Nurse Staffing and Hospital Characteristics Predictive of Time to Diagnostic Evaluation for Patients in the Emergency Department

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Introduction: In the 2014 Emergency Department Benchmarking Alliance Summit, for the first time, participants recommended tracking nursing and advanced practice nurse hours. Performance data from the Centers for Medicare and Medicaid Services provides an opportunity to analyze factors associated with delays in emergency care. The purpose of this study was to investigate hospital characteristics associated with time to a diagnostic evaluation in 67 Massachusetts emergency departments from 2013 to 2014.

Methods: Covariates significantly correlated with time to diagnostic evaluation, and factors associated with timely care in emergency departments were included in the stepwise linear regression analysis. Differences in nurse staffing and performance measures in trauma and nontrauma emergency departments were examined with analysis of variance and *t* tests.

Results: Two predictors explained 38% of the variance in time a diagnostic evaluation (1): nurse staffing ($P < .001$) and (2) trauma centers ($P < .001$). In trauma centers, the time to a diagnostic evaluation significantly increased ($P = .042$) from 30.2 minutes when a nurse cared for fewer than 11.32 patients in 24 hours to 61.4 minutes when a nurse cared for 14.85 or more patients in 24 hours.

Discussion: Efforts to improve patient flow often focus on process interventions such as improved utilization of observation beds or transfers of patients to inpatient units. In this study, time to diagnostic evaluation significantly increased when emergency nurses care for higher numbers of patients. The findings present new evidence identifying the relationship of specific nurse to patient ratios to wait time in emergency departments.

Key words: Nurse staffing ratios; Emergency nurse; Emergency department crowding; Emergency department wait times; Patient outcomes; CMS performance measures

Emergency departments in hospitals in the United States are struggling with overcrowding that has reached crisis proportion.[1] Delays in care due to ED holding, crowding, and poor flow challenge performance, increase costs, undermine confidence in the health care system, and adversely affect patient outcomes and access to care.[2] Data on ED performance available from the Centers for Medicare and Medicaid Services (CMS) provide an opportunity to analyze factors associated with delays in ED care. Hospitals are obliged to demonstrate efficient patient flow management in the emergency department as a condition of accreditation[3] and to report to CMS measures of timely and effective care. Under the CMS Pay-for-Performance Program, emergency departments with longer wait times will be penalized, whereas those that outperform others will be rewarded through additional revenue.[4]

Massachusetts's health insurance reform is considered the model for the Affordable Care Act (ACA). Examining trends in CMS measures reported in Massachusetts emergency departments may foreshadow patterns of timely and effective care for emergency departments nationwide.[5] In Massachusetts, after health insurance reforms were

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enacted, there was a measurable increase in ED visits, suggesting that full implementation of the ACA is likely to result in a rise in ED volume across the United States.[6] Although higher numbers of Americans will have health insurance under the ACA, emergency departments will still serve as a safety net for patients who cannot access outpatient care as a result of insufficient primary care providers or who cannot be admitted to a hospital because of a shortage of inpatient beds.

Patient flow is a key factor in reducing crowding and improving performance.[7,8] The time a patient waits to be evaluated by a qualified health professional has been shown to be more affected by physician and emergency nurse staffing than by the volume of ED patients.[7] Improvements in staffing models have been reported using sophisticated analytic decision support tools to predict staffing needs based on historical data about busy times or "surges" in ED demand.[9–11] Staffing models to decrease ED length of stay include using advanced practice nurses (APNs), physician-assisted triage, and "medical assessment units."[8] The addition of nurse practitioners decreased ED length of stay by 49% and decreased the number of patients who left without being seen by 71%.[12] In addition to improving patient flow, the use of APNs is cost-effective because more APNs may be employed for a cost similar to that of one physician.[13]

A systematic review focusing on 15 measures of ED crowding found that the 3 measures most frequently linked to the quality and outcomes of care were the number of patients in the waiting room, the percentage of ED beds that were occupied, and the number of ED patients awaiting inpatient beds.[14] Delay in evaluation time has been associated with an increased risk of death and significant delays in receiving pain medication.[15,16] The number of patients who leave without being evaluated is considered a significant indicator of ED performance because it presents risk for both patients and the hospital. An analysis of ED performance found that volume alone did not explain patients who left without being seen, rather "better resourced emergency departments with efficient flow processes perform better regardless of volume and acuity."[7]

Agreement is widespread about the need to study how resources and processes in emergency departments influence crowding and care quality.[14] However, a gap in knowledge exists about how specific numbers of patients assigned to emergency nurses affect the wait time to diagnostic evaluation in emergency departments. The purpose of this study was to determine[1] the percent of variance in the time from a patient arrival at the ED door to a diagnostic evaluation by a qualified medical/health care professional that could be explained by hospital characteristics and emergency nurse staffing in Massachusetts hospitals and[2] whether there are differences in nurse staffing and time to diagnostic evaluation between certified trauma emergency departments and nontrauma emergency departments.

Methods

This cross-sectional study examined factors associated with the median time from ED door to diagnostic evaluation by a qualified medical/health care professional in 67 Massachusetts emergency departments from 2013 through 2014. The dependent measure in this study is defined by CMS and reported in the set of timely and effective care measures for emergency departments. This measure captures how much time elapses in minutes from when a patient arrives in the emergency department until the patient has a direct diagnostic evaluation with a qualified medical/health care professional. A "qualified health care professional" is defined as an institutionally credentialed provider, including an emergency nurse under the supervision of a physician, a nurse practitioner, certified nurse specialist, certified registered nurse anesthetist, certified nurse midwife, or physician assistant.[17] CMS technical specifications note that documentation of initial evaluation or assessment as recorded by the emergency nurse is acceptable.[18]

DATA SOURCES

The publicly available data sources used in this study included the CMS "timely and effective care ED measures" from January 1, 2013 to December 31, 2014,[19] the Massachusetts Center for Health Information and Analysis hospital profile data from 2010 to 2014,[20] and the Massachusetts Hospital Association Healthcare Provider Data report of emergency nurse staffing plans in emergency departments from 2013 to 2014.[21] These data sources were merged using the CMS hospital identifier number with the American Hospital Association Annual Survey of Hospitals released for 2009.[22] This study is exempt from an institutional review board approval because the data are available from public sources.

SAMPLE

All 70 nonfederal Massachusetts hospitals were included in the initial sample, and therefore a power analysis was not performed. Hospital closures or mergers between 2013 and 2014 and the exclusion of a trauma emergency department for children resulted in a final sample of 15 certified adult trauma emergency departments and 52 nontrauma emergency departments. In the final sample of 67 hospitals, random missing data in the 18 variables used in the data analysis totaled 3.8% and lowered sample sizes reported in Table 1 (N = 62, N = 37), Table 2 (N = 37), the Figure (N = 61), and the independent *t* test (N = 63).

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TABLE 1

Correlations with time to diagnostic evaluation by a qualified health care professional (one-tailed), Centers for Medicare and Medicaid Services, January 1, 2014–December 31, 2014

Variable	Coefficient	*P*	N
CMS performance measures January 2013–December 2014			
ED patients left without being seen (%)[19]	.464	<.001	62
ED median time arrival to departure for discharged patients[19]	.360	.002	62
ED median time to pain medication for long bone fracture[19]	.324	.005	61
ED median time arrival to departure for admitted ED patients[19]	.148	.126	62
Average wait time after physician decided to admit to inpatient[19]	.147	.127	62
Model factors included in stepwise linear regression			
Certified adult trauma center (0 = No, 1 = Yes)[20]	.377	.011	37
ED patients assigned to RN in 24 hours, FY 2013[21]	.354	.016	37
ED patients assigned to RN in 24 hours, FY 2014[21]	.138	.207	37
Total annual ED visits, FY 2013[21]	.474	.002	37
Total annual ED visits, FY 2014[21]	.346	.018	37
ED inpatient admissions, FY 2010[20]	.282	.045	37
ED observation admission, FY 2010[20]	.253	.065	37
Disproportionate share (0 = No, 1 = Yes)[20]	–.247	.070	37
Total profit or loss, FY 2012[20]	–.157	.177	37
Hospital beds staffed, FY 2013[20]	.119	.241	37
Hospital beds occupied (%), FY 2013[20]	.113	.252	37
Teaching hospital (0 = No, 1 = Yes)[20]	.068	.344	37
Springfield health referral region (0 = No, 1 = Yes)[22]	.151	.185	37
Boston health referral region (0 = No, 1 = Yes)[22]	-.121	.238	37
Worcester health referral region (0 = No, 1 = Yes)[22]	-.013	.470	37
Total adult ICU beds to total facility beds staffed,[22]	.043	.401	37
Medicare case mix, FY 2011[20]	-.016	.463	37

CMS, Centers for Medicare and Medicaid Services; *FY,* fiscal year.

DATA ANALYSIS

Correlations, analysis of variance, independent *t* tests, and a stepwise linear regression were conducted using IBM SPSS version 21.[23] Variables were computed in the American Hospital Association dataset to permit comparisons across hospitals in the stepwise linear model analysis. Dummy variables were created for each of the 3 hospital referral regions in Massachusetts defined as representing regional

TABLE 2

Stepwise linear regression of ED door to diagnostic evaluation by a qualified health care professional with predictors

Predictor	Unstandardized coefficients		Standardized coefficients	*t* Value	95% CI	*P* value
	B	SE (B)	(β)			
ED patients assigned to RN in 24 hours, FY 2013	3.290	.827	.559	3.980	1.610-4.970	<.001
Certified adult trauma center	21.522	5.249	.576	4.101	10.856-32.189	<.001

CI, Confidence interval; *FY,* fiscal year; *RN,* registered nurse; *SE,* standard error.
Stepwise: R^2 = 0.415; adjusted R^2 = 0.380; standard error of estimate = 14.24082; sum of squares SS = 11778.919; P < .001; N = 37.

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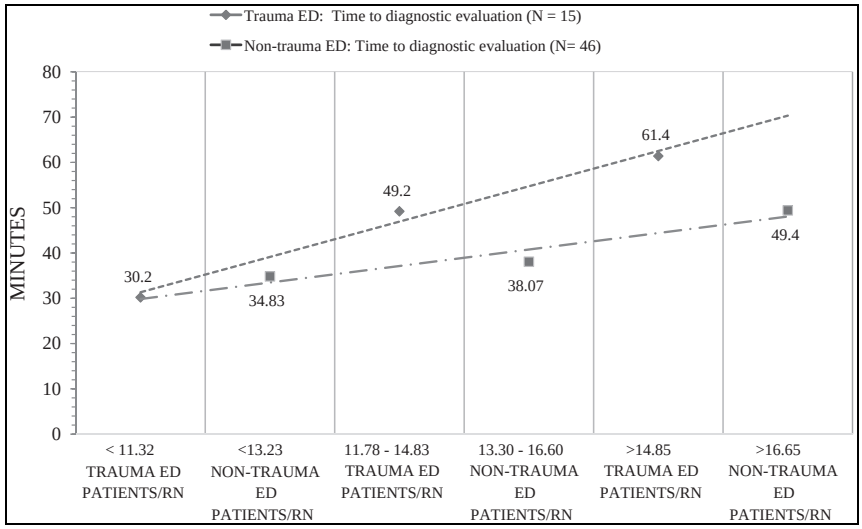

FIGURE

Average daily patients cared for by registered nurses in trauma and nontrauma emergency departments with time to diagnostic evaluation in minutes by a qualified medical/healthcare professional, 2013. Data from https://data.medicare.gov/data/hospital-compare and http://patientcarelink.org/healthcare-provider-data/hospital-data/staffing-plans-reports/.

health care markets for tertiary medical care.[24] Medicare case mix index, teaching hospitals, the proportion of adult ICU beds to total staffed hospital beds, and disproportionate share hospitals defined as having a public payer mix of 63% or greater were included as proxy measures of intensity of care. Nurse staffing variables were calculated from the publicly reported nurse staffing plans on the Massachusetts Hospital Association PatientCareLink Web site.[21] The average number of patients cared for by a registered nurse (RN) in the emergency department in 24 hours was calculated by dividing the average daily volume reported in each hospital's emergency department by the total daily RN staffing in the hospital's emergency department reported on the PatientCareLink Web site by each Massachusetts hospital for 2013 and 2014.

The data file was examined for random or systematic missing data and marked skewness. No systematic missing data or marked skewness were found in the variables included in the data analysis. Scatterplots of the candidate predictors were examined for applicability of the linear model, outliers, or unusual distributional shapes. Table 1 lists the 5 CMS measures of timely and effective ED care that were excluded from the model because they are surrogates for the dependent variable. Table 1 also describes the pairwise correlations of 17 covariates examined for significant association or scientific relevance with the dependent variable. One hospital was an outlier on the dependent variable. The stepwise linear regression analysis was computed with and without the hospital outlier, and there was no difference in the findings, so this hospital was not excluded from the data analysis.

Covariates that were significantly positively or negatively correlated with ED door to diagnostic evaluation by a qualified health care professional, as well as factors known to be associated with timely and effective care in emergency departments, were included in the stepwise linear regression analysis. All terms were initially placed in the model and then eliminated by stepwise modeling if they remained associated at $P = .05$ and were removed at $P = .10$. This was determined by stepwise procedures and likelihood ratio tests.

Results

Table 2 shows the 2 factors that significantly predicted the median time to a diagnostic evaluation by a qualified medical/health care professional in Massachusetts emergency departments. The median time from ED door to diagnostic evaluation by a qualified medical/health care professional increased by 0.559 standard deviations (SDs) for each increase of one SD in the average ED patients assigned to emergency nurse and 0.576 SDs in adult trauma emergency departments. In clinical terms, the median time to diagnostic evaluation increased by 21.522 minutes when a patient was evaluated in a trauma emergency department instead of a nontrauma emergency department and 3.29 minutes for each additional patient cared for by an emergency nurse. Massachusetts hospital characteristics including teaching status, disproportionate share, profit or loss, health referral region, intensity of hospital services, ED visits, ED inpatient admissions, ED observation admissions,

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and the percentage of hospital beds occupied did not explain the variation in time to diagnostic evaluation in this study.

The likelihood ratio test from the analysis of variance ($\alpha = .05$) was used to further examine time to diagnostic evaluation by low, average, and high numbers of patients cared for by RNs in trauma and nontrauma emergency departments. The Figure illustrates that in trauma emergency departments, time to diagnostic evaluation significantly increased, more than doubling in emergency departments where RNs cared for the highest number of patients ($F = 4.208$, $P = .041$). In nontrauma emergency departments, time to diagnostic evaluation also increased as RNs cared for more patients; however, the increase was not statistically significant ($F = 1.079$, $P = .349$).

Differences between trauma (N = 15) and nontrauma emergency departments (N = 48) on CMS measures of timely and effective care were examined using an independent sample t test with post hoc Bonferroni corrections ($\alpha = .05$). The average time patients spent in the emergency department after a physician decided to admit them before leaving for their inpatient room was significantly higher in trauma emergency departments (M = 175.533, SD ± 63.109) than in nontrauma emergency departments (M = 118.479, SD ± 43.724) ($P < .001$). The median time from ED arrival to ED departure for admitted ED patients was significantly higher in trauma emergency departments (M = 385.800, SD ± 75.054) than in nontrauma emergency departments (M = 306.938, SD ± 42.602) ($P = .001$). The median time from ED arrival to ED departure for discharged ED patients was significantly higher in trauma emergency departments (M = 182.400, SD ± 36.870) than in nontrauma emergency departments (M = 156.170, SD ± 27.624) ($P = .005$).

Discussion

Although 15 factors reported in the literature to be associated with timely ED care were included in our analysis, these factors did not explain the time interval from patient arrival at the emergency department to a diagnostic evaluation by a qualified medical/health care professional. In our study, 38% of the variance in the amount of time that elapsed from when a patient arrived in the emergency department to when they received a diagnostic evaluation was explained by 2 factors: a higher number of patients assigned to emergency nurses, and emergency departments that were certified trauma centers. These findings support prior research that associated high-acuity patients and staffing patterns with patient wait times in the emergency department.[7,25] Our study is unique in providing new evidence about how specific numbers of patients cared for by nurses in trauma and nontrauma emergency departments contributes to delays in ED diagnostic evaluation.

As shown in Table 1, Timely diagnostic evaluation in the emergency department is strongly associated with other CMS measures of timely and effective care, in particular, patients who left without being seen ($P < .001$). Barriers to improving flow are the inability of hospitals to efficiently admit ED patients to the inpatient units because of system issues such as a lack of technology that allows bedside registration and resources for proper staffing.[26] A great deal of complexity is involved in ED operations, including a myriad of staffing patterns. More research is needed on the numbers and mix of ED professionals, patient demographics, and severity, as well as overall hospital characteristics, to more fully understand the dynamics that contribute to ED crowding. Important community factors to consider include access to urgent care and outpatient clinics, case management availability, and other non–hospital-based supports that may contribute to the 62% variation in ED door to diagnostic evaluation that remained unexplained in this study.

Limitations

A limitation of this study is that medical staffing in Massachusetts emergency departments is not publicly available and therefore was not included in the analysis. The sample consisted of Massachusetts emergency departments, and the findings are not generalizable to other states. Although 4 covariates were entered into the model to account for the intensity of care, the data analyzed in this study did not account for comorbid medical diagnoses, psychiatric conditions, or socioeconomic factors that may also increase the time to evaluation in emergency departments. It is also important to note that variation has been found among hospitals in measuring and reporting the CMS measures for timely and effective care.[27]

Implications for Emergency Nurses

Consensus is evolving about the best metrics for tracking ED performance, and their usefulness will ultimately depend on the potential for improving clinical outcomes, safety, patient/staff satisfaction, and cost.[28] In the 2014 Emergency Department Benchmarking Alliance Summit, for the first time, participants recommended tracking nursing and advanced practice nurse hours per 100 ED visits.[29] Our study reinforces the value of developing

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standardized metrics to capture emergency nurse resources. When emergency nurses cared for 3 additional patients in 24 hours, the time to diagnostic evaluation in trauma emergency departments doubled from approximately ½ hour to 1 hour, and in nontrauma emergency departments, time to diagnostic evaluation increased by approximately 15 minutes. Our study also underscores the importance of stratifying CMS measures of timely and effective care by hospital characteristics such as trauma and nontrauma emergency departments as stakeholders develop metrics on ED performance that allow for fair comparisons on timely and effective care.

Appropriate emergency nurse staffing has a demonstrated effect on enhancing patient flow and the overall consumer experience, whereas insufficient emergency nurse staffing can delay care in emergency departments and become a source of ED liability claims.[30] Utilizing nurse practitioners in emergency departments has been found to reduce wait times and persons leaving without being seen.[8,11,12] More research is warranted to discern the appropriate mix of nursing personnel among emergency nurses and advanced practice nurses to maximize ED performance.

Conclusions

We found that higher numbers of patients cared for by emergency nurses in trauma centers significantly increased the time to a diagnostic evaluation. Innovative models of improving patient flow in emergency departments often focus on process interventions such as improved utilization of observation beds or efficient transfers of patients to inpatient units. The findings in this study suggest that lowering the number of ED patients cared for by emergency nurses is the single best solution to improve patient flow and minimize ED crowding.

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