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Trauma Center-Based Surveillance of Nontraffic Pedestrian Injury among California Children

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Introduction: Every year in the United States, thousands of young children are injured by passenger vehicles in driveways or parking areas. Little is known about risk factors, and incidence rates are difficult to estimate because ascertainment using police collision reports or media sources is incomplete. This study used surveillance at trauma centers to identify incidents and parent interviews to obtain detailed information on incidents, vehicles, and children.

Methods: Eight California trauma centers conducted surveillance of nontraffic pedestrian collision injury to children aged 14 years or younger from January 2005 to July 2007. Three of these centers conducted follow-up interviews with family members.

Results: Ninety-four injured children were identified. Nine children (10%) suffered fatal injury. Seventy children (74%) were 4 years old or younger. Family members of 21 victims from this study (23%) completed an interview. Of these 21 interviewed victims, 17 (81%) were male and 13 (62%) were 1 or 2 years old. In 13 cases (62%), the child was backed over, and the driver was the mother or father in 11 cases (52%). Fifteen cases (71%) involved a sport utility vehicle, pickup truck, or van. Most collisions occurred in a residential driveway.

Conclusion: Trauma center surveillance can be used for case ascertainment and for collecting information on circumstances of nontraffic pedestrian injuries. Adoption of a specific external cause-of-injury code would allow passive surveillance of these injuries. Research is needed to understand the contributions of family, vehicular, and environmental characteristics and injury risk to inform prevention efforts. [West J Emerg Med. 2012;13(2):139–145.]

Table 1. Case ascertainment and recruitment.

Institution	County	Designation*	Cases	Fatalities	Recruited†	Enrolled‡ (%)	Participation§
University Medical Center	Fresno	Level I	6	2	6	0 (0)	0%
University of California at Davis Medical Center	Sacramento	Pediatric I	25	3	8	8 (100)	32%
UCSF/San Francisco General Hospital	San Francisco	Level I	5	1	0		
Children's Hospital and Research Center Oakland	Alameda	Pediatric I	22	0	11	6 (55)	27%
Santa Clara Valley Medical Center	Santa Clara	Level I	15	0	13	7 (54)	47%
Stanford University Medical Center	Santa Clara	Level I	4	0	4	0 (0)	0%
Children's Hospital and Health Center	San Diego	Pediatric II	9	1	2	0 (0)	0%
Loma Linda University Children's Hospital	San Bernardino	Pediatric I	8	2	0		
Total			94	9	44	21 (48)	22%

UCSF, University of California, San Francisco.
* California Emergency Medical Services Authority designations.
† Invited family members to participate.
‡ Family member completed questionnaire (percent of recruited families that were enrolled).
§ (Enrolled/cases) × 100%.

INTRODUCTION

Every year in the United States, thousands of children are injured by motor vehicles in driveways or parking areas.[1,2] Because of their short stature, toddlers and young children are at risk of being struck by slow-moving passenger vehicles engaged in parking maneuvers. These incidents often occur in nontraffic environments, such as single or shared driveways or other parking facilities at or near the child's home. These incidents are not recorded by police as typical traffic or pedestrian incidents since they do not occur on public roads. Injuries to victims are sometimes fatal, and effects on family members, who are often the vehicle drivers, can be emotionally devastating. The problem has been referred to variously as backover, frontover, rollover, or driveway injury. We use the term nontraffic pedestrian collision in this paper.

Previous studies have identified many characteristics of pediatric nontraffic pedestrian collisions. Associated factors include involvement of sport utility vehicles (SUV) and light trucks,[3–8] shared driveways,[9] family members driving,[3,10,11] late afternoon occurrence,[12,13] large family size,[9] and minority ethnic status.[14,15] The National Highway Traffic Safety Administration estimates that there are at least 210 pediatric (aged 14 years or younger) fatalities due to these incidents per year in the United States, as well as 5,000 injuries, but this estimate is probably low because of poor ascertainment in law enforcement databases.[16] The United States Centers for Disease Control and Prevention (CDC) reports similar estimates of backovers and notes that most victims are one-year olds.[2] CDC's estimate excludes frontovers and vehicles set in motion by the victim or another child. KidsAndCars.org, a national advocacy organization addressing the dangers to children in and around passenger vehicles, estimates that 68% of child deaths around vehicles in nontraffic situations are due to backovers, frontovers, or vehicles set in motion.[17] KidsAndCars.org obtains much of its data through news media, which are more likely to cover incidents involving severe or fatal injuries to children than incidents resulting in less severe injury.

The objectives of this study were to (1) demonstrate the feasibility of conducting trauma center surveillance of nontraffic collision injury to young children in California and (2) enhance our understanding of the circumstances of these events to support evidence-based prevention.

METHODS

The California Department of Public Health and 8 trauma centers in California conducted surveillance of nontraffic pedestrian collision injury among children aged 14 years or younger from January 2005 to July 2007. Children presenting with injury at any time of day were assessed for study eligibility by trauma center nurses and physicians. Three of the trauma centers were Pediatric Level I centers, 1 was a Pediatric Level II center, and 4 were Adult Level I centers (Table 1). KidsAndCars.org conducted statewide surveillance of media-reported California incidents for that same time period. Cases were defined as children aged 14 years or younger injured in a collision with a motor vehicle in a nontraffic environment. Nontraffic environments include private and public parking

Table 2. Collision, vehicle, and child characteristics, cases with completed family interview.

Characteristic	No.	%
Gender		
Male	17	81
Female	4	19
Median age, months	28	
Incident type		
Backover	13	62
Frontover	4	19
Set in motion	3	14
Unknown	1	5
Length of hospital stay, median	2 days	
Fatality		
Yes	0	0
No	21	100
Time of day		
5:00–7:59 AM	1	5
8:00–10:59 AM	2	10
11:00 AM–1:59 PM	6	29
2:00–4:59 PM	3	14
5:00–7:59 PM	4	19
Unknown	5	24
Location		
Driveway (home)	11	52
Driveway (neighbor)	1	5
Pathway near apartment	1	5
Private field	1	5
Public parking lot	1	5
Residential parking lot	3	14
Street parking	2	10
Unknown	1	5
Driver		
Family friend	1	5
Father	5	24
Grandfather	1	5
Mother	6	29
Neighbor	3	14
No driver	3	14
Unknown	2	10
Vehicle type		
Farm equipment	1	5
Minivan	3	14
Pickup	5	24
SUV	8	38
Sedan	3	14
Sports car	1	5
Reported to police		
Yes	15	71
No	2	10
Unknown	4	19
Total	21	100

SUV, sport utility vehicle.

facilities, private driveways, private roadways, and public or private open land. KidsAndCars.org monitored newspaper and other media reporting using Google Reader and by referrals from injury prevention professionals and advocates. Matching of cases in the two data systems was performed.

Because the International Classification of Diseases has no specific external cause of injury code (E-code) for these nontraffic injuries, case identification was done by trauma center staff rather than by analysis of electronic patient records. Staff were instructed on the nature of the problem, the definition and protocol for case identification, and how to contact a trained interviewer at each center when eligible cases presented. Interviewers approached families to invite their participation in the study.

Five centers collected hospital chart reviews only. Three centers completed in-person interviews with case families, in which they collected information on the location of the incident, driver characteristics and perceptions of the incident, child behavior, type of vehicle, time of incident, and injury outcomes. Families were also asked to consent to a medical chart review, from which additional details were collected, such as injury diagnoses and E-code. Every family that consented to a chart review also consented to an interview. Interviews were conducted by trauma nurses of injury prevention specialists.

This research was approved by local institutional review committees at all sites.

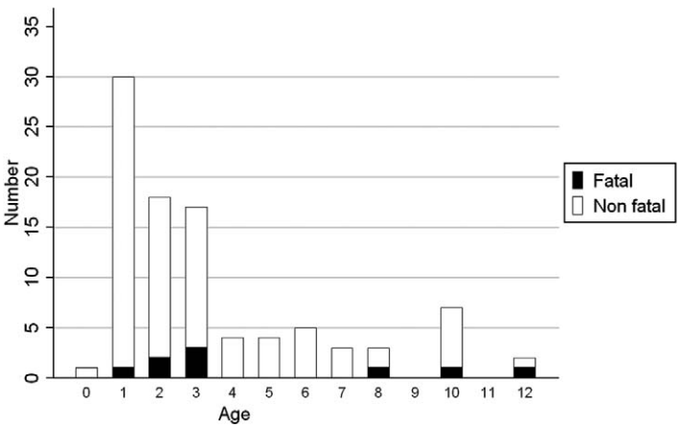

Figure. Nontraffic collisions by age and injury outcome among 94 cases.

Table 3. Child age and activity at time of injury, cases with completed family interview.*

Child age		Activity at time of injury			
Year	Month	Playing in area	Going to an adult	Driverless vehicle	Other
1	4	x			
1	4		x		
1	5		x		
1	6			x	
1	6	x			
1	8		x		
1	11		x		
2	0		x		
2	4			x	
2	4	x			
2	8		x		
3	6	x			
3	6	x			
4	0	x			
4	2				x
6	0	x			
6	10			x	
10	0	x			

* Two children with unknown activity and 1 child struck by farm equipment excluded.

RESULTS

A total of 94 cases were identified (Table 1). Nine cases (10%) were fatal. Seventy of the victims (74%) were aged 4 years or younger; 31 (33%) were aged 1 year or less (Figure). Interview and expanded chart review participation rates ranged from 0% to 27% among the 6 trauma centers that attempted to enroll case families.

Of the 21 victims whose families were interviewed, 17 (81%) were male. Median age was 28 months (Table 2). Thirteen cases (62%) were struck as the vehicle moved in reverse, and 4 (19%) occurred as the vehicle moved forward. In 3 incidents (14%), the car began rolling while parked or was unintentionally set in motion by the victim or another child. The median hospital stay was 2 days, and the mean hospital stay was 2.9 days. There was no fatality among the interviewed cases.

Most of the incidents were clustered around 11:00 AM, 1:00 PM, and 5:00 PM. Twelve incidents (57%) occurred in a residential driveway, and 4 (19%) occurred in a residential parking lot. In 11 cases (52%), the driver was a parent of the victim. Three drivers (14%) were neighbors, 1 was a grandfather, and 1 was a family friend. Sixteen incidents (76%) involved an SUV, pickup truck, or minivan. Fifteen incidents (71%) were reported to the police.

The victims were involved in 3 primary activities at the time they were struck (Table 3). In 8 cases (44%), the child was playing in the vicinity of the vehicle. Six children (33%) were walking or running to greet or say goodbye to the driver. In 3 cases (17%) the child was struck by a driverless vehicle. These vehicles were set in motion by the victim or another child or started rolling after being improperly parked. The child's activity for 2 incidents (10%) could not be determined, and 1 child (5%) was injured by farm equipment.

Twenty-seven body regions were injured among 18 children with injury-specific data (Table 4). Fourteen children (78%) suffered injury to a major region (head, chest, abdomen, or pelvis); 4 (15%) suffered injury to extremities only. Six children (23%) had injuries to more than 1 body region, with an average of 1.4 injured regions per child. Overall, lower extremity injuries were the most common, with 6 of 26 diagnoses (23%).

Four cases (19%) were correctly coded using either ICD E-code E822.7 (other motor vehicle nontraffic accident involving collision with moving object) or E825.7 (other motor vehicle nontraffic accident of other and unspecified nature). The other 17 cases (81%) had a traffic-related injury code, no code, or an incorrect code.

KidsAndCars.org statewide data for the same period included 41 deaths and 17 nonfatal injuries.

Table 4. Injured body regions, cases with completed family interview.*

	Case																		
Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Head	x	x	x	x															4
Chest					x	x	x	x											4
Abdomen			x						x	x	x	x							5
Pelvis				x				x					x	x					4
Upper extremities												x		x	x	x			4
Lower extremities			x	x										x		x	x	x	6
Total																			27

* Three cases with missing data excluded.

DISCUSSION

This study demonstrated the feasibility of trauma center surveillance of nontraffic pedestrian collision injury to young children.

The trauma centers identified 9 fatal and 85 nonfatal incidents. KidsAndCars.org identified 41 fatal and 17 nonfatal incidents during the same period. Only 4 of the fatal incidents and 1 of the nonfatal incidents identified by KidsAndCars.org were also identified by our trauma center surveillance system, whose catchment areas covered the areas surrounding Sacramento, Fresno, San Francisco, Oakland, San Jose, and San Diego. The lack of data overlap indicates that KidsAndCars.org was more likely to identify severe and fatal injury incidents than less severe injury incidents, while the trauma center surveillance system was more likely to identify nonfatal incidents. The 2 surveillance systems together identified 101 nonfatal incidents and 46 fatal incidents during the 2-year period.

This study also brought to light inconsistency in the use of external cause-of-injury codes[18] by emergency departments. Coding is done by medical records staff who assign a code based on the narrative recorded by a physician in the medical chart. Nine of the 21 interviewed cases were coded E814.7 (motor vehicle traffic accident involving collision with pedestrian), and only 4 were correctly coded with either E822.7 (other motor vehicle nontraffic accident involving collision with moving object) or E825.7 (other motor vehicle nontraffic accident of other and unspecified nature). The remaining 10 cases had either no code or other incorrect codes. The inconsistent use of the codes may result from a lack of clarity on the definitions of traffic and nontraffic incidents. It may also be related to the lack of any specific code to capture pedestrian injuries in parking environments. The result, in this study, is that only 4 of 21 interviewed cases would have been identified by surveillance using emergency department records, inpatient hospital discharge records, or injury trauma registries. In addition, if these 4 patients were identified in a data system, they would not be differentiable from children injured by other means and coded with 1 of these 2 codes.

This medical record external cause coding problem has been recognized by the National Highway Traffic Safety Administration[19] because the primary data used in studies of motor vehicle-related injury, police collision reports, also perform poorly in the ascertainment of these incidents. Police collision report data systems generally include only events on public roadways and thus often miss driveway and parking lot incidents. When these incidents are captured in a police collision report, they are often recorded as vehicle-versus-pedestrian events[3] without reference to the nontraffic environment in which they occur. This omission makes it impossible to differentiate them from more typical vehicle-versus-pedestrian traffic collisions.

The children our surveillance identified had characteristics similar to those found in other studies that examined nontraffic incidents.[20,13] Most were aged 1 to 3 years, and boys strongly predominated. This contrasts with the approximately equal incidence for vehicle occupant injury among young boys and girls and suggests that pediatric nontraffic pedestrian collisions are not a variety of traffic collision but a distinct injury problem.

Our examination of the circumstances of the collisions revealed a basic typology of activities. The most common activity was playing, primarily in children aged 2.5 years or older. The most common activity observed among children younger than this age was going to an adult, usually to say hello or goodbye. Although a majority of the interviewed family members reported that the child was with an adult at the time of the incident, a majority also reported that the child was out of sight of the adult at the time of the incident. This finding underscores the role that supervision plays in the occurrence of backover collisions.

In our data, pickups and SUVs predominated among the involved motor vehicles. The large blind zone behind light trucks, which are generally higher and longer than passenger cars, has been cited as a risk factor for nontraffic collision injury to young children.[17,21,22] Consumers Union measured the blind zone of popular passenger vehicles for male and female drivers of average height (5 feet 8 inches [173 cm] for males, 5 feet 4 inches [163 cm] for females).[23] The blind zone ranged from 12 feet (3.7 m) for a typical passenger car to 51 feet (28.5 m) for a large SUV or pickup truck. Drivers who are shorter than average height would experience even larger blind zones.

A primary strength of this study was the participation of several large pediatric trauma centers with catchment areas covering the populations of several large urban areas. More cases were identified than would have been possible using police reports alone. In addition, our surveillance approach was able to identify incidents with less severe injury, which appear to be underreported by media-based surveillance.

The salient characteristics of the incidents identified in this study included driveway occurrence, large passenger vehicles, vehicles operated in reverse, family members as drivers, and the absence of immediate child supervision. Pediatric health professionals who work with parents should focus on these factors as targets of educational efforts. Parents should be educated on how child mobility, developmental stage, vehicle blind zones, and environmental features contribute to risk, as well as the importance of close, constant supervision of children around driveways. An example of an educational countermeasure is Spot the Tot, a national campaign that encourages parents to walk around their vehicles before moving them.[24] Other studies have also noted the importance of parental education and behavior modification in preventing these injuries.[17,20,21,23,25] Several studies have recommended environmental countermeasures, such as play areas that are physically separated from driveways.[11,13,15,26,27] Separated

driveway areas would likely have prevented some of the incidents reported here, since most of the victims appeared to have access to parking areas, particularly in the morning and afternoon hours when outside play is most likely.

Additional research is needed to clarify the individual and joint contributions of the risk factors identified in this and other studies. Case-control studies should be used to identify modifiable risk factors that can be targeted by prevention programs.

LIMITATIONS

A primary limitation of the study was the low participation rate among case families. Of the 44 families that were invited to participate, 21 agreed (48%), giving an overall participation rate of 22% (21 of 94 total cases). Another limitation is the lack of a defined at-risk population. Most of our trauma centers had no geographically defined or otherwise identifiable catchment area. In addition, the interview questions had unknown validity and reliability.

The implementation of this surveillance effort proved to be challenging. Initially, trauma center staff struggled with obtaining human subject approval and standardizing case definitions and study protocols. Several centers were limited by the lack of interviewers (or translators) who could interview families who spoke languages other than English. Some trauma center staff were uncomfortable making a request for an interview during a time of crisis. Families often experienced strong feelings of guilt and grief and were at risk for posttraumatic stress. Lastly, there were instances of family discord over who was at fault.

Studies in Australia and New Zealand have used child death registry data to examine the involvement of larger vehicles,[5,26] victim outcomes,[28] and victim and place characteristics[13,15] of nontraffic incidents. In the United States, surveillance efforts have relied primarily on hospital data[29,30] and media reports[17] because of the lack of existing data systems with relevant information. Both approaches have limitations. To our knowledge, child death review teams, nearly universal in large US cities, have not been fully exploited to study nontraffic pedestrian collision injury to children.

Surveillance conducted at large trauma centers is likely to miss children with less severe injuries who may present at community hospitals with lower level trauma centers. Regional surveillance could be conducted at smaller, nontrauma center hospitals, but statewide surveillance would not be possible due the large number of these hospitals in California and many other states. In addition, trauma center catchment areas are often unknown, particularly in urban areas, which may have several trauma centers and whose centers may receive patients transferred from other cities or rural areas.

During the study period, KidsAndCars.org media reports identified 41 fatal and 17 nonfatal collisions. KidsAndCars.org was much more likely than our surveillance system to identify incidents resulting in fatal injury, presumably because fatalities are more newsworthy to the media. For every fatal collision, they identified 0.4 nonfatal collisions, whereas the trauma centers identified 10 nonfatal collisions for every fatality. This indicates that media-based surveillance will severely underestimate the number of incidents of minor or moderate severity injury. If we accept as accurate the 10:1 ratio of moderate/severe injury to fatal injury observed by the trauma centers, we can infer that at least 200 children suffer moderate or severe injury in California each year. The 10:1 ratio may be an underestimate of the true ratio because some fatal incidents may not present at a trauma center, and thus the true number of children with moderate or severe injury may by higher than 200. This possibility is supported by the observation that only 4 fatalities were found in both systems' data.

Despite the limitations of the 2 surveillance approaches used in this study, the data suggest that nontraffic pedestrian collision injury among young children is an under-recognized public health problem. Assuming the media-based surveillance of KidsAndCars.org ascertains almost all fatal incidents, a minimum of 20 or so children are killed each year in California in these events. However, 5 of the 9 trauma center-identified fatalities were not captured by the KidsAndCars.org system, indicating that the estimate of 20 deaths per year may be significantly understated.

CONCLUSION

In this study, nontraffic pedestrian injuries occurred primarily to boys aged 1 to 3. These events often occurred in driveways, involved large vehicles, and included parents or relatives as the drivers. Surveillance of nontraffic pedestrian injury at trauma centers is a promising approach to identifying incidents that are not captured by other data systems. Family member interviews provided detailed information not found in other data sources. This study also highlighted the inadequacy of ICD E-codes at classifying nontraffic pedestrian collisions. Only 4 of 21 interviewed cases were correctly coded and would be identifiable in hospital data systems. The utility of existing data systems will be improved if the use of ICD E-codes for these collisions is standardized or if a new, unambiguous code is adopted.

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Violent and Fatal Youth Trauma: Is There a Missed Opportunity?

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Introduction: Accidents and assaults (homicides) are the leading causes of death among the youth of the United States, accounting for 53.3% of deaths among children aged 1 to19 years. Victim recidivism, defined as repeated visits to the emergency department (ED) as a victim of violent trauma, is a significantly growing public health problem. As 5-year mortality rates for recidivism are as high as 20%, it is important to determine whether victims with a history of violent trauma are at increased risk for fatal outcome with their next trauma. We hypothesized that victims of violent trauma who have had 1 prior ED visit for violent trauma will have increased odds of fatal outcome.

Methods: A retrospective chart review was conducted for patients presenting with penetrating trauma to the ED from January 1, 1999 to December 31, 2009. All patients between the ages of 15 to 25 years who presented to the ED for any penetrating trauma were included. Patients with prior presentations for penetrating trauma were compared to those patients who were first-time presenters to determine the odds ratio of fatal outcome.

Results: Overall, 15,395 patients were treated for traumatic presentations. Of these, 1,044 met inclusion criteria. Demographically, 79.4% were Hispanic, 19.4% were African American, and 0.96% were Caucasian. The average age was 21 years, and 98% of the population was male. One hundred and forty-seven (14%) had prior presentations, and 897 (86%) did not. Forty of the 147 patients (27%) with prior presentations had a fatal outcome as compared to 29 patients of the 868 (3%) without prior presentations, with odds ratio of 10.8 (95% confidence interval, 6.4–18.1; Pearson χ^2, $P < 0.001$). The 5-year mortality rate for those patients with fatal outcomes was calculated at 16.5%.

Conclusion: Patients who had prior ED visits for penetrating trauma were at greater risk for fatal outcomes compared to those with no prior visits. Therefore, trauma-related ED visits might offer an opportunity for education and intervention. This may help to prevent future fatalities. [West J Emerg Med. 2012;13(2):146–150.]

INTRODUCTION

Accidents (unintentional injury) and assaults (homicides) are the leading causes of death among the youth of the United States.[1,2] Together, they account for 53.3% of deaths among children aged 1 to 19 years. Of these, assaults, whether penetrating or blunt, account for 10.9% of all deaths. Penetrating injuries account for up to 20% of all pediatric trauma admissions. Homicides are the second leading cause of death among people aged 15 to 24 years, responsible for 5,284 deaths (12.4/100,000).[3] Youth violence is a significant and growing public health problem, especially in urban areas.[4,5] Gunshot wounds are responsible for the overwhelming majority of penetrating traumatic injuries and have a high mortality rate.[1,6] Neighborhood factors that affect youth violence include employment opportunities, local businesses, trash management, vacant housing, street lighting, gang prominence, and the illicit drug market.[7] Other risk factors for the incidence of violent traumatic death include socioeconomic status, race, and place of residence (rural vs urban).[1,8–12] Although these factors may not be modifiable in the acute setting, explaining the consequences of behavior leading to these presentations may stave off future visits. Emergency medicine physicians are frequently at the forefront of the problem, treating young victims of violent crimes. Studies have shown that violence and injury prevention programs can be successful at educating at-risk youths.[13,14] With 5-year mortality rates for recidivism (>2 prior presentations) as high as 20%,[15] it is important to determine whether or not victims of violent trauma are at increased risk for fatal outcomes with only a single prior presentation. These patients may have only 1 opportunity for intervention to help change their behavior and break the cycle putting them at risk. The primary objective of this study was to determine the odds of a fatal outcome for patients with violent trauma and with a single prior presentation of the same. In addition, we sought to determine the 5-year mortality rate of these patients. We hypothesize that victims of violent trauma who have 1 prior visit for violent trauma will have increased odds of a fatal outcome. Secondly, we hypothesize that the 5-year mortality rate will be as high as the national average for all patients with violent trauma.

METHODS

We conducted a retrospective chart review for patients presenting with penetrating trauma to the emergency department (ED) of an inner city hospital. We reviewed the medical records from January 1, 1999 to December 31, 2009. Three separate abstractors (research assistants in the department of emergency medicine) were assigned to review the charts of any patient presenting for penetrating trauma, which are catalogued in the New York State Trauma Registry (NYSTR). The abstractors were trained with practice cases (10 each) of patients outside the study age range. They were blinded to the hypotheses of the study. All 3 abstractors used a standardized form to collect information about penetrating trauma, defined as any gunshot or stab wound not self-inflicted, as coded in the medical record. The abstractors did not review the same cases, as time did not permit for the number of cases being reviewed. The study was conducted at an urban, 347-bed level 1 trauma center, which serves about 155,000 patients in the ED annually. This study was approved by the institutional review board.

Inclusion criteria for this study were patients between the ages of 15 and 25 years who presented to the ED for any penetrating trauma, defined as gunshot or stab wound. Patients who were dead on arrival were included in this study. Patients were excluded if penetrating trauma was self-inflicted.

A list of patient medical record numbers was generated from the NYSTR by using International Classification of Diseases, 9th Revision codes for gunshot and stab wounds. From this list, the electronic records of these patients were obtained. The patient's problem list was then accessed to determine whether or not the patient had presented to our institution in the past for a prior penetrating trauma. Fatal outcomes were determined by electronic death note records. Demographic information was obtained, which included age, gender, ethnicity, and zip code, from the registration information of each patient. Type of injury and location of injury were also recorded. It was not possible to obtain data on patients from other institutions or facilities to determine if patients had had prior visits, as these data were not readily available.

Statistical analyses were performed with the SPSS (IBM, New York, New York) statistical computer software package. Risks of fatal outcome for patients with prior presentations for penetrating trauma were compared to those of patients who were first-time presenters to determine the odds ratio, with statistical significance set at the $P < 0.05$ level. Patient demographics were presented as mean data ($\pm$ standard deviation). To calculate the difference in occurrence of prior stab wounds and gunshot wounds between the groups, z values were determined. The 5-year mortality rate was calculated by determining the number of patients with prior trauma who had died within 5 years of their original episode and dividing this number by all patients with prior trauma visits, both living and dead [5-year mortality rate = prior dead within 5 years/(all prior dead + prior living) $\times$ 100].

RESULTS

During the study period, 15,395 patients were treated for traumatic presentations. Of these, 1,044 patients met the inclusion criteria set forth (age, penetrating injury, etc). This represents 6.78% of the total population sampled. The sample was then further divided into those patients with prior traumatic presentations (147 patients, 14% of population meeting inclusion criteria), and those without such prior presentations (897, 86%). The Table demonstrates the basic demographics of these 2 groups. Our population is mostly composed of Hispanics (829, 79%), followed by African Americans (203, 19%) and Caucasians (11, 1%).

Table. Patient demographics.

	Dead		Living	
	Prior	No prior	Prior	No prior
n	40	29	107	868
Age (y)	22	23	20	21
Gender (% M)	97	96	91	90
Ethnicity (%)				
Caucasian	5	17.24	0.93	0.46
African American	37.5	31.03	44.86	15.09
Hispanic	57.5	51.72	54.21	84.45
Odds ratio (95% CI)	10.8 (6.4–18.1)			
5-Year survival (%)	29 (16.5)			

CI, confidence interval.

Forty of the 147 patients (27%) with prior presentations had a fatal outcome compared to 29 patients of the 868 (3%) without prior presentations. This led to a calculated odds ratio of 10.8 with 95% confidence interval (CI) of 6.4 to 18.1, $P < 0.001$ when tested with Pearson χ^2. This indicates that patients with 1 prior presentation for penetrating trauma had greater odds of having a fatal outcome than those who did not have any prior visits. The 5-year mortality rate for those patients with fatal outcomes was calculated at 16.5%. Overall, 82% of prior presentations were for stab wounds, while only 18% of patients had previously been shot. Patients with prior visits and fatal outcomes had a higher rate of previous gunshot wounds (22.5%) versus stab wounds (77.5%), while patients with prior visits and nonfatal outcomes had a higher rate of stab wounds (84%) versus gunshot wounds (16%). There was no significant difference between the 2 groups when comparing the proportion of prior stab wounds (z value, 0.772; CI, 77.2%) or prior gunshot wounds (z value, 0.606; CI 72.8%). Figure 1 shows the location of injury for patients in each group as well as for the total sample studied. Interestingly, patients were more likely to have a fatal outcome if the injury sustained was to the chest, as opposed to the head or abdomen.

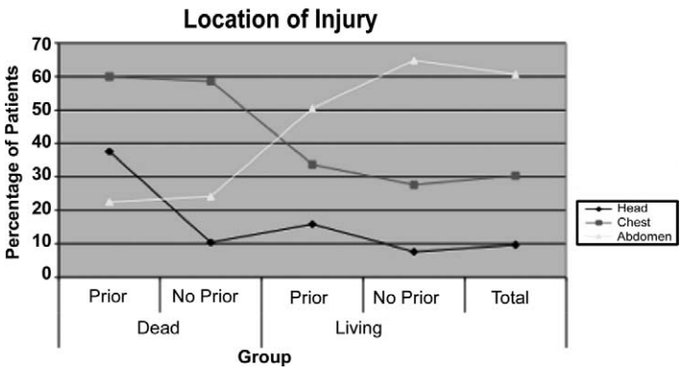

Figure 1. Location of injury in each group. Prior: Patients with any prior presentation for penetrating trauma. No prior: Patients who had no history of prior penetrating trauma.

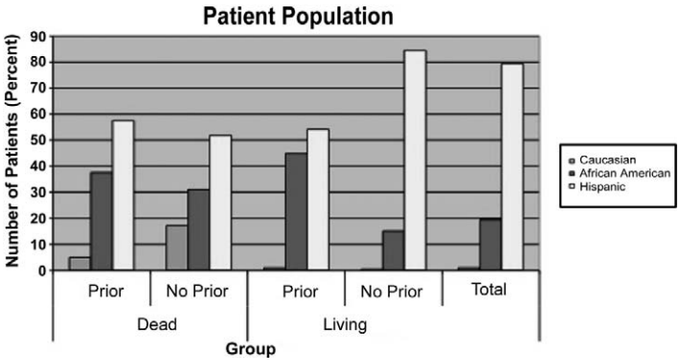

Figure 2. Mean number of presentations per month during the 10-year period, 1999–2009.

During the course of the study, summer and fall were found to be the busiest seasons for traumatic presentations to the emergency department. These were followed by the winter season, with spring being the least busy time of year. Figure 2 demonstrates the monthly breakdown of visits as an average of the 10-year period. Finally, traumatic presentations were seen more commonly at night (defined as 8 PM–8 AM) when compared to the day (defined as 8 AM–8 PM), with a rate of 71% for violent trauma occurring at night.

DISCUSSION

This study demonstrates that the last 10 years have seen a continued increase in the risk for violent trauma recurrence and that interventions should be implemented by public health organizations to evaluate whether the problem can be combated. Although the 14% rate of recidivism in our study is lower than the 18% to 21% rate demonstrated by other recent studies, it nevertheless indicates a failure in prevention.[12,14] Even more considerable is the substantially increased probability of fatal outcome from violent trauma for those young individuals with a history of only 1 prior violent event. Specifically, those with a history of a single prior visit to the ED for violent penetrating trauma were more at risk (odds ratio of 10.8) of death from subsequent violent trauma as compared to those with no prior incidents. The importance of this finding lies in the fact that there may be only a single opportunity for intervention to help reduce a fatal outcome in this vulnerable population. This argument is further supported by our finding of a 5-year mortality rate of 16.5%, highlighting the grave problem that persists despite a reduction in the 5-year mortality, from a rate of 20%, in the last 2 decades.[3]

In our study, victims of violent trauma were almost uniformly of male gender more often than not (98%). This is consistent with prior studies wherein males were found to be the victims of violent trauma 64% to 85% of the time.[14,16,17,20] Distribution of ethnicity, although consistent with the increased number of minority subjects, was weighed more heavily toward

Hispanics in our study, representing 79% of sample subjects. This sample distribution not only reliably represents the demographics of the area surrounding our trauma center but also may indicate a shift in susceptible minority groups.

Racial and socioeconomic parameters including urban setting, low income, unemployment, and access to firearms have been associated with increased violence and death risk.[12,14] Although lower socioeconomic status was not formally evaluated in this study as a potential risk factor for death from violent trauma, it may yet play a role. Information obtained from the US Census Bureau indicates that the population percentage below the poverty level in the Bronx is 27% as compared to 13.8% in New York State and 12.6% in the United States.[18] This suggests that our population suffers from low socioeconomic status, with the risk factors for violence associated with such status (unemployment, gang violence, fewer educational opportunities, etc). Although most of these previously described risk factors cannot be modified, others, such as access to firearms, avoidance of higher-risk situations, and access to care and education, may be improved and result in decreased death rates in this age group. Interestingly, stabbings make up most prior wounds, but subjects with prior gunshot wounds represent most deaths. Consequently, reduction in access to guns may decrease the mortality associated with victim recidivism. This information is especially important in our population, given that deaths from firearms affect minority youth disproportionally both in our sample as well as in others.[14,17,19]

Temporal associations were identified and they indicated that 77% of violent trauma visits occurred during the summer and fall months, with an overwhelming majority occurring in the late night hours. Although no data were available for further analysis, the increased rates of penetrating trauma during these months may be associated with summer recess periods. Prolonged periods of idleness and loitering in this age group, caused by being out of school or unemployed, have been implicated in increased risk-taking behaviors.[12,20,21] Death due to violence has been described as a chronic disease due to recidivism that ultimately can result in death. Several secondary prevention programs have been implemented in major cities including Chicago, Philadelphia, Milwaukee, and Oakland, showing that these programs can reduce future criminal involvement and possibly result in a reduction in death rates.[22] Several screening tools, including the FiGHTS screen, have been shown to decrease violent injury and death.[18] A study (n = 829) performed by Walton et al[23] in Flint, Michigan, showed reduction in violent behavior (risk reduction: intervention, −10.4%; control, +4.7%; relative risk, 0.70; 95% CI, 0.52–0.95) and substance use (risk reduction: intervention, −32.2%; control, −17.7%; odds ratio, 0.56; 95% CI, 0.34–0.91) after a brief intervention in the ED.[23] Although the study differed from ours in that the patient population comprised mostly African Americans (55.9%) and patients were only enrolled at a specific time (between 12 PM and 11 PM), the study still demonstrated a considerable risk reduction through short interventions by ED therapists. Presentation to the ED represents a teachable moment for educating about the risk of future death even after a single violent event. Similar programs may prove successful for the population of the South Bronx.

LIMITATIONS

There are 2 limitations to this study. First, this is a single-center study. The patient population was drawn from those patients admitted to the trauma service and entered into the NYSTR. Consequently, any presentations and deaths due to violent trauma occurring outside of our center were not included in our analysis. Also, patients admitted for trauma to our center may have had prior visits to other medical centers, including for prior penetrating trauma. Second, the population demographics also show a shift in the minority group at risk (ie, Hispanics) as compared to prior studies whose populations are mostly composed of African Americans. Our center is also located in the poorest congressional district in the United States. This demographic tendency may not be typical of other areas, and therefore may decrease the generalizability of our findings. Nonetheless, the problem of victim recidivism itself has been shown to be a significant one in almost all major cities, and we believe the effect of ethnicity is relatively minor. Finally, it may stand to reason that patients with prior traumatic injuries may have died at second presentation because they had a lesser physiologic reserve. These patients may have been weaker (ie, physiologically sicker) to begin with because of a prior traumatic injury. This would be an interesting question to examine in future studies.

CONCLUSION

This study demonstrates a significantly higher odds ratio for fatal outcome, following violent penetrating trauma after just 1 prior presentation for the same. This observation may not allow sufficient time to implement long-term prevention programs as those started for patients with multiple prior presentations. It may therefore be beneficial that the emergency medicine physician try and intervene to change the behavioral pattern of these youths. Brief screening tools and ED interventions with victims of violent trauma have been previously evaluated in prospective trials and have shown promising results in decreasing violent injury and death in young people.

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Alcohol Misuse and Multiple Sexual Partners

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Introduction: We examine the association between self-reported alcohol misuse and alcohol use within 2 hours of having sex and the number of sexual partners among a sample of African-American and Latino emergency department (ED) patients.

Methods: Cross-sectional data were collected prospectively from a randomized sample of all ED patients during a 5-week period. In face-to-face interviews, subjects were asked to report their alcohol use and number of sexual partners in the past 12 months. Data were analyzed using multiple variable negative binomial regression models, and effect modification was assessed through inclusion of interaction terms.

Results: The 395 study participants reported an average of 1.4 (standard error = 0.11) sexual partners in the past 12 months, 23% reported misusing alcohol, and 28% reported consuming alcohol before sex. There was no statistically significant association between alcohol misuse and the number of sexual partners; however, alcohol before sex was associated with a larger number of sexual partners in the past year. Moreover, among those who misused alcohol, participants who reported alcohol before sex were 3 times more likely to report a higher number of sexual partners (risk ratio = 3.2; confidence interval [CI] =1.9–5.6). The association between alcohol use before sex and number of sexual partners is dependent upon whether a person has attributes of harmful drinking over the past 12 months. Overall, alcohol use before sex increases the number of sexual partners, but the magnitude of this effect is significantly increased among alcohol misusers.

Conclusion: Alcohol misusers and those who reported having more than 1 sexual partner were more likely to cluster in the same group, ie, those who used alcohol before sex. Efforts to reduce the burden of sexually transmitted diseases, including human immunodeficiency virus, and other consequences of risky sexual behavior in the ED population should be cognizant of the interplay of alcohol and risky sexual behaviors. EDs should strive to institute a system for regular screening, brief intervention, and referral of at-risk patients to reduce negative consequences of alcohol misuse, including those of risky sexual behaviors. [West J Emerg Med. 2012;13(2):151–159.]

INTRODUCTION

Hospital emergency departments (ED) remain a healthcare safety net for much of the inner-city ED population.[1] Therefore, emergency physicians often have to play the role of primary care providers in addition to attending to the immediate care of their patients. As a result, they have a unique opportunity to understand their patients' risky behaviors and facilitate their access to other needed but unmet services.[2]

Of approximately 100 million annual visits to the ED, nearly 5 million are alcohol related,[1,3] and ED patients are up to 3 times more likely to report negative consequences of heavy drinking.[4] A large portion of these patients are trapped in the habitual misuse of alcohol and use the ED as a revolving door to receive care for alcohol-related diseases and consequences. Improving medical screening and prevention strategies for such patients in the ED can improve the outcome of many of these visits. It would also help ED physicians to redirect the care of these patients to subacute centers, potentially saving EDs millions of dollars spent on patients trapped in a cycle of recidivism for alcohol-related negative consequences.[5] However, this requires clinicians who are vigilant to the screening needs of their patients.[6]

Risky sexual behavior is defined as any behavior that increases the probability of negative consequences associated with sexual contact, including sexually transmitted diseases (STD) and unplanned pregnancy.[7] Risky sexual behaviors are the primary determinants for the risk of STDs, including human immunodeficiency virus (HIV).[8] Specifically, sexual activity with multiple sexual partners is a well-documented risk factor for STDs.[9]

Studies from various populations have documented the role of alcohol in the engagement of risky sexual behaviors.[10–11] These studies report that individuals who misuse alcohol are more likely to report greater intention to engage in risky sexual behaviors,[12] more likely to report having multiple sexual partners,[13–14] less likely to use condoms during sex,[15] and more likely to have sex with someone who they have just met (unintended).[7,16] The underlying assumption of these studies (ie, global association studies) is that drinking alcohol in excessive amounts can increase the likelihood that an individual will engage in unplanned sexual activities or will not use protection when having sex (ie, unsafe sexual practices).[17] Furthermore, the association of alcohol before sex with risky sexual encounters has been reported by earlier studies (ie, situational association and event-level studies).[18–19] Specifically, the relationship between alcohol before sex has been documented among men who have sex with men,[9,20] bisexual men,[21–22] injection drug users,[13,23] young gay men, female bar drinkers,[24] and abused ethnic minority adolescent women.[25]

After decades of research, the purported link between alcohol and risky sexual behavior remains intricate and multifaceted. There are also limited data on the relationship between these variables among African-American and Latino inner-city ED patients. To this end, this paper aims to examine the relative association of alcohol misuse on having sex with more than 1 partner among a sample of African-American and Latino inner-city ED patients, a relationship that has not been well studied in this population. We hypothesize the following: (1) alcohol misuse is directly associated with an increased number of risky sexual activities, measured by a higher number of sexual partners (main-effect hypothesis); (2) there is a stronger direct association between alcohol use within 2 hours of having sex and reported number of sexual partners (situational association hypothesis); and (3) the effect of alcohol before sex on the number of sexual partners is greater among persons who misuse alcohol (interaction-effect hypothesis). We believe results of this study will provide ED clinicians with useful information to improve the delivery of patient care.

METHODS

Study Site and Population

In this prospective study, cross-sectional data were collected from ED patients receiving care in an inner-city large teaching hospital with approximately 50,000 to 60,000 annual visits in South Los Angeles. The area in which the study was conducted is one of the most heavily populated, ethnically, socially, and economically diverse counties in the United States. Of the 1.8 million residents in the area, approximately 36% are African American and 59 % Latino. Approximately 28% of the population lives below the federal poverty level, and 36% of adults are uninsured.[26] This community also has fewer physicians per capita (91.1) compared with Los Angeles county (302.4).[26] A prior study of ED patients revealed that 67% of patients did not have health insurance, and 80% did not have a primary care physician.[2]

Recruitment, Data Collection, and Study Sample

The recruitment for this study was conducted at the urgent care, emergency room (ER), and trauma bay facilities at the ED by 6 bilingual, trained interviewers. Interviewers were stationed in the triage area of the ED on a 24-hour basis for a 5-week period (March through April 2001). Interviewers used computerized logs in the triage area of the ED, which reflected consecutive patients who arrived and registered in the ED. Every other patient from this list was selected for this study. Patients, both male and female, at least 18 years of age, and from all ethnicities, were eligible to participate in the study. Patients in need of immediate medical attention, as determined by the attending physician, were approached for recruitment following their treatment. Patients who showed signs of cognitive impairment, as assessed by the trained interviewers, spoke a language other than English or Spanish, or who were in police custody, were excluded from participation. We delayed recruitment of intoxicated patients until after they became adequately alert. Consenting patients were interviewed using a closed format 45-minute questionnaire, which was available

both in English and Spanish. Approval for this study was obtained from the university institutional review board committee.

Outcome Measures

Number of sexual partners was the primary outcome variable and was measured by asking participants, "How many sexual partners have you had in the past 12 months?".

Predictor Variables

The study predictor variables included alcohol misuse and alcohol use before sex. Alcohol misuse was constructed by using 4 validated alcohol measures, each with a distinct attribute of harmful drinking. The first measure was the Rapid Alcohol Problems Screen 4 (RAPS4), which is a brief screening tool identifying harmful drinking. The RAPS4 has 4 items each scored yes or no; a positive answer to at least 1 item suggests harmful drinking.[27] The reliability and validity of this instrument among African Americans and Latinos is well established.[28] The second measure was the Alcohol Use Disorders Identification Test (AUDIT), which measures at-risk drinking. It is a 10-item questionnaire with a range of possible scores from 0 to 40. We used the recommended cutoff of 8 to detect at-risk drinking.[29] The AUDIT performs well for both genders and ethnic minority groups.[30] The third measure was alcohol abuse, which is assessed by 6 items reflecting the negative physical, social, legal, and psychosocial consequences of drinking.[31] These dichotomous items operationalize the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition* (DSM-IV) of the American Psychiatric Association criteria for alcohol abuse and have been validated for the minority population.[27] A positive response to 1 or more items reflects alcohol abuse.[32] Finally, alcohol dependence was measured by 19 items reflecting the DSM-IV criteria for alcohol dependence in the past year.[33] These items assess 7 domains of tolerance, withdrawal, unintended drinking, unsuccessful efforts to control drinking, giving up pleasures or interests to drink, spending a great deal of time in drinking activities, and continued use despite problems. Individuals were diagnosed as alcohol dependent if, in their responses to the 19 items, they endorsed at least 3 of the 7 domains. The aforementioned 4 measures were combined to generate a more comprehensive and robust measure of alcohol misuse within the past 12 months. Participants who scored positive on at least 2 of the alcohol measures were grouped as having a history of alcohol misuse (Cronbach's $\alpha = 0.87$).

Alcohol use before sex was measured by asking the patient, "In the last 12 months, how often did you use alcohol within 2 hours of having sex"? Responses were scored as 1 (all the time) to 5 (never). Respondents who reported all the time, most of the time, and/or some of the time were recoded as yes (or 1); and those who reported rarely and/or never were recoded as no (or 0).

Psychosocial and Demographic Control Variables

For this study, we measured risk-taking/impulsivity and depressive symptoms because evidence suggests that these conditions are related to both alcohol use and risky sexual behaviors.[34–40] We measured risk-taking/impulsivity using the revised version of the Eysenck[41] impulsivity subscale; a 5-item, 4-point scale, ranging from 5 to 20 with a Cronbach's α of 0.80. A composite score of these 5 items was computed with higher values corresponding to higher impulsivity. We classified respondents with a score of 9 or less as less impulsive (=0) and those with higher scores as highly impulsive (=1).[34]

Depression symptoms were measured by the Center for Epidemiological Studies Depression Scale (CES-D) that includes a 20-item, 4-point scale, ranging from 4 to 60 with Cronbach's α of 0.80.[42] We assigned respondents with a score of less than 16 as no symptoms of depression and those with a score of 16 or greater as depressed.[43] The time period used in all analyses was the previous 12 months, except for CES-D, which provided an estimate of depressive symptoms for the last 7 days. The decisions for cutoff points for the variables in the study were directed by previous studies, as cited above. Demographic variables included gender, age, education, marital status, and ethnicity. Ethnicity was assessed by asking the respondents to self-identify their own ethnicity from 9 categories, including black, African American, Latino, Mexican, Mexican American, Chicano, or of other Spanish heritage, white, Middle Eastern, and Native American Indian.

Data Analysis

Exploratory analyses were performed to assess the relationship between the alcohol variables and the number of sexual partners and to guide the specification of which psychosocial and demographic variables to include in the final multivariable models. Diagnostic analyses indicated evidence of overdispersion; therefore, negative binomial regression models were used to examine the association between the number of sexual partners in the past 12 months and each alcohol measure. Negative binomial regression provides risk ratios (RR), interpreted as the ratio of means and for presentation. Results from all regression models are reported in terms of the RR rounded to the second decimal place. All regression models simultaneously were adjusted for the same psychosocial measures and demographics. Statistical analyses were performed using the software package Stata version 11[44] and were based on 2-sided hypotheses and a 5% significance level.

RESULTS

Descriptive Findings

Of 579 eligible patients, 412 completed the study survey, representing a 71% survey completion rate, which approximates rates of previous ER studies.[45] Participants and nonparticipants were similar with respect to ethnicity, age, and gender. Given the frequency distribution of the race/ethnicity

Table 1. Descriptive statistics and unadjusted bivariate negative binomial regression analyses.

	Mean or proportion (SE)	Bivariate model (RR [SE]; 95% CI)
Number of sexual partners	1.42 (0.11)	
Alcohol measures		
Alcohol misuse (yes)	0.23 (0.02)	1.29 (0.17); 1.00–1.66*
Alcohol prior to sex (yes)	0.28 (0.02)	1.80 (0.21); 1.43–2.27‡
Psychosocial variables		
Risk-taking/impulsivity (>9.01)	0.38 (0.02)	1.43 (0.16); 1.15–1.77†
Depression symptoms (CES-D $\geq$ 16)	0.51 (0.03)	1.15 (0.13); 0.92–1.43
Demographics		
Gender (male)	0.62 (0.03)	2.01 (0.24); 1.60–2.53‡
Race (African-American)	0.51 (0.03)	1.51 (0.17); 1.21–1.88‡
Education (less than high school)	0.49 (0.03)	0.77 (0.09); 0.62–0.96*
Marital status (separated/divorced/widowed/not married)	0.60 (0.03)	1.23 (0.14); 0.99–1.55
Age	37.95 (0.76)	0.98 (0.00); 0.97–0.99‡

RR, risk ratio; *SE*, standard error; *CI*, confidence interval; *CES-D*, Center for Epidemiological Studies Depression Scale.
* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$

variable, we recoded this variable into 2 groups; African American versus Latino. Thirteen patients who identified their race/ethnicity as other were excluded from the analysis, in addition to 4 who would not answer this question. Therefore, the final sample for this study included 395 African-American and Latino ED patients**.**

Table 1 displays the overall characteristics of the participants in reference to the study variables (second column). On average, participants reported 1.4 sexual partners (standard error = 0.11) in the past 12 months; 13% had 2 partners, and 15% had 3 or more. Nearly a quarter misused alcohol (23%) or reported drinking alcohol within 2 hours prior to sex (28%). Approximately half exhibited depression symptoms (51%), and over a third were considered highly impulsive (38%). The average age of the participants was 38 years (standard deviation = 14). Participants were equally divided between African Americans (51%) and Latinos (49%), 62% were male, 51% did not graduate from high school, and 60% were living alone.

Bivariate Findings

The second column of Table 1 displays the unadjusted associations between the independent variables and outcome. Both alcohol measures were positively associated with the number of sexual partners. Individuals with a history of alcohol misuse reported 28% more sexual partners (RR = 1.29; 95% confidence interval [CI] = 1.0–1.66), whereas those drinking alcohol before sex reported 88% more sexual partners (RR = 1.8; 95% CI = 1.43–2.27). Further, reporting depressive symptoms in the past 7 days, being highly impulsive, male, African American, or single increased the reporting of more sexual partners ($P < 0.05$). However, being less educated (less than high school vs completed high school or GED) and of older age decreased the average number of sexual partners.

Multivariate Findings

We excluded nonsignificant demographic variables identified in the unadjusted analysis from the multivariable analysis. To test the first 2 study hypotheses, which were to determine if alcohol misuse and alcohol use before sex were statistically and directly associated with number of sexual partners, we estimated the negative binomial regression models 1 and 2. After inclusion of the psychosocial and demographic variables, alcohol misuse lost the direct association with number of sexual partners ([RR = 1.06; 95% CI = 0.81, 1.40]; model 1) but alcohol use before sex remained significantly and positively associated with number of sexual partners ([RR = 1.4; 95% CI = 1.11, 1.78]; model 2).

Interaction Test

In the third model (Table 2), we added an interaction term to test the hypothesis that alcohol misuse modified the effect of alcohol before sex on the number of sexual partners. Among those who misused alcohol, those reporting alcohol before sex, on average, had 3 times more sexual partners than those not consuming alcohol prior to sex (RR = 3.2; 95% CI = 1.84, 5.57). This effect between alcohol before sex and number of sexual partners was attenuated among individuals without a history of alcohol misuse (RR = 1.33; 95% CI = 0.98, 1.81).

Further, consistent across all 3 models in Table 2, the number of sexual partners significantly varied by gender, race/ethnicity, and age. In other words, males and African

Table 2. Results of multivariable negative binomial regression analyses on number of sexual partners in the past month.

	Risk ratio (standard error); 95% CI		
	Model 1	Model 2	Model 3
Alcohol misuse			
No (ref.)			
Yes	1.06 (0.15); 0.81–1.40		0.46 (0.13); 0.27–0.78†
Alcohol before sex			
No (ref.)			
Yes		1.40 (0.17); 1.11–1.78‡	1.33 (0.21); 0.98–1.81
Risk-taking			
Low (ref.)			
High	1.07 (0.14); 0.83–1.37	1.13 (0.13); 0.89–1.42	1.06 (0.13); 0.83–1.36
Depression symptoms			
No (ref.)			
Yes	1.18 (0.14); 0.93–1.48	1.13 (0.13); 0.91–1.41	1.17 (0.14); 0.93–1.47
Gender			
Female (ref.)			
Male	1.82 (0.23); 1.42–2.34‡	1.79 (0.22); 1.41–2.27‡	1.77 (0.22); 1.38–2.27‡
Race			
Latino (ref.)			
African American	1.26 (0.15); 0.99–1.60	1.38 (0.16); 1.10–1.73	1.28 (0.15); 1.02–1.62*
Education			
Less than high school (ref.)			
High school or GED	1.02 (0.13); 0.80–1.30	1.01 (0.12); 0.80–1.27	1.05 (0.13); 0.83–1.33
Age	0.98 (0.00); 0.97–0.99‡	0.98 (0.00); 0.97–0.99‡	0.98 (0.00); 0.97–0.99‡
Alcohol prior to sex			
Alcohol misuse (yes)			3.20 (0.90); 1.84–5.57†
Alcohol misuse (no)			1.33 (0.21); 0.98–1.81

CI, confidence interval; *ref.*, reference; *GED*, general educational development.
* $P < 0.05$.
† $P < 0.01$.
‡ $P < 0.001$.

Americans reported, on average, more sexual partners, and the average number of sexual partners in the sample decreased with increasing age. Unlike the unadjusted analysis, neither of the psychosocial variables was significant in the 3 multivariable models.

DISCUSSION

The primary objective of this study was to test a series of models to assess the role of alcohol for differences in the number of sexual partners among a sample of ED patients. We were not able to detect a statistically significant direct association between alcohol misuse and report of higher number of sexual partners in our sample in the adjusted multivariable model. This finding is in contrast with findings that support global association between problem drinking and risky sexual behavior.[46–48] Several proponents of the global link between alcohol and risky sexual behavior offer alcohol myopia theory[49] to explain this relationship. They suggest that alcohol reduces individuals' capacity to engage in high-order cognitive functions, and instead individuals become preoccupied with salient clues such as intimacy and immediate pleasure without due consideration of the potential risk involved with risky sexual activity.[50] They directly relate the level of intoxication with the diminution of the capacity to appropriately process risk. Intoxication, therefore, becomes an important determinant of risky sexual behavior.[51] Lack of global association in our data could be the result of chemical tolerance that individuals build over time with chronic use of alcohol; therefore, they have more control over their behaviors when intoxicated. Alternatively, it could be the result of the limited definition of unsafe sex we used in this study. Additional items besides

number of sexual partners are needed to substantiate our findings.

We also tested the situational association hypothesis, claiming that there will be a statistically significant association between alcohol use before sex and report of higher number of sexual partners in the sample. This hypothesis was confirmed by our data in bivariate as well as multivariable models, supporting findings similar to situational association studies[52] and some event-level association studies that suggest drinking prior to sexual activity is associated with increased sexual risks. This association is partly explained by alcohol expectancy theory.[53] Proponents of this theory[54] argue that individuals who think that drinking alcohol will cause them to become less nervous and more sexually uninhibited are more likely to use it before a sexual encounter.

Finally, we tested an interaction hypothesis claiming that the effect of alcohol before sex on the number of sexual partners will be greater among those who misuse alcohol. We found that alcohol use before sex did increase the average number of sexual partners and that this association was significantly magnified among those who misused alcohol. Therefore, the context of harmful drinking in the past 12 months affects the relationship between alcohol before sex and the number of sexual partners. This finding can help to better understand the nature of the relationship between alcohol and risky sexual behavior. It seems alcohol misusers and those who report having more than 1 sexual partner in the past 12 months are more likely to cluster in 1 group, those who use alcohol prior to sex. Therefore, this group might benefit from prevention measures to reduce negative consequences of alcohol misuse and the burden of STDs, including HIV, in the ED population.

It is also worth mentioning that, while our study sample was not a priori selected for HIV risk behaviors, 28% of this sample engaged in 1 aspect of HIV-related risk behaviors (ie, having multiple sexual partners). This in combination with the 23% who reported misusing alcohol, 28% who used alcohol before sex, 51% who reported symptoms of depression, and 28% who were highly impulsive calls for the attention of hospital EDs to facilitate or integrate risk prevention efforts into the existing services of the ED, an opportunity that is not available elsewhere for most of these patients.

ED providers are in a unique position to use an ED visit as a window of opportunity and the concept of the teachable moment for contemplating change in their patients.[55] A 5-year evaluation of an ED-based screening, brief intervention, and referral to a treatment program for unhealthy alcohol and other drug use showed that the project has been successful at integrating into an urban ED.[56] Also, results of screening and providing brief intervention and referral for counseling or treatment (SBIRT) suggest this technique may be among inexpensive, evidence-based solutions to intervene with risky behaviors and unmet needs of ED patients.[1,57,58] Delivered by ED providers and tested in 14 ED settings nationwide, SBIRT offers a brief negotiated interview with direct referral for treatment to at-risk and alcohol-dependent patients. Results of the 3-, 6-, and 12-month follow-up surveys indicated that this technique has the short-term effect of reducing alcohol consumption by ED patients. It further confirmed the earlier finding that ED physicians with appropriate training and institutional support can deliver SBIRT.[59] Nevertheless, the authors suggested that multicontact interventions or booster programs may be needed to maintain long-term reductions in risky drinking. High participation rates of ED patients in SBIRT-related studies suggest patients are also ready for and accept counseling for alcohol problems.[60] Yet practice of SBIRT seems to be lagging behind national guidelines that recommend all level 1 and 2 trauma centers implement SBIRT as part of routine trauma care.[61–62]

Limitations

Bias related to respondent recall and social desirability of responses should be considered. This study utilized standardized measures and intensive training of research assistants to minimize any such bias. In addition, the study instrument included several alcohol-related measures for assessing the subject's alcohol consumption to guard against acquiescence bias (subjects' tendency to express agreement or disagreement toward a statement regardless of its content).[63] Reliability of alcohol intake based on self-report is based upon evidence for a close correlation between biological markers and self-report of alcohol intake.[64] Another significant limitation has to do with the lack of multiple items to measure risky sexual behaviors. Future studies should include a more comprehensive assessment of such risk s (eg, unprotected sex, condom use, etc) to capture the full magnitude of the effect of alcohol-related global association. These studies also should collect information regarding the frequency of sex while intoxicated and the antecedent or temporal behavioral factors that influence such decisions. This will allow for a determination of any existing associations at the sexual event level and also identify risks individuals are willing to incur during sexual encounters.[49]

CONCLUSION

This study examined the association between alcohol misuse, alcohol use before sex, and multiple sex partners among ED patients in a US inner-city hospital. The study population allowed for targeting a disadvantaged, high risk-taking group with over a quarter of the sample reporting multiple sex partners.

While we failed to support the purported global link between alcohol misuse and number of sexual partners, we found patients who used alcohol within 2 hours of having sex were more likely to engage in sex. Furthermore, the interaction effect between alcohol misuse and alcohol use before sex suggests that the effect of the transient acute use of alcohol

before sex on the number of sexual partners is dependent on whether the person misuses alcohol or not.

Future Direction

Those striving to reduce the burden of STDs, including HIV, and other consequences of risky sexual behavior in the inner-city ED population should be cognizant of the interplay of alcohol and risky sexual behaviors. To adequately address these issues, EDs should institute a system for regular screening, brief intervention, and referral of patients at risk for alcohol misuse. Several ED studies have reported the feasibility,[65] benefits,[57] and acceptability[66] of this approach. Further, the American College of Surgeons Committee on Trauma mandated in 2006 that SBIRT be implemented in ED settings,[61] and the US Center for Medicare and Medicaid Services since 2007 has allowed hospital EDs to reimburse for alcohol and drug screening and brief intervention. These are potentials for providing EDs with a regular revenue stream; a built-in incentive that may encourage EDs and ED physicians to facilitate implementation of this critically important public health intervention.[1]

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Red Flags in ECG for Emergency Physicians: Remembering Wellens' Syndrome and Upright T wave in V_1

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We present a case of Wellens' syndrome together with upright T wave in lead V_1 in a man presenting with atypical chest pain, and we discuss the significance of its prompt recognition by the emergency physicians who are involved in the evaluation of patients with coronary artery disease in emergency departments. [West J Emerg Med. 2012;13(2):160–162.]

INTRODUCTION

As the electrocardiography (ECG) is a simple, noninvasive tool in the diagnosis and management of coronary artery disease (CAD), emergency physicians (EP) must be proficient in the interpretation of ECGs during evaluation of patients in the emergency department (ED). Sometimes specific T-wave changes for coronary artery disease in precordial ECG derivations may be interpreted as nonspecific T-wave changes by EPs. Failure to diagnose these conditions with subsequent inappropriate management may have fatal consequences.

CASE REPORT

A 67-year-old man presented to the ED with anterior chest pain that did not radiate to the neck and left arm. The pain was localized, tight in nature, and had no association with exertion. The patient came from home where the chest pain initiated and was pain free on admission to the ED. His positive cardiac risk factors were smoking and hypertension. The examination was unremarkable. A 12-lead ECG was performed when the patient was free of discomfort and showed normal sinus rhythm with positive T wave in V_1, which was greater than T waves in V_6 (Figure 1, upper trace). Serum troponin I concentration was 0.03 ng/ml (normal values $<$0.04 ng/ml). The patient was admitted to the cardiology service for ECG and cardiac marker follow up. Approximately 4 h later, repeated ECG (Figure 1, lower trace) showed obvious positive T waves in V_1 and biphasic T waves in leads V_{2-3} and negative T waves in V_{4-5} without chest pain. There were also inverted T waves in lateral leads. Repeated serum troponin I concentration was within the normal range. The electrocardiograph pattern raised the possibility of left anterior descending (LAD) coronary T-wave syndrome. The patient was transferred to another center for cardiac catheterization, which revealed a 95% proximal LAD artery occlusion (Figure 2). The patient underwent emergent percutaneous coronary intervention following coronary angiography with successful outcome.

DISCUSSION

Chest pain is one of the chief presenting complaints among patients attending EDs. Emergency physicians must be able to evaluate these patients and identify those with an underlying life-threatening cause. The ECG is a better predictor of adverse events than history and presenting symptoms in patients with probable acute coronary syndrome (ACS), and it plays a large role in the EP's disposition decision.[1]

T-wave abnormalities are the most common ECG abnormality seen in ED patients, occurring in up to 30% of patients with a potential ACS, and their significance has been less clearly defined.[2] Studies conducted on cardiac care unit patient populations have shown that, in patients with isolated

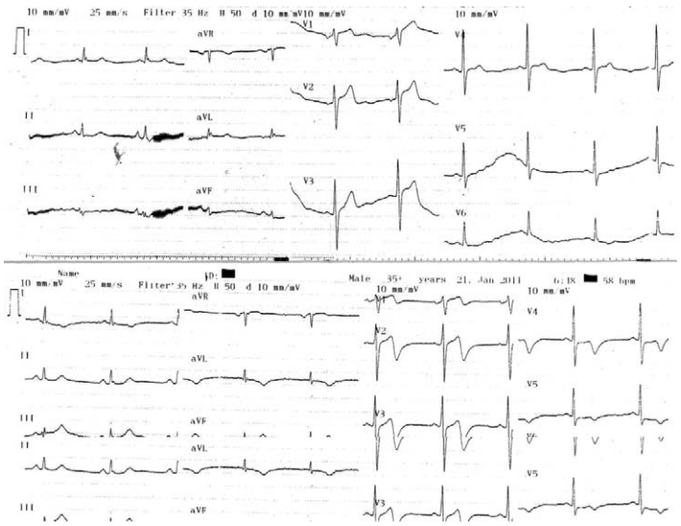

Figure 1. ECG of the patient at presentation showing tall, positive T wave in lead V_1 (upper trace). ECG of the patient 4 h later showing biphasic T-wave inversions in right precordial leads and deep negative T-wave inversions in left precordial leads. There is no significant ST segment elevation or R progression loss (lower trace).

precordial T-wave inversions, up to 87% have LAD artery stenosis documented at angiography.[3] In patients with known CAD, T-wave flattening or inversions raise concern for an ACS; and in patients without known CAD, T-wave abnormalities should still be considered to raise a patient's 30-day risk. Presence of isolated T-wave abnormalities at the time of ED presentation predict 30-day cardiovascular events, even in patients without a prior history of CAD.[4]

It has been shown that there is a close association between precordial T-wave inversions and LAD disease in the setting of unstable angina, and 47% of patients presenting with acute myocardial infarction with upright T-waves in V_1–V_3 had significant LAD disease in coronary angiography.[3,5] Studies have shown that development of new T-wave changes in the precordial leads (which need not be isolated in midprecordial leads) in patients with unstable angina is a predictor of significant stenosis of the LAD artery and can identify a subgroup of patients with angina with a poor response to medical treatment.[3,6–8]

In 1982, De Zwann et al[9] described a characteristic ECG pattern associated with a critical stenosis of the LAD coronary artery and impending myocardial infarction. Tilkian[10] was the first to use the term Wellens' syndrome defined as a group of ECG signs that occur during the pain-free period in a patient with unstable angina. These ECG changes in the absence of pathologic Q waves are predictive of a critical proximal LAD stenosis.[9] They consist of an isoelectric or minimally elevated ST segment followed by a concave or straight ST segment and symmetrically inverted (or biphasic) T waves in the precordial

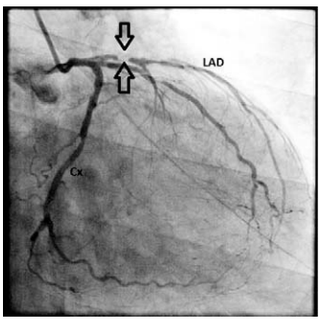

Figure 2. Coronary angiography showing critical, high-grade narrowing of the proximal left anterior descending coronary artery (between arrows). LAD, left anterior descending coronary artery; Cx, circumflex artery.

leads, frequently in V_2–V_3, but sometimes involving V_4, V_5, or V_6.[9] This was the case for our patient, who showed biphasic T waves in $V_{2–3}$ and negative T waves in $V_{4–5}$ during pain-free period. Other than Wellens' syndrome, there was a subtle ECG change, which was an upright T wave in V_1.

Wellens' syndrome and positive T waves in lead V_1 in patients with chest pain are preinfarction stages of coronary artery disease. Patients with this syndrome present with characteristic ECG findings in the precordial leads. Sometimes more subtle changes precede the development of the Wellens' syndrome, such as isolated T-wave changes in precordial leads, which are also predictors of advanced LAD lesion and can be easily misinterpreted. While evaluating the ECG on ED settings, one should not forget these red flags for emergency patients. Once these changes have been recognized, cardiology consultation for possible coronary angiography is likely necessary to further evaluate the patient. Stress imaging is strongly discouraged in the presence of suspected left main or left main equivalent lesions and may result in fatal outcome in patients with Wellens' syndrome.[11,12]

Without prompt diagnosis and aggressive intervention, patients with Wellens' syndrome may go on to develop extensive anterior wall myocardial infarction, the majority occurring within a matter of days.[9]

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Time Series Analysis of Emergency Department Length of Stay per 8-Hour Shift

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Introduction: The mean emergency department (ED) length of stay (LOS) is considered a measure of crowding. This paper measures the association between LOS and factors that potentially contribute to LOS measured over consecutive shifts in the ED: shift 1 (7:00 AM to 3:00 PM), shift 2 (3:00 PM to 11:00 PM), and shift 3 (11:00 PM to 7:00 AM).

Methods: *Setting:* University, inner-city teaching hospital. *Patients:* 91,643 adult ED patients between October 12, 2005 and April 30, 2007. *Design:* For each shift, we measured the numbers of (1) ED nurses on duty, (2) discharges, (3) discharges on the previous shift, (4) resuscitation cases, (5) admissions, (6) intensive care unit (ICU) admissions, and (7) LOS on the previous shift. For each 24-hour period, we measured the (1) number of elective surgical admissions and (2) hospital occupancy. We used autoregressive integrated moving average time series analysis to retrospectively measure the association between LOS and the covariates.

Results: For all 3 shifts, LOS in minutes increased by 1.08 (95% confidence interval 0.68, 1.50) for every additional 1% increase in hospital occupancy. For every additional admission from the ED, LOS in minutes increased by 3.88 (2.81, 4.95) on shift 1, 2.88 (1.54, 3.14) on shift 2, and 4.91 (2.29, 7.53) on shift 3. LOS in minutes increased 14.27 (2.01, 26.52) when 3 or more patients were admitted to the ICU on shift 1. The numbers of nurses, ED discharges on the previous shift, resuscitation cases, and elective surgical admissions were not associated with LOS on any shift.

Conclusion: Key factors associated with LOS include hospital occupancy and the number of hospital admissions that originate in the ED. This particularly applies to ED patients who are admitted to the ICU. [West J Emerg Med. 2012;13(2):163–168.]

INTRODUCTION

Emergency department (ED) mean length of stay (LOS) per patient measured from the patient's arrival to departure has been promoted as a surrogate indicator of crowding in the absence of a standard or universal definition. It is also frequently considered a key process indicator for performance improvement and clinical and operational efficiency.[1] From the patient's perspective, total LOS and long wait times to see a physician or for test results create the sense that the ED is busy and crowded; however, a major limitation of LOS as an indicator of crowding is the retrospective nature of the measure; it cannot readily be used to manage flow real time.

It is important that variables associated with crowding are identified for optimal management of flow in the ED. It is of particular interest to define variables that are amenable to administrative change and redesign in order to reduce variability in performance.[2] Asplin et al developed an input-throughput-output conceptual model of ED crowding which forms the basis for our selection of factors for study.[3] Input factors, such as the number of unscheduled ambulatory care ED visits and emergency medical services transports, cannot be controlled except by diverting ambulances away from the ED. These factors were therefore not included as covariates in the current analysis. Throughput relates to factors that are influenced by flow processes in the emergency, laboratory, and radiology departments from the time of triage to the time of disposition. Nursing staffing was included as a throughput factor in this study, as it can be controlled by administrative design. Mandatory ED nursing staffing ratios of 1 nurse for every 4 patients has led to a reduction in wait time to ED bed and ED bed to departure in the State of California.[5] While staffing patterns would appear to be an important throughput factor, previous studies have not found attending physician staffing to be a statistically significant factor influencing LOS.[4] Consequently, attending physician staffing was not included in the present analysis. Output factors relate to the disposition of patients to home, chronic care facilities, or inpatient beds. Intense competition for the latter may occur especially on weekdays, when patients are frequently admitted to an inpatient bed either before or after elective surgical procedures; this is an example of artificial variability that is amenable to change on an institutional level. Similarly, the expediency of the departure process from the ED is an important output factor and the number of discharged patients per shift (ED discharges) leaving for home, an inpatient bed, or for another facility was therefore incorporated as a covariate in the study.

Studies have documented statistically significant associations between LOS measured over 24-hour periods and hospital occupancy, the number of ED admissions, and the number of elective surgical cases that were admitted directly to an inpatient bed while bypassing the ED.[4] As recommended by other investigators, our goal was to measure the associations between throughput and output factors and LOS in more discreet time periods than previously reported.[6,7] Since ED crowding and volume vary greatly during a given 24-hour period, we measured the independent variables during 3 separate 8-hour shifts per 24-hour period, when possible. Our purpose was to discern which covariates of interest were associated with LOS and, when relevant, whether this relationship was present during all shifts or only specific 8-hour shifts.

METHODS

Study Design

The purpose of the study was to measure the associations between the LOS measured during 8-hour time periods and covariates that we believed were related to ED crowding. LOS was measured in minutes as a continuous variable from the time of registration to the time of departure from the ED for all patients whether they were discharged, transferred to another facility, or admitted to an inpatient ward.

Setting and Participants

The study was conducted in a level 1 trauma center in an inner-city university teaching hospital. Data was collected retrospectively from ED and hospital electronic logs for all 91,643 adult ED visits over an 18-month period from October 12, 2005 to April 30, 2007. Patients aged 21 and under were not included in this analysis, as they were seen in a separate pediatric ED. The only exception to this rule was multiple trauma patients aged 15 and over.

Methods of Measurement

LOS and the covariates were measured with an electronic information technology system (IBEX, now Piscis ED Pulsecheck), which allowed reporting of these data during 8-hour shifts.[8] We chose the following 8-hour time periods since they coincided with the clinical shifts for nurses: shift 1 (7:00 AM to 3:00 PM), shift 2 (3:00 PM to 11:00 PM), and shift 3 (11:00 PM to 7:00 AM). We measured the LOS per shift as well as the LOS on the previous shift. For each 8-hour shift, we measured the numbers of (1) ED nurses on duty; (2) ED discharges defined as patients leaving the ED whether admitted, transferred to another facility, or discharged; (3) ED discharges (as explained earlier) on the previous shift; (4) resuscitation cases; (5) admissions, ie patients seen in the ED who are subsequently admitted to an inpatient unit; and (6) intensive care unit (ICU) admissions, ie patients seen in the ED who are subsequently admitted to the ICU. The number of nurses on duty was included as a measure of staffing.[9] ED resuscitation cases were cared for in resuscitation bays by a designated team of physicians, nurses, and aides drawn from the ED's staffing pool. Our information technology system assigned patient visits to a specific shift based on the time of departure from the ED rather than the time of initial presentation.

The following independent variables were measured for each 24-hour period and therefore did not vary in their relationship with LOS by shift: (1) number of elective surgical cases that were admitted directly as inpatients while bypassing the ED (elective surgical admissions) and (2) hospital medical-surgical occupancy (hospital occupancy). The latter was defined as the number of patients in an adult medical or surgical hospital bed at midnight plus the number of patients discharged in the preceding 24 hours divided by the total number of staffed inpatient beds. Forster et al previously described this definition of hospital occupancy.[10] We chose this definition in our analysis because the measure more accurately reflects total inpatient bed utilization over a 24-hour period than hospital occupancy measured at a given point in time.

Data Analysis

We retrospectively analyzed the associations between the LOS per 8-hour shift and the covariates of interest. LOS on the previous shift, hospital occupancy, and the numbers of ED discharges on the current shift as well as the previous shift, nurses on duty, admissions, resuscitation cases, and elective surgical admissions were analyzed as continuous variables. The number of ICU admissions was analyzed as a categorical variable based on the admission of 1, 2, or 3 critical care patients from the ED per shift. Descriptive statistics included frequency distributions, means, medians, and 95% confidence intervals. Only those variables with a confidence interval that did not contain 0 were considered statistically significant.

Observations between consecutive 8-hour shifts are not independent of each other due to the correlation of LOS between one shift and the next. The data was therefore analyzed using an autoregressive integrated moving average (ARIMA) time series model to account for the presumed serial correlation between successive 8-hour periods.[11] The autoregressive term refers to the period of autocorrelation. For example, in our dataset, the unit of measure was 1 shift defined as a single 8-hour period. An autoregressive process or lag of 1 would indicate that the model takes into account the ED mean LOS of the previous shift. The adequacy of the model was analyzed using the autocorrelation function and periodogram. We used the Akaike information criteria (AIC) to select the appropriate ARIMA model. Stationarity of the ARIMA model was examined by using the Dickey-Fuller and Phillips-Perron unit root tests. Portmanteau statistics were used to determine if any autocorrelation remained in the residuals of the model. Interaction terms between the shift and other covariates were examined for statistical significance to determine if key variables varied in their relationship with LOS at different times of the day.

All variables of interest were included in the models to illustrate their impact on LOS, whether or not it was significant. We additionally investigated the impact of removing variables that were not significant and found that the results did not change dramatically. Therefore, we report results of the full models. Data were analyzed using STATA/SE 8.2 for Windows (Stata Corporation, College Station, Texas). The study was approved as exempt research by local institutional review.

RESULTS

A total of 1,689 8-hour shifts were analyzed during the study period. The mean number of patient visits per 8-hour shift was 54.2, and the mean LOS was 232 minutes for all patients, whether they were admitted, discharged, or transferred. Hospital occupancy was high during the study period with a mean of 94.9% and a range of 67.6% and 112.1%. The measure may exceed 100% since the numerator is the sum of patients physically in beds at midnight plus the number of patients discharged in the previous 24 hours. We could not demonstrate a nonlinear effect of occupancy on LOS after analyzing residuals and considering a quadratic term for occupancy in the models. The residual plots looked good and showed no signs of heteroscedasticity. The quadratic term was not significant, and the fit of the model by AIC was not improved significantly when it was added. The mean number of elective surgical admissions was 24 per 24-hour period. As expected, shift 2 was the busiest in terms of numbers of discharged patients, admissions, ICU admissions, and resuscitation cases. Outcome and explanatory variables are summarized in total and by 8-hour shift in Table 1.

The results of the ARIMA time series analysis are presented in Table 2. An ARIMA (2, 2) model provided the best fit to control for autocorrelation in the data. Most notably, the interaction between shift and hospital occupancy was not statistically significant, indicating that hospital occupancy did not vary by shift in its statistically significant association with LOS.

For every additional 1% increase in hospital occupancy, LOS in minutes increased by 1.08 (0.68, 1.50, $P < 0.001$). The number of ED admissions was statistically significantly associated with LOS on all 3 shifts. For every additional admission from the ED, LOS in minutes increased by 3.88 (2.81, 4.95) on shift 1, 2.88 (0.47, 5.28) on shift 2, and 4.91(2.29, 7.53) on shift 3. Three or more ICU cases (compared to 0) admitted from the ED per shift prolonged LOS by 14.27 minutes (2.01, 26.52) on shift 1, but a significant association was not found on shifts 2 or 3. Fewer than 3 ICU admissions failed to demonstrate an association with LOS on any of the 3 shifts. Every additional 1 minute increase in LOS on shift 1 was associated with a 0.29-minute (0.08, 0.51) increase in LOS on shift 2. For every additional ED discharge, LOS decreased by 1.10 minutes (1.52, 0.69) on shift 1, but increased by 1.54 minutes (0.54, 2.54) on shift 3. The numbers of nurses, ED resuscitation cases, discharges on the previous shift, and elective surgical admissions were not associated with LOS in multivariate analysis.

DISCUSSION

A number of prior studies have attempted to measure the associations between input, throughput, and output variables and ED LOS measured during 24-hour periods.[4,12] Asplin et al has suggested that measuring LOS during shorter time periods may offer more relevant data since the level of crowding can change significantly from hour to hour;[7] to that end, we measured variables during 8-hour shifts and performed a multivariate analysis to determine significant predictors of ED flow and LOS.

We chose to use a definition of hospital occupancy that reflects total inpatient bed utilization and demand over a 24-hour period. The results of prior studies that have used a similar measure suggest that it is a predictor of ED flow and LOS.[4,10] Our study also supports this conclusion as it was a significant predictor of LOS in the analysis. The mean hospital occupancy in our institution during the study period was 94.9%. At this

Table 1. Summary of length of stay (LOS) and throughput and output factors.*

	Overall	Shift 1	Shift 2	Shift 3
Throughput factors				
Mean ED LOS (min, SD)	232.81 (47.22)	211.42 (42.50)	244.95 (40.27)	242.08 (50.80)
Mean number of nurses per shift (SD)	12.01 (2.02)	11.71 (0.94)	14.35 (0.99)	9.98 (0.80)
Mean number of ED resuscitation cases per shift (% of total, SD)	1.56 (1.26)	1.12 (0.95)	2.29 (1.37)	1.28 (1.10)
Output factors				
Mean number of ED discharges per shift (SD)	54.15 (17.50)	49.35 (7.60)	74.52 (10.37)	38.58 (8.53)
Mean number of ED admissions per shift (SD)	11.99 (5.98)	8.08 (2.97)	18.56 (4.80)	9.34 (3.18)
Number of ED ICU admissions (%)				
0 per shift	338 (59.93)	348 (61.81)	274 (48.67)	391 (69.45)
1 per shift	169 (29.96)	174 (30.91)	195 (34.64)	137 (24.33)
2 per shift	43 (7.62)	35 (6.22)	67 (11.90)	27 (4.80)
3 per shift	14 (2.48)	6 (1.07)	27 (4.80)	8 (1.42)
Mean number of elective surgical admissions (SD)	24.09 (14.26)			
Mean hospital occupancy (%, range 67.6–112.1, SD)	94.9 (8.35)			

ED, emergency department; *SD*, standard deviation; *ICU*, intensive care unit.
* All values are reported as mean (±SD), except for the number of ICU admissions, which give the count and percent for each category. Results are given averaged over a 24-hour period (overall) and for each of the 8-hour shifts. The total number of 8-hour periods measured equals 1,689.

Table 2. Autoregressive integrated moving average time series analysis model, factors associated with emergency department (ED) mean length of stay (LOS).*

	Estimate (min, 95% confidence interval)		
	Shift 1	Shift 2	Shift 3
Throughput factors			
Per additional nurse	−0.58 (−3.80, 2.64)	−0.32 (−7.93, 7.28)	−4.13 (−3.92, 12.17)
Per resuscitation cases	−5.65 (−12.16, 0.86)	−2.16 (−17.59, 13.27)	−3.49 (−19.30, 12.32)
Per 1 min additional LOS on previous shift	0.01 (−0.10, 0.12)	0.29 (0.08, 0.51)	0.02 (−0.19, 0.23)
Output factors			
Per additional admission	3.88 (2.81, 4.95)	2.88 (0.47, 5.28)	4.91 (2.29, 7.53)
Per ED discharge	−1.10 (−1.52, −0.69)	−0.21 (−1.14, 0.73)	1.54 (0.54, 2.54)
Per ED discharge on previous shift	0.34 (−0.13, 0.82)	−0.37 (−1.54, 0.79)	−0.23 (−1.27, 0.81)
Number of ICU admissions per shift (0 is baseline)			
When 1 ICU admission per shift	1.04 (−6.20, 8.29)	4.11 (−17.37, 25.59)	4.39 (−13.26, 22.06)
When 2 ICU admissions per shift	4.53 (−4.27, 13.33)	−1.67 (−25.34, 22.00)	−3.91 (−25.29, 17.48)
When 3 ICU admissions per shift	14.27 (2.01, 26.52)	4.89 (−24.36, 34.13)	−10.50 (−38.76, 17.75)
Per additional percent hospital occupancy	1.08 (0.68, 1.50)		
Per additional elective surgical admission	−0.10 (−0.38, 0.20)		

ICU, intensive care unit.
* All variables are shown as varying with LOS by shift, except hospital occupancy and the number of elective surgeries. Estimates indicate the deviation from the mean LOS for the indicated variables. For example, the LOS decreases on average by 0.58 minutes if the number of nurses is increased by 1 on shift 1. The numbers in parentheses indicate the 95% confidence interval for these estimates. Only those with a confidence interval that does not contain 0 are considered statistically significant.

high level of demand for inpatient beds, our results suggest that even a mere 1% increase in occupancy can result in delays in the ED. Conversely, investigators that have measured inpatient census at a single point in time as a surrogate for hospital occupancy have not been able to demonstrate a similar relationship.[12] Real-time changes in demand for inpatient beds cannot be assessed with a single daily measurement, which therefore lacks in utility from a real-time management perspective. The demand for inpatient beds often exceeds 100% of capacity during the late morning and early afternoon hours on weekdays. In order to alleviate this bed crunch, administrative efforts should be focused on early discharge of inpatients destined for home or transfer to another institution.

The adverse impact of an increased number of ED admissions, ie patients seen in the ED who are subsequently admitted, on LOS has been consistent in the literature. We demonstrated that LOS per patient on all 3 shifts increased by approximately 3 to 5 minutes for every additional ED admission. Of particular note is the fact that the number of ICU admissions, ie patients who are ultimately admitted to the ICU from the ED, were an important subset of all ED admissions, as they were independently associated with an increase in mean LOS for all ED patients. Intensive care unit boarders, ie admitted patients remaining in the ED for a period of time prior to transport to the ICU, were counted as admissions while still in the ED. The admission of 3 or more ICU patients in an 8-hour period prolonged LOS by more than 14 minutes for all ED patients on shift 1. The result inherently makes sense as these patients are labor intensive and typically require 1:1 or 2:1 patient-to-nurse ratios, even when boarding in the ED. Conversely, fewer than 3 ICU admissions during any shift were not associated with LOS. Administrative data from the ED at our university medical center confirm that ICU admissions boarding in the ED consume significant resources and impact flow. More than 80% of all ambulance diversions occurred when 1 or more ICU patients were boarding in the ED (institutional database, May 2007). The decision to admit a patient to the ICU may be amenable to administrative redesign as disease-specific protocols can appropriately allow a subset of these patients to be cared for in a step-down or telemetry unit.

The number of elective surgical admissions was calculated over a 24-hour period and therefore did not vary by shift in the relationship with LOS. Elective surgical admissions were included in the overall hospital occupancy measure when they occupied an inpatient bed either before or after the procedure. We could not demonstrate an independent association between these elective admissions and LOS presumably because they were subsumed by the greater role of hospital occupancy. It is conceivable that an independently significant increase in LOS can be demonstrated if the sum total of all elective scheduled admissions, including surgical procedures, cardiac catheterizations, endoscopies, etc, is taken into account.

Nursing staffing ratios on inpatient units and in the ED have received much attention in recent years.[13,14] Mandatory ED and inpatient staffing ratios of 1 nurse for every 4 patients has been implemented in California hospitals; in this state, the throughput measures of wait time to ED bed and ED bed to departure were shorter when the ED nurse staffing was within state-mandated levels, after controlling for ED census and patient acuity.[5] Simple measures of nursing staffing, such as nurse-to-patient ratios, perform as well as complicated formulas that correct for patient severity.[9] We therefore chose to simply measure the number of nurses on duty on any given shift but, surprisingly, did not find that increasing nursing staffing reduced LOS. Previous studies have also failed to show that attending physician staffing affects LOS to a significant degree.[4] While nursing staffing may impact crowding and LOS, the magnitude of the association pales in comparison with the effect of other factors that are not easily controlled by the ED. Our analysis suggests that nursing staffing is overshadowed in importance by hospital occupancy, the number of ED admissions in general, and ICU admissions in particular.

It makes intuitive sense that mean LOS decreased as the number of ED discharges increased on shift 1. Emphasizing the timely departure of appropriate patients will serve to increase ED capacity and decrease the time from arrival to ED bed for new patients. Patient flow on the night shift is inherently different than shifts 1 and 2. For humanitarian reasons, patients who come in during the evening shift with alcohol or substance abuse or are homeless are often allowed to stay in the ED for the night in our institution. Additionally, other categories of patients may be held until the morning when family members are available to retrieve them or public transportation resumes service. Many of those patients are discharged in the early morning hours immediately before the start of the next shift and therefore have a prolonged LOS. This may explain the paradoxical positive association between the number of ED discharges and increased LOS on shift 3. Early discharge of inpatients destined for home or transfer to another facility will increase the supply of inpatient beds and reduce the variability in hospital occupancy that occurs during a 24-hour period. This in turn will reduce LOS and relieve crowding during hours of peak demand in the ED.[15]

The number of resuscitation cases does not appear to have been large enough (mean 0.53 per shift) or exhibit sufficient variability to affect LOS. Future questions must assess how reducing variability and LOS affect patient outcomes and medical error. The impact of ED crowding and delays in flow on patient safety and quality of care must be evaluated by both quantitative and qualitative methods. The financial implications of ED crowding must also be measured, including costs and lost potential revenue.

LIMITATIONS

Our study had some limitations. Due to the retrospective nature of the model, it cannot be used to demonstrate causality, but merely to measure associations. LOS is an imperfect

retrospective measure that cannot easily be used as a real-time indicator of ED crowding. Although LOS may not be normally distributed, we were not able to measure median LOS because of the constraints of our electronic information technology system. Based on recent studies, we do not believe that substituting median for mean LOS would have substantively altered our results.[12,16] This is also a single-center study performed at a large inner-city level 1 trauma center ED; the results may not apply to institutions with a different size and patient demographic pattern.

The covariates analyzed were limited. It is conceivable that the results may have been different if patient visits were assigned to a given shift based on the time of arrival rather than the time of ED discharge. The number of new arrivals per shift may be a better indicator of the demand for services. Future studies should account for additional measures, such as triage severity, the number of patients in each triage category, ED capacity, ie number of bays, and the practice patterns of individual providers. Based on previous literature, we do not believe that inclusion of hours of coverage by attending physicians as covariates will provide additional information in the model. Although there is no data to support the assertion, we believe that the same applies to resident physicians and midlevel providers. The efficiency with which ancillary services, such as radiology and laboratory services, perform testing and report results is an important variable that affects flow.

CONCLUSIONS

Our study focused on the association between LOS and throughput and output factors related to the conceptual model of ED crowding. Not surprisingly, hospital medical-surgical occupancy is associated with LOS on all 3 shifts but is difficult to change with administrative redesign within the purview of the ED. Change in this variable requires broad hospital-wide redesign efforts in terms of capacity and practice protocols. On all 3 shifts, the number of admissions is associated with an increase in LOS. In addition, LOS on shift 1 increased by more than 14 minutes per patient whenever 3 or more ICU patients were boarding in the ED. Conversely, the numbers of resuscitation cases, elective surgical admissions, and nurses were not independently associated with LOS in this analysis. This is presumably because these measures are overshadowed by the greater effects of hospital occupancy, the number of ED admissions as a whole, and ICU admissions in particular.

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Insurance Exchange Marketplace: Implications for Emergency Medicine Practice

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The Patient Protection and Affordable Care Act of 2010 requires states to establish healthcare insurance exchanges by 2014 to facilitate the purchase of qualified health plans. States are required to establish exchanges for small businesses and individuals. A federally operated exchange will be established, and states failing to participate in any other exchanges will be mandated to join the federal exchange. Policymakers and health economists believe that exchanges will improve healthcare at lower cost by promoting competition among insurers and by reducing burdensome transaction costs. Consumers will no longer be isolated from monthly insurance premium costs. Exchanges will increase the number of patients insured with more cost-conscious managed care and high-deductible plans. These insurance plan models have historically undervalued emergency medical services, while also underinsuring patients and limiting their healthcare system access to the emergency department. This paradoxically increases demand for emergency services while decreasing supply. The continual devaluation of emergency medical services by insurance payers will result in inadequate distribution of resources to emergency care, resulting in further emergency department closures, increases in emergency department crowding, and the demise of acute care services provided to families and communities. [West J Emerg Med. 2012;13(2):169–171.]

Insurance exchanges have for a long time been involved in healthcare reform discussions. The Clinton Health Security Act of 1993, the Massachusetts Health Connector of 2006, and the most recent Patient Protection and Affordable Care Act of 2010 all established insurance exchanges. The intent of an insurance exchange is to benefit consumers by reducing barriers to the purchase of health insurance. In its most simple form, a healthcare insurance exchange is a marketplace where insurers come to provide their goods for sale. Policymakers and health economists believe that exchanges will improve healthcare at lower cost by promoting competition among insurers and by reducing burdensome transaction costs. Where exchanges can differ is in their capacity to regulate the insurers who sell goods in the marketplace.

Federal legislation requires each state to start or join an exchange by January 1, 2014. States are permitted to begin their own state-run insurance exchange or may join to form regional exchanges. A federally operated exchange will be established, and states failing to participate in any other exchanges will be mandated to join the federal exchange. Insurance exchanges established by states must include 1 for individuals and 1 for small businesses (these can be combined). The exchange is to be Web based, with participating insurance plans available in 4 tiers from the least comprehensive coverage, "bronze," to the most comprehensive, "platinum." Insurance premiums for these standardized insurance plans are to be equivalent in price in and outside the exchanges. In addition, the state-run exchanges can exclude insurers from the exchanges on the basis of cost and quality value.[1]

The federal government defers to state legislatures in structuring these insurance exchanges. The exchanges have a range of potential responsibilities to be established by state legislation: providing standardized information about all products offered, developing risk-adjustment mechanisms, and overseeing health plans' practices with respect to benefit and design.[2] What body or organization will govern the exchange?

The establishment of a board of directors to organize and govern the insurance exchange and the board's selection process will be proscribed by state legislation. The board will be responsible for enforcing insurers' establishment of premiums based on a community rating as dictated by federal legislation. Adjustments to the fixed community rate can only be made on the basis of age, family composition, tobacco use, and location. The board will also be responsible for establishing a risk-adjustment system pursuant to which insurers providing coverage to unhealthier patient populations receive additional reimbursement.[1]

California recently adopted legislation to establish a state insurance exchange as described in California Health Benefit Exchange.[3] This legislation establishes the California Health Benefit Exchange as an independent public entity governed by an executive board consisting of 5 members: 2 appointed by the governor, 1 by the Senate Committee on Rules, and 1 by the Speaker of the Assembly and the Secretary of California Health and Human Services or his designee. Licensure and regulation of healthcare service plans remains in the scope of the Department of Managed Health Care and the Department of Insurance.[3] The board will not be a third regulating body that controls insurance premiums. The executive board has the power to select insurance providers permitted to participate in the Web-based exchange at the recommendation of the Department of Insurance and the Department of Managed Health Care.[4]

How will the development of insurance exchanges affect emergency medicine? This question is difficult to answer because the exchanges can have a broad range of functions, not all of which are clearly defined at this time. A better question for the immediate time is, how have managed care and high-deductible plans affected emergency services' reimbursement? Managed care has reduced physician reimbursement while not containing costs.[5] This occurs by managed care plans shifting sicker patients into fee-for-service plans, placing an unfair burden on the resources of these insurance pools.[5] High-deductible plans of people with limited means place them in a state of being underinsured, resulting in their delaying or foregoing necessary care.

The insurance exchange will change how insurance is purchased. In the current employer system, consumers of insurance are separated from the cost of premiums. The purpose of an insurance exchange is to increase transparency to make the cost of insurance obvious and to reduce the transaction costs on the healthcare system. With consumers for the first time confronted with the cost of "purchasing" insurance and a plethora of options, what will be the outcome? In Massachusetts, the Health Connector (the statewide insurance exchange) has performed market research of customer preferences and now sells lower-priced, less well-known health plans than conventional market channels.[6]

It should be noted, however, that the insurance market in California is considerably different from that of Massachusetts. The California insurance market is an oligopoly, making penetration by competitors difficult. Fifty-eight percent of the entire California market is controlled by 2 entities, Kaiser and WellPoint Inc. Lack of meaningful competition is even more evident in individual regions within California.[7]

Proponents of insurance exchanges believe that the increased transparency will lead to further competition, resulting in technologic innovation and higher quality of care provided at a lower cost. Jon Kingsdale, PhD, the founding Executive Director of the Commonwealth Health Insurance Connector Authority in Massachusetts and current consultant to the State of California in the implementation of the insurance exchange, in a recent publication offers some insight into recent innovations in the Massachusetts insurance market spurred by its insurance exchange.[6] Dr Kingsdale points out that, in the current system, an employer selects 1 health plan to provide care to all its employees. Only 1 health plan is selected in order to save on the administrative costs of having to deal and interact with multiple health plans. This 1 plan must provide a broad range of services and providers that will allow the employer's large group of employees, all with ranging demands, to be satisfied with the care provided. Insurers then have less bargaining power because they must be all-inclusive to keep their large group of insureds satisfied, and this results in rising insurance premiums. Dr Kingsdale asserts that an exchange counters this by allowing each employee to choose among a large group of health plans to find a less encompassing plan that will satisfy his or her individual demands. How will the Emergency Medical Treatment and Active Labor Act providers be able to negotiate fair value for their services in these market conditions?[7]

Insurance exchanges will reshape the insurance marketplace and impact the value attributed to emergency medical services. Many details have yet to be finalized in defining this marketplace, but with the ever-increasing pressure by health reform pundits to shift from a hospital-centered care structure to a preventive outpatient clinical structure, there is significant potential for emergency medical services to be falsely deflated in value.

The following is a noninclusive list of questions still to be answered; now is the time, as emergency care providers, to help find answers to these questions so that healthcare reform results in realistic improved care for our patients.

1. Will patients, by their own choice, pick higher-deductible plans that make emergency visits less affordable because of greater out-of-pocket payment?
2. Will more patients choose managed care options resulting in restricted access to providers and emergency departments?
3. Will patients demand knowledge of emergency department services costs while being treated in the emergency

department, with concern for greater out-of-pocket payment? Will this result in greater medical legal exposure?

4. Will the effect of the cost of medical malpractice on medical insurance premiums become more obvious to insurance consumers?

5. What is the value of 24-hour emergency services care to a community?

The last question is the most significant in demonstrating the true societal impact on emergency care services. What is the value of 24-hour emergency services care to a community? California recently passed a law that allows for selective contracting by California Health Benefits Exchange, meaning that the Exchange will be empowered to restrict insurers from participating. The certification process will involve the establishment of formal scoring criteria by which to compare and contrast insurance plans, similar to those used by Medi-Cal, the Department of Managed Health Care, and Pacific Business Group. How emergency medical services are qualified by these formal scoring criteria should be done with the input of emergency physicians and with the consideration of the value to society of having 24-hour emergency services care available to our communities.[8–12]

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Patient and Physician Willingness to Use Personal Health Records in the Emergency Department

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Introduction: Patient care in the emergency department (ED) is often complicated by the inability to obtain an accurate prior history even when the patient is able to communicate with the ED staff. Personal health records (PHR) can mitigate the impact of such information gaps. This study assesses ED patients' willingness to adopt a PHR and the treating physicians' willingness to use that information.

Methods: This cross-sectional study was answered by 184 patients from 219 (84%) surveys distributed in an academic ED. The patient surveys collected data about demographics, willingness and barriers to adopt a PHR, and the patient's perceived severity of disease on a 5-point scale. Each patient survey was linked to a treating physician survey of which 210 of 219 (96%) responded.

Results: Of 184 surveys completed, 78% of respondents wanted to have their PHR uploaded onto the Internet, and 83% of providers felt they would access it. Less than 10% wanted a software company, an insurance company, or the government to control their health information, while over 50% wanted a hospital to control that information. The patients for whom these providers would not have used a PHR had a statistically significant lower severity score of illness as determined by the treating physician from those that they would have used a PHR (1.5 vs 2.4, $P < 0.01$). Fifty-seven percent of physicians would only use a PHR if it took less than 5 minutes to access.

Conclusion: The majority of patients and physicians in the ED are willing to adopt PHRs, especially if the hospital participates. ED physicians are more likely to check the PHRs of more severely ill patients. Speed of access is important to ED physicians. [West J Emerg Med. 2012;13(2):172–175.]

INTRODUCTION

A personal health record (PHR) is a patient-controlled tool used to manage health information.[1–3] By centralizing the patient's medical history, different physician encounters, evaluations and treatments, a PHR offers more complete medical information. The individual can access and has ownership of this information, making PHRs a consumer-centered model that bridges different providers.[4] Increased adoption of PHRs might lead to better care by providing the physician with a more complete picture of the patient, thereby reducing errors and improving follow-up regardless of provider location or network interoperability.[1,5,6]

Some of the barriers to PHR adoption previously identified include the economic costs of developing and paying for the system, transferring information from paper charts, an inadequate level of computer competency on the part of physicians and patients, and an absence of a universal or standard platform for interoperability.[1,7,8] Emergency departments (ED) might provide an alternative method for increasing patient use of PHRs since they serve as an entry point into the medical system. Patients might be uniquely

willing to initiate a PHR while waiting for ED care and the importance of their medical care is in focus. This study aims to identify which ED patients are willing to initiate a PHR and whether the treating ED physicians would use this PHR. Our primary hypothesis was that most ED patients are willing to have their data entered into a PHR and that their willingness is a function of their severity of illness. Also, we hypothesized that ED physicians are more likely to review PHRs of patients that they perceive to be more seriously ill.

METHODS

Study Design

This was an observational cross-sectional survey study (Appendix, online only). Stanford's Institutional Review Board approved this study and waived the signature requirement for patient consent; verbal consent was obtained.

Study Setting and Population

Surveys were distributed between April 2008 and November 2008 at the Stanford University Medical Center Emergency Department. Stanford University Medical Center is an academic level 1 trauma center with an annual patient volume in the ED of 50,000. Physicians and nurses at Stanford use EPIC (EPIC Spring 2007 IU1; Verona, Wisconsin) for electronic health records. Images and medications are also ordered and stored in EPIC. Currently, no PHR is offered by Stanford.

Study Protocol

The study population was comprised of a convenience sample of patients over 18 presenting to the ED who were medically stable. A research assistant did a rotating shift, 7:00 AM to 3:00 PM, 3:00 PM to 11:00 PM, and 11:00 PM to 7:00 AM, approaching patients, distributing and collecting surveys at regular intervals. Patients well enough to respond were asked if they would be willing to answer questions and either handed the survey to read or read the survey by the assistant. A standard introduction was read to all patients. Patients unable or unwilling to answer the survey were excluded; however, their treating physician was still surveyed to gather data on the physician's willingness to use the PHR. Consequently, there are more physician responses than patient responses. Similarly, patients whose corresponding physician could not be surveyed were not excluded.

The patient survey described a PHR and then asked 24 questions answered via checking a box on 1 double-sided page. Demographic data on age, race, sex, insurance coverage, income, and education level was collected. We asked the patient about their perceived state of health, computer familiarity, and degree of concern about their current visit as measured on a 5-point scale. In addition, the survey assessed patient attitudes towards PHR availability, utilization, and security.

A separate physician survey asked whether they would have accessed the given patient's PHR at all, whether they would spend less than 5 minutes, 5 to 10 minutes, or over 15 minutes accessing the patient's PHR, and how sick they considered the patient to be as measured on a 5-point scale. Physician and patient surveys were coupled through a nonidentifying marker and stored for analysis. Neither physician nor patient ever saw their counterpart's survey. Prior to use, the survey was distributed to several patients and physicians to assess its readability.

Data Analysis

Statistical analysis was completed with the aid of SAS software (9.0, Cary, North Carolina). Descriptive statistics were computed for demographic and preference characteristics. The primary mode of comparison was achieved with a chi-square test for binary comparisons such as willingness to use a PHR between different comparison groups. A Mann-Whitney test was used for ranked comparisons that involved a response with the 5-point scale, such as willingness to use a PHR and severity of illness. Significance was determined by a P value less than 0.05. A power calculation for proportions suggested a sample size of 190, given a power of 80 and a significance level of 0.05, in order to test our primary hypothesis that patient willingness to use a PHR related to the severity of their illness.

RESULTS

A total of 219 patients were approached, and 184 (84%) surveys were completed. Thirty-five surveys were excluded for incompleteness or patients who refused to be surveyed. Of the 219 physician surveys distributed, 210 (96%) were returned. All physicians agreed to answer the survey. The resultant demographics are summarized in Figure 1. Males comprised 56% of the sample population, while females comprised 44%. In the survey population, 93% were insured (including Medicaid recipients), 78% had a primary care provider, and 54% had changed providers in the past 5 years.

Seventy-eight percent of the respondents were willing to have all of their health information available on the Internet. In a life-threatening emergency, 96% of respondents wanted the physician to access all of their health information. Of those surveyed, 68% would upload their information only if they did not have to perform the task of entering the information. As summarized in Figure 2, over 50% of respondents used the Internet daily, and a similar percentage wanted the hospital to retain their health information. Respondents with multiple medical problems, life threatening allergies, a primary doctor, and private insurance were just as likely to use a PHR as those who did not have these characteristics ($P > 0.05$, chi-square). There was no significant relationship between the patient's perceived severity of disease and their willingness to use a PHR ($P > 0.05$, Mann-Whitney).

Providers assigned an illness severity score for each patient. Eighty-three percent of providers would have accessed the PHR. The patients for whom the providers would not have used a PHR had significantly lower average severity score (1.5)

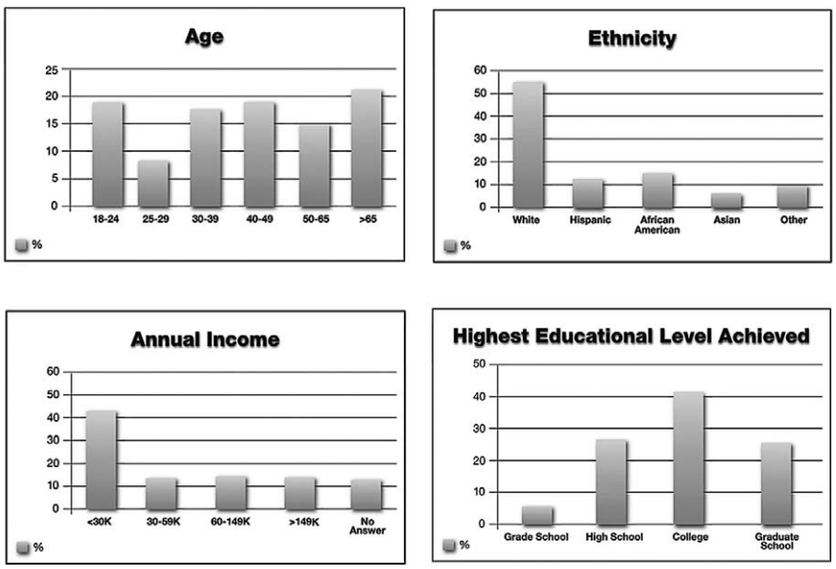

Figure 1. Patient demographics.

than those for whom they would have used a PHR (2.4) ($P <$ 0.01 by Mann-Whitney test). Among the physicians who would not have used the PHR of a patient under their care, 74% of these patients had 0 to 1 medical problem. Among providers who wanted to use their patient's PHR, 57% would only use the PHR if it took less than 5 minutes to access and review.

DISCUSSION

Seventy-eight percent of patients surveyed in the ED were willing to adopt a PHR. However, while more than half of the patients surveyed would accept the hospital as the source of the PHR, less than 10% would accept control by a private software enterprise or even a governmental agency (Figure 2). Other factors related to PHR adoption included assistance with information upload, as 68% of users would upload their information only if they didn't have to do it themselves.

Emergency physicians were very likely to use a PHR if it was available, though they usually did not want to spend more than 5 minutes interfacing with the system. They were more likely to use the system for patients with more than 1 medical

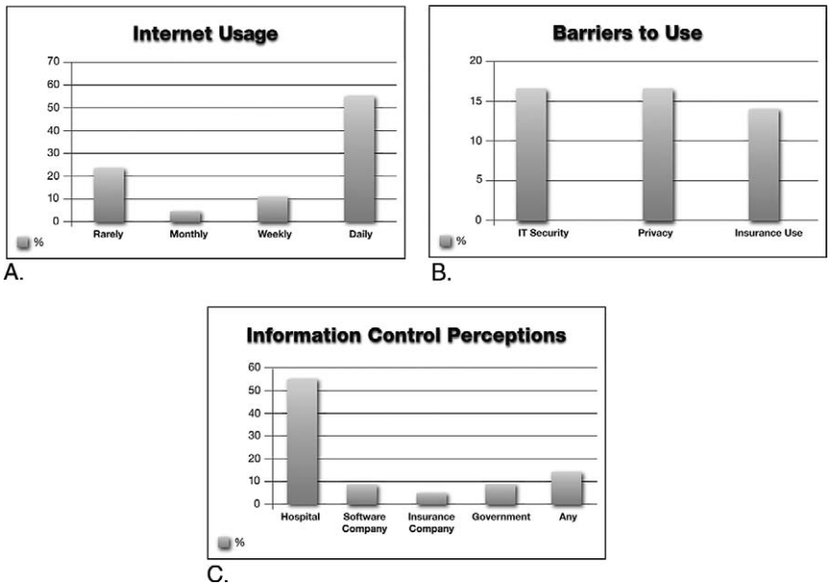

Figure 2. A, Frequency of Internet use. B, Perceived barriers to uploading information. C, Location where patients would allow their information to be stored. *IT*, information technology.

problem and those with a higher illness severity. Though not specific to the ED, time constraints may heighten the need for a rapidly accessible PHR in complicated patients.

LIMITATIONS

The sample's demographics may limit generalizability of the results. Though many income levels were represented, the demographics of our sample do not mirror those of many rural or county EDs or many urban and academic institutions. Additionally, the critical or unresponsive patients who might have benefited from a PHR could not be assessed, so a proportion of ill patients were lost from this assessment. As there is often a discrepancy between stated patient intent and actual patient action, expressing a willingness to adopt a PHR does not necessarily translate into actual completion of the act. Our study only measured their willingness. In addition, the 5-point scale was not previously validated to assess injury severity. Also, physicians were surveyed throughout the day and over 8 months to capture a variety of providers, but it is possible that bias was introduced by multiple responses from a given provider.

CONCLUSION

This survey suggests that many ED patients in this population are willing to start a PHR, and ED physicians would likely access it. Patients would be more comfortable if the PHR was created for them and was controlled by a healthcare facility rather than a nonhealthcare private entity or a governmental agency. Development should focus on speed of access for physicians while focusing on assisting initiation for patients. Though a PHR can be discussed and initiated during a primary care visit, the ED might provide an additional opportunity when wait times permit further consideration and patients are worried about their health. We feel that the ED is a potential focal point for PHR developers and hospitals interested in PHR adoption and utilization.

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Measuring Emergency Physicians' Work: Factoring in Clinical Hours, Patients Seen, and Relative Value Units into 1 Metric

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Measuring workplace performance is important to emergency department management. If an unreliable model is used, the results will be inaccurate. Use of inaccurate results to make decisions, such as how to distribute the incentive pay, will lead to rewarding the wrong people and will potentially demoralize top performers. This article demonstrates a statistical model to reliably measure the work accomplished, which can then be used as a performance measurement. [West J Emerg Med. 2012;13(2):176–180.]

WORK ACCOMPLISHED VERSUS PERFORMANCE

It is important to emphasize that the measurement presented is individual work accomplished and not work performance, which are related but different measures. For example, working a slow night shift is not an indicator of performing poorly and this factor needs to be recognized. Work accomplished is a more objective measurement, while performance is customarily a combination of objective and subjective measures. Having a reliable objective measurement should therefore help us judge performance better.

VARIABLES AFFECTING WORK ACCOMPLISHED

Accurately measuring work accomplished is important to emergency physicians, because often their salary, or in the example for this article, their incentive pay, is in some manner based on a measure of their performance. Figure 1 represents some of the major variables involved in the individual performance of an emergency department (ED). We must start by making sure the data are accurate. Then, we determine if the group deserves any incentive pay and what the total should be. Finally, it is necessary to determine how to distribute this incentive to the eligible individuals. We have to account for each physician's clinical hours, patients, RVUs (a relative value unit that is a measure of work or effort applied to a patient and is related to the revenue potential), research, administrative tasks, or other unnamed tasks. We may have incentive-eligible physicians working with noneligible physicians, residents, and physician assistants. Although the different techniques used to sort out all of these issues and variables can be demonstrated, they are outside the narrower scope of this article. The core of the approach for solving these problems requires first an understanding of how to measure the performance of a group of incentive-eligible physicians, based on their clinical hours worked, patients seen, and RVUs generated. This article will demonstrate a technique that is statistically sound and that reliably measures an individual's performance on the basis of these 3 productivity factors. Once this concept is understood, how to incorporate the remaining variables in Figure 1 can be discussed. We will start by introducing an artificial department scenario involving 3 physicians to demonstrate the major advantages of the suggested technique.

EMERGENCY DEPARTMENT SCENARIO

Let us consider a department that employs physicians A, B, and C and compare the work each physician accomplishes during a period spanning twelve 10-hour shifts. The Table, part A1, shows the raw data available for these physicians. If we had knowledge that these physicians were equal workers, then they could all be considered average and we would simply compensate them with an incentive based on the percentage of hours they will have worked, as seen in the Table, part A3, first column. They would receive 16.7%, 33.3%, and 50% of the total incentive pay, respectively. We know that, for various reasons, the work each physician will

Part A	*Does this group qualify for a Bonus?*	*Calculation Method Not Discussed in this Paper*	*Amount of Bonus*

Part B	*EMERGENCY DEPARTMENT PROVIDERS*	CLINICAL			*RESEARCH*	*ADMINISTRATION*	*OTHER*	***Bonus Distribution based on Work Accomplished***
		Hours	**Patients**	**RVUs**				
Bonus Eligible	**Physician A**							
	Physician B							
	Physician C							
Not Eligible for Bonus	*Other Physicians* *Contingent Physicians* *Residents* *Physician Assistants*							*N/A* *N/A* *N/A* *N/A*

KEY
Input Data for this Paper
Output Results for this Paper
Methods of incorporating this data are beyond scope of this paper

Figure 1. Variables affecting work accomplished.

actually have accomplished is different, maybe because of a performance difference or just because one shift happened to be busier with higher-acuity patients. Therefore, just looking at the hours worked does not give a reliable measure of work accomplished.

We could take a "bottom-line" approach and evaluate these physicians by the amount of revenue potential or RVUs they generate. According to the Table, part A3, third column, all 3 physicians would each receive 33.3% of the incentive. We now get very different answers from the ones obtained with the previous approach based on the hours worked. Which is right? Well, physician A argues he created a lot of revenue by seeing 10 of the sickest patients in the ED and his RVUs/patient and RVUs/hour, shown in the Table, part A2, were the highest in the department. Therefore he deserves a higher share of the incentive than do the other physicians. Physician B reminds us that while his RVUs/patient and RVUs/hour were lower, he created just as much revenue as physician A and saw more patients. Some of the patients were considered low acuity but some were high acuity. Also, because he worked more hours than physician A, his share of the incentive should be greater than that of physician A. Physician C had the lowest combination of RVUs/patient and RVUs/hour but he reminds us that while physician A was "stuck" in the intensive care bay with high-acuity patients, he was out in the department seeing more patients, keeping them satisfied, and maintaining the flow throughout the department. Furthermore, physician C had most of the typically quieter night shifts during that period and worked more hours, and he kept the ED functioning for as long as did the other 2 physicians combined. All 3 physicians bring up valid points and each feels deserving of more than an equal share of the incentive. What is a logical answer to these various opinions, each of which has valid points?

THE PROPOSED SOLUTION

The answer lies in all of the physician's arguments. The hours present at work, patients seen, and RVUs created are all important. Therefore, we must incorporate these various factors into 1 statistically sound quantity that is the measure of the total work accomplished. While it is not absolutely required, in our example it will be assumed that all 3 of these factors are equally important. It is important to work clinically and keep the department open 24 hours a day, 7 days a week. It is equally important to see any patient presenting to the ED. We must care for the high-acuity patients but we should not be penalized for being in the intensive care bay, spending time stabilizing one patient while being unable to get out in the department to care for other patients. These physicians need to get credit for the extra RVUs they generate. On the other hand, the physician who is out in the ED should not be penalized for not getting the RVUs associated with the high-acuity patient while he is busy caring for more patients with lower acuity.

The approach that takes into account all 3 productivity factors is outlined in the Table, part A3. We start by normalizing each column's raw data in the Table, part A1, and we calculate the percentage of the total hours worked, patients seen, and RVUs created for each physician. Next, we calculate each physician's average for these 3 percentages. This average is the percentage of the group's total work accomplished by each physician and this is the percentage of the total incentive

Table. Example of data and results for an emergency department.

Physician	Hours	Patients	RVUs	Patients/h	RVUs/ patient	RVUs/h	Hours (%)	Patients (%)	RVUs (%)	Work accom- plished (%)*	Equivalent- hours†
	TABLE A1			**TABLE A2**			**TABLE A3**				
A	20.0	10.0	40.0	0.50	4.00	2.00	16.7	11.1	33.3	20.4	24.4
B	40.0	40.0	40.0	1.00	1.00	1.00	33.3	44.4	33.3	37.0	44.4
C	60.0	40.0	40.0	0.67	1.00	0.67	50.0	44.4	33.3	42.6	51.1
Total	120.0	90.0	120.0	0.75	1.33	1.00	100.0	100.0	100.0	100.0	120.0
	TABLE B1			**TABLE B2**			**TABLE B3**				
1	40.0	20.0	80.0	0.50	4.00	2.00	33.3	23.1	54.5	37.0	44.4
2	40.0	40.0	40.0	1.00	1.00	1.00	33.3	46.2	27.3	35.6	42.7
3	40.0	26.7	26.7	0.67	1.00	0.67	33.3	30.8	18.2	27.4	32.9
Total	120.0	86.7	146.7	0.72	1.69	1.22	100.0	100.0	100.0	100.0	120.0

RVUs, relative value units.
* Percentage of work accomplished is the average of each individual's percentages for hours, patients, and RVUs.
† Equivalent-hours represent each individual's percentage of work accomplished × total hours.

each physician deserves for his work. To give a clinical meaning to this quantity, we multiply each physician's percentage of work accomplished by the total hours for the group. This gives the equivalent-hours, which is the number of hours the physician would have worked if he had been an average physician in the group. The average physician is the performance of the entire group combined as 1 entity. In other words, every physician's work is compared to the work of the entire department that worked 120 hours and saw 90 patients, creating 120 RVUs. You can see that physician A is credited with working 24.4 equivalent-hours in his 20 clinical hours present. In other words, compared to the department average, physician A did 24.4 hours of work in only 20 hours. This physician's incentive share of 20.4% is appropriately above the average because he got 4.4 hours extra credit for his 2 shifts. Physician B is credited with working 44.4 equivalent-hours for his 40 clinical hours. His incentive share of 37.0% is appropriately above average, with 4.4 hours extra credit for his work. Finally, physician C was credited with working only 51.1 equivalent-hours for his 60 clinical hours. His incentive share of 42.6% was appropriately below average, with 8.8 hours subtracted from his work. By using an equivalent-hours concept, a physician knows exactly how much work above or below the department average he completed (in hours). A difference in hours from the average is a quantity that should be easily understood. Also, we have not artificially created hours; notice that in the Table, the 120 total hours in part A1 are unchanged in part A3. Equivalent-hours are a redistribution of an individual's clinical hours, based on his hours, patients, and RVU data, as compared to the total work accomplished by the group. Therefore, for whatever number of hours a physician worked, if he saw more patients, or generated more RVUs, he will get additional credit for this work accomplished.

Notice that we have now combined the 3 completely different entities of hours, patients, and RVUs into 1 quantity. The statistics of this approach will not be discussed in depth in this article. A graphical representation shown in Figure 2 and Appendix 1 (online only) does show this statistical detail. Each individual's information is contained in a right triangle (see physician B), where the magnitude of the hypotenuse is proportional to the magnitude of the vector containing an individual's percentages of hours, patients, and RVUs. The magnitude of 1 leg of the triangle is the standard deviation. The magnitude of the other leg is the individual's percentage of the group's total work that he accomplished, which is determined by averaging the individual's percentages of hours, patients, and RVUs. It is the value of this second leg of the triangle that is used to determine an individual's contribution to the group and his share of the incentive. By simply averaging 3 numbers, we have silently incorporated the standard deviation to transform an individual's percentages of hours, patients, and RVUs into the magnitude of an individual's work accomplished in the group of physicians. A notable advantage to this approach is that the control group for measuring each individual physician's work accomplished is the sum of physicians in the group. They are not compared to the performance of another group of EDs from different regions, which is supposed to be exactly like their department. There is no need to spend time and money to collect outside data.

RATIOS NOT RECOMMENDED

An additional point is that, while the ratios including patients/hour, RVUs/patient, and RVUs/hour were mentioned,

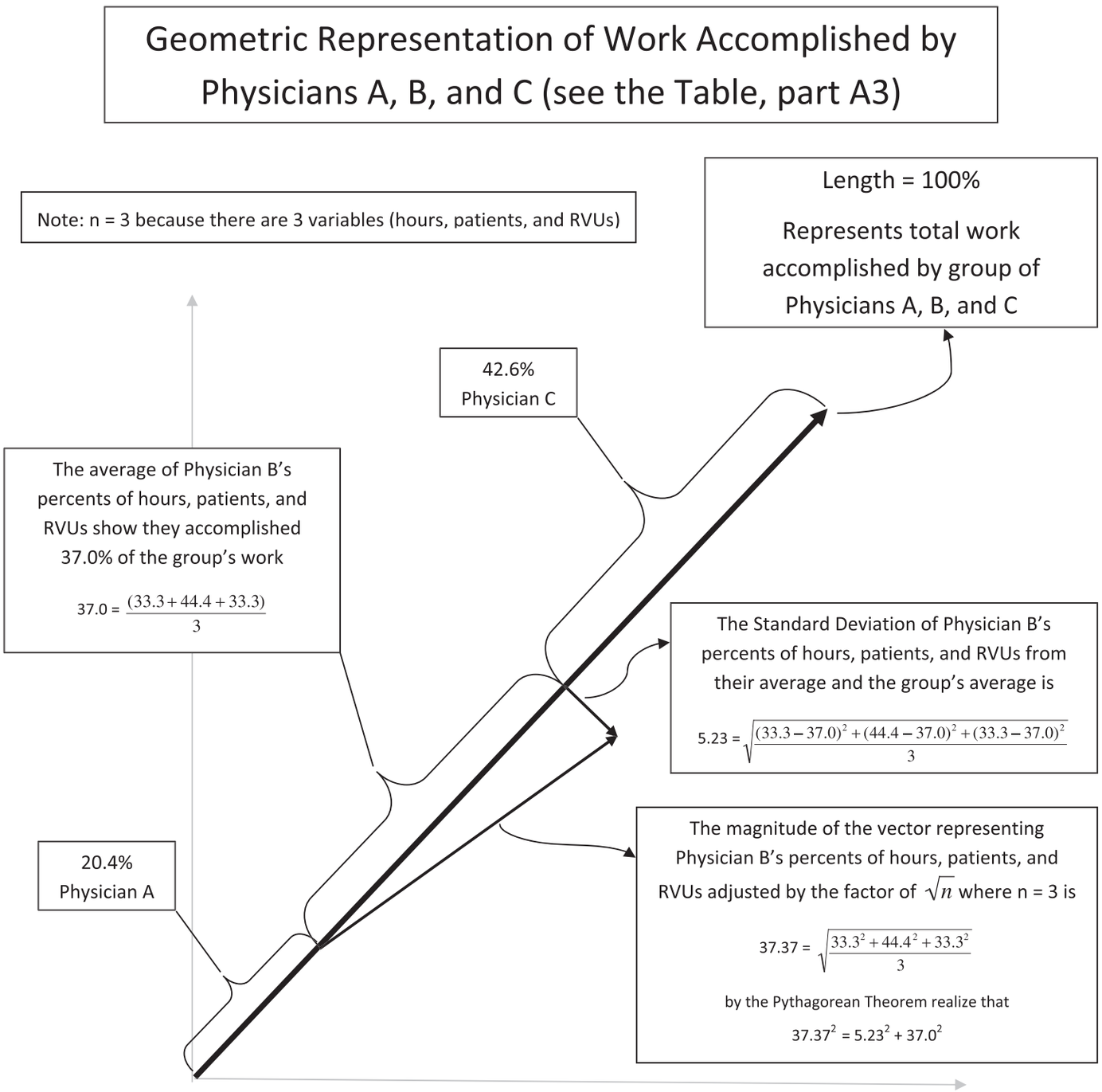

Figure 2. Geometric representation of work accomplished by physicians A, B, and C. Note: Scale is not precise. *RVUs*, relative value units.

they were *not* used in the calculations. Use of these ratios should be avoided because they are ambiguous terms. The simplest example is illustrated when physician groups 1, 2, and 3 (Table, part B2) are seen to have the same ratios as physician groups A, B, and C (Table, part A2). In the Table, the raw data in parts A1 and B1, which produce the data in parts A2 and B2, respectively, are not alike except that the total hours happen to be identical. There are in fact an infinite number of different tables such as B1 that could each produce B2. These ratios simply are not representative of any one set of raw data; therefore, any results derived from these terms do not uniquely apply to the initial raw data used. Part B3 is included to show that there is a difference in percentage work accomplished in part A3, even though both groups have identical ratios in parts

A2 and B2. A difference was detected only because the data from parts A1 and B1 were used rather than the data from parts A2 and B2.

SUMMARY

Details about other potential variables and types of work (academic, teaching, research) have been omitted from this discussion. Comparing the ED in this scenario to other EDs, and determining if a department qualifies for any incentive pay, requires a different approach.

Physicians should be more satisfied in their workplace if they know evaluation of their performance is fair and objective. One step toward this goal is to appropriately measure work. This article focused on 3 important components of work: clinical hours, patients seen, and RVUs generated. Problems associated with using fewer items than these 3 were discussed in an artificial ED scenario. Combining these terms into commonly used ratios is problematic because of ambiguity and cannot be recommended. The proposed solution converts the raw data into percentages and then averages them to give a single percentage, which is an individual's contribution toward the group's total work. Appendix 2 (online only) presents a program that calculates the answer by using this technique for up to 6 physicians. Individuals are compared to their entire department, with the aggregate work performance serving as an internal control. This obviates the time and expense to produce comparison data from other EDs. In this approach, a physician will be rewarded by an increase in his equivalent-hours if he sees an above-average number of patients or generates an above-average number of RVUs for each clinical hour of work.

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Physician Assistants Contribution to Emergency Department Productivity

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Introduction: The objective of this report is to determine physician assistant (PA) productivity in an academic emergency department (ED) and to determine whether shift length or department census impact productivity.

Methods: A retrospective chart review was conducted at a tertiary ED during June and July of 2007. Productivity was calculated as the mean number of patients seen each hour. Analysis of variance was used to compare the productivity of different length shifts, and linear regression analysis was used to assess the relationship between productivity and department volume.

Results: One hundred sixty PA shifts were included. Shifts ranged from 4 to 13 hours. Mean productivity was 1.16 patients per hour (95% confidence interval [CI] = 1.12–1.20). Physician assistants generated a mean of 2.35 relative value units (RVU) per hour (95% CI = 1.98–2.72). There was no difference in productivity on different shift lengths ($P = 0.73$). There was no correlation between departmental census and productivity, with an R^2 (statistical term for the coefficient of determination) of 0.01.

Conclusion: In the ED, PAs saw 1.16 patients and generated 2.35 RVUs per hour. The length of the shift did not affect productivity. Productivity did not fluctuate significantly with changing departmental volume. [West J Emerg Med. 2012;13(2):181–185.]

INTRODUCTION

Physician assistants (PA) were introduced to the United States workforce in the 1960s and have played an ever-increasing role in medical care since their inception.[1–4] There are more than 79,000 graduates of PA programs in the United States today, and they practice in a wide variety of settings, including primary care, critical care, pediatrics, surgery, and emergency medicine.[5] A large and growing body of literature supports the use of midlevel providers (both PAs and nurse practitioners) as clinicians and that the care they provide does not compromise outcomes in selected patients. Several studies in a variety of settings have shown that using PAs and nurse practitioners instead of physicians does not result in increased morbidity or mortality or adversely affect visit times and cost.[6–10]

Emergency departments (ED) have increasingly used PAs over time with 28% of EDs employing PAs in 1997 compared to 77% of EDs in 2006.[11] A study from 2005 revealed that 1 out of every 8 ED visits are managed by a midlevel provider, and 5% of these have no physician involvement at all.[12] The field of emergency medicine currently attracts 10% of graduates from PA programs as a primary site of work, and over 20% of PAs report spending some time working in EDs.[5] Physician assistants working in EDs have on average higher salaries than PAs working in other settings,[5] and some sites are now offering postgraduate specialty training to PAs in emergency medicine. It is expected, therefore, that PA use in EDs will continue to increase.

In spite of the large numbers of PAs working in EDs, very little is known about their contribution to workflow or

departmental productivity. Research has shown similar prescribing patterns of medications between physicians and PAs in EDs, and 1 study showed similar cost and length of stay in an urgent care setting between PAs working alone and attending physicians.[4,7] This is the first study in the literature that examines PA productivity defined as patients seen per hour and relative value unit (RVU) generated per hour in an academic residency training center.

At the study institution, PAs function in several capacities. They staff a fast track area which is located in the main ED (not a separate site). Patients triaged to the fast track have Emergency Severity Index (ESI) scores of 4 and 5 and are not anticipated to need ancillary studies beyond plain radiographs, urine point-of-care testing, and glucometry. Patients requiring simple laceration repair or splinting of a musculoskeletal injury are preferentially triaged to fast track, while those with complex lacerations, those requiring sedation, and patients with obvious fractures are not. When no patients are waiting in the fast track area, PAs are permitted to see patients with ESI scores of 4 and 5 in triage and manage them there. Additionally, if there are no patients with ESI scores of 4 or 5 waiting, PAs are permitted to float out of fast track and see high-acuity patients waiting in the main ED (this rarely occurs). Finally, on resident conference day, 1 PA staffs fast track, and 1 floats in the main ED. Physician assistants have access to an attending ED physician for consultation at all times but are not required to present their patients to attending physicians, and attendings do not see and examine the majority of PA patients.

Recent research done at this institution suggests that emergency medicine residents are very limited in their capacity to increase productivity in response to changes in ED volume,[13] and therefore, increased patient volume must be compensated for by either the attending physicians' or PAs' adjustment in productivity.

Purpose

We sought to determine the number of patients seen per hour and RVUs generated per hour (productivity) by ED PAs working a variety of different shift lengths and to correlate that number with ED census volume in order to determine whether PAs can respond to variations in patient volume with variations in their productivity.

METHODS

A retrospective chart review was conducted of all the patients seen in the ED at a 70,000-volume tertiary care center in the months of June and July of 2007. Productivity data were collected by review of the computerized timeline available for all patients seen in the ED, which creates a record of patient registration and caregiver assignment to the patient. The hour of care initiation was determined from the time recorded by the ED tracker (EM Track) when a PA signed up for a patient. The PA was considered the primary provider if they initiated patient care and provided documentation on the patient. If more than 1 PA or resident signed up for the patient, the computerized medical record was accessed to determine which provider dictated the chart. All PAs were eligible to work the full complement of shift lengths, as all PAs rotate through the schedule in an equitable fashion, with no PAs restricted to short shifts or shifts at certain times of day. Eight PAs participated in the study.

Productivity was defined as patients seen during a given shift divided by the total hours that a PA saw patients that shift. Relative value unit data were collected from a separate database, and a total was calculated for all of the PA shifts worked and was compared against the total hours worked by PAs during those months, giving a mean RVU per hour for each of the PAs (to use as a reference standard). Productivity by shift length was compared using an analysis of variance (ANOVA) statistical test. Productivity by day of the week was also calculated and compared using ANOVA.

Hourly productivity for each shift was calculated so that patterns of patient care could be compared between different shifts lengths. At the study institution, PAs are responsible for following up on variances from prior shifts, such as imaging studies that are read differently by radiology and ED personnel, and therefore do not always start their shifts at the same time. This leads to differences in shift lengths and shift start times. The start of a shift was determined to be the hour in which a PA initiated care on their first patient, and shift end was determined from their preset schedule.

ED volume was calculated to determine if there was a correlation between PA productivity and the volume of patients seen in the ED. Daily volume was calculated as the number of patients registered between 0700 and 2359 each day; 0700 was chosen because that is the hour that ED residents working the day shift start their shifts, and it was hypothesized that their work load might affect PA productivity. This was also thought to be a reasonable time, as PA coverage begins at 0900, and we wanted our volume calculations to adequately represent the volume in the department, which often lags behind actual time of registration, as patients are moved from the waiting room through triage and into their rooms. Volume was not analyzed for the early morning hours because all PA shifts at our institution end by midnight, and none of the other providers working before 0700 overlap with PAs. Hourly volume, defined as patients registered per hour, was also calculated for each day of the study period. Linear regression analysis was used to determine the relationship between productivity overall and daily departmental census, as well as to determine the relationship between productivity and hourly volume. Microsoft Excel (Redmond, Washington) was used for statistical calculations.

No financial or other incentives were in place to encourage PA productivity or efficiency during the study period.

The institutional review board reviewed this study and found it to be exempt.

RESULTS

During the study period of June and July 2007, there were 160 PA shifts, including lengths of 4 hours (n = 2), 5 hours (n = 2), 7 hours (n = 1), 8 hours (n = 8), 9 hours (n = 5), 10 hours (n = 9), 11 hours (n = 58), 12 hours (n = 70), and 13 hours (n = 5). The mean productivity of all shifts was 1.16 patients per hour (95% confidence interval [CI] = 1.12–1.20). The productivity of different shift lengths was as follows: 1.25 patients per hour for 4-hour shifts, 1.3 patients per hour for 5-hour shifts, 0.714 patients per hour on 7-hour shifts, 1.14 patients per hour (95% CI = 0.91–1.37) on 8-hour shifts, 1.20 patients per hour (95% CI = 0.75–1.65) on 9-hour shifts, 1.13 patients per hour (95% CI = 0.90–1.36) on 10-hour shifts, 1.17 patients per hour (95% CI = 1.11–1.23) on 11-hour shifts, 1.16 patients per hour (95% CI = 1.11–1.21) on 12-hour shifts, and 1.17 patients per hour (95% CI = 1.00–1.34) on 13-hour shifts. By ANOVA calculation, there was no statistical difference between productivity of different shift lengths ($P = 0.73$).

ANOVA yielded no statistical difference between hourly productivity on different shift lengths (ie productivity in the third hour of any shift length was not statistically different), except the 11-hour shift, which had significantly lower productivity in the 11th hour than productivity in the 11th hour of the 12- and 13-hour shifts ($P = 0.0001$), and the 5-hour shift, which had significantly lower productivity in its last hour than other shifts in their fifth hour ($P = 0.01$). Productivity in terms of mean RVUs per hour during the study period was calculated as 2.35 RVUs per hour (95% CI = 1.98–2.72).

The daily number of patients registered in the ED (0700–2359), ranged from 133 patients to 198 patients (mean = 160 ± 14.8), whereas anywhere from 0 to 22 patients were registered on an hourly basis (mean = 9.4 ± 3.9). Linear regression analysis examining shift productivity related to daily volume showed an R^2 (statistical term for the coefficient of determination) of 0.01. Linear regression analysis of productivity per hour plotted against volume per hour yielded an R^2 of 0.02.

DISCUSSION

Overall, our PAs saw a mean of 1.16 patients per hour across all shift lengths. This number did not seem to vary with departmental census in any appreciable way, which may speak to the PAs being maximized in terms of ability to move through more cases, since they are already working as hard and as fast as they can. Alternatively, this phenomenon may speak to departmental gridlock, when patients are in fact waiting to be seen but cannot find a physical space within the department due to inpatient holds or other patients undergoing extensive workups, and so sit in the waiting room where the PA cannot gain access to them. Those patients could potentially not make their way into the ED until after the PA shifts are over, as they are typically lower-acuity cases and can afford to wait. They would then be seen overnight by residents or perhaps would choose to leave without being seen. Previous research at this institution has demonstrated essentially no relationship between departmental volume and resident productivity on a day-to-day basis with R^2 values ranging between 0.08 and 0.20, depending on level of training,[13] so it is unclear which provider group is able to adjust their productivity to compensate for volume fluctuations. Given a system with a finite number of beds, PAs, attendings, and residents, one would assume that if the PAs and residents cannot adjust their productivity with increasing patient volume, attendings must be able to adjust their productivity, but further research is needed to determine if this is the case.

Our PA productivity of 1.16 patients per hour compares well with the productivity (as patients per hour) of emergency medicine residents during the later years of their training, which ranges from 1.19 to 1.41 in different studies.[13–15] At the study institution, data show that senior-level residents see 1.25 patients per hour, while second-year residents see 1.13.[13] Although the number of patients seen by PAs is similar to that of residents, it is important to recognize that their roles in the ED are very different. Residents do not act independently. Their patients must be seen by an attending physician, and they need to gain appropriate education while in the ED. As residents become experienced and accomplished, they do receive graduated responsibility, but every June brings about a new change of resident classes and a starting over of the educational process. In this way, residents have the potential to use more limited resources (in this case, the attending physician) than a PA might on a busy shift.

Our data on RVUs showed that PAs billed 2.35 RVUs per hour during the study period. This figure is lower than that in a study by Pershad et al, who looked at RVUs per hour in a pediatric ED and found that pediatric emergency medicine physicians saw 4.36 RVUs per hour, and pediatricians and nurse practitioners saw 3.08 RVUs per hour.[16] Another study showed emergency medicine resident productivity in RVUs to range from 2.51 as first-year residents to 3.61 as third-year residents.[17] It is unclear if this discrepancy in RVU data is based on the lower acuity of the patients seen by PAs or if it is an issue with incomplete documentation. Relative value unit determination is highly dependent on completeness of documentation, and PAs may not document as well as residents, whose charts are generally carefully reviewed by their attendings. This data also fails to reflect the other components of the PA workload, such as reviewing radiology and lab variances and calling or writing to follow-up patients. These jobs are of critical importance to sound patient care in any ED, but do not itemize out in traditional billing schemes.

LIMITATIONS

There are several limitations to our study. Calculations for ED volume were based on total numbers of patients registered in the department per day (0700–2359), and on patients registered per hour. By not including patients registered before 0700, some early fluctuations that impacted PA productivity at

the start of their shifts may have been missed. Similarly, by measuring hourly volume as patients registered per hour, it was not possible to determine if that was the volume of patients actually seen during that hour. Although the time the patient was placed in their room could have been used, it was felt that this number was less reliable due to the fact that there is a substantial lag where patients often sit in the waiting room after they are placed in a room in the computer.

Data were only collected from a very specific time period during the year (June and July of 2007). It is possible that there is significant variation in productivity and patterns of care during the year. Specifically, PAs may see more patients during the summer months when new ED residents are starting to work and learn the system and more experienced residents learn to handle new positions and duties. On the other hand, inexperienced physicians may require more help and have difficulty moving patients through the ED, slowing down their fellow providers. It would be beneficial to compare these data to data collected during other times of the year when resident inexperience was less of an issue.

This study did not look at the number of procedures accomplished by PAs during their productive hours. It is possible that PAs, who see a selected group of lower-acuity patients, have increased or decreased hourly productivity because they spend a different amount of time on procedures, such as suturing, than emergency medicine residents or attending physicians. Theoretically this should be reflected in the RVU data, although this relies on proper documentation. Additionally, no data were analyzed on PA productivity based on the number of consecutive or cumulative days worked, so we did not account for fatigue. This would be an interesting analysis and may provide further information regarding PA productivity and staffing patterns that would best support optimal productivity and enhance patient flow. Additionally, our study was not adequately powered to parse out the strengths or weaknesses of individual providers, and all PA data were analyzed as a whole with no attempt made to compare PAs of differing skill or seniority.

Finally, these data were drawn from a single academic institution and may not be able to be generalized to other institutions. In community settings without residents, PAs may see a broader range of patients and have different productivity characteristics. At this institution, length of stay for patients in the ED is 3 hours for discharged patients and 7.5 hours for admitted patients, which has implications for patient turnover and accessibility to new patients for our PAs during their shifts.

Although it is beyond the scope of this paper, it is also important to recognize that questions of PA use should always address educational objectives of residents at teaching institutions as well as those of the PAs themselves. Physician assistants generally receive only on-the-job training with few PAs choosing to engage in postgraduate subspecialty training. Therefore, it is important to recognize that young or inexperienced PAs may lack adequate training in system management to efficiently manage numerous patients and document appropriately. Residents may be deprived of the bread and butter of emergency medicine in the form of abscess drainages and laceration repairs by these cases getting preferentially picked up by PAs. As always, one must balance service requirements with educational objectives when deciding on a staffing model.

CONCLUSION

ED physician assistants at this institution see 1.16 patients per hour, and generate 2.35 RVUs per hour. Productivity is not impacted by shift length or changes in volume in the ED. If specific days of the week or times of the day are known statistically to have higher volume, those times should be staffed with a larger number of PAs to absorb the extra patients.

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Teaching and Clinical Efficiency: Competing Demands

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Introduction: Teaching ability and efficiency of clinical operations are important aspects of physician performance. In order to promote excellence in education and clinical efficiency, it would be important to determine physician qualities that contribute to both. We sought to evaluate the relationship between teaching performance and patient throughput times.

Methods: The setting is an urban, academic emergency department with an annual census of 65,000 patient visits. Previous analysis of an 18-question emergency medicine faculty survey at this institution identified 5 prevailing domains of faculty instructional performance. The 5 statistically significant domains identified were: Competency and Professionalism, Commitment to Knowledge and Instruction, Inclusion and Interaction, Patient Focus, and Openness and Enthusiasm. We fit a multivariate, random effects model using each of the 5 instructional domains for emergency medicine faculty as independent predictors and throughput time (in minutes) as the continuous outcome. Faculty that were absent for any portion of the research period were excluded as were patient encounters without direct resident involvement.

Results: Two of the 5 instructional domains were found to significantly correlate with a change in patient treatment times within both datasets. The greater a physician's Commitment to Knowledge and Instruction, the longer their throughput time, with each interval increase on the domain scale associated with a 7.38-minute increase in throughput time (90% confidence interval [CI]: 1.89 to 12.88 minutes). Conversely, increased Openness and Enthusiasm was associated with a 4.45-minute decrease in throughput (90% CI: −8.83 to −0.07 minutes).

Conclusion: Some aspects of teaching aptitude are associated with increased throughput times (Openness and Enthusiasm), while others are associated with decreased throughput times (Commitment to Knowledge and Instruction). Our findings suggest that a tradeoff may exist between operational and instructional performance. [West J Emerg Med. 2012;13(2):186–193.]

INTRODUCTION

Across the United States attending physicians prepare emergency medicine (EM) residents to care for millions of patient encounters each year.[1] There are multiple time demands placed on the attending physician while running an emergency department (ED). Attending physicians are presented with the critical task of teaching future emergency physicians the medical knowledge and skills needed to successfully care for patients of varying ages, medical conditions, and socioeconomic backgrounds. Unlike a traditional classroom, attending physicians must master the skill of teaching while simultaneously moving patients safely through the ED.

To date, there have been few investigations evaluating the association between the quality of EM physician teaching and clinical efficiency. A crucial first step in the promotion of excellence in education and clinical efficiency is discovering

physician qualities that contribute to both effective teaching and clinical efficiency.

The objective of this investigation was to evaluate the relationship between EM educator performance (within and across 5 education performance domains) and their operational performance (as measured by their ability to maintain patient flow in an academic ED). We hypothesized that the teaching proficiency of an EM staff physician, as viewed by EM residents, is independent of clinical productivity.

METHODS

Study Design

We retrospectively analyzed prospectively collected data from 2 sources to determine if a correlation exits between physician productivity and teaching aptitude. Approval by the local institutional review committee was obtained prior to the initiation of the investigation.

Teaching aptitude was derived from resident evaluations of staff physicians. Resident evaluations utilized the New Innovations Program Residency Management Suite (New Innovations Inc, Uniontown, Ohio). Residency Management Suite is an instrument that facilitates medical education by unifying data into a centralized data warehouse and then completing tasks through a common interface. The authors have no financial relationship with New Innovations.

Physician clinical performance was defined as the median throughput time for all patients treated by that physician. Data for throughput time were abstracted from the Epic Systems Corporation (Verona, Wisconsin) electronic medical record (EMR) system.

Study Setting and Population

This study was undertaken at an urban, academic, level-1 trauma center (Regions Hospital, St Paul, Minnesota). The annual ED census at the study site is 65,000 patient visits, with a 21% hospital admission rate and 2,500 trauma admissions per year.

The Regions Hospital EM program is a year 1 through 3 training program with 9 residents per year for a total of 27 residents. Residents are asked to complete an annual 18-item survey for each faculty member to evaluate instructional performance.

The 18-item survey was originally developed and administered as a faculty evaluation instrument. When it was first developed, the survey's questions were intended to identify various attributes of teaching aptitude based the Accreditation Council for Graduate Medical Education (ACGME) core competencies. Questions were intended to represent an individual area of the ACGME core competencies (patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skill, professionalism, and systems-based practice).

The 18-item electronic survey for all faculty cohort was administered to residents in late fall twice over a 2-year period (2004–2005). Residents had over 2 weeks to fill out the survey. Using 2004 data, 5 domains of instructional quality were derived (Competency and Professionalism, Commitment to Knowledge and Instruction, Inclusion and Interaction, Patient Focus, and Openness and Enthusiasm) and then validated using 2005 data.[2]

Complete data were available for 24 faculty members from 2004 and 29 faculty members for 2005 and 2006. Throughput data from the ED operations warehouse were collected for the final year, 2006.[3]

Study Protocol

Faculty performance data were collected in the following manner. Residents at all levels of training were asked to evaluate the teaching performance of EM faculty with an online survey (Table 1) (New Innovations Inc). This 18-question survey identifies various attributes of teaching aptitude based on ACGME core competencies. Respondents score each item using a 9-point Likert scale adapted from the American Board of Internal Medicine mini-clinical evaluation exercise.[4] Responses were then assigned the following meaning: 1 through 3 indicate "below expectations"; 4 through 6 indicate "meets expectations"; and 7 through 9 indicate "exceeds expectations." New Innovations survey software (New Innovations Inc) computed descriptive statistics (max, min, mean, median, standard deviation) for each faculty member. Three sets of survey data were collected corresponding to the years 2004, 2005, and 2006, respectively.

In a prior investigation we identified independent domains of teaching aptitude through maximum-likelihood factor analysis (see Data Analysis section for details). Five domains of instructional performance were identified: (1) Competency and Professionalism, (2) Commitment to Knowledge and Instruction, (3) Resident Inclusion and Interaction, (4) Patient Focus, and (5) Openness and Enthusiasm.[2]

Patient-level throughput data were gathered from the Regions Hospital ED operations warehouse. The ED operations warehouse is a structured query language database developed at the Regions Hospital ED to assist in patient tracking and measuring operational performance. The database is populated by event level data from the Regions Hospital EMR (EPIC system). In the EMR a patient encounter begins as soon as the patient enters the ED and requests care. The encounter ends when the system records a final ED disposition. The ED operations warehouse defines throughput as the difference between these 2 timestamps. Of the approximately 65,000 patient encounters tracked in the ED operations warehouse, those without direct resident involvement were excluded. This resulted in 38,526 patient encounters in the final dataset used to compare physician teaching and throughput performance.

Table 1. Online survey to evaluate teaching performance.

Contact
Compared to other faculty you are evaluating, what is the amount of contact you have had during this evaluation period?
Patient care
Able to provide care that is appropriate and effective for the treatment of patients.
Able to provide compassionate patient care.
Medical knowledge
Demonstrates knowledge about established and evolving biomedical sciences and applies this knowledge to patient care.
Practice-based learning
Investigates and evaluates patient care practices and appraises and assimilates scientific evidence (eg, evidence-based test ordering).
Interpersonal and communication skills
Demonstrates interpersonal and communication skills that result in effective information exchange and teaming with patients, patients' families, and professional associates.
Professionalism
Demonstrates a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population.
System-based practice
Demonstrates an awareness of and responsiveness to the larger context and system of healthcare (eg, compliance with systems).
Clinical instruction and supervision
Clinical teaching: faculty teaches at the bedside and in the emergency department.
Participation in trauma team activations.
Participation in ultrasound activities.
Feedback
Shift feedback: faculty provides effective feedback during and after clinical shifts.
Availability
Makes him/herself available to the residents.
Reception to new ideas
Is usually flexible or open to new ideas.
Enthusiasm
Program commitment
Has made a firm commitment to the residency program and will give residents his/her full support.
Potential as mentor
Desirability as a mentor.
Overall evaluation
Overall evaluation in relation to all (Institution Name) Emergency Medicine faculty with whom you had had contact.

Data Analysis

Analysis proceeded in 2 phases. The first phase used data from physician teaching performance surveys completed by the EM residents. These data were separated by year (2004, 2005, and 2006). Using the 2004 survey data, an exploratory maximum-likelihood factor analysis employing a Varimax rotation identified potential, independent domains of EM faculty performance. Two confirmatory factor analyses using the data from 2005 and 2006 were conducted to confirm the consistency of the latent structure (eg, performance domains) identified in the 2004 data. The consistency of the performance within a given instructional domain over time was confirmed using Cronbach alpha at the physician level.

The second phase of the analysis used a multivariate, random effects model with gamma-distributed errors to compare EM faculty member's instructional and operational performance. The 38,526 patient-level encounters were randomly assigned to either the estimation or validation datasets. The estimation dataset was used to develop the model, the validation dataset to protect against over fitting. In this model, patient encounters were nested with EM faculty. Construction of the models used the estimation dataset and proceeded in a bottom-up fashion. First, the possibility of significant variation at the physician level (eg, a significant random effect) was examined. Then, a baseline model using patient-level confounding factors such as age, gender, time/day of presentation, and acuity as measures by emergency severity index scale was developed. All potential confounders were screened prior to inclusion. Those significant at the 10% level in a univariate model were retained in the final multivariate model. Using the final patient-level baseline model, the relation in performance along each educational domain was explored in a series of separate models. Finally, a multivariate model simultaneously including all 5 domain scores was estimated to determine which domain effects were dominant. The validation datasets were used to confirm the findings.

RESULTS

Exploratory factor analysis of the 2004 data revealed 5 latent constructs (eg, educational performance domains) that explained 92.5% ($\chi^2 = 2.33$, $P = 0.11$) of the variation in the data. Factor analysis of the 2005 and 2006 resident surveys confirmed the validity of these constructs; they explained 89.6% and 90.5% of the data's variations, respectively ($\chi^2 = 1.89$, $P = 0.25$). The 5 instructional domains were (1) Competency and Professionalism (30% of variation explained), (2) Commitment to Knowledge and Instruction (17% of variation explained), (3) Inclusion and Interaction (17% of variation explained), (4) Patient Focus (13% of variation explained), and (5) Openness and Enthusiasm (9% of variation explained).[2] Table 2 presents the factor loadings and proportion of variance explained using the 2004 data. Performance across the instructional domains appeared consistent across years per Cronbach alpha at the physician level (0.675–0.752). The items

Table 2. Results of factor analysis.

Survey questions*	Competency and Professionalism	Commitment to Knowledge and Education	Inclusion and Interaction	Patient Focus	Openness and Enthusiasm
Compassionate patient care	*0.463*	0.381	0.300	**0.702**	0.228
Ethical principles, sensitivity to diverse patient populations	0.599	0.366	0.236	*0.498*	0.283
Appropriate and effective care for treatment of patients	**0.634**	0.285	0.419	0.519	0.178
Effective information exchange and teaming with patients, families, and associates	**0.633**	0.285	0.362	0.413	0.380
Faculty teaches at bedside	0.522	*0.485*	*0.496*	0.414	0.208
Participation in trauma team	0.425	0.387	**0.652**	0.340	0.176
Feedback during and after clinical shifts	0.284	**0.627**	0.412	0.325	0.320
Enthusiasm	*0.485*	0.365	0.383	0.352	0.577
Firm commitment to the residency program and will support residents	0.444	**0.743**	0.294	0.307	0.187
Desirability as a mentor	0.582	0.517	0.398	0.302	0.353
Available to the residents	0.413	**0.644**	*0.467*	0.278	0.327
Knowledgeable of established and evolving biomedical science and applies to patient care	**0.793**	0.447	0.265	0.279	0.101
Appraises and assimilates scientific evidence	**0.791**	0.403	0.315	0.264	0.175
Compliance with larger medical systems	**0.800**	0.343	0.142	0.209	0.311
Flexible and open to new ideas	0.517	*0.487*	0.415	0.260	*0.451*
Ultrasound participation	0.143	0.235	**0.703**	0.125	0.124
Quality of conference presentations and participation	0.412	**0.755**	0.333	0.183	0.121
Proportion of variance explained	0.306	0.231	0.169	0.133	0.086
Cumulative variation explained	0.306	0.537	0.706	0.839	0.925
Standard deviation of factor score	1.007	1.027	1.057	1.013	1.055

* Numbers represent the strength of association between each survey question and the associated domain. Absolute values ranging from 0.45 to 0.5 (italics) indicate moderate association, those between 0.5 and 0.6 indicate a strong positive association, and those greater than 0.6 (bold) indicate a very strong association and have the greatest impact upon the domain's interpretation. The sign of the value indicates the direction of the correlation.

contributing most to developing Competency and Professionalism were compliance with the medical system (0.8), knowledge and application of science (0.79), appraisal of scientific evidence (0.79), appropriate and effective care (0.63), and effective information exchange (0.63). Items contributing to Commitment to Knowledge and Instruction were conference presentations and participation (0.75), commitment to residency program (0.74), availability (0.64), and feedback (0.62). Items contributing to Inclusion and Interaction were ultrasound participation (0.70) and trauma team participation (0.65). Patient Focus was mainly determined by compassionate patient care (0.70), with appropriate and effective treatment (0.52) also contributing. The final factor, Openness and Enthusiasm, has no strong contributors, with only enthusiasm (0.57) and flexibility (0.45) contributing (Table 3).

Prior to inclusion in these models physician scores across all 5 educational domains were centered at 0. Standard errors (SE) are listed at the bottom of Table 2. Table 4 contains the results from the final multivariate model incorporating all of the educational domains and patient-level confounders. These results were estimated using the validation dataset. The average patient throughput time at the study site was 188.53 minutes (SE 11.5). In addition to hour of arrival the following patient-level confounders were found to significantly impact patient flow: age $\geq$ 65 years (15.45 minutes, SE 4.2), age $<$ 18 years ($-$36.43 minutes, SE 4.5), low acuity (67 minutes, SE 5.2), moderate acuity (62 minutes, SE 3.9), fast track ($-$79 minutes, SE 4.4), and behavioral health (328 minutes, SE 6.4).

All 5 of the educational domains were significantly related to patient throughput times when included independently in

Table 3. Delineation of the 5 domains of instructional performance.

1. Medical Competency and Professionalism
Compliance with larger medical systems
Knowledgeable of established and evolving biomedical science and applies to patient care
Appraises and assimilates scientific evidence
Appropriate and effective care for treatment of patients
Effective information exchange and teaming with patients, families, and associates
Ethical principles, sensitivity to diverse patient populations
Desirability as a mentor
Faculty teaches at bedside
Flexible and open to new ideas
2. Commitment to Knowledge and Education
Quality of conference presentations and participation
Firm commitment to the residency program and will support residents
Available to the residents
During and after clinical shifts
Desirability as a mentor
Flexible and open to new ideas
Faculty teaches at bedside
3. Resident Inclusion and Interaction
Ultrasound participation
Participation in trauma team
Faculty teaches at bedside
Available to the residents
4. Patient Focus
Compassionate patient care
Appropriate and effective care for treatment of patients
Ethical principles, sensitivity to diverse patient populations
5. Openness and Enthusiasm
Enthusiasm
Flexible and open to new idea

multivariate models adjusting for patient-level factors only. Competency and Professionalism (−5.3, SE 2.1) and Openness and Enthusiasm (−8.2, SE 1.9) were associated with decreased throughput times (eg, improved patient flow). In contrast, Commitment to Knowledge and Instruction (11.5, SE 2.8), Inclusion and Interaction (6.3, SE 2.4), and Patient Focus (4.5, SE 2.1) were associated with increased throughput times. When simultaneously incorporated into a single multivariate model, the directionality of all 5 educational domains was consistent, but only 2 remained significant at the $\alpha = 0.1$ level. Commitment to Knowledge and Instruction was associated with increased throughput time (7.38, SE 3.2) while Openness and Enthusiasm was associated with decreased throughput time (−4.45, SE 2.6). From this final model, 2 statements can be made regarding the interrelated nature of instructional performance and patient flow. For the domain Commitment to Knowledge and Instruction each standard deviation (1.027) increase in the domain was associated with a 7.59-minute increase in patient throughput time (90% confidence interval [CI]: 1.94 to 13.23 minutes). For the domain Openness and Enthusiasm each standard deviation (1.06) increase was associated with a 4.69-minute decrease in patient throughput time (90% CI: −9.31 to −0.074 minutes). A histogram of patient throughput time can be seen in the Figure.

DISCUSSION

Teaching residents is an important aspect of academic medicine. Clinical teaching in the ED has a significant impact on medical knowledge, professionalism, medical decision making, procedural skills, and communication.[5–9]

The relationship between faculty and resident is a mentoring one. The "Osler" model of residency training suggests that staff physicians are not merely distant figures but are actively involved in instructing residents while caring for patients.[10] William Osler stated "the art of medicine is an observation, as the old motto goes, but to educate the eye to see, the ear to hear, and the finger to feel takes time, and to make a beginning to start a man on the right path is all that we can do."[11] When time with the learner is hurried the end result is often not quite what the mentor had planned.[12]

Clinical education of residents is a priority for both academic departments of EM and the ACGME. The following language is included in the ACGME statement on duty hours, "Didactic and clinical education must have priority in the allotment of residents' time and energy."[13] In the same document the ACGME goes on to say, "The program must ensure that qualified faculty provide appropriate supervision of residents in patient care activities."[13]

Many factors compete with faculty time for education. We specifically evaluated the relationship between clinical productivity and time spent instructing and mentoring residents. Throughput time is an important component of the much larger healthcare issue of over-crowding facing EM in the United States.[14,15]

The escalation of crowding in EDs across the United States will likely result in increasing pressure placed on faculty to improve patient throughput time and may further deter faculty time away from resident instruction. More than ever, the clinician educator must balance the needs of the learner with the larger issues of patient care. In truth this is only one piece of a large puzzle. Faculty not only have to balance resident education, clinical productivity, and issues of the nation's healthcare safety net such as crowding, but also provide sufficient documentation to meet the Centers for Medicare and Medicaid services guidelines for evaluation and management coding that emergency practitioners face regardless of practice setting.[16–18]

Table 4. Results of multivariate model.

	Average effect (min)	SE	90% confidence interval	
			Lower	Upper
Average patient throughput	188.53	11.5	153.40	223.66
Patient level demographics				
Geriatric patient (age > 64 y)	15.45	4.2	8.53	22.37
Pediatric patient (age < 18 y)	−36.43	4.5	−43.91	−28.95
Low acuity (ESI 4 or 5 versus ESI 1 or 2)	67.47	5.2	58.85	76.08
Moderate acuity (ESI 3 versus ESI 1 or 2)	62.12	3.9	55.72	68.52
ED South (Fast-track)	−78.74	4.4	−85.92	−71.55
Behavioral health patient	328.60	6.4	317.90	339.20
Domains of instructor performance				
Competency and professionalism	−3.05	2.6	−7.46	1.36
Commitment to knowledge and instruction	**7.38**	**3.2**	**1.89**	**12.88**
Inclusion and interaction	3.07	2.5	−1.17	7.32
Patient focus	2.04	2.6	−2.48	6.57
Openness and enthusiasm	**−4.45**	**2.6**	**−8.83**	**−0.07**

SE, standard error; *ESI*, emergency severity index; *ED*, emergency department.

Investigations by several authors have indicated that staff physicians feel that the demands of increasing clinical productivity and documentation directly inhibit teaching success.[17–20] The results of a survey by McLean and Feldman[17] indicate clinical documentation demands are associated with a decrease in teaching time. Fields and colleagues[18] expressed a similar concern (regarding the demands of documentation) and commented that the medical curricula were at risk. Bandiera et al[19] state "frequent interruptions and competing demands are perceived as detrimental to effective teaching" in the ED. The authors further note "during busy ED shifts, with patient waiting times measured in hours, dedicated teaching time is hard to find." Berger et al[20] remarked that 96% of the faculty at a large teaching institution believed that the time demand for clinical productivity was the largest limiting factor in being able to effectively teach students. However, the authors found no relationship between staff productivity and medical student teaching evaluations.[20]

The above investigations did not specifically evaluate the association between the quality of physician teaching and clinical efficiency. We sought to evaluate the relationship between teaching performance (measured by instructional domains identified within teaching evaluations) and physician throughput time. Our results suggest that certain aspects of teaching aptitude are associated with patient flow. We found that the instructional performance domain Commitment to Knowledge and Instruction was associated with a significant increase in throughput time. Conversely, the instructional performance domain of Openness and Enthusiasm was associated with decreased throughput time.

Overall, academic contribution, educational quality, and operational performance are aspects of EM physician performance. EM faculty must impart knowledge while simultaneously moving patients safely and efficiently through the ED. We observed that instructional performance was significantly correlated with operational performance in that all 5 domains in the study correlated with patient throughput times in separate models. As demands for physicians' time increase, it is important to understand the relationship between competing demands facing academic faculty. Perhaps the most important findings in this investigation involve identifying faculty attributes that most affect the potential to successfully educate and mentor residents as well as efficiently maintain patient flow within an ED. Defining faculty attributes that are mutually beneficial to both education and clinical productivity are important as the pressure increases to do both well. Of the 5 educational performance domains, Openness and Enthusiasm was mutually beneficial to education and clinical productivity.

LIMITATIONS

Our study has several limitations. First, we chose a method of faculty evaluation that residents perform on an annual basis. Annual evaluations may not accurately depict daily learning interactions. Second, ED-related factors such as faculty and resident patient load and level of resident training (the amount of time a faculty spent teaching and supervising a first year resident versus a more senior resident) were not controlled for. Therefore, the effect these variables may have had on teaching performance or clinical productivity is unknown. Third, third-party independent observation of teaching encounters was not performed. As such, there is not a benchmark to compare the teaching interactions of faculty with residents, students, and

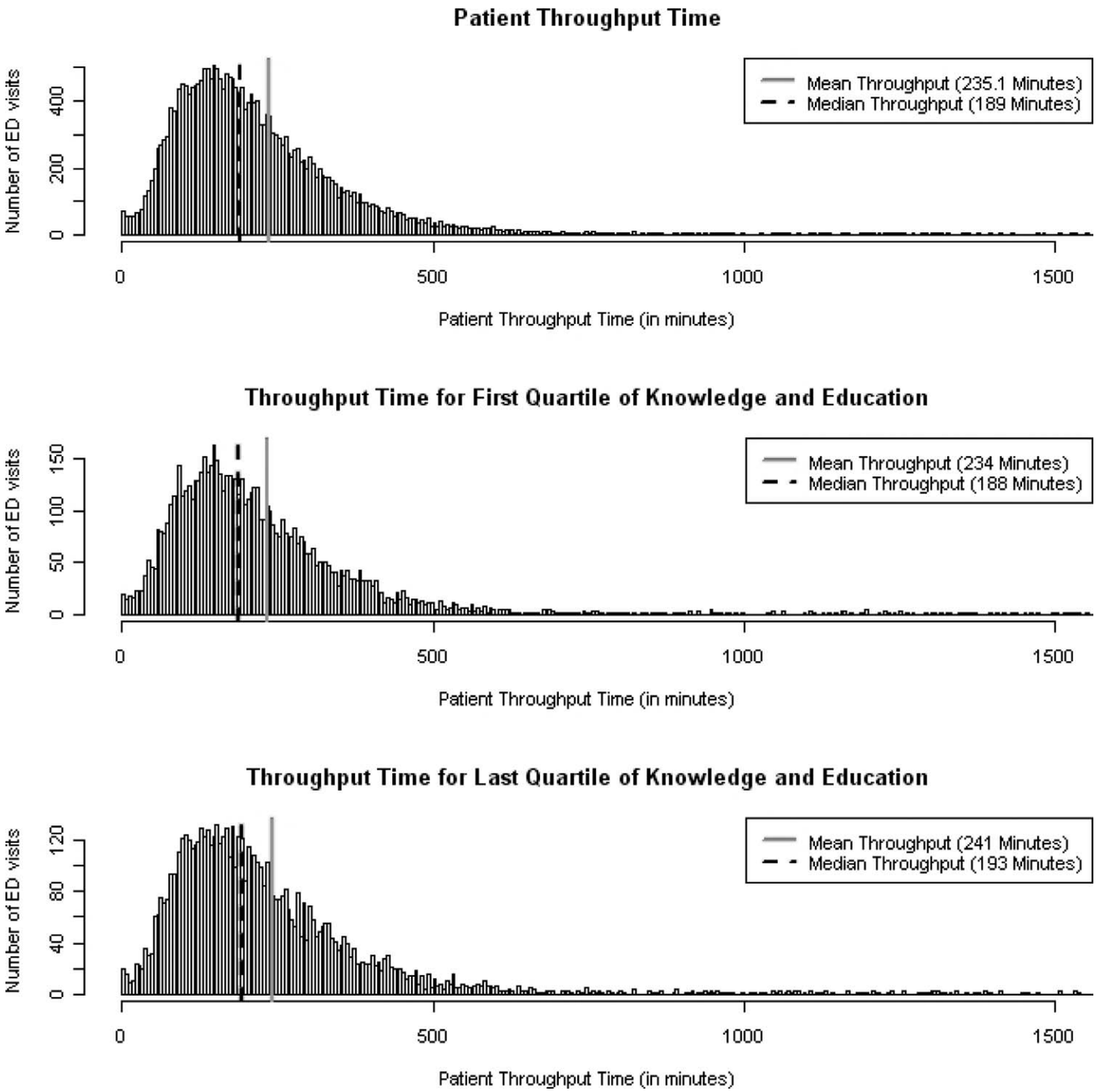

Figure. Histogram of patient throughput time. *ED*, emergency department.

other midlevel providers (physician's assistants and sexual assault nurse examiners) on a given shift. Nor was there a benchmark to determine the effect that midlevel providers and students had on clinical efficiency. Furthermore, the effect that an individual faculty member's personality had on their evaluation is unknown. Fourth, faculty behaviors may not have been static and independent of context. For example, in low departmental demand states, faculty may have spent more time with residents showing a higher Commitment to Knowledge and Instruction. Conversely, in high departmental demand states, faculty may have exhibited behavior more consistent with Openness and Enthusiasm. Fifth, this investigation was performed at a single institution. An investigation with multiple clinical sites would need to be undertaken in order to increase the generalizability of the study's findings. Sixth, as is common among academic institutions, there is some heterogeneity in

shift distribution and number of clinical hours faculty members work.

CONCLUSION

Faculty performance in specific domains of instructional quality has significant but varied associations with patient throughput time. Some aspects of teaching aptitude appear to improve throughput time (Openness and Enthusiasm) while other aspects appear to hinder throughput time (Commitment to Knowledge and Instruction). Our findings suggest that a tradeoff may exist between operational performance and certain areas of instructional performance.

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Emergency Department Management of Delirium in the Elderly

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An increasing number of elderly patients are presenting to the emergency department. Numerous studies have observed that emergency physicians often fail to identify and diagnose delirium in the elderly. These studies also suggest that even when emergency physicians recognized delirium, they still may not have fully appreciated the import of the diagnosis. Delirium is not a normal manifestation of aging and, often, is the only sign of a serious underlying medical condition. This article will review the significance, definition, and principal features of delirium so that emergency physicians may better appreciate, recognize, evaluate, and manage delirium in the elderly. [West J Emerg Med. 2012;13(2):194–201.]

BACKGROUND

The elderly, defined as 65 years of age and older, are rapidly representing a larger portion of the population in the United States. In 2000, they numbered 34.6 million, or 12% of the population. By the mid-21st century, this number will increase to 82 million, or 20% of the population,[1,2] It is estimated that 10% to 30% of the elderly evaluated in the emergency department (ED) will present with delirium.[3–5] The prevalence might be even higher, as patients who are unable to communicate due to critical illness or are unable to cooperate are excluded from many studies.[6] Several other studies have suggested that emergency physicians are "suboptimal" at recognizing mental status impairment in the elderly as well as eliciting signs and symptoms necessary to diagnose delirium.[6–8] Physicians correctly diagnose delirium in only 24% to 35% of elderly patients,[3,4,8] with one study revealing that nearly half of the patients with delirium were discharged with little consideration that delirium could be the harbinger of a serious underlying medical condition.[7] Failure to detect delirium in the elderly in the ED and subsequent discharge has the potential for increased mortality within 6 months of discharge.[9] Several authors also noted that even when delirium was diagnosed, some patients were still inappropriately discharged. The high prevalence of impaired mental status combined with the number of elderly patients with delirium discharged has led some experts to suggest that age alone should be a criterion for screening the elderly for delirium through the use of a formal mental status evaluation.[10] Elderly patients diagnosed with delirium in the ED had a 12-month mortality rate of 10% to 26%.[6,11,12] Similar mortality rates have been observed with acute myocardial infarction and sepsis.[5] In addition, delirious elderly patients tend to have poorer outcomes and their short-term risk of mortality increases when compared with their nondelirious counterparts.[4,7,13] A recent meta-analysis found that delirium in the elderly is independently associated with poorer outcomes, regardless of factors such as other illnesses and baseline dementia.[14] Even when admitted, older patients ultimately diagnosed with delirium have increased mortality during the 12 months following hospital admission. Delirium was identified to be an independent risk factor of increased mortality, and especially significant if underlying dementia was absent.[12] Cognitive impairment is not considered a normal part of the aging process. As a result, emergency physicians should recognize delirium, even if subtle, as a medical emergency. Early diagnosis, treatment, and the appropriate disposition of the delirious elderly patient may facilitate a faster recovery and more desirable longer-term outcomes.[11]

DEFINING DELIRIUM

Delirium is a syndrome defined by the American Psychiatric Association as "a disturbance of consciousness and a change in cognition that develops over a short period of time."[15] Delirium is derived from the Latin word "delirare,"

Table 1. Causes of delirium ("I WATCH DEATH").*

Potential causes	Differential diagnosis
Infectious	Sepsis, encephalitis, meningitis, syphilis, central nervous system abscess
Withdrawal	Alcohol, barbiturates, sedative-hypnotics
Acute metabolic	Acidosis, electrolyte disturbance, hepatic/renal failure, other metabolic disturbances (glucose, magnesium, calcium)
Trauma	Head, burns
CNS disease	Hemorrhage, cerebrovascular accident, vasculitis, seizures, tumor
Hypoxia	Acute hypoxia, chronic lung disease, hypotension
Deficiencies	Vitamin B_{12}, hypovitaminosis, niacin, thiamine
Environmental	Hypo/hyperthermia, endocrinopathies, diabetes, adrenal, thyroid
Acute vascular	Hypertensive emergency, subarachnoid hemorrhage, sagittal vein thrombosis
Toxins/drugs	Medications, street drugs, alcohols, pesticides, industrial poisons, carbon monoxide, cyanide, solvents, etc
Heavy metals	Lead, mercury

* The above table was adapted from Table 102–1 of Smith and Seirafi,[16] which the authors modified from Wise MG.

Table 2. Commonly prescribed drugs associated with delirium.*

Classes of drugs	Examples
Sedative/hypnotics	Benzodiazepines (especially flurazepam, diazepam)
	Barbiturates
	Sleeping medications (diphenhydramine, chloral hydrate)
Narcotics	All, but especially meperidine
Anticholinergics	Antihistamines (diphenhydramine, hydroxyzine)
	Antispasmodics (belladonna, diphenoxylate and atropine)
	Heterocyclic antidepressants (amitriptyline, imipramine, doxepin)
	Neuroleptics (chlorpromazine, haloperidol, thioridazine)
Incontinence	Oxybutynin
	Hyoscyamine
	Atropine/scopolamine
Cardiac	Digitalis glycosides
	Antiarrhythmics (quinidine, procainamide, lidocaine) Antihypertensives (beta-blockers, methyldopa)
Gastrointestinal	H_2-blockers (cimetidine, ranitidine, famotidine)
	Proton pump inhibitors
	Metoclopramide
	Herbal remedies (valerian root, St John's Wort, kava kava)

* Adapted from Table 117-3 of Agostini et al.[5]

which literally means, "to go out of the furrow" or figuratively, "crazy or deranged."[16] Thus, delirium is a transient cerebral dysfunction resulting in an acute reversible decline in attention and cognition. Delirium may manifest itself clinically in the hyperactive, the hypoactive, or the mixed form.[11] The hyperactive form is identified by agitation, increased vigilance, and hallucinations. The hypoactive form is associated with lethargy and reduced psychomotor functioning. Often, this leads the caregiver or practitioner to believe that the patient is doing fine due to the lack of any sign of discomfort or distress. Unfortunately, the hypoactive form is more common and generally portends a poorer prognosis. In the mixed form of delirium, characteristics from both the hyperactive and hypoactive forms are manifested. Special care must be given to patients with the mixed form of delirium, as they may vacillate unpredictably and can be especially difficult to manage.[5,8,16]

ETIOLOGY

The etiology of delirium in the elderly is multifactorial as any one or more predisposing and precipitating factors may be involved (Table 1). As compared to a younger, healthier patient, an elderly patient can enter a delirious state when exposed to a simple noxious insult or precipitating event. Predisposing factors include advanced age, preexisting cognitive impairment/dementia, severe underlying illness (eg, chronic renal insufficiency), functional impairment, male gender, depression, dehydration/malnutrition, alcohol abuse, and sensory impairment (vision or hearing). In addition to a noxious insult such as acute pain, other precipitating factors include medication use, acute medical illness or infection, immobilization or the use of physical restraints, urinary retention or Foley catheterization,[17] dehydration, environmental factors, alcohol/drug use, and psychosocial factors.[18–21] One of the most common causes of delirium in the elderly is the use of medications (Table 2), especially routinely prescribed medications (psychoactive agents such as benzodiazepines, narcotic analgesics, and drugs with anticholinergic effects),[18–26] with an overall incidence of 22% to 39%.[16] Living in a nursing home has also been identified as an independent risk factor for delirium, as up to 40% of nursing home residents will experience delirium, usually from an infection.[18]

Commonly noted signs and symptoms for certain ailments are not always evident in the elderly. For example, an elderly patient may be experiencing respiratory difficulty, but not have

dyspnea or tachypnea, or an acute myocardial infarction without the expected classic complaint of chest pain. Pneumonia, urinary tract infection, endocarditis, abdominal abscess, and infected joints have all been diagnosed in elderly patients who were afebrile and did not have an elevated white blood cell count.[5] In short, a "common herald" of a physical illness in the elderly may be the onset of an acute confusional state, rather than the signs and symptoms classically associated with a particular illness.[16]

Studies involving electroencephalograms, evoked-potential studies, neuroimaging, and other modalities suggest that neurotransmitter abnormalities are associated with delirium.[5] At the cellular level, widespread alterations in cerebral metabolic activity with secondary deregulation of neurotransmitter synthesis and metabolism are present. The elderly appear especially vulnerable to cerebral biochemical alteration. Although multiple neurotransmitters have been implicated, the most prominent agent in the development of delirium is acetylcholine. Delirium is frequently caused by anticholinergic drugs, and increased serum anticholinergic activity has been demonstrated in delirious elderly patients.[5,22,23] Elevated serotonin levels have been identified in patients with sepsis, hepatic encephalopathy, serotonin syndrome, and psychedelic drug ingestion. Other disturbances associated with delirium are cytokine increases and oxidative metabolism substrate disturbances (eg, glucose, oxygen, gamma-aminobutyric acid, cortisol, dopamine, beta endorphins).[5]

DIAGNOSING DELIRIUM

Diagnosing delirium in the elderly requires recognition of the syndrome and a systematic approach (Figure).[27] Some patients are obviously delirious. Patients who present without overt delirium pose a more difficult diagnostic challenge, especially when information or patient corroboration is limited. Most etiologies of delirium may be uncovered by a guided history and physical examination, with special emphasis on medication history, combined with focused ancillary testing and a search for occult infection.[5] An important caveat to remember is that a delirious person may be oriented to person, place, and time, but that apparent alertness and orientation do not preclude delirium. Eliciting a more subtle presentation may require more substantial questioning.[11] Unfortunately, early or evolving baseline dementia may complicate initial evaluation.

Dementia may be distinguished from delirium (Table 3)[28] by the tempo of onset, clinical course, level of attention and consciousness, orientation, and changes in speech patterns. For dementia, onset is insidious and progressive, occurring over months to years. The course usually does not fluctuate throughout the day, and inattention and disorientation are not usually observed until the latter stages of dementia. A demented individual's speech may be marked by parsimony, anomia, or even aphasia, while a delirious person will talk incoherently, illogically, and have dysnomia. Dysnomia (the inability to name objects correctly) and dysgraphia (impaired writing ability) are 2 of the most sensitive indicators of delirium.[16] In summary, the hallmark of delirium is the acute onset (hours to days) of changes in attention and cognition.

HISTORY-TAKING

Detailed history-taking may also require interviewing multiple people, including the prehospital providers who evaluated and transported the patient to the ED, family members, and other caregivers. It is critical to ascertain the patient's cognitive baseline, the recent sequence of events, any history of similar problems or prior episodes, new medications (including prescribed medications, dietary supplements, and over-the-counter agents), and any history of alcohol use or substance abuse. Past medical history and comorbid conditions, such as diabetes, hypertension, and any immunosuppressive disease should be confirmed.[5,16] A comprehensive review of systems should then be conducted since, as noted above, the elderly may often report vague or nonspecific complaints, such as weakness.[29] The patient's baseline activities of daily living (ADL) should also be verified. The normal progression of functional decline or inability to perform these activities typically occurs in the following manner: bathing, dressing, toileting/continence, transferring (bed/chair), and, lastly, feeding. If difficulty with a specific ADL occurs acutely or out of order (eg, an elderly patient has decreased ability to feed but can still dress), an underlying medical condition should be suspected.[29]

PHYSICAL EXAMINATION

A thorough physical examination is essential, especially if the cause of delirium is not obvious. As with any patient, observation of the patient's general behavior should be conducted as subtle or obvious abnormalities in breathing, walking, and reactions to activity or conversations in the room may be noted. Delirious patients are easily distracted and have difficulty maintaining focus and performing simple repetitive tasks, such as counting backwards from 100 by 7s or reciting the days of the week or months backwards. They will often perseverate, not be able to follow a conversation, and answer a question with the response given to a previous question.[16] Delirious patients are usually oriented to person, but not to time and/or place. They may also manifest memory impairment, especially short-term, and the inability to assimilate new information. Disorganized thought processes and speech (disjointed or incoherent speech, an unclear or illogical progression of ideas), sleep-wake cycle disturbances, and perceptual disturbances may also be reported or observed. There may be a misperception of the environment with poorly formed delusions and hallucinations. Emotions may also be affected and can become quite labile. The delirious person can have a decreased capacity to modulate fine emotional expression. Also, a significant portion of confused patients will have impairments with spelling, writing, and spatial organization.[5,16]

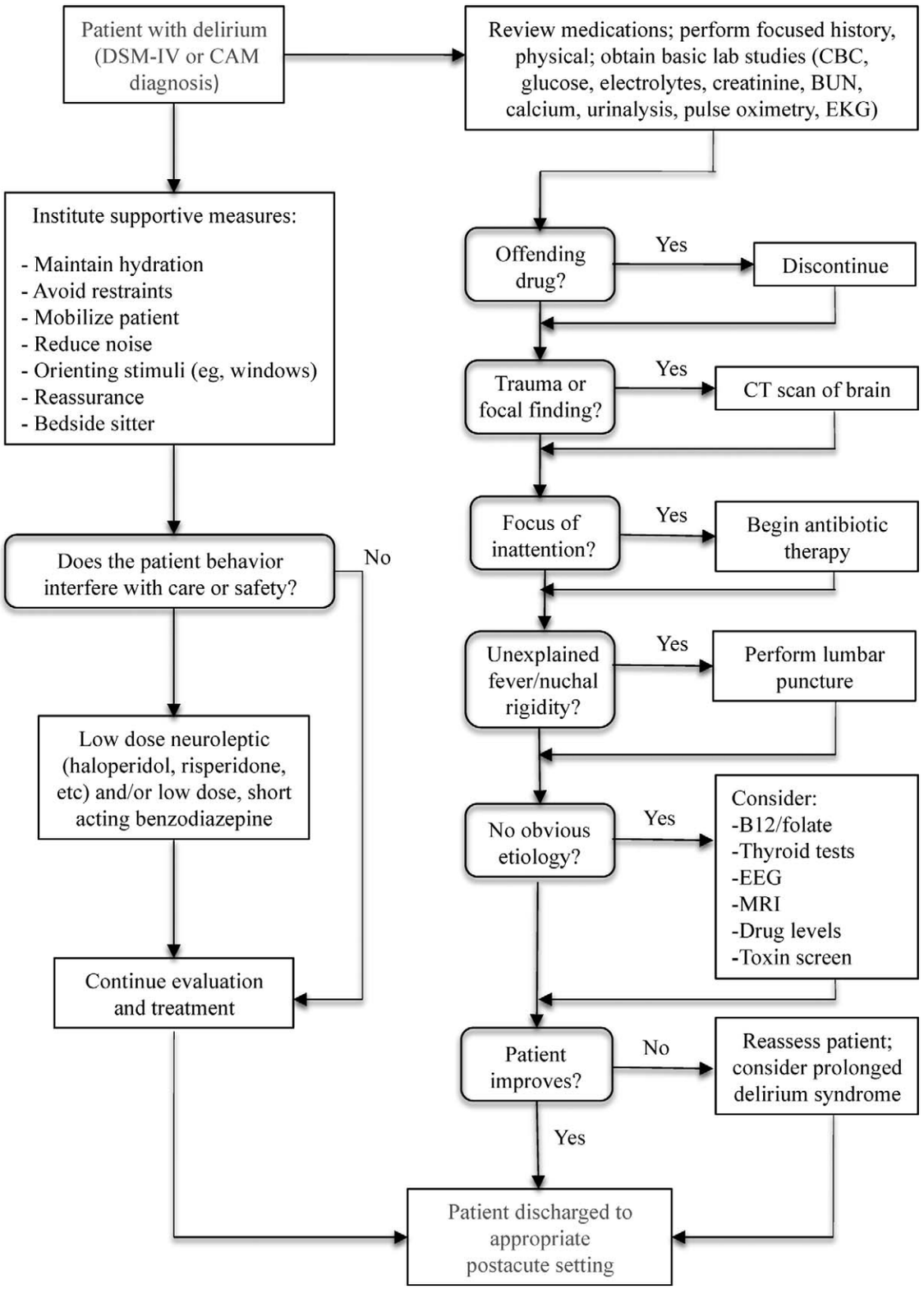

Figure. Assessment and management of patient with delirium.[27] *DSM-IV*, Diagnostic and Statistical Manual, 4th ed; *CAM*, Confusion Assessment Method; *CBC*, complete blood count; *BUN*, blood urea nitrogen; *EKG*, electrocardiogram; *CT*, computed tomography; *EEG*, electroencephalogram; *MRI*, magnetic resonance imaging.[30]

Table 3. Comparison of delirium and dementia.[28]

	Delirium	Dementia
Onset	Abrupt	Usually insidious; abrupt in some strokes or trauma
Course	Fluctuates	Slow decline
Duration	Hours to weeks	Months to years
Attention	Impaired	Intact early; often impaired late
Sleep-wake	Disrupted	Usually normal
Alertness	Impaired	Normal
Orientation	Impaired	Intact early; impaired late
Behavior	Agitated, withdrawn or depressed; or combination	Intact early
Speech	Incoherent, rapid/ slowed	Word-finding problems
Thoughts	Disorganized, delusions	Impoverished
Perceptions	Hallucinations/ illusions	Usually intact early

Table 4. Confusion Assessment Method.[31]

Feature*	Assessment
1. Acute onset and fluctuating course	Usually obtained from a family member or nurse and shown by positive responses to the following questions:
	"Is there evidence of an acute change in mental status from the patient's baseline?"
	"Did the abnormal behavior fluctuate during the day, that is, tend to come and go, or increase and decrease in severity?"
2. Inattention	Shown by a positive response to the following:
	"Did the patient have difficulty focusing attention, for example, being easily distractible or having difficulty keeping track of what was being said?"
3. Disorganized thinking	Shown by a positive response to the following:
	"Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject?"
4. Altered level of consciousness	Shown by any answer other than "alert" to the following:
	"Overall, how would you rate this patient's level of consciousness?"
	Normal = alert
	Hyperalert = vigilant
	Drowsy, easily aroused = lethargic
	Difficult to arouse = stupor
	Unarousable = coma

* The diagnosis of delirium requires the presence of features 1 AND 2 plus either 3 OR 4. Copyright 2011. UpToDate®.

Standard questions should assess orientation to person, time, place, and self, as well as 3-item recall. These should then be followed by more in-depth questioning if cognitive impairment is noted.[16,29] The assessment methods most cited in research are the Mini-Mental State Examination (MMSE) and the Confusion Assessment Method (CAM).[8,30] The MMSE involves a series of questions that elicit a maximum score of 30 points and can be performed in less than 5 minutes. The areas tested are: orientation, registration, attention and calculation, recall, and language and praxis. A score of 23 or below indicates organic brain syndrome.[16] The CAM scale (Table 4)[31] assesses 4 criteria: acute onset and fluctuating course, inattention, disorganized thinking, and altered level of consciousness. Diagnosis of delirium requires the presence of the first 2 criteria and either the third or the fourth criteria.[29] The CAM scale has a sensitivity of 93% to 100% and a specificity of 90% to 95%.[30]

Bedside cognitive tests have some limitations. The MMSE lacks questions evaluating executive function. Patients with mild impairment can pass the test. To offset this limitation, the patient's category fluency (eg, name as many animals as possible in 1 minute) and phonemic fluency (eg, name as many words beginning with the letter "F" in 1 minute) should be tested. Furthermore, cognitive tests may also be affected by the patient's general intelligence or level of education.[16]

The physical examination should continue in a head-to-toe systematic fashion with a keen eye toward findings that may mark an underlying precipitant condition. Common examination findings causing delirium in the elderly include, but are not limited to, urinary retention, constipation/fecal impaction, and sources of occult infection.[16] The simple procedure of relieving urinary retention (in men) can sometimes resolve an episode of delirium. The most common reversible cause of geriatric urinary retention is constipation/ fecal impaction.[17] The elderly person has increased susceptibility to infection and may have an atypical disease presentation, such as lack of focal signs and symptoms of an infection, isolated fever, or hypothermia, instead of hyperthermia. Common infection sites are the lungs, abdomen, urinary tract, and skin.[23]

DIAGNOSTIC TESTING

Ancillary testing should be ordered as indicated by clinical examination, and usually include blood oxygen saturation, complete blood count, chemistry panel, urinalysis, and a chest radiograph. An electrocardiogram should also be obtained

because there is a higher risk of silent myocardial infarction in the elderly population.[16] Elderly patients with cognitive dysfunction warrant special consideration as to whether or not they should undergo a lumbar puncture. The classic meningeal findings of fever, headache, and stiff neck are often absent.[16,32] A retrospective chart review studied the utility of lumbar puncture (LP) to detect meningitis in elderly patients with altered mental status, including those afebrile on presentation. The results indicated that 18% (15/84) of the afebrile patients had meningitis versus 24% of the febrile patients, prompting the authors to suggest consideration of an LP in all elderly patients with altered mental status, even if afebrile. They also acknowledged that a limitation of the chart review design is the inability to ascertain whether information in the patient's history or examination would provoke the physician to perform an LP, even in the absence of a fever.[32]

Finally, additional studies worth considering are: arterial blood gas (hypercarbia, hypoxia), thyroid function tests (hypothyroid and hyperthyroid), liver function tests (liver failure, encephalopathy), blood alcohol level, drug levels (intoxication), toxin screens (overdose), rapid plasma reagin test (syphilis), vitamin B_{12} and folic acid (metabolic deficiencies) levels, and carbon monoxide level (hypoxia, poisoning)[4,15] (Figure).

MANAGEMENT OF CAUSES OF DELIRIUM REQUIRING EMERGENT ATTENTION

Initial management of the delirious patient should start with the standard assessment of airway, breathing, circulation, and, if indicated, cervical spine precautions. Intravenous access, cardiac monitoring, and simultaneous screening for readily reversible causes, such as hypoglycemia, hypoxia, and excessive opioid use should be initiated. Elderly patients with multisystem trauma may present with initially normal vital signs prior to a precipitous clinical deterioration.[24] An acute ischemic stroke and other neurologic conditions, such as Wernicke encephalopathy, should not be overlooked.[16]

For elderly patients with hyperactive delirium, chemical restraints may be required to complete the examination, perform vital tests or procedures, or for personal safety. Haloperidol, a starting dose of 0.5 to 1.0 mg, may be effective. However, haloperidol should be used with caution in elderly patients with acute coronary ischemia, decompensated congestive heart failure, or those taking medications associated with QTc prolongation.[16] A QTc of less than 440 msec, however, is believed to have a decreased risk of dysrhythmia.[33] A prospective study that evaluated the effectiveness of haloperidol versus lorazepam, and the combination of both agents, in the treatment of psychotic agitation demonstrated that the use of both medications appeared to be more effective during the first hours of treatiment.[34] In contrast, a 2004 treatment algorithm for ED patients who presented with acute psychotic agitation requiring chemical restraint suggested that the use of lorazepam in the elderly or cognitively impaired should be avoided, unless the cause of their agitation was due to sedative or alcohol withdrawal.[35] The newer atypical antipsychotics, such as risperidone or olanzapine, may also be effective and tend to have fewer extrapyramidal side effects. Risperidone is predominantly used in the elderly, with a recommended starting dose of 0.25 to 0.50 mg.[16,36] The use of physical restraints should be avoided. If necessary, the use of physical restraints for elderly patients should be temporary, as it may contribute to delirium.[16]

When providing analgesia, morphine should be used judiciously since any associated dysphoria, respiratory depression, and hepatic encephalopathy may be more pronounced in elderly patients. Similarly, diazepam should be avoided, except in alcohol or sedative hypnotic withdrawal, due to its long half-life and the increased potential for respiratory depression.[16] Other simple, but often overlooked, measures to facilitate the evaluation and management of delirious elderly patients include adequate lighting, close monitoring with one-to-one support (ideally a family member or caregiver, or someone else the person knows), a quiet environment to decrease sensory overload, the use of hearing aids/glasses, and addressing the patient by name (Figure).

DISPOSITION

Younger patients with delirium are more likely to be diagnosed as well as to recover fully, although mild cognitive dysfunction may linger for some time. As already noted, elderly patients with delirium generally do not fare as well and usually experience a persistent decline in their baseline level of functioning. They also tend to have longer hospital stays, higher rates of institutionalized care, increased long-term mortality risk, and lose one or more ADLs.[16,37] One article asserts that any elderly patient with delirium should be admitted for definitive diagnosis and treatment, unless the cause is easily reversible or the delirium abates while in the ED.[38]

CONCLUSION

Delirium in elderly patients can manifest subtly and often may be the only sign of an underlying serious and potentially life-threatening illness. Numerous studies have revealed that emergency physicians are not proficient at recognizing and diagnosing delirium in elderly patients or that they believe the condition is a normal process of aging. Most causes of delirium are usually readily reversible. However, if not diagnosed and treated promptly, delirium in elderly patients is associated with strikingly elevated morbidity and mortality rates.

Emergency physicians should also be cognizant that many delirious elderly patients warrant and benefit from admission. As the number of elderly patients presenting to EDs continues to increase, emergency physicians must strive to better appreciate, identify, and manage delirium in the elderly.

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Radiation Dose from Medical Imaging: A Primer for Emergency Physicians

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Introduction: Medical imaging now accounts for most of the US population's exposure to ionizing radiation. A substantial proportion of this medical imaging is ordered in the emergency setting. We aim to provide a general overview of radiation dose from medical imaging with a focus on computed tomography, as well as a literature review of recent efforts to decrease unnecessary radiation exposure to patients in the emergency department setting.

Methods: We conducted a literature review through calendar year 2010 for all published articles pertaining to the emergency department and radiation exposure.

Results: The benefits of imaging usually outweigh the risks of eventual radiation-induced cancer in most clinical scenarios encountered by emergency physicians. However, our literature review identified 3 specific clinical situations in the general adult population in which the lifetime risks of cancer may outweigh the benefits to the patient: rule out pulmonary embolism, flank pain, and recurrent abdominal pain in inflammatory bowel disease. For these specific clinical scenarios, a physician-patient discussion about such risks and benefits may be warranted.

Conclusion: Emergency physicians, now at the front line of patients' exposure to ionizing radiation, should have a general understanding of the magnitude of radiation dose from advanced medical imaging procedures and their associated risks. Future areas of research should include the development of protocols and guidelines that limit unnecessary patient radiation exposure. [West J Emerg Med. 2012;13(2):202–210.]

INTRODUCTION

Over the last 2 decades, a dramatic rise in the use of diagnostic computed tomography (CT) has led to concerns about increased cancer risks from cumulative exposure to ionizing radiation.[1,2] Debate continues regarding the lifetime risk of fatal cancer imparted by any single imaging study or series of studies. However, several prominent regulatory and scientific societies state that no radiation dose is without carcinogenic risk.[3]

Although the American College of Radiology (ACR) and Society for Pediatric Radiology have addressed concerns regarding radiation dose with campaigns such as "Image Gently" and "Image Wisely," recent media reports of unnecessary exposure from CT have garnered national attention. One recent report found that 206 patients undergoing emergent "rule out stroke" CT protocols at a single hospital received up to 8 times the standard radiation dose for perfusion CT, which amounts to the equivalent of 200 noncontrast head CT.[4] Such errors have prompted investigation by the US Food and Drug Administration (FDA) and calls for a framework to monitor radiology examination indications, dose delivery, and imaging history.[5]

As the volume of medical imaging obtained in the emergency department (ED) has increased over the last 2

decades, emergency physicians are now at the forefront of determining patients' exposure to ionizing radiation.[6] Indeed, from 1995 to 2007 the number of ED visits that included a CT examination has burgeoned from 2.7 million to 16.3 million.[7] Emergency physicians must be aware of risks inherent to ionizing radiation, available alternative imaging modalities, and appropriateness of each study. Currently, there are no review articles in the emergency medicine literature focused specifically on radiation dose in the ED setting. This article provides a general review of the current literature regarding radiation dose in the ED, highlighting recent efforts while also identifying areas for future research aimed at decreasing unnecessary radiation exposure in the emergency setting.

METHODS

We conducted a literature search for all journal publications regarding radiation dose from medical imaging in the ED setting in MEDLINE through calendar year 2010. Specifically, we performed a literature search for all articles with no limitations on date, type of journal article, or language by using the keywords "emergency medicine," "radiation dose," and several variations and combinations of the keywords. The first and last author independently reviewed 90 preliminary articles for relevance to the ED and radiation exposure from medical imaging. We included all articles pertaining to the level of radiation dose experienced by patients in the ED, the education or awareness of emergency physicians regarding radiation dose, and initiatives to reduce radiation exposure in the ED. We then reviewed all related citations for these preliminary articles that we deemed relevant, including all citations from the bibliography section of the selected articles.

To provide information specific to emergency physicians, we start with a brief, general overview of radiation dose terminology and then organize the results of our literature review into 3 commonly encountered clinical presentations for which medical imaging plays a major role in making the diagnosis in the ED: pulmonary embolism, renal colic, and recurrent abdominal pain in patients with inflammatory bowel disease. For each of these topics, we refer to ACR appropriateness criteria for medical imaging.[8] We chose to exclude articles regarding radiation dose in trauma patients for whom rapid imaging likely outweigh the risks of radiation in most cases. We also excluded articles for the special cases of children and pregnant females for which discussion of radiation dose is beyond the scope of this general primer and would be more appropriately discussed in a separate article. Thus, for the purposes of our article we provide a literature review of specific clinical scenarios for adult, nonpregnant patients for whom action can be taken to decrease radiation exposure by avoiding equivocal or marginally indicated CT.

RESULTS

General Overview of Radiation Dose

Radiologic procedures that produce ionizing radiation include CT, plain radiography, nuclear medicine, and fluoroscopy. The largest component of imaging-based radiation stems from CT, which is the focus of our article. Ionizing radiation causes damage at the cellular level via free radical formation, eventually leading to DNA mutation or cell death.[9,10] Cellular mutations may eventually lead to radiation-induced cancers including leukemia, myeloma, or cancer of the thyroid, breast, lung, bone, and skin.[11]

While the magnitude of cancer induction from any individual exposure to ionizing radiation cannot be measured exactly, the most widely accepted theoretical dose-response model is the linear no-threshold model.[12–15] This model is an extrapolation of atomic bomb survivor data from Hiroshima and Nagasaki and is the most conservative, assuming even the smallest exposure to ionizing radiation has the potential to induce future cancer.[16,17] The US National Academy of Sciences Biological Effects of Ionizing Radiation (BEIR) and the US National Council on Radiological Protection and Measurements both suggest the use of this model for estimating risks of ionizing radiation.[11,18]

Several measurements are available for quantifying radiation dose. The quantity of ionizing radiation is measured in Gray (Gy) and is analogous to the older unit called a rad (radiation absorbed dose). Each radioactive particle—alpha, beta, and gamma rays (gamma is used in radiographs)—has a unique ionizing effect on biological tissue. This "equivalent dose" of gamma rays is expressed as the sievert (Sv) or rem (radiation equivalent in man). The conversion for radiographs is 1:1 such that 1 Gy of radiograph = 1 Sv (or 1 rad = 1 rem). Alpha and beta particles, emitted from a nuclear reactor or radiopharmaceutical, produce different effective doses and are beyond the scope of this review.

The term *effective dose* is widely used in the medical community and represents the weighted average of doses absorbed by irradiated organs, therefore reflecting the equivalent whole-body dose that would result in an equivalent risk from a nonuniform radiation source. It provides an estimate of a patient's risk of harm from any radiologic procedure, including all possible future cancers and hereditary effects. The effective dose allows for comparison across different imaging modalities and distributions across the body. However, the biological effect of radiation exposure varies substantially with age. It is most pronounced for young patients, whose organs are in closer proximity and whose cells are undergoing constant mitosis.

Moreover, the effective dose for radiologic studies can be considered in the context of normal annual background radiation for the general public. At approximately 3 mSv per year, the average background radiation from radon, cosmic rays, and other sources is not considered to be a significant cancer risk. For common radiologic procedures with an effective dose of 10 mSv (approximately equivalent to 1 CT of the chest, abdomen, or pelvis), the 2006 BEIR VII lifetime attributable cancer risk model predicts that 1 in 1,000 persons

Table. Average effective doses for common emergency department radiology studies.*

Procedure	Average effective dose (mSv)	Chest radiograph equivalent (PA and lateral)
Average background radiation exposure (per year)	3	30
Chest radiograph (PA and lateral)	0.1	1
Cervical spine radiograph	0.2	2
Thoracic spine radiograph	1.0	10
Lumbar spine radiograph	1.5	15
Pelvis radiograph	0.6	6
Abdomen radiograph	0.7	7
Hip radiograph	0.7	7
Shoulder radiograph	0.01	0.1
Knee radiograph	0.005	0.05
CT head	2	20
CT spine	6	60
CT stroke protocol (CT, CTA, and CTP)	14	140
CT chest	8	80
CT angiogram of thorax (rule out pulmonary embolism)	15	150
Lung V/Q scan	2.2	22
CT abdomen and pelvis	14	140
CT angiogram aorta (chest, abdomen, pelvis—rule out dissection or aneurysm)	24	240
Trauma CT "pan-scan" (head, neck, chest, abdomen, pelvis)	34	340

mSv, millisievert; *PA*, posteroanterior; *CT*, computed tomography; *CTA*, computed tomography angiogram; *CTP*, computed tomography perfusion; *V/Q*, ventilation-perfusion.
* Source: references 23 through 28.

will develop cancer due to such an exposure.[18,19] Cumulative effective dose greater than 100 mSv from repeated exposures shows even more convincing evidence for increased cancer risk.[1,20,21] A cumulative exposure of 1 Sv (1,000 mSv) confers a 4% to 5% increased relative risk of fatal cancer according to the International Commission on Radiological Protection.[22] As discussed above, relative cancer risk varies with age, and, therefore, these estimates must be adjusted for younger and older patients accordingly.

We provide a table with average effective doses for common radiologic procedures ordered in the emergency setting (Table). This table is adapted from a number of recent reports in the medical literature and provides effective doses for adults.[23–28] A recent study suggests that average effective doses may differ by up to 10-fold depending on specific imaging protocols and equipment settings.[23] Nevertheless, these doses allow for a general estimate of the risks associated with each type of study and can be used in helping to determine the risks in relation to the benefits of emergent radiologic procedures. Chest radiograph equivalents are also provided in the Table, which may be helpful in any patient-physician discussion regarding radiation dose from medical imaging.

Rule Out Pulmonary Embolism

Patients with suspected acute pulmonary embolism (PE) require rapid and accurate diagnosis to initiate anticoagulation. Workups for PE should begin with clinical risk stratification using standardized criteria. The Wells score and revised Geneva score are 2 commonly used prediction rules that can divide cases into high or low pretest probability of PE by risk factors and biomarkers.[29–33] False-positive D-dimer test results in low-risk patients are common, however, and thus can lead to unnecessary CT if D-dimer testing is used for extremely low-risk populations. This problem prompted development of the PE rule-out criteria (PERC), which selects a population with low enough risk to not warrant D-dimer testing. PERC allows for risk stratification in which a negative score correlates with an acceptable, lower than 2% outcome rate of PE.[34–36]

Posteroanterior and lateral chest radiographs serve as a useful screening tool that may reveal an alternative cause for pleuritic chest pain.[37,38] If advanced imaging is necessary, CT pulmonary angiography (CTPA) of the chest has overtaken ventilation-perfusion (V/Q) scans as the modality of choice for suspected PE.[39,40] The Prospective Investigation of Pulmonary Embolism Diagnosis II trial demonstrated that CTPA was more sensitive for detecting PE than V/Q scans, though the 2 modalities had similar positive predictive values.[40] The CTPA

technique has the added advantage of being able to identify alternative diagnoses such as aortic pathology, pneumothorax, or pericardial effusion.[41]

While CTPA is the imaging modality of choice, the total effective dose from CTPA is about 5 times greater than that from V/Q scans.[25,42–44] Ventilation-perfusion scanning remains a valuable diagnostic modality in patients with contrast allergies, renal insufficiency, excessive obesity, and claustrophobia.[45] Unfortunately, V/Q scans are frequently indeterminate such that further diagnostic evaluation is often required. Indeterminate V/Q scans can be minimized by selecting patients who are young and have normal chest radiographic findings. Moreover, while fetal radiation is comparable between V/Q and CTPA, there is much less radiation exposure to radiosensitive breast tissue in pregnant females from V/Q scans than from CTPA.[2] Thus, V/Q scanning remains the primary modality for imaging female patients of child-bearing age with suspected PE and normal chest radiographic findings. Also, the dose of radiopharmaceutical in V/Q scans can be decreased by at least a factor of 3 with longer acquisition times in order to reduce radiation in pregnancy.[46]

Renal Colic

Urolithiasis is a common condition that can lead to renal dysfunction if concomitant hydronephrosis is left untreated.[47] Imaging plays a role in the evaluation of suspected urolithiasis by demonstrating a stone's size, location, and effect on renal anatomy. Imaging can confirm the diagnosis and distinguish patients who need urologic intervention from those who do not. Moreover, an appropriate imaging study can also rule out more sinister etiologies of flank pain, such as renal cancer or nonurinary disorders such as appendicitis, diverticulitis, ovarian pathology, and abdominal aortic aneurysm (AAA).[48]

CT is the modality of choice for evaluating adult patients with signs and symptoms of renal colic presenting for the first time.[49] A noncontrast CT of the abdomen and pelvis can quickly identify 95% of stones and rule out diagnoses such as appendicitis and AAA. Radiologists can also adjust certain parameters to reduce the effective radiation dose.[50,51] These lower-dose protocols have effective doses as small as 1.5 mSv while maintaining high sensitivity and specificity.[52–54] Recent studies have shown that low-dose CT stone protocols have the same sensitivity as usual CT for stones 3 mm or greater in size.[51,55]

Some studies have suggested ultrasound (US) and magnetic resonance imaging (MRI) as alternatives to CT for renal colic.[56] However, institution-specific expertise and availability are limiting factors with both modalities. US of the urinary tract is highly operator-dependent, with sensitivity of US for acute flank pain reported at 61% to 93% and largely limited by poor visualization of the ureters.[57–59] While plain radiography with US would greatly decrease radiation dose by an order of magnitude, sensitivity is lower than for CT.[60–62] This is why US leads to many equivocal studies for which CT may ultimately be necessary.[63] Finally, although MRI can identify ureteral obstruction, its limited availability and suboptimal power to identify the cause and exact location limits its use.[64]

Up to 50% of stone formers will suffer a recurrence within 10 years[2] and may undergo many CT.[65,66] Katz et al[66] reported on the use of CT stone protocols for 4,562 patients during a 6-year period. They found that a single stone protocol CT imparted an effective dose between 6.5 and 8.5 mSv, with 4% of patients obtaining 3 or more CT examinations with a cumulative radiation dose between 10.5 and 153.7 mSv. In another study of 262 ED patients with renal colic who underwent CT, 92 patients had 3 or more studies within 10 months.[67] Repeated CT of chronic stone formers, compared to patients presenting with renal colic for the first time, has been shown to rarely change the diagnosis or treatment plan.[68]

This population, thus, presents a dilemma to the emergency physician, who must weigh the risks of additional radiation from yet another CT against the risks of a missed alternative diagnosis or impassable stone. Combining US and kidney ureter bladder radiograph has been suggested as a first-line strategy for chronic stone formers with high pretest probability and low risk of other diagnoses.[66] Others feel that a patient with renal colic symptoms and a history of stones with a US finding negative for hydronephrosis or AAA can be discharged from the ED with putative treatment for uncomplicated urolithiasis.

Recurrent Abdominal Pain in Inflammatory Bowel Disease

Abdominal pain is the most common chief complaint in the ED associated with CT.[7] Diffuse nonspecific abdominal pain results in fewer positive CT findings than localized pain, and may benefit from a period of observation.[69] However, no imaging substitute can effectively rule out a disease process with the sensitivity of CT, as evidenced by a 32% rate of positive findings in clinically ambiguous cases.[69,70] In light of this, we advocate focusing dose-reduction strategies for patients with recurrent abdominal pain who are likely to undergo repeated CT, such as patients with inflammatory bowel disease (IBD).

IBD incidence peaks between 15 and 25 years of age, subjecting patients to a long period of remaining lifespan in which to manifest radiation-induced carcinogenesis.[71] Moreover, IBD itself predisposes patients to gastrointestinal, liver, and biliary tract tumors.[72] Recurrent flareups and complications such as strictures, fistulae, and abscesses lead patients to seek emergency care, with a high likelihood for obtaining repeated scans. CT utilization for such IBD complications has grown at a faster rate than other indications among the general population.[73] A study of 409 patients with Crohn disease found that 15% received a high cumulative effective dose (>75 mSv), a level of exposure that has been reported to increase cancer mortality by as much as 7.3%.[74]

One alternative to CT for the IBD populations is US.[75] US has proved effective in detecting features of active IBD in

nonobese children, such as thickened bowel walls, hypoactive peristalsis, and increased mesenteric blood flow by Doppler.[76–78] Bowel wall thickness greater than 2.5 mm in the terminal ileum or greater than 3 mm in the colon predicts active disease with 93% specificity.[79] Although 1 study suggested that US and CT had comparable diagnostic accuracy in identifying fistulae and abscesses in patients with IBD,[80] US in the setting of IBD remains highly operator-dependent, and sensitivity is variable between studies.[81] Small-bowel obstruction, a common complication of Crohn disease, is best seen on CT rather than US.

MRI has gained increasing popularity in IBD evaluation. Active disease demonstrates thickened bowel that is enhanced on MRI with intravenous contrast.[82] Compared to the gold standard of endoscopy or open surgery, these findings are more sensitive (92%) and specific (75%) than those of CT.[83] MRI can identify abscesses and fistulas as well.[84] Although availability and cost may limit use of MRI, its radiation-sparing effects are appealing.[85] Factors correlated with greatest risk for repeated imaging in patients with IBD include early age of onset, corticosteroid therapy, and need for multiple surgeries. Griffey and Sodickson[86] found that ED patients at 1 institution who underwent multiple CT had a mean cumulative radiation dose of 91 mSv and a lifetime attributable cancer risk of 1 in 110. These patients stand to gain the most benefit from choosing US or MRI over CT as the first line of imaging.

DISCUSSION

We have provided one of the first general overviews regarding radiation dose for the emergency medicine community and, to our knowledge, the first literature review regarding efforts to decrease unnecessary radiation exposure in the ED setting. It is obvious that CT imaging has had a transformative effect on emergency care by dramatically improving the speed and accuracy of diagnosis, thereby facilitating patient treatment and disposition. The explosion in CT utilization over the last 2 decades, however, has raised concerns about the deleterious effects of cumulative ionizing radiation. If current models of the carcinogenic risk imparted by low-dose radiation prove to be correct, CT may be contributing to a growing public health problem of radiation-induced cancers at the population level. Since ED physicians are ordering about one third of all CT studies in the United States, they must increasingly be knowledgeable about radiation dose and future radiation-induced cancer risks in their decision-making process, and possibly discuss these risks with their patients in cases for which the immediate benefits may not outweigh future risks.[87]

On the basis of our literature review, we can conclude that there are 3 specific clinical scenarios among adults for which the ED physician should consider the risks of ionizing radiation from CT before ordering such studies, and for which alternative imaging modalities may be appropriate. These include ruling out PE, renal colic, and recurrent abdominal pain. While the available literature focuses on possible avenues for decreasing radiation exposure in these specific situations, there is currently a paucity of rigorous and reliable protocols for ED physicians to follow in order to prevent unnecessary radiation exposure.

The most researched scenario for decreasing radiation dose to patients in the ED setting is the case of ruling out PE. A current review of the literature yields several steps that may help prevent unnecessary patient radiation exposure. First, standardized criteria for risk stratification should be used (eg, PERC rule or Wells score) for all cases. Second, an initial chest radiograph may reveal an alternative diagnosis and thus prevent the need for CTPA. Additionally, given its lower effective dose to the breasts, V/Q scanning should remain the primary modality for ruling out PE in pregnant patients and young women.

In recent years, abdominal pain has become the leading indication for CT in the ED, surpassing trauma and neurologic complaints.[7] Unlike the case for PE, no established algorithms are in place to decrease CT studies among ED patients. Our literature review suggests that imaging abdominal pain varies with institutional preference, although centers with an interest in reducing radiation dose have developed low-dose CT protocols and the use of US as a screening tool for specific patient populations. Emerging studies suggest that low-dose CT protocols for renal colic may represent a compromise between risk of radiation and benefit of confirming the diagnosis of urolithiasis and possess equivalent sensitivity to standard CT.[88,89]

More recently, chronic abdominal pain and IBD populations have been singled out as being at increased risk of radiation-induced cancer. Some experts have suggested that US be the initial study for patients with repeated IBD to assess for disease exacerbation. A diagnostic US study may obviate the need for CT, limiting repeated radiation to those with equivocal findings. MR enterography has become the imaging modality of choice for IBD in Europe, and advances in technique continue to drive adoption in the United States.[84,90]

In addition to becoming familiar with radiation risks associated with common CT studies, emergency physicians should be aware of the risks associated with repeated scanning. A recent study that estimated cumulative radiation exposure from CT of adults in a tertiary academic medical center found that one third of all patients underwent 5 or more CT during their lifetime and that 15% of all patients had estimated cumulative effective doses greater than 100 mSv.[91] Another study found that those who obtained repeated CT imaging from a single ED increased their risk of developing cancer from their repeated exposure, and that the same study type represented most repeated imaging.[86] Furthermore, Kline et al[34] determined that at least one third of ED patients who undergo CTPA to rule out PE will return for a second negative CTPA finding within 5 years.

As the public's exposure to radiation from man-made sources has become a national topic of interest and concern, more and more patients will likely want to discuss possible radiation-induced cancer risks with their ED physicians before

obtaining a CT. Moreover, as national governing bodies such as the FDA have classified ionizing radiation from medical imaging as a human carcinogen, patients are becoming more aware of the link between CT and cancer.[92,93] The principles of medical ethics and patient autonomy dictate that ED physicians provide information regarding the risks, benefits, and alternatives of any given procedure to allow patients to make an informed decision.

Many physicians currently support the practice of obtaining informed consent for CT, including disclosure of minimal radiation-induced cancer risks.[94] If physicians do speak with patients about such risks, they should do so in language that is understandable by the average patient. For instance, the magnitude of average effective doses for a particular CT could be expressed in terms of number of chest radiographs, transcontinental flights, or additional days of background exposure.[93,95] Furthermore, these risks should be expressed in light of the immediate benefits of obtaining a CT for any acute condition. It should also be stressed that any theoretic risk in increase of radiation-induced cancer from a single CT is actually a very small risk on top of the baseline cancer rate of 42% in the United States. For instance, since lifetime associated risk of fatal cancer from a single CT is estimated at around 0.1%, an abdominal CT effective dose is expected to increase the risk of developing cancer from 42% to 42.1%.[23]

Concerns that patients will refuse necessary examinations because of irrational fear of developing cancer have not been borne out in practice. In fact, patients may prefer to confirm their diagnosis with CT despite the radiation risks involved.[96] Larson et al[92] found that providing radiation-induced cancer risk information to parents of pediatric patients did not cause parents to refuse studies recommended by the referring physician. In another survey, nearly half of adult patients wanted to be informed about severe side effects with a 0.1% risk, whereas 13% of patients wished to be informed only when the risk reached 50% to 100%.[97]

LIMITATIONS

As discussed in the "Methods" section, this literature review does not cover the pediatric and pregnant female populations. These special patient populations are outside of the scope of this general primer. Our article does not discuss technical aspects of CT, which we believe are best left to radiologists, radiology technologists, and radiation physicists. In addition, most of the literature regarding radiation dose outside of the ED setting was deemed to be outside the scope for this article. Our literature review was based entirely on a MEDLINE search, as no additional articles specific to radiation dose in the ED setting were identified from additional databases such as Cochrane Review and Google Scholar.

CONCLUSION AND POLICY IMPLICATIONS

While the ACR and similar organizations in Europe have developed appropriateness criteria for specific imaging studies, the emergency medicine community has yet to become intimately involved. Since emergency physicians are now responsible for a large and growing percentage of the overall CT volume, ED governing bodies must work closely with the radiology governing bodies to further develop clinical algorithms and guidelines to streamline the most effective use of CT in the ED. Moreover, many current guidelines are not geared toward the ED setting and, therefore, are of limited use to the emergency physician.

Recent studies have shown that ED physicians and patients alike are largely unaware of associated radiation-induced cancer risks from CT.[93] Educational interventions may be effective for increasing such awareness. Stein et al[98] demonstrated that practice patterns of physicians changed in response to an educational intervention including the emergency, radiology, and nuclear medicine departments at 1 institution, resulting in a reduction in radiation exposure to ED patients with suspected PE without compromising patient safety.

Recently, California became the first state to require the reporting of radiation exposure for every CT performed after reports of recent higher-than-normal radiation doses from CT stroke protocols at several southern California hospitals. If more states follow suit or if there is eventual national legislation mandating such measures, ED physicians will be responsible for using dose-level information in their clinical algorithms for repeated CT imaging. Innovative research opportunities currently exist for the use of electronic medical records and computer-assisted physician order entry systems for helping to track radiation dose from imaging in the ED setting. In all of these future patient safety endeavors, emergency physicians will play a central role in minimizing unnecessary radiation exposure and they should be versed in discussing the topic with their patients, radiologists, and consulting physicians.

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Downwind from the Great Tohoku Earthquake: A Call to Global Action

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LIMITS OF OUR CAPACITY

The last 3 decades have seen a worldwide appreciation for advances in disaster medicine and public health preparedness that have accelerated our awareness of how humankind and nature interact. More than ever, societies need a comprehensive approach to anticipate, assess, prevent, prepare, respond, and recover from large-scale disasters worldwide.[1] Better research, education, training, and advanced technologies have markedly improved our capacities as responders at every level of management.[2] In support of the new emphasis on translational science, multiple disciplines from medical and public health, engineering, law, security, economics, the social sciences—to name but a few—along with freshly committed public and private sectors, confirm the benefits of a more comprehensive and formalized approach to all hazards. A better-educated citizenry has led to a convergence of dedicated volunteerism that works alongside newly defined crisis standards of care, highly professional rescue workers, and specialized teams expertly trained to identify and remove entrapped victims. Yet, new data had shown scientists that the frequency and severity of large-scale disasters had increased in the last 2 decades, reawakening a lingering and unsettling worry especially among those who study the earthquake and volcanic activities that make up the Asia-Pacific *Rim of Fire*.

Weeks and months have slipped by since the fateful earthquake and tsunami that struck the Sendai area of Japan on March 11, 2011. The amazing power of nature spoke once again, and confirmed the "every 100 years monster quake" that scientists had predicted. Despite the massive number of direct deaths, some solace could be found knowing the unique resilience, industry, and prowess of the Japanese people in returning Kobe to its former self within 6 months of the Great Hanshin earthquake of 1995. No country was better prepared than Japan.

What we call in disaster medicine an "indirect casualty event," the failures in multiple nuclear reactors suddenly silenced any optimism and immediately rewrote the tragedy in terms few could fathom or comprehend. It grasped the attention of the entire world in great part because it was not supposed to happen—revealing new questions and dilemmas that would challenge the very limits of human capacity. Tragically, the 40-year-old Fukushima Dai-ichi Nuclear Power Station was to shut down in 2 weeks' time. Individual resiliency studies, critical to survival, have focused on acts of nature such as hurricanes and floods but generally exclude mass crises of the nature seen in Japan. While the recovery and rehabilitation is still expected to occur, it has clearly become a global task beyond that of Japan alone.

MORE WORK TO BE DONE

In the Western world we do well with crises we are familiar with and fear little. Preparation must meet the realities of the crisis. A study done in Australia rated nuclear events and reactor failures as the events most unfamiliar and feared by prehospital professionals.[3] Disaster Medical Assistance Teams (DMAT) prepared to manage trauma victims had to reassess their role and capacities when they found themselves and their equipment totally unprepared to handle critical care patients who crowded the airport during the evacuation of New Orleans after Hurricane Katrina.[4] Similarly, today Japanese DMATs find themselves unprepared and overwhelmed, attempting to maintain some semblance of primary healthcare and infrastructure protections (water, sanitation, shelter, food, and basic health) among the half-million evacuated survivors.

The reality of a similar event happening in 1 or more of 104 nuclear reactors in North America is not going away. The Great Tohoku earthquake and its aftermath are fixed in our consciousness and have catalyzed reassessments of those risks, uncomfortable but real, which threaten human security. Disaster medicine has a crucial role in this process of preparedness but it must resist the temptation to fit new crisis scenarios into existing response systems, protocols, and crisis

standards of care. Except in a few classroom and exercise settings, coordinating actual skill sets with emerging crises has not been a priority. Without delay we must now pay attention to developing requisite operational skill sets in:

- mass evacuation care,
- radiation detection, screening, and management,
- radiation-specific triage protocols,
- mass palliative care protocols,
- population-based psychosocial and behavioral care management, and
- to developing mass sheltering and communication assets.

DEFINING GLOBAL HEALTH

Collectively, the global community faces limited financial resources and political support, but that cannot diminish the responsibilities that must be met by every individual and community. This is especially true in communities compelled to look more closely at the potential risks of ageing reactors of the same design within their midst. This tragedy has also brought us closer to recognizing that we are already a global community. Both the Haitian earthquake and the Sendai tragedy have catalyzed major changes internationally to professionalize humanitarian actions, develop core competencies, and create a universal certification system for aid workers. Increasing numbers of engineers, economists, lawyers, and nurses are in joint degree programs in public and global health.[5] It should not be a surprise that the younger generation is demanding more courses in global health at the undergraduate, graduate, and professional school levels. They know well that their productive years will be spent in some aspect of a globalized world that will demand global responsibilities and response to global tragedies. Crises bring communities together at strange times and usually advance our capacities to respond to future crises. The emergent use of social media, a critical component of globalization, is changing the way we communicate, especially during crisis situations. Half of respondents to a 2010 American Red Cross survey stated they would use social media channels (Facebook, blog, Twitter, etc) to transmit or receive emergency information. In the aftermath of the Sendai tragedy, as well the current Middle East democratic revolts, social media channels proved to be the major lifeline to loved ones eager to receive word of survival. Seventy-four percent expect response agencies to answer social media calls for help within an hour.[6] Many lessons from the Great Tohoku earthquake will be digested over the coming months and years. Unique solutions, no doubt, will emerge from a better prepared and committed generation of global professionals.

WHAT ROLE FOR DISASTER MEDICINE?

The question remains: what role in promoting and accelerating progress will disaster medicine and public health preparedness play? Disaster medicine is a multidisciplinary, professional discipline, made up of medical and public health professionals and a multitude of essential *nonhealth* professionals from every sector crucial to recovery from large-scale disasters and rehabilitation efforts. Domestic emergency medicine and management professionals number in the millions in the developed world, but in the developing world 30 years ago, the international humanitarian community could count on 2 hands who remained in the profession as a career. A decade ago those calling themselves humanitarian professionals increased to 100,000; today they number more than 220,000, with many dedicated health professionals in their ranks.[5] While many spend their careers responding to large-scale crises in resource-poor countries such as Sudan, this generation of humanitarian professionals has not turned its back on domestic needs at home. In many respects we are seeing this play out in Japan today. A large and highly respected Japanese medical nongovernmental organization (NGO) called Humanitarian Medical Assistance is being supplemented by crucial Israeli health specialists that the NGO lacks. As global health matures it will no longer be a "them and us" mentality. The Great Tohoku disaster has made clear that this community of professionals will have to unite, share, and adapt its skills to solve regional and nation-state crises on a global playing field. The alternative is unthinkable.

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Bilateral Spontaneous Pneumothorax

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A 15-year-old boy presented to the emergency department with a chief complaint of bilateral pleuritic chest pain and shortness of breath. His symptoms began suddenly, hours earlier, while studying in school without any history of trauma. The patient did not smoke, denied illicit drug use, had no known toxic exposures, but did report cough and upper respiratory symptoms for the previous 2 days. Otherwise, he had no significant past medical or surgical history. The patient was alert, appropriately responsive, and in moderate respiratory distress. He was afebrile with a heart rate of 105 beats per minute, blood pressure of 135/90 mmHg, respiratory rate of 30 breaths per minutes and peripheral oxygen saturation was 97% on room air. The patient was noted to have decreased breath sounds bilaterally. Supplemental oxygen via a nasal cannula was started, and an emergent chest radiograph was obtained (Figure 1).

A diagnosis of bilateral spontaneous pneumothorax was made and given the possibility of progression to tension; needle decompression was performed anteriorly to both sides of the chest. Although a less invasive Heimlich valve placement was favored, lack of stock within the department limited this option.

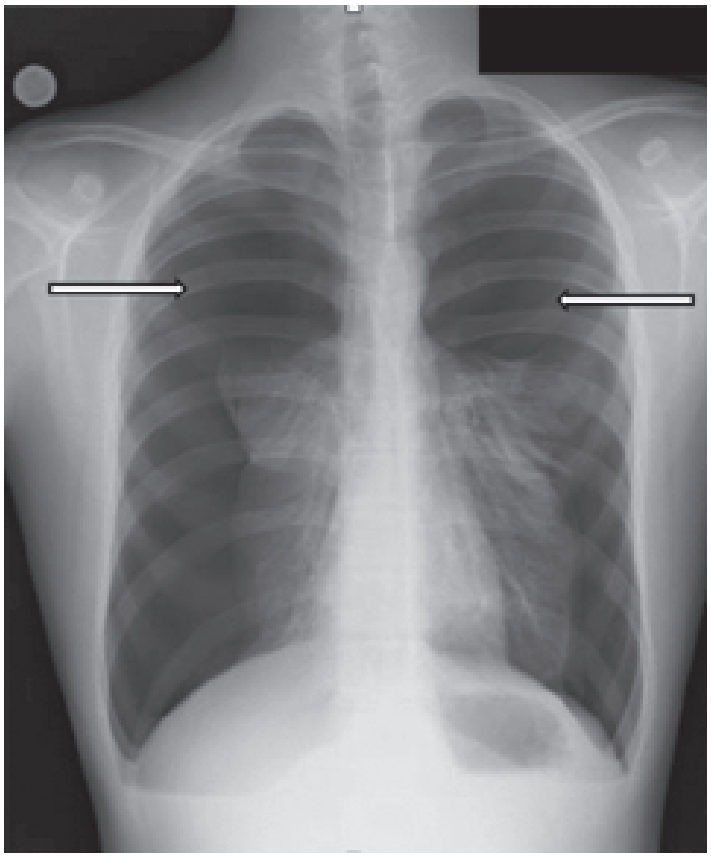

Figure 1. Postero-anterior radiograph of the chest shows near complete bilateral pneumothorax without evidence of pneumomediastinum, pneumopericardium, or subcutaneous emphysema.

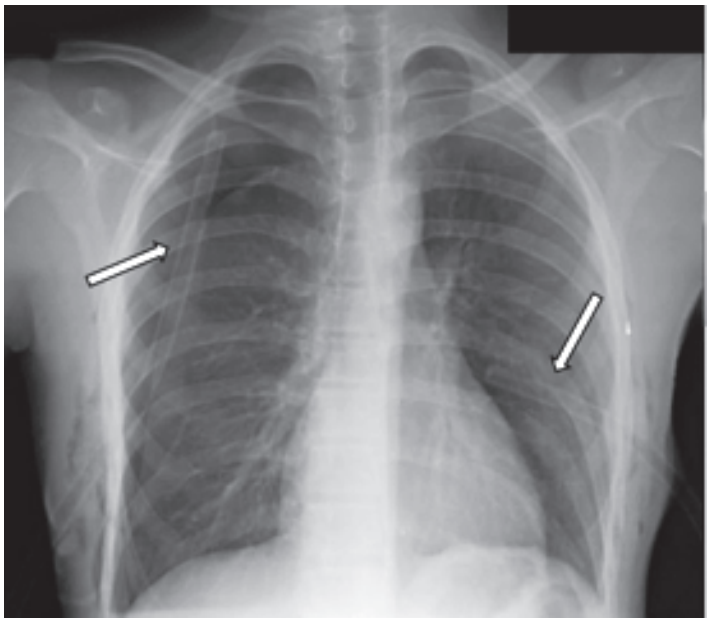

Figure 2. Postero-anterior radiograph of the chest shows interval placement of bilateral chest thoracostomy tubes with complete re-expansion of the left lung and partial (~70%) re-expansion of the right.

As a result, emergent chest thoracostomy tubes were placed (Figure 2).

The patient had complete re-expansion of the left lung, and partial re-expansion on the right. No clinically significant signs of postprocedural pulmonary edema were noted. Subsequent computed tomography of the chest revealed apical subpleural blebs, and the patient underwent thoracoscopic surgical resection followed by bilateral pleurodesis.

Bilateral spontaneous pneumothorax is an extremely rare clinical condition representing approximately only 1% of all cases of spontaneous pneumothorax.[1–2] Even rarer is to see a patient with near complete spontaneous bilateral pneumothorax without cardiovascular collapse. Perhaps this suggests that the patient had asymptomatic or compensated unilateral symptoms followed by acute decompensation following onset of bilateral spontaneuous pneumothorax.

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APPENDIX 1

The Math behind Using Vectors to Calculate the Work Accomplished by 3 Physicians in an Emergency Department

Let m = 3 stand for 3 members, or vectors, in the group.

Let n = 3 stand for 3 variables: hours worked, patients seen, and RVUs[1] completed.

Given the following data table (Table 1), write these data in vector[2] form such that

$$\mathbf{d}_1 = [d_{11}, d_{12}, d_{13}] = [20, 10, 40]$$
$$\mathbf{d}_2 = [d_{21}, d_{22}, d_{23}] = [40, 40, 40]$$
$$\mathbf{d}_3 = [d_{31}, d_{32}, d_{33}] = [60, 40, 40]$$

and

$$\mathbf{d}_{\text{Total}} = [d_{11}, d_{12}, d_{13}] = [120, 90, 120] \quad (1)$$

Next, represent each variable as a proportion of the sum of that dimension's values. The total of each dimension will then equal 1. This allows us to combine the previously unlike terms and it ensures each variable has equal importance or equal weight.

Therefore,[3]

$$\mathbf{D}_1 = [D_{11}, D_{12}, D_{13}] = [20/120, 10/90, 40/120] = [0.167, 0.111, 0.333]$$
$$\mathbf{D}_2 = [D_{21}, D_{22}, D_{23}] = [40/120, 40/90, 40/120] = [0.333, 0.444, 0.333]$$
$$\mathbf{D}_3 = [D_{31}, D_{32}, D_{33}] = [60/120, 40/90, 40/120] = [0.500, 0.444, 0.333]$$

and

$$\mathbf{D}_{\text{Total}} = [D_1, D_2, D_3] = [1, 1, 1] \quad (2)$$

Refer to Figures 1 and 2.

$$\mathbf{D}_1 + \mathbf{D}_2 + \mathbf{D}_3 = \mathbf{R}_1 + \mathbf{R}_2 + \mathbf{R}_3 \quad (3)$$

Therefore,

$$\mathbf{D} = \mathbf{R} = [1, 1, 1] \quad (4)$$

Table 1. Example of emergency department raw data.

Physician	Hours	Patients	RVUs
1	20.0	10.0	40.0
2	40.0	40.0	40.0
3	60.0	40.0	40.0
Total	120.0	90.0	120.0

RVUs, relative value units.

and

$$||\mathbf{D}_{\text{Total}}|| = ||\mathbf{R}_{\text{Total}}|| = (1^2 + 1^2 + 1^2)^{0.5} \quad \text{magnitude of the vector}$$
$$= (3 \cdot 1^2)^{0.5}$$
$$= 1.73$$
$$= (n)^{0.5} \quad (5)$$

where n = 3 is the number of variables.

These 2 identical sums of vectors represent the total work accomplished by the 3 physicians together.

Each physician performed various amounts of work based on his hours, patients, and RVU data.

Looking at the first physician, let the vectors $\mathbf{D_1}$ and $\mathbf{R_1}$ be related such that

$$\mathbf{R}_1 + \mathbf{S}_1 = \mathbf{D}_1 \quad \text{and}$$
$$\mathbf{R}_1 \cdot \mathbf{S}_1 = 0 \quad (\text{so } \mathbf{S}_1 \text{ is orthogonal to } \mathbf{R}_1) \quad (6)$$

and realize that $\mathbf{R_1} = [R_{11}, R_{12}, R_{13}]$ is parallel to $\mathbf{R}$. Therefore,

$$\mathbf{R}_1 = r_1[1, 1, 1] = [r_1, r_1, r_1]$$
$$||\mathbf{R}_1|| = r_1 \cdot (n)^{0.5} \quad (7)$$
$$||\mathbf{R}_1||/||\mathbf{R}_{\text{Total}}|| = r_1 \quad (8)$$

Now we have

$$\mathbf{S}_1 = \mathbf{D}_1 - \mathbf{R}_1 = [D_{11} - r_1, D_{12} - r_1, D_{13} - r_1]$$
$$\mathbf{R}_1 \cdot \mathbf{S}_1 = [r_1, r_1, r_1] \cdot [D_{11} - r_1, D_{12} - r_1, D_{13} - r_1] = 0$$
$$r_1(D_{11} + D_{12} + D_{13}) - n \cdot r_1^2 = 0$$
$$r_1 = (D_{11} + D_{12} + D_{13})/n \quad (9)$$

where n = 3 is the number of variables.

$$r_1 = (0.167 + 0.111 + 0.333)/3 = 0.204.$$

Also, notice that **r_1 is the average of the terms in vector $\mathbf{D_1}$.**

The amount of work contributed by physician 1 toward the group's total work is the average of physician 1's variables as long as each variable is expressed as a proportion of that dimension's total. The total for each dimension then becomes 1.

These same conclusions can be made for each of the other 2 physicians by going through the same process as above for each corresponding vector $\mathbf{D_2}$ and $\mathbf{D_3}$.

The reason $\mathbf{S_1}$ was chosen to be orthogonal to $\mathbf{R_1}$ is because it not only makes $\mathbf{R_1}$ the projection of $\mathbf{D_1}$ onto $\mathbf{R}$ but also it relates $\mathbf{D_1}$ to $\mathbf{R}$ in a significant statistical manner.

Let us look at the magnitude of $\mathbf{S_1}$.

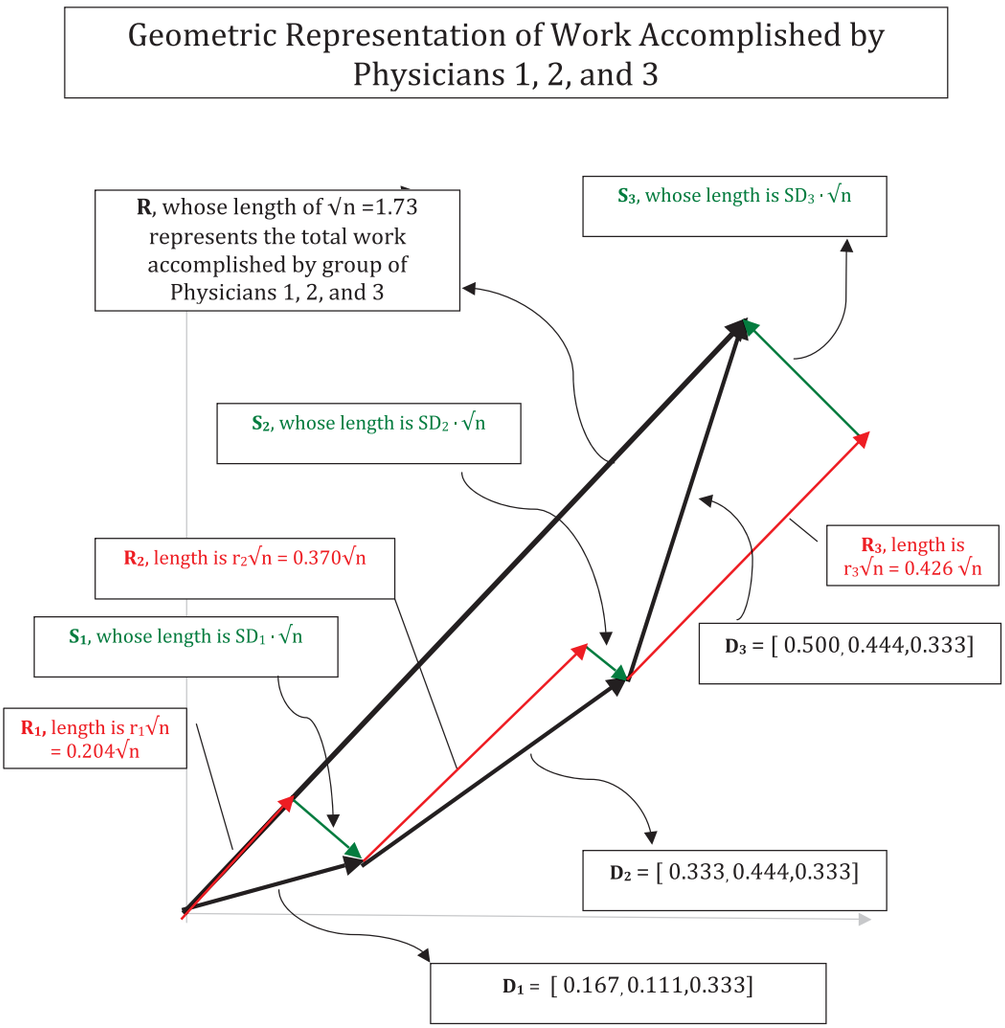

Figure 1. Geometric representation of work accomplished by physicians 1, 2, and 3. Note: n = 3 because there are 3 variables (hours, patients, and relative value units). Refer to equations 2, 4 and 5, 7 and 9, and 11. Scale not precise.

$$||\mathbf{S}_1|| = \left\{(D_{11} - r_1)^2 + (D_{12} - r_1)^2(D_{13} - r_1)^2\right\}^{0.5} = 0.163. \quad (10)$$

Dividing both sides by the square root of n, where n = 3 is the number of variables in $\mathbf{D_1}$, we get

$$\frac{||\mathbf{S}_1||}{||\mathbf{R}_{\text{Total}}||} = \frac{\left\{(D_{11} - r_1)^2 + (D_{12} - r_1)^2(D_{13} - r_1)^2\right\}^{0.5}}{(n)^{0.5}} = 0.094 = \text{SD}_1. \quad (11)$$

This expression is recognized as being the definition of the standard deviation (SD) of the data contained in $\mathbf{D_1}$. In this setting, the SD is the measure of how much work the physician accomplished deviates from the norm of the whole group when they are considered 1 entity. Having an SD from the norm is not necessarily a bad thing. Physician 1's average (r_1) is equal to 0.204. This means physician 1 completed 20.4% of the work while working only 16.7% of the hours. The average work accomplished by the group as a whole in 16.7% of the hours would include 16.7% of the patients and 16.7% of the RVUs. Clearly, physician 1's SD is a positive indicator, as physician 1 did more work than the average physicians in the group. We can generally say that those physicians associated with small SDs are working close to the average. Physicians with large SDs may be working significantly more or less than the average physician.

Therefore, while never actually calculating the standard deviation, we are still incorporating its value to relate how each physician's work contributed to the entire group's work. This is done by first measuring each variable's value as a proportion of the total such that the total of each variable is 1. Then, we simply take the average of all the variables in the physician's

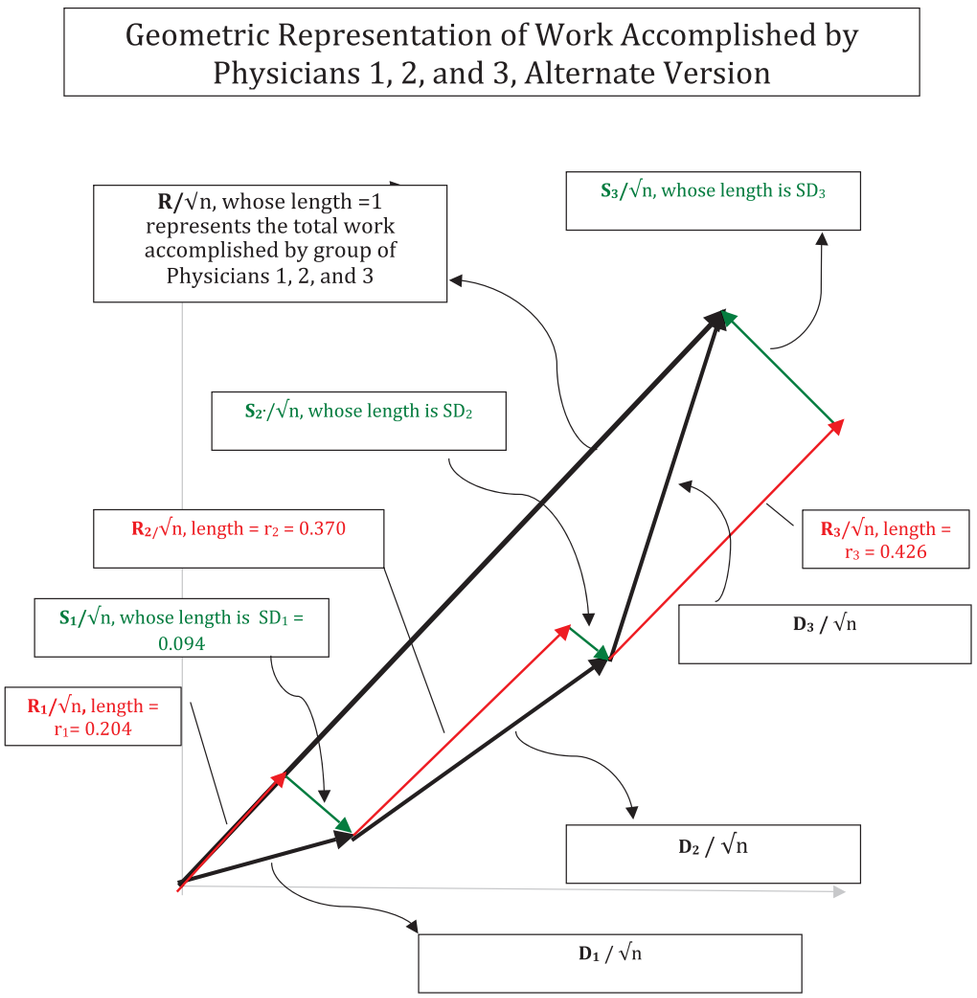

Figure 2. Geometric representation of work accomplished by physicians 1, 2, and 3, alternative version. Note: n = 3 because there are 3 variables (hours, patients, and relative value units). Refer to equations 2, 4 and 5, 7 and 9, and 11. Scale not precise.

vector to find that particular physician's contribution to the entire work accomplished by the group. Applying this approach to measure the work accomplished by a physician ensures that each physician is measured with respect to the group he belongs to and not any external measure.

Table 2 summarizes the final calculations of the averages for each physician. This average gives the final measure of the amount of work each physician accomplished for the group of physicians. Note that there is no need to calculate a standard deviation or collect outside data. Working more hours, seeing

Table 2. Percent of work accomplished as the average of hours (%), patients (%), and RVUs (%).

Physician	Hours	Patients	RVUs	Hours (%)	Patients (%)	RVUs (%)	Work accomplished (%)
1	20.0	10.0	40.0	16.7	11.1	33.3	20.4
2	40.0	40.0	40.0	33.3	44.4	33.3	37.0
3	60.0	40.0	40.0	50.0	44.4	33.3	42.6
Total	120.0	90.0	120.0	100.0	100.0	100.0	100.0

RVUs, relative value units.

more patients, and accomplishing more RVUs will result in a higher percentage of work accomplished.

Explanatory Notes

1. RVU is a relative value unit and is a measure of work or effort applied to a patient and is related to the revenue potential.
2. Boldface symbols represent vectors.
3. We could represent our proportions as a percentage and the final results would not change; therefore,

$$\mathbf{D}_1 = [0.167, 0.111, 0.333] = [16.7\%, 11.1\%, 33.3\%].$$

APPENDIX 2

Measuring Emergency Physician's Clinical Work

INPUT DATA in PURPLE cells only!

Provider	Clinical Hours	Patients	RVUs	Percent Clinical Hours	Percent Pts	Percent RVUs	% Work Accomplished	Equivalent-Hours	Pts/Hr	RVUs/Pt	RVUs/Hr
Doc 1	0.0	0	0	0.0%	0.0%	0.0%		Clinical			
Doc 2	0.0	0	0	0.0%	0.0%	0.0%		Hour			
Doc 3	0.0	0	0	0.0%	0.0%	0.0%		Total			
Doc 4	0.0	0	0	0.0%	0.0%	0.0%		cannot			
Doc 5	0.0	0	0	0.0%	0.0%	0.0%		equal			
Doc 6	0.0	0	0	0.0%	0.0%	0.0%		zero			
Department Total	0.0	0.0	0.0	0.0%	0.0%	0.0%					

Note: The Department Total Clinical Hours cannot equal zero.

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APPENDIX

Thank you in advance for completing this survey.

No personal information about you or your visit will be collected during the survey, and all responses will remain anonymous.

Read the short paragraph below. Answer the following questions. You will be done in minutes!

Every time you leave a doctor office, hospital, or clinic, your records do not leave with you. A Personal Health Record (PHR) would contain all your health related information in one place for you and for those you want to share it with.

1. During your visit today, would you allow ALL of your health information to be stored in a secure location on the internet that can be accessed by you or your doctors in the future?

❑ YES ❑ NO

2. Would you only allow some of your information to be stored in this location?

❑ YES ❑ NO

3. Would you allow a PHR to be stored in a portable device to be carried with you (eg, keychain, ID card)?

❑ YES ❑ NO

4. Would you allow your information to be stored in a PHR if it was run by (check to indicate YES and unmarked NO):

❑ the government

❑ a software company

❑ a hospital

❑ an insurance company

❑ it doesn't matter

5. Would you want your emergency physician to access ALL of your health information using your PHR?

❑ YES ❑ NO

6. If you were severely ill and unable to speak or think clearly, would you want your emergency physician to access all of this information?

❑ YES ❑ NO

7. How worrisome is your current visit (check scale between 1 and 5)?

❑ 1 ------ ❑ 2 ------ ❑ 3 ------ ❑ 4 ------ ❑ 5

1 means not concerned 5 means extremely worried

8. I would not want a PHR started because (check all that apply):

❑ I am concerned about my information security

❑ I am concerned about privacy or confidentiality

❑ I do not want health insurers to use this information against me.

❑ I do not think it is necessary.

❑ Other _____

9. I would put my medical information into a PHR today:

❑ Only if it was done for me

❑ Even if I had to put it in myself

10. My age is:

❑ 18–24 ❑ 25–29 ❑ 30–39 ❑ 40–59 ❑ 50–65 ❑ 65 or older

11. My sex is:

❑ MALE ❑ FEMALE

12. My ethnicity is:

❑ White Non-Hispanic ❑ Hispanic ❑ African American ❑ Asian ❑ Native American ❑ Other _____

13. Yearly income is:

❑ 0–29,000 ❑ 30–59,000 ❑ 60–149,000 ❑ 150,000 or more ❑ I would rather not answer

14. My educational level is:

❑ Grade school ❑ High School/GED ❑ College ❑ Graduate

15. I use the internet:

❑ none or rarely ❑ at least monthly ❑ at least weekly ❑ daily

16. I use the internet at:

❑ Home ❑ Work ❑ Internet café ❑ School ❑ A friend's connection

17. Do you feel comfortable using computers?

❑ Yes ❑ No

18. Do you feel comfortable buying things on the internet?

❑ YES ❑ NO

19. I have health insurance.

❑ YES ❑ NO

20. I have a primary care provider.

❑ YES ❑ NO

21. I have changed providers in the past 5 years.

❑ None ❑ 1–3 times ❑ 4 times or more

22. I receive most of my medical care from:

❑ a primary care provider ❑ a specialist ❑ the ER

23. I have life threatening allergies.

❑ YES ❑ NO

24. The number of major medical problems I have ranges from:

❑ 0–1 ❑ 2–4 ❑ 5 or more

Surveyor:

Medical record number:

Room/bed:

Patient was not surveyed because:

Patient "one-liner:"

Patient seen by resident:

Physician:

I would have found this patient's PHR useful:

❑ YES ❑ NO

I would have accessed this patient's PHR:

❑ NO

❑ if it required 0–5 min

❑ if it required 5–10 min

❑ if it required more than 10 min

This patient's diagnosis is (1 benign, 5 definitely serious):

❑ unknown

❑ 1 ------ ❑ 2 ------ ❑ 3 ------ ❑ 4 ------ ❑ 5