with each residency training center, whereas most centers have multiple general EDs who can train students. Thus, the effect of learners may be magnified in the pediatric ED setting.

4.2.2 Physician Factors

The residency training background of physicians was postulated by some pediatric ED physicians to impact upon the time needed to treat ED patients. Pediatric emergency physicians come from a variety of training backgrounds. The majority have their primary training in either pediatrics or emergency medicine. A proportion of these physicians have further fellowship training in pediatric emergency medicine. A small group of physicians have their primary training in family medicine with an additional year of emergency medicine training. No previous studies have compared physician efficiency in a pediatric ED setting based on background training.

4.3 Patient Volumes

An assessment of pediatric ED physician workload must consider not just the time demands of individual patients, but total patient volumes as well. The aggregate physician clinical workload of an institution is likely best estimated by including the product of the mean time needed to treat patients and the total number of patients treated. The ACH annual ED census has shown a steady rate of growth over the past 2 decades, from an annual census of 32,000 in 1993 to over 47,000 in 2006.[46] Major factors postulated to contribute to pediatric ED patient volumes include population growth, health care restructuring, and family physician shortages.[2,4,47]

The most straightforward factor is population growth. Canada has seen a steady increase in the size of its population.[36] Between the 1996 and 2001 national censuses, Canada's population grew by 4.0%, and Alberta's by 10.3%. Calgary has experienced brisk population growth in recent years. In 1986 there were 201,145 children aged 0-19 years living in Calgary. By 2002, that number had risen to 259,186; a 29% increase over 16 years.[36] Despite this increase in population, Calgary has not increased its number of EDs, and there remains only one pediatric ED.

During the later part of the 1990's, Canadian health care underwent significant restructuring.[2] Increased regionalization and health care spending cuts resulted in economic pressures on hospitals which resulted in the closure of large numbers of acute care beds and rising occupancy rates in hospitals. For example, within Ontario, between the 1995 and 2000, acute care beds were decreased by 22% and mean hospital occupancy rates increase from 85.6% in 1994/95 to 93% in 1999/2000.[2] As a result, patients who would once have been managed in an in-patient setting were now managed in the community, increasing the burden of care for EDs. In addition, lack of in-patient beds resulted in the need for EDs to hold admitted patients for prolonged periods. Thus, the net result of health care restructuring on EDs was an increase in patient visits and a prolongation of patient length of stay, both of which contribute to increased patient loads for ED physicians.

Family physician shortages may contribute to increasing ED volumes as well. A CIHI report released in 2002 concluded that the total physician workforce in Canada had dropped by 5% between 1993 and 2000.[47] It is estimated that 4.2 million Canadians do not have a family doctor.[48] The Alberta Physician Resource Planning Committee reported that as of 2005, Alberta had a shortage of approximately 600 full-time equivalent (FTE) family physicians.[49] In Calgary, it is estimated that there is a shortage of approximately 200 FTE family physicians.[50] With this paucity of family physicians, more families may choose to use the pediatric ED for their children's illnesses.

The impact of increased patient volumes on physician workload is complex and the relationship between the two may not linear. In other words, as the number of patients that an ED physician simultaneously treats increases, the time needed to treat individual patients may increase. Thus, patient volumes may be a significant independent variable when modeling physician time needed to treat. Pediatric ED physicians postulated that high patient loads may result in less efficiency due to the need for increased multitasking and interruptions. In an observational time study designed to detect workplace interruptions, ED physicians in a non-teaching hospital were interrupted an average of 9.7 times per hour.[51]

Although total patient volume while on shift was felt to be a factor which might influence physician time needed to treat patients, it's inclusion in the model was felt to be of lower priority given that this parameter is, by nature, random and unpredictable. Last year at the ACH ED, there were significant and unpredictable day to day fluctuations in the number of visits. The mean number of visits per day was 127, with a wide range of 80-183 visits.[17] If a variable is not readily forecastable, it will have less value in the model.

4.4 Selection of Variables for the Model

All proposed variables were considered by the investigators and a set of independent variables were selected by consensus for inclusion in the study. Variables with strong literature support or those which pediatric ED physicians strongly felt were related to physician time needed to treat were included. For those variables with little support from the literature and weaker ED physician consensus, two key considerations were used in the variable selection. First, if measurement of a variable required the observed physicians' participation, they were not included, as the negative impact of having the study itself influence ED physician time expenditure was felt to outweigh the benefit of including these variables in the model. Second, if information on a variable was not likely to be readily available to administrators, or not plausibly forecastable, then its utility in the model was felt to be limited, and it was not included.

Chapter Five: Methods

5.1 Setting

The Pediatric Emergency Department of the Alberta Children's Hospital (ACH), is a free-standing, tertiary care facility, with approximately 50,000 patient visits annually.

5.2 Design

This was a prospective time study of 12 pediatric emergency physician shifts.

5.3 Study Population

All pediatric emergency physicians at the ACH were eligible to participate as study subjects. Physician-patient contacts were eligible for inclusion if the patient was less than 18 years of age.

5.4 Data Collection and Operational Definitions

ED physician staffing at the ACH during the time of the study included six overlapping 8 hour shifts per day. One of the six shifts (from 1500-2300) was in a minor treatment area, where less severely ill children are seen (CTAS 4 and 5). The primary investigator (KM) selected a convenience sample of 12 physician shifts to shadow over a 4 week period in July and August, 2007. The shifts selected for shadowing included day, evening and night shifts and the physicians assigned to those shifts were representative of the physician group with respect to training backgrounds and years of experience. During the shadow shifts, the ED physician was followed for their entire shift and the activity undertaken by the ED physician was documented in 15 second intervals throughout the shift. The investigator did not interact in any way with the physician or their patients.

Time spent by the ED physician on various elements of patient specific care, non-patient specific teaching and non-patient specific departmental administration were recorded as described below:

- Patient-specific time
    - Direct patient care (defined as direct interaction with patient/family)
    - Indirect patient care (out of patient room time – discussion of patients with other health care members or trainees, review of investigations, charting, consultation of resources to assist in patient care, handovers, etc)
- Non patient-specific time
    - Trainee teaching (teaching unrelated to the care of an active patient)
    - External communication (ambulance patches, consult calls, review of previous day's lab results)
    - Other (personal time, otherwise unclassifiable)

In order to preserve patient confidentiality, physicians were not followed into patient rooms. Time spent in patient rooms was coded as direct patient care.

For patients who were handed over at the end of a physician's shift, the receiving physician's time expenditure was tracked for each patient.

The following patient variables were obtained from the emergency department computerized tracking system: arrival by ambulance, time of arrival, age, sex, CTAS score, laboratory test performed, radiography performed, subspecialty consultation performed and disposition (admitted or discharged). Physicians completed a check box form after each patient history to provide information on the following variables: referral from another physician, presence of language barrier, and presence of a significant past medical history. Patients were considered to have been referred by another physician if they had been seen by that physician within the past 24 hours and a written or verbal referral from that physician was provided to the ED. Language barrier was categorized as none, moderate (barrier to clear communication) or severe (translator required). Past medical history was categorized as none, single chronic medical condition (eg. asthma, chronic otitis, eczema), or complex past medical history (eg. multiple congenital anomalies or syndrome, oncology patients, technology dependent children).

The presence of a student learner, their level of training and whether a procedure was performed by the physician (or their learner) was documented by direct observation.

5.5 Outcome Measures

5.5.1 Primary Outcome Measure

Our primary outcome measure was the total physician time needed to treat each individual patient. This was defined as the sum of direct patient care and indirect patient care for each specific patient.

5.5.2 Secondary Outcome Measures

Our secondary outcome measure was the proportion of physician time spent on each of the coded activities (direct and indirect patient care, teaching, external communication and other).

5.6 Analysis

5.6.1 Derivation of a New Predictive Model (Primary Objective)

The independent variables hypothesized to be related to physician time needed to treat were initially evaluated at a bivariate level to determine if they were individually associated with time needed to treat. These variables are summarized in Table 5.1.

Table 5.1 – Variables Hypothesized to be Related to Physician Time Needed to Treat

Variable	Data type	Description
Patient age	Continuous	Recorded in years
Arrival by ambulance	Binary	• Yes • No
Referred by a physician	Binary	• Yes • No
Past medical history	Categorical	• Well child • Chronic single medical condition o For example: asthma, chronic otitis • Complex medical history o For example: multiple congenital anomalies or syndrome, oncology patients, technology dependence
Language barrier	Categorical	• No barrier • Moderate barrier (barrier to clear communication) • Severe barrier (translator needed)
CTAS score	Categorical	• 1 • 2 • 3 • 4 • 5
Procedure performed by physician	Binary	• Yes (may be performed by attending physician of by trainee under the supervision of the attending physician) • No
Laboratory investigation	Binary	• Yes • No
Radiological investigation	Binary	• Yes • No
Trainee primarily involved in case	Categorical	• No trainee • Junior resident (year 1-2) or medical student • Senior resident (year 3, 4, or 5) or pediatric emergency fellow
Admitted	Binary	• Yes • No
Subspecialty consultation performed	Binary	• Yes • No

Those variables which demonstrated a significant association with physician time needed to treat were then considered in the derivation of the multivariate linear regression model to establish which variables had the strongest association with physician time needed to treat patients. We defined our dependent variable as the time needed to treat an ED patient. One unit of observation was considered one ED patient visit.

In developing our model, we examined our data to ensure that three assumptions were met: 1) that the dependent variable was normally distributed, 2) that the residuals were normally distributed, and 3) that there was homogeneous dispersion of the variance of the residuals across an expected data range.

Independent variables were also investigated for effect modification.

5.6.2 Pediatric ED Physician Activity (Secondary Objective)

Physician activity was reported as a proportion of time spent on each of the coded activities (direct and indirect patient care, teaching, external communication and other).

5.6.3 General Considerations

4.6.3.1 Handover Patients

One group of patients posed a challenge for the analysis. Patients are often handed over from one physician to the next if they are anticipated to be in the ED long after the end of a physician's shift. The number of handover patients can vary, but averages about 2-3 per shift. Patients received in handover at the beginning of a study physician's shift were not included in the model derivation, as the majority of those patient's physician time requirements were unknown. However, the receiving physician's time spent caring for these patients was tracked and included in the description of that physician's activity.

For patients who were handed over at the end of a study physician's shift, data recorded by the receiving physicians was used to complete the total physician time needed to treat these patients. These patients were included in the model derivation as accurate physician time needed to treat data was collected for the entire patient visit.

4.6.3.2 Consideration of Trainee Time

In this study, only attending physician time needed to treat patients was recorded. It is acknowledged that medical students and residents contribute to the total time required to manage patients. However, the goal of this study was to examine only the time expenditure of attending physicians.

4.6.3.3 Statistical Software

Data analysis was performed using Intercooled Stata Version 7.

5.7 Sample Size Calculation

The sample size was based on the multiple linear regression model. We assumed a maximum of 12 independent variables with a minimum of 15 observations per variable and an alpha of 0.05 and power of 90%. Given this, we calculated a minimum of 170 patients to perform our analysis based on Tabachnick and Fidell's rule of thumb for testing R-square ($N >= 50 + 8m$, m = number of independent variables.)[52] Given that the preliminary phase of the Vancouver workload study utilized a sample size of 205 in generating a model which predicted greater than 30% of variance in time needed to treat explained by the model, we elected to replicate their methods and sample size.[53]

5.8 Ethical Considerations

Written informed consent was obtained from all emergency department physicians who agreed to participate in the study. Consent was not obtained from individual ED patients/families, nor was any explanation of the study provided to families.

Obtaining informed consent from all families who were seen by the physician being studied would both interfere with the primary outcome measure and potentially introduce significant selection bias into the study. Obtaining informed consent from families for an emergency department study requires significant time and in this circumstance, would likely have delayed the treating physician from seeing the patient. Further, families often have many questions relating to research studies and will often direct their questions to the treating physician, thus altering our primary outcome measure. If informed consent was obtained prior to each family seeing a physician, it is likely that we would be unable to obtain consent from families of critically ill children, those who have significant language barriers, and those whose parents are not present when the child arrives. As these are all factors which would be expected to significantly modify the primary outcome, the exclusion of these patient groups would severely bias the data and the interpretation of the findings.

The University of Calgary Conjoint Health Research Ethics Board approved this study.

Chapter Six: Results I – Introduction and General Demographics

The results of this study have been divided into 4 chapters. This chapter begins with a description of the general demographics of the physicians and shifts observed in the study, followed by a description of the study patient characteristics. These characteristics are then compared to historical population data to ensure that the patient sample was representative of the population from which they were sampled. Finally, this chapter reviews some of the interesting associations that were noted between various patient characteristics.

Chapters seven and eight provide the results relating to the study primary objective: To determine which demographic and clinical variables are associated with physician time needed to treat patients in a pediatric emergency setting. Chapter seven describes how each independent variable, when considered in isolation, is associated with physician time needed to treat. Chapter eight presents the results of the multivariate analysis of the relationship between the postulated independent variables and physician time needed to treat. Finally, chapter nine presents the results of the secondary objective: To determine the proportion of time physician spend on various activities during their shifts.

6.1 Physician and Shift Characteristics

Ten pediatric emergency physicians were approached to participate in the study. All provided written consent to participate. Eight of the ten physicians were shadowed for one shift and two of the physicians for two shifts. The shadowed shifts were as follows:

- 0700-1500 (one shift)
- 1000-1800 (two shifts)
- 1500-2300, minor treatment area (two shifts)

- 1500-2300 (three shifts)
- 1800-0200 (three shifts)
- 2300-0700 (one shift)

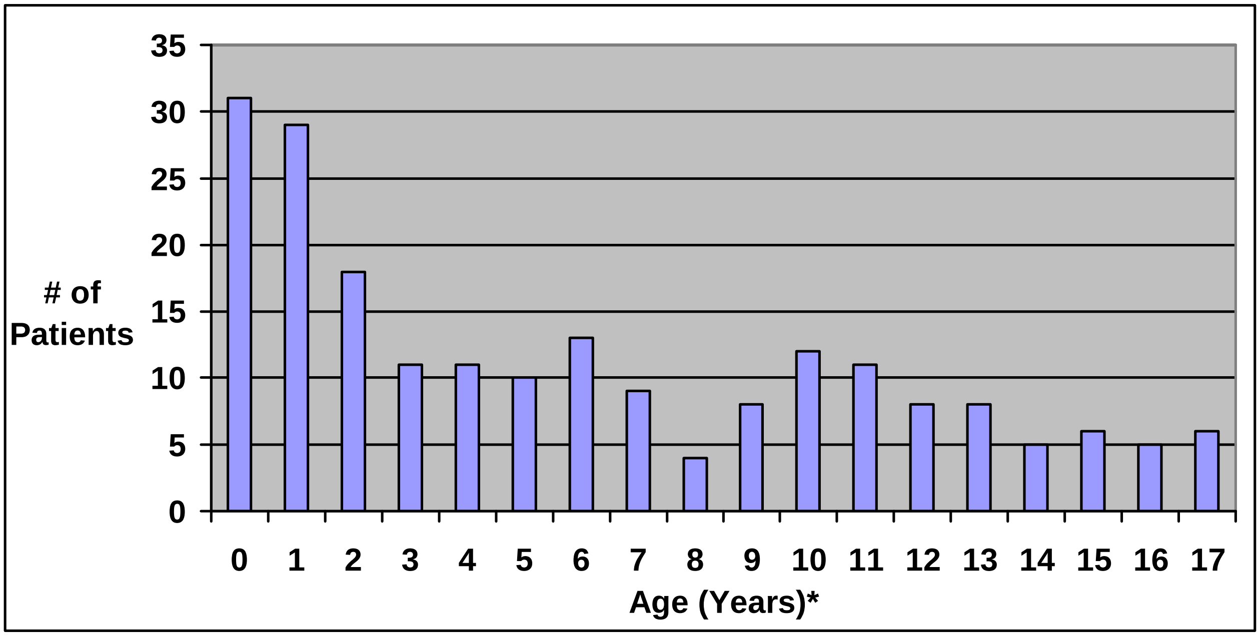
Of the ten physicians, 4 were pediatricians with pediatric emergency fellowship training, 3 were pediatricians without pediatric emergency fellowship training, and 3 were Royal College emergency medicine physicians without pediatric emergency fellowship training.

Of the 12 shifts, 2 had no trainee, 7 had junior trainees, 1 a senior trainee and 2 shifts had both a junior and senior trainee.

6.2 Patient Characteristics

Data was collected on 205 patient visits. Information on all variables was complete for all patients. Figure 6.1 shows the age distribution of the patients in the study. Children of all ages were represented, however, the age of the study patients was skewed towards younger patient ages.

Figure 6.1: Age of Study Patients



* Note: 0 Years = birth-11.99 months, 1 Year = 12-23.99 months, etc

Figure 6.2 shows the time of day that patients in the study were triaged. Triage rates peaked in the late afternoon and early evening between 1400 hours and 1900 hours. Only one 0700-1500 shift was shadowed, and no patients arrived during that shift prior to 0900. This is not unusual during the summer months.

Figure 6.2: Triage Time of Study Patients

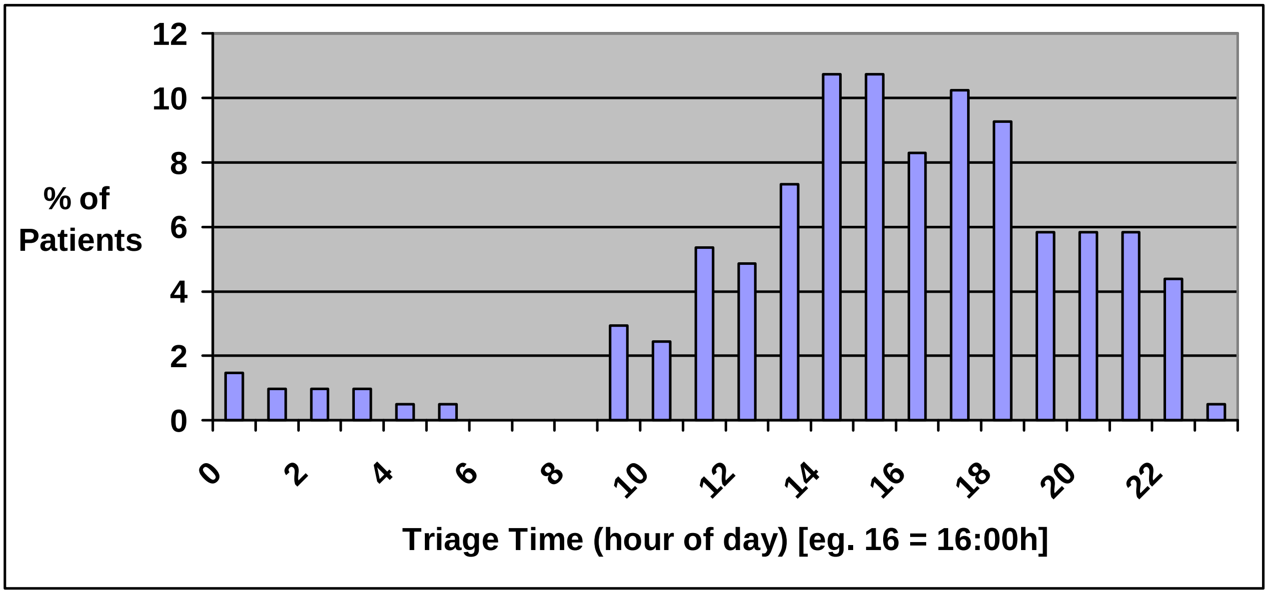


Table 6.1 summarizes the study patient characteristics. Both male and female patients were equally represented. Less than 16% of patients arrived in the ACH ED with the resuscitation (1) or emergent (2) CTAS scores. Relatively few patients arrived by ambulance or were referred by another physician and the large majority of patients were previously healthy. Language barriers were present in over 13% of patient families. Trainees were involved in the care of more than a third of the patients. Laboratory tests and radiographs were performed in nearly a third of patients. Procedures and subspecialty consultations were less commonly performed. Admission was required 11.2% of children.

Table 6.1: Patient Characteristics

Variable	N	%
Gender		
• Male	104	50.7
• Female	101	49.3
CTAS		
• 1	1	0.5
• 2	30	14.6
• 3	89	43.4
• 4	74	36.1
• 5	11	5.4
Arrival by Ambulance		
• Yes	21	10.2
• No	184	89.8
Referred by Physician		
• Yes	18	8.8
• No	187	91.2
Language Barrier		
• None	178	86.8
• Moderate	26	12.7
• Severe	1	0.5
Past Medical History		
• Healthy	161	78.5
• Single Chronic Condition	30	14.6
• Complex Medical History	14	6.8
Trainee Involvement		
• None	128	62.4
• Junior	56	27.3
• Senior	21	10.2
Procedure Performed by MD		
• Yes	26	12.7
• No	179	87.3
Laboratory Investigation Performed		
• Yes	59	28.8
• No	146	71.2
Radiographic Investigation Performed		
• Yes	64	31.2
• No	141	68.8
Subspecialty Consult Performed		
• Yes	15	7.3
• No	190	92.7
Admitted		
• Yes	23	11.2
• No	182	88.8

Given that only one patient had a severe language barrier, the categories moderate and severe were combined for subsequent data analysis and this variable was analysed as dichotomous (language barrier, yes or no). The physician time required to treat the patient with the severe language barrier was 8 minutes. This value fell well within the range of values for the moderate language barrier patients (1.75 – 50.75 minutes).

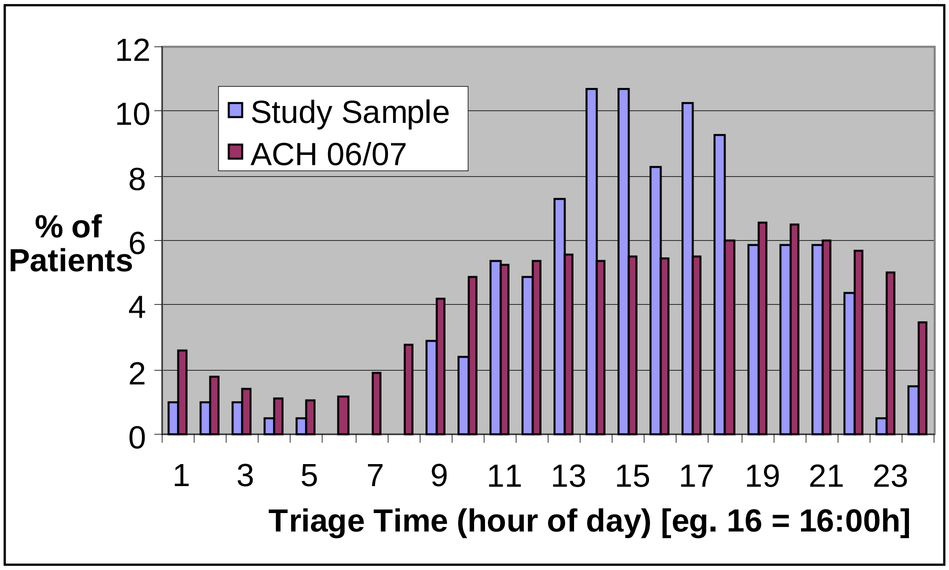
6.3 Comparison of Study Sample to ACH Patient Population

In order to determine if the study sample was representative of the general ACH pediatric emergency department patient population, the study sample was compared to aggregate pediatric emergency department data for the 2006/2007 fiscal year for five basic demographic variables: triage time, age, gender, CTAS score and admission rate.

6.3.1 Triage Time

Figure 6.3 shows the triage times for both the study sample and for the ACH 2006/2007 fiscal year. The study sample demonstrated a peak in triage times in the late afternoon and early evening. This trend is consistent with that of the aggregate 2006/2007 data although the mid afternoon peak was higher in the study sample than in the overall population. This was due to a relatively larger proportion of afternoon and evening shifts sampled.

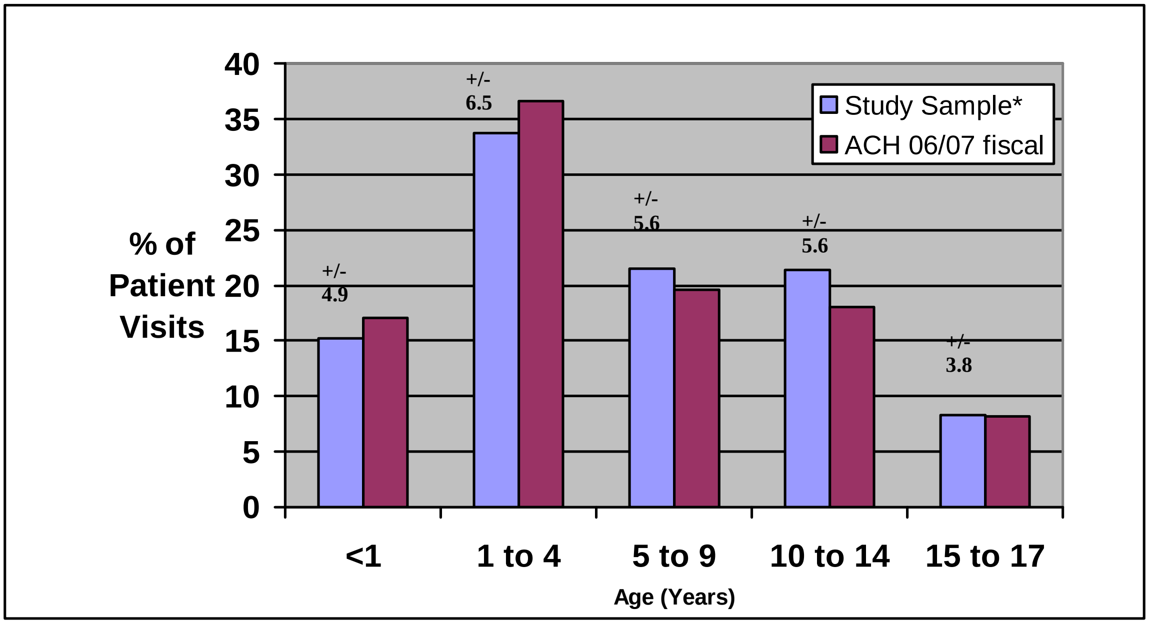
Figure 6.3: Triage Times - Comparison of Study Sample with ACH 2006/07



6.3.2 Age

Figure 6.4 shows the proportion of patient visits in each age category in both the study sample and for the ACH 2006/2007 fiscal year. The distribution of ages is similar in both groups.

Figure 6.4: Patient Age - Comparison of Study Sample with ACH 2006/07



* 95% confidence intervals for the study samples are as indicated.

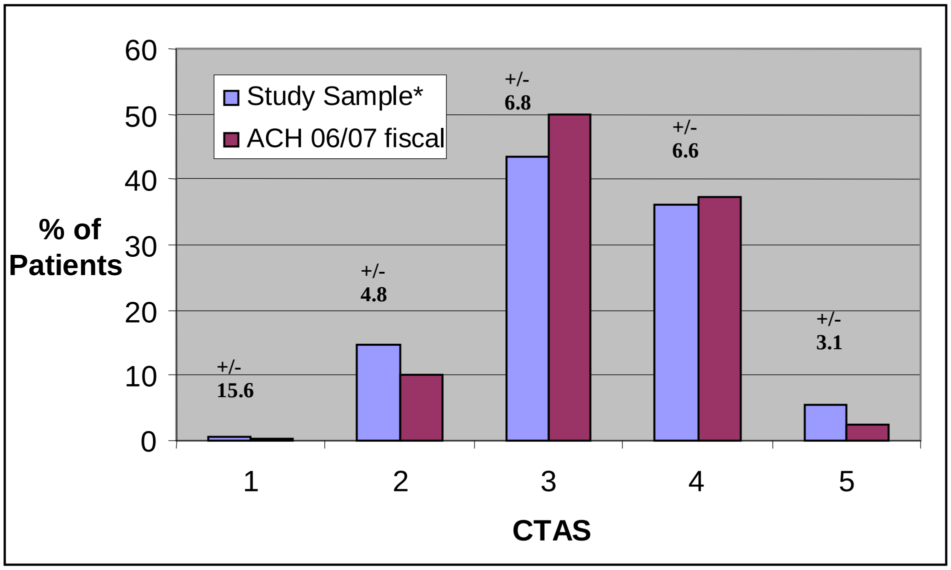
6.3.3 Gender

Our study sample was 50.7% male. During the ACH 2006/2007 fiscal year, 55.4% of patients were male (Chi square p=0.1822).

6.3.4 CTAS Scores

Figure 6.5 shows the distribution of CTAS scores for both the study sample and the ACH 2006/07 fiscal year. The proportion of CTAS 2 patients was slightly higher than expected, however the confidence intervals for the study sample included the value for the fiscal year data.

Figure 6.5: CTAS - Comparison of Study Sample with ACH 2006/07



* 95% confidence intervals for the study samples are as indicated.

6.3.5 Admissions

The rate of admission in the study sample was 11.2%. The overall admission rate for the 2006/2007 fiscal year was 7.5%. The admission rate for the study sample was statistically significantly higher than the overall ACH ED population. (Chi square, p = 0.0228) The admission rate was adjusted for CTAS score to determine if the relatively high number of CTAS 2 patients in the sample could account for the high admission rate. The adjusted admission rate was 11.0% suggesting that the higher number of CTAS 2 patients did not account for the higher than expected admission rate.

6.4 Independent Variable Associations

It was anticipated that some independent variables would be significantly associated with other independent variables. Postulated associations were assessed using logistic regression, chi-squared tests and Spearman’s rank tests where appropriate.

Given the high likelihood that acuity would be a key factor influencing the time needed to treat, the relationship between CTAS scores and several other independent variables was assessed, as outlined in Table 6.2. Higher acuity CTAS scores were found to be significantly related to arrival by ambulance, referral from another physician, history of a complex medical problem, performance of a laboratory test or consultation in the ED and need for admission.

Table 6.2-The Relationship Between CTAS Score and Other Independent Variables

CTAS (N)	Arrived by Ambulance N (%) [p=0.000][#]	Referred by Physician N (%) [p=0.045][#]	Past Medical History N (%) [p=0.001][ŧ]	Laboratory Test Performed N (%) [p=0.000][#]	Consultation Performed in ED N (%) [p=0.029][#]	Admitted N (%) [p=0.000][#]
1 (1)	0 (0.0)	0 (0.0)	Healthy 0 (0.0) Single 1 (100.0) Complex 0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2 (30)	9 (30.0)	5 (16.7)	Healthy 20 (66.7) Single 5 (16.7) Complex 5 (16.7)	17 (56.7)	3 (10.0)	8 (26.7)
3 (89)	11 (12.4)	9 (10.1)	Healthy 66 (74.2) Single 15 (16.9) Complex 8 (9.0)	34 (38.2)	11 (12.4)	14 (15.7)
4 (74)	1 (1.4)	4 (5.4)	Healthy 64 (86.5) Single 9 (12.2) Complex 1 (1.4)	8 (10.8)	1 (1.4)	1 (1.4)
5 (11)	0 (0.0)	0 (0.0)	Healthy 11 (100.0) Single 0 (0.0) Complex 0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

[#] Logistic Regression ŧ Spearman's Rank Test

In addition to CTAS, past medical history was associated with several variables (Table 6.3). Patients with increasingly complex past medical histories were more likely to have been referred by a physician, have laboratory tests and consultations performed and be admitted.

Table 6.3-The Relationship Between Past Medical History and Other Independent Variables

Past Medical History (N)	Referred by Physician N (%) [p=0.017]#	Laboratory Test Performed N (%) [p=0.008]#	Consultation Performed in ED N (%) [p=0.001]#	Admitted N (%) [p=0.000]#
None (161)	11 (6.8)	41 (25.5)	8 (5.0)	12 (7.5)
Single (30)	3 (10.0)	9 (30.0)	2 (6.7)	4 (13.3)
Complex (14)	4 (28.6)	9 (64.3)	5 (35.7)	7 (50.0)

Logistic Regression

In addition to CTAS and past medical history, laboratory investigation was associated with the presence of a junior trainee, consultation in the ED and admission (Table 6.4)

Table 6.4-The Relationship Between Laboratory Investigation and Other Independent Variables

Variable (N)	Laboratory Investigation # yes (%)	[p-value]
Presence of Trainee		[p=0.021]#
• None (128)	29 (22.7)	
• Senior (21)	6 (28.6)	
• Junior (56)	24 (42.9)	
Consultation in PED		[p=0.006]#
• Yes (15)	9 (60.0)	
• No (190)	50 (26.3)	
Admission		[p=0.000]#
• Yes (23)	20 (87.0)	
• No (182)	39 (21.4)	

chi-squared

Patients with language barriers had a procedure rate of 25.9% versus 10.7% among those without a language barrier (p=0.026). A complete matrix of the associations between the independent variables is provided in Appendix 1.

Chapter Seven: Results – Bivariate Analysis of Independent Variable Associations with Physician Time Needed to Treat

7.1 Methodology

Total physician time needed to treat (TNT) was examined in relationship to each independent variable. TNT was defined as the sum of direct patient care and indirect patient care for each specific patient.

Tests for association between TNT and dichotomous variables were done with student t-tests. Associations between TNT and past medical history, CTAS, and presence of trainee were assessed using analysis of variance. An association between TNT and patient age was tested for using Pearson's correlation.

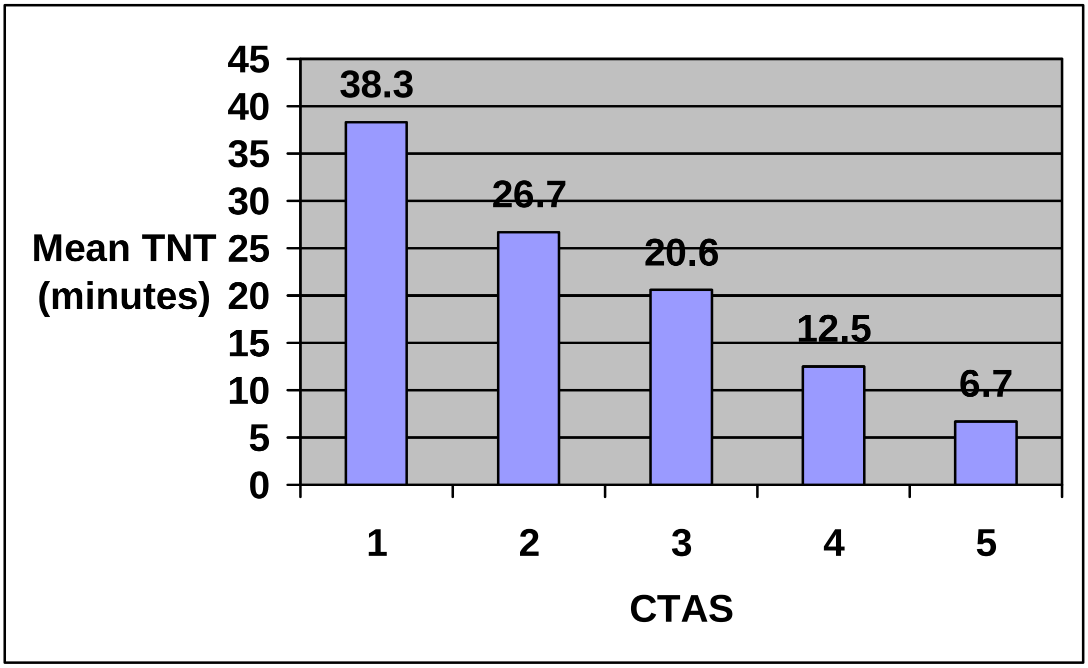
7.2 Variables with Potential Association with Physician Time Needed to Treat

Seven of the twelve independent variables demonstrated a statistically significant association with TNT ($p<0.05$).

7.2.1 CTAS

Figure 7.1 shows mean TNT for each CTAS category (analysis of variance; $p=0.000$) and suggests that CTAS scores are highly correlated with mean TNT. Patients with escalating acuity require more physician time.

Figure 7.1 : Physician Time Needed to Treat (TNT) by CTAS Category



7.2.2 Arrival by Ambulance

Patients arriving by ambulance had a longer mean TNT than those who did not (29.3 versus 16.6 minutes, t-test; p=0.000).

7.2.3 Past Medical History

Patients without a past medical history had a mean TNT of 16.4 minutes compared to those with a single chronic medical condition at 21.5 minutes and those with a complex past medical history at 27.8 minutes (analysis of variance; p=0.002).

7.2.4 Laboratory Investigation

Patients undergoing laboratory investigation had a longer TNT than those who did not have laboratory testing (27.5 minutes vs 14.0 minutes; t-test, p=0.000).

7.2.5 Procedure Performed by MD

Patients undergoing a procedure performed by a physician had a longer TNT than those who did not have a procedure (26.3 minutes vs 16.7 minutes; t-test, p=0.000).

7.2.6 Consultation in the ED

Patients requiring a consultation in the ED had a longer TNT than those who did not have a consultation (29.3 minutes vs 17.0 minutes; t-test, p=0.000).

7.2.7 Admission

Patients requiring admission had a longer TNT than those who were discharged home (35.3 minutes vs 15.7 minutes; t-test, p=0.000).

7.3 Variables Without Association to Physician Time Needed to Treat

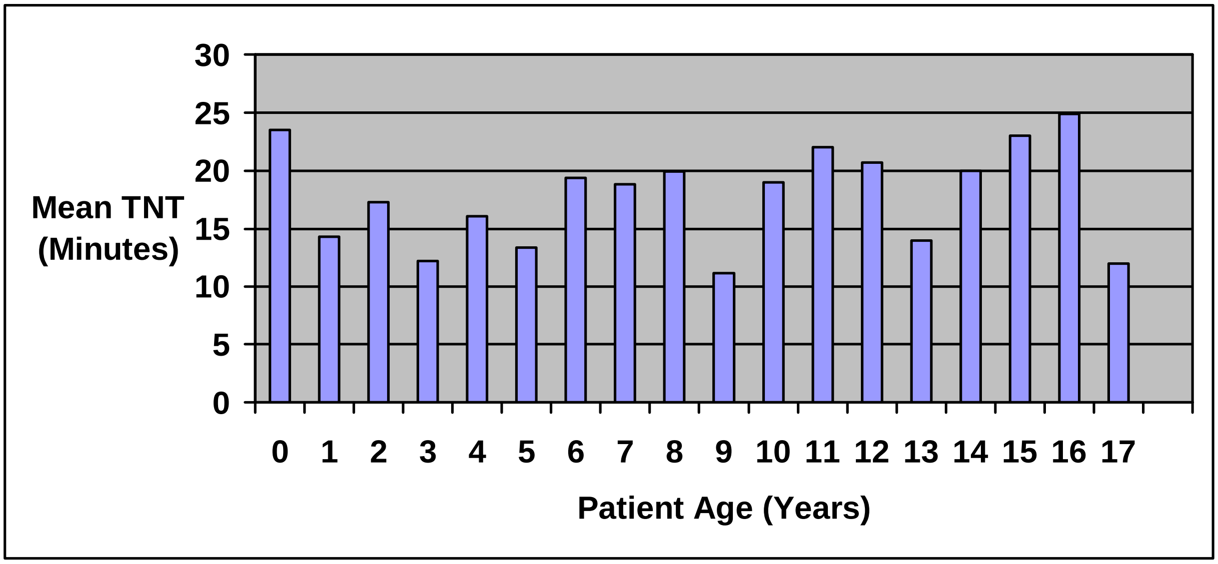
The remaining independent variables did not show a statistically significant association with total physician time needed to treat (Table 7.1).

Table 7.1:Variables Without Association with Physician Time Needed to Treat

Independent Variable (N)	Mean TNT (Minutes)	Test for Association
Referred by Physician		t-test (p=0.197)
• Yes (18)	21.69	
• No (187)	17.54	
Radiography		t-test (p=0.153)
• yes (64)	19.84	
• no (141)	17.02	
Language barrier		t-test (p=0.309)
• yes (27)	20.29	
• no (178)	17.54	
Presence of junior trainee		chi ^{2} (p=0.325)
• yes (56)	19.37	
• no (149)	17.35	
Presence of senior trainee		chi ^{2} (p=0.070)
• yes (21)	13.02	
• no (184)	18.46	

Figure 7.2 shows the mean TNT for each age group. There was no clear association with TNT and age (Pearson’s Correlation Coefficient = 0.013).

Figure 7.2 – Mean Total Physician Time Needed to Treat (TNT) by Patient Age

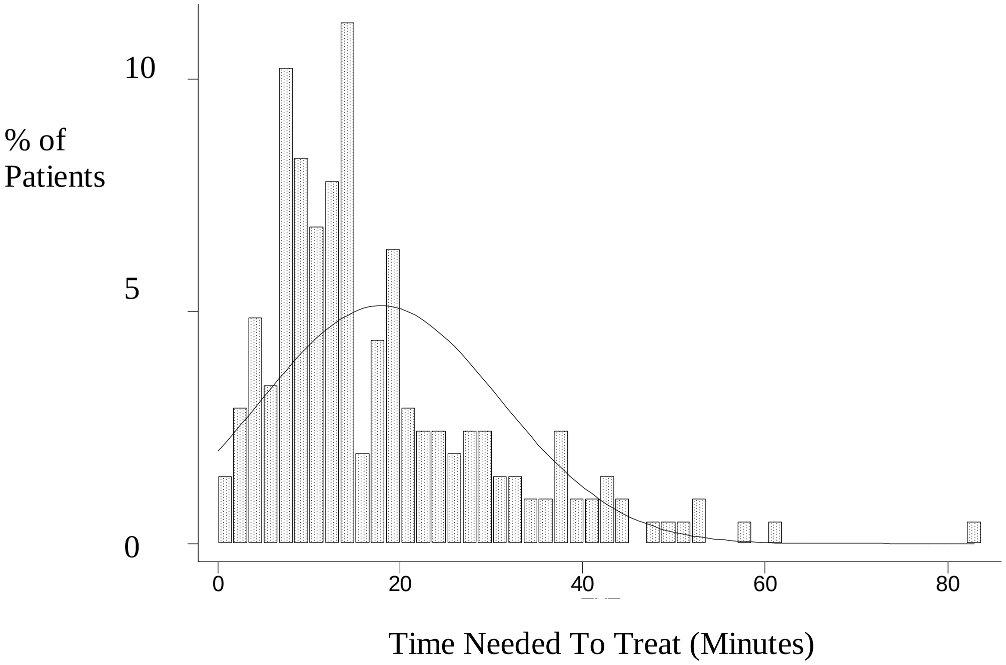


Chapter Eight: Results II – Primary Objective: Generation of a Multiple Regression Model

8.1 Assessment of Normal Distribution of Primary Outcome Variable

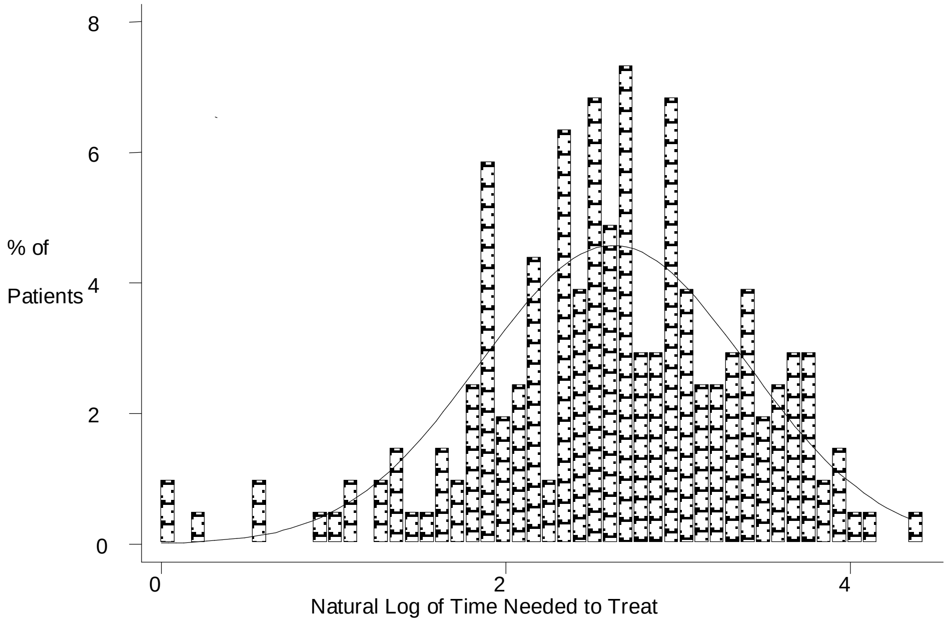
The primary outcome variable, time needed to treat (TNT), was plotted and examined to determine if it demonstrated a normal distribution (Figure 8.1). The mean and median values for time needed to treat were 17.9 and 14.0 minutes respectively.

Figure 8.1: Physician Time Needed to Treat (Untransformed)



The data for TNT was skewed and was consequently transformed using the natural logarithm (ln) of TNT. This transformation was necessary to make TNT normally distributed as this normal distribution is required for multiple regression to be valid. The natural logarithm of TNT was plotted and was determined to have a normal distribution (Figure 8.2). All subsequent modelling was performed using this transformed primary outcome variable.

Figure 8.2: Natural Log of Physician Time Needed to Treat (Transformed)



8.2 Generation of Regression Models

8.2.1 Model 1 – Utilization of Independent Variables with Statistically Significant Association with Time Needed To Treat

For generation of the first regression model, the independent variables with the strongest bivariate association with TNT were selected ($p<0.05$) and a standard multiple regression including all seven variables was performed using Intercooled Stata version 7. Table 8.1 summarizes the regression coefficients and p-values for each independent variable selected for the first model.

Table 8.1 – Regression Coefficients and p-values for Independent Variables for Model 1

Variable	**Coefficient**	**P-value**
CTAS	-0.2847	0.000
Arrival by Ambulance	0.3214	0.035
Procedure	0.2753	0.038
Laboratory	0.4719	0.000
Consult in the ED	-0.0169	0.931
Admitted	0.3268	0.069
Past Medical History	0.0484	0.548
Constant	*3.3139*	*0.000*

The resultant model was:

ln TNT = 3.3139 - 0.2847(CTAS) + 0.3214(arrival by ambulance) + 0.2753(procedure) + 0.4719(laboratory) - 0.0169(consult in ED) + 0.3268(admitted) + 0.0484(past medical history). The R-squared for this model was 0.3740.

8.2.2 Model 2 – Refinement of Model

To develop an efficient model predictive of time needed to treat, the model was refined by exclusion of two variables with highly non significant p values, consult in the ED and past medical history. CTAS, mode of arrival, and procedure were all retained as they had highly significant p-values. The p-value for admission (0.069) was not statistically significant using a cut-off of 0.05, however, this variable was highly correlated with TNT in the bivariate analysis and had a high regression coefficient in the first iteration of the model. As such, it was retained for testing in the second model. A second model was generated with the following results (Table 8.2).

Table 8.2 – Regression Coefficients and p-values for Independent Variables for Model 2

Variable	**Coefficient**	**P-value**
CTAS	-0.2911	0.000
Arrival by Ambulance	0.3203	0.034
Procedure	0.2692	0.041
Laboratory	0.4725	0.000
Admitted	0.3428	0.029
Constant	*3.3461*	*0.000*

The resultant model was:

ln TNT = 3.3461 - 0.2911(CTAS) + 0.3203(arrival by ambulance) + 0.2692(procedure) + 0.4725(laboratory) + 0.3428(admitted). The R-squared for this model is 0.3729. This model was reduced by two variables with very little reduction in the R-squared.

8.3 Model 3 - Assessment for Effect Modification

The five predictor variables in the refined model were examined for possible effect modification. An independent variable is considered an effect modifier if the relationship of a second independent variable to the dependent variable differs at varying values of the effect modifying variable. In other words, when two independent variables interact to exert effects on the dependent variable, effect modification exists. It seemed plausible that both ambulance arrival and CTAS might exert an effect on how the performance of a laboratory test might affect TNT. Patients arriving by ambulance and those with low CTAS scores (sicker patients) may have laboratory tests drawn prior to being seen by a physician. This might result in a lab test being available sooner and reduce the time needed to treat.

In order to test whether arrival by ambulance was an effect modifier in the relationship between laboratory test and TNT, an interaction variable (cross-product) was generated for Laboratory test x Arrival by ambulance. A multiple regression was conducted using the five independent variables from model 2 plus this new interaction variable.

The results of the regression model including in interaction term for arrival by ambulance and laboratory are summarized in Table 8.3.

Table 8.3 – Regression Coefficients and p-values for Model Containing Interaction Term for Mode of Arrival and Laboratory

Variable	**Coefficient**	**P-value**
CTAS	-0.2897	0.000
Arrival by ambulance	0.3607	0.055
Procedure	0.2772	0.038
Laboratory	0.4856	0.000
Admitted	0.3462	0.028
Arrival by ambulance x Laboratory	-0.1095	0.717
Constant	*3.3366*	*0.000*

The interaction term for arrival by ambulance and laboratory was not significant, with a p-value of 0.717. Ambulance arrival was therefore determined not to be an effect modifier of the relationship between laboratory performance and TNT.

In order to test whether CTAS was an effect modifier in the relationship between laboratory test and TNT, an interaction variable (cross-product) was generated for Laboratory test x CTAS. A multiple regression was conducted using the five independent variables from model 2 plus this new interaction variable.

The results of the regression model including the interaction term for CTAS and laboratory are summarized in Table 8.4.

Table 8.4 – Regression Coefficients and p-values for Model Containing Interaction Termfor CTAS and Laboratory

Variable	**Coefficient**	**P-value**
CTAS	-0.3694	0.000
Arrival by ambulance	0.3353	0.024
Procedure	0.3300	0.012
Laboratory	0.7584	0.094
Admitted	0.4083	0.009
CTAS x Laboratory	0.4075	0.005
Constant	*3.6095*	*0.000*

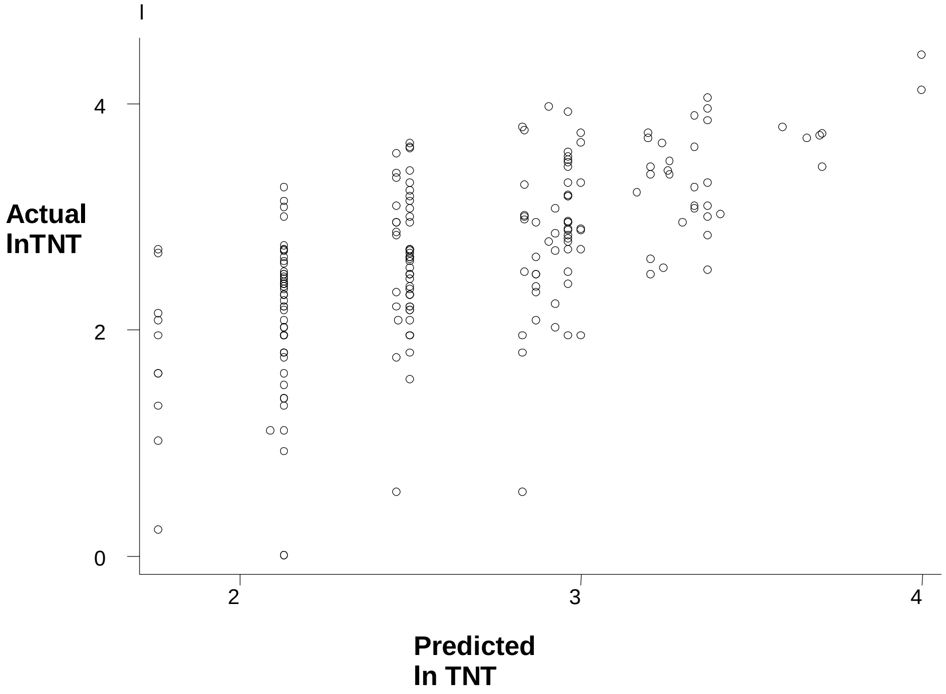
The interaction term for CTAS and laboratory was significant, with a p-value of 0.005. CTAS was determined to be an effect modifier of the relationship between the performance of a laboratory test and time needed to treat, such that at lower CTAS scores (higher acuity), performance of a laboratory test resulted in a smaller increase in time needed to treat than at higher CTAS scores. The R-squared of the new model containing the interaction term for CTAS and laboratory was 0.3970, higher than the model that did not include this interaction term.

The optimal model was thus determined to be:

ln TNT = 3.6095 - 0.3694(CTAS) + 0.3353(arrival by ambulance) + 0.3300(procedure) + 0.7584(laboratory) + 0.4083(admitted) + 0.4075(CTAS x laboratory).

This final model explains nearly 40% of the variance in time needed to treat. An R^2 of 0.40 represents a moderate correlation between actual time needed to treat and TNT predicted by the model.[54] This proportion of variance explained by this final model can be seen graphically by plotting the predicted values for ln TNT generated by the model and the actual ln TNT seen in the study sample. Figure 8.3 demonstrates a linear correlation between the predicted ln TNT based on this model and the actual ln TNT from the sample. The more linear this relationship, the better the model is at predicting time needed to treat.

Figure 8.3: Plot of Predicted ln TNT vs Actual ln TNT



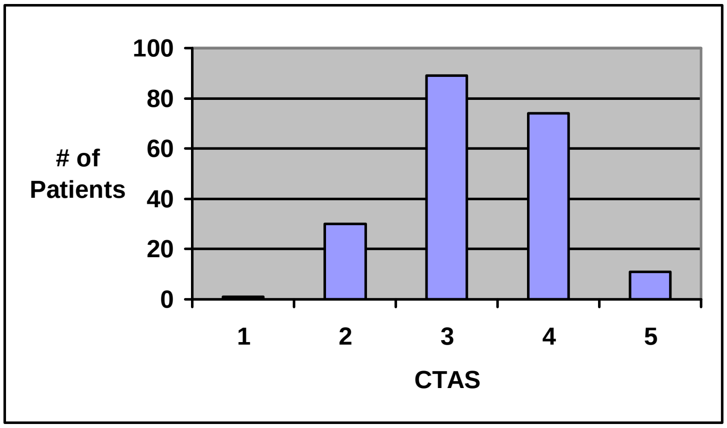
8.4 Final Model – Assessment of Assumptions

This final model was examined to ensure that all of the assumptions of multiple regression were met.

The first assumption is that the variables are normally distributed. As demonstrated above, the primary outcome variable, time needed to treat, was skewed. A natural logarithm transformation of this variable resulted in a normally distributed outcome variable.

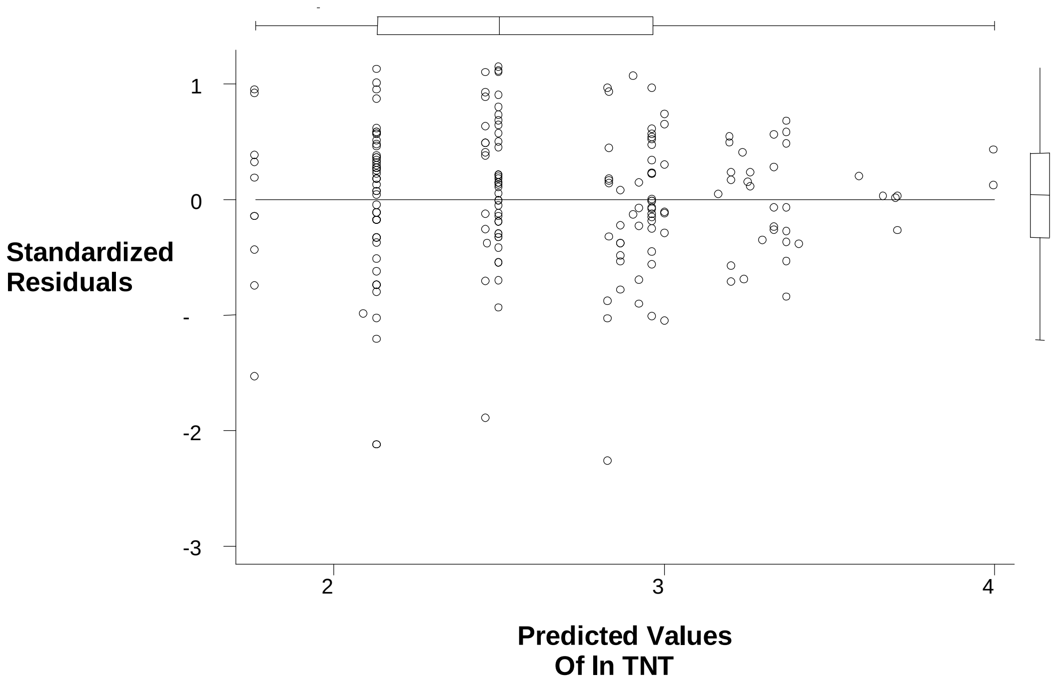
Of the five independent variables that remained in the final model, four were dichotomous. Only CTAS could be examined for a normal distribution. Figure 8.4 shows the distribution of CTAS scores for the study population. The scores are reasonably normally distributed.

Figure 8.4 – Distribution of CTAS Scores



The second assumption that was evaluated was the assumption of a linear relationship between the independent and dependent variables. To assess this assumption, the standardized residuals were plotted as a function of the predicted values for ln TNT. Residuals are the difference between the predicted value for ln TNT and the actual value for ln TNT. To stanardize the residuals, the value for the residual was divided by the standard deviation for all of the residuals. Figure 8.5 shows that the range of standardized residuals is similar across the range of predicted values for ln TNT. This supports a linear relationship between the independent variables and ln TNT.

Figure 8.5: Plot of Standardized Residuals vs Predicted Values for ln TNT



The third assumption that was assessed was homoscedasticity, defined as the similar distribution of an independent variable's residuals across all values of the variable. This assessment is important as variables which fail to demonstrate homoscedasticity may require transformation to a quadratic or log scale to ensure a linear relationship with the dependent variable. Each retained independent variable was assessed to determine if the variance of the errors was similarly distributed across all values for that variable. Figures 8.6, 8.7, 8.8, 8.9, and 8.10 demonstrate that the residuals were distributed similarly for all values of each independent variable.

Figure 8.6: Plot of Standardized Residuals Across the Range of CTAS Values

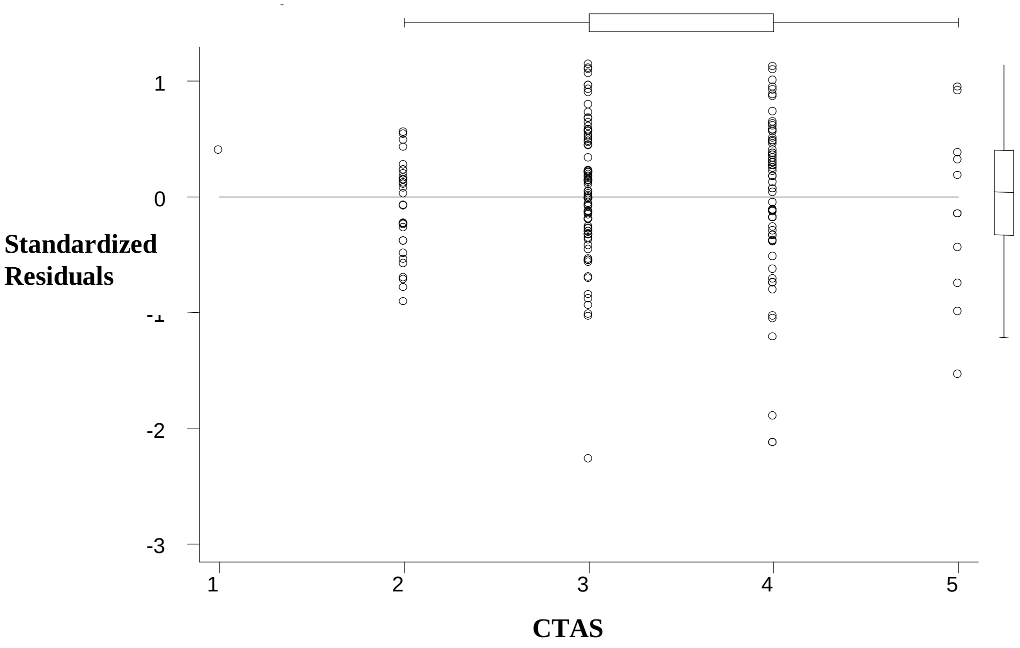


Figure 8.7: Plot of Standardized Residuals Across the Range of Values for Arrival by Ambulance

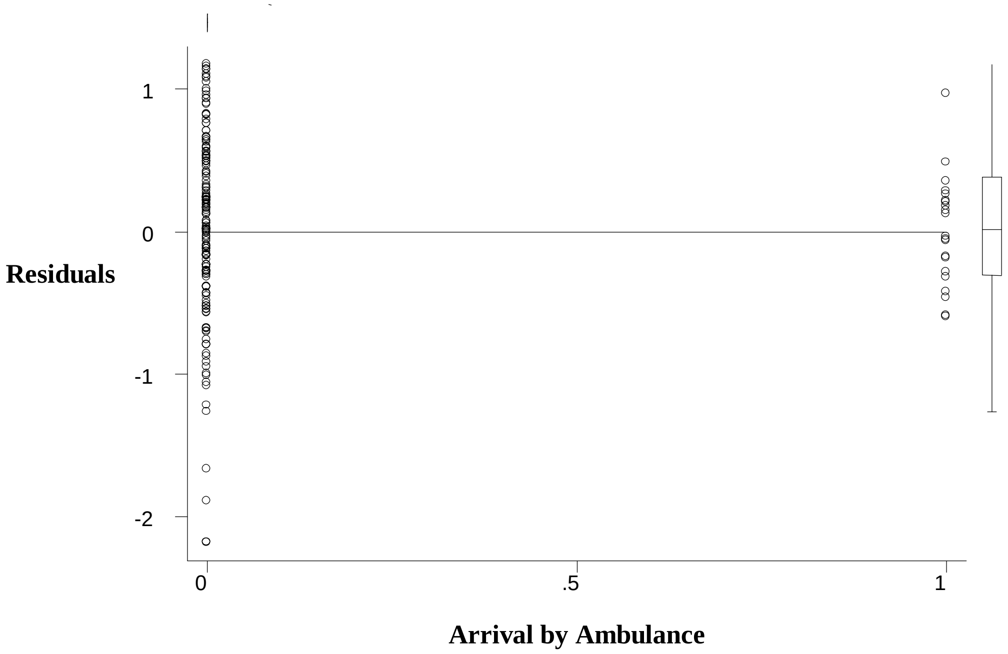


Figure 8.8: Plot of Standardized Residuals Across the Range of Values for Procedure

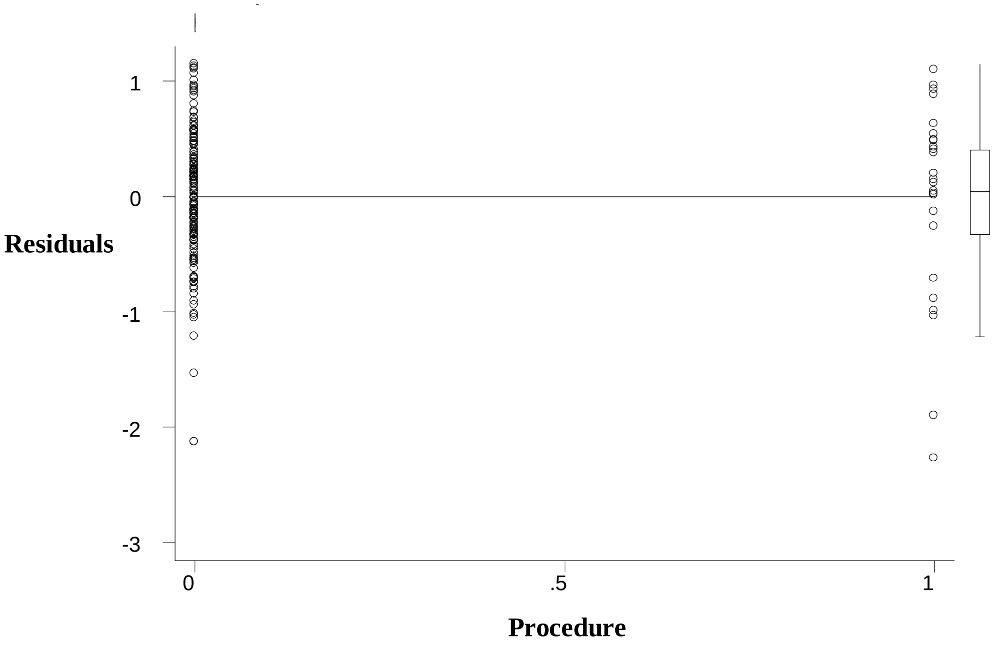


Figure 8.9: Plot of Standardized Residuals Across the Range of Values for Laboratory

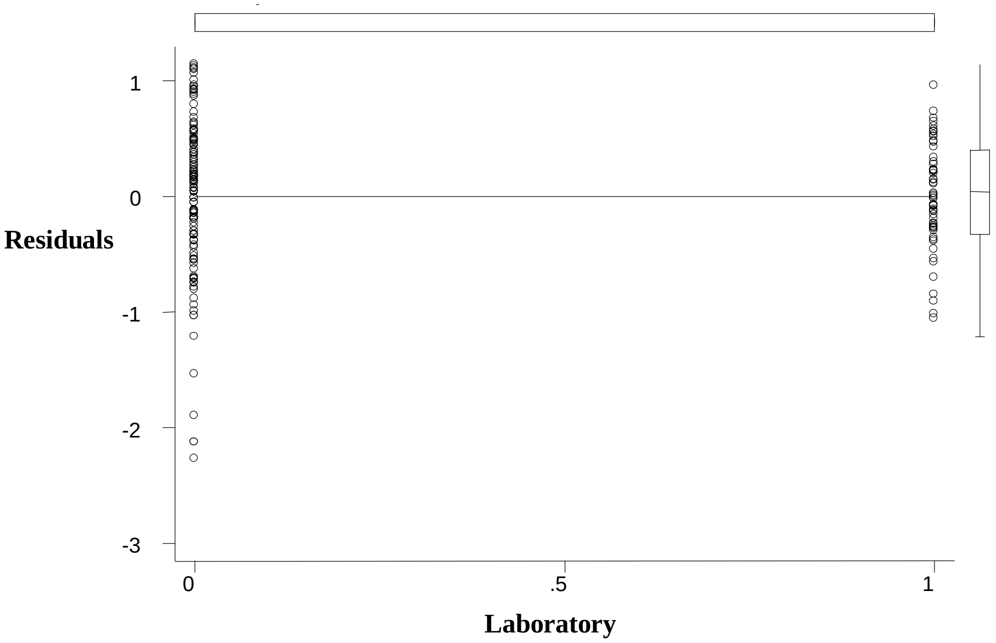
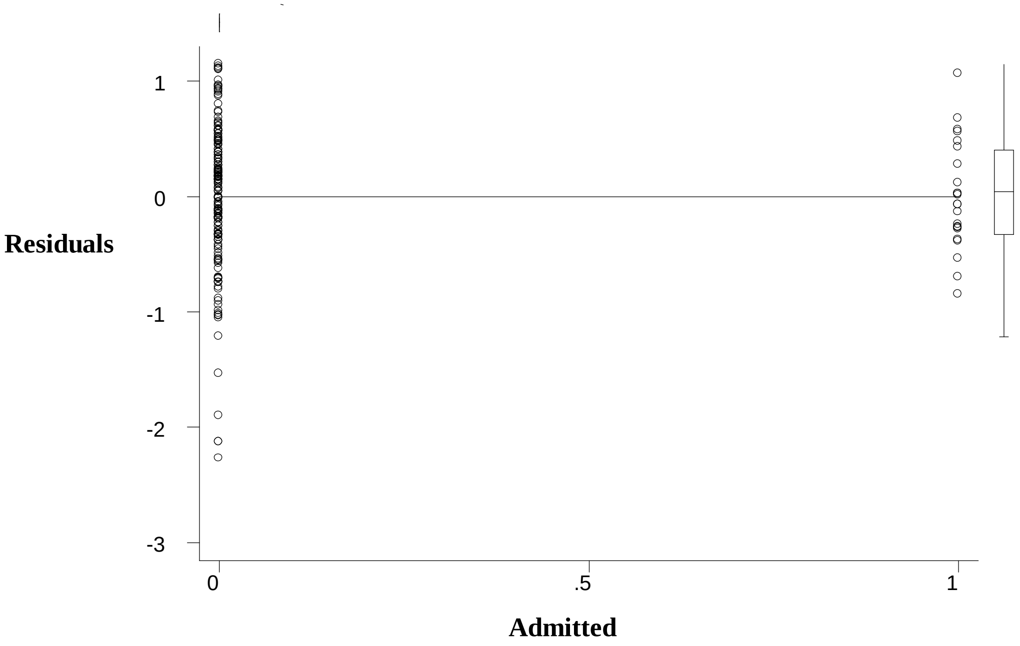


Figure 8.10: Plot of Standardized Residuals Across the Range of Values for Admitted



Chapter Nine: Results – Secondary Objective: Physician Time Expenditure While on Shift

Physician time expenditure is summarized in Figure 9.1. Physicians spent the majority of their time (80%) on patient care related activities.

Figure 9.1 – Physician Time Expenditure During Shifts

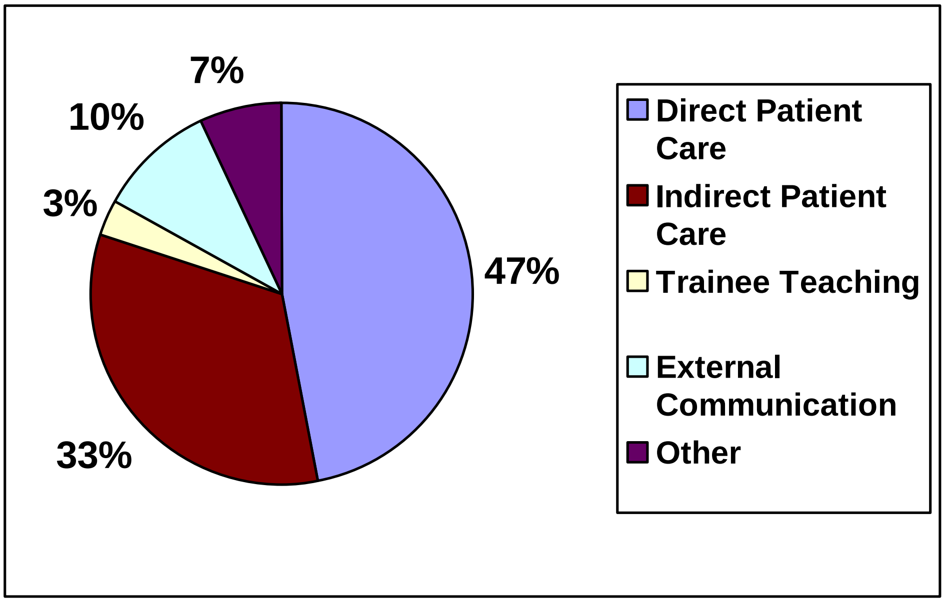


Table 9.1 shows a summary of physician activities relating to direct and indirect patient care. Both the mean time expenditure and the number of discrete events for each category are shown. A discrete event was defined as a continuous span of time in which the physician tended to a specific patient, either directly or indirectly. For example, if a physician entered and left a patient room 3 times during the patient's stay, that would be coded as 3 discreet direct patient care events.

Table 9.1 – Physician Activities Relating to Patient Care Performed During Shifts

Activity	Mean time in minutes: (SD)	Mean number of discreet events per patient (SD)
Direct Patient Care	11.22 (9.64)	1.69 (1.02)
Indirect Patient Care	6.68 (6.31)	2.33 (1.81)
TOTAL Patient Care	17.90 (13.04)	4.07 (2.42)

Chapter Ten: Discussion

10.1 Overview of Study Findings

The results of this physician time study demonstrated that the characteristics which were most strongly predictive of physician time needed to treat patients in a pediatric ED were CTAS score, arrival by ambulance, performance of a procedure by a physician, performance of a laboratory test, and need for admission. Employing these five key variables in a regression model enabled the prediction of nearly 40% of the variance in physician time needed to treat patients.

Pediatric ED physicians spent 20 % of their time during shifts on non-patient specific duties and 80% of their time providing patient care. Thus the ratio of non-patient specific duties to patient care was 1:4 (0.25). If this ratio is assumed to be reasonably constant across a broad range of patient volumes, then total physician workload can be estimated as follows:

Workload = (number of patients x TNT) + 0.25 (number of patients x TNT)

where TNT = inv ln [3.6095 - 0.3694(CTAS) + 0.3353(arrival by ambulance) + 0.3300(procedure) + 0.7584(laboratory) + 0.4083(admitted) + 0.4075(CTAS x laboratory)]

Workload is measured in minutes per unit of time (eg. one week) and number of patients is the number of patients seen during that unit of time (eg. number per week).

10.2 Validity of the Study Findings

An assessment of the validity of this newly derived workload measure must consider both internal and external validity. Measurement tools are considered internally valid if they properly demonstrate a causal relationship between two variables. Threats to internal validity that are most relevant to this study include selection bias, measurement bias, confounding and effect modification. These will be discussed in turn with regard to the study findings.

10.2.1 Selection bias

Selection bias is the systematic introduction of error into a study as a result of non-random sampling of study subjects.[55] In order to minimize selection bias in this study, shifts selected for shadowing were selected a priori in order to ensure a broad sampling of the physician group and patient population.

Physicians practicing emergency medicine in Canada have a variety of educational backgrounds, ranging from no emergency medicine training to five or more years of specialty training.[56] Similar variation in educational background exists among pediatric emergency physicians, with some physicians having their primary training in emergency medicine and others in pediatrics. Some physicians have also completed additional years of training in pediatric emergency medicine. There has been debate among members of the Canadian Association of Emergency Physicians as to how these variations in levels of training affect patient care.[57] However, there have been no systematic studies of how physician educational background affects patient care in the pediatric ED setting. In order to minimize the potential for bias, this study included a representative sample of physicians with educational backgrounds in both pediatrics and emergency medicine. All physicians asked to participate in the study agreed to do so, therefore significant selection bias with respect to the participating physician group is unlikely.

All patients seen during a physician's shift were included in the study, therefore, there was no potential for selection bias at the individual patient level. However, there was potential for selection bias in the overall study sample. It was our aim to study a sample of patients who were representative of the overall patient population in our ED. Given that the study data was acquired over a 4 week time period, there may have been a season-specific selection bias in certain patient characteristics. For example, pediatric EDs in northern hemispheres see a significant spike in the number of visits for viral induced asthma in the fall of each school year.[58] This is thought to be due to decreased use of asthma medications in the summer and exposure to rhinovirus upon return to school in September.[58] Asthma is the second most common diagnosis in the ACH ED and has a mean length of stay that is 78 minutes longer than the departmental average.[17] As such, seasonal variation in disease prevalence can have a significant impact upon the workload in the ED and it would be important to validate the findings of this study in other seasons.

A second potential source of bias relating to seasonal effects is the experience of trainees at various times of the year. One third of patients in this study had trainees involved in their care. The majority of resident trainees spend time in the pediatric ED during their first year of residency training.[41] Residents begin their training in July of each year. Therefore, patients presenting in July may be seen by a resident with only weeks of residency training, whereas those presenting in June will see a more experienced resident. The effect of inexperienced residents on the quality of patient care has been termed “the July Phenomenon”. Shulkin conducted a hospital-wide study which was designed to investigate the relationship between the clinical experience of resident physicians and quality of care.[59] A severity-weighted index of adverse events was used to assess quality of care in a wide selection of clinical departments. They were unable to demonstrate a relationship between adverse events and resident clinical experience, although they did note that residents demonstrated poorer documentation practices in the earlier parts of the academic year. Resident experience is unlikely to be a significant source of bias in our study, as trainee involvement was not found to be a significant predictor of attending physician time required to treat patients.

Overall, the patient demographics of the study sample were a reasonable representation of the pediatric ED patient population as a whole. The sample population had a slightly higher proportion of CTAS 2 patients and higher admission rate than the population annual data, suggesting that these patients were perhaps more seriously ill. This difference was not likely to negatively affect the validity of the model as both CTAS score and admission were ultimately selected to remain in the model. As such, institutional variations in mean CTAS score and admission rate would be accounted for if this model was used to predict total physician time requirements within an institution.

10.2.2 Measurement Bias

A second important element of internal validity relates to the construct validity and reliability of the measurements that were taken. Construct validity refers to the degree to which the primary outcome measure truly reflects the concept of the primary outcome that was intended to be measured.[55] Our primary outcome measure was physician time needed to treat an individual patient. We defined this measure as all elements of physician time that were related to that specific patient, including elements of trainee teaching that were related to the management of that patient. Some may argue that a different construct of total physician time needed to treat is more appropriate. Specifically, some may consider time reviewing patients with residents as teaching time rather than patient treatment time. However, our outcome measure was clearly defined and given that all Canadian pediatric EDs have trainees, this is likely more a matter of definition, than a threat to validity.

The reliability of observational measurements for data collection is a significant strength of this study as the measurements were taken by an experienced pediatric emergency physician rather than a by someone unfamiliar with the knowledge of the content and processes within the ED. It is likely that the categorization of ED physician activity by observation alone was more accurate when measured by a fellow ED physician who is familiar with the medical content and multitasking elements of ED physician work.

A potential study limitation relating to the observed measurements is the possibility that the Hawthorne effect may have influenced some of the physician treatment times. Some physicians may have altered their practice behaviours as a result of being shadowed by a colleague. The direction and magnitude of this effect is not easily surmised. Physicians may have attempted to speed up their patient care activities in order to appear more efficient. They might also have slowed their activities if they felt nervous or feared making a mistake in front of a colleague.

10.2.3 Confounding and Effect Modification

Confounding is suggested when a variable which is associated with both an independent variable and the dependent variable has not been considered in a study.[60] For example, if a study was designed to determine if ambulance arrival to an ED resulted in shorter waits to see a physician, and the only 2 variables measured were ambulance arrival and wait time, it is likely that arrival by ambulance would appear to diminish the wait time significantly. However, patient acuity (CTAS score) is a potential confounder in this study example, as acuity is likely to be related both to ambulance arrival and time to be seen by a physician. If the same study was repeated, but the results were stratified by CTAS score, the relationship between ambulance arrival and shorter wait times may be significantly diminished.

In our study, it is unlikely that significant confounders have been omitted as a strategic process was undertaken to identify all variables postulated to be related to our dependent variable, including expert opinion and literature review.

Within the independent variables selected for inclusion in the study, it was anticipated that the variables would be confounders of each other's relationship to time needed to treat. As such, none of the associations noted in the bivariate analyses between independent variables and physician time needed to treat were considered conclusive. Rather, these bivariate analyses were used to guide the generation of a multivariate model which could adjust for these confounders.

One potential confounder that was not measured in this study was the number of nurses on shift for a given day. It is possible that nursing staff numbers may influence physician workload. For example, if nursing resources are limited, physicians may need to search for needed supplies and take patient vital signs. If nursing resources are plentiful, nurses may anticipate equipment needs for physicians and have up to date vital signs available for physicians as they see patients. Unfortunately, this was not a variable that we were able to explore with our study design, as nursing compliments werre relatively fixed, and day to day variation was limited. As such, we were not able to measure how different nursing staff levels impacted physician times required to treat patients. The impact of nursing and other health care professional staffing levels on physician workload is an area that requires further study.

Effect modification exists when two independent variables interact to exert effects on the dependent variable.[60] Two plausible variable interactions were mathematically investigated in the generation of our model: ambulance arrival and laboratory test and CTAS and laboratory test. We postulated that patients with low CTAS scores may have laboratory tests drawn by nurses prior to being seen by a physician, resulting in earlier availability of test results and shorter physician time demands. It was determined that among patient's with lower CTAS scores (higher acuity), performance of a laboratory test had a smaller effect on physician time requirements than performance of a laboratory test among high CTAS score patients. Although the inclusion of this interaction term in our final model did increase the complexity of the model, we elected to retain it as the magnitude of the coefficient for this interaction term was comparable to all other variables retained in the model, and the percentage of variance in physician time explained by the model was increased by 2.3% when the interaction term was included.

10.2.4 External Validity

External validity exists when study findings can be generalized to other populations and settings.[55] Given that the diversity of ED settings formed a key element in the rationale for conducting this study, it seems reasonable to question whether a model derived in one ED can be applied to a different ED setting.

10.2.4.1 Comparison of Pediatric and General ED Physician Workload Models

It was anticipated that a model derived in a pediatric ED setting would not be generalizable to the general ED setting given the difference in patient populations. The optimal model derived to predict physician time needed to treat in a general ED in the Vancouver workload study shared three variables in common with the final model derived from this analysis: CTAS score, arrival by ambulance, and performance of a procedure by a physician.[11] The distribution of these variables was different between the general and pediatric ED settings. 58.5% of our patient sample were CTAS 1, 2 or 3, versus 48% in the Vancouver study.[11] Ambulance arrivals were less prevalent in our study than in the general ED (10.2% vs 28%) and performance of procedures was lower in our study than the Vancouver study (12.7% vs 22.4%).[11] These findings suggest that these three variables are strong predictors of ED physician workload regardless of patient age, setting or variable frequency. These findings are consistent with the previous ED physician time study conducted by Graff et al which showed that patients with lower acuity (those triaged to the walk in clinic area) required significantly shorter physician time than higher acuity patients.[16]

The Vancouver workload model did not include the need for a laboratory test or admission status.[11] Admission was explored as a potential independent variable in their model, but was found not to be a key predictor. This is somewhat surprising given the difficulty in finding services to accept admitted patients and the long ED lengths of stay that many admitted patients experience prior to transfer to an in-patient bed. It is not clear if the difference in these study findings is a reflection of the physician time needed to admit patients, or the physician time needed to discharge patients who do not require admission. Children generally have motivated caregivers and a home to be discharged to, whereas, ill adults may not have a suitable environment to be discharged to. Thus, finding placement for ill adults who do not require admission to hospital may be more complex than discharging ill children to the care of their parents.

Data on laboratory testing was not included in the Vancouver workload study.[11] The reason for not including laboratory testing is not known. It may be that such a large proportion of general ED patients require lab tests, that it is simply not a valuable predictor. It may also be that many tests are performed by the nursing staff prior to physician assessment, so that results are available to the physician at the time of first patient contact.

Factors found to be key predictors in the general ED which were not found to be significant in our pediatric ED setting included age and past medical history (presence of a co-morbid condition).

The Vancouver workload study showed that age greater than 75 years was a predictor of longer physician time requirements.[11] However, the study contained very few children and the authors postulated that physician time requirements and age may not have a linear relationship, but rather, it might be “u-shaped” with increased time needed at the extremes of age. We did not detect a difference in physician time requirements by age in the pediatric population. The relationship between age and physician time in the general ED population revealed that for every 10 years that the patient’s age increased, the physician time increased by 0.6 minutes.[11] Given that their mean age was 43.7 years and ours was 6.0 years, we would expect that our mean physician time would be about 2.3 minutes shorter than that seen in the adult study. Their mean physician time was 19.2 and ours was 17.9, a difference of 1.3 minutes, not far from the expected value derived from the Vancouver model. So our data suggests that the age relationship may, in fact, be linear and not u-shaped. However, all of the physicians in our group have extensive pediatric experience, and it may be that our data is not generalizable to a general ED setting. Perhaps general ED physicians with less comfort managing ill infants, may require longer times to treat infants.

The difference between the two studies with respect to the effect of past medical history on physician time requirement is likely related to methodology. We elected to categorize past medical history into three groups: none, single chronic condition, and complex medical history. Complex medical histories were uncommon in our study and most of the single chronic medical conditions present in children, such as asthma or diabetes, do not require extensive physician interview time or chart review. The Vancouver study captured this element of patient history by defining, a priori, a list of significant co-morbid conditions which they postulated to contribute to increased physician workload.[11] They recorded this variable as dichotomous, co-morbid condition present or not present. The rate of either a single chronic medical condition or complex past medical history was only 21.5% in our study, whereas the predefined co-morbid conditions were present in 52.33% of patients in the Vancouver study.[11] Further, all of the co-morbid conditions included in the general ED study would have met our criteria for "complex medical history". As such, the presence of a co-morbid condition in the Vancouver study was likely indicative of a much more complex medical situation than that measured in our study. Both studies sought some measure of past medical history, but they were not measuring the same trait or magnitude of past medical illness.

Overall, models to predict total physician time needed to treat which were derived using similar methodology in a pediatric and general ED setting shared some variables but differed in other key variables. It would appear that these two settings are unique and that the optimal model for predicting physician workload is different in the two types of EDs.

10.2.4.2 Comparison of Pediatric and General ED Physician Time Expenditure

Physicians in our study spent 47% of their time on direct patient care activities and 33% on indirect patient care activities. These results are very similar to those of the Vancouver workload study in which physicians spent 48% of their time on the following direct patient care activities: history and physical exam, performing procedures, bedside care, and providing discharge instructions. However, these results differ somewhat from a study conducted by Hollingsworth et al in which ED physician time expenditure was tracked in a large American teaching hospital.[27] This general ED was located in a central urban area and had an annual census of 84,000 visits. A research assistant shadowed ED physicians for 180 minute time intervals and found that attending physicians spent only 32% of their time on direct patient care and 45% of their time on indirect patient care. Total patient care time was therefore similar, but the proportion of time spent in direct contact with patients was significantly smaller in this study.

The mean physician time required to treat patients, 17.9 minutes, was similar to that reported in previous studies of general EDs: 19.2 minutes in Innes et al and 24.2 minutes in Graff et al.[11,16] The mean number of discrete patient care events in this study was 4.07 per patient. In Graff's study, which was the only one other study found to have measured this parameter, the mean number of discrete patient care events was half that seen in our study, at 2.2 events per patient.[16] The reasons for the higher number of patient care events in a pediatric ED setting are not readily explainable. It may be that physicians feel the need for repeated examination of children to improve the accuracy of their diagnoses. Younger children can exhibit behaviours which make it challenging for physicians to perform an accurate assessment. For example, a child may cry when approached, may be irritable from fear, hunger or fatigue, or may be too sleepy to rouse when initially examined by a physician. A physician may need to allow a child to settle or wake up before being able to make a judgment as to the child's medical condition. Although similar situations do exist with older patients, for example ethanol intoxication, adults may be more able to cooperate with a physician during the initial encounter. The need for repeated examination of a patient is likely to impact upon a physician's efficiency, as such, further exploration of the increased number of mean patient care events in pediatrics would be valuable.

10.3 Clinical Relevance of Study Findings

Although several of our independent variables showed a statistically significant association with physician time needed to treat, it is important to consider the magnitude of these effects to determine if they are clinically relevant. Due to the need to transform the dependent variable into a logarithmic scale, the β coeffiecients in our multivariate model could not be simply interpreted to estimate the magnitude of the effect of the various independent variables. However, when we examine the results of the bivariate associations with physician time, positive values for statistically significant variables generally doubled the physician time needed to treat. For example, patients arriving by ambulance required nearly twice the physician time needed to treat than those who did not arrive by ambulance (29.3 versus 16.6 minutes). As such, we feel that the variables in our model are both statistically and clinically relevant.

10.4 Utility of Study Findings

The results of this study could be used to assist administrators and governments to objectively assess the workload placed on pediatric emergency physicians who service a given population. Workload estimates derived from this research could also aid in future manpower planning

10.4.1 Forecasting Future Manpower Needs

10.4.1.1 Theoretical Framework: Operations Management

In trying to address the complex challenges of ED physician manpower needs, a framework of operations management principles for service industry businesses is helpful. Although health care in Canada is not a business per se, many operations management theories are directly applicable to the operations of an ED.

Operations management is the business function responsible for planning, coordinating and controlling the resources needed to produce a company's products or services.[61] A service organization is defined by an intangible product which cannot be inventoried. Service organizations are typically labour intensive, with short response times and high customer contact rates.[61] All of these descriptors are applicable to an ED.

10.4.1.2 Environmental Scanning

In order for an organization to successfully meet its mission, it must consider the external environment in which the organization operates. Environmental scanning involves monitoring the external environment for changes and trends in the market, in the economic and political environment, and in society in order to determine opportunities and threats.[61] Understanding changing patient demographics, the regional and provincial economic and political environments, and public expectations are all integral components to the success of an ED.

10.4.1.3 Forecasting

Forecasting is the process by which organizations predict future events and may be another way to frame the results of this study. The steps generally taken in forecasting include 1) deciding what to forecast, 2) selecting the appropriate data for analysis, 3) selecting and testing a forecast model, 4) generating a forecast, and 5) monitoring the accuracy of the forecast.[61]

In an ED, there are many aspects of organizational functioning that would benefit from forecasting. For example, having the ability to accurately predict both the short and long term physician workload would greatly aid in staffing and scheduling decisions.

There are two broad methodologies for forecasting. Qualitative methods rely on expert opinion and educated guesses. Quantitative methods are based on mathematical modeling.[61] The two types of quantitative methods most widely used are time series models and causal models.[61] Studies aimed at forecasting physician workload have used elements of both methodologies.

Time series models are based on the assumption that a forecast can be generated from the information contained in a time series of data. For example, if one wished to forecast the number of physician-hours that would be needed to staff an ED two years from now, one could examine the historical data on the number of physician-hours utilized over the past five years and make a prediction based on observed trends. Unfortunately, the use of simple time series models to predict physician workload has, in the past, met with inaccurate predictions.

In the early 1990's, governments and health care policy analysts believed that Canada had a physician surplus.[62,63] These estimates were based on historical trends of physician workforce which expressed workload as a function of physician to population ratios. In response to these estimates, governments sought to control physician supply growth by putting a number of policies into effect, including a reduction in Canadian medical school positions by 10%.[64] A 2002 Canadian Institute for Health Information (CIHI) Study report was highly critical of the physician workload forecasts that were made in the early 1990's.[64] The report asserted that the forecasts upon which these policies were based did not comprehensively take into consideration the changing demographics of Canada's physician and patient populations. As a result, Canada failed to train the number of physicians it required in the 1990's and a significant physician shortage resulted.[64]
For example, Canada was faced with a growing elderly population due to the aging of the "baby-boomer" generation. The CIHI report estimated that the increased proportion of elderly patients in Canada increased the demand for physician services by 0.4% per year during the 1990's. The CIHI report also described a significant change in the physician demographic with respect to gender and age. The proportion of women entering medical school rose steadily from 13% in 1981 to 29% in 2000. The proportion of the physician workforce who were under 35 years of age steadily declined from 22% in 1988 to 13% in 2000 and the proportion who were over 65 years has rose from 7% in 1981 to 11% in 2000.[64] Both the change in gender and age of physicians had an important impact upon the available manpower, as female physicians were shown to have a practice activity that was 21% lower than their male colleagues and physicians over the age of 65 years were shown to have a workload that was only 0.66 times the average.[64]

The above example demonstrates that quantitative model development may be more accurate if causal model methodology is utilized. Causal models are based on the assumption that the variable being forecast is related to other variables in the environment. The methodology used in our study is an example of causal model forecasting. The model derived in our study allows for anticipated changes in patient demographics to be considered when planning for future physician manpower needs. The model could be used to provide precise estimates of changes in physician workload given forecasted changes in the patient population.

10.4.1.4 Example of Model Utilization for Forecasting Physician Manpower

The Alberta Children's Hospital ED anticipates making a significant change in the services provided to pediatric trauma patients in the Calgary Health Region. At present, trauma patients aged 14 years and greater are managed at Foothills Medical Centre (FMC).[41] The proposed changes involve a new regional policy whereby all trauma patients less than 18 years of age will be managed at the Children's Hospital. This new population of adolescent trauma patients is anticipated to have a significant effect on the mean values for a number of ACH ED patient characteristics.

Let us assume that the following predictions can be made based on information provided from the current adolescent trauma patient population at FMC: 6.2 additional trauma patients per day, all arriving by ambulance, 20% CTAS 1, 80% CTAS 2, 80% requiring a procedure, all requiring lab tests and admission. Assuming a mean current daily census of 127, we can then make the following predictions about the values for the five key variables in the model (Table 10.1).

Table 10.1 – Summary of Current and Predicted Values for Model Variables for Forecast Example

	Current ACH Value (based on study results)	Predicted ACH Value after proposed changes
Mean CTAS score	3.3	3.2
% Arriving by ambulance	10.2	14.4
% Requiring a procedure	12.7	15.8
% Requiring a laboratory test	28.8	32.1
% Admitted	11.2	15.3

We can then calculate and compare our current and predicted physician workload as follows:

<u>Current mean physician time needed to treat (TNTc) =</u>

$$\text{inv ln}\,[3.6095 - 0.3694(3.3) + 0.3353(0.102) + 0.3300(0.127) + 0.7584(0.288) + 0.4083(0.112) + 0.4075(3.3 \times 0.288)]$$

Solving for mean TNTc, we have:

$$\text{inv ln}\,[3.6095 – 1.21902 + 0.03420 + 0.04191 + 0.21842 + 0.04573 + 0.38729] = 21.9 \text{ minutes}$$

Current Workload = (127 x 21.9) + 0.25 (127 x 21.9) = 3476.6 min/day (57.9 hours/day)

<u>Predicted mean physician time needed to treat (TNTp) =</u>

$$\text{inv ln}\,[3.6095 - 0.3694(3.2) + 0.3353(0.144) + 0.3300(0.158) + 0.7584(0.321) + 0.4083(0.153) + 0.4075(3.2 \times 0.321)]$$

Solving for mean TNTp, we have:

inv ln [3.6095 – 1.18208 + 0.04828 + 0.05214 + 0.24345 + 0.06247 + 0.41858] = 25.9 minutes

Predicted Workload = (133.2 x 25.9) + 0.25 (133.2 x 25.9) = 4312.4 min/day (71.9 hours/day)

Therefore, in this example, utilization of this model to forecast the new physician manpower requirements would indicate that the ACH ED would require 14 more hours (71.9-57.9) of physician time per day to manage the change in the patient population.

10.4.2 Additional Utilities for Model

10.4.2.1 Staffing Sub-Areas of an ED

In addition to aiding in the planning for future manpower needs, this model may also assist administrators in making staffing decisions related to sub-areas of their ED. For example, many EDs have minor treatment areas where lower acuity patients are managed. These areas are generally staffed by separate physicians and nurses, who do not have simultaneous responsibilities for seeing new patients in the acute area of the ED. Administrators could use this workload formula to estimate the workload for physicians in the minor and acute areas of their EDs. Physician resources could then be allocated based on estimated workload and acceptable wait times for various acuity levels.

10.4.2.2 Assessment of Physician Efficiency

Measures of physician efficiency are often quite simplistic, and are reported as the mean number of patients seen per hour of work. This measure is quite crude, as it does not take into account the varying lengths of time required to treat different types of patients. Further, not all physicians may see the same mixture of patients, as some physicians may avoid signing up for certain types of patients. This model could be used to assess the difference between the expected and actual amount of time needed to treat patients for individual physicians, and may be a valuable addition to physician performance evaluation.

10.5 Areas for Future Research

10.5.1 Validation of the Study Model

The next phase of this research will be to validate the model that was derived in this study with a second sample of ACH ED patients. Using the same methodology, data collected on a second patient sample of the same size will be entered into the model derived in this study. The proportion of variance of physician time needed to treat (R^2) will be compared in both the derivation and validation samples. The current model would be considered valid if the R^2 in the validation sample does not drop significantly when compared to the derivation sample.

10.5.2 Interesting Observations

Most of the bivariate associations between predictor variables were not unexpected, however, some interesting potential associations were noted. The rate of laboratory testing was significantly associated with trainee involvement. Patients who had a junior trainee involved in their care had a laboratory investigation rate of nearly twice that of patients managed without a trainee. Patients managed by senior trainees had a slight increase in laboratory investigations as compared to those managed by attending physicians alone. This dramatic rise is laboratory testing among the junior trainee-associated patients is surprising, given that junior trainees are not permitted to order any tests until the attending physician has reviewed the patient. Thus, inexperience on the part of the trainee cannot explain the increased rate of laboratory tests. The trend was consistent across all CTAS scores, thus differential patient acuity is not likely to explain these results. One possible explanation could be the attending physicians feel less confident with their clinical judgement when they have received a history second hand from a trainee. Perhaps this is compensated for with increased testing. The impact of trainees on resource utilization and other aspects of patient care would be valuable to explore with future research. This is particularly important in our pediatric ED setting, where the proportion of patients seen by learners was significantly higher than that in the Vancouver general ED setting (37.6% vs 23.9%).

A second unexpected association was that of language barrier and procedure. Patients with language barriers had a considerably higher procedure rate than those without language barriers (25.9 vs 10.7%). An explanation for this association is not immediately obvious, as the most commonly performed procedures such as suturing, foreign body removal and fracture reduction seem unlikely to be related to language. Further research into the experiences of patients and families with language barriers would be valuable as little is known about the differences experienced by this large (13.2%) and possibly growing segment of pediatric ED visitors.

10.5.3 Remaining Unexplained Variance

The model derived in this study only explained 40% of the variance in the physician time needed to treat patients. Further research aimed at finding explanations for the other 60% of the variance would be interesting and valuable. Potential areas for exploration include physician practice and teaching style, factors driving fluctuations in patient volumes, and the effects of variation in numbers of other health care workers (nurses, respiratory technicians) on physician workload.

10.6 Summary of Key Points

Overall, this study has demonstrated that the pediatric emergency department is a unique medical environment which is distinct from the general emergency department with respect to factors which impact physician workload. Pediatric emergency department physicians spent 80% of their time during shifts on patient care activities. Factors most strongly associated with physician time needed to care for pediatric patients were CTAS score, arrival by ambulance, performance of a procedure by a physician, performance of a laboratory test, and need for admission. Employing these five key variables in a regression model enabled the prediction of nearly 40% of the variance in physician time needed to treat patients.

References

1. Shute N, Marcus M. Code blue crisis in the ER. US News and World Report. September 10, 2001:54-61,64,66. Available on-line at: http://www.usnews.com/usnews/health/articles/010910/archive_003670.htm Accessed last March 28, 2006.

2. CAEP Position Statement: Access to acute care in the setting of emergency overcrowding. From the Canadian Association of Emergency Physicians website: www.caep.ca last accessed March 27, 2006.

3. American College of Emergency Physicians website: http://www.acep.org/webportal/PatientsConsumers/critissues/overcrowding last accessed March 27, 2006.

4. Understanding Emergency Department Wait Times. Canadian Institute for Health Information. From the CIHI website:www.cihi.ca last accessed January 15, 2006.

5. American College of Emergency Physicians. The National Report Card on the State of Emergency Medicine. January 2006. From the ACEP website: www.acep.org last accessed January 15, 2006.

6. Lambe S, Washington DL, Fink A, Laouri M, Liu H, Scura Fosse J, Brook RH, Asch SM. Waiting times in California's emergency departments. Ann Emerg Med. 2003;41(1):35-44.

7. Canadian Institute for Health Information, Understanding Emergency Department Wait Times: Access to Inpatient Beds and Patient Flow (Ottawa: CIHI, 2007).

8. Kyriacou D, Ricketts V, Dyne P. A 5-Year Time Study Analysis of Emergency Department Patient Care Efficiency. Ann Emerg Med. 1999;34(3):326-335.

9. Rathlev N, Chessare J, Olshaker J et al. Time Series Analysis of Variables Associated With Daily Mean Emergency Department Length of Stay. Ann Emerg Med 2007;49(3):265-271

10. Sprivulis P. Estimation of the general practice workload of a metropolitan teaching hospital emergency department. Emergency Medicine. 2003;15(1):32-37.

11. Innes G, Stenstrom R, Grafstein E, et al. Prospective time study derivation of emergency physician workload predictors. Canadian Journal of Emergency Medicine. 2005;7(5):299-308.

12. Moorhead JC, Gallery ME, Hirshkorn C, et al. A study of the workforce in emergency medicine: 1999. Ann Emerg Med. 2002;40(1):3-15.

13. Haase CE, Lewis LM, Kao B. Do estimates of emergency physician workforce underestimate current needs? Ann Emerg Med. 1996;28(6):666-70.

14. Holley JE, Kellerman AL, Andrulis DP. Physician staffing in the emergency departments of public teaching hospitals: a national survey. Ann Emerg Med 1992;21(1):53-7.

15. Graff L, Radford M. Formula for Emergency Physician Staffing. Am J Emerg Med. 1990;8(3):194-199.

16. Graff LG, Wolf S, Dinwoodie R, et al. Emergency physician workload: A time study. Ann Emerg Med 1993;22(7):1156-63.

17. Data obtained via personal communication with Dr. Francois Belanger, Division Head, Emergency Medicine, Department of Paediatrics, University of Calgary. Data abstracted from Calgary Health Region Databases.

18. Canadian Triage and Acuity Scale. Available within the Canadian Association of Emergency Physicians website:
http://www.caep.ca
Accessed under "Policies/Guidelines", then under CTAS. Last accessed November 9, 2007.

19. Canadian Paediatric Triage and Acuity Scale: Implementation Guidelines for Emergency Departments. Can J Emerg Med. 2001;3(4)S19.

20. Drummond A. CFRN Story on the CIHI Report on ER wait times. Letter from the Canadian Association of Emergency Physicians to the CFRN News producer, September 14, 2005. Available on-line at www.caep.ca/CMS/get_file.asp?id=CD1C40E4DF7449FFBBC61B6D738D5233&ext=.pdf&name=050915-letter.CFRN.rep. Last accessed November 4, 2007.

21. Irazuzta J, Sullivan K, Celiny P et al. Pharmacologic support of infants and children in septic shock. Jornal de Pediatria. 2007;83(2):S36-45.

22. Cooke T, Watt D, Wertzler W, Quan H. Patient expectations of emergency department care: Phase II – a cross-sectional survey. Can J Emerg Med 2006;8(3):148-157.

23. Spaite D, Bartholomeaux F, Guisto J, et al. Rapid Process Redesign in a University-Based Emergency Department: Decreasing Waiting Time Intervals and Improving Patient Satisfaction. Ann Emerg Med. 2002;39(2):168-177.

24. Thompson D, Yarnold P, Williams D, Adams S. Effects of Actual Waiting Time, Perceived Waiting Time, Information Delivery, and Expressive Quality on patient Satisfaction in the Emergency Department. Ann Emerg Med 1996;29(6):657-665.

25. Cassidy-Smith T, Baumann B, Boudreaux E. The disconfirmation paradigm: Throughput times and emergency department patient satisfaction. The Journal of Emergency Medicine. 2007;32(1):7–13.

26. Hobgood C, Villani J, Quattlebaum R. Impact of Emergency Department Volume on Registered Nurse Time at the bedside. Annals of Emergency Medicine. 2005;46(6):481-9.

27. Hollingsworth JC, Chisholm CD, Giles BK, et al. How do physicians and nurses spend their time in the emergency department? Ann Emerg Med 1998;31(1):87-91.

28. Chin L, Fleisher G. Planning model of resource utilization in an academic pediatric emergency department. Pediatr Emerg Care. 1998;14(1):4-9.

29. Burke T, McKee K, Wilson H, et al. A Comparison of Time-and-Motion and Self-Reporting Methods of Work Measurement. J Nurs Adm. 2000;30(3):118-25.

30. Finkler SA; Knickman JR; Hendrickson G; Lipkin M Jr; Thompson WG. A comparison of work-sampling and time-and-motion techniques for studies in health services research. Health Serv Res. 1993;28(5):577-97.

31. Chan B, Schull M, Schultz S. Emergency Department Services in Ontario 1993-2000. From the Institute for Clinical Evaluative Sciences website: www.ices.on.ca Last accessed January 15, 2006.

32. Chan L, Reilly KM, Salluzzo RF. Variables that affect patient throughput times in an academic emergency department. Am J Med Qual 1997;12(4)183-186.

33. Sprivulis P. Estimation of the general practice workload of a metropolitan teaching hospital emergency department. Emergency Medicine. 2003;15(1):32-37.

34. Hampers LC, et al. Fast track and the pediatric emergency department: resource utilization and patient outcomes. Acad Emerg Med 1999;6(11):1153-9.

35. Sprivulis P. Pilot study of metropolitan emergency department workload complexity. Emergency Medicine Australasia. 2004;16(1):59-64.

36. Statistics Canada. http://www12.statcan.ca/english/census01/products/standard/popdwell/Table-PR.cfm. Accessed January 14, 2006.

37. Woloshin et al. Language barriers in medicine in the United States. JAMA. 1995;273:724-728.

38. Hampers LC et al. Language barriers and resource utilization in a pediatric emergency department. Pediatrics. 1999;103(6):1253-1256.

39. Goldman R, Amin P, Macpherson A. Language and Length of Stay in the Pediatric Emergency Department. Pediatric Emergency Care. 2006;22(9):640-643.

40. Tocher MT, Larson, EB. Do physicians spend more time with non-English speaking patients? J Gen Intern Med 1999;14:303-309.

41. Belanger F. 2006 Divisional Service Plan. Division of Emergency Medicine, Department of Paediatrics, Alberta Children's Hospital. Unpublished. Provided by personal communication with author.

42. ACH time in motion data for the University of Calgary Department of Pediatrics Alternate Relationship Plan preparation – unpublished data obtained from personal communication with plan members.

43. Denton G, Durning S. A time and motion study of the effect of ambulatory medical students on the duration of general internal medicine clinics. Journal of General Internal Medicine. 2003;18 (Supplement 1):238.

44. Lammers RL, Roiger M, Rice L et al. The effect of a new emergency medicine residency program on patient length of stay in a community hospital emergency department. Acad Emerg Med 2003;10(7):725-30.

45. French D, Zwemer FL, Schneider S. The effects of the absence of emergency medicine residents in an academic emergency department. Acad Emerg Med. 2002;9(11):1205-10.

46. Nijssen-Jordan C. Division Chief, Pediatric Emergency, Alberta Children's Hospital 1993-2004. *Personal communication*.

47. Chan B. From perceived surplus to perceived shortage:What happened to Canada’s physician workforce in the 1990’s? Canadian Institute of Health Research. June 2002. From the CIHI website: www.cihi.ca
last accessed January 15, 2006.

48. Avinashi V, Moeller E. Canadian Federation of Medical Students Position Paper: Decreased Interest in Family Medicine. April 30, 2005.
www.cfms.org/representation/papers_view.cfm?id=13&what_section=representation
Last accessed January 15, 2006.

49. The Alberta Physician Resource Planning Committee. Predicting physician supply and future need: PRPC’s 2006 report. The Alberta Doctor’s Digest 2007;32(5):18-20.

50. Davis AA. The Doctor Cannot See You Now: A critical shortage of doctors is forcing Calgary patients to audition for the few available spots, plead with receptionists or rely on walk-in clinics. Avenue Magazine June 2003.

51. Chisholm CD, Dornfeld AM, Nelson DR, Cordell WH. Work interrupted: A comparison of workplace interruptions in emergency departments and primary care offices. Ann Emerg Med. 2001;38:146-151.

52. Using Multivariate Statistics. Tabachnick BG, Fidell LS. Allyn & Bacon (2001) p. 117.

53. Stenstrom R, Innes G, Grafstein E, Christenson J. Establishing a Valid Predictive Model for Physician Clinical Workload. Presented in abstract form at the 2003 Canadian Association of Emergency Physicians Conference in Hamilton. Information also obtained from not yet published data provided by personal communications with Dr. Grant Innes in 2004.

54. Hamilton L. Regression With Graphics. (1992) Duxbury Press. Belmont, California. p 40.

55. Trochin W. Research Methods Knowledge Base. (2006) On-Line Text available at http://www.socialresearchmethods.net/kb/index.php.
Last accessed November 19, 2007.

56. Moore K, Lucky C. Emergency medicine training in Canada. Can J Emerg Med. 1999;1(1).

57. Ducharme J, Innes G. The FRCPC vs. the CCFP(EM): Is there a difference 10 years after residency? CAEP Communiqué 1997;Fall:1-4.

58. Sears M, Johnston N. Understanding the September asthma epidemic. J Allergy Clin Immunol. 2007;120(3):526-29.

59. Shulkin DJ. The July phenomenon revisited: Are hospital complications associated with new house staff? Am J Med Qual. 1995;10(1):14-17.

60. Cook L. Health Research Methods 1: Fundamentals of Epidemiology, Section A & B. Course text for MDSC 647.01. (2002) Pages 119-122.

61. Reid R, Sanders N. Operations Management. (2002) John Wiley and Sons Inc. New York, New York.

62. Barer ML, Stoddart GL. Toward integrated medical resource policies for Canada: Background, process and perceived problems. CMAJ 1992;146(3):347-51.

63. ML Barer, GL Stoddart. Toward integrated medical resource policies for Canada. Prepared for the Federal/Provincial/Territorial Conference of Deputy Ministers of Health, June 1991.

64. Chan B. From perceived surplus to perceived shortage: What happened to Canada's physician workforce in the 1990's? (2002) Canadian Institute for Health Information. From the CIHI website:www.cihi.ca
last accessed January 15, 2006.

Appendix 1: Associations Between Independent Variables

Each independent variable was assessed for associations with the other independent variables. Comparisons of 2 binary variables were made using chi-squared tests for proportions (mode of arrival, referral, procedure, laboratory, radiography, consult performed, admission, language barrier). Comparisons of ordinal variables (past medical history, CTAS) with dichotomous variables were made using logistic regression. Comparisons of age (ratio variable) with dichotomous variables were made with student t-tests. Comparisons of age with ordinal and nominal (trainee) data were made using analysis of variance. Chi square tests were also performed to assess associations between presence of trainee (nominal data) and dichotomous and ordinal variables.

Table A-1 is a matrix which depicts all possible combinations of associations between independent variables. All variables demonstrated the potential for a significant association with at least one other variable ($p<0.05$ denoted in bold). Given the large number of associations tested (66), at least three of the tests with a $p<0.05$ would be expected by chance alone, thus this matrix is likely to overestimate the number of significant associations. The associations are therefore for interest only and can be considered hypothesis generating.

Table A-1 - Matrix Depicting All Associations Between Independent Variables

	Mode of arrival	Referral	Procedure	Laboratory	Radiography	Consult in ED	Admitted	Language Barrier	PMHx	CTAS	Age	Trainee
Mode of arrival												
Referral	0.899 (chi2)											
Procedure	0.355 (chi2)	0.595 (chi2)										
Laboratory	0.320 (chi2)	0.922 (chi2)	0.492 (chi2)									
Radiography	0.027 (chi2)	0.839 (chi2)	0.394 (chi2)	0.063 (chi2)								
Consult in ED	0.029 (chi2)	0.111 (chi2)	0.937 (chi2)	0.006 (chi2)	0.012 (chi2)							
Admitted	0.054 (chi2)	0.020 (chi2)	0.471 (chi2)	0.000 (chi2)	0.001 (chi2)	0.000 (chi2)						
Language Barrier	0.602 (chi2)	0.787 (chi2)	0.026 (chi2)	0.309 (chi2)	0.279 (chi2)	0.985 (chi2)	0.184 (chi2)					
PMHx	0.233 (LR)	0.017 (LR)	0.401 (LR)	0.008 (LR)	0.625 (LR)	0.001 (LR)	0.000 (LR)	0.055 (LR)				
CTAS	0.000 (LR)	0.045 (LR)	0.770 (LR)	0.000 (LR)	0.347 (LR)	0.029 (LR)	0.000 (LR)	0.532 (LR)	0.001 (Sp R)			
Age	0.403 (tt)	0.047 (tt)	0.140 (tt)	0.375 (tt)	0.002 (tt)	0.021 (tt)	0.669 (tt)	0.108 (tt)	0.209 (Anova)	0.704 (Anova)		
Trainee	0.912 (chi2)	0.633 (chi2)	0.069 (chi2)	0.021 (chi2)	0.204 (chi2)	0.152 (chi2)	0.576 (chi2)	0.173 (chi2)	0.470 (chi2)	0.028 (chi2)	0.691 (Anova)	
TNT	0.000 (tt)	0.197 (tt)	0.000 (tt)	0.000 (tt)	0.153 (tt)	0.000 (tt)	0.000 (tt)	0.309 (tt)	0.002 (Anova)	0.000 (Anova)	*0.013* (Cor)*	0.160 (Anova)

chi2 = chi square LR = logistic regression Sp R = Spearman's Rank Correlation
tt = student's t-test Anova = analysis of variance *Cor* = Pearson's Correlation (* correlation coefficient, not p-value)