Effect of a HEART Care Pathway on Chest Pain Management Within an Integrated Health System

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Study objective: We describe the association of implementing a History, ECG, Age, Risk Factors, and Troponin (HEART) care pathway on use of hospital care and noninvasive stress testing, as well as 30-day patient outcomes in community emergency departments (EDs).

Methods: We performed a prospective interrupted-time-series study of adult encounters for patients evaluated for suspected acute coronary syndrome. The primary outcome was hospitalization or observation, noninvasive stress testing, or both within 30 days. The secondary outcome was 30-day all-cause mortality or acute myocardial infarction. A generalized estimating equation segmented logistic regression model was used to compare the odds of the primary outcome before and after HEART implementation. All models were adjusted for patient and facility characteristics and fit with physicians as a clustering variable.

Results: A total of 65,393 ED encounters (before, 30,522; after, 34,871) were included in the study. Overall, 33.5% (before, 35.5%; after, 31.8%) of ED chest pain encounters resulted in hospitalization or observation, noninvasive stress testing, or both. Primary adjusted results found a significant decrease in the primary outcome postimplementation (odds ratio 0.984; 95% confidence interval [CI] 0.974 to 0.995). This resulted in an absolute adjusted month-to-month decrease of 4.39% (95% CI 3.72% to 5.07%) after 12 months' follow-up, with a continued trend downward. There was no difference in 30-day mortality or myocardial infarction (0.6% [before] versus 0.6% [after]; odds ratio 1.02; 95% CI 0.97 to 1.08).

Conclusion: Implementation of a HEART pathway in the ED evaluation of patients with chest pain resulted in less inpatient care and noninvasive cardiac testing and was safe. Using HEART to risk stratify chest pain patients can improve the efficiency and quality of care. [Ann Emerg Med. 2019;74:171-180.]

Please see page 172 for the Editor's Capsule Summary of this article.

0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2019.01.007

SEE EDITORIAL, P. 181.

INTRODUCTION

Background

Heart disease is a leading cause of mortality,[1] and chest pain, a symptom that often triggers an evaluation for suspected acute coronary syndrome, is the second most frequent reason for all emergency department (ED) visits.[2] This leads to greater than $3 billion in hospital costs each year to evaluate patients with possible acute coronary syndrome.[3] However, there is no evidence that the current paradigm of acute care, which frequently includes hospital observation and cardiac stress testing, actually improves patient outcomes.[4-6] Objective risk scores, such as History, ECG, Age, Risk Factors, Troponin (HEART), are designed to help clinicians identify which patients require further hospital-based observation or testing and who may be discharged safely.[7] HEART is a validated 0- to 10-point acute coronary syndrome scoring system.[7-9] Patients with a HEART score between 0 and 3 have been shown to have a low risk (<1%) of 30-day major adverse cardiac events.[8,10-12]

Importance

Recent evidence suggests that risk-stratification tools in the ED can identify patients with suspected acute coronary syndrome who are at low risk and thus can defer further hospital observation or noninvasive cardiac testing. However, there are limited data on the effect of the adoption of such tools on health care use and patient outcomes. A single-site randomized trial at an academic medical center suggested that a HEART pathway to discharge low-risk patients may safely reduce admissions,[13]

Editor's Capsule Summary

What is already known on this topic

Extensive resources are devoted to the urgent risk stratification of patients who present to the emergency department (ED) with chest pain and concern for acute myocardial infarction.

What question this study addressed

This prospective before-and-after study of approximately 65,000 ED patients sought to determine whether implementation of a clinical pathway based on the History, ECG, Age, Risk Factors, and Troponin (HEART) score could safely increase the proportion of patients discharged directly from the ED without extensive observation or stress testing.

What this study adds to our knowledge

Implementation of the HEART score decreased hospital admission and stress testing within 30 days by 1% to 3% each, without an observed increase in missed myocardial infarction or increased 30-day mortality.

How this is relevant to clinical practice

This clinical pathway modestly decreased hospital admissions.

but a larger cluster-randomized trial in the Netherlands resulted in no change in use.[14] To our knowledge, there are no reports to describe the safety and efficacy of similar care pathways in community hospitals.

Goals of This Investigation

The primary aim of this study was to describe the effect of implementing a HEART care pathway designed to reduce hospitalization and noninvasive stress testing in 13 community EDs in Southern California. We also report rates of 30-day acute myocardial infarction and all-cause death before and after the intervention. We hypothesized that the HEART pathway would decrease hospitalizations and noninvasive cardiac testing without adverse effect on 30-day acute myocardial infarction and death rates.

MATERIALS AND METHODS

Study Design and Setting

We conducted a prospective interrupted-time-series study of all adult ED encounters for suspected acute coronary syndrome at 13 community hospitals between May 6, 2015, and June 3, 2017. Study sites were all part of Kaiser Permanente Southern California, an integrated health system providing health care for greater than 4 million members. Kaiser Permanente Southern California hospitals provide care to greater than 1 million ED patients per year (study sites ranging from ≈25,000 to 95,000 ED visits per year). Of these ED patients, approximately 80% are health plan members. We excluded one new hospital that did not have predata for comparison and one hospital not staffed by Kaiser Permanente Southern California physicians, who were therefore not trained or educated in regard to the HEART recommendations. Our data set allowed us to track detailed information for our members' in-network encounters, as well as capture claims data for out-of-network encounters.

Selection of Participants

ED encounters were included for adult patients (≥18 years) who were health plan members and had both a troponin laboratory test and a chest pain diagnosis (Appendix E1, available online at http://www.annemergmed.com). All sites used the same troponin laboratory assay (Beckman Coulter Access AccuTnI+3; Beckman Coulter, Brea, CA). We included only health plan members because we did not have accurate follow-up information for our outcomes for nonmember patients. Our data set allowed us to identify claims data for any hospital or ED encounter, as well as all in-network health care. We excluded patients with a do-not-resuscitate status, who had an acute myocardial infarction identified in the ED, who were transferred from another hospital, or who died in the ED (Figure 1). Encounters that occurred from May 6, 2015, to May 5, 2016, were included in the preimplementation period; May 6, 2016, to June 2, 2016, was the washout period; and June 3, 2016, to June 2, 2017, was the postimplementation period. In January 2016, Kaiser Permanente Southern California adopted HEART to be used by emergency physicians during the clinical evaluation and management of patients with possible acute coronary syndrome. The implementation included clinical recommendations for patients with low- (0 to 3), moderate- (4 to 6), and high-risk (7 to 10) HEART scores. An education module and plenary presentation at a local conference disseminated information to all emergency physicians, summarizing current medical evidence related to the management of possible acute coronary syndrome, as well as the expectation that physicians use HEART scores as part of routine clinical care. Decision support was embedded into the electronic

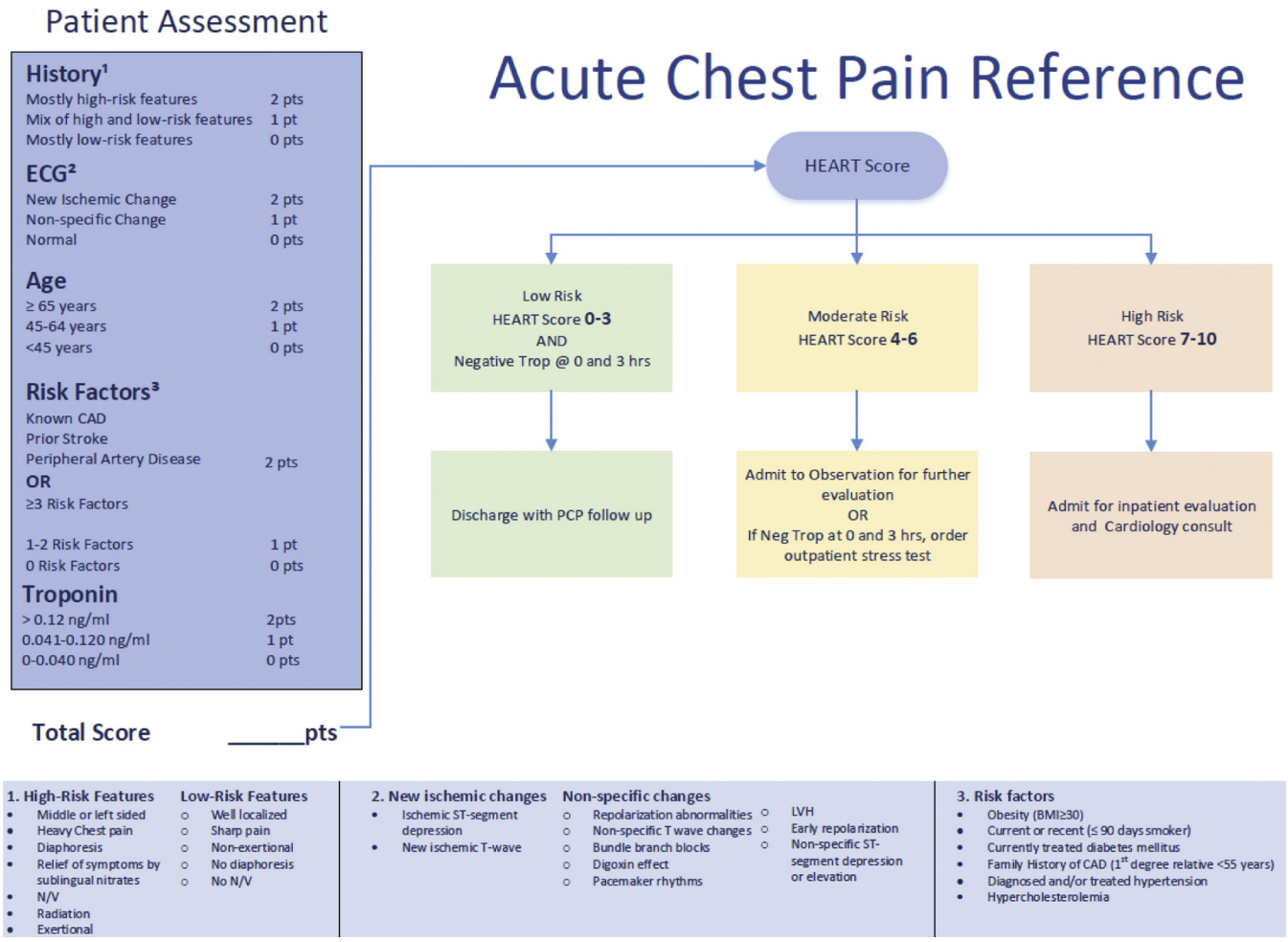

Figure 1. The HEART pathway. *CAD*, Coronary artery disease; *N/V*, nausea and vomiting; *LVH*, left ventricular hypertrophy; *BMI*, body mass index.

health record (May 2016), and prompts alerted physicians to insert the history, ECG, and risk factors necessary to calculate a HEART score. The age and troponin values were automatically included to allow an automated calculation of the HEART score.[15] Each physician and ED maintained the autonomy to document HEART, follow the recommendations, or adjust according to patient needs. There is no standard type or location of observation units nor pathway to cardiology referrals for noninvasive testing among our study sites. A formal power calculation was not performed, but it was estimated that the approximately 30,000 ED chest pain encounters before and after implementation in our 13 EDs would provide sufficient data to detect a meaningful difference in outcomes, if such a difference existed.

Methods of Measurement

Covariates included patient demographic information. Age, sex, and race data were obtained from administrative records, whereas education was proxied by the percentage of college-educated individuals at the census-block level according to a patient's home zip code. Clinical patient variables and physician data were similarly obtained by querying the structured electronic medical records. Cardiac risk factors such as hypertension and diabetes were defined with the Elixhauser index codes. The *International Classification of Diseases, Ninth Revision (ICD-9)* and *ICD-10* codes used to define dyslipidemia, coronary artery disease, stroke, percutaneous coronary intervention, and coronary artery bypass graft can be found in Appendix E1 (available online at http://www.annemergmed.com). Body mass index was measured from ED intake documentation or the most recently available visit, whereas smoking and family history of coronary artery disease were self-reported fields in electronic health records. Patients with a history of percutaneous coronary intervention or coronary artery bypass graft were considered to have had

previous coronary vascularization. The Kaiser Permanente Southern California medical center was recorded at the ED encounter.

Outcome Measures

The primary outcome was admission to the hospital, which included patients admitted under observation status, ordering of a noninvasive cardiac stress test, or both. The stress testing was defined as either an ED referral to a cardiology department for a noninvasive stress test or a direct order for stress testing during the ED encounter. The secondary outcome was 30-day acute myocardial infarction or all-cause mortality (Appendix E1, available online at http://www.annemergmed.com). We considered that any statistically significant increase in 30-day acute myocardial infarction or all-cause mortality would indicate failure and any improvement a success. We believed that a small increase (0.2%) in month-to-month hospitalizations or stress tests associated with improved acute myocardial infarction or mortality, or a small decrease (0.2%) month to month in admissions or stress testing with no association with acute myocardial infarction or mortality rates would have long-term benefits for our health system and members.

Primary Data Analysis

Continuous patient and encounter characteristics were summarized with means and SDs, whereas categoric characteristics were calculated as frequencies and percentages. Forest plots were generated for each outcome to summarize variability by medical center in the pre- and postperiod.

To assess changes in the odds of hospitalization, stress testing, or both before and after HEART implementation, we fit a generalized estimating equation segmented logistic regression model because this strategy is a favored methodology to account for secular trends while assessing an intervention's effect.[16-20] The unit of analysis was ED encounter. The model included terms for the year-long preintervention baseline monthly trend of each outcome, as well as terms for the change in level during the 4-week washout period when the intervention was implemented (May 6, 2016, to June 3, 2016) and the monthly trend in the year after the intervention was implemented. To account for known correlation among encounters for the same physician, we fit our model with physician as a clustering variable. All models were adjusted for the following characteristics: age, sex, race, medical center, college education, comorbidities expressed as Elixhauser index,[21] hypertension, diabetes, dyslipidemia, body mass index, smoking, family history of coronary artery disease, coronary artery disease, previous coronary revascularization, and stroke. Results were summarized with odds ratios (ORs) and 95% confidence intervals (CIs).

We performed several sensitivity analyses to confirm our findings. We ran models with unique patient identifiers as an alternative clustering variable to provider and found nearly identical results. Because provider and medical center were not completely independent (some providers worked at more than one medical center; N=206), we present results from the model with physician as a clustering variable, using unique provider–medical center indicators. Potential associations by medical center were assessed to identify any heterogeneity in the change in outcomes after implementation.

The change in hospitalization and stress testing associated with the intervention was graphically depicted by plotting the predicted values obtained from the model during the pre- and postimplementation periods. Furthermore, we plotted the predicted values had the intervention not occurred along with the values of the effect with HEART implementation.

The same analysis approach was used to assess changes in our secondary outcome, 30-day acute myocardial infarction or death, to analyze any potential changes pre- and postimplementation of HEART. Last, we analyzed a subset of the postintervention sample with documented HEART scores to report primary and secondary outcomes stratified by low-, moderate-, and high-risk groups.

All analyses were conducted with SAS (version 9.3; SAS Institute, Inc., Cary, NC). All tests of statistical significance were 2 sided, with α=.05. This study was approved by the Kaiser Permanente Southern California institutional review board.

RESULTS

Characteristics of Study Subjects

A total of 67,953 encounters were included in the analysis (before, 30,522; after, 34,871) (Figure 2). Table 1 shows patient characteristics from ED encounters in the pre- and postimplementation periods. The distribution of age, sex, and race was similar across periods. The mean age of the population was 58 years (before, 57.9; after, 58.0), most were women (before, 57.6%; after, 57.1%), and most were white (before, 52.3%; after, 50.9%). Body mass index varied little before and after implementation, and most patients were either overweight (33.8%) or obese (42.5%). Similar prevalence of cardiac-specific comorbidities, including coronary artery disease, previous coronary revascularization, and stroke, was observed in the pre- and

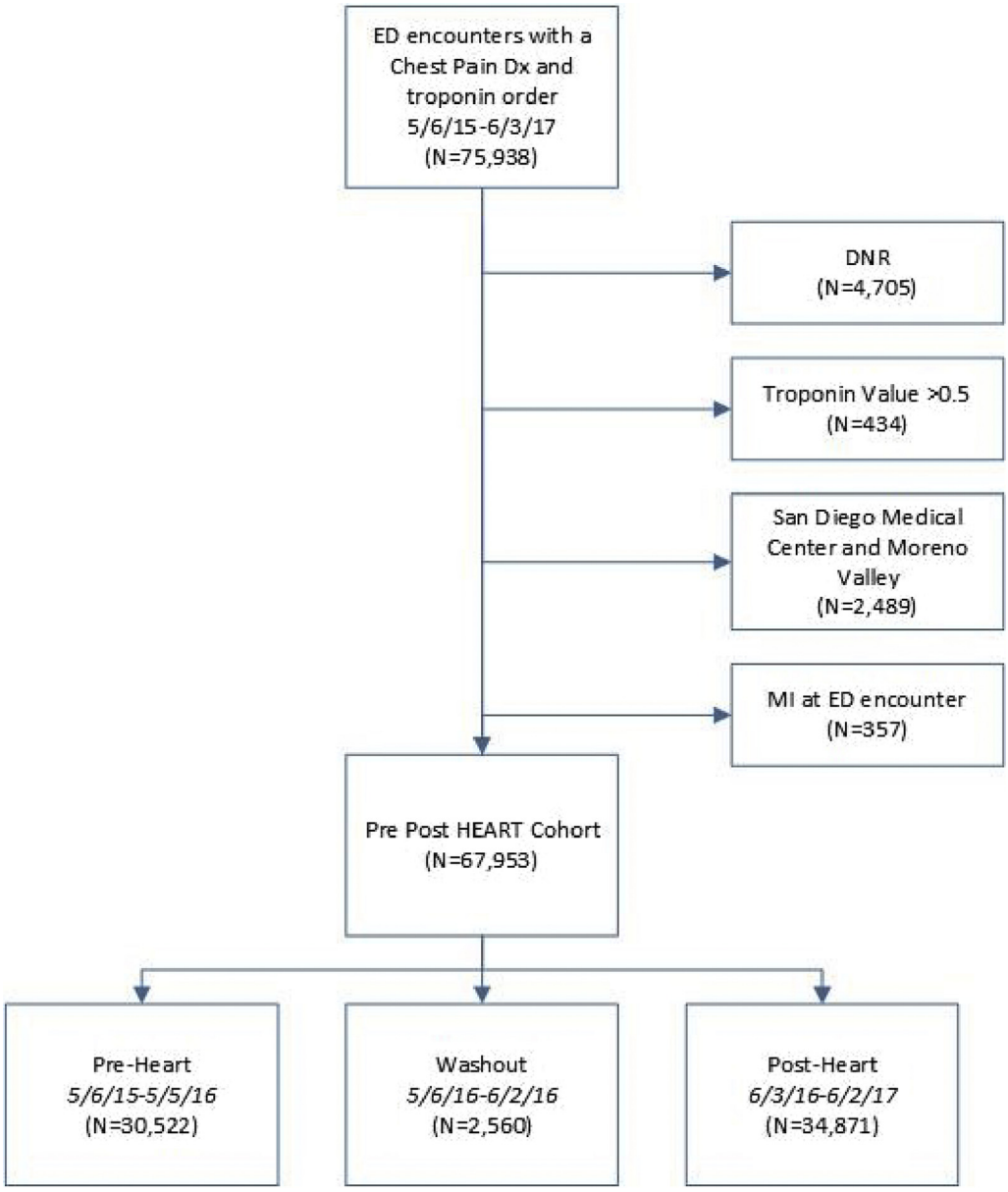

Figure 2. Flow diagram of the study cohort used for analysis. *DNR*, Do-not-resuscitate; *MI*, myocardial infarction.

postperiods (Table 1). Overall, 33.5% of encounters resulted in the primary outcome (before, 35.5%; after, 31.8%). Decreases in hospitalization or observation (14.7 [before] versus 13.2 [after]) and noninvasive stress testing (27.8% [before] versus 24.3% [after]) contributed to the overall reduction (Table 2).

Main Results

Primary analysis demonstrated a significant decrease in month-to-month trends postimplementation (OR 0.984; 95% CI 0.974 to 0.995) (Figure 3) (Table E1, available online at http://www.annemergmed.com). There was not a significant decreasing trend in the primary outcome month to month in the preperiod (OR 0.997; 95% CI 0.990 to 1.005), nor an immediate change between the end of the preperiod and the beginning of the postperiod (OR 0.968; 95% CI 0.904 to 1.036). Overall, the HEART pathway resulted in a 4.39% adjusted decrease (95% CI 3.72% to 5.07%) between expected results and the observed proportion of encounters resulting in the primary outcome after the intervention (Figure 3).

The difference in the proportion of encounters resulting in admission, stress testing, or both between the pre- and

Table 1. Characteristics of ED acute coronary syndrome encounters before HEART implementation (May 6, 2015, to May 5, 2016) and afterward (June 3, 2016, to June 2, 2017 [postintervention]).

	Patient-Level Characteristics*			Encounter-Level Characteristics		
Patient Variables	**Pre-HEART, N=27,726**	**Post-HEART, N=31,481**	**Total, N=59,207**	**Pre-HEART, N=30,522**	**Post-HEART, N=34,871**	**Total, N=65,393**
Mean age (SD), y	57.6 (16.25)	57.6 (16.29)	57.6 (16.27)	57.9 (16.29)	58.0 (16.35)	58.0 (16.32)
Female sex	16,031 (57.8)	18,053 (57.3)	34,084 (57.6)	17,569 (57.6)	19,905 (57.1)	37,474 (57.3)
Race						
Alaska Native/Pacific Islander	502 (1.8)	525 (1.7)	1,027 (1.7)	549 (1.8)	585 (1.7)	1,134 (1.7)
Asian	2,772 (10)	3,090 (9.8)	5,862 (9.9)	3,023 (9.9)	3,377 (9.7)	6,400 (9.8)
Black	4,437 (16)	4,996 (15.9)	9,433 (15.9)	5,039 (16.5)	5,753 (16.5)	10,792 (16.5)
Other	5,551 (20)	6,847 (21.7)	12,398 (20.9)	5,963 (19.5)	7,401 (21.2)	13,364 (20.4)
White	14,464 (52.2)	16,023 (50.9)	30,487 (51.5)	15,948 (52.3)	17,755 (50.9)	33,703 (51.5)
Hispanic ethnicity	10,311 (37.2)	12,060 (38.3)	22,371 (37.8)	11,282 (37.0)	13,280 (38.1)	24,562 (37.6)
Some college education,† % (SD)	57.1 (18.95)	56.6 (19.21)	56.8 (19.09)	56.9 (18.96)	56.4 (19.22)	56.6 (19.10)
Elixhauser Comorbidity Index, mean (SD)	3.8 (3.12)	3.7 (3.04)	3.7 (3.08)	4.0 (3.26)	4.0 (3.17)	4.0 (3.21)
Hypertension	15,026 (54.2)	16,827 (53.5)	31,853 (53.8)	17,127 (56.1)	19,376 (55.6)	36,503 (55.8)
Diabetes	7,432 (26.8)	8,725 (27.7)	16,157 (27.3)	8,490 (27.8)	10,108 (29)	18,598 (28.4)
High cholesterol	16,607 (59.9)	18,839 (59.8)	35,446 (59.9)	18,694 (61.2)	21,402 (61.4)	40,096 (61.3)
BMI category, kg/m^2						
Underweight <18.5	295 (1.1)	327 (1)	622 (1.1)	347 (1.1)	402 (1.2)	749 (1.1)
Normal weight 18.5–24.9	6,148 (22.2)	6,683 (21.2)	12,831 (21.7)	6,779 (22.2)	7,447 (21.4)	14,226 (21.8)
Overweight 25–29.9	9,409 (33.9)	10,671 (33.9)	20,080 (33.9)	10,338 (33.9)	11,795 (33.8)	22,133 (33.8)
Obese >30	11,663 (42.1)	13,551 (43)	25,214 (42.6)	12,845 (42.1)	14,976 (42.9)	27,821 (42.5)
Unknown	211 (0.8)	249 (0.8)	460 (0.8)	213 (0.7)	251 (0.7)	464 (0.7)
Smoking status						
Never	16,778 (60.5)	19,133 (60.8)	35,911 (60.7)	18,327 (60)	20,991 (60.2)	39,318 (60.1)
Passive	166 (0.6)	166 (0.5)	332 (0.6)	173 (0.6)	188 (0.5)	361 (0.6)
Quit	8,266 (29.8)	9,204 (29.2)	17,470 (29.5)	9,288 (30.4)	10,453 (30)	19,741 (30.2)
Active	1,836 (6.6)	2,071 (6.6)	3,907 (6.6)	2,036 (6.7)	2,317 (6.6)	4,353 (6.7)
Missing	680 (2.5)	907 (2.9)	1,587 (2.7)	698 (2.3)	922 (2.6)	1,620 (2.5)
Family history of CAD	9,118 (32.9)	10,702 (34)	19,820 (33.5)	10,187 (33.4)	12,143 (34.8)	22,330 (34.1)
CAD	5,435 (19.6)	6,187 (19.7)	11,622 (19.6)	6,711 (22)	7,770 (22.3)	14,481 (22.1)
Previous coronary revascularization	381 (1.4)	415 (1.3)	796 (1.3)	524 (1.7)	571 (1.6)	1,095 (1.7)

Data are presented as No. (%) unless otherwise indicated.
*For patients with more than one encounter in the pre- or postimplementation period, information from the first encounter was used.
†Some college education missing (patient level before=49, after=39; encounter level before=53, after=42).

postimplementation periods varied by medical center (Figure 4). Most medical centers decreased their percentage of encounters that resulted in admission or stress testing. There was no statistically significant association between the monthly time trend in either the pre- (P=.93) or postperiod (P=.34) with medical center.

Analysis of the secondary outcome (30-day acute myocardial infarction or all-cause mortality) showed no difference between pre- and postperiods (0.6% [before] versus 0.6% [after]). The adjusted analysis showed no baseline monthly trend preimplementation (OR 0.987; 95% CI 0.946 to 1.029), no initial change pre- to postimplementation (OR 1.183; 95% CI 0.782 to 1.789), and no overall change in monthly trends postimplementation (OR 1.024; 95% CI 0.967 to 1.084).

Table 2. Thirty-day outcomes of ED chest pain encounters before (May 6, 2015, to May 5, 2016) and after (June 3, 2016, to June 2, 2017) implementation of a HEART care pathway.

		Postimplementation (N=34,871)					
		HEART Score					
	Preimplementation (N=30,522)	Low (N=7,204)	Intermediate (N=4,596)	High (N=467)	Total (N=12,267)	All Post (N=34,871)	Difference Between Pre- and Postimplementation (95% CI), %
Admission or stress testing	13,828 (35.5)	1,807 (25.1)	2,353 (51.2)	323 (69.2)	4,483 (36.5)	11,092 (31.8)	−3.7 (−4.4 to −2.9)
Admission to hospital	4,480 (14.7)	172 (2.4)	983 (21.4)	270 (57.8)	1,425 (11.6)	4,592 (13.2)	−1.5 (−2 to −1)
Stress test within 30 days	8,470 (27.8)	1,734 (24.1)	1,965 (42.8)	180 (38.5)	3,879 (31.6)	8,457 (24.3)	−3.5 (−4.2 to −2.8)
Died or AMI within 30 days	171 (0.6)	12 (0.2)	27 (0.6)	12 (2.6)	51 (0.4)	225 (0.6)	0.1 (−0.0 to 0.2)

AMI, Acute myocardial infarction.
Data are presented as No. (%).

Subgroup analysis of postintervention encounters demonstrated that 35.2% of encounters (12,267 of 34,871) had documented HEART scores. The majority were low risk (58.7%) and the primary outcome increased with higher-risk HEART scores (low risk 25.1%, moderate risk 51.2%, and high risk 69.2%). Overall, patients with HEART scores had low rates of 30-day acute myocardial infarction or death (0.4%), and increasing HEART scores showed higher risks of this secondary outcome (low risk 0.2%, moderate risk 0.6%, and high risk 2.6%).

LIMITATIONS

Variables with missing data and the strategies to account for each were as follows. Patients with missing zip codes to designate college education (N=95, or 0.1% of the before/after encounters) were excluded from multivariate analyses.

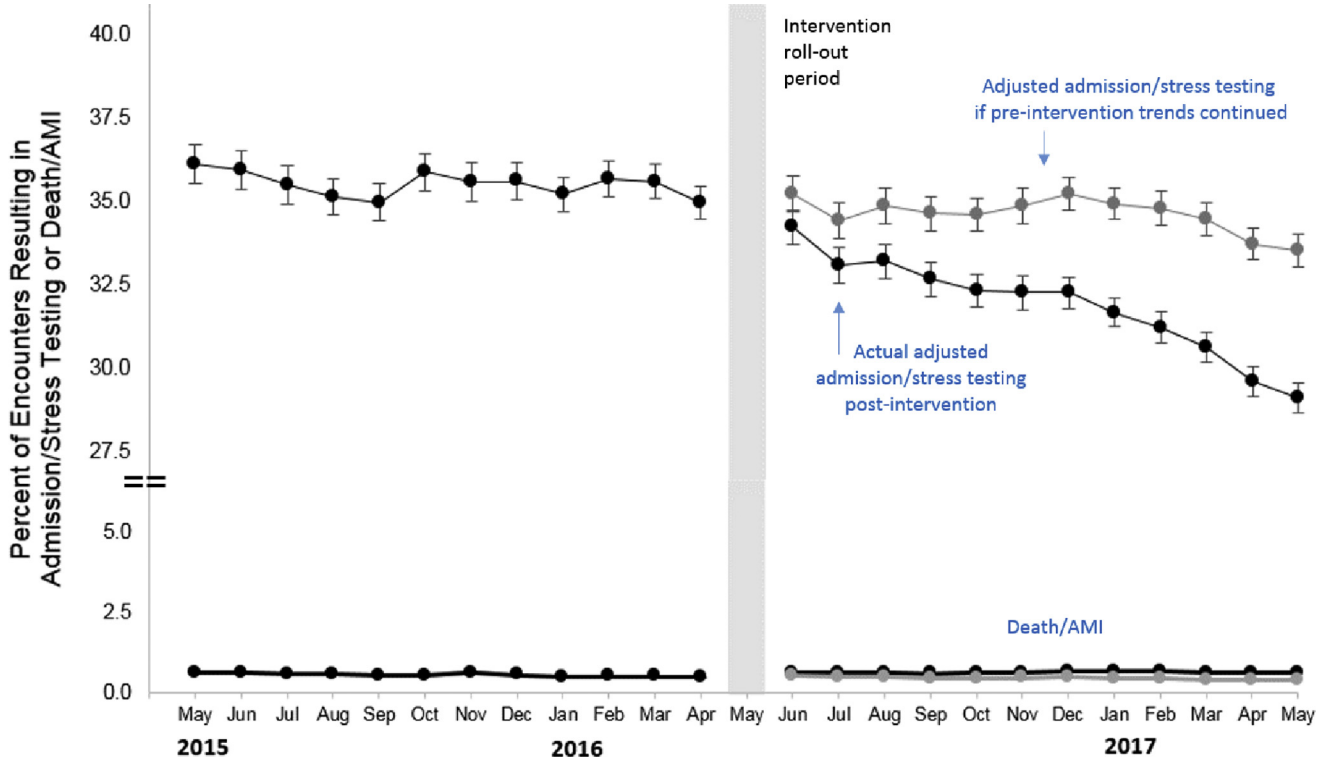

Figure 3. Adjusted interrupted time series showing the changes in pre- and postintervention month-to-month trends for ED chest pain encounters. The top black lines indicate encounters resulting in hospital admission, cardiac stress testing, or both, and the bottom black lines represent 30-day death or AMI rates. The gray lines demonstrate the predicted results had the preintervention trends continued without the HEART care pathway.

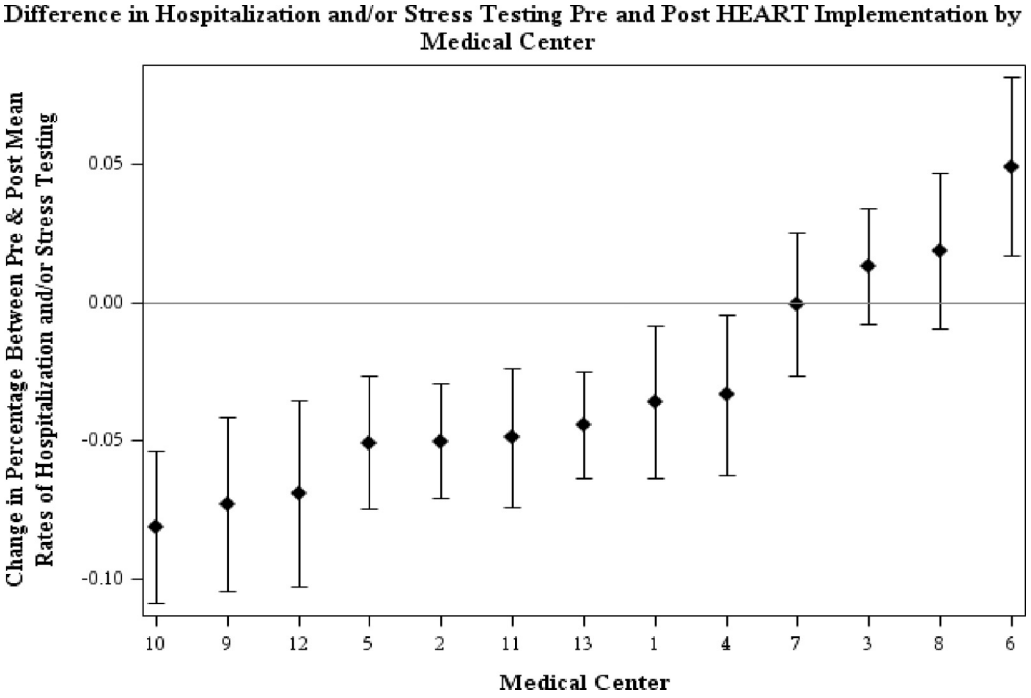

Figure 4. Changes in hospitalization or stress testing before and after a HEART care pathway was implemented at 13 EDs within an integrated health system.

In addition, 13 encounters were missing a discharge status from the ED and were excluded from the analysis for admission to the hospital or observation (N=13) and the analysis for the combined primary outcome (N=7). Categoric outcomes with missing data in the pre- or postperiods (body mass index N=464 and smoking N=1,620) were included as an "unknown" category. We acknowledge that our study population had a low rate of major adverse cardiac events; other patient populations with a higher rate of major adverse cardiac events may yield different results.

DISCUSSION

Our study found that implementation at community EDs of a care pathway using HEART to risk stratify ED patients with suspected acute coronary syndrome safely reduced downstream hospital care and noninvasive cardiac testing. Our results should influence physicians, administrators, and policymakers to consider a standardized approach to the evaluation and management of patients with chest pain or other presentations concerning for acute coronary syndrome.

These results confirm our hypothesis that standard risk stratification and clear care recommendations for low-risk patients can safely decrease hospital care and stress testing. As have other researchers, we found variability in the effect of the care pathway at each of the study sites.[3,5] Our findings are consistent with similar strategies for other clinical conditions that have demonstrated benefits of validated decision instruments and care pathways.[20] Furthermore, our study expands on the findings of a small single-site randomized controlled trial that used a similar HEART care pathway[13] but contradicts the results of the cluster-randomized trial from Dutch hospitals, which reported no change in use.[14]

Despite the overall results and improvements in use, our subgroup analysis of low-risk HEART scores demonstrated there is still ample room for improvement. In fact, we found that one ED increased hospitalizations/cardic testing after implementation of our HEART pathway despite low-risk HEART scores with 30-day major adverse cardiac event risks of 0.2%, which still resulted in hospitalization, stress testing, or both for 25% of encounters. This represents opportunities for future research and further implementation strategies to optimize patient care and resource use.

Observational quasi-experimental studies like this one cannot definitively attribute causality. However, we used an established and recommended interrupted-time-series design to account for this as much as possible.[16,17] The study was also performed in an integrated health system that may offer better coordinated outpatient follow-up than

other fee-for-service models in the United States. This may have some effect on the outcomes of ED patients after discharge and the generalizability of our findings. However, our baseline rates of hospital use are lower than national estimates (13.9% versus 16.2%),[3] which indicates that similar care pathways might have even greater opportunities to reduce this care in different settings. In fact, because our findings suggest reduced use of testing is safe for patients with low-risk chest pain, it may be especially useful in resource-constrained settings and safety-net hospitals.

In summary, implementation of HEART as a standard risk-stratification tool in the ED evaluation of patients with chest pain resulted in less inpatient care and noninvasive cardiac testing without affecting patient safety. Using a tool to standardize the ED risk stratification of chest pain patients can improve the efficiency of care safely for patients.

Supervising editor: Keith A. Marill, MD, MS. Specific detailed information about possible conflict of interest for individual editors is available at https://www.annemergmed.com/editors.

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Author contributions: ALS and BCS conceived the study. ALS drafted the article. ASB, ES, and CZ designed the analysis methods and performed data collection. All authors interpreted and analyzed the data, edited the article, and approved the final article for publication. ALS takes responsibility for the paper as a whole.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). Research reported in this publication was supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health (NIH) under award R01HL134647. Dr. Ferencik was supported by the American Heart Association Fellow-to-Faculty Award (13FTF16450001). Dr. Sun reports being a consultant for Medtronic.

Publication dates: Received for publication September 12, 2018. Revisions received December 7, 2018, and December 17, 2018. Accepted for publication December 31, 2018.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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Future Meetings of the American College of Emergency Physicians

The following are the planned sites and dates for the future annual meetings of the American College of Emergency Physicians:

October 28-31, 2019	Denver, CO
October 26-29, 2020	Dallas, TX
October 25-28, 2021	Boston, MA
October 1-4, 2022	San Francisco, CA
October 9-12, 2023	Philadelphia, PA