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Patient, provider, and environmental factors associated with adherence to cardiovascular and cerebrovascular clinical practice guidelines in the ED★

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Abstract

Objectives: Myocardial infarction and stroke are two of the leading causes of death in the U.S. Both diseases have clinical practice guidelines (CPGs) specific to the emergency department (ED) that improve patient outcomes. Our primary objectives were to estimate differences in ED adherence across CPGs for these diseases and identify patient, provider, and environmental factors associated with adherence.

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Author contributions

Study Concept and Design – ST, EH, JH.

Acquisition of Data – ST, MJ, EM.

Analysis and Interpretation of Data – ST, JH.

Drafting of Manuscript – ST.

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Conflicts of interest

ST reports grant money to AHRQ to conduct research conceived and written by ST from Denver Health. JH reports grant money to NIAID to conduct research conceived and written by JH from Denver Health.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajem.2017.12.062>.

Methods: *Design:* Retrospective study at 3 hospitals in Colorado using standard medical record review. *Population:* Consecutive adults (18) hospitalized for acute coronary syndrome (ACS), ST-elevation myocardial infarction (STEMI), or acute ischemic stroke (AIS), who were admitted to the hospital from the ED and for whom the ED diagnosed or initiated treatment. *Outcome:* ED adherence to the CPG (primary); in-hospital mortality and length-of-stay (secondary). *Analysis:* Multivariable logistic regression using generalized estimating equations was used.

Results: Among 1053 patients, ED care was adherent in 84% with significant differences in adherence between CPGs ($p < 0.001$) and across institutions ($p = 0.04$). When patients presented with atypical chief complaints, the odds of receiving adherent care was 0.6 (95% CI 0.4–0.9). When the primary ED diagnosis was associated but not specific to the CPG, the odds of receiving adherent care was 0.5 (95% CI 0.3–0.9) and 0.3 (95% CI 0.2–0.5) for unrelated primary diagnoses.

Conclusions: Adherence to ED CPGs for ACS, STEMI and AIS differs significantly between cardiovascular and cerebrovascular diseases and is more likely to occur when the diagnosis is highly suggested by the patient's complaint and acknowledged as the primary diagnosis by the treating ED physician.

1. Introduction

1.1. Background

Cardiovascular and cerebrovascular disease are two of the top causes of death, hospitalization, and hospital charges in the United States, accounting for > 770,000 deaths in 2015 and 1.2 million hospitalizations and \$86 billion in aggregate hospital charges in 2014 [1,2]. Emergency departments (ED) play a vital role in providing evidence-based care for the management of acute myocardial infarction and acute ischemic stroke as both are initially evaluated and treated in the ED and both have evidence-based, time-sensitive treatments (i.e. early aspirin for acute coronary syndrome, rapid percutaneous coronary intervention (PCI) for ST-elevation myocardial infarction, and systemic thrombolysis for acute ischemic stroke) that have been shown to improve morbidity or mortality [3-6].

While large national registries including the American College of Cardiology's (ACC) National Cardiovascular Data Registry and the American Heart Association's (AHA) Get with the Guidelines Registry have been used to perform large, observational studies on guideline adherence for acute coronary syndromes, these studies largely mix ED and inpatient care, making it difficult to assess guideline adherence specifically initiated in the ED.[5-11] Similarly, large, observational studies on guideline adherence for acute ischemic stroke using data from the AHA's Get with the Guidelines-Stroke Registry have focused on door-to-needle time in patients who received thrombolysis within 2 h of symptom onset, which excludes the majority of patients who present to the ED with stroke symptoms and ignores other elements of the guideline that are relevant to ED stroke care, including assessment of eligibility for thrombolysis [12-14]. Moreover, to our knowledge, no study has assessed if there are common patient, provider, or environmental factors that are associated with adherence to these CPGs. Given the important parallels between the emergent care for acute myocardial infarction and acute ischemic stroke, identifying common barriers to

adherence to these CPGs may help identify common areas for improvement that could lead to improved quality of care for both acute myocardial infarction and acute ischemic stroke.

The primary objective of this study was to estimate differences in ED adherence to CPGs for acute coronary syndromes (ACS), acute ST-elevation myocardial infarction (STEMI), and acute ischemic stroke (AIS). Secondary objectives were to identify patient, physician, and environmental factors associated with ED adherence, and estimate the association between adherence and patient outcomes in our cohort.

2. Methods

2.1. Study design

We performed a retrospective cohort study at three distinct hospitals in Colorado to identify a large, consecutive patient population to evaluate differences in ED adherence to cardiovascular and cerebrovascular CPGs including: aspirin in the ED for ACS, door-to-balloon time for STEMI, and systemic thrombolysis for AIS. Additionally we used this cohort to identify patient, physician, and environmental factors associated with adherence to these CPGs. The institutional review boards at each participating hospital approved the study (IRB #13-0051 and #11-13-0003).

2.2. Study setting

This study was performed at three EDs in Colorado with heterogeneous and diverse practice environments that represent the main types of EDs including: an urban safety-net hospital, a suburban tertiary care hospital, and a community hospital in a small city. Detailed characteristics of each site are presented in the Table 1. Each hospital was independent of the others in the study (i.e. each hospital was from a different health system with no cross-over of physician staffing). All three EDs were staffed by board-certified or board-eligible emergency physicians at all times.

2.3. Study population

Consecutive patients were identified retrospectively by any hospital discharge ICD-9 codes for ACS (410.xx, 411.1), STEMI (410.xx, except 410.7), and AIS (434) [15,16]. Investigators at each site obtained a list of consecutive patients with these ICD-9 codes, who were admitted to the hospital from the ED beginning on December 31, 2012 and extending retrospectively until sufficient sample sizes for each diagnosis were obtained. From the initial cohort, each chart was screened by a physician abstractor for inclusion using the following criteria: [1] a discharge diagnosis in the medical record of ACS, STEMI, or AIS; [2] admission to the hospital from the ED; and [3] diagnosis or initiated treatment of the disease process in the ED. Exclusion criteria were age < 18 years of age, ED disposition other than admission, and patients transferred from another facility as the initial management would not have occurred in the included EDs.

2.4. Study protocol

To maximize validity and reliability of the medical record abstraction process, we used the following established methodologies: [1] physician abstractors, blinded to the purpose of the

study, to ensure expert familiarity with medical records and documentation; [2] abstractors trained by the lead author (ST) using a set of “test cases” to standardize approaches; [3] use of a previously developed and refined closed-response data collection instrument; [4] performance of 10 pilot reviews, using actual cases sampled from each hospital but not included for analysis in order to gain familiarity with each hospital's medical record system; [5] re-abstraction of 15% of included cases to estimate intra-abtractor agreement, with the intention of performing re-abstraction with adjudication of 100% of the cases if agreement of the 15% is less than excellent ($\kappa < 0.8$); and [6] routine oversight of the abstractor team by the lead author (ST), who was also available throughout the data collection process to address questions and problems that may arise [17,18]. Using a structured data abstraction form, abstractors documented the presence of all pre-specified variables necessary to assess adherence with each CPG. Using the same data abstraction form, we collected data related to patient, physician, and environmental characteristics that had been shown to be associated with CPG adherence in previous studies [19-22].

Patient factors included: patient demographics, primary health insurance, primary language, cardiovascular and cerebrovascular comorbidities, and chief complaint. Patient demographics, insurance, and language were obtained directly from each hospital's administrative database. Missing data were abstracted directly from the patient's medical record when available. All remaining characteristics were obtained directly from the medical record. Cardiovascular and cerebrovascular comorbidities were stratified into two separate variables: “prior disease” and “number of cardiovascular comorbidities”. For patients in the ACS and STEMI subgroups, prior disease was defined as documentation of a prior myocardial infarction. For patients in the AIS subgroup, prior disease was defined as documentation of a prior ischemic stroke. Patient chief complaints were stratified into three groups, defined by the authors (ST and JH), based on how typical the complaint was for the diagnosis. Typical chief complaints for ACS and STEMI included: chest pain and cardiac arrest. Typical chief complaints for AIS included: focal weakness, focal numbness, or alteration in speech. Associated chief complaints for ACS and STEMI included: shortness of breath, nausea, vomiting, fatigue, dizziness, jaw pain, epigastric pain, syncope, and palpitations. Associated chief complaints for AIS included: headache, ataxia, dizziness, fall, seizure, vision change, and altered mental status. All other chief complaints were grouped into an “other” category.

Provider factors include: ED provider, ED provider's experience, medical degree, and ED provider's ED diagnosis as well as the hospital unit (i.e. floor versus intensive care) and type of inpatient service (i.e. specialist versus generalist service). ED provider's experience was determined as the number of years of independent practice at the time the patient was seen (i.e. graduation from residency, physician assistant, or nurse practitioner school). ED provider's medical degree was categorized into MD, DO, PA, or NP. ED provider's ED diagnosis was categorized into three groups based on its association with ACS, STEMI, or AIS. If the ED physician documented ACS, STEMI, AIS, or an equivalent diagnosis as the primary ED diagnosis, then the ED diagnosis was designated as “primary”. For patients with ACS, if the ED physician documented cardiac arrest, hypertensive emergency, congestive heart failure exacerbation, syncope, or dysrhythmia as the primary diagnosis, then the ED diagnosis of ACS was designated as “associated” with the primary

diagnosis. Similarly for patients with STEMI, if the ED physician documented cardiac arrest or ventricular arrhythmia as the primary diagnosis, then the ED diagnosis of STEMI was designated as “associated”. Lastly, for patients with AIS, if the ED physician documented altered mental status, ataxia, vertigo, aphasia, seizure, headache, transient ischemic attack, numbness, or weakness as the primary diagnosis, then the ED diagnosis of acute ischemic stroke was designated as “associated”. All other primary ED diagnoses were categorized as “other”.

Environmental factors included: time of day, day of week, ED occupancy, and hospital. Time of day was categorized into three groups: day (7a-4:59p), evening (5p-11:59p), and night (12a-6:59p). Day of week was categorized into two groups: weekday (Monday 7a – Friday 4:59p) and weekend (Friday 5p – Monday 6:59a). In order to compare ED occupancy between different EDs, the distribution of each ED's daily occupancy was used to categorize daily ED occupancy into one of three groups: normal (± 1 standard deviation (SD)), slow (< 1 SD), and busy (> 1 SD).

2.5. Outcome measures

The primary outcome was ED adherence to the respective CPG for ACS, STEMI, and AIS as written or endorsed by the American Heart Association, American Stroke Association, The Joint Commission, Center for Medicare and Medicaid Services and the National Quality Forum [8,23, 24]. Table 2 describes how adherence was determined for each CPG. Secondary outcomes included intensive care unit (ICU) length of stay (LOS), hospital LOS, and all cause in-hospital mortality. ICU LOS was measured in days from time of admission (or transfer) to the ICU to time of transfer to a lower level of care or hospital discharge, whichever came first. Hospital LOS was measured in days from time of hospital admission order to time of hospital discharge.

2.6. Data management and statistical analyses

All data management and statistical analysis were performed using SAS Version 9.4 (SAS Institute, Inc., Cary, NC). Descriptive statistics were calculated for all variables. Continuous data were reported as medians with interquartile ranges and categorical variables as percentages with 95% confidence intervals (CIs). Prevalence estimates with 95% CIs were used to report adherence with CPGs, and a chi-square test was used to test the a priori hypothesis that a statistically significant difference in adherence existed across the three CPGs. A p -value ≤ 0.05 was considered statistically significant.

Unadjusted logistic regression was used to estimate the association of each patient, provider, and environmental variable with ED adherence to CPGs within the combined cohort and each disease subgroup. Hierarchical multivariable logistic regression using generalizing estimating equations was used to estimate associations between patient, provider, and environmental factors and ED adherence with CPGs within the combined cohort, while accounting for clustering of patients within physicians. Adherence for all CPGs was initially modeled as a composite outcome to evaluate for factors associated with ED adherence to cardiovascular and cerebrovascular CPGs. Secondary models for each individual CPG were also developed, recognizing that different characteristics may be associated with adherence

between CPGs. Models were developed by first creating a full model followed by dropping variables thought to be collinear. Previously reported confounders were then evaluated one at a time and retained if the point estimate of the candidate variable changed by > 10% [25]. ED provider was included as a random effect, while hospital was included as a fixed effect irrespective of its effect on other variables. Effect modification, using interaction terms, was assessed for gender, primary language, and race/ethnicity by complaint category, and included if they contribute significantly to the model (p -value 0.05).

2.7. Sample size estimation

In an effort to report estimates with reasonable precision, we chose a priori to include numbers of patients based on an upper 95% confidence limit of 5% (10% total CI). This degree of precision allowed for appropriate statistical separation between estimates across institutions with relatively high and relatively low adherence, and allowed for separation of all estimates from our a priori-defined 95% adherence threshold. Using point estimates from our preliminary data, we calculated a sample size of 350 total patients for each disease process (1050 total patients) to provide a power of 95% resulting in 117 patients for each disease process per study site.

3. Results

3.1. Patient characteristics

Overall, 1551 patient charts were reviewed to obtain the final cohort of 1053 patients (351 per disease). Three patients had missing race/ethnicity data and were removed for multivariable modeling. Table 3 describes the characteristics of patients in the study. The median age was 63 years (IQR 53–73), and 65% of patients were male. The majority of patients were non-Hispanic whites (61%), followed by Hispanics (24%), and non-Hispanic blacks (13%). English was the primary language for 87% of patients, and 10% of patients spoke Spanish. Medicare (44%) and private health insurance (22%) comprised the majority of patients' primary health insurance. An additional 9% of patients primarily utilized Medicaid, and 22% of patients were uninsured. >90% of patients had at least one cardiovascular comorbidity with hypertension (64%) being the most common, followed by tobacco use (40%) and hyperlipidemia (38%). Patients overwhelmingly presented with typical chief complaints (71%) for their diseases.

3.2. Prevalence of adherence

Overall, the prevalence of adherence to ED cardiovascular and cerebrovascular CPGs was 84% (95% CI: 82–86%) (Table 4). ED adherence was significantly different between CPGs, with adherence ranging from 96% (95% CI: 94%–98%) for systemic thrombolysis following AIS to 73% (95% CI: 68%–78%) for primary coronary intervention (PCI) within 90 min following acute STEMI ($p < 0.001$). ED adherence to aspirin administration for ACS was 83% (95% CI: 79%–87%). The overall prevalence of adherence was significantly different across hospitals ($p = 0.04$).

3.3. Multivariable analyses

Unadjusted associations between ED adherence to CV CPGs and all patient, provider, and environmental variables for the combined cohort are provided in the Supplement (Tables S1 and S2). In addition, all results by disease subgroup are presented in the Supplement (Tables S3-S6). Table 5 shows results of our adjusted multivariable analysis for the combined cohort. Patients were more likely to receive adherent care in the ED if they presented with chief complaints that were typical for the diagnosis and if the primary diagnosis in the ED was specific to the CPG. When patients presented with atypical or unrelated chief complaints, the odds of receiving adherent care in the ED were 0.6 (95% CI: 0.4–0.9) for atypical complaints and 0.6 (95% CI: 0.3–1.2) when the complaint was unrelated to the ED diagnosis. When the primary ED diagnosis was associated but not specific to the CPG, the odds of receiving adherent care were 0.5 (95% CI 0.3–0.9) and 0.3 (95% CI 0.2–0.5) for unrelated primary diagnoses. Lastly, patients, who presented in the overnight hours between midnight and 7 am, were less likely to receive adherent care than patients who presented during the day (OR 0.6, 95% CI 0.4–0.9).

3.4. Secondary outcomes

In the combined cohort, 59 (5.6%) patients died during the index hospitalization including 8.1% ($n = 28$) of STEMI patients, 4.8% ($n = 17$) of ACS patients, and 4.0% ($n = 14$) of AIS patients. Adjusted for patient age, sex, comorbidities, and disease subgroup the odds of in-hospital mortality were not significantly different between patients who did and did not receive adherent care in the ED, but trended towards decreased odds of in-hospital death with adherent ED care (OR 0.6, 95% CI 0.3–1.1) (Table 6). The median ICU length of stay (LOS) and hospital LOS for patients receiving adherence and non-adherent care were not different between groups (Table 7). However, median hospital length of stay was lower for STEMI patient receiving adherent care in the ED (median difference 1 day, 95% CI 0.3–1.7).

4. Discussion

To our knowledge, this is the first study to examine differences in adherence to ED specific CPGs across multiple cardiovascular and cerebrovascular diseases. In this cohort study, which included EDs with heterogeneous and diverse practice environments, we found ED adherence to cardiovascular and cerebrovascular CPGs showed room for improvement with 16% of patients receiving non-adherent care. At the patient level, no demographic variables was associated with adherence to CPGs. Chief complaint and the primary ED diagnosis, however, were significantly associated with ED adherence, such that the more straight forward the complaint and diagnosis, the more likely ED care was to be adherent. At the provider level, the random effect of provider was small, accounting for only 2.5% of the variability in ED adherence. At the environmental level, only time of day was significantly associated with adherence, which is largely the result of differences in care for the STEMI subgroup during these hours secondary to delays in assembling the catheterization team in the middle of the night. Lastly, we found no association between ED adherence to cardiovascular and cerebrovascular CPGs and in-hospital mortality. Importantly though, our study was not powered to find a difference in in-hospital mortality, and our results suggest

a trend towards lower odds of in-hospital death when ED care is adherent to cardiovascular and cerebrovascular CPGs.

Prior studies using data from national, observational studies on guideline adherence in hospitalized patients for ACS have mixed ED and inpatient care, making it difficult to assess guideline adherence specifically in the ED. [19,26] The Center for Medicare and Medicaid Services (CMS) currently reports aspirin administration within 24 h of admission for ACS, which accounts for aspirin given in the ED as well as aspirin given during the early hours of hospitalization. Thus, while our reported prevalence of aspirin adherence for ACS (83%) may seem low, our numbers reflect the component of this guideline that was fulfilled in the ED. Additionally, a lack of certainty around the diagnosis of ACS may have contributed to our lower than expected prevalence of aspirin adherence for ACS. While an elevated troponin is specific to myocardial injury, it is not specific to the cause of myocardial injury. While aspirin administration is standard of care for myocardial injury due to ACS, the utility of aspirin for myocardial injury due to causes other than ACS has not been studied, and current guidelines do not provide specific recommendations for type 2 myocardial infarctions [27, 28]. In 28% of our ACS subgroup, ACS or an equivalent diagnosis was not listed as the primary ED diagnosis and thus may represent patients with type 2 myocardial infarctions. In these patients, only 57% (95% CI 47–67%) received aspirin in the ED as compared to 93% (95% CI 90–96%) of patients with a primary ED diagnosis of ACS. International Classification of Disease codes need to incorporate myocardial infarction subtype nomenclature both to aid research in this area and remove the risk of penalty from CMS for withholding guideline recommended therapies for myocardial infarction subtypes for which the benefit of therapies specific to ACS are unknown [27].

Adherence to rapid PCI for STEMI has been extensively reported from national registry data from ACC and AHA [29-32]. Our median door-to-balloon time for patients presenting to a STEMI receiving hospital (73 min, IQR 56–93) and proportion of eligible patients receiving PCI within the guideline recommended time (69%) are very similar to the most recent 2006–2009 data published from the American Heart Association's (AHA) Get With the Guidelines-Coronary Artery Disease registry (74 min and 68% respectively) [30]. Door-to-balloon time inherently reflects 4 unique stages in STEMI diagnosis and early management: [1] diagnosis (ED time), [2] cardiac catheterization (cath) lab activation (ED time), [3] cath lab preparation (cardiology time), and [4] PCI completion (cardiology time). Thus determining the ED contribution to door-to-balloon time requires documentation of the time of cath lab activation, which was often not documented in the medical records in our study. We found only one prior study that explored the ED contribution to door-to-balloon time. Tsai et al. reported door-to-ED disposition times and found that only 49% of patients were transferred to the cath lab from the ED within 60 min of arrival [26]. While we primarily reported door-to-balloon time, our door-to-ED disposition times were improved from those reported by Tsai et al. In our study, 73% (95% CI: 68–78%) of patients, who arrived to a STEMI receiving hospital and were eligible of PCI, arrived in the cath lab within 60 min of ED arrival. While the ACC and AHA have provided recommendations for ED disposition times for patients diagnosed at a STEMI referral center (i.e. door-in-door-out time < 30 min), similar recommendations have not been extended to STEMI receiving hospitals. ACC and AHA could provide a similar recommendation for STEMI receiving hospitals,

without specifically calling for a reportable quality metric, so as to provide a benchmark for hospitals trying to improve their door-to-balloon times. Additionally, our results suggest that continued focus on door-to-ecg time is warranted given its association with meeting guideline recommended door-to-balloon times.

Similar to studies for ACS, data from large observational studies, such as the Get With the Guidelines-Stroke registry, mix stroke patients presenting to the ED with inpatient stroke patients, making it difficult to assess ED guideline adherence specifically [12]. In addition, prior studies on guideline adherence for treatment with systemic thrombolysis for AIS have focused on door-to-needle time for administration of intravenous tissue-type plasminogen activator (tPA) in eligible patients arriving to the ED within 2 h of symptom onset [13,14,33,34]. While this is an important metric given that tPA has been shown to be more likely to reduce morbidity following an AIS the earlier it is given, it ignores ED care for the majority of ED stroke patients. Our assessment of guideline adherence for treatment of AIS with tPA includes both the assessment of eligibility for all acute stroke patients as well as the administration of tPA within 270 min of symptom onset. In our study, 96% of ED patients admitted to the hospital for AIS received guideline adherent care. However, the vast majority of patients were ineligible for systemic thrombolysis, primarily due to delayed presentations, with 63% (95% CI: 58–68%) presenting after 210 min. Only 30% of patients in our cohort presented within 2 h of symptoms, and 90% of patients presenting within 210 min of symptom onset received guideline recommended care. Thus, while ED adherence to systemic thrombolysis for AIS is high, the majority of patients are ineligible for tPA mostly due to delayed presentations. With the goal to decrease the burden of stroke morbidity, emphasis on improving door to needle times may yield little improvement in the prevalence of tPA administration for AIS. Rather, broader public health projects to improve patient awareness of stroke symptoms and the importance of precipitous presentations to the ED following stroke symptom onset are more likely to yield improvements in tPA administration rather than focusing on physician utilization of the drug.

5. Limitations

The use of discharge ICD-9 codes to identify ED patients is limited because discharge diagnoses may not be relevant to the reasons for admission from the ED. Consequently, using discharge ICD-9 codes was coupled with direct chart review to ensure the sample only represented patients with the diagnoses of interest, who were admitted to the hospital from the ED specifically for these diagnoses. Additionally, including hospital admission as an inclusion criterion may have excluded patients who died in the ED, had an unknown disposition, or were discharged from the ED. Given the cardiovascular and cerebrovascular diseases included in this study, limiting patients to those who were admitted helped limited chart reviews to patient who were most likely to truly have the disease and in whom the guideline recommended care could actually have been enacted, especially in the case of PCI. Missing documentation within the medical chart is a known limitation to medical record abstraction. Missing documentation could have affected our estimates of adherence especially in the ACS subgroup. While prehospital records were reviewed when available in the medical record, prehospital records were not present for all patients who presented to the ED by ambulance. Thus, our estimated prevalence of aspirin administration in patients

admitted primarily for ACS is likely low, reflecting missing documentation. Only three patients had missing demographic data, and these patients were removed from multivariable modeling. Although we abstracted a comprehensive list of potential patient, physician, and environmental factors that have been shown to be associated with CPGs in other studies, additional variables may have been left out of the model. We used admitting hospital unit as a proxy for illness severity. The use of a more robust illness severity score may have resulted in a more specific variable for illness severity. Similarly we used daily ED occupancy as a measure of ED crowding because we were unable to obtain hourly occupancy data from each institution. Consequently, at the patient level, our measure of ED occupancy may not reflect how busy the ED was at the time the patient was seen.

6. Conclusions

In summary, adherence to ED CPGs for ACS, STEMI and AIS differs significantly across disease and hospitals. While adherence to cardiovascular and cerebrovascular CPGs in the ED for ACS, STEMI, and AIS is high, significant room for improvement exists, most notably in door-to-balloon times for STEMI and aspirin administration for ACS. Adherence to ED cardiovascular CPGs is most likely to occur when the diagnosis is highly suggested by the patient's complaint and when the diagnosis is the patient's primary ED diagnosis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of Study Sites in 2012

	Urban safety-net DHMC	Rural community NMC	Academic Tertiary UCH
Annual adult ED census	80,000	55,000	67,800
% ED patients admitted	15	20	19
% admitted ED patients to ICU	26	14	15
Beds in ED	72	41	38
Beds in hospital	500	378	437
% Patients seen by residents	95	<1	65
% Patients seen by PA or NP	0	30	16
Trauma level designation	1	2	2
JCAHO stroke center	No	No	Yes
In-house neurology consultation	Yes	No	Yes
Hours interventional cardiology available	9	24	24

Abbrev: ED = Emergency Department; ICU = intensive care unit; PA = physician assistant; NP = nurse practitioner

JCAHO = joint commission: accreditation, health care, certification; DHMC = Denver Health Medical Center

NMC=North Colorado Medical Center; UCH = University of Colorado Hospital.

Table 2

Description of Quality Measures for ED Cardiovascular and Cerebrovascular Care

Quality measures	Numerator	Denominator
Acute coronary syndrome		
Aspirin Given in ED	Aspirin given in ED OR Plavix given in ED if patient has allergy to Aspirin OR documentation of Aspirin or Plavix taken within 24 h OR documented contraindication OR patient refusal	Patients in whom ED provider suspected ACS and ordered an ECG and troponin AND the patient had an abnormal troponin or ischemic ECG changes in ED OR patient was primarily admitted from ED for ACS, chest pain or rule-out ACS.
ST elevation myocardial infarction		
Time to PCI	PCI within 90 min of arrival to a STEMI receiving center OR PCI within 120 min of arrival to a STEMI referral center OR documented contraindication OR patient refusal	All ED patients with ST-elevation on ECG concerning for acute MI
Acute ischemic stroke		
Time to Thrombolytics	tPA administered within 4.5 h of symptom onset OR documented contraindication OR patient refusal	All ED patients with symptoms of an acute ischemic stroke

Abbrev: ED = emergency department; ACS = acute coronary syndrome; ECG = electrocardiogram; PCI = percutaneous coronary intervention; MI = myocardial infarction; tPA = tissue plasminogen activator.

Table 3

Patient Characteristics

Characteristics	Overall % (n)	Acute coronary syndrome % (n)	ST-elevation myocardial infarction % (n)	Acute ischemic stroke % (n)	Acute ischemic stroke % (n)
Age (median years (IQR))	63.0 (53–73)	63.0 (54–73)	59.0 (51–66)	66.0 (57–78)	
Gender					
Male	64.4 (678)	66.1 (232)	77.8 (273)	49.3 (173)	
Female	35.6 (375)	33.9 (119)	22.2 (78)	50.7 (178)	
Race/ethnicity					
Non-Hispanic White	60.9 (641)	63.3 (222)	65.0 (228)	54.4 (191)	
Hispanic	23.7 (250)	21.9 (77)	23.4 (82)	25.9 (91)	
Non-Hispanic Black	12.4 (130)	13.1 (46)	8.0 (28)	16.0 (56)	
Other	2.8 (29)	1.7 (6)	2.8 (10)	3.7 (13)	
Missing	0.3 (3)		0.8 (3)		
Language					
English	87.4 (920)	88.6 (311)	86.6 (304)	86.9 (305)	
Spanish	9.9 (104)	9.4 (33)	11.1 (39)	9.1 (32)	
Other	2.7 (29)	2.0 (7)	2.3 (8)	4.0 (14)	
Primary health insurance					
Medicare	44.3 (466)	47.6 (167)	33.1 (116)	52.1 (183)	
Private	22.4 (236)	23.1 (81)	28.2 (99)	15.9 (56)	
Uninsured	22.0 (232)	16.2 (57)	28.2 (99)	21.7 (76)	
Medicaid	8.8 (93)	9.4 (33)	8.5 (30)	8.6 (30)	
Other source	2.5 (26)	3.7 (13)	2.0 (7)	1.7 (6)	
CV comorbidities					
Coronary artery disease	29.4 (310)	39.9 (140)	29.9 (105)	18.5 (65)	
Diabetes	30.6 (322)	34.5 (121)	26.8 (94)	30.5 (107)	
Hypertension	63.8 (672)	64.4 (226)	55.0 (193)	72.1 (253)	
Hyperlipidemia	38.3 (403)	41.9 (147)	36.2 (127)	36.8 (129)	
Heart failure	7.3 (77)	13.1 (46)	3.4 (12)	5.4 (19)	
Stroke	12.2 (128)	6.3 (22)	3.7 (13)	26.5 (93)	
Tobacco abuse	39.8 (419)	43.6 (153)	43.9 (154)	31.9 (112)	

Characteristics	Overall % (n)	Acute coronary syndrome % (n)	ST-elevation myocardial infarction % (n)	Acute ischemic stroke % (n)
Atrial fibrillation				
# CV comorbidities (median (IQR))	2.0 [1-3]	2.0 [1-3]	2.0 [1-3]	2.0 [1-3]
Chief complaint				
Typical symptoms	71.1 (749)	63.5 (223)	81.5 (286)	68.4 (240)
Associated symptoms	23.9 (252)	27.4 (96)	17.1 (60)	27.4 (96)
Other symptoms	4.9 (52)	18.8 [32]	1.4 [5]	4.3 [15]

Abbrev: IQR = interquartile range; CV = cardio/cerebrovascular.

Table 4

Adherence to ED Cardiovascular Clinical Practice Guidelines

	Overall adherence % (95% CI)	Acute coronary syndrome % (95% CI)	ST-elevation myocardial infarction % (95% CI)	Acute ischemic stroke % (95% CI)	<i>p</i>
Adherence to CPG	84.0 (81.8–86.3)	82.9 (78.9–86.7)	72.9 (68.3–77.6)	96.3 (94.3–98.3)	<0.001
Hospital type					
Safety-net	81.8 (77.7–85.8)	81.2 (74.0–88.4)	69.2 (60.7–77.7)	94.9 (90.8–98.9)	0.04 [‡]
Community	88.0 (84.6–91.4)	88.0 (82.1–94.0)	78.6 (71.1–86.2)	97.4 (94.5–100)	
Tertiary care	82.3 (78.0–86.1)	79.5 (72.1–86.9)	70.9 (62.6–79.3)	96.6 (93.2–99.9)	

Abbrev: ED = emergency department; CI = confidence interval; CPG = clinical practice guidelines.

[‡] *p* value represents significance of overall % adherence across hospital types.

Table 5

Hierarchical Adjusted Model of ED Adherence to CV CPGs, accounting for patients clustered within physicians

	N (%)	Adherence (%)	Adjusted OR (95% CI)
Age *	63.3 (14.2)	63.3 (14.2)	1.0(0.99–1.02)
Sex			
Male	676 (64.4)	83.6	Ref
Female	374 (35.6)	84.8	1.2 (0.8–1.7)
Race/Ethnicity			
Non-Hispanic White	641 (61.0)	83.6	Ref
Non-Hispanic Black	130 (12.4)	86.2	1.8 (1.0–3.3)
Hispanic	250 (23.8)	83.2	1.1 (0.7–1.7)
Other	29 (2.8)	89.7	2.3 (0.6–8.2)
Insurance			
Private	234 (22.3)	87.6	Ref
Medicare	466 (44.4)	83.9	0.8 (0.5–1.5)
Medicaid	93 (8.7)	81.7	0.8 (0.4–1.6)
Other source	26 (2.5)	80.8	0.9 (0.3–2.8)
Uninsured	231 (22.0)	81.8	0.6 (0.3–1.02)
# CV Comorbidities *	2.2 (1.4)	2.2 (1.4)	0.9 (0.8–1.1)
Prior disease (MI or Stroke)			
Yes	336 (32.0)	81.3	Ref
No	714 (68.0)	85.3	1.4 (0.9–2.1)
Complaint			
Typical	746 (71.0)	87.8	Ref
Associated	252 (24.0)	75.0	0.6 (0.4–0.9)
Other	52 (5.0)	73.1	0.6 (0.3–1.2)
ED diagnosis			
Primary	919 (87.5)	86.8	Ref
Associated	57 (5.4)	70.2	0.5 (0.2–0.9)
Other	74 (7.1)	59.5	0.3 (0.2–0.5)
Time of day			
Day (7a-4:59p)	614 (58.5)	85.0	Ref
Evening (5p-11:59p)	299 (28.5)	84.3	1.0 (0.6–1.4)
Overnight (midnight – 6:59a)	137 (13.1)	78.8	0.6 (0.4–0.9)
Hospital			
Tertiary care	349 (33.4)	82.2	Ref
Safety-net	350 (33.2)	81.7	1.2 (0.8–1.8)
Community	351 (33.3)	88.0	1.6 (0.9–2.4)

Abbrev: CV = cardio/cerebrovascular; CPG = clinical practice guideline; OR = odds ratio; CI = confidence interval; Ref = reference; NHW = Non-Hispanic White; MI = myocardial infarction.

* Age and # CV Comorbidities are presented as mean (standard deviation).

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Table 6**Adjusted Multivariable Logistic Model of In-Hospital Mortality**

	N (%)	In-hospital mortality (%)	Adjusted OR (95% CI)
Age *	63.3 (14.2)	65.2 (15.1)	1.02 (1.0–1.04)
Sex			
Male	675 (64.3)	45 (6.7)	Ref
Female	375 (35.7)	14 (3.7)	0.5 (0.3–1.0)
# CV Comorbidities *	2.2 (1.4)	2.2 (1.3)	0.9 (0.7–1.1)
Prior disease (MI or Stroke)			
Yes	337 (32.1)	23 (6.8)	Ref
No	713 (67.9)	36 (5.1)	0.7 (0.4–1.3)
Admitting disease			
STEMI	348 (33.1)	28 (8.1)	Ref
ACS	351 (33.4)	17 (4.8)	0.6 (0.3–1.1)
AIS	351 (33.4)	14 (4.0)	0.6 (0.3–1.2)
Adherent ED care			
No	882 (84.0)	16 (9.5)	Ref
Yes	168 (16.0)	43 (4.9)	0.6 (0.3–1.1)

Abbrev: OR = odds ratio; CI = confidence interval; Ref = reference; CV = cardio/cerebrovascular MI = myocardial infarction; STEMI = ST elevation myocardial infarction; ACS = acute coronary syndrome; AIS = acute ischemic stroke; ED = emergency department.

* Age and # CV Comorbidities are presented as means (standard deviation).

Table 7

ICU and Hospital Length of Stay and Association with Adherence to ED

	Overall			Adherence			Non-Adherence			Median difference		
	Median	(95% CI)	Median	(95% CI)	Median	(95% CI)	Median	(95% CI)	Median	(95% CI)	Median	(95% CI)
ICU length of stay (days)	3	[3-3]	3	[3-3]	3	[3-3]	3	[3-4]	0	(0-0)		
Disease type												
ACS (n = 193)	3	[3-3]	3	[2-3]	3	[2-4]	0	(-1.1 to 1.1)				
STEMI (n = 305)	3	[3-3]	3	[3-3]	3	[3-4]	0	(-0.5 to 0.5)				
AIS (n = 104)	3	[3-3]	3	[3-3]	3	[3-3]	0	(0-0)				
Hospital length of stay (days) Disease type	4	[4-4]	4	[3-4]	4	[4-4]	0	(-0.5 to 0.5)				
ACS	4	[3-4]	4	[3-4]	4	[4-6]	0	(-1.1 to 1.1)				
STEMI	4	[3-4]	3	[3-4]	4	[3-4]	1	(0.3-1.7)				
AIS	4	[4-4]	4	[4-4]	4	[3-5]	0	(-0.9 to 0.9)				

Cardiovascular and Cerebrovascular CPGs.

Abbrev: ICU = intensive care unit; ED = emergency department; CPGs = clinical practice guidelines; CI = confidence interval; ACS = acute coronary syndromes; STEMI = ST elevation myocardial infarction; AIS = acute ischemic stroke.