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External Validation of the San Francisco Syncope Rule

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Study objective: We externally validate the ability of the San Francisco Syncope Rule to accurately identify syncope patients who will experience a 7-day serious clinical event.

Methods: Patients who presented to a single academic emergency department (ED) between 8 AM and 10 PM with syncope or near-syncope were prospectively enrolled. Treating physicians recorded the presence or absence of all San Francisco Syncope Rule risk factors. Patients were contacted by telephone at 14 days for a structured interview. A 3-physician panel, blinded to the San Francisco Syncope Rule score, reviewed ED medical records, hospital records, and telephone interview forms to identify predefined serious clinical events. The primary outcome was the ability of the San Francisco Syncope Rule to predict any 7-day serious clinical event. A secondary outcome was the ability of the San Francisco Syncope Rule to predict 7-day serious clinical events that were not identified during the initial ED evaluation.

Results: Of 592 eligible patients, 477 (81%) provided informed consent. Direct telephone contact or admission/outpatient records were successfully obtained for 463 (97%) patients. There were 56 (12%) patients who had a serious 7-day clinical event, including 16 (3%) who received a diagnosis after the initial ED evaluation. Sensitivity and specificity of the San Francisco Syncope Rule for the primary outcome were 89% (95% confidence interval [CI] 81% to 97%) and 42% (95% CI 37% to 48%), respectively, and 69% (95% CI 46% to 92%) and 42% (95% CI 37% to 48%), respectively, for the secondary outcome. Estimates of sensitivity were minimally affected by missing data and most optimistic assumptions for missing follow-up information.

Conclusion: In this external validation cohort, the San Francisco Syncope Rule had a lower sensitivity and specificity than in previous reports. [Ann Emerg Med. 2007;49:420-427.]

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INTRODUCTION

Background and Importance

Syncope, defined as a transient loss of consciousness, may herald life-threatening events. As a result, patients presenting with syncope to emergency departments (EDs) are frequently hospitalized. Syncope accounts for 1% to 3% of all ED visits and hospital admissions from the ED.¹⁻⁷ Unfortunately, current admission practices result in marginal diagnostic and therapeutic benefit^{8,9} and consume enormous health care resources. Between 39% and 50% of admitted patients are discharged without an

explanation for syncope,^{4,10} and syncope-related admissions in the United States account for \$2.4 billion in annual health care costs.¹¹

The San Francisco Syncope Rule is an instrument designed to identify patients with syncope or near-syncope who are at low risk of a short-term, serious clinical event.^{12,13} Low-risk patients can potentially be discharged for an outpatient evaluation of syncope. The San Francisco Syncope Rule predictors include an abnormal ECG result, complaint of shortness of breath, hematocrit level less than 30%, systolic blood pressure less than 90 mm Hg, and a history of congestive heart failure.

Editor's Capsule Summary

What is already known on this topic

The San Francisco Syncope Rule was developed to identify emergency department (ED) syncope patients who are at low risk for adverse events within the succeeding 7 days. In initial derivation and validation studies, the San Francisco Syncope Rule was found to have a sensitivity of 96% to 98%.

What question this study addressed

Does the San Francisco Syncope Rule perform comparably in a similar sample of patients from a different ED?

What this study adds to our knowledge

The sensitivity of the San Francisco Syncope Rule was 89%. It is unclear whether the lower sensitivity represents different performance of the rule, different application of the rule, or random variation.

How this might change clinical practice

These results suggest that the San Francisco Syncope Rule requires further external validation before being adopted into general ED use.

In a derivation study, outcomes included any predefined clinical events within 7 days; the San Francisco Syncope Rule demonstrated 96% sensitivity (95% confidence interval [CI] 92% to 100%) and 62% specificity (95% CI 58% to 66%).¹² In a validation study, outcomes included 30-day predefined events that were diagnosed after the ED visit; the San Francisco Syncope Rule demonstrated 98% sensitivity (95% CI 89% to 100%) and 56% specificity (95% CI 52% to 60%).¹³ These studies suggest that application of the San Francisco Syncope Rule may safely decrease syncope-related admissions by 7% to 10%.

Goals of This Investigation

The published San Francisco Syncope Rule derivation and validation studies have been performed at the same institution. Our goal was to evaluate the accuracy of the San Francisco Syncope Rule to identify "low-risk" patients in an independent, prospective validation sample. The primary outcome included all 7-day serious clinical events. The secondary outcome included 7-day serious clinical events that were diagnosed only after the index ED visit. Analysis of the secondary outcome is important because there is little clinical utility in "predicting" serious conditions that are evident at the ED evaluation.

MATERIALS AND METHODS

Study Design and Setting

This was a single-center, prospective, observational, cohort study that enrolled patients from April 18, 2005, to April 18,

2006. The study site is an urban, academic, Level I trauma center with an emergency medicine residency and an annual volume of 40,000 visits. The study site institutional review board approved the research protocol.

Selection of Participants

Adult patients with a complaint of syncope or near-syncope were eligible for enrollment. Syncope is defined as a sudden, transient loss of consciousness. Near-syncope is defined as a sensation of imminent loss of consciousness, without actual syncope. The treating resident or attending physician determined patient eligibility for study enrollment.

Exclusion criteria included loss of consciousness related to a witnessed seizure, loss of consciousness after head trauma, ongoing confusion (including baseline cognitive impairment or dementia), intoxication, age younger than 18 years, inability to speak English or Spanish, do-not-resuscitate (DNR) or do-not-intubate (DNI) status, and lack of follow-up contact information.

An ED-based research assistant was available from 8 AM to 10 PM, 7 days a week. Research assistants identified all potentially eligible patients by reviewing the ED intake log and querying the charge nurse, attending physicians, and resident physicians as they were evaluating active ED patients. A research assistant explained the goals of the study to eligible patients and obtained informed consent for enrollment. Retrospective internal quality checks, including medical record review and ED intake log review, demonstrated that 76% of eligible patients were identified and screened. There were no differences in age and sex among potentially eligible patients who were screened and those who were not screened.

All elements of the San Francisco Syncope Rule were collected prospectively. For each enrolled patient, the treating resident emergency physician completed a structured data form about that patient's clinical presentation (Appendix E1 available online at <http://www.annemergmed.com>). Presence of shortness of breath, history of congestive heart failure, or abnormal ECG result was obtained from the physician structured data form. For shortness of breath and history of congestive heart failure, the treating physician could record "yes," "no," or "unknown." The ECG was considered abnormal if the treating physician noted it to show any rhythm other than sinus, any bundle-branch block, left-axis deviation, mono- or biventricular hypertrophy, any abnormal conduction interval except for first-degree atrioventricular block, any Q/ST/T change consistent with ischemia (acute or chronic), or isolated, nonspecific ST/T abnormalities. A research assistant verified completeness of data forms and abstracted triage systolic blood pressure from nursing notes. Hematocrit values were obtained from a computerized laboratory reporting system. Information about age, sex, race, and ethnicity were obtained from administrative data.

The clinical evaluation data forms were completed by emergency medicine residents with 2 to 4 years of experience. To assess the interrater reliability of clinical predictors and to assess San Francisco Syncope Rule accuracy as a function of

clinician experience, the attending emergency physician independently completed a second data form in a convenience sample of patients. The research assistant requested that the attending physician complete a second form for all patients; however, attending physicians were occasionally unable to complete the form because of other clinical responsibilities. Attending and resident physicians were trained in the completion of the data forms in 1 session before and 1 session after initiation of the study. Physicians were instructed to treat and admit patients in their usual manner, without any specific study intervention or testing.

For patients who did not receive ECG testing as part of routine care, a research assistant obtained patient permission to perform a study ECG. Study ECGs were immediately sealed, were not available to treating physicians, and were interpreted later by a study investigator (B.C.S.) who was blinded to other information about the patient's presentation. Hematocrit testing was performed at the discretion of treating physicians, and we did not collect hematocrit data if this test was not ordered as part of routine care.

The primary outcome included all 7-day predefined serious clinical events. The secondary outcome included 7-day serious clinical events that were diagnosed only after the initial ED evaluation.

Predefined outcomes included death, myocardial infarction, arrhythmias, pulmonary embolism, stroke or transient ischemic attack, subarachnoid or nontraumatic cerebral hemorrhage, aortic dissection, new diagnosis of structural heart disease thought to be related to syncope, and significant hemorrhage or anemia requiring blood transfusion. Explicit criteria were used to identify outcomes (Appendix E2, available online at <http://www.annemergmed.com>). Any patient who was discharged from the ED or hospital after an episode of syncope and then readmitted for similar symptoms related to the initial event was considered to have a serious outcome. Admitted patients who required a predefined acute intervention during their stay were also considered to have a serious outcome. An acute intervention was defined as a procedure required to treat a condition related to a patient's symptoms of syncope, including pacemaker insertion, coronary angioplasty, surgery for valvular heart disease, balloon pump insertion, use of vasopressors, surgery to treat an abdominal aortic aneurysm surgery for ruptured spleen, surgery for ruptured ectopic pregnancy, and endoscopic treatment of esophageal varices. Our outcomes definitions are consistent with those used by the San Francisco Syncope Rule investigators,^{12,13} and the outcomes period is consistent with that of the original derivation study.¹²

Outcomes Measurement

Direct patient telephone follow-up was performed to identify admissions or serious clinical events that occurred outside the study site. We attempted to contact all patients at 14 days after the index ED visit for a structured telephone interview by a research assistant (Appendix E3, available online at <http://www.annemergmed.com>). Inpatient records and

discharge summaries were obtained for all patients transferred from the study site ED to other hospitals for admission.

Two emergency physicians independently reviewed available ED documentation, inpatient records, and telephone interview forms for all enrolled patients. Records for all patients identified as potentially experiencing a serious outcome were then reviewed by a panel of 3 emergency physicians. All reviewing physicians were blinded to the structured data forms completed by treating physicians. Occurrence and timing of the predefined, serious clinical events were determined through panel consensus and recorded on a structured data form (Appendix E4, available online at <http://www.annemergmed.com>).

According to published data, we assumed that the San Francisco Syncope Rule would have a sensitivity of 98%.^{12,13} Power analyses suggested that approximately 50 enrolled patients with the primary outcome would be required to achieve a 95% CI width of 10%.

Primary Data Analysis

We performed descriptive analysis of baseline patient characteristics stratified by occurrence of a serious outcome. Between-group differences and CIs in characteristics were estimated using Wilson estimates for binomial variables. The κ statistic was used to assess the interrater reliability of clinical predictors.

In the base case analysis, we analyzed all patients who either had the presence of at least 1 of the 5 high-risk predictors (because these patients were classified as "at risk" regardless of missing data on other predictors) or who had complete data on all 5 predictors recorded on the form (completed by a resident physician). For shortness of breath and history of congestive heart failure, we treated a response of "unknown" as missing data. ECG data were considered missing if an ECG was not ordered by the treating physician and a study ECG was not performed. Hematocrit data were considered missing if this test was not ordered by the treating physician. We determined sensitivity, specificity, negative predictive value, and positive predictive value of the San Francisco Syncope Rule to identify patients with all 7-day outcomes, as well as 7-day outcomes that were diagnosed after the initial ED evaluation. In this base case subgroup, we compared the San Francisco Syncope Rule test characteristics with physician judgment, which we defined as the treating physicians' decision to hospitalize the patient.

Sensitivity Analyses

We performed sensitivity analyses to assess the impact of missing data. We estimated the upper bounds of sensitivity by assuming that all missing data represented the presence of a predictor. To estimate the upper bounds of specificity, we assumed that all missing data represented the absence of a predictor. We compared the results of these sensitivity analyses against the treating physician's judgment in the entire study cohort.

Table 1. Study population characteristics.*

Characteristic	All Patients (n=477), %	No Serious Event (n=421), %	7-Day Serious Event (n=56), %	Difference Between Groups (95% CI), % [†]
Age, median, y (IQR)	58 (35, 79)	55 (32, 78)	76 (60, 85)	
<40	30	33	7	24 (9 to 40)
40-59	23	24	18	5 (-7 to 17)
60-79	24	22	38	-15 (-26 to -5)
>80	21	21	38	-17 (-27 to -7)
Male	44	41	66	-24 (-35 to -13)
Hispanic	10	10	11	-2 (-10 to 6)
Race				
White	77	76	86	-8 (-18 to 1)
Black	9	10	4	5 (-4 to 13)
Asian	11	11	11	-1 (-10 to 7)
Other	3	3	0	2 (-3 to 7)
Disposition				
Admitted	51	45	93	-46 (-54 to -39)
Transferred	7	7	7	-1 (-8 to 6)
Discharged	40	45	0	44 (25 to 62)
Left against medical advice	2	2	0	1 (-4 to 5)
SFSR predictors				
Abnormal ECG	37	32	73	-41 (-50 to -32)
Shortness of breath	12	11	20	-10 (-18 to -2)
Hematocrit <30	6	4	15	-12 (-17 to -8)
SBP <90 mm Hg	5	5	9	-5 (-11 to 1)
History of CHF	8	7	16	-10 (-17 to -3)
Any SFSR predictor	46	41	89	-46 (-53 to -38)

IQR, Interquartile range; SBP, systolic blood pressure; CHF, congestive heart failure; SFSR, San Francisco Syncope Rule.

*Subgroups may not add to exactly 100% because values are rounded to the nearest integer.

[†]Represents group difference of (no serious event)-(serious event); point estimates are based on Wilson estimates and may not be exactly the same as the absolute difference of group proportions.

We also assessed the potential impact of missing follow-up information, again in a manner that would estimate the maximal sensitivity and specificity of the San Francisco Syncope Rule. We made the following assumptions for patients without follow-up information: (1) for patients with at least 1 San Francisco Syncope Rule high-risk predictor or who had complete data on all San Francisco Syncope Rule predictors, we assumed that the patient experienced the outcome predicted by the San Francisco Syncope Rule; and (2) for patients with missing data on the San Francisco Syncope Rule predictors and who did not have at least 1 San Francisco Syncope Rule high-risk predictor, we assumed that the patient was classified as low risk by the San Francisco Syncope Rule and did not experience any serious clinical event. In a separate analysis to estimate the lower bounds of sensitivity and specificity caused by missing follow-up information, we made the following assumption for patients without follow-up: (1) for patients with at least 1 San Francisco Syncope Rule predictor, we assumed that the patient did not experience a serious outcome; and (2) for patients who did not have any of the San Francisco Syncope Rule predictors, we assumed that the patient did experience a serious outcome.

Finally, we assessed whether San Francisco Syncope Rule test characteristics were dependent on the clinical experience of the treating physician. We repeated the analysis described above

using clinical evaluation data completed by attending physicians.

Data management and statistical analyses were conducted using SAS software, version 8.02 (SAS Institute Inc., Cary, NC). Test characteristics and associated 95% CIs were calculated using a publicly available SAS macro.¹⁴

RESULTS

Of the 709 patients who were screened during the study period, 592 (83%) were eligible, and 477 (81%) provided informed consent to participate. We found no important differences in age, sex, race, or ethnicity between eligible patients who provided or declined informed consent. Direct telephone follow-up was obtained in 436 patients (91%). Of the remaining 41 patients, 27 (6% of the entire cohort) had available inpatient or outpatient data for at least 2 weeks after the date of enrollment, and 14 (3%) had no available follow-up information. Patients without any available follow-up information were younger and more likely to be of nonwhite race compared with patients with follow-up information.

Study sample characteristics are presented in Table 1. Of the overall cohort, 58% were admitted or transferred to another hospital. Blood pressure data were available for all patients, and data were missing in less than 1.5% of patients for presence of

Table 2. Seven-day serious clinical events.*

Type of Event [†]	All 7-Day Events No. (%)	"Delayed" 7-Day Events No. (%)
Arrhythmia	32 (57)	7 (44)
Hemorrhage/anemia	8 (14)	0
Structural heart disease	6 (11)	3 (19)
Stroke/TIA	2 (4)	2 (13)
Pacemaker placement	2 (4)	2 (13)
PTCA	2 (4)	2 (13)
Myocardial infarction	1 (2)	0
Pulmonary embolism	1 (2)	0
Cerebral hemorrhage	1 (2)	0
Aortic dissection	1 (2)	0
Total	56	16

*Some patients experienced more than 1 event; this table classifies patients by the first clinically observed event.

[†]Denominator is total number of patients experiencing an event; columns may not add to exactly 100% because values are rounded to the nearest integer.

Table 3. Interobserver agreement for shortness of breath and abnormal ECG.

Predictor	Subgroup No.	Percentage Agreement	κ (95% CI)
Shortness of breath	288	90	0.5 (0.3–0.6)
Abnormal ECG	241	75	0.5 (0.4–0.6)
Any high-risk predictor*	225	85	0.6 (0.5–0.7)

*Observations were dropped if either rater did not complete all elements of the SFSR and no abnormal findings were present.

shortness of breath ($n=7$) or history of congestive heart failure ($n=6$). Less than 7% of patients did not receive an ECG as part of routine care and refused a study ECG ($n=33$). Finally, 32% of patients did not receive hematocrit testing as part of routine care ($n=153$).

The proportion of patients with any 7-day serious clinical event was 11.7% (56 of 477 patients), and the proportion of patients with a 7-day serious clinical event that was diagnosed only after the index ED visit was 3.4% (16 of 477 patients). Serious clinical events are described in Table 2.

Second rater evaluation forms were completed by an attending physician in a convenience sample of 307 patients. Interrater reliability for presence of shortness of breath, abnormal ECG, and presence of any San Francisco Syncope Rule predictor was modest (Table 3).

Table 4 presents the test characteristics of the San Francisco Syncope Rule under various assumptions. In the base case analysis, a decision by the managing physicians to admit the patient was 100% sensitive and 30% specific for all 7-day outcomes. The point estimates for San Francisco Syncope Rule sensitivity were 89% for any 7-day serious event and 69% for a 7-day serious event that was diagnosed only after the initial ED visit. If patients without San Francisco Syncope Rule risk factors were discharged and all others admitted, hospitalizations would have decreased in the base case subgroup by 12%, but at the

price of having discharged 5 patients (10% of primary outcomes) who would have subsequently been diagnosed with a serious event.

Estimates of sensitivity were minimally affected by missing data on the San Francisco Syncope Rule predictors, whereas estimates of specificity depended on how missing data were handled. San Francisco Syncope Rule test characteristics were minimally affected by missing follow-up information when the most optimistic assumptions were used. Point estimates for sensitivity and specificity were lower when elements of the San Francisco Syncope Rule were calculated from forms completed by an attending physician. The Figure describes patients who were misclassified as "low risk" by the San Francisco Syncope Rule in the base case analysis.

LIMITATIONS

We performed a prospective cohort study designed to minimize missing data bias and maximize direct patient follow-up with a standardized protocol. Nevertheless, there are potential limitations to our study.

We excluded children, patients with DNR/DNI status, and patients without follow-up contact information, whereas these were not exclusion criteria used by the San Francisco Syncope Rule investigators. It is possible that the San Francisco Syncope Rule demonstrated different test characteristics in these patients.

We did not enroll patients between 10 PM and 8 AM, for logistic reasons, and this may be a source of selection bias. We did not detect age or sex differences between eligible patients during study hours and patients with a chief complaint of "syncope" who presented after study hours, although we did not have data to perform a more detailed analysis of differences between the 2 groups. However, we have no reason to believe that the San Francisco Syncope Rule would have different test characteristics in patients who present between 10 PM and 8 AM.

We successfully screened 76% of potentially eligible patients during study hours. Most of the potentially eligible patients who were not screened were missed because of research assistant unavailability (eg, multiple patients requiring screening at the same time, or gaps in research assistant coverage schedule). Although we did not find a difference in age and sex between potentially eligible patients who were screened and those who were not, this may be a source of selection bias.

We collected data on triage blood pressure and did not have data on other recorded blood pressure measurements during the ED visit. Clinicians may be influenced by the lowest measured blood pressure value, and future studies should explore the importance of serial blood pressure measurements.

ECG and hematocrit testing were not available in 7% and 32% of enrolled patients, respectively. Of patients with a 7-day serious outcome, all but 1 patient received an ECG, and all received hematocrit testing. A 21-year-old man diagnosed with upper gastrointestinal bleeding and a hematocrit level of 22% did not receive ECG testing. Thus, such missing data could not substantially affect our estimates of sensitivity, whereas it tends to provide an upwardly biased estimate of specificity because of

Table 4. San Francisco Syncope Rule test characteristics with likelihood ratios.

Assumption	No.	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)	Likelihood Ratio Positive	Likelihood Ratio Negative
All 7-day serious outcomes							
Physician decision to admit, base case*	351	100 (94–100)	30 (25–35)	21 (16–26)	100 (96–100)	1.4	0
SFSR base case*	351	89 (81–97)	42 (37–48)	22 (17–28)	95 (92–99)	1.5	0.3
Physician decision to admit, all patients	477	100 (94–100)	47 (42–51)	20 (19–25)	100 (98–100)	1.9	0
SFSR missing predictors set to “present”	477	89 (81–97)	30 (25–34)	15 (11–18)	95 (92–99)	1.3	0.4
SFSR missing predictors set to “absent”	477	88 (79–96)	59 (55–64)	22 (17–28)	97 (95–99)	2.1	0.2
“Delayed” 7-day serious outcomes (exclude 40 patients with serious events diagnosed during ED evaluation)							
SFSR base case*	311	69 (46–92)	42 (37–48)	6 (3–10)	96 (93–100)	1.2	0.7
SFSR missing predictors set to “present”	437	69 (46–92)	30 (25–34)	4 (2–6)	96 (93–99)	1.0	1.0
SFSR missing predictors set to “absent”	437	69 (46–92)	59 (55–64)	6 (3–10)	98 (96–100)	1.7	0.5
All 7-day serious outcomes, best case assumptions for missing follow-up information[†]							
SFSR base case*	361	90 (83–98)	45 (40–51)	26 (20–32)	96 (92–99)	1.6	0.2
All 7-day serious outcomes, worst case assumptions for missing follow-up information[†]							
SFSR base case*	361	75 (63–84)	42 (36–48)	22 (17–29)	88 (81–93)	1.3	0.6
All 7-day serious outcomes, resident and attending evaluations available							
SFSR base case, attending physicians*	206	81 (69–94)	32 (25–39)	20 (14–27)	89 (81–97)	1.2	0.6
SFSR base case, residents*	206	89 (79–99)	40 (32–47)	25 (17–32)	94 (89,100)	1.5	0.3

*Includes patients for whom an SFSR score could be calculated.

[†]See Materials and Methods section for description of assumptions.

- 63M who developed ventricular tachyarrhythmia and bradyarrhythmia on hospital day 2
No inducible ventricular tachycardia on electrophysiology study
- 84F diagnosed with clinically significant hypertrophic obstructive cardiomyopathy on hospital day 3; began receiving β -blockers
- 80F diagnosed with acute brain infarct on MRI on hospital day 2, no neurologic deficits noted by multiple examiners
- 93F who developed ventricular tachycardia on hospital day 2; patient made DNR, with no further testing or interventions
- 80F diagnosed during ED evaluation with cerebral hemorrhage, thought to precede syncope by admitting and neurology teams
- 51M, who developed supraventricular tachycardia responsive to adenosine on hospital day 2; discharged receiving β -blockers

Figure. Patients misclassified as “low risk” in the base case analysis.

the potential for false-positive test results, which is supported by results of our preplanned sensitivity analysis assessing the effects of missing data.

Our definition of an abnormal ECG was slightly different from that used by the San Francisco Syncope Rule investigators. The San Francisco Syncope Rule derivation study considered an ECG with new changes to be abnormal. We did not have uniform data on past ECGs on enrolled

patients; therefore, any predefined findings on ECG were considered abnormal, regardless of past ECG testing. Therefore, our estimates of sensitivity are likely to be biased upward and specificity downward because of this measurement difference, although the effect size of this variation is likely minimal.

We used outcomes as defined by the original San Francisco Syncope Rule derivation study, including all 7-day predefined, serious clinical events.¹² In their validation study, however, the San Francisco Syncope Rule investigators used a different outcomes definition, which included 30-day serious clinical events that were diagnosed after the initial ED presentation.¹³ In pilot work, we found an unacceptable decrease in telephone interview response rate when the follow-up period was extended from 14 to 30 days. Therefore, we cannot assess the exact outcome used in the validation study reported by the San Francisco Syncope Rule validation study. In post hoc analysis to assess the impact of measuring a longer period, however, we found no qualitative differences in San Francisco Syncope Rule sensitivity estimates when we used a 14-day period for all serious events, as well as events that were diagnosed after the initial ED visit.

This was a single-center study, and it is possible that the San Francisco Syncope Rule demonstrates different test characteristics when applied by physicians at other institutions. Finally, we observed a relatively small number of serious events in our study cohort, and a larger study with more outcomes would provide narrower 95% CIs for estimates of San Francisco Syncope Rule sensitivity and specificity.

DISCUSSION

We performed a prospective cohort study to externally validate the San Francisco Syncope Rule. Study strengths

include a protocol to minimize missing ECG data, high rates of direct patient follow-up, a physician outcomes review panel that was blinded to data recorded by treating physicians, and explicit methods for assessing the effects of missing data on San Francisco Syncope Rule predictors and missing follow-up information. At our institution, physician application of the San Francisco Syncope Rule demonstrated lower sensitivity and specificity than previously reported.^{12,13} In particular, the San Francisco Syncope Rule demonstrated poor sensitivity for identifying patients with a serious event that was first diagnosed after the initial ED visit. Estimates of sensitivity were minimally affected by missing ECG and hematocrit data, whereas estimates of specificity depended on how missing data were analyzed. Test characteristics were minimally affected by missing follow-up information under the most optimistic assumptions. Treating physicians admitted all patients who developed a 7-day serious event. Application of the San Francisco Syncope Rule in this study cohort could have reduced hospitalizations by 12%, but at the price of missing 10% of patients with a 7-day serious outcome.

Two previous syncope risk prediction instruments focused on 1-year outcomes, including death or arrhythmias.^{15,16} Risk prediction for 1-year outcomes, however, is unlikely to be helpful for ED decisionmaking about whether to acutely hospitalize a patient. A recent study reported a risk score for predicting arrhythmias in patients with unexplained syncope, although the study entry criteria required research physician evaluation and did not specify when outcomes occurred.¹⁷

The San Francisco Syncope Rule represents a potentially important advance in syncope risk stratification for emergency physicians because of its focus on short-term serious events for which hospitalization may be beneficial. The San Francisco Syncope Rule investigators have reported the results of a derivation and validation study. The derivation study included 684 enrolled patients, and 79 (11.5%) experienced a 7-day serious event. The San Francisco Syncope Rule demonstrated 96% sensitivity (95% CI 92% to 100%) and 62% specificity (95% CI 58% to 66%). The proportion of patients with a serious event that was diagnosed after the initial ED evaluation was not reported for the derivation study. The validation study included 791 patients, and 54 (6.8%) experienced a 30-day serious event after their initial ED visit. The San Francisco Syncope Rule demonstrated 98% sensitivity (95% CI 89% to 100%) and 56% specificity (95% CI 52% to 60%) in the validation study. ECG and hematocrit testing, 2 of the San Francisco Syncope Rule predictors, were not mandatory in either the San Francisco Syncope Rule derivation or validation study, and it is unclear how frequently these tests were ordered and how missing data affected the reported results.

The lower sensitivity and specificity of the San Francisco Syncope Rule noted in our study may have several explanations. First, physicians at our site may be unskilled in applying the San Francisco Syncope Rule criteria. The criteria are relatively simple, however, and we did provide 2 training sessions to train

study site physicians in the completion of the data form. We did not find that the San Francisco Syncope Rule test characteristics improved when applied by attending physicians compared to resident physicians. Second, it is possible that San Francisco Syncope Rule accuracy varies by patient population. Our study site is an academic, tertiary-care referral center that treats many patients with complex medical conditions. However, the San Francisco Syncope Rule was derived and validated at a center with similar characteristics. Third, because of the relatively small number of patients who experienced a serious event in our study, there are fairly wide CIs around our point estimates for sensitivity and specificity. CIs for sensitivity overlap from our study and the San Francisco Syncope Rule derivation and validation reports. However, our findings suggest that the San Francisco Syncope Rule may require further validation before safe clinical application.

We propose the following recommendations for future syncope risk stratification research. First, research should focus on short-term serious events that are diagnosed after the initial ED visit. In our cohort, internal hemorrhage and anemia were always diagnosed in the ED, whereas undeclared outcomes included only cardiac and neurologic events. Narrowing the scope of outcomes may result in a more accurate and clinically intuitive prediction instrument.

Second, future studies should include sufficient numbers of serious events to allow for robust multivariate risk prediction analysis. Because the rate of delayed serious events is low (approximately 3% at 7 days in our study), an adequately powered study may require thousands of patients.

Finally, older patients (age >60 years) accounted for the majority of serious events in our cohort, as well as the majority of serious outcomes missed by the San Francisco Syncope Rule. Although other investigators have found age to be a powerful predictor of syncope-related adverse events,¹⁵⁻²⁰ the San Francisco Syncope Rule does not include age as a risk factor. The importance of age as a risk predictor should be reevaluated in future studies. An ideal study setting for further risk stratification research would be a large, population-based, closed-cohort system, with older patients accounting for a high proportion of syncope-related ED visits.

In summary, we performed an external validation study of the San Francisco Syncope Rule. In our cohort, the San Francisco Syncope Rule displayed lower sensitivity and specificity for 7-day serious events than previously reported. Point estimates of sensitivity were minimally affected by missing data. Test characteristics were minimally affected by missing follow-up information under the most optimistic assumptions. Our results suggest that further validation studies should be performed before widespread implementation of the San Francisco Syncope Rule.

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Appendix E1. Data Collection Form*

HISTORY OF PRESENT ILLNESS: Current syncopal episode:

Associated with shortness of breath Yes No Unknown

PAST MEDICAL HISTORY:

Congestive heart failure Yes No Unknown

ECG :

ECG performed as part of routine care ECG not performed as part of routine care

ECG Interpretation (If sealed study ECG, leave this section blank and do not unseal ECG):

Normal: includes sinus tachycardia, first degree block, sinus bradycardia > 50, premature atrial contractions

Isolated, nonspecific ST/T abnormalities

Abnormal. Check all the following that apply:

Non-sinus rhythms Bundle branch block Left axis deviation LVH/RVH

Abnormal conduction intervals excluding first degree block

Q/ST/T changes consistent with acute or chronic ischemia

Other- describe: _____

*This is an abbreviated version of the data collection form that includes variables relevant for this report.

Appendix E2. Explicit Criteria for Outcomes.

Arrhythmia

- Ventricular tachycardia >3 beats
- Sick sinus disease, with alternating sinus bradycardia and tachycardia
- Sinus pause >3 s
- Third-degree atrioventricular block
- Mobitz II atrioventricular block
- Symptomatic supraventricular tachycardia (pulse rate >100 beats/min)
- Symptomatic atrial flutter or fibrillation with rapid ventricular response (pulse rate >100 beats/min)
- Symptomatic bradycardia (pulse rate <60 beats/min), OR pulse rate <40.
- “Symptomatic” refers to the simultaneous occurrence of dizziness, lightheadedness, hypotension (systolic blood pressure <90), or syncope with an arrhythmia on ECG monitoring.

Myocardial Infarction

- Requires increase of troponin or ECG change AND
- Documentation that cardiology consultation concurs with diagnosis of myocardial infarction

Stroke/TIA

- Documentation that neurology consultation concurs with diagnosis of stroke/TIA

Pulmonary Embolism

- Requires confirmatory testing (high-probability VQ scan, chest CTA, pulmonary angiography, or new deep vein thrombosis noted on duplex ultrasonography WITH an abnormal VQ scan OR abnormal chest CTA OR abnormal pulmonary angiography)

Aortic Dissection

- Requires confirmatory testing (chest CT, transesophageal echocardiogram, MRI, or angiography)

Subarachnoid or Intracranial Hemorrhage (Nontraumatic)

- Requires that neurology or neurosurgical consultation concur with diagnosis

Internal Hemorrhage/Anemia Requiring Transfusion

- Any source of bleeding (GI, vaginal, ruptured AAA) or anemia requiring blood transfusion (includes patients who refuse recommended transfusion, eg, Jehovah's witnesses)
-

Appendix E3. Contact script for telephone interview.

Hello, Mr./Mrs. _____, my name is _____. I work with Dr. XXXXXXXX at XXXXXXXX Emergency Medicine Center. You have previously agreed to participate in our survey when you were seen on _____ (date of enrollment) at the XXXXXXXX Medical Center Emergency Department. Please know that it is your right to decline to participate in this study for any reason, at any time. In addition, whether you decide to participate or not will not affect any aspect of your medical care.

Would you like to take part in this final portion of the study?
Do you have any questions or concerns I can address for you about the study?

If study participant answers affirmatively to participation, then request study related questions as follows:

Did you return to the hospital or were you seen by a healthcare provider after discharge from the XXXXXXXX Medical Center?

Yes No Patient died

(If **no**: "Thank you for your time. Good bye.")

Were you admitted to a hospital?
(explain): _____

Yes No Unknown

If you were admitted, which hospital
were you admitted to? _____

When were you admitted? _____

Have you received any medical procedures since your visit to the emergency department (for example, heart catheterization, heart surgery, pacemaker placement, colonoscopy)?

Yes No

If yes, what procedure: _____
Where was the procedure performed? _____

Have you had any new medication started or medications changed since your visit to the emergency department (for example, heart medications, blood thinners, antibiotics)?

Yes No

If yes, please describe: _____

Who is the physician who recommended the medication? _____

What institution is that physician affiliated with? _____

"Thank you so much for your participation."

Appendix E4. Adverse Event Form.

Adverse Events

Did the patient develop any of the following adverse events on 14 day followup (check boxes that apply- indicate number of days after ED presentation that adverse event occurred- use 0 if adverse event was noted in the initial emergency department evaluation)?

- Death If yes, days after initial ED evaluation: _____
Indicate presumed cause of death: Sudden Cardiac Non-Cardiac
- Arrhythmia: specify type If yes, days after initial ED evaluation: _____
 Ventricular tachycardia PSVT (includes PAT) Mobitz II or Type III block
 Atrial fibrillation/flutter Bradycardia Sick sinus syndrome
 Other
- Myocardial Infarction If yes, days after initial ED evaluation: _____
- Acute pulmonary edema If yes, days after initial ED evaluation: _____
- Stroke/TIA If yes, days after initial ED evaluation: _____
- Pulmonary embolism If yes, days after initial ED evaluation: _____
- Aortic dissection If yes, days after initial ED evaluation: _____
- Clinically significant structural heart disease
If yes, days after initial ED evaluation: _____
Indicate condition (e.g. aortic stenosis, cardiomyopathy, etc): _____
- Aneurysmal subarachnoid hemorrhage
If yes, days after initial ED evaluation: _____
- Major bleed/anemia If yes, days after initial ED evaluation: _____
Indicate type of bleed (e.g. GI bleed, ruptured AAA, etc): _____
- Major Cardiac Procedure If yes, days after initial ED evaluation: _____
Indicate type of procedure (e.g. CABG, valve surgery, pacemaker, etc): _____
- Other unusual events noted in discharge summary:
- Readmission after initial ED evaluation/admission
If yes, days after initial ED evaluation: _____
Indicate reason for readmission: _____
- NONE