ED Staffing and Patient Outcomes

Final Report

Nina A. Bickell, MD, MPH, Principal Investigator

Team Members:
Rebecca Anderson, MPH, Project Manager
Carol Barsky, MD, Co-Investigator
Mary Rojas, PhD, Co-Investigator

Department of Health Policy
Mount Sinai School of Medicine
New York, NY

Project Period: 9/30/02 – 9/29/04

Project Officer: Eileen Hogan

Funded by the Agency for Healthcare Research and Quality
Grant Number: 1R03HS013464

*Please do not release, copy, or distribute report contents pending publication of the manuscript.

ABSTRACT

Purpose: Emergency Departments (EDs) provide a safety net for seriously ill individuals. Overcrowding and understaffing of EDs may adversely affect users' health. Little is known about the relationship of physician, nurse, and ED support personnel staffing on time to treatment or health outcomes of patients with time-sensitive conditions.

Methods: Detailed clinical and time data were abstracted from charts of 242 appendicitis patients presenting to an urban tertiary hospital ED. ED census, patient triage, and acuity were obtained from ED tracking software. Hourly staffing levels were obtained from physician schedules, nursing, and clerical payroll. Hospital census at time of appendicitis patients' diagnosis came from the hospital bed-board database. ED information was available for the hours that 237 appendicitis patients were in the ED. Bi- & multivariate relationships between ED staffing, patient characteristics, and time between ED arrival and first exam and ED length of stay were examined and modeled.

Results: Nine percent of appendicitis patients arrived by ambulance; 21% experienced perforation. During the hours appendicitis patients were in the ED, the average hourly patient census was 51 (1-104), with an acuity of 4.6 (0=low; 6=critical). The average staffing per hour was: physician = 9.2 (4-15); nurse = 16.3 (9-24); support technicians = 8.7 (3-14); clerks = 9 (3-14). Linear models found arrival by ambulance and younger age were the only factors associated with examinations within 1 hour of ED arrival. Greater physician staffing, diagnostic first impression of appendicitis, and the presence of rebound were associated with shorter lengths of stay, and undergoing CT was associated with longer length of stay (model r^2=.48; p<.0001). ED staffing was not associated with rates of perforation.

Conclusion: The swiftness of initial ED exams is most affected by physician perceived illness severity. The swiftness with which appendicitis patients move from the ED is affected by level of physician staffing, perceived illness severity, and their diagnostic first impression. Nurse and support personnel staffing is not related to ED length of stay. To maximize patient safety and quality of care, ED administrators should ensure adequate physician staffing.

Key Words: Emergency, staffing, quality of care, time

PURPOSE

Emergency Departments act as a safety net for individuals in need; they are open 24 hours a day, 7 days a week, and can provide immediate care to seriously ill individuals. Overcrowding and understaffing in Emergency Departments are serious issues and may adversely affect the health and safety of individuals in need of timely care. EDs were the hospital site with the highest percentage of adverse events caused by negligent care in the Harvard Medical Practice Study, and most of these errors were due to diagnostic mishaps, noninvasive therapeutic mishaps, and delays in diagnosis and treatment (1). We proposed to assess the relationship of Emergency Department physician, nurse, and support personnel staffing on time to treatment and patients' health outcomes for two time-sensitive conditions: appendicitis and intestinal obstruction. Using detailed clinical and time data collected in the previously AHRQ-funded project, "Assessing the Variability in Time to Treatment in Surgery," we examined symptom onset time, ER arrival and discharge times, exam times, times of diagnosis and treatment, clinical characteristics, the course of care, and outcomes for patients with appendicitis or intestinal obstruction. No new patients were enrolled for the purposes of this study. In addition to the data collected in the "Assessing the Variability in Time to Treatment in Surgery" study, we obtained data on Emergency Department physician, nurse and support staffing, patient census, and patient level of nursing acuity from the Emergency Department's computer tracking software and other hospital data systems.

The specific aims of the study were:

1. To explore and quantify the relationship between ED staffing and different components of time to treatment.
2. To explore and quantify the relationship between ED staffing and patient risk of adverse health outcomes.

Analyses can provide important information about the association of ED staffing on patients' receipt of timely care and the health consequences of the current emergency delivery system. Specifically, the analyses allow us to measure the relationship between ED staffing and 1) time to first examination in the ED, 2) length of stay in the ED, and 3) the risk of rupture or resection for patients with time-sensitive conditions.

Background

Society depends on accessible and responsive emergency medical care. The increasing use of and overcrowding of Emergency Departments (ED) poses a potential threat to the public's safety and well-being. Past studies have found EDs to be the site of relatively frequent errors, and some have suggested that such error may be due to overcrowding and understaffing (1). The American College of Emergency Physicians Report of Patient Safety in the Emergency Department Environment stated that the shortage of healthcare workers likely contributes to errors in the ED (2) but did not have evidence to support that supposition.

To date, the literature is replete with discussions about ED crowding with a focus on its prevalence and the need to define a consistent level that reflects crowding (3,4,5,6,7). Few have examined the effect of crowding or understaffing on processes of care or health outcomes in the ED. One study found that ambulance diversion, usually a consequence of emergency department overcrowding, affected the prehospital transport time of patients with chest pain (8).

Overcrowding occurs when the number of patients in the ED outweighs the number of patients that ED staff can adequately service. Perceived causes of overcrowding include an increase in ED volume, an increase in patient acuity, nursing and physician shortages, delays in diagnostic evaluations, insufficient ED space, and hospital bed shortages. Despite these perceptions, little data have been collected that can identify whether staffing affects the safety and health outcomes of patients presenting to an ED.

In hospitalized patients, greater nurse staffing levels are associated with better quality of care and patient outcomes (9,10,11,12). Physician staffing, measured as expertise not number, is associated with reduced ICU and hospital mortality and length of stay (13). These studies did not specifically assess ED staffing, care processes, or patient health outcomes.

We undertook this study to determine whether physician, nurse, or support personnel (those individuals responsible for blood draws, labeling specimens, transport) staffing affects time to treatment among patients with time-sensitive conditions. Time-sensitive conditions are those in which the amount of time that passes between onset of symptoms and receipt of definitive treatment can impact the course of the disease and the subsequent recovery. Appendicitis and intestinal obstruction are two time-sensitive conditions in which increasing time between symptom onset and treatment is associated with greater risk of perforation and resection,

respectively (14). The timely responsiveness of an ED to evaluate, diagnose, and facilitate treatment for these illnesses may be a critical factor in patient morbidity and mortality.

METHODS:

The study was conducted in an 1171-bed urban, academic medical center. The ED has about 80,000 patient visits annually and averages about 200 visits per day. The ED is divided into five separate patient care areas: acute, sub-acute, urgent, pediatrics, and psychiatry. Psychiatry staffing and admissions were not included in the study analyses.

The study sample comes from a previously AHRQ-funded study to determine time-sensitive conditions. In "Assessing the Variability in Time to Treatment in Surgery," patients with appendicitis, tubal pregnancy, or intestinal obstruction who were admitted between June 2001 and November 30, 2002, were identified in real time, and eligible patients were enrolled. To be included in the current study, patients from the previous study had to have been seen in the ED of the academic medical center prior to their inpatient admission. Because so few patients with tubal pregnancy were identified in the first study (N=37), a small portion of whom went through the ED, and because tubal pregnancy was not found to be time sensitive (15), only patients with appendicitis or intestinal obstruction are included in this project's analyses.

Detailed clinical and time data on the patients from the prior study were collected through medical record review by a trained data abstractor. This includes information on their ED arrival time, ED departure time, and clinical data on their conditions. ED arrival and discharge times for appendicitis and obstruction patients were used to set the time intervals examined for this ED staffing project. For each hour that appendicitis or obstruction patients were in the ED, we obtained data about the average number of patients and their acuity, the number of physicians, nurses, and support personnel in the ED. Information about ED census, patient triage, and acuity was obtained from the ED tracking software, Emergisoft. Data on physician staffing, including both residents and attendings, were compiled using each month's shift schedule. Because physician staffing varied by day and hour, we developed a database indicating the number of physicians in the ED each hour of the day and each day of the week for every month between 6/1/2001-11/30/2002. To determine the level of nurse and support staffing in the ED for the same time period, we used the nursing and clerical staffing payroll databases, respectively.

Hospital units to which patients with the conditions would be admitted were identified (i.e., surgical units for appendicitis patients; GI care center, medical and surgical floors for obstruction patients). Hospital census for each of the identified relevant units was obtained from the hospital bed-board database for the day and time of diagnosis of each appendicitis and obstruction patient. A ratio of bed use and its complement indicating bed availability was created using the number of occupied beds in the units at each patient's time of diagnosis as the numerator and the total number of beds in these units as the denominator; 192 appendicitis patients and 175 obstruction patients were diagnosed in the ED. Using the time of diagnosis data for these patients, we assessed the relationship of hospital inpatient bed availability at the point in time a decision was made to admit a patient.

Diagnostic first impression was created from the assessment portion of the initial ED examination note. Those appendicitis and obstruction patients for whom the first diagnosis of the differential was appendicitis or bowel obstruction were classified as having a correct diagnostic first impression.

Patient triage, assigned by a nurse at registration, follows this classification: 1) critical; 2) acute; 3) subacute; 4) urgent; 5) psychiatric (with 1-to-1 observation); and 6) psychiatric (no observation). Acuity was based on nursing level of acuity assigned by nurses at the time of ED discharge. Levels are 0) low intensity; 1) brief; 2) limited; 3) intermediate; 4) extended; 5) comprehensive; 6) critical care; 7) trauma; 8) trauma intensive.

Each measure for each hour was combined to create a summary measure reflecting the average conditions in the ED during each study patient's time there. If an appendicitis patient was in the ED for 4 hours and the number of nurses for each of those hours was 14, 21, 17, and 20, the mean nurse staffing level for that patient's stay was 18. Mean scores were created for physician, nurse, and ED support personnel staffing; ED census; patient acuity; and triage priority of all patients in the ED for each hour that each study patient was in the ED.

Time of diagnosis of appendicitis patients was based on the time of the exam at which a surgeon diagnosed appendicitis. Time of obstruction diagnosis was based on the time at which an imaging study was read as showing evidence of obstruction. Exam times were estimated when time was not documented. Estimation was based on the midpoint of the nearest identifiable time points surrounding that exam. Only one appendicitis patient and none of the obstruction patients had estimated exam times.

Two outcome measures of time were assessed: time to first physician examination in the ED and ED length of stay. We chose these intervals, because time to first physician exam would likely reflect a combination of how sick a patient looked upon arrival to the ED as well as nursing and physician ability to evaluate a patient quickly. Length of stay in the ED would likely be related to the staff's ability to evaluate and admit a patient in a timely fashion. ED length of stay would likely be affected by the number of patients in the ED, their acuity, availability of test results and inpatient beds, and nurse and physician staffing. We report these findings as the number of patients examined within 1 hour of ED arrival and the number moved out of the ED within 4 hours of length of stay, because these intervals are reasonable benchmarks of time and to present the data in a more clinically useful way. For multivariate modeling, outcome time variables were log transformed to normalize distribution. Parameter estimates were converted to relative risks to present the data in a more clinically useful way. Appendiceal perforation and intestinal resection were determined from operative reports.

RESULTS

In the "Assessing the Variability in Time to Treatment in Surgery" study, 242 appendicitis patients and 208 intestinal obstruction patients were seen in the ED. Patients were included in the study if they had been seen in the ED between June 1, 2001, and November 30, 2002. During that time period, there were 99,750 unique visits to the ED, as documented in the ED software. Of those 99,750 visits, 1268 had missing, negative, or >72 hours length of stay and therefore were removed from the database. Appendicitis and obstruction patients for whom ED census information was not available for >50% of that patient's ED stay were dropped from the sample. This left 237 appendicitis and 205 obstruction patients. These patients spent a total of 3374 hours in the ED.

Table 1 shows patients characteristics. Appendicitis patients ranged in age from 4 to 93 years (median age = 29 y); 54% were men, 43% were White, and 31% had Medicaid or were uninsured. Twenty-one (9%) of 229 patients arrived by ambulance. Physicians thought appendicitis was the leading diagnosis in the differential in 54% of appendicitis cases; 21% experienced appendiceal rupture. Sixty-two percent of appendicitis patients were seen within an hour of their ED arrival.

The median length of stay in the ED was 7.0 hours (range: 1 h-24 h).

Obstruction patient ages ranged from 8 months to 98 years (mean age = 55y); 44% were male, 53% were White and 28% had Medicaid or were uninsured. Twelve (<1%) of 208 obstruction patients arrived by ambulance. Examining physicians thought obstruction was the leading diagnosis in the differential in 45% of obstruction cases (88/194); 50% were surgically treated, and 26% underwent resection of bowel.

Table 2 shows the ED characteristics for the time periods when appendicitis and obstruction patients were in the ED. On average, there were 51 patients (range: 1-104) in the ED during the hours the appendicitis patients were there. The average level of patient acuity in the ED during those hours was 4.6 (0=low intensity to 6= critical care). The average triage level was 4.0 (1= critical to 4=urgent). The average number of nurses in the ED per hour was 16.3 (range: 9-24); the average number of physicians in the ED per hour was 9.2 (range: 4-15). The average number of technicians (individuals who draw blood or transport patients) was 8.7 (range: 3-14). The average number of clerical staff per hour was 9 (range: 3-14). The ratio of relevant inpatient beds available when appendicitis patients' diagnosis was made was .22.

On average, there were 50 patients (range: 1-105) in the ED during the hours the obstruction patients were there. The average level of patient acuity in the ED during those hours was 4.5 (0=low intensity to 6= critical care). The average triage level was 4.0 (1= critical to 4=urgent). The average number of nurses in the ED per hour was 15.9 (range: 10-21); the average number of physicians in the ED per hour was 8.5 (range: 3-13). The average number of technicians was 8.5 (range: 3-13). The average number of clerical staff per hour was 8.3 (range: 3-13). The ratio of inpatient beds available during the time obstruction patients were diagnosed and the decision to admit was made was .18.

Appendicitis patients who were seen within 1 hour of their arrival to the ED, compared to those who were seen later, were more likely to be younger (85% of 18 y or younger vs 55% of >18 y seen in first hour; p<.0001) and to be brought to the ED by ambulance (87% of patients brought by ambulance vs 60% of those arriving by other routes were seen within 1 hour of arrival; p=.01). Patients with physical signs of more severe illness (e.g., tachycardia, rebound tenderness or fever >101°F) were not seen more quickly (Table 3), nor was there a difference in rates of perforation between patients seen more, or less, quickly.

Table 4 shows the multivariate linear regression assessing the impact of staffing, patient acuity, and demographics. Younger patient age and arrival by ambulance were the only factors significantly associated with shorter times to first ED examination.

Bivariate analyses found that ED length of stay was shorter for patients who were triaged to more critical areas of the ED, who had tachycardia and rebound on physical exam, and for patients in the ED when there was a greater number of nurses and physicians working (Table 3). Patient census, level of acuity, and support personnel staffing were not significantly related to shorter length of stay in the ED. Inpatient bed availability was not related to appendicitis patients' ED length of stay; 29% (17/59) of patients with a correct diagnostic first impression were sent for CT, compared with 52% of patients for whom appendicitis was not the leading diagnosis ($p<.01$). There was no significant difference in rate of appendiceal perforation between those who left the ED more quickly and were taken to the operating room versus those with longer ED stays. Multivariate modeling revealed that greater physician staffing and a diagnostic impression of appendicitis were associated with shorter lengths of stay in the ED (Table 5). Being sent for CT scan was associated with longer lengths of stay in the ED.

Similar analyses of obstruction patients are currently underway.

Discussion:

For appendicitis patients, the swiftness of a patient's initial evaluation in the ED is most affected by how sick a patient seems to be, as measured by physical signs such as rebound tenderness and the mode of transportation. It is likely perceived by providers that patients transported by ambulance are presumably sicker than those who walk into an ED. ED characteristics, such as levels of staffing (physician, nurse, support personnel), patient census, and acuity, do not appear to affect how quickly patients are seen.

The swiftness with which appendicitis patients move from the ED to undergo surgical treatment is affected by the level of physician staffing in the ED as well as physicians' diagnostic first impression. Closely tied to the length of time an appendicitis patient remains in the ED is the process of evaluating the underlying condition, which often includes testing to arrive at a diagnosis and treatment plan. We found that patients sent for CT imaging studies have longer stays in the ED; these patients tend to be those for whom appendicitis is not the leading

diagnosis. We did not find an increased risk of poorer outcome, appendiceal rupture, with varying levels of staffing. This may be due to the small overall number of poor outcomes in our sample or because time spent in the ED represents just a small portion of overall time between symptom onset and treatment.

Our findings show that a patient's perceived illness severity is a determining factor in how quickly he is examined and it is the physician's diagnostic impression of a time-sensitive condition that most affects how quickly treatment is dispensed. The timing with which a physician ascertains an appendicitis patient's diagnosis and arranges appropriate treatment is affected by the number of physicians working in the ED at that time.

Intuitively, one would expect that the sheer number of patients to be cared for would affect the length of time patients remain in the ED. It is somewhat surprising then that the number of patients in the ED in a particular hour is not associated with either the time to first examination or the length of stay in the ED. How can it be that neither the number of patients in the ED nor their level of acuity seems to predict the length of stay of appendicitis patients in the ED? Perhaps patients who appear to be acutely ill are tended to quickly regardless of the overall patient load. Perhaps those patients for whom emergency physicians thought the diagnosis was appendicitis got surgeons in quickly to evaluate the patients in order to get them to the operating room. Perhaps the nursing acuity level does not accurately reflect a patient's physiologic illness severity. Perhaps emergency physicians simply sped up their evaluations, expedited referrals, and hastened patient turnover. If this were the case, our data would show, as it appears, shortened time intervals, such as length of stay, rather than the longer expected times. Hasty exams might result in worse patient outcomes, but we did not find this. The small number of ruptures in our sample precludes the ability to show a negative impact of prolonged time in the ED on poorer health outcomes, and we are unable to assess the relationship of exam duration on rupture. Lack of detailed medical record documentation precludes the ability to measure the duration of examination time to determine whether physicians truly hastened their exam times. Although time in the ED is highly correlated with total time between symptom onset and treatment, it may not be a large enough portion of that total time to significantly affect a patient's risk of appendiceal rupture.

Why doesn't nurse or support personnel staffing influence time in the ED? These staff can hasten the processes required for diagnosis and treatment. In this ED, the number of nurses and support personnel on duty is flexible and responds to the demand. If the administration notes that conditions are busy, additional nurses are pulled from other sites. However, there is no such accommodation for physician staffing; a fixed number of physicians is assigned for specific shifts. Our finding of physician staffing to be the only significant staffing variable may reflect the key role physicians play in diagnosing and arranging patient disposition. However, more likely, it suggests that the inflexibility in physician staffing, despite increasing demand, affects the time to treatment among patients with time-sensitive conditions. It is quite likely that prolonged times to diagnosis and treatment are experienced by other patients in the Emergency Department, though we did not have detailed clinical and time data on all ED patients to determine this.

For appendicitis patients, we did not find an association between length of ED stay and hospital bed availability. Because most appendicitis patients go directly to the operating room and not to the floors, it is not surprising that we did not detect an influence of the back-ups created by occupied hospital beds, as others have found (16). We did not have a measure of operating room availability for these hours. However, other studies have found that physician perception of delays in operating room availability was not an important contributor of delays in treatment among appendicitis patients (17).

This study was conducted in one urban, academic medical center and therefore has somewhat limited generalizability. There were no incentives for staff to meticulously code time intervals in the Emergisoft database. However, it is unlikely that times were misclassified in a set direction and, therefore, unlikely to bias the data in a particular way. Patient acuity is based on the nursing level of acuity, a measure of intensity of nursing service required. This measure was the best available proxy for illness acuity but is limited in that it does not contain physiologic measures of illness severity. Because of the relatively small sample size and small difference in the number of staff compared to the large variability in patient census, we were unable to determine whether there are specific optimal ratios of nurse or clerk or physician to patient or how many nurses and clerks to physicians would provide the ideal combination to maximize efficiency and patient flow and minimize delays resulting from inadequate staffing.

We have shown that ED physician staffing levels affect time to treatment among patients with a time-sensitive condition. In an environment of increasing attention to improve patient safety and quality of care while simultaneously maintaining a high level of emergency preparedness, Emergency Department administrators must pay close attention to ensure adequate physician staffing. It is time to determine ED staffing levels that maximize patients safety while maintaining ED efficiency.

References:

1. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA, Hebert L, Newhouse JP, Weiler PC, Hiatt H. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N Engl J Med 1991;324:377-84.
2. American College of Emergency Physicians. Guidelines for Emergency Department Physician Staffing. Ann Emerg Med 1984;13:1165-66.
3. Hwang U, Concato J. Care in the emergency department: How crowded is overcrowded? Academic emergency medicine 2004; 11:1097-1101.
4. Derlet RW. Richards JR, Kravitz RL. Frequent overcrowding in US emergency departments. Academic Emergency Medicine 2001;8:151-155.
5. Solberg LI, Asplin BR, Weinick RM, Magid DJ. Emergency department crowding: consensus development of potential measures. Ann Emerg Med. 2003 Dec;42(6):824-34.
6. Bernstein SL, Verghese V, Leung W, Lunney AT, Perez I. Development and validation of a new index to measure emergency department crowding. Acad Emerg Med 2003;10:938-42.
7. Miro O, Sanchez M, Espinosa G, Coll-Vinent B Bragulat E, Milla J. Analysis of patient flow in the emergency department and the effect of an extensive reorganisation. Emerg Med J 2003;20:143-148.
8. Schull MF, Morrison LJ, Vermeulen M, Redelmeier DA. Emergency department overcrowding and ambulance transport delays for patients with chest pain. CMAJ 2003; 168:277-83.
9. Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med. 2002 May 30;346(22):1715-22.
10. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA. 2002 Oct 23-30;288(16):1987-93.
11. Pronovost PJ, Dang D, Dorman T, Lipsett PA, Garrett E, Jenckes M, Bass EB. Intensive care unit nurse staffing and the risk for complications after abdominal aortic surgery. ECP 2001;4:199-206.
12. Pronovost PJ, Jenckes MW, Dorman T, Garrett E, Breslow MJ, Rosenfeld BA, Lipsett PA, Bass E. Organizational characteristics of intensive care units related to outcomes of abdominal aortic surgery. JAMA 1999;281:1310-17.
13. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremsizov TT, Young TL. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. JAMA. 2002 Nov 6;288(17):2151-62.
14. Bickell NA, Aufses AH, Rojas M, Bodian C. Time is a terrible thing to waste: The risk of appendiceal rupture. JGIM 2002; 17 (suppl 1)184.
15. Bickell NA, Bodian C, Anderson RM, Kase, N. Time & the risk of ruptured tubal pregnancy. *Obstet Gynecol* 2004 104: 789-794
16. Forster AJ, Stiell I, Wells, G, Lee AJ, van Walraven C. The effect of hospital occupancy on emergency department length of stay and patient disposition. Academic emergency medicine 2003;10:127-133.
17. Bickell NA, Rojas M, Anderson RM, Chatterjee S, Leventhal H. What Takes So Long for My Patient to Get Treated? JGIM 2004; 19(supplement1):238

Table 1. Patient Characteristics	**Appendicitis N=229 (%)**	**Obstruction N=208 (%)**
Age 2-18	59 (26)	3 (2)
19-40	115 (50)	48 (24)
41-64	38 (17)	70 (35)
65-92	17 (7)	78 (39)
Male	123 (54)	90 (44)
White (race)	98 (43)	108 (53)
Medicaid or Uninsured	70 (31)	58 (28)
RLQ pain/Abdominal pain	144 (63)	175 (90)
Nausea or vomiting	148 (65)	170 (88)
Anorexia	91 (40)	
No flatus in past 24 hours	NA	41 (21)
Fever (>=101)	29 (13)	1 (.01)
Tachycardia	64 (29)	66 (34)
Rebound tenderness	78 (34)	8 (.04)
Abdominal Tenderness of 1st ED physical exam	180 (79)	
Guarding	65 (28)	
White Blood Cell count median (sd)	14,000 (4571)	
Arrived by Ambulance	21(9)	11 (5)
Had CT done in ED	105 (46)	
Appendicitis/Obstruction diagnosis as 1st impression	123 (54)	88 (45)
Perforation/Resection	49 (21)	54 (26)

Table 2. Characteristics of the Emergency Department

Characteristics	Appendicitis mean score (sd) N=235	Ranges	Obstruction mean score (sd) N=205	Ranges
Acuity	4.6 (0.5)	2.6 - 5.9	4.5 (0.5)	2.3 - 5.9
Triage	4.0 (0.2)	3 - 4.6	4.0 (0.2)	3 - 4.5
Nurses	16.3 (2.7)	9 - 24	15.9 (2.5)	10 – 21
Technicians	8.6 (1.8)	3 - 14	8.5 (2.0)	3 – 13
Physicians	9.2 (2.6)	4 - 15	8.5 (2.3)	3 – 13
Clerical staff	8.7 (2.0)	3 - 14	8.3 (2.0)	3 - 13
Patient census in ED	51.0 (21.1)	1 - 104	50.0 (18.2)	1 - 105
Ratio of bed availability*	.22 (.08)	.04 - .54	.18 (.07)	.02 - .44

**based on available beds in relevant units at time of diagnosis in ED*

Table 3. Appendicitis patient and ED characteristics and time to first examination and length of stay (N=236).

Patient Characteristics	N(%)	First exam <60 mins N (%)	LOS < 4 hrs N (%)
Age 2-18	59 (26)	50 (85) †	19 (31)
19-40	115 (50)	58 (50)	38 (33)
41-64	38 (17)	25 (66)	14 (37)
65-92	177 (7)	10 (59)	3 (18)
Female	106 (46)	61 (58)	30 (28)
Male	123 (57)	82 (67)	43 (35)
White	104 (44)	61 (59)	42 (40)*
Uninsured or Medicaid	71 (30)	48 (68)	16 (23)*
Fever (>=101)[1]	29 (13)	19 (66)	12 (41)
Elevated HR[2]	64 (29)	39 (61)	26 (40)*
Rebound	78 (34)	56 (72)*	32 (41)*
Tender	180 (79)	114 (63)	63 (35)
Guarding	65 (28)	48 (74)*	25 (39)
RLQ pain	144 (63)	98 (68)*	57 (40)†
Nausea	148 (65)	87 (59)	38 (26)**
Dysuria	11 (5)	5 (45)	1 (9)
Anorexia	91 (40)	62 (68)	35 (39)
Diarrhea	34 (15)	22 (65)	10 (29)
Median (range) WBC	13,800 (1,600-28,700)	14,000 (16,000-28,700)	12,550 (4,600-28,700)
Arrived by Ambulance	21 (9)	19 (91)**	3 (14)
CT	105 (46)	61 (41)	5 (5) †
Appendicitis as 1st impression	107 (45)	72 (67)	43 (40)**
Perforated	49 (21)	32 (62)	16 (33)
ED Characteristics		**r**	**r**
Triage		.08	-.19**
Acuity		.0002	.04
Nurses		.02	.28†
Technicians		-.01	.10
Physicians		.0001	.27†
Patient census		.02	.16

[1] 11 patients missing data
[2] 10 patients missing data
* p < .05, ** p < .01, † p <.001

Table 4. Multivariate model of appendicitis patient and ED characteristics on minutes to first examination (N=236).

Characteristics	RR	95% CI	
Triage	1.17	0.48	2.89
ER census	1.00	0.99	1.00
Nurse staffing	0.98	0.90	1.06
Clerical staffing	0.95	0.86	1.04
Rebound	0.79	0.55	1.15
Age less than 19	**0.64**	**0.44**	**1.00**
Arrived by ambulance	**0.57**	**0.33**	**0.99**

Bolded rows indicate statistically significance ($p<.05$) for the regression coefficient.
(Time to first exam is log transformed.)

Table 5. Multivariate model of appendicitis patient and ED characteristics on ED length of stay (N=236).

Characteristics	Relative Risk	95% CI	
CT in ED	**2.20**	**1.92**	**2.53**
Triage	1.39	0.96	2.03
Age <=18y	1.05	0.90	1.00
Nurse staffing	1.02	0.99	1.06
ED census	1.0	0.99	1.0
Clerical staffing	0.99	0.95	1.03
Physician staffing	**0.96**	**0.93**	**0.99**
Appendicitis 1st impression	**0.87**	**0.76**	**1.00**
Rebound	**0.84**	**0.72**	**0.98**

Bolded rows indicate statistically significance ($p<.05$) for the regression coefficient. (Length of stay is log transformed.)

LIST OF PUBLICATIONS

Bickell NA, Siu AL. Why do delays in treatment occur? Lessons learned from ruptured appendicitis. *Health Services Research* 2001;36:1-5.

Bickell NA, Bodian C, Rojas M, Aufses AH, Chassin MR. Time is a terrible thing to waste. *J Gen Intern Med* 2002; 17 (suppl 1)184.

Bickell NA, Aufses AH, Rojas M, Bodian C. Time is a terrible thing to waste: The risk of appendiceal rupture. (Manuscript submitted).

Bickell NA, Bodian C, Anderson RM, Kase, N. Time & the risk of ruptured tubal pregnancy. *Obstet Gynecol* 2004 104: 789-794

Bickell NA, Federman AD, Aufses AH. Influence of time on risk of bowel resection among patients with complete intestinal obstruction. (Submitted).

Menes TS, Aufses AH, Rojas M, Bickell NA. The role of computed tomography in patients with acute appendicitis. (Submitted).

ABSTRACTS AND PRESENTATIONS

Bickell NA, Rojas M, Anderson RM, Chatterjee S, Leventhal H. What Takes So Long for My Patient to Get Treated? JGIM 2004; 19(supplement1):238.

Barksy CL, Rojas M, Lee DS, Bickell NA. Time matters: risk of appendiceal rupture in ED patients. Acad Emerg Med 2002.

Bickell, NA. The Importance of the Emergency Department in Delay Sensitive Conditions. Harlem Hospital Emergency Department, NY, NY. January 2001.