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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department

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Title Page

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Running Head: ED Discharge Failure Scoring Systems

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department

Abstract

OBJECTIVES: Identifying patients with high risk potential of discharge failure allows for implementation of interventions to improve patient-centered care. However, current literature has very diverse concepts of discharge failure and, therefore, makes such interventions less efficient. We aim to derive a screening tool based on the diversity of discharge failure models.

DESIGN, SETTING AND PARTICIPANTS: This is a single center retrospective cohort study. Data from all patients discharged from the Emergency Department (ED) were collected from Jan. 1, 2015 through Dec. 31, 2017 and followed up at least 30-days.

METHODS: Scoring systems were derived using modified Framingham methods. Sensitivity, specificity, and area under the receiver operational characteristic (AUC) were calculated and compared using both the broad and restricted discharge failure models.

RESULTS: A total of 227,627 patients were included. **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) scoring system was derived based on the broad and restricted discharge failure models and applied back to the entire study cohort. A sensitivity of 80% and a specificity of 71% were found in SHOUT scores to identify patients with broad discharge failure with AUC of 0.83 (95% CI 0.83-0.84). When applied to the restricted discharge failure model, a sensitivity of 86% and a specificity of 60% were found to identify patients with AUC of 0.79 (95% CI 0.78-0.80).

CONCLUSIONS: The SHOUT scoring system was derived and used to screen and identify patients that would ultimately be a discharge failure. They were internally validated and can be used to identify such patients regardless of the diverse definitions of discharge failure.

Key Words: Emergency Department, Discharge Failure, Follow-up, Return Visit

Strengths and Limitations of this study:

1) SHOUT scoring systems are different than other tools reported in the literature with more potential for applying to general population
2) SHOUT scoring system was derived by large sample size and applicable to diverse concepts of discharge failure models thus reaching broad applications
3) This is a relatively simple and easy scoring calculations to predicts of patients with different types of discharge failures
4) To the best of our knowledge, this is the first reported ED discharge failure prediction tool that combined with all validated discharge failure risk factors by using a LASSO regression model thus improved the model accuracy
5) Being a single-center, retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided

Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department

Introduction

Traditional practice recommends arranging timely clinic follow-up for patients who are discharged from the Emergency Department (ED) and such follow up has been shown to improve patient-centered care specifically for disease prevention, monitoring, and management [1,2]. However, nearly one third of ED patients who have sought access to health care rarely follow up with their primary care physician (PCP) or specialist after ED discharge [2]. Such patients were historically considered a discharge failure. However, the definition of discharge failure varies among most studies. A very broad definition used in previous studies included patients who had no shown/no appointment at their clinic after index ED discharge or short ED returns (e.g. 3-days, 7-days, 14-days, or 30-days) [3-6]. Such definition might not be accurate since patents might use ED for episodic acute care with no urgent clinic follow-up needs. On the other hand, patients with extremely short ED returns that had significant deviation of the treatment regimen from the index ED management should be questioned on potential inappropriate ED discharge during the initial ED visit. Alternatively, their ED return could be unrelated to the initial visit. We believe that a more restricted definition of discharge failure truly reflecting the value of arranging timely clinic follow-up should be applied. Unfortunately, such studies are lacking in the current literature.

Additionally, six screening tools have been reported currently to identify patients with high risk potential for discharge failure [7-11]. However, all of these tools intended to screen older patients with poor-to-moderate discriminations and none of such tools can be used in general patient populations. A majority of these tools used self-assessed questionnaires (e.g. assistance with daily activity, healthcare recommendation for added assistance, having a predicted need for more help after ED discharge, etc.) and rarely linked screening with predictive risk factors [9-11]. Many studies in the past have identified a diversity of risk factors predictive of discharge failure [3,4,12]. The most common validated ones are either social or medical factors. These common social factors include insurance type, homeless, lack of PCP, and race/ethnicity [4,5,12], whereas medical factors could be attributed to age, gender, alcohol/drug history, and chronic medical conditions [7,13-15]. Given that validated risk factors already been reported, the derivation of a tool associated with such factors might be deserved at present.

Our overarching goal is to implement efficient interventions to minimize discharge failure. However, these interventions are costly and time/resource consuming if applied to every discharged ED patient. Identifying patients within certain types of discharge failure matched to local institutional policy by using a valid tool for screening will prioritize and optimize subsequent interventions to high risk patients thus gaining the maximal healthcare benefits. Therefore, we aim to 1) determine the differences in ED discharged patients using either a broad or restricted discharge failure model; and 2) derive novel tools associated with predictive risk factors for the initial screening of ED patients with diverse concepts of discharge failures.

Methods

Study Setting and Design

This was a single center retrospective cohort study. Study hospital is a public funded county hospital and an urban tertiary referral center. Study hospital ED is a level-1 trauma center, acute chest pain and comprehensive stroke center whose ED volume reached approximately 120,000 visits annually. Study ED also sponsors an Emergency Medicine (EM) residency program. This study was approved by the local Institutional Review Board.

Study Participant

Patients who presented to study ED from Jan.1, 2015 to Dec. 31, 2017 and were subsequently discharged after the index ED visit were included in this study. All enrolled patients were followed up by reviewing their Electronic Medical Record (EMR) until Feb. 1, 2018. This allowed all enrolled patients had a minimal of 30 days after the index ED discharge. All patient data were electronically retrieved by data management persons from Department of Information Technology. We excluded patients during the index ED visits who 1) were admitted, 2) expired, 3) transferred to other facilities, 4) left without being seen (LWBS), eloped, or left against medical advice (AMA), and 5) prisoners. Since this study mainly focused on the differentiation of discharge failure, we further divided discharged patients into two large categories with either patients with no discharge failure or patients with broad discharge failure potential. We defined patients with no discharge failure as meeting at least one of the following criteria: 1) patients visited their PCP/specialist clinic follow-up with no further ED revisits and their clinic follow-ups were within one year from the index ED discharge; or 2) patients visited their PCP/specialist clinical follow-up within one year from the index ED discharge and prior to their ED revisits, in addition, their ED revisits were beyond 30-days from the index ED visits.

Broad and Restricted Discharge Failure Models

In general, discharge failure was defined as ED revisits within short period of time from the index ED visit (e.g. 3-day, 7-day, 14-day, or 30-days) and poor patient adherence to PCP or specialist clinic follow-up. Broad discharge failure was considered if patients did not meet no discharge failure criteria and met one of the following criteria: 1) patient had ED returns but did not have any PCP/specialist follow-ups from the index ED discharge; 2) patient had ED returns but their clinic follow-up beyond one year from the index ED discharge; 3) patients returned ED prior to their clinical follow-ups and their ED returns were considered non-emergent; 4) patients who had neither subsequent ED nor clinical visits; 5) patients had no subsequent ED visits and their clinic visits were longer than one year from the index ED visit; 6) patients ED returns and clinical visits fell on the same day; 7) patients had subsequent clinical visits earlier than ED returns and their ED returns were within 30-days from the index ED discharge; 8) patients had ED returns earlier than subsequent clinical visits and their ED utilizations considered emergent; and 9) patients had ED returns beyond 30-days from the index ED discharge and their ED visits were earlier than their clinical visits. Patients who met the first three criteria were considered possible discharge failures whereas ones who met the last six criteria were considered discharge failure potential. Considering the broad definition of discharge failure, we categorized all these patients to broad discharge failure group (see detail in Supplemental Table-1). As mentioned above, multiple factors can impact patients resulting in no follow-ups after the index ED discharge (e.g. patient conditions do not require clinical follow-up, patients having an acute episodic care at ED and conditions completely resolved, etc.). Additionally, patients could revisit the ED under appropriate ED utilization conditions or unrelated to their initial ED visit prior to their clinic follow-ups (e.g. acute trauma). These patients might need to be excluded from discharge failure.

Therefore, a more restricted discharge failure model was applied to the study patients. Restricted discharge failure was considered if patients met all the following criteria: 1) patients revisited ED prior to their clinical follow-ups, 2) such ED revisits were within 30-days from the index ED discharge, and 3) patients were discharged from their return ED visits and were considered inappropriate ED utilizations. To satisfy diverse concepts of discharge failure in the literature, we expanded our restricted discharge failure models to the following four extended-restricted discharge failure groups: 1) restricted discharge failure with ED return of <3-days); 2) restricted discharge failure with ED return of <7-days; 3) restricted discharge failure with ED return of <14-days; and 4) restricted discharge failure with ED return of <30-days.

Appropriateness of ED Utilizations

New York University ED algorithm (NYUA) was used in this study to determine the appropriateness of ED utilizations in ED return visits [16]. Briefly, four major categories were used in NYUA: 1) emergent not avoidable considered as ED appropriate visits; 2) primary care treatable defined as care that can be safely provided in a primary care setting without the need for emergent treatment; 3) emergent care needed but preventable / avoidable defined as patients whose disease conditions can be prevented/avoided if preventive care is received in a timely fashion; and 4) non-emergent. Appropriate ED utilization was considered if patients met the emergent not avoidable category criteria and inappropriate utilization was determined if patients were classified within the other three categories. Since NYUA only used to determine the appropriateness of ED utilizations among ED discharged patients. In addition to NYUA, among all patients who revisited ED within 30-days, appropriate ED utilizations were considered if such patients were: 1) admitted to hospital, 2) moved to the Operating Room, 3) transferred to other facilities, or 4) expired.

Variables

Patient general characteristics including patient age, gender, and race/ethnicity were collected in this study. Other patient and clinical variables were listed as the following: 1) patient ED total length of stay: divided into two categories including patients stay equal or less than 4-hours or longer than 4-hours, 2) patient waiting room time in minutes, 3) mode of arrival: divided into two categories (healthcare assisted arrival including ambulance or hospital/healthcare facility-arranged transportations versus others including private car, public transportation, taxi, wheelchair, ambulatory, police, or unknown), 4) level of acuity: divided into three categories based on ESI (Emergency Severity Index) level including high (ESI1-2), moderate (ESI-3), and low (ESI 4-5) acuities, 5) homeless status, 6) patient last vital signs upon disposition (including heart rate, respiratory rate, blood pressure, oxygenation, and temperature): divided into two categories including patients who had normal vital signs versus ones who had any abnormal vital signs (e.g. heart rate<50 or >100, respiratory rate <8 or >20, systolic blood pressure <90mmHg or >140mmHg, diastolic blood pressure <60mmHg or >90mmHg, pulse oximetry<94%, temperature >100.4F° or <96.8F°, 7)next subsequent healthcare visits (e.g. ED, PCP/specialist clinic, or none) and its time interval from the index ED discharge, 8) whether patients had their PCP assigned, 9) number of medications prescribed upon the index ED discharge: divided into two categories including patients who had prescriptions versus those who had not, 10) insurance type divided into two categories including patients who had any type of insurances versus who did not, and 11) patient's chronic disease conditions: divided into two categories including patients who had versus ones hadn't. Chronic disease conditions were determined using the chronic condition indicator (CCI) for the international classification

of diseases tenth revision, clinical modification (ICD-10-CM). It was developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ) [17].

Study Protocol

To differentiate patients with discharge failure, study patients were divided into two groups: 1) patients with discharge failure, and 2) patients without discharge failure. General characteristics (age, gender, and ethnicity) and clinical variables (mode of arrival to ED, homeless status, PCP assignment conditions, history of chronic diseases, number of medication prescribed upon discharge, and ED total length of stay) were analyzed and compared separately. To determine and compare the current status of patients with ED returns versus clinic follow-up, an inverse of the Kaplan-Meier survival curves, which shows the proportion of patients (probability) that return to the ED and ones that visit the clinic within time frames of interest, were also drawn. Scoring systems were derived to differentiate patients with different concepts of discharge failure. Such scoring systems were then applied to patients for the accuracy testing of predicting discharge failure in different models (e.g. predictive of 3-day, 7-day, 14-day, versus 30-days; predictive of restricted versus broad discharge failure model).

Derivation and Validation of SHOUT Scoring Systems

To identify potential ED discharge failure patients, SHOUT (**S**creening for **H**ealthcare f**O**llow-**U**p **T**ool) scoring systems were derived. Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance. We built five scoring systems using predictive logistic regression modeling. Each model predicted a specific outcome as defined above: broad discharge failure, 3-day, 7-day, 14-day, and 30-day restricted discharge failure. In our sample, less than 5% of the patients had missing data on predictor variables (specific variables denoted in Table 1, see Supplemental Table 2). To build the predictive model for broad discharge failure, we used 50% of the data to train the model and 50% to test the model because we had a large sample size. We dichotomized the predictors for simplicity in clinical practice. Neither making the variables continuous nor including interaction terms added substantially to the model's performance, and we preferred parsimony for generalizability. To avoid over-fitting, we used the least absolute shrinkage and selection operator (LASSO) to fit the most informative but parsimonious model [18]. The LASSO model predicted a patient's probability of broad discharge failure, and we used a threshold value to classify the patient (0 or 1). Simple point scoring systems were then derived using methods described by Framingham with minor modifications [19]. We used the receiver operating characteristic (ROC) curve to define the threshold as the value that maximizes the model's sensitivity and minimizes the false positive rate. Because the model's primary purpose was to classify patients, we focused on the model's discriminative abilities. Accuracy of the prediction was reported with sensitivity, specificity, positive and negative likelihood ratios. Scores were calculated among all patients in both the derivation and validation groups, the sensitivity, specificity, positive and negative likelihood ratios, and AUC were compared between groups of different models in both the derivation and validation data.

Data Analysis

Student's t-test was used to compare continuous variables while Pearson Chi-square (χ^2) analysis was used to compare categorical variables between groups. We plotted the inverse of the Kaplan-Meier survival curves for the frequency comparison of patients who returned to ED versus ones had clinic follow-up after the index ED discharge. Method that used to derive and validate scoring systems was addressed above.

All descriptive and statistical analyses were conducted using STATA 14.2 (College Station, TX). A *p* value <0.05 was considered statistically significant.

Patients and public involvement

Patients and the public were not directly involved in this study.

Results

General Information

A total of 227,627 ED discharged patients were retrieved from EMR with only 33,357 patients categorized to the no discharge failure group. A detail flow diagram was shown in Figure 1. Overall, 85% (194,270/227,627) of patients were considered broad discharge failures and only 15% of ED discharged patients were compliance with their clinical follow-ups. When restricted discharge failure models were applied, 3.0% (6,715/227,627) of patients were considered restricted discharge failures with 30-days, 2.2% (4,957/227,627) failure rate within 14-days, 1.5% (3,518/227,627) within 7-days, and 0.9% (2,086/227,627) within 3-days. Table 1 described the general information among different models specifically comparing patients of different restricted and broad discharge failures. Patients who had restricted discharge failure were more likely Caucasian, homeless, relied on healthcare assisted transportations, with more chronic disease conditions, more insurance covered, and less likely to have a primary care physician (PCP) assigned in comparisons to ones with broad discharge failures. Patients with no discharge failures tended to be female predominant, less under the homeless statuses, less use of health-assisted transportations with less PCP coverage (Table 1). When reverse Kaplan-Meier curves were drawn among the study patients who had either ED returns or clinical follow-up visits subsequently after the index ED discharge, it showed that 24% of patients returned to the ED subsequently within 7 days while 18% of patients had clinic follow-ups within 7 days. Similarly, 46% of patients returned to the ED within 30 days, and 45% of patients had a clinic follow-up within 30 days. At 32 days, the curves crossed indicating that patients seeking clinic visits more frequently than ones returning to ED after 32 days. The graph also showed a median of 38 days for subsequent ED returns in comparison to a median of 37 days for subsequent clinic follow-up in this cohort (Figure 2). Our results indicated that high frequency of ED returns occurred within the first 32 days from the index ED discharge.

Table 1. Study Patient General Characteristics

	Diverse Discharge Failure Models					Control
	Board N=194,270	Restricted (3-day) N=2,086	Restricted (7-day) N=3,518	Restricted (14-day) N=4,957	Restricted (30-day) N=6,715	No Discharge Failure N=33,357
Race/Ethnicity (n, %)						
Non-Hispanic White	63,438 (33)	867 (42)	1,424 (40)	1,948 (39)	2,573 (38)	9,813 (29)
Others	130,832 (67)	1,219 (58)	2,094 (60)	3,009 (61)	4,142 (62)	23,544 (71)
Gender (n, %)						
Male	96882 (50)	1,160 (56)	1,868 (53)	2,514 (51)	3,238 (48)	12,141 (36)
Female	97380 (50)	926 (44)	1,650 (47)	2,443 (49)	3,477 (52)	21,216 (64)
PCP provider (n, %)						

Yes	129,345 (67)	445 (21)	658 (19)	821 (17)	1,014 (15)	3,621 (11)
No	64,925 (33)	1,641 (79)	2,860 (81)	4,136 (83)	5,701 (85)	29,736 (89)
Homeless (n, %)						
Yes	16,783 (9)	663 (32)	1,090 (31)	1,386 (28)	1,694 (25)	1,719 (5)
No	177,487 (91)	1,423 (68)	2,428 (69)	3,571 (72)	5,021 (75)	31,638 (95)
Means of arrival (n, %)						
Healthcare-assisted	51,181 (27)	802 (39)	1,268 (36)	1,682 (34)	2,106 (31)	5,449 (16)
Others	141,688 (73)	1,278 (61)	2,242 (64)	3,264 (66)	4,597 (69)	27,840 (84)
Any insurance (n, %)						
Yes	99,827 (51)	1,757 (84)	2,942 (84)	4,112 (83)	5,515 (82)	28,774 (86)
No	94,268 (49)	329 (16)	576 (16)	845 (17)	1,200 (18)	4,579 (14)
ESI level (n, %)						
ESI (1,2,3)	150,277 (78)	1,606 (77)	2,654 (76)	3,740 (76)	5,062 (75)	27,621 (83)
ESI (4,5)	43,423 (22)	477 (23)	859 (24)	1,211 (24)	1,646 (25)	5,680 (17)
Last vitals upon discharge (n, %)						
Normal	23,338 (13)	235 (12)	389 (12)	547 (12)	739 (11)	4,287 (13)
Abnormal	162,312 (87)	1,739 (88)	2,968 (88)	4,190 (88)	5,690 (89)	28,172 (87)
Any chronic conditions (n, %)						
Yes	91,194 (47)	1,338 (64)	2,277 (65)	3,161 (64)	4,224 (63)	18,649 (56)
No	103,076 (53)	748 (36)	1,241 (35)	1,796 (36)	2,491 (37)	14,708 (44)
Prescriptions upon discharge (n, %)						
Yes	129,198 (67)	1,177 (56)	2,086 (59)	3,050 (62)	4,322 (64)	22,356 (67)
No	65,072 (34)	909 (44)	1,432 (41)	1,907 (38)	2,393 (36)	11,001 (33)
Length of ED stay (n, %)						
Equal or longer than 4-hours	127,708 (66)	808 (39)	1,364 (39)	1,907 (38)	2,550 (38)	13, 964 (42)
Less than 4-hours	66,538 (34)	1,277 (61)	2,153 (61)	3,049 (62)	4,164 (62)	19,393 (58)

Derivation of SHOUT Scoring Systems for Diversity of Discharge Failure Models

Nine independent risks predictive of patients with discharge failures were: 1) homelessness; 2) patient PCP status; 3) Male; 4) history of chronic diseases; 5) patient without insurance; 6) low level of acuity (ESI 4-5); 7) non-Caucasian; 8) health-assisted transportations; and 9) last vital signs abnormal upon index ED discharge. Therefore, these factors were incorporated into the SHOUT scores for diversity of discharge failure models (Table 2). These scores were applied back to the derivation data yielding good discriminations indicating the feasibility of using SHOUT scores for the initial screening of different discharge failure models (Table 3).

Table 2. SHOUT Scoring System for Different Discharge Failure Models

	Broad	Restricted (3-day)	Restricted (7-day)	Restricted (14-day)	Restricted (30-day)
Gender					

Female	0	0	0	0	0
Male	2	1	1	1	1
Race/Ethnicity					
Non-Hispanic White	1	1	1	1	1.5
Others	0	0	0	0	0
PCP provider assigned					
Yes	21	0	0	0	0
No	0	6	6	11	15.5
Homeless					
Yes	7	5	5	7	9
No	0	0	0	0	0
Means of arrival					
Health-care assisted	6	1	1	1.5	1.5
Others	0	0	0	0	0
Any insurance					
Yes	0	3	3	4	5
No	10.5	0	0	0	0
Last vital signs upon discharge					
Abnormal		1	1	1	1.5
Normal		0	0	0	0
ESI level					
ESI (1,2,3)	0	0	0	0	0
ESI (4, 5)	1.5	1	1	2	3
History of chronic conditions					
Yes	0	1	1	1.5	2
No	1	0	0	0	0
Score Range	0-50	0-20	0-20	0-30	0-40
Predicted Discharge Failure	≥9	≥9	≥9	≥14	≥20

Table 3. Predictive Performance of Different Discharge Failure Models in Derivation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.83 (0.83-0.84)	80%	71%	2.77	0.28
Restricted (3-days)	0.79 (0.78-0.80)	86%	60%	2.14	0.24
Restricted (7-days)	0.79 (0.79-0.80)	86%	60%	2.17	0.23
Restricted (14-days)	0.79 (0.78-0.80)	84%	61%	2.18	0.25
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.21	0.29

Validations of SHOUT Scoring Systems for Diversity of Discharge Failure Models

SHOUT scores were again applied back to the study validation data using different discharge failure models. First, AUC comparisons of SHOUT scores predicting patients with restricted discharge failure within 3-days, 7-days, 14-days, and 30-days were performed. Similar AUC to predict patients with short-

term restricted discharge failure were observed among the cohort (Table 4). Secondly, SHOUT score was applied to patients with broad discharge failure model, higher AUC (0.84, 95% CI 0.84-0.84) was yielded with sensitivity of 80%, specificity of 72%, positive likelihood of 2.85, and negative likelihood of 0.27 (Table 4).

Table 4. Predictive Performance of Different Discharge Failure Models in Validation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.84 (0.84-0.84)	80%	72%	2.85	0.27
Restricted (3-days)	0.79 (0.78-0.80)	85%	60%	2.13	0.25
Restricted (7-days)	0.80 (0.79-0.80)	87%	61%	2.20	0.22
Restricted (14-days)	0.79 (0.78-0.80)	85%	62%	2.21	0.24
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.22	0.29

Discussion

Timely arrangement of post-ED follow-up is critical to ensure patient safety, monitor patient disease progression, and adjust management regimen properly [2,20]. In this study, we found higher ED returns occurred within the first 32 days whereas higher clinic follow-up initiated after 32 days from the index ED discharge. If we considered ED returns without clinic follow-up as a broad concept of discharge failure, our findings might suggest implementing clinic follow-up within 32 days among these high-risk patients. Unfortunately, the median time of patients return ED (38 days) or clinic visits (37 days) subsequently after the index ED discharge were very close, indicating only arranging clinic follow-up did not prevent patients from ED returns. Therefore, differentiating patients with different type of discharge failures, whether occurred within the first 30 days or having broad discharge failure potential seem important to further implementing efficient interventions in the future to enhance the clinic follow-up compliance among the cohort.

We thus introduced the diversity of discharge failure concept and categorized patients as either having broad discharge failure potential or having short-term restricted discharge failure. Therefore, the SHOUT scoring system was derived and internally validated to differentiate patients with different discharge failure models and approved to be broadly applicable among diversity of discharge failure patients. This study has several strengths: 1) large sample size was used and applicable to diverse concepts of discharge failure models thus reaching broad applications; 2) using LASSO regression model improved the accuracy of identifying independent risks; 3) relatively simple and easy scoring calculations to predicts of patients with discharge failures; and 4) SHOUT scoring systems are different than other tools reported in the literature with more potential for applying to general population.

This study differentiated patients between “broad” and “restricted” discharge failures. Given the uncertainty of ED returns and poor adherence of patient clinic follow-up, we believe that a more restricted discharge failure model can minimize the potential biases. Derivation of screening tool based on the restricted model seems different than that of the broad one. It can specifically differentiate patients with high risk potential of having short-term discharge failure. With the expanding use of tool to a broader population, we expect to catch up more patients within the broad discharge failure model. Different institutions can choose the one better fit for their own operational needs.

Risks identified in our study to predict patients with discharge failure have also been validated in previous studies to a certain level [3,4,14]. Patients lacking insurance coverage, having their PCP, homeless, and having chronic disease conditions are most commonly addressed in the literature with different concepts of discharge failure models [5,12,13,13]. Lacking insurance coverage prevented patients from seeking healthcare follow-up whereas favored patients using ED as their medical home, which usually resulting in inappropriate ED utilization [21]. Patients with homeless status and chronic disease conditions favored resulting in a discharge failure due to the facts of certain associations occurred between homeless patients and chronic disease conditions [22]. Studies showed more homeless patients sustaining chronic diseases in comparison to general population [23]. Additionally, homeless patients tended to use ED more often as their medical home resulting in higher inappropriate ED utilization [24]. Our study also showed patients of lower acuities (ESI 4-5), male, and non-Hispanic-White favored towards discharge failure. Similar findings reported that patients with lower acuities, male, and race/ethnicity had a higher inappropriate ED visits and higher 72-hour ED return [6,15]. However, such findings are controversial in different studies probably due to different study patient populations [25].

Though risks predictive of broad and restricted seems similar, three risks had opposite effects on such predictions. No PCP assignment, patients with chronic disease conditions, and patients with healthcare insurance coverage seemed to predict restricted discharge failure that protect patients from broad discharge failures. This might be, partly, due to current study hospital healthcare policies. In the study hospital, it advocates for PCP assignments and clinic follow-up arrangements, provides charity insurance coverage among certain patients (e.g. high psychosocial risks, homeless, low-income residents, etc.), and has developed outreach programs for patients with special needs (e.g. homeless, chronic heart failure outreach programs, etc.) [24,26]. It has been reported that these patients had high risk of short-term ED returns (e.g. 72-h) both in the literature and in our own study [3,13,24]. In addition, such implementations are not uncommon across public funded or not-for-profit hospitals in the US [27,28]. However, when applied to patients with long-term discharge failure potential, such effects seemed faded-off and became the protective risks predicting broard discharge failures which are consistent to other reports in the literature [29]. Therefore, we believe the SHOUT score for broad discharge failure can be used more broadly with the diversity of hospital settings (e.g. charity, public-funded, Veteran Affair, private or community hospitals, etc.). Whereas, the SHOUT scores for restricted discharge failures might be limited to public-funded hospitals with similar policies as the study hospital.

Our study has its own limitations. First, given the nature of study design being a single-center, retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided. Secondly, we were not able to include all potential variables that may predict study outcomes. In general, ED providers are busy during clinical shifts with limited time to collect pertinent information, we intended to include convenient variables that can be common and easily identified within short period thus making feasible applying to any EDs across the nation. Thirdly, though SHOUT scores can identify patients with potential risks of discharge failure, based on the AUC results, these models have good but not excellent discriminations. Using our recommended cutoff scores yielded fair sensitivities and specificities but not excellent. Considering such outcomes are multifactorial with diversity of patient population, it is challenging to derive scoring systems with higher sensitivity/specificity and excellent discriminations. Such scoring systems might only be used as initial screening tools and further multi-center external validations are warranted.

In summary, **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) might be used as initiate screening to differentiate patients with different discharge failure models. It can be broadly used to identify patients with broad discharge failure potentials. Its use of identifying restricted discharge failures might be limited only in public-funded or not-for-profit hospitals similar as the study hospital.

Figure legend:

Figure 1 shows the study flow diagram

Figure 2 shows time to next-event curve to determine the probability of subsequent events (ED return vs. clinic follow-up) occurred among discharged patients

Reference List

1. Misky GJ, Wald HL, Coleman EA: Post-hospitalization transitions: Examining the effects of timing of primary care provider follow-up. J Hosp Med 2010, 5: 392-397.

2. Schull MJ: Making aftercare more than an afterthought: patient follow-up after emergency department discharge in Ontario. Healthc Q 2014, 17: 11-13.

3. Pham JC, Kirsch TD, Hill PM, DeRuggerio K, Hoffmann B: Seventy-two-hour returns may not be a good indicator of safety in the emergency department: a national study. Acad Emerg Med 2011, 18: 390-397.

4. Magnusson AR, Hedges JR, Vanko M, McCarten K, Moorhead JC: Follow-up compliance after emergency department evaluation. Ann Emerg Med 1993, 22: 560-567.

5. Klinkenberg WD, Calsyn RJ: The moderating effects of race on return visits to the psychiatric emergency room. Psychiatr Serv 1997, 48: 942-945.

6. Khan NU, Razzak JA, Saleem AF, Khan UR, Mir MU, Aashiq B: Unplanned return visit to emergency department: a descriptive study from a tertiary care hospital in a low-income country. Eur J Emerg Med 2011, 18: 276-278.

7. McCusker J, Cardin S, Bellavance F, Belzile E: Return to the emergency department among elders: patterns and predictors. Acad Emerg Med 2000, 7: 249-259.

8. Graf CE, Giannelli SV, Herrmann FR, Sarasin FP, Michel JP, Zekry D et al.: Can we improve the detection of old patients at higher risk for readmission after an emergency department visit? J Am Geriatr Soc 2012, 60: 1372-1373.

9. Hegney D, Buikstra E, Chamberlain C, March J, McKay M, Cope G et al.: Nurse discharge planning in the emergency department: a Toowoomba, Australia, study. J Clin Nurs 2006, 15: 1033-1044.

10. Runciman P, Currie CT, Nicol M, Green L, McKay V: Discharge of elderly people from an accident and emergency department: evaluation of health visitor follow-up. J Adv Nurs 1996, 24: 711-718.

11. Moons P, De RK, Geyskens K, Sabbe M, Braes T, Flamaing J et al.: Screening for risk of readmission of patients aged 65 years and above after discharge from the emergency department: predictive value of four instruments. Eur J Emerg Med 2007, 14: 315-323.

12. Boudreaux ED, Clark S, Camargo CA, Jr.: Telephone follow-up after the emergency department visit: experience with acute asthma. On behalf of the MARC Investigators. Ann Emerg Med 2000, 35: 555-563.

13. White D, Kaplan L, Eddy L: Characteristics of patients who return to the emergency department within 72 hours in one community hospital. Adv Emerg Nurs J 2011, 33: 344-353.

14. Lamantia MA, Platts-Mills TF, Biese K, Khandelwal C, Forbach C, Cairns CB et al.: Predicting hospital admission and returns to the emergency department for elderly patients. Acad Emerg Med 2010, 17: 252-259.

15. Heng KW, Tham KY, How KY, Foo JS, Lau YH, Li AY: Recall of discharge advice given to patients with minor head injury presenting to a Singapore emergency department. Singapore Med J 2007, 48: 1107-1110.

16. Ballard DW, Price M, Fung V, Brand R, Reed ME, Fireman B et al.: Validation of an algorithm for categorizing the severity of hospital emergency department visits. Med Care 2010, 48: 58-63.

17. Agency for Healthcare Research and Quality . Beta Chronic Condition Indicator (CCI) for ICD-10-CM. 2018.
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18. Friedman J, Hastie T, Tibshirani R: Regularization Paths for Generalized Linear Models via Coordinate Descent. J Stat Softw 2010, 33: 1-22.

19. Sullivan LM, Massaro JM, D'Agostino RB, Sr.: Presentation of multivariate data for clinical use: The Framingham Study risk score functions. Stat Med 2004, 23: 1631-1660.

20. Schectman JM, Schorling JB, Voss JD: Appointment adherence and disparities in outcomes among patients with diabetes. J Gen Intern Med 2008, 23: 1685-1687.

21. Gandhi SO, Grant LP, Sabik LM: Trends in nonemergent use of emergency departments by health insurance status. Med Care Res Rev 2014, 71: 496-521.

22. McCarthy ML, Hirshon JM, Ruggles RL, Docimo AB, Welinsky M, Bessman ES: Referral of medically uninsured emergency department patients to primary care. Acad Emerg Med 2002, 9: 639-642.

23. Wiersma P, Epperson S, Terp S, LaCourse S, Finton B, Drenzek C et al.: Episodic illness, chronic disease, and health care use among homeless persons in Metropolitan Atlanta, Georgia, 2007. South Med J 2010, 103: 18-24.

24. Wang H, Nejtek VA, Zieger D, Robinson RD, Schrader CD, Phariss C et al.: The role of charity care and primary care physician assignment on ED use in homeless patients. Am J Emerg Med 2015, 33: 1006-1011.

25. Goldman RD, Ong M, Macpherson A: Unscheduled return visits to the pediatric emergency department-one-year experience. Pediatr Emerg Care 2006, 22: 545-549.

26. Nejtek VA, Aryal S, Talari D, Wang H, O'Neill L: A pilot mobile integrated healthcare program for frequent utilizers of emergency department services. Am J Emerg Med 2017, 35: 1702-1705.

27. Mercer T, Bae J, Kipnes J, Velazquez M, Thomas S, Setji N: The highest utilizers of care: individualized care plans to coordinate care, improve healthcare service utilization, and reduce costs at an academic tertiary care center. J Hosp Med 2015, 10: 419-424.

28. Gingold DB, Pierre-Mathieu R, Cole B, Miller AC, Khaldun JS: Impact of the Affordable Care Act Medicaid expansion on emergency department high utilizers with ambulatory care sensitive conditions: A cross-sectional study. Am J Emerg Med 2017, 35: 737-742.

29. Yeatts KB, Lippmann SJ, Waller AE, Hassmiller LK, Travers D, Weinberger M et al.: Population-based burden of COPD-related visits in the ED: return ED visits, hospital admissions, and comorbidity risks. Chest 2013, 144: 784-793.

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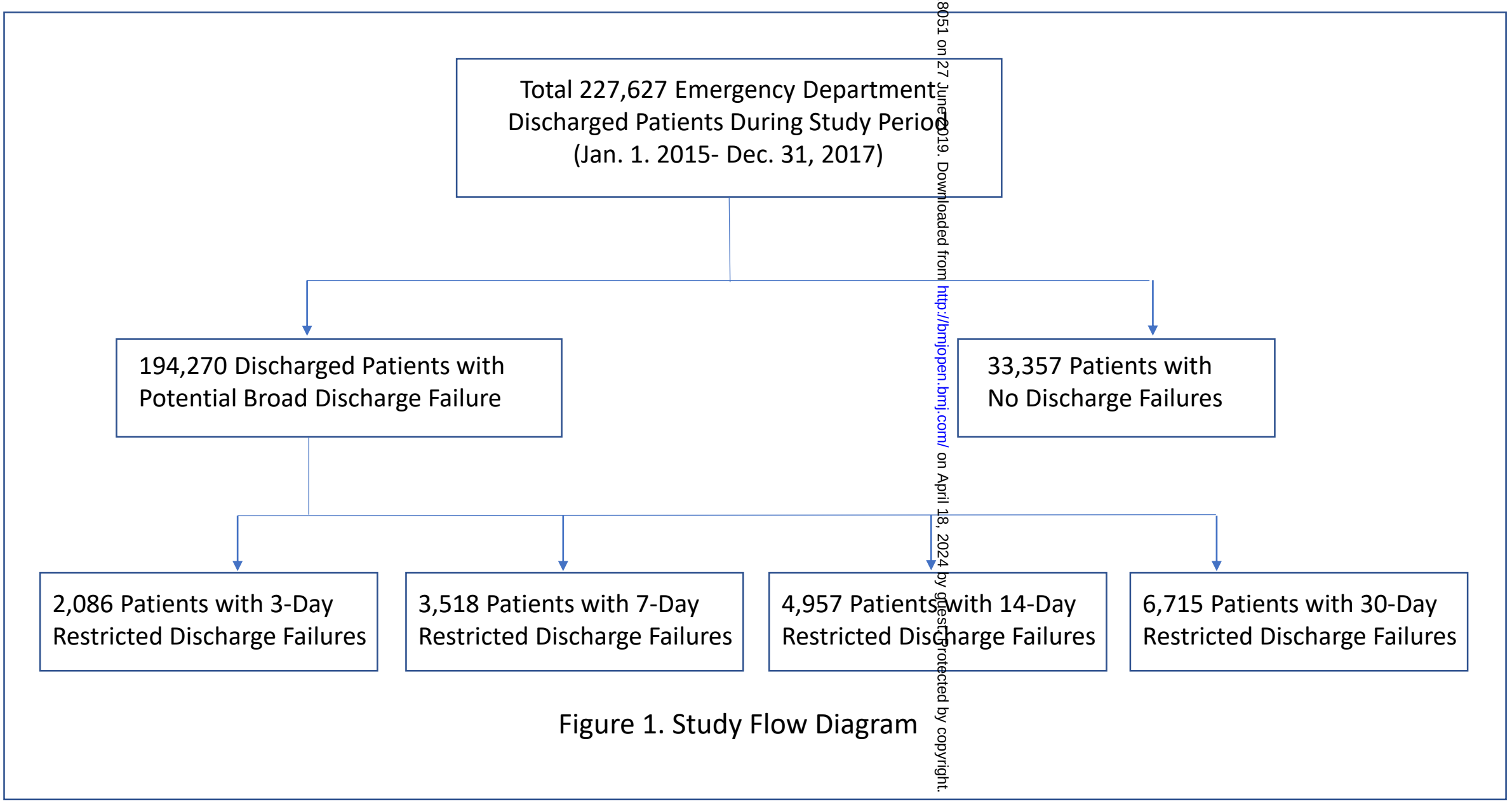

Figure 1. Study Flow Diagram

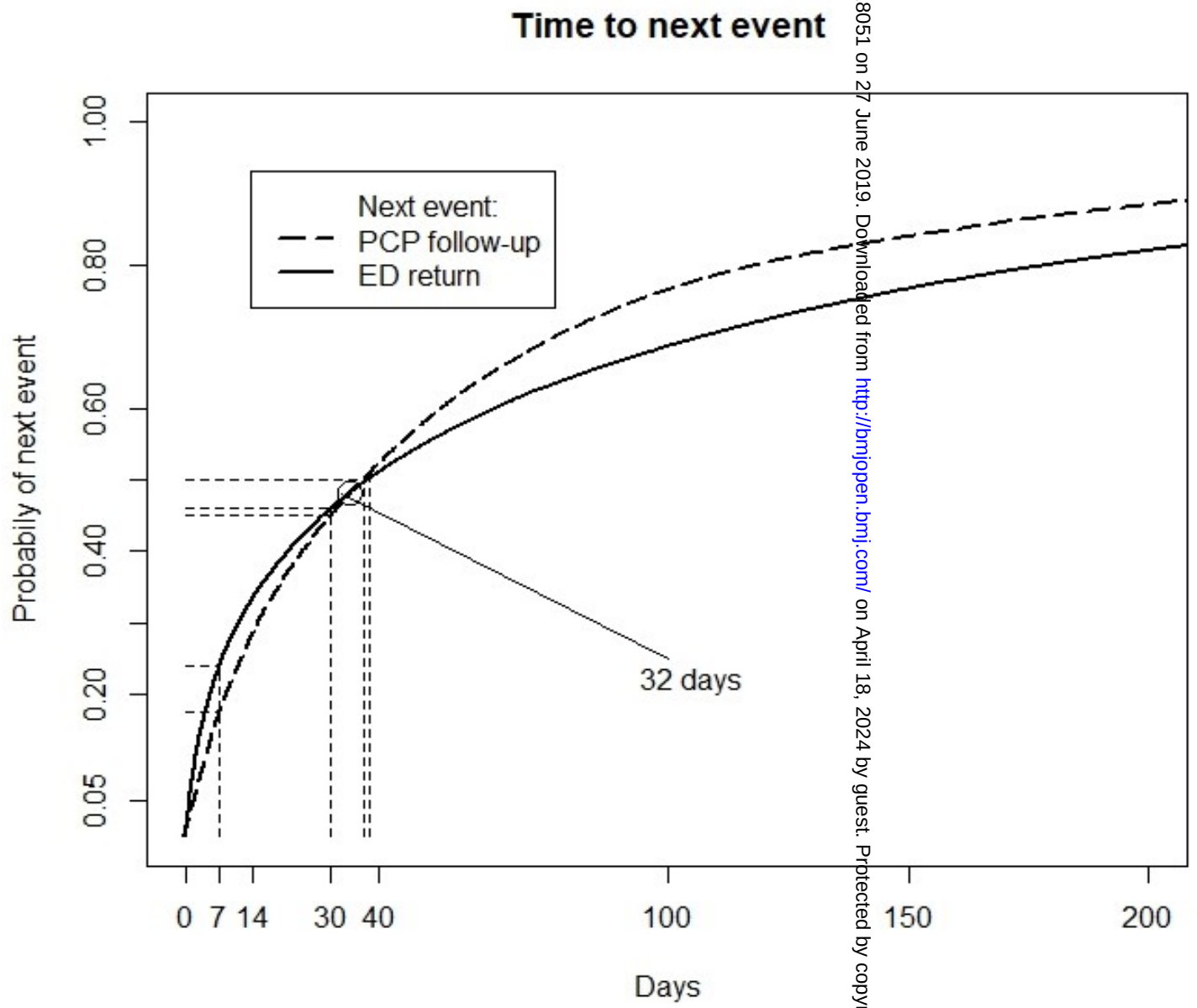

Figure 2. Time to Next-Event Curve to Determine the Probability of Subsequent Events (ED Return vs. Clinic Follow-up) Occurred Among Study Discharged Patients

Supplemental Table 1. General Information of Uncertain Discharge Failure Patients

Uncertain Discharge Failure Patients (N=102,787)	
a. Category of Uncertain Discharge Failures (N, %)	
1)patients who had neither subsequent ED nor clinical visits	84,049 (82)
2) patients had no subsequent ED visits and their clinic visits were longer than one year from the index ED visit;	1,398 (1.4)
3) patients ED returns and clinical visits fell on the same day;	299 (0.3)
4) patients had subsequent clinical visits earlier than ED returns and their ED returns were within 30-days from the index ED discharge;	2,295 (2.2)
5) patients had ED returns earlier than subsequent clinical visits and their ED utilizations considered emergent;	9,640 (9.4)
6) patients had ED returns beyond 30-days from the index ED discharge and their ED visits were earlier than their clinical visits	5,106 (5)
b. Patient General Characteristics	
Gender (Male)---yes, n (%)	50,830 (49)
Race --- n (%)	
None-Hispanic Caucasian	33,100 (32)
Others	69,687 (68)
Homeless --- yes, n (%)	4,992 (4.9)
Chronic Disease Conditions --- yes, n (%)	43,435 (42)
No Insurance --- n (%)	52,049 (51)
Primary Care Physician Assignment --- yes, n (%)	71,182 (69)
ESI (4-5) low level of acuity --- yes, n (%)	21,664 (21)

Supplemental Table 2. Number of Study Missing Variables

	Total Sample Size (N=227,627)
Gender, n (%)	8 (0.004)
Race, n (%)	0
Homeless, n (%)	0
Mode of Arrival, n(%)	1469 (0.6)
Chronic Disease Conditions, n (%)	0
Insurance, n (%)	179 (0.08)
Primary Care Physician Assignment, n (%)	0
ESI level of acuity, n (%)	626 (0.3)
Prescriptions, n (%)	0
Prolonged ED Length of Stay, n (%)	24 (0.01)
Abnormal vital signs, n(%)	9518 (4.2)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	6

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

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Title Page

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Abstract

OBJECTIVES: Identifying patients who are high risk for discharge failure allows for implementation of interventions to improve their care. However, discharge failure is currently defined in literature with great variability, making targeted interventions more difficult. We aim to derive a screening tool based on the existing diverse discharge failure models.

DESIGN, SETTING, AND PARTICIPANTS: This is a single-center retrospective cohort study. Data from all patients discharged from the Emergency Department (ED) were collected from Jan. 1, 2015 through Dec. 31, 2017 and followed up within 30-days.

METHODS: Scoring systems were derived using modified Framingham methods. Sensitivity, specificity, and area under the receiver operational characteristic (AUC) were calculated and compared using both the broad and restricted discharge failure models.

RESULTS: A total of 227,627 patients were included. The **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) scoring system was derived based on the broad and restricted discharge failure models and applied back to the entire study cohort. A sensitivity of 80% and a specificity of 71% were found in SHOUT scores to identify patients with broad discharge failure with AUC of 0.83 (95% CI 0.83-0.84). When applied to a 3-day restricted discharge failure model, a sensitivity of 86% and a specificity of 60% were found to identify patients with AUC of 0.79 (95% CI 0.78-0.80).

CONCLUSIONS: The SHOUT scoring system was derived and used to screen and identify patients that would ultimately become discharge failures, especially when using broad definitions of discharge failure. The SHOUT tool was internally validated and can be used to identify patients across a wide spectrum of discharge failure definitions.

Key Words: Emergency Department, Discharge Failure, Follow-up, Return Visit

Strengths and Limitations of this study:

1) The SHOUT scoring system is different than other tools reported in the literature and has more potential for applying to the general population.
2) The SHOUT scoring system was derived from a large sample size and is applicable to diverse concepts of discharge failure model, giving it broad application.
3) This is a relatively simple and easy scoring calculation to predict patients with different types of discharge failures.
4) To the best of our knowledge, this is the first reported ED discharge failure prediction tool that combined all validated discharge failure risk factors using a LASSO regression model, making it a more accurate model.
5) As a single-center retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided.

Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Introduction

Traditional practice recommends arranging timely clinic follow-up for patients who are discharged from the Emergency Department (ED). Such follow up has been shown to improve patient-centered care specifically for disease prevention, monitoring, and management [1,2]. However, nearly one-third of ED patients who have sought access to health care rarely follow up with their primary care physician (PCP) or specialist after ED discharge [2]. Such patients were historically considered a discharge failure. However, the definition of discharge failure varies among most studies. A very broad definition used in previous studies included patients who had no-showed for a clinic appointment after an index ED discharge, had no clinic appointment after an index ED discharge, or had short ED returns (e.g. 3-day, 7-day, 14-day, or 30-day) [3-6]. Such definitions may not be accurate since patents might use the ED for episodic acute care and have no urgent clinic follow-up needs. On the other hand, patients with extremely short ED returns or that had significant deviation from the usual treatment regimen following an index ED visit may have been inappropriately discharged in the first place from their initial ED visit. Alternatively, their ED return could be unrelated to the initial visit. We believe that a more restricted definition of discharge failure truly reflecting the value of arranging timely clinic follow-up should be applied. Unfortunately, such studies are lacking in the current literature.

Six screening tools have been reported currently to identify patients with high risk potential for discharge failure [7-11]. However, all of these tools are intended for screening older patients with poor-to-moderate discrimination, and none of them can be used in general patient populations. A majority of these tools used self-assessed questionnaires (e.g. assistance with daily activity, healthcare recommendation for added assistance, having a predicted need for more help after ED discharge, etc.) and rarely linked screening with predictive risk factors [9-11]. Many studies in the past have identified a variety of risk factors predictive of discharge failure [3,4,12]. The most common validated ones are either social or medical factors. These common biological and social factors include insurance type, homelessness, lack of PCP, age, gender, and race/ethnicity [4,5,7,12,13], whereas medical factors could be attributed to alcohol/drug history and chronic medical conditions [14,15]. Given that validated risk factors have already been reported, the derivation of a tool associated with such factors might be beneficial.

Our goal is to identify patients at risks for discharge failures so that efficient interventions can be implemented to prevent ED returns, reduce cost, and save health care resources. Therefore, we aim to 1) determine the differences in ED discharged patients using either a broad or restricted discharge failure model; and 2) derive novel tools associated with predictive risk factors for the initial screening of ED patients for discharge failures.

Methods

Study Setting and Design

This was a single-center retrospective cohort study. The study hospital is a publicly-funded county hospital and urban tertiary referral center. The study hospital ED is a level-1 trauma center, acute chest pain and comprehensive stroke center whose ED volume reached approximately 120,000 visits annually. The ED also sponsors an Emergency Medicine (EM) residency program. This study was approved by John Peter Smith Health Network Institutional Review Board.

Study Participants

Patients who presented to study ED from Jan.1, 2015 to Dec. 31, 2017 and were subsequently discharged after the index ED visit were included in this study. The study hospital system uses the same Electronic Medical Record (EMR) including ED, hospital, and clinics. The medical records of all enrolled patients were retrieved automatically until Feb. 1, 2018. This allowed all enrolled patients to have 30 days after the index ED discharge to follow up. All patient data was electronically retrieved by data managers from the Department of Information Technology. We excluded patients during the index ED visits who 1) were admitted, 2) expired, 3) transferred to other facilities, 4) left without being seen (LWBS), eloped, or left against medical advice (AMA), and 5) prisoners. Since this study mainly focused on the characteristics of discharge failure, we further divided discharged patients into two large categories of patients without discharge failure and patients with broad discharge failure potential. We defined patients without discharge failure as meeting all the following criteria: 1) patients visited their PCP/specialist clinic within one year from the index ED discharge; 2) patients visited their PCP/specialist clinics prior to their ED revisits; and 3) patients had no ED revisits within 30 days.

Broad and Restricted Discharge Failure Models

In general, discharge failure was defined as ED revisits within a short period of time from the index ED visit (e.g. 3-day, 7-day, 14-day, or 30-days) and poor patient adherence to PCP or specialist clinic follow-up. We divided patients with discharge failure into broad and restricted categories. Patients with restricted discharge failures were confirmed discharge failure within 30 days from the index ED discharges. Whereas, patients with broad discharge failures included not only ones with confirmed discharge failures but also ones with discharge failure potential or uncertainty. Broad discharge failure was considered if patients met one of the following criteria: 1) patient had no PCP/specialist follow-ups from the index ED discharge; 2) patient had clinic follow-up longer than one year from the index ED discharge; 3) patients returned to the ED prior to their clinical follow-up; 4) patients with ED returns and clinic visits on the same day; and 5) patients with ED returns within 30-days from the index ED discharge. (see detail in Supplemental Table-1). As mentioned above, multiple factors can impact patient follow up after the index ED discharge (e.g. patient conditions do not require clinical follow-up, patient ED condition completely resolved, etc.). Additionally, patients could revisit the ED appropriately or unrelated to their initial ED visit prior to their clinic follow-ups (e.g. acute trauma). These patients might need to be excluded from the discharge failure category. Therefore, a more restricted discharge failure model was applied to the study patients. Restricted discharge failure was considered if patients met all the following criteria: 1) patients returned to the ED prior to their clinic follow-ups, 2) such ED revisits were within 30-days from the index ED discharge, and 3) patients were discharged from their ED return and the visit reason was considered inappropriate ED utilization. To satisfy diverse concepts of discharge failure in the literature, we expanded our restricted discharge failure models to the following four extended-restricted discharge failure groups: 1) restricted discharge failure with subsequent ED return of <3-days); 2) restricted discharge failure with

ED return of <7-days; 3) restricted discharge failure with ED return of <14-days; and 4) restricted discharge failure with ED return of <30-days.

Appropriateness of ED Utilization

New York University ED Algorithm (NYUA) was used in this study to determine the appropriateness of ED return visits [16]. Briefly, the four major categories were used in NYUA: 1) emergent and not avoidable, considered appropriate ED visits; 2) primary care treatable, defined as care that can be safely provided in a primary care setting without the need for emergent treatment; 3) emergent care needed but preventable/avoidable, defined as patients whose disease conditions can be prevented/avoided if preventive care is received in a timely fashion; and 4) non-emergent. Appropriate ED utilization was considered if patients met the emergent not avoidable category criteria and inappropriate utilization was determined if patients were classified within the other three categories. However, since NYUA is only used to determine the appropriateness of ED utilization among ED discharged patients, for patients who revisited ED within 30-days, appropriate ED utilization was also considered if such patients were: 1) admitted to hospital, 2) moved to the Operating Room, 3) transferred to other facilities, or 4) expired.

Variables

Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance [4-8]. Patient general characteristics including age, gender, and race/ethnicity were collected. Other patient and clinical variables included were: 1) patient total ED length of stay (LOS), divided into two categories of LOS stay equal to or less than 4-hours and LOS longer than 4-hours, 2) patient waiting room time in minutes, 3) mode of arrival, divided into two categories of healthcare-assisted arrival (ambulance or hospital/healthcare facility-arranged transportation) and other (private car, public transportation, taxi, wheelchair, ambulatory, police, or unknown), 4) level of acuity, divided into three categories based on ESI (Emergency Severity Index) level including high (ESI 1-2), moderate (ESI 3), and low (ESI 4-5), 5) homeless status, 6) patient's last vital signs at disposition (including heart rate, respiratory rate, blood pressure, oxygenation, and temperature): divided into two categories of patients who had normal vital signs versus ones who had any abnormal vital signs (e.g. heart rate<50 or >100, respiratory rate <8 or >20, systolic blood pressure <90mmHg or >140mmHg, diastolic blood pressure <60mmHg or >90mmHg, pulse oximetry<94%, temperature >100.4F° or <96.8F°, 7) next healthcare visit (e.g. ED, PCP/specialist clinic, or none) and its time interval from the index ED discharge, 8) whether patients had a PCP assigned, 9) number of medications prescribed upon the index ED discharge, divided into two categories of patients who had prescriptions versus those who had none, 10) insurance status, and 11) presence of chronic disease, with chronic disease conditions were determined using the chronic condition indicator (CCI) for the international classification of diseases tenth revision, clinical modification (ICD-10-CM). CCI was developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ) [17].

Study Protocol

Patients were divided into those with discharge failure and those without discharge failure. General characteristics (age, gender, and ethnicity) and clinical variables (mode of arrival to ED, homeless status, PCP assignment conditions, history of chronic diseases, number of medications prescribed upon discharge, and ED total length of stay) were analyzed and compared separately. To determine and compare the

current status of patients with ED returns versus clinic follow-up, an inverse of the Kaplan-Meier survival curve was also drawn, which showed the proportion of patients (probability) that return to the ED and ones that visit the clinic within time frames of interest. Scoring systems were derived to differentiate patients with different models of discharge failure. Such scoring systems were then applied to patients for accuracy testing in predicting discharge failure in different models (e.g. predictive of 3-day, 7-day, 14-day, versus 30-days; predictive of restricted versus broad discharge failure models).

Derivation and Validation of SHOUT Scoring System

To identify potential ED discharge failure patients, the SHOUT (**S**creening for **H**ealthcare f**O**llow-**U**p **T**ool) scoring system was derived. Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance. We built five scoring systems using predictive logistic regression modeling. Each model predicted a specific outcome as defined below: broad discharge failure, and 3-day, 7-day, 14-day, and 30-day restricted discharge failure. In our sample, less than 5% of the patients had missing data on predictor variables (specific variables denoted in Table 1, see Supplemental Table 2). To build the predictive model for broad discharge failure, we used 50% of the data to train the model and 50% to test the model because we had a large sample size. We dichotomized the predictors for ease of use in clinical practice. Neither making the variables continuous nor including interaction terms added substantially to the model's performance, and we preferred parsimony for generalizability. To avoid over-fitting, we used the least absolute shrinkage and selection operator (LASSO) to fit the most informative but parsimonious model [18]. The LASSO model predicted a patient's probability of broad discharge failure, and we used a threshold value to classify the patient (0 or 1). Simple point scoring systems were then derived using methods described by Framingham with minor modifications [19]. We used the receiver operating characteristic (ROC) curve to define the threshold as the value that maximizes the model's sensitivity and minimizes the false positive rate. Because the model's primary purpose was to classify patients, we focused on the model's discriminative abilities. Accuracy of the prediction was reported with sensitivity, specificity, positive and negative likelihood ratios. Scores were calculated among all patients in both the derivation and validation groups, the sensitivity, specificity, positive and negative likelihood ratios, and AUC were compared between groups of different models in both the derivation and validation data.

Data Analysis

Student's t-test was used to compare continuous variables while Pearson Chi-square (χ^2) analysis was used to compare categorical variables between groups. We plotted the inverse of the Kaplan-Meier survival curves for the frequency comparison of patients who returned to ED versus those who had clinic follow-up after the index ED discharge. Methods used to derive and validate scoring systems are addressed above. All descriptive and statistical analyses were conducted using STATA 14.2 (College Station, TX). A *p* value <0.05 was considered statistically significant.

Patients and public involvement

Patients and the public were not directly involved in this study.

Results

General Information

A total of 227,627 ED discharged patients were retrieved from the EMR with only 33,357 patients categorized to the without discharge failure group (Figure 1). Overall, 85% (194,270/227,627) of patients were considered broad discharge failures and only 15% of ED discharged patients had their clinic follow-ups. When restricted discharge failure models were applied, 3.0% (6,715/227,627) of patients were considered restricted discharge failures within 30-days, 2.2% (4,957/227,627) within 14-days, 1.5% (3,518/227,627) within 7-days, and 0.9% (2,086/227,627) within 3-days. Patients who had restricted discharge failure were more likely white, homeless, relied on healthcare assisted transportations, had chronic disease conditions, had extended insurance coverage, and were less likely to have a primary care physician (PCP) assigned in comparison to patients with broad discharge failures. Patients with no discharge failures tended to be female, not homeless, used less health-assisted transportation, and had less PCP coverage (Table 1). When reverse Kaplan-Meier curves were drawn among the study patients who had either ED returns or clinical follow-up visits after the index ED discharge, it showed that 24% of patients returned to the ED within 7 days while 18% of patients had clinic follow-ups within 7 days. Similarly, 46% of patients returned to the ED within 30 days, and 45% of patients had a clinic follow-up within 30 days. At 32 days, the curves crossed indicating that patients sought clinic visits more frequently than ED return visits after 32 days. The graph also showed a median of 38 days for subsequent ED returns in comparison to a median of 37 days for subsequent clinic follow-up in this cohort (Figure 2). Our results indicated that a high frequency of ED returns occurred within the first 32 days from the index ED discharge.

Table 1. Study Patient General Characteristics

	Diverse Discharge Failure Models					Control
	Broad N=194,270	Restricted (3-day) N=2,086	Restricted (7-day) N=3,518	Restricted (14-day) N=4,957	Restricted (30-day) N=6,715	No Discharge Failure N=33,357
Age --- year mean(SD)	39 (16)	47(14)	47(14)	47(14)	47(14)	47(16)
median (IQR)	38(27,51)	49(37,58)	49(37,58)	49(37,57)	48(37,57)	49(36,58)
Race/Ethnicity (n, %)						
Non-Hispanic White	63,438 (33)	867 (42)	1,424 (40)	1,948 (39)	2,573 (38)	9,813 (29)
Others	130,832 (67)	1,219 (58)	2,094 (60)	3,009 (61)	4,142 (62)	23,544 (71)
Sex (n, %)						
Male	96882 (50)	1,160 (56)	1,868 (53)	2,514 (51)	3,238 (48)	12,141 (36)
Female	97380 (50)	926 (44)	1,650 (47)	2,443 (49)	3,477 (52)	21,216 (64)
PCP provider (n, %)						
Yes	129,345 (67)	445 (21)	658 (19)	821 (17)	1,014 (15)	3,621 (11)
No	64,925 (33)	1,641 (79)	2,860 (81)	4,136 (83)	5,701 (85)	29,736 (89)
Homeless (n, %)						
Yes	16,783 (9)	663 (32)	1,090 (31)	1,386 (28)	1,694 (25)	1,719 (5)
No	177,487 (91)	1,423 (68)	2,428 (69)	3,571 (72)	5,021 (75)	31,638 (95)
Means of arrival (n, %)						
Healthcare-assisted	51,181 (27)	802 (39)	1,268 (36)	1,682 (34)	2,106 (31)	5,449 (16)
Others	141,688 (73)	1,278 (61)	2,242 (64)	3,264 (66)	4,597 (69)	27,840 (84)
Any insurance (n, %)						
Yes	99,827 (51)	1,757 (84)	2,942 (84)	4,112 (83)	5,515 (82)	28,774 (86)

No	94,268 (49)	329 (16)	576 (16)	845 (17)	1,200 (18)	4,579 (14)
ESI level (n, %)						
ESI (1,2,3)	150,277 (78)	1,606 (77)	2,654 (76)	3,740 (76)	5,062 (75)	27,621 (83)
ESI (4,5)	43,423 (22)	477 (23)	859 (24)	1,211 (24)	1,646 (25)	5,680 (17)
Last vitals upon discharge (n, %)						
Normal	23,338 (13)	235 (12)	389 (12)	547 (12)	739 (11)	4,287 (13)
Abnormal	162,312 (87)	1,739 (88)	2,968 (88)	4,190 (88)	5,690 (89)	28,172 (87)
Any chronic conditions (n, %)						
Yes	91,194 (47)	1,338 (64)	2,277 (65)	3,161 (64)	4,224 (63)	18,649 (56)
No	103,076 (53)	748 (36)	1,241 (35)	1,796 (36)	2,491 (37)	14,708 (44)
Prescriptions upon discharge (n, %)						
Yes	129,198 (67)	1,177 (56)	2,086 (59)	3,050 (62)	4,322 (64)	22,356 (67)
No	65,072 (34)	909 (44)	1,432 (41)	1,907 (38)	2,393 (36)	11,001 (33)
Length of ED stay (n, %)						
Equal or longer than 4-hours	127,708 (66)	808 (39)	1,364 (39)	1,907 (38)	2,550 (38)	13, 964 (42)
Less than 4-hours	66,538 (34)	1,277 (61)	2,153 (61)	3,049 (62)	4,164 (62)	19,393 (58)

Derivation of SHOUT Scoring Systems for Diversity of Discharge Failure Models

Nine independent variables predicting discharge failures were: 1) homelessness; 2) PCP status; 3) Male gender; 4) history of chronic diseases; 5) lack of insurance; 6) low level of acuity (ESI 4-5); 7) White race/ethnicity; 8) arriving by health-assisted transportation; and 9) abnormal vital signs at discharge. These factors were incorporated into the SHOUT scores for discharge failure models (Table 2). These scores were applied back to the derivation data yielding good discriminations indicating the feasibility of using SHOUT scores for the initial screening of different discharge failure models (Table 3).

Table 2. SHOUT Scoring System for Different Discharge Failure Models

	Broad	Restricted (3-day)	Restricted (7-day)	Restricted (14-day)	Restricted (30-day)
Sex					
Female	0	0	0	0	0
Male	2	1	1	1	1
Race/Ethnicity					
Non-Hispanic White	1	1	1	1	1.5
Others	0	0	0	0	0
PCP provider assigned					
Yes	21	0	0	0	0
No	0	6	6	11	15.5
Homeless					
Yes	7	5	5	7	9
No	0	0	0	0	0
Means of arrival					

Health-care assisted	6	1	1	1.5	1.5
Others	0	0	0	0	0
Any insurance					
Yes	0	3	3	4	5
No	10.5	0	0	0	0
Last vital signs upon discharge					
Abnormal		1	1	1	1.5
Normal		0	0	0	0
ESI level					
ESI (1,2,3)	0	0	0	0	0
ESI (4, 5)	1.5	1	1	2	3
History of chronic conditions					
Yes	0	1	1	1.5	2
No	1	0	0	0	0
Score Range	0-50	0-20	0-20	0-30	0-40
Predicted Discharge Failure	≥9	≥9	≥9	≥14	≥20

Table 3. Predictive Performance of Different Discharge Failure Models in Derivation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.83 (0.83-0.84)	80%	71%	2.77	0.28
Restricted (3-days)	0.79 (0.78-0.80)	86%	60%	2.14	0.24
Restricted (7-days)	0.79 (0.79-0.80)	86%	60%	2.17	0.23
Restricted (14-days)	0.79 (0.78-0.80)	84%	61%	2.18	0.25
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.21	0.29

Validation of SHOUT Scoring System for Discharge Failure Models

SHOUT scores were again applied back to the study validation data using different discharge failure models. First, AUC comparisons of SHOUT scores predicting patients with restricted discharge failure within 3-days, 7-days, 14-days, and 30-days were performed. Similar AUCs predicted patients with short-term restricted discharge failure in this cohort (Table 4). Secondly, when the SHOUT score was applied to patients with broad discharge failures, higher AUC (0.84, 95% CI 0.84-0.84) yielded a sensitivity of 80%, specificity of 72%, positive likelihood of 2.85, and negative likelihood of 0.27 (Table 4).

Table 4. Predictive Performance of Different Discharge Failure Models in Validation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.84 (0.84-0.84)	80%	72%	2.85	0.27
Restricted (3-days)	0.79 (0.78-0.80)	85%	60%	2.13	0.25
Restricted (7-days)	0.80 (0.79-0.80)	87%	61%	2.20	0.22
Restricted (14-days)	0.79 (0.78-0.80)	85%	62%	2.21	0.24
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.22	0.29

Discussion

Timely arrangement of post-ED follow-up is critical to ensure patient safety, monitor patient disease progression, and adjust management properly [2,20]. In this study, we found higher ED returns occurred within the first 32 days whereas higher clinic follow-up occurred 32 days after the index ED discharge. If we considered ED returns without clinic follow-up as a broad concept of discharge failure, our findings might suggest implementing clinic follow-up within 32 days among these high-risk patients. Unfortunately, the median time for patient return to the ED (38 days) and clinic visit follow-up after the index ED discharge (37 days) were very close, indicating only arranging clinic follow-up did not prevent patients from ED returns. Therefore, differentiating patients with different type of discharge failures, whether failure occurred within the first 30 days, and broad discharge failure potential seem important to further implement efficient interventions in the future to enhance the clinic follow-up compliance among the cohort.

We thus introduced different discharge failure concepts and categorized patients as either having broad discharge failure potential or having short-term restricted discharge failure. The SHOUT scoring system was derived and internally validated to differentiate patients with different discharge failure models and proved to be broadly applicable among the types of discharge failure patients. It is reported that providing a follow-up appointment prior to the patient departing the ED can significantly increase follow-up care [21]. However, making real-time PCP appointments among all ED discharged patients might be challenge with limited healthcare resources. Therefore, our study differentiated patients between “broad” and “restricted” discharge failures and emphasized the “restricted” discharge failure patients. Patients with broad discharge failures accounted for most of the ED discharge patients (>85%) while patients with restricted discharge failures only accounted for a small portion (<5%). Given the uncertainty of ED returns and poor adherence for clinic follow-up, we believe that the restricted discharge failure prediction tool with its higher sensitivity and small patient size can provide better ED administrative value (e.g. capturing more patients and providing real-time patient PCP appointments at patient discharge). Whereas, a broad discharge failure tool with higher specificity and large patient size can better help with healthcare utilization (e.g. capturing more “true” discharge failure patients and limiting the urgent needs for PCP follow-up). Different institutions can choose the one that better fits their own operational needs.

This study has several strengths: 1) large sample size was used and applicable to diverse concepts of discharge failure thus reaching broad application; 2) the LASSO regression model improved the accuracy of identifying independent risks; 3) relatively simple and easy scoring calculations to predict patients with discharge failures; and 4) the SHOUT scoring system is different than other tools reported in the literature with more potential for applying to general population.

Risks identified in our study to predict patients with discharge failure have also been validated in previous studies to a certain level [3,4,13]. Lack of insurance coverage, lack of a PCP, homelessness, and chronic diseases are most commonly addressed in the literature with different discharge failure models [5,12,14,]. Lacking insurance coverage prevented patients from seeking healthcare follow-up and incentivized patients to use the ED as their medical home, which usually resulted in inappropriate ED utilization [22]. Patients with homelessness and chronic disease conditions more frequently had discharge failures due to the certain association between homeless patients and chronic disease conditions [23]. Studies showed homeless patients had more chronic diseases in comparison to general population [24]. Additionally,

homeless patients tended to use ED more often as their medical home resulting in higher inappropriate ED utilization [25]. Our study also showed patients of lower acuity (ESI 4-5), male gender, and non-Hispanic-White ethnicity had more discharge failure. Similar findings reported that patients with lower acuity, male gender, and White race/ethnicity had higher inappropriate ED visits and higher 72-hour ED returns [6,15]. However, such findings are controversial in different studies probably due to different study patient populations [26].

Though risks predictive of broad and restricted discharge failure seem similar, three risks had opposite effects on such predictions. Lack of PCP assignment, presence of chronic disease conditions, healthcare insurance coverage seemed to predict restricted discharge failure and protected patients from broad discharge failures. This might be partly due to current study hospital healthcare policies. The study hospital advocates for PCP assignments and clinic follow-up arrangements, provides charity insurance coverage among certain patients (e.g. high psychosocial risks, homeless, low-income residents, etc.), and has developed outreach programs for patients with special needs (e.g. homeless, chronic heart failure outreach programs, etc.) [25,27]. It has been reported that these patients had high risk of short-term ED returns (e.g. 72-h) both in the literature and in our own study [3,14,25]. In addition, such policies are not uncommon across publicly-funded or nonprofit hospitals in the US [28,29]. However, when applied to patients with long-term discharge failure potential, such effects protected against broad discharge failures. This is consistent to other reports in the literature [30]. Therefore, we believe the SHOUT score for broad discharge failure can be used more broadly in a diversity of hospital settings (e.g. charity, public-funded, Veteran Affair, private or community hospitals, etc.). However, the SHOUT score for restricted discharge failure might be limited to public-funded hospitals with similar policies as the study hospital.

Our study has its own limitations. First, with a study design using a single-center, retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided. In this study, not all patients had EMR data after one-year of post ED discharge which might potentially affect the accuracy of SHOUT scores. In addition, we were unable to capture patient follow-up information if follow up occurred outside of the study hospital system. Secondly, we were not able to include all potential variables that may predict study outcomes. However, ED providers are busy during clinical shifts with limited time to collect pertinent information. We intended to include convenient variables that can be common and easily identified within a short period to make it feasible for any ED. Thirdly, though SHOUT scores can identify patients with potential risk of discharge failure, based on the AUC results, these models have good but not excellent discrimination. Using our recommended cutoff scores yielded fair sensitivities and specificities but not excellent ones. Considering such outcomes are multifactorial with the diversity of patient populations, it is challenging to derive scoring systems with both higher sensitivity/specificity and excellent discrimination. Such scoring systems might only be used as initial screening tools, and further multi-center external validation is warranted.

In summary, **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) might be used as initial screening to differentiate patients with different discharge failure models. It can be used to identify patients with broad or restricted discharge failure potentials. However, its use might be limited only in publicly-funded or not-for-profit hospitals similar as the study hospital.

Figure legend:

Figure 1 shows the study flow diagram

Figure 2 shows time to next-event curve to determine the probability of subsequent events (ED return vs. clinic follow-up) occurring among discharged patients

Reference List

1. Misky GJ, Wald HL, Coleman EA: **Post-hospitalization transitions: Examining the effects of timing of primary care provider follow-up.** *J Hosp Med* 2010, **5:** 392-397.

2. Schull MJ: **Making aftercare more than an afterthought: patient follow-up after emergency department discharge in Ontario.** *Healthc Q* 2014, **17:** 11-13.

3. Pham JC, Kirsch TD, Hill PM, DeRuggerio K, Hoffmann B: **Seventy-two-hour returns may not be a good indicator of safety in the emergency department: a national study.** *Acad Emerg Med* 2011, **18:** 390-397.

4. Magnusson AR, Hedges JR, Vanko M, McCarten K, Moorhead JC: **Follow-up compliance after emergency department evaluation.** *Ann Emerg Med* 1993, **22:** 560-567.

5. Klinkenberg WD, Calsyn RJ: **The moderating effects of race on return visits to the psychiatric emergency room.** *Psychiatr Serv* 1997, **48:** 942-945.

6. Khan NU, Razzak JA, Saleem AF, Khan UR, Mir MU, Aashiq B: **Unplanned return visit to emergency department: a descriptive study from a tertiary care hospital in a low-income country.** *Eur J Emerg Med* 2011, **18:** 276-278.

7. McCusker J, Cardin S, Bellavance F, Belzile E: **Return to the emergency department among elders: patterns and predictors.** *Acad Emerg Med* 2000, **7:** 249-259.

8. Graf CE, Giannelli SV, Herrmann FR, Sarasin FP, Michel JP, Zekry D *et al.*: **Can we improve the detection of old patients at higher risk for readmission after an emergency department visit?** *J Am Geriatr Soc* 2012, **60:** 1372-1373.

9. Hegney D, Buikstra E, Chamberlain C, March J, McKay M, Cope G *et al.*: **Nurse discharge planning in the emergency department: a Toowoomba, Australia, study.** *J Clin Nurs* 2006, **15:** 1033-1044.

10. Runciman P, Currie CT, Nicol M, Green L, McKay V: **Discharge of elderly people from an accident and emergency department: evaluation of health visitor follow-up.** *J Adv Nurs* 1996, **24:** 711-718.

11. Moons P, De RK, Geyskens K, Sabbe M, Braes T, Flamaing J *et al.*: **Screening for risk of readmission of patients aged 65 years and above after discharge from the emergency department: predictive value of four instruments.** *Eur J Emerg Med* 2007, **14:** 315-323.

12. Boudreaux ED, Clark S, Camargo CA, Jr.: **Telephone follow-up after the emergency department visit: experience with acute asthma. On behalf of the MARC Investigators.** *Ann Emerg Med* 2000, **35:** 555-563.

13. Lamantia MA, Platts-Mills TF, Biese K, Khandelwal C, Forbach C, Cairns CB *et al.*: **Predicting hospital admission and returns to the emergency department for elderly patients.** *Acad Emerg Med* 2010, **17:** 252-259.

14. White D, Kaplan L, Eddy L: **Characteristics of patients who return to the emergency department within 72 hours in one community hospital.** *Adv Emerg Nurs J* 2011, **33:** 344-353.

15. Heng KW, Tham KY, How KY, Foo JS, Lau YH, Li AY: **Recall of discharge advice given to patients with minor head injury presenting to a Singapore emergency department.** *Singapore Med J* 2007, **48:** 1107-1110.

16. Ballard DW, Price M, Fung V, Brand R, Reed ME, Fireman B *et al.*: **Validation of an algorithm for categorizing the severity of hospital emergency department visits.** *Med Care* 2010, **48:** 58-63.

17. Agency for Healthcare Research and Quality . Beta Chronic Condition Indicator (CCI) for ICD-10-CM. 2018. Ref Type: Online Source

18. Friedman J, Hastie T, Tibshirani R: **Regularization Paths for Generalized Linear Models via Coordinate Descent.** *J Stat Softw* 2010, **33:** 1-22.

19. Sullivan LM, Massaro JM, D'Agostino RB, Sr.: **Presentation of multivariate data for clinical use: The Framingham Study risk score functions.** *Stat Med* 2004, **23:** 1631-1660.

20. Schectman JM, Schorling JB, Voss JD: **Appointment adherence and disparities in outcomes among patients with diabetes.** *J Gen Intern Med* 2008, **23:** 1685-1687.

21. Atzema CL, Maclagan LC: **The Transition of Care Between Emergency Department and Primary Care: A Scoping Study.** *Acad Emerg Med* 2017, **24:** 201-215.

22. Gandhi SO, Grant LP, Sabik LM: **Trends in nonemergent use of emergency departments by health insurance status.** *Med Care Res Rev* 2014, **71:** 496-521.

23. McCarthy ML, Hirshon JM, Ruggles RL, Docimo AB, Welinsky M, Bessman ES: **Referral of medically uninsured emergency department patients to primary care.** *Acad Emerg Med* 2002, **9:** 639-642.

24. Wiersma P, Epperson S, Terp S, LaCourse S, Finton B, Drenzek C *et al.*: **Episodic illness, chronic disease, and health care use among homeless persons in Metropolitan Atlanta, Georgia, 2007.** *South Med J* 2010, **103:** 18-24.

25. Wang H, Nejtek VA, Zieger D, Robinson RD, Schrader CD, Phariss C *et al.*: **The role of charity care and primary care physician assignment on ED use in homeless patients.** *Am J Emerg Med* 2015, **33:** 1006-1011.

26. Goldman RD, Ong M, Macpherson A: **Unscheduled return visits to the pediatric emergency department-one-year experience.** *Pediatr Emerg Care* 2006, **22:** 545-549.

27. Nejtek VA, Aryal S, Talari D, Wang H, O'Neill L: **A pilot mobile integrated healthcare program for frequent utilizers of emergency department services.** *Am J Emerg Med* 2017, **35:** 1702-1705.

28. Mercer T, Bae J, Kipnes J, Velazquez M, Thomas S, Setji N: **The highest utilizers of care: individualized care plans to coordinate care, improve healthcare service utilization, and reduce costs at an academic tertiary care center.** *J Hosp Med* 2015, **10:** 419-424.

29. Gingold DB, Pierre-Mathieu R, Cole B, Miller AC, Khaldun JS: **Impact of the Affordable Care Act Medicaid expansion on emergency department high utilizers with ambulatory care sensitive conditions: A cross-sectional study.** *Am J Emerg Med* 2017, **35:** 737-742.

30. Yeatts KB, Lippmann SJ, Waller AE, Hassmiller LK, Travers D, Weinberger M *et al.*: **Population-based burden of COPD-related visits in the ED: return ED visits, hospital admissions, and comorbidity risks.** *Chest* 2013, **144:** 784-793.

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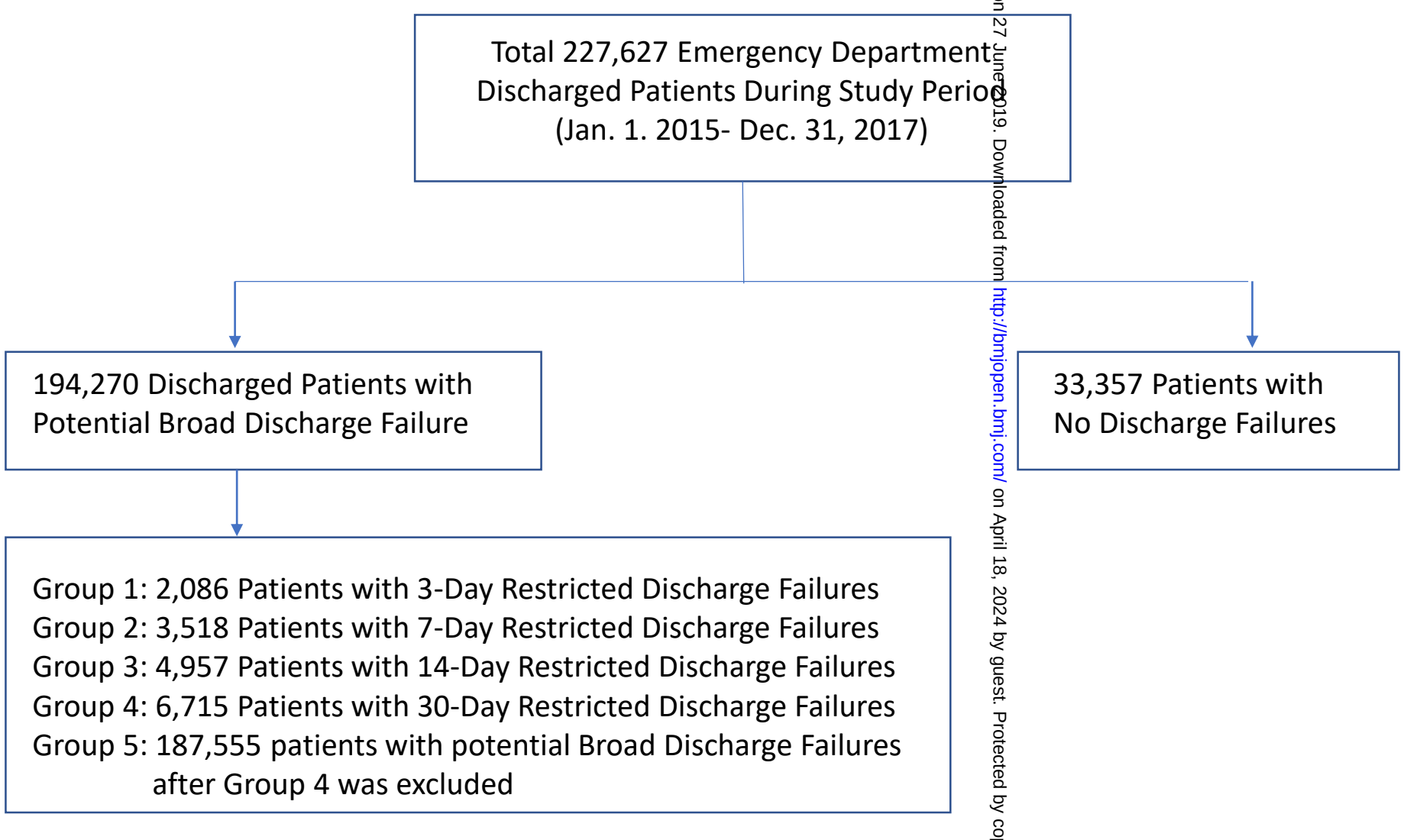

Figure 1. Study Flow Diagram

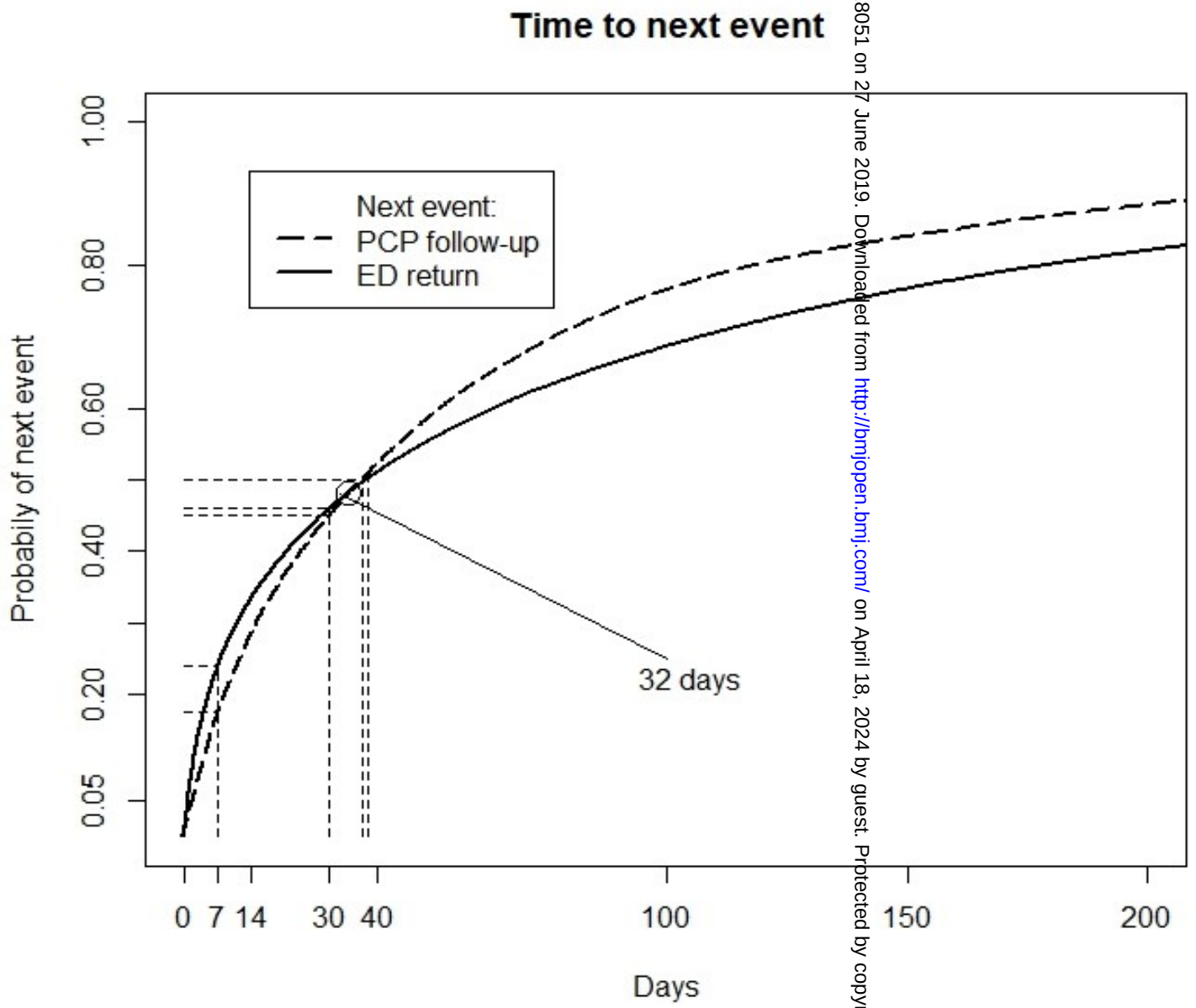

Figure 2. Time to Next-Event Curve to Determine the Probability of Subsequent Events (ED Return vs. Clinic Follow-up) Occurred Among Study Discharged Patients

Supplemental Table 1. Detail Information of Broad Discharge Failure Patients

Broad Discharge Failure Patients (N=194,270)*	
1)patients who no PCP/specialist follow-ups from the index ED discharge	
patients had neither subsequent ED nor clinical visits	84,049
patients had ED visits but no clinical visits	75,605
2)patients had clinic visits longer than one year from the index ED visit	
patients had ED visits but clinic visits longer than one year	7,136
patients had no ED visits but clinic visits longer than one year	1,398
3)patients returned to ED prior to their clinic follow-up	30,234
4)patients ED returns and clinical visits fell on the same day	299
5)patients with ED returns within 30 days from the index ED discharge	50,996

*the number of each category added up exceeds the total number of patients due to same patients meeting multiple categories.

Supplemental Table 2. Number of Study Missing Variables

	Total Sample Size (N=227,627)
Gender, n (%)	8 (0.004)
Race, n (%)	0
Homeless, n (%)	0
Mode of Arrival, n(%)	1469 (0.6)
Chronic Disease Conditions, n (%)	0
Insurance, n (%)	179 (0.08)
Primary Care Physician Assignment, n (%)	0
ESI level of acuity, n (%)	626 (0.3)
Prescriptions, n (%)	0
Prolonged ED Length of Stay, n (%)	24 (0.01)
Abnormal vital signs, n(%)	9518 (4.2)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	6

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		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

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Title Page

Complete Manuscript Title: Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Running Head: ED Discharge Failure Scoring Systems

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Abstract

OBJECTIVES: Identifying patients who are high risk for discharge failure allows for implementation of interventions to improve their care. However, discharge failure is currently defined in literature with great variability, making targeted interventions more difficult. We aim to derive a screening tool based on the existing diverse discharge failure models.

DESIGN, SETTING, AND PARTICIPANTS: This is a single-center retrospective cohort study. Data from all patients discharged from the Emergency Department (ED) were collected from Jan. 1, 2015 through Dec. 31, 2017 and followed up within 30-days.

METHODS: Scoring systems were derived using modified Framingham methods. Sensitivity, specificity, and area under the receiver operational characteristic (AUC) were calculated and compared using both the broad and restricted discharge failure models.

RESULTS: A total of 227,627 patients were included. The **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) scoring system was derived based on the broad and restricted discharge failure models and applied back to the entire study cohort. A sensitivity of 80% and a specificity of 71% were found in SHOUT scores to identify patients with broad discharge failure with AUC of 0.83 (95% CI 0.83-0.84). When applied to a 3-day restricted discharge failure model, a sensitivity of 86% and a specificity of 60% were found to identify patients with AUC of 0.79 (95% CI 0.78-0.80).

CONCLUSIONS: The SHOUT scoring system was derived and used to screen and identify patients that would ultimately become discharge failures, especially when using broad definitions of discharge failure. The SHOUT tool was internally validated and can be used to identify patients across a wide spectrum of discharge failure definitions.

Key Words: Emergency Department, Discharge Failure, Follow-up, Return Visit

Strengths and Limitations of this study:

1) The SHOUT scoring system is different than other tools reported in the literature and has more potential for applying to the general population.
2) The SHOUT scoring system was derived from a large sample size and is applicable to diverse concepts of discharge failure model, giving it broad application.
3) This is a relatively simple and easy scoring calculation to predict patients with different types of discharge failures.
4) To the best of our knowledge, this is the first reported ED discharge failure prediction tool that combined all validated discharge failure risk factors using a LASSO regression model, making it a more accurate model.
5) As a single-center retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided.

Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Introduction

Traditional practice recommends arranging timely clinic follow-up for patients who are discharged from the Emergency Department (ED). Such follow up has been shown to improve patient-centered care specifically for disease prevention, monitoring, and management [1,2]. However, nearly one-third of ED patients who have sought access to health care rarely follow up with their primary care physician (PCP) or specialist after ED discharge [2]. Such patients were historically considered a discharge failure. However, the definition of discharge failure varies among most studies. A very broad definition used in previous studies included patients who had no-showed for a clinic appointment after an index ED discharge, had no clinic appointment after an index ED discharge, or had short ED returns (e.g. 3-day, 7-day, 14-day, or 30-day) [3-6]. Such definitions may not be accurate since patents might use the ED for episodic acute care and have no urgent clinic follow-up needs. On the other hand, patients with extremely short ED returns or that had significant deviation from the usual treatment regimen following an index ED visit may have been inappropriately discharged in the first place from their initial ED visit. Alternatively, their ED return could be unrelated to the initial visit. We believe that a more restricted definition of discharge failure truly reflecting the value of arranging timely clinic follow-up should be applied. Unfortunately, such studies are lacking in the current literature.

Six screening tools have been reported currently to identify patients with high risk potential for discharge failure [7-11]. However, all of these tools are intended for screening older patients with poor-to-moderate discrimination, and none of them can be used in general patient populations. A majority of these tools used self-assessed questionnaires (e.g. assistance with daily activity, healthcare recommendation for added assistance, having a predicted need for more help after ED discharge, etc.) and rarely linked screening with predictive risk factors [9-11]. Many studies in the past have identified a variety of risk factors predictive of discharge failure [3,4,12]. The most common validated ones are either social or medical factors. These common biological and social factors include insurance type, homelessness, lack of PCP, age, sex, and race/ethnicity [4,5,7,12,13], whereas medical factors could be attributed to alcohol/drug history and chronic medical conditions [14,15]. Given that validated risk factors have already been reported, the derivation of a tool associated with such factors might be beneficial.

Our goal is to identify patients at risks for discharge failures so that efficient interventions can be implemented to prevent ED returns, reduce cost, and save health care resources. Therefore, we aim to 1) determine the differences in ED discharged patients using either a broad or restricted discharge failure model; and 2) derive novel tools associated with predictive risk factors for the initial screening of ED patients for discharge failures.

Methods

Study Setting and Design

This was a single-center retrospective cohort study. The study hospital is a publicly-funded county hospital and urban tertiary referral center. The study hospital ED is a level-1 trauma center, acute chest pain and comprehensive stroke center whose ED volume reached approximately 120,000 visits annually. The ED also sponsors an Emergency Medicine (EM) residency program. This study was approved by John Peter Smith Health Network Institutional Review Board.

Study Participants

Patients who presented to study ED from Jan.1, 2015 to Dec. 31, 2017 and were subsequently discharged after the index ED visit were included in this study. The study hospital system uses the same Electronic Medical Record (EMR) including ED, hospital, and clinics. The medical record of all enrolled patients was retrieved automatically until Feb. 1, 2018. This allowed all enrolled patients to have 30 days after the index ED discharge to follow up. All patient data was electronically retrieved by data managers from the Department of Information Technology. We excluded patients during the index ED visits who 1) were admitted, 2) expired, 3) transferred to other facilities, 4) left without being seen (LWBS), eloped, or left against medical advice (AMA), and 5) prisoners. Since this study mainly focused on the characteristics of discharge failure, we further divided discharged patients into two large categories of patients without discharge failure and patients with broad discharge failure potential. We defined patients without discharge failure as meeting all of the following criteria: 1) patients visited their PCP/specialist clinic within one year from the index ED discharge (under normal circumstance, at least one clinic visit should be ranged every year for regular check-up and screening); 2) patients visited their PCP/specialist clinics prior to their ED revisits; and 3) patients had no ED revisits within 30 days.

Broad and Restricted Discharge Failure Models

In general, discharge failure was defined as ED revisits within a short period of time from the index ED visit (e.g. 3-day, 7-day, 14-day, or 30-days) and poor patient adherence to PCP or specialist clinic follow-up. We divided patients with discharge failure into broad and restricted categories. Patients with restricted discharge failures were confirmed discharge failure within 30 days from the index ED discharges. Whereas, patients with broad discharge failures included not only ones with confirmed discharge failures but also ones with discharge failure potential or uncertainty. Broad discharge failure was considered if patients met one of the following criteria: 1) patient had no PCP/specialist follow-ups from the index ED discharge; 2) patient had clinic follow-up longer than one year from the index ED discharge; 3) patients returned to the ED prior to their clinical follow-up; 4) patients with ED returns and clinic visits on the same day; and 5) patients with ED returns within 30-days from the index ED discharge. (see detail in Supplemental Table-1). As mentioned above, multiple factors can impact patient follow up after the index ED discharge (e.g. patient conditions do not require clinical follow-up, patient ED condition completely resolved, etc.). Additionally, patients could revisit the ED appropriately or unrelated to their initial ED visit prior to their clinic follow-ups (e.g. acute trauma). These patients might need to be excluded from the discharge failure category. Therefore, a more restricted discharge failure model was applied to the study patients. Restricted discharge failure was considered if patients met all the following criteria: 1) patients returned to the ED prior to their clinic follow-ups, 2) such ED revisits were within 30-days from the index ED discharge, and 3) patients were discharged from their ED return and the visit reason was considered inappropriate ED utilization. To satisfy diverse concepts of discharge failure in the literature, we expanded our restricted discharge failure models to the following four extended-restricted discharge failure groups: 1) restricted discharge failure with subsequent ED return of <3-days); 2) restricted discharge failure with

ED return of <7-days; 3) restricted discharge failure with ED return of <14-days; and 4) restricted discharge failure with ED return of <30-days.

Appropriateness of ED Utilization

New York University ED Algorithm (NYUA) was used in this study to determine the appropriateness of ED ED return visits [16]. Briefly, the four major categories were used in NYUA: 1) emergent and not avoidable, considered appropriate ED visits; 2) primary care treatable, defined as care that can be safely provided in a primary care setting without the need for emergent treatment; 3) emergent care needed but preventable/avoidable, defined as patients whose disease conditions can be prevented/avoided if preventive care is received in a timely fashion; and 4) non-emergent. Appropriate ED utilization was considered if patients met the emergent not avoidable category criteria and inappropriate utilization was determined if patients were classified within the other three categories. However, since NYUA is only used to determine the appropriateness of ED utilization among ED discharged patients, for patients who revisited ED within 30-days, appropriate ED utilization was also considered if such patients were: 1) admitted to hospital, 2) moved to the Operating Room, 3) transferred to other facilities, or 4) expired.

Variables

Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance [4-8]. Patient general characteristics including age, sex, and race/ethnicity were collected. Other patient and clinical variables included were: 1) patient total ED length of stay (LOS), divided into two categories of LOS stay equal to or less than 4-hours and LOS longer than 4-hours, 2) patient waiting room time in minutes, 3) mode of arrival, divided into two categories of healthcare-assisted arrival (ambulance or hospital/healthcare facility-arranged transportation) and other (private car, public transportation, taxi, wheelchair, ambulatory, police, or unknown), 4) level of acuity, divided into three categories based on ESI (Emergency Severity Index) level including high (ESI 1-2), moderate (ESI 3), and low (ESI 4-5), 5) homeless status, 6) patient's last vital signs at disposition (including heart rate, respiratory rate, blood pressure, oxygenation, and temperature): divided into two categories of patients who had normal vital signs versus ones who had any abnormal vital signs (e.g. heart rate<50 or >100, respiratory rate <8 or >20, systolic blood pressure <90mmHg or >140mmHg, diastolic blood pressure <60mmHg or >90mmHg, pulse oximetry<94%, temperature >100.4F° or <96.8F°, 7) next healthcare visit (e.g. ED, PCP/specialist clinic, or none) and its time interval from the index ED discharge, 8) whether patients had a PCP assigned, 9) number of medications prescribed upon the index ED discharge, divided into two categories of patients who had prescriptions versus those who had none, 10) insurance status, and 11) presence of chronic disease, with chronic disease conditions were determined using the chronic condition indicator (CCI) for the international classification of diseases tenth revision, clinical modification (ICD-10-CM). CCI was developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ) [17].

Derivation and Validation of SHOUT Scoring System

To identify potential ED discharge failure patients, the SHOUT (**S**creening for **H**ealthcare f**O**llow-**U**p **T**ool) scoring system was derived. Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance. We built five scoring systems using predictive logistic regression modeling. Each model predicted a specific

outcome as defined above: broad discharge failure, and 3-day, 7-day, 14-day, and 30-day restricted discharge failure. In our sample, less than 5% of the patients had missing data on predictor variables (specific variables denoted in Table 1, see Supplemental Table 2). To build the predictive model for broad discharge failure, we used 50% of the data to train the model and 50% to test the model because we had a large sample size. We dichotomized the predictors for ease of use in clinical practice. Neither making the variables continuous nor including interaction terms added substantially to the model's performance, and we preferred parsimony for generalizability. To avoid over-fitting, we used the least absolute shrinkage and selection operator (LASSO) to fit the most informative but parsimonious model [18]. The LASSO model predicted a patient's probability of broad discharge failure, and we used a threshold value to classify the patient (0 or 1). Simple point scoring systems were then derived using methods described by Framingham with minor modifications [19]. We used the receiver operating characteristic (ROC) curve to define the threshold as the value that maximizes the model's sensitivity and minimizes the false positive rate (1-specificity). Because the model's primary purpose was to classify patients, we focused on the model's discriminative abilities. Accuracy of the prediction was reported with sensitivity, specificity, positive and negative likelihood ratios. Scores were calculated among all patients in both the derivation and validation groups, the sensitivity, specificity, positive and negative likelihood ratios, and AUC were compared between groups of different models in both the derivation and validation data.

Data Analysis

Student's t-test was used to compare continuous variables while Pearson Chi-square (χ^2) analysis was used to compare categorical variables between groups. We plotted the inverse of the Kaplan-Meier survival curves for the frequency comparison of patients who returned to ED versus those who had clinic follow-up after the index ED discharge. Methods used to derive and validate scoring systems are addressed above. All descriptive and statistical analyses were conducted using STATA 14.2 (College Station, TX). A p value <0.05 was considered statistically significant.

Patients and public involvement

Patients and the public were not directly involved in this study

Results

General Information

A total of 227,627 ED discharged patients were retrieved from the EMR with only 33,357 patients categorized to the without broad discharge failure group (Figure 1). Overall, 85% (194,270/227,627) of patients were considered broad discharge failures and only 15% of ED discharged patients had their clinic follow-ups within the study period. When restricted discharge failure models were applied, 3.0% (6,715/227,627) of patients were considered restricted discharge failures within 30-days, 2.2% (4,957/227,627) within 14-days, 1.5% (3,518/227,627) within 7-days, and 0.9% (2,086/227,627) within 3-days. Patients who had restricted discharge failure were more likely white, homeless, relied on healthcare assisted transportations, had chronic disease conditions, had extended insurance coverage, and were less likely to have a primary care physician (PCP) assigned in comparison to patients with broad discharge failures. Patients with no discharge failures tended to be female, not homeless, used less health-assisted transportation, and had less PCP coverage (Table 1). When reverse Kaplan-Meier curves were drawn among the study patients who had either ED returns or clinical follow-up visits after the index ED discharge,

it showed that 24% of patients returned to the ED within 7 days while 18% of patients had clinic follow-ups within 7 days. Similarly, 46% of patients returned to the ED within 30 days, and 45% of patients had a clinic follow-up within 30 days. At 32 days, the curves crossed indicating that patients sought clinic visits more frequently than ED return visits after 32 days. The graph also showed a median of 38 days for subsequent ED returns in comparison to a median of 37 days for subsequent clinic follow-up in this cohort (Figure 2). Our results indicated that a high frequency of ED returns occurred within the first 32 days from the index ED discharge.

Table 1. Study Patient General Characteristics

	Diverse Discharge Failure Models					Control
	Broad N=194,270	Restricted (3-day) N=2,086	Restricted (7-day) N=3,518	Restricted (14-day) N=4,957	Restricted (30-day) N=6,715	No Discharge Failure N=33,357
Age --- year mean(SD)	39 (16)	47(14)	47(14)	47(14)	47(14)	47(16)
median (IQR)	38(27,51)	49(37,58)	49(37,58)	49(37,57)	48(37,57)	49(36,58)
Race/Ethnicity (n, %)						
Non-Hispanic White	63,438 (33)	867 (42)	1,424 (40)	1,948 (39)	2,573 (38)	9,813 (29)
Others	130,832 (67)	1,219 (58)	2,094 (60)	3,009 (61)	4,142 (62)	23,544 (71)
Sex (n, %)						
Male	96882 (50)	1,160 (56)	1,868 (53)	2,514 (51)	3,238 (48)	12,141 (36)
Female	97380 (50)	926 (44)	1,650 (47)	2,443 (49)	3,477 (52)	21,216 (64)
PCP provider (n, %)						
Yes	129,345 (67)	445 (21)	658 (19)	821 (17)	1,014 (15)	3,621 (11)
No	64,925 (33)	1,641 (79)	2,860 (81)	4,136 (83)	5,701 (85)	29,736 (89)
Homeless (n, %)						
Yes	16,783 (9)	663 (32)	1,090 (31)	1,386 (28)	1,694 (25)	1,719 (5)
No	177,487 (91)	1,423 (68)	2,428 (69)	3,571 (72)	5,021 (75)	31,638 (95)
Means of arrival (n, %)						
Healthcare-assisted	51,181 (27)	802 (39)	1,268 (36)	1,682 (34)	2,106 (31)	5,449 (16)
Others	141,688 (73)	1,278 (61)	2,242 (64)	3,264 (66)	4,597 (69)	27,840 (84)
Any insurance (n, %)						
Yes	99,827 (51)	1,757 (84)	2,942 (84)	4,112 (83)	5,515 (82)	28,774 (86)
No	94,268 (49)	329 (16)	576 (16)	845 (17)	1,200 (18)	4,579 (14)
ESI level (n, %)						
ESI (1,2,3)	150,277 (78)	1,606 (77)	2,654 (76)	3,740 (76)	5,062 (75)	27,621 (83)
ESI (4,5)	43,423 (22)	477 (23)	859 (24)	1,211 (24)	1,646 (25)	5,680 (17)
Last vitals upon discharge (n, %)						
Normal	23,338 (13)	235 (12)	389 (12)	547 (12)	739 (11)	4,287 (13)
Abnormal	162,312 (87)	1,739 (88)	2,968 (88)	4,190 (88)	5,690 (89)	28,172 (87)
Any chronic conditions (n, %)						
Yes	91,194 (47)	1,338 (64)	2,277 (65)	3,161 (64)	4,224 (63)	18,649 (56)

No	103,076 (53)	748 (36)	1,241 (35)	1,796 (36)	2,491 (37)	14,708 (44)
Prescriptions upon discharge (n, %)						
Yes	129,198 (67)	1,177 (56)	2,086 (59)	3,050 (62)	4,322 (64)	22,356 (67)
No	65,072 (34)	909 (44)	1,432 (41)	1,907 (38)	2,393 (36)	11,001 (33)
Length of ED stay (n, %)						
Equal or longer than 4-hours	127,708 (66)	808 (39)	1,364 (39)	1,907 (38)	2,550 (38)	13, 964 (42)
Less than 4-hours	66,538 (34)	1,277 (61)	2,153 (61)	3,049 (62)	4,164 (62)	19,393 (58)

Derivation of SHOUT Scoring Systems for Diversity of Discharge Failure Models

Nine independent variables predicting discharge failures were: 1) homelessness; 2) PCP status; 3) Male sex; 4) history of chronic diseases; 5) lack of insurance; 6) low level of acuity (ESI 4-5); 7) White race/ethnicity; 8) arriving by health-assisted transportation; and 9) abnormal vital signs at discharge. These factors were incorporated into the SHOUT scores for discharge failure models (Table 2). These scores were applied back to the derivation data yielding good discriminations indicating the feasibility of using SHOUT scores for the initial screening of different discharge failure models (Table 3).

Table 2. SHOUT Scoring System for Different Discharge Failure Models

	Broad	Restricted (3-day)	Restricted (7-day)	Restricted (14-day)	Restricted (30-day)
Sex					
Female	0	0	0	0	0
Male	2	1	1	1	1
Race/Ethnicity					
Non-Hispanic White	1	1	1	1	1.5
Others	0	0	0	0	0
PCP provider assigned					
Yes	21	0	0	0	0
No	0	6	6	11	15.5
Homeless					
Yes	7	5	5	7	9
No	0	0	0	0	0
Means of arrival					
Health-care assisted	6	1	1	1.5	1.5
Others	0	0	0	0	0
Any insurance					
Yes	0	3	3	4	5
No	10.5	0	0	0	0
Last vital signs upon discharge					
Abnormal		1	1	1	1.5
Normal		0	0	0	0
ESI level					
ESI (1,2,3)	0	0	0	0	0
ESI (4, 5)	1.5	1	1	2	3

History of chronic conditions					
Yes	0	1	1	1.5	2
No	1	0	0	0	0
Score Range	0-50	0-20	0-20	0-30	0-40
Predicted Discharge Failure	≥9	≥9	≥9	≥14	≥20

Table 3. Predictive Performance of Different Discharge Failure Models in Derivation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.83 (0.83-0.84)	80%	71%	2.77	0.28
Restricted (3-days)	0.79 (0.78-0.80)	86%	60%	2.14	0.24
Restricted (7-days)	0.79 (0.79-0.80)	86%	60%	2.17	0.23
Restricted (14-days)	0.79 (0.78-0.80)	84%	61%	2.18	0.25
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.21	0.29

Validation of SHOUT Scoring System for Discharge Failure Models

SHOUT scores were again applied back to the study validation data using different discharge failure models. First, AUC comparisons of SHOUT scores predicting patients with restricted discharge failure within 3-days, 7-days, 14-days, and 30-days were performed. Similar AUCs predicted patients with short-term restricted discharge failure in this cohort (Table 4). Secondly, when the SHOUT score was applied to patients with broad discharge failures, higher AUC (0.84, 95% CI 0.84-0.84) yielded a sensitivity of 80%, specificity of 72%, positive likelihood of 2.85, and negative likelihood of 0.27 (Table 4).

Table 4. Predictive Performance of Different Discharge Failure Models in Validation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.84 (0.84-0.84)	80%	72%	2.85	0.27
Restricted (3-days)	0.79 (0.78-0.80)	85%	60%	2.13	0.25
Restricted (7-days)	0.80 (0.79-0.80)	87%	61%	2.20	0.22
Restricted (14-days)	0.79 (0.78-0.80)	85%	62%	2.21	0.24
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.22	0.29

Discussion

Timely arrangement of post-ED follow-up is critical to ensure patient safety, monitor patient disease progression, and adjust management properly [2,20]. The SHOUT scoring system was derived and internally validated to differentiate patients with different discharge failure models and shown to be broadly applicable among the types of discharge failure patients. In this study, we categorized patients as either having broad discharge failure potential or having short-term restricted discharge failure. Our study findings add some evidence to the literature pool on capable of early recognizing different ED discharge

failure patients, thus could provide the potential to implement interventions earlier to prevent discharge failures.

It is reported that providing a follow-up appointment prior to the patient departing the ED can significantly increase follow-up care [21]. However, making real-time PCP appointments among all ED discharged patients might be challenge with limited healthcare resources. Therefore, our study differentiated patients between "broad" and "restricted" discharge failures. Given the uncertainty of ED returns and poor adherence for clinic follow-up, we believe that the restricted discharge failure prediction tool with its higher sensitivity and small patient size can provide better ED administrative value (e.g. capturing more patients and providing real-time patient PCP appointments at patient discharge). Whereas, a broad discharge failure tool with higher specificity and large patient size can better help with healthcare utilization (e.g. capturing more "true" discharge failure patients and limiting the urgent needs for PCP follow-up). Different institutions can choose the one that better fits their own operational needs.

Risks identified in our study to predict patients with discharge failure have also been validated in previous studies to a certain level [3,4,13]. Lack of insurance coverage, lack of a PCP, homelessness, and chronic diseases are most commonly addressed in the literature with different discharge failure models [5,12,14,]. Lacking insurance coverage prevented patients from seeking healthcare follow-up and incentivized patients to use the ED as their medical home, which usually resulted in inappropriate ED utilization [22]. Patients with homelessness and chronic disease conditions more frequently had discharge failures due to the certain association between homeless patients and chronic disease conditions [23]. Studies showed homeless patients had more chronic diseases in comparison to general population [24]. Additionally, homeless patients tended to use ED more often as their medical home resulting in higher inappropriate ED utilization [25]. Our study also showed patients of lower acuity (ESI 4-5), male, and non-Hispanic-White ethnicity had more discharge failure. Similar findings reported that patients with lower acuity, male , and White race/ethnicity had higher inappropriate ED visits and higher 72-hour ED returns [6,15]. However, such findings are controversial in different studies probably due to different study patient populations [26].

Though risks predictive of broad and restricted discharge failure seem similar, three risks had opposite effects on such predictions. Lack of PCP assignment, presence of chronic disease conditions, healthcare insurance coverage seemed to predict restricted discharge failure and protected patients from broad discharge failures. This might be partly due to current study hospital healthcare policies. The study hospital advocates for PCP assignments and clinic follow-up arrangements, provides charity insurance coverage among certain patients (e.g. high psychosocial risks, homeless, low-income residents, etc.), and has developed outreach programs for patients with special needs (e.g. homeless, chronic heart failure outreach programs, etc.) [25,27]. It has been reported that these patients had high risk of short-term ED returns (e.g. 72-h) both in the literature and in our own study [3,14,25]. In addition, such policies are not uncommon across publicly-funded or nonprofit hospitals in the US [28,29]. However, when applied to patients with long-term discharge failure potential, such effects protected against broad discharge failures. This is consistent to other reports in the literature [30]. Therefore, we believe the SHOUT score for broad discharge failure can be used more broadly in a diversity of hospital settings (e.g. charity, public-funded, Veteran Affair, private or community hospitals, etc.). However, the SHOUT score for restricted discharge failure might be limited to public-funded hospitals with similar policies as the study hospital.

This study has several strengths: 1) large sample size was used and applicable to diverse concepts of discharge failures; 2) the LASSO regression model improved the accuracy of identifying independent risks; 3) relatively simple and easy scoring calculations to predict patients with discharge failures; and 4) the SHOUT scoring system is different than other tools reported in the literature with more potential for applying to general population.

Our study has its own limitations. First, with a study design using a single-center, retrospective data analysis, limited and potential incorrect information, and potential patient population selection bias cannot be avoided. In this study, not all patients had EMR data after one-year of post ED discharge which might potentially affect the accuracy of SHOUT scores. In addition, we were unable to capture patient follow-up information if follow up occurred outside of the study hospital system. Secondly, we were not able to include all potential variables that may predict study outcomes. However, ED providers are busy during clinical shifts with limited time to collect pertinent information. We intended to include convenient variables that can be common and easily identified within a short period to make it feasible for any ED. Thirdly, though SHOUT scores can identify patients with potential risk of discharge failure, based on the AUC results, these models have good but not excellent discrimination. Using our recommended cutoff scores yielded fair sensitivities and specificities but not excellent ones. Considering such outcomes are multifactorial with the diversity of patient populations, it is challenging to derive scoring systems with both higher sensitivity/specificity and excellent discrimination. Such scoring systems might only be used as initial screening tools, and further multi-center external validation is warranted.

In summary, **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) might be used as initial screening to differentiate patients with different discharge failure models. It can be used to identify patients with broad and restricted discharge failure potentials. However, its use might be limited only in publicly-funded or not-for-profit hospitals similar as the study hospital.

Figure legend:

Figure 1 shows the study flow diagram

Figure 2 shows time to next-event curve to determine the probability of subsequent events (ED return vs. clinic follow-up) occurring among discharged patients

Reference List

1. Misky GJ, Wald HL, Coleman EA: **Post-hospitalization transitions: Examining the effects of timing of primary care provider follow-up.** *J Hosp Med* 2010, **5:** 392-397.

2. Schull MJ: **Making aftercare more than an afterthought: patient follow-up after emergency department discharge in Ontario.** *Healthc Q* 2014, **17:** 11-13.

3. Pham JC, Kirsch TD, Hill PM, DeRuggerio K, Hoffmann B: **Seventy-two-hour returns may not be a good indicator of safety in the emergency department: a national study.** *Acad Emerg Med* 2011, **18:** 390-397.

4. Magnusson AR, Hedges JR, Vanko M, McCarten K, Moorhead JC: **Follow-up compliance after emergency department evaluation.** *Ann Emerg Med* 1993, **22:** 560-567.

5. Klinkenberg WD, Calsyn RJ: **The moderating effects of race on return visits to the psychiatric emergency room.** *Psychiatr Serv* 1997, **48:** 942-945.

6. Khan NU, Razzak JA, Saleem AF, Khan UR, Mir MU, Aashiq B: **Unplanned return visit to emergency department: a descriptive study from a tertiary care hospital in a low-income country.** *Eur J Emerg Med* 2011, **18:** 276-278.

7. McCusker J, Cardin S, Bellavance F, Belzile E: **Return to the emergency department among elders: patterns and predictors.** *Acad Emerg Med* 2000, **7:** 249-259.

8. Graf CE, Giannelli SV, Herrmann FR, Sarasin FP, Michel JP, Zekry D *et al.*: **Can we improve the detection of old patients at higher risk for readmission after an emergency department visit?** *J Am Geriatr Soc* 2012, **60:** 1372-1373.

9. Hegney D, Buikstra E, Chamberlain C, March J, McKay M, Cope G *et al.*: **Nurse discharge planning in the emergency department: a Toowoomba, Australia, study.** *J Clin Nurs* 2006, **15:** 1033-1044.

10. Runciman P, Currie CT, Nicol M, Green L, McKay V: **Discharge of elderly people from an accident and emergency department: evaluation of health visitor follow-up.** *J Adv Nurs* 1996, **24:** 711-718.

11. Moons P, De RK, Geyskens K, Sabbe M, Braes T, Flamaing J *et al.*: **Screening for risk of readmission of patients aged 65 years and above after discharge from the emergency department: predictive value of four instruments.** *Eur J Emerg Med* 2007, **14:** 315-323.

12. Boudreaux ED, Clark S, Camargo CA, Jr.: **Telephone follow-up after the emergency department visit: experience with acute asthma. On behalf of the MARC Investigators.** *Ann Emerg Med* 2000, **35:** 555-563.

13. Lamantia MA, Platts-Mills TF, Biese K, Khandelwal C, Forbach C, Cairns CB *et al.*: **Predicting hospital admission and returns to the emergency department for elderly patients.** *Acad Emerg Med* 2010, **17:** 252-259.

14. White D, Kaplan L, Eddy L: **Characteristics of patients who return to the emergency department within 72 hours in one community hospital.** *Adv Emerg Nurs J* 2011, **33:** 344-353.

15. Heng KW, Tham KY, How KY, Foo JS, Lau YH, Li AY: **Recall of discharge advice given to patients with minor head injury presenting to a Singapore emergency department.** *Singapore Med J* 2007, **48:** 1107-1110.

16. Ballard DW, Price M, Fung V, Brand R, Reed ME, Fireman B *et al.*: **Validation of an algorithm for categorizing the severity of hospital emergency department visits.** *Med Care* 2010, **48:** 58-63.

17. Agency for Healthcare Research and Quality . Beta Chronic Condition Indicator (CCI) for ICD-10-CM. 2018. Ref Type: Online Source

18. Friedman J, Hastie T, Tibshirani R: **Regularization Paths for Generalized Linear Models via Coordinate Descent.** *J Stat Softw* 2010, **33:** 1-22.

19. Sullivan LM, Massaro JM, D'Agostino RB, Sr.: **Presentation of multivariate data for clinical use: The Framingham Study risk score functions.** *Stat Med* 2004, **23:** 1631-1660.

20. Schectman JM, Schorling JB, Voss JD: **Appointment adherence and disparities in outcomes among patients with diabetes.** *J Gen Intern Med* 2008, **23:** 1685-1687.

21. Atzema CL, Maclagan LC: **The Transition of Care Between Emergency Department and Primary Care: A Scoping Study.** *Acad Emerg Med* 2017, **24:** 201-215.

22. Gandhi SO, Grant LP, Sabik LM: **Trends in nonemergent use of emergency departments by health insurance status.** *Med Care Res Rev* 2014, **71:** 496-521.

23. McCarthy ML, Hirshon JM, Ruggles RL, Docimo AB, Welinsky M, Bessman ES: **Referral of medically uninsured emergency department patients to primary care.** *Acad Emerg Med* 2002, **9:** 639-642.

24. Wiersma P, Epperson S, Terp S, LaCourse S, Finton B, Drenzek C *et al*.: **Episodic illness, chronic disease, and health care use among homeless persons in Metropolitan Atlanta, Georgia, 2007.** *South Med J* 2010, **103:** 18-24.

25. Wang H, Nejtek VA, Zieger D, Robinson RD, Schrader CD, Phariss C *et al*.: **The role of charity care and primary care physician assignment on ED use in homeless patients.** *Am J Emerg Med* 2015, **33:** 1006-1011.

26. Goldman RD, Ong M, Macpherson A: **Unscheduled return visits to the pediatric emergency department-one-year experience.** *Pediatr Emerg Care* 2006, **22:** 545-549.

27. Nejtek VA, Aryal S, Talari D, Wang H, O'Neill L: **A pilot mobile integrated healthcare program for frequent utilizers of emergency department services.** *Am J Emerg Med* 2017, **35:** 1702-1705.

28. Mercer T, Bae J, Kipnes J, Velazquez M, Thomas S, Setji N: **The highest utilizers of care: individualized care plans to coordinate care, improve healthcare service utilization, and reduce costs at an academic tertiary care center.** *J Hosp Med* 2015, **10:** 419-424.

29. Gingold DB, Pierre-Mathieu R, Cole B, Miller AC, Khaldun JS: **Impact of the Affordable Care Act Medicaid expansion on emergency department high utilizers with ambulatory care sensitive conditions: A cross-sectional study.** *Am J Emerg Med* 2017, **35:** 737-742.

30. Yeatts KB, Lippmann SJ, Waller AE, Hassmiller LK, Travers D, Weinberger M *et al*.: **Population-based burden of COPD-related visits in the ED: return ED visits, hospital admissions, and comorbidity risks.** *Chest* 2013, **144:** 784-793.

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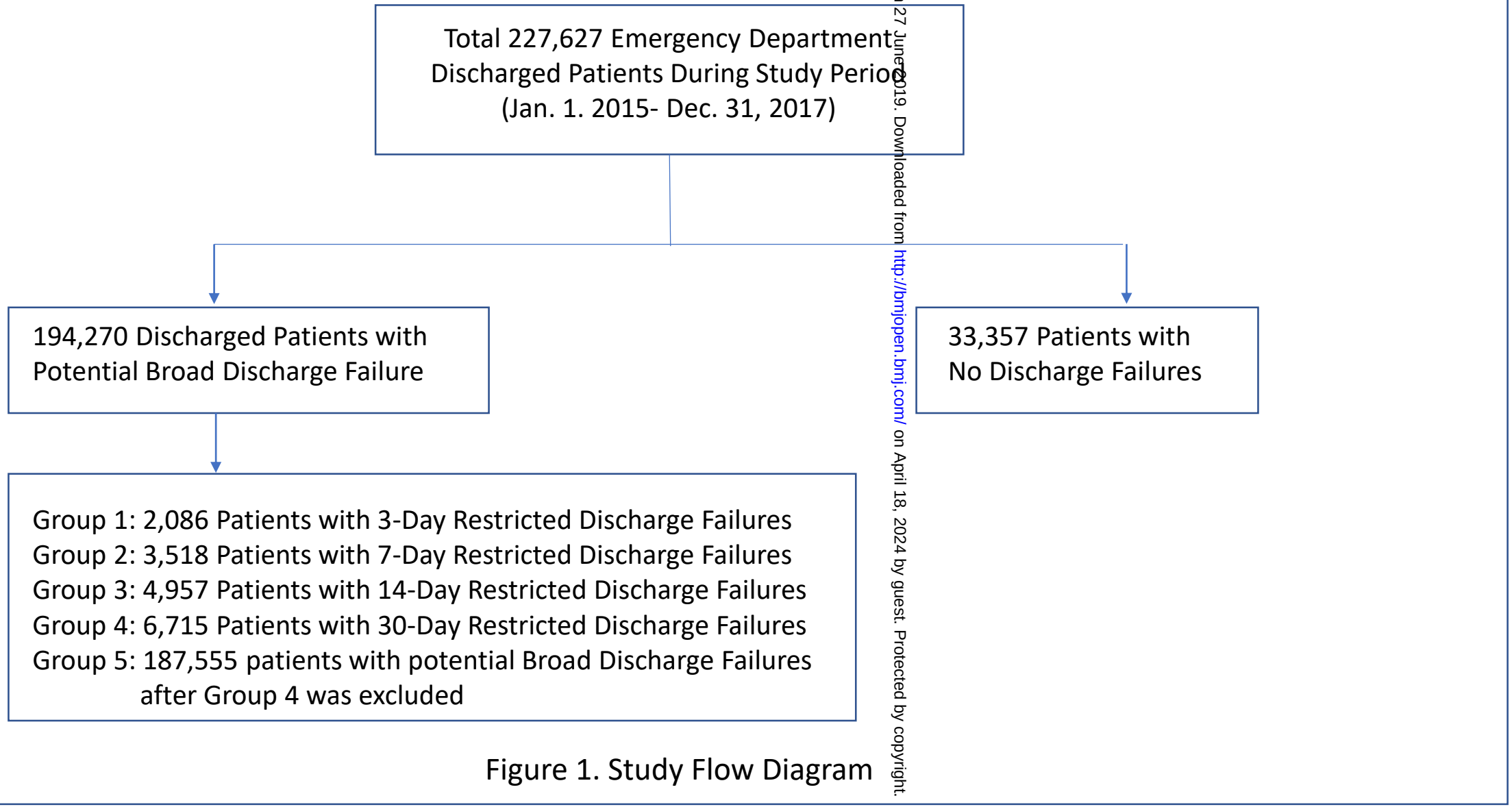

Figure 1. Study Flow Diagram

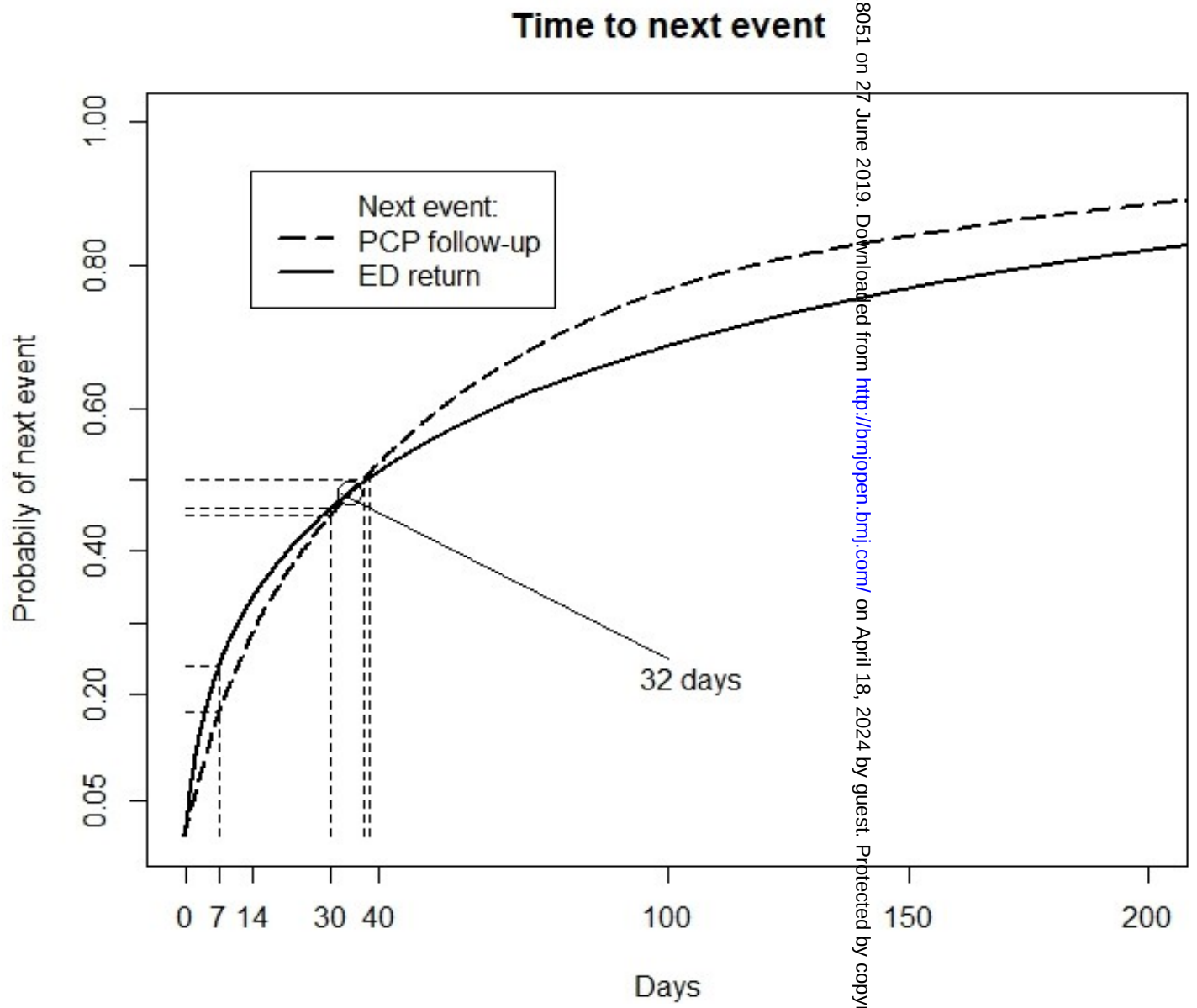

Figure 2. Time to Next-Event Curve to Determine the Probability of Subsequent Events (ED Return vs. Clinic Follow-up) Occurred Among Study Discharged Patients

Supplemental Table 1. General Information of Uncertain Discharge Failure Patients

Uncertain Discharge Failure Patients (N=102,787)	
a. Category of Uncertain Discharge Failures (N, %)	
1)patients who had neither subsequent ED nor clinical visits	84,049 (82)
2) patients had no subsequent ED visits and their clinic visits were longer than one year from the index ED visit;	1,398 (1.4)
3) patients ED returns and clinical visits fell on the same day;	299 (0.3)
4) patients had subsequent clinical visits earlier than ED returns and their ED returns were within 30-days from the index ED discharge;	2,295 (2.2)
5) patients had ED returns earlier than subsequent clinical visits and their ED utilizations considered emergent;	9,640 (9.4)
6) patients had ED returns beyond 30-days from the index ED discharge and their ED visits were earlier than their clinical visits	5,106 (5)
b. Patient General Characteristics	
Gender (Male)---yes, n (%)	50,830 (49)
Race --- n (%)	
None-Hispanic Caucasian	33,100 (32)
Others	69,687 (68)
Homeless --- yes, n (%)	4,992 (4.9)
Chronic Disease Conditions --- yes, n (%)	43,435 (42)
No Insurance --- n (%)	52,049 (51)
Primary Care Physician Assignment --- yes, n (%)	71,182 (69)
ESI (4-5) low level of acuity --- yes, n (%)	21,664 (21)

Supplemental Table 2. Number of Study Missing Variables

	Total Sample Size (N=227,627)
Gender, n (%)	8 (0.004)
Race, n (%)	0
Homeless, n (%)	0
Mode of Arrival, n(%)	1469 (0.6)
Chronic Disease Conditions, n (%)	0
Insurance, n (%)	179 (0.08)
Primary Care Physician Assignment, n (%)	0
ESI level of acuity, n (%)	626 (0.3)
Prescriptions, n (%)	0
Prolonged ED Length of Stay, n (%)	24 (0.01)
Abnormal vital signs, n(%)	9518 (4.2)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	6

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department in the United States: A Large-Scale Retrospective Observational Study

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Title Page

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Running Head: ED Discharge Failure Scoring Systems

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Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department in the United States: A Large-Scale Retrospective Observational Study

Abstract

OBJECTIVES: Identifying patients who are high risk for discharge failure allows for implementation of interventions to improve their care. However, discharge failure is currently defined in literature with great variability, making targeted interventions more difficult. We aim to derive a screening tool based on the existing diverse discharge failure models.

DESIGN, SETTING, AND PARTICIPANTS: This is a single-center retrospective cohort study in the United States. Data from all patients discharged from the Emergency Department (ED) were collected from Jan. 1, 2015 through Dec. 31, 2017 and followed up within 30-days.

METHODS: Scoring systems were derived using modified Framingham methods. Sensitivity, specificity, and area under the receiver operational characteristic (AUC) were calculated and compared using both the broad and restricted discharge failure models.

RESULTS: A total of 227,627 patients were included. The **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) scoring system was derived based on the broad and restricted discharge failure models and applied back to the entire study cohort. A sensitivity of 80% and a specificity of 71% were found in SHOUT scores to identify patients with broad discharge failure with AUC of 0.83 (95% CI 0.83-0.84). When applied to a 3-day restricted discharge failure model, a sensitivity of 86% and a specificity of 60% were found to identify patients with AUC of 0.79 (95% CI 0.78-0.80).

CONCLUSIONS: The SHOUT scoring system was derived and used to screen and identify patients that would ultimately become discharge failures, especially when using broad definitions of discharge failure. The SHOUT tool was internally validated and can be used to identify patients across a wide spectrum of discharge failure definitions.

Key Words: Emergency Department, Discharge Failure, Follow-up, Return Visit

Strengths and Limitations of this study:

1) The SHOUT scoring system is different than other tools reported in the literature and has more potential for applying to the general population.
2) The SHOUT scoring system was derived from a large sample size and is applicable to diverse concepts of discharge failure model, giving it broad application.
3) This is a relatively simple and easy scoring calculation to predict patients with different types of discharge failures.
4) To the best of our knowledge, this is the first reported ED discharge failure prediction tool that combined all validated discharge failure risk factors using a LASSO regression model, making it a more accurate model.
5) As a single-center retrospective data analysis, limited and potential incorrect information, missing data, and potential patient population selection bias cannot be avoided.

Identifying Diverse Concepts of Discharge Failure Patients at Emergency Department: A Large-Scale Retrospective Observational Study

Introduction

Traditional practice recommends arranging timely clinic follow-up for patients who are discharged from the Emergency Department (ED). Such follow up has been shown to improve patient-centered care specifically for disease prevention, monitoring, and management [1,2]. However, nearly one-third of ED patients who have sought access to health care rarely follow up with their primary care physician (PCP) or specialist after ED discharge [2]. Such patients were historically considered a discharge failure. However, the definition of discharge failure varies among most studies. A very broad definition used in previous studies included patients who had no-showed for a clinic appointment after an index ED discharge, had no clinic appointment after an index ED discharge, or had short ED returns (e.g. 3-day, 7-day, 14-day, or 30-day) [3-6]. Such definitions may not be accurate since patents might use the ED for episodic acute care and have no urgent clinic follow-up needs. On the other hand, patients with extremely short ED returns or that had significant deviation from the usual treatment regimen following an index ED visit may have been inappropriately discharged in the first place from their initial ED visit. Alternatively, their ED return could be unrelated to the initial visit. We believe that a more restricted definition of discharge failure truly reflecting the value of arranging timely clinic follow-up should be applied. Unfortunately, such studies are lacking in the current literature.

Six screening tools have been reported currently to identify patients with high risk potential for discharge failure [7-11]. However, all of these tools are intended for screening older patients with poor-to-moderate discrimination, and none of them can be used in general patient populations. A majority of these tools used self-assessed questionnaires (e.g. assistance with daily activity, healthcare recommendation for added assistance, having a predicted need for more help after ED discharge, etc.) and rarely linked screening with predictive risk factors [9-11]. Many studies in the past have identified a variety of risk factors predictive of discharge failure [3,4,12]. The most common validated ones are either social or medical factors. These common biological and social factors include insurance type, homelessness, lack of PCP, age, sex, and race/ethnicity [4,5,7,12,13], whereas medical factors could be attributed to alcohol/drug history and chronic medical conditions [14,15]. Given that validated risk factors have already been reported, the derivation of a tool associated with such factors might be beneficial.

Our goal is to identify patients at risks for discharge failures so that efficient interventions can be implemented to prevent ED returns, reduce cost, and save health care resources. Therefore, we aim to 1) determine the differences in ED discharged patients using either a broad or restricted discharge failure model; and 2) derive novel tools associated with predictive risk factors for the initial screening of ED patients for discharge failures.

Methods

Study Setting and Design

This was a single-center retrospective cohort study. The study hospital is a publicly-funded county hospital and urban tertiary referral center. The study hospital ED is a level-1 trauma center, acute chest pain and comprehensive stroke center whose ED volume reached approximately 120,000 visits annually. The ED also sponsors an Emergency Medicine (EM) residency program. This study was approved by John Peter Smith Health Network Institutional Review Board.

Study Participants

Patients who presented to study ED from Jan.1, 2015 to Dec. 31, 2017 and were subsequently discharged after the index ED visit were included in this study. The study hospital system uses the same Electronic Medical Record (EMR) including ED, hospital, and clinics. The medical record of all enrolled patients was retrieved automatically until Feb. 1, 2018. This allowed all enrolled patients to have 30 days after the index ED discharge to follow up. All patient data was electronically retrieved by data managers from the Department of Information Technology. We excluded patients during the index ED visits who 1) were admitted, 2) expired, 3) transferred to other facilities, 4) left without being seen (LWBS), eloped, or left against medical advice (AMA), and 5) prisoners. Since this study mainly focused on the characteristics of discharge failure, we further divided discharged patients into two large categories of patients without discharge failure and patients with broad discharge failure potential. We defined patients without discharge failure as meeting all of the following criteria: 1) patients visited their PCP/specialist clinic within one year from the index ED discharge (under normal circumstance, at least one clinic visit should be ranged every year for regular check-up and screening); 2) patients visited their PCP/specialist clinics prior to their ED revisits; and 3) patients had no ED revisits within 30 days.

Broad and Restricted Discharge Failure Models

In general, discharge failure was defined as ED revisits within a short period of time from the index ED visit (e.g. 3-day, 7-day, 14-day, or 30-days) and poor patient adherence to PCP or specialist clinic follow-up. We divided patients with discharge failure into broad and restricted categories. Patients with restricted discharge failures were confirmed discharge failure within 30 days from the index ED discharges. Whereas, patients with broad discharge failures included not only ones with confirmed discharge failures but also ones with discharge failure potential or uncertainty. Broad discharge failure was considered if patients met one of the following criteria: 1) patient had no PCP/specialist follow-ups from the index ED discharge; 2) patient had clinic follow-up longer than one year from the index ED discharge; 3) patients returned to the ED prior to their clinical follow-up; 4) patients with ED returns and clinic visits on the same day; and 5) patients with ED returns within 30-days from the index ED discharge. (see detail in Supplemental Table-1). As mentioned above, multiple factors can impact patient follow up after the index ED discharge (e.g. patient conditions do not require clinical follow-up, patient ED condition completely resolved, etc.). Additionally, patients could revisit the ED appropriately or unrelated to their initial ED visit prior to their clinic follow-ups (e.g. acute trauma). These patients might need to be excluded from the discharge failure category. Therefore, a more restricted discharge failure model was applied to the study patients. Restricted discharge failure was considered if patients met all the following criteria: 1) patients returned to the ED prior to their clinic follow-ups, 2) such ED revisits were within 30-days from the index ED discharge, and 3) patients were discharged from their ED return and the visit reason was considered inappropriate ED utilization. To satisfy diverse concepts of discharge failure in the literature, we expanded our restricted discharge failure models to the following four extended-restricted discharge failure groups: 1) restricted discharge failure with subsequent ED return of <3-days); 2) restricted discharge failure with

ED return of <7-days; 3) restricted discharge failure with ED return of <14-days; and 4) restricted discharge failure with ED return of <30-days.

Appropriateness of ED Utilization

New York University ED Algorithm (NYUA) was used in this study to determine the appropriateness of ED ED return visits [16]. Briefly, the four major categories were used in NYUA: 1) emergent and not avoidable, considered appropriate ED visits; 2) primary care treatable, defined as care that can be safely provided in a primary care setting without the need for emergent treatment; 3) emergent care needed but preventable/avoidable, defined as patients whose disease conditions can be prevented/avoided if preventive care is received in a timely fashion; and 4) non-emergent. Appropriate ED utilization was considered if patients met the emergent not avoidable category criteria and inappropriate utilization was determined if patients were classified within the other three categories. However, since NYUA is only used to determine the appropriateness of ED utilization among ED discharged patients, for patients who revisited ED within 30-days, appropriate ED utilization was also considered if such patients were: 1) admitted to hospital, 2) moved to the Operating Room, 3) transferred to other facilities, or 4) expired.

Variables

Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance [4-8]. Patient general characteristics including age, sex, and race/ethnicity were collected. Other patient and clinical variables included were: 1) patient total ED length of stay (LOS), divided into two categories of LOS stay equal to or less than 4-hours and LOS longer than 4-hours, 2) patient waiting room time in minutes, 3) mode of arrival, divided into two categories of healthcare-assisted arrival (ambulance or hospital/healthcare facility-arranged transportation) and other (private car, public transportation, taxi, wheelchair, ambulatory, police, or unknown), 4) level of acuity, divided into three categories based on ESI (Emergency Severity Index) level including high (ESI 1-2), moderate (ESI 3), and low (ESI 4-5), 5) homeless status, 6) patient's last vital signs at disposition (including heart rate, respiratory rate, blood pressure, oxygenation, and temperature): divided into two categories of patients who had normal vital signs versus ones who had any abnormal vital signs (e.g. heart rate<50 or >100, respiratory rate <8 or >20, systolic blood pressure <90mmHg or >140mmHg, diastolic blood pressure <60mmHg or >90mmHg, pulse oximetry<94%, temperature >100.4F° or <96.8F°, 7) next healthcare visit (e.g. ED, PCP/specialist clinic, or none) and its time interval from the index ED discharge, 8) whether patients had a PCP assigned, 9) number of medications prescribed upon the index ED discharge, divided into two categories of patients who had prescriptions versus those who had none, 10) insurance status, and 11) presence of chronic disease, with chronic disease conditions were determined using the chronic condition indicator (CCI) for the international classification of diseases tenth revision, clinical modification (ICD-10-CM). CCI was developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ) [17].

Derivation and Validation of SHOUT Scoring System

To identify potential ED discharge failure patients, the SHOUT (**S**creening for **H**ealthcare f**O**llow-**U**p **T**ool) scoring system was derived. Variables chosen for model building were selected from previous studies and reviewed by clinicians experienced in healthcare quality studies to ensure consistent clinical significance. We built five scoring systems using predictive logistic regression modeling. Each model predicted a specific

outcome as defined above: broad discharge failure, and 3-day, 7-day, 14-day, and 30-day restricted discharge failure. In our sample, less than 5% of the patients had missing data on predictor variables (specific variables denoted in Table 1, see Supplemental Table 2). To build the predictive model for broad discharge failure, we used 50% of the data to train the model and 50% to test the model because we had a large sample size. We dichotomized the predictors for ease of use in clinical practice. Neither making the variables continuous nor including interaction terms added substantially to the model's performance, and we preferred parsimony for generalizability. To avoid over-fitting, we used the least absolute shrinkage and selection operator (LASSO) to fit the most informative but parsimonious model [18]. The LASSO model predicted a patient's probability of broad discharge failure, and we used a threshold value to classify the patient (0 or 1). Simple point scoring systems were then derived using methods described by Framingham with minor modifications [19]. We used the receiver operating characteristic (ROC) curve to define the threshold as the value that maximizes the model's sensitivity and minimizes the false positive rate (1-specificity). Because the model's primary purpose was to classify patients, we focused on the model's discriminative abilities. Accuracy of the prediction was reported with sensitivity, specificity, positive and negative likelihood ratios. Scores were calculated among all patients in both the derivation and validation groups, the sensitivity, specificity, positive and negative likelihood ratios, and AUC were compared between groups of different models in both the derivation and validation data.

Data Analysis

Student's t-test was used to compare continuous variables while Pearson Chi-square (χ^2) analysis was used to compare categorical variables between groups. We plotted the inverse of the Kaplan-Meier survival curves for the frequency comparison of patients who returned to ED versus those who had clinic follow-up after the index ED discharge. Methods used to derive and validate scoring systems are addressed above. All descriptive and statistical analyses were conducted using STATA 14.2 (College Station, TX). A p value <0.05 was considered statistically significant.

Patients and public involvement

Patients and the public were not directly involved in this study

Results

General Information

A total of 227,627 ED discharged patients were retrieved from the EMR with only 33,357 patients categorized to the without broad discharge failure group (Figure 1). Overall, 85% (194,270/227,627) of patients were considered broad discharge failures and only 15% of ED discharged patients had their clinic follow-ups within the study period. When restricted discharge failure models were applied, 3.0% (6,715/227,627) of patients were considered restricted discharge failures within 30-days, 2.2% (4,957/227,627) within 14-days, 1.5% (3,518/227,627) within 7-days, and 0.9% (2,086/227,627) within 3-days. Patients who had restricted discharge failure were more likely white, homeless, relied on healthcare assisted transportations, had chronic disease conditions, had extended insurance coverage, and were less likely to have a primary care physician (PCP) assigned in comparison to patients with broad discharge failures. Patients with no discharge failures tended to be female, not homeless, used less health-assisted transportation, and had less PCP coverage (Table 1). When reverse Kaplan-Meier curves were drawn among the study patients who had either ED returns or clinical follow-up visits after the index ED discharge,

it showed that 24% of patients returned to the ED within 7 days while 18% of patients had clinic follow-ups within 7 days. Similarly, 46% of patients returned to the ED within 30 days, and 45% of patients had a clinic follow-up within 30 days. At 32 days, the curves crossed indicating that patients sought clinic visits more frequently than ED return visits after 32 days. The graph also showed a median of 38 days for subsequent ED returns in comparison to a median of 37 days for subsequent clinic follow-up in this cohort (Figure 2). Our results indicated that a high frequency of ED returns occurred within the first 32 days from the index ED discharge.

Table 1. Study Patient General Characteristics

	Diverse Discharge Failure Models					Control
	Broad N=194,270	Restricted (3-day) N=2,086	Restricted (7-day) N=3,518	Restricted (14-day) N=4,957	Restricted (30-day) N=6,715	No Discharge Failure N=33,357
Age --- year mean(SD)	39 (16)	47(14)	47(14)	47(14)	47(14)	47(16)
median (IQR)	38(27,51)	49(37,58)	49(37,58)	49(37,57)	48(37,57)	49(36,58)
Race/Ethnicity (n, %)						
Non-Hispanic White	63,438 (33)	867 (42)	1,424 (40)	1,948 (39)	2,573 (38)	9,813 (29)
Others	130,832 (67)	1,219 (58)	2,094 (60)	3,009 (61)	4,142 (62)	23,544 (71)
Sex (n, %)						
Male	96882 (50)	1,160 (56)	1,868 (53)	2,514 (51)	3,238 (48)	12,141 (36)
Female	97380 (50)	926 (44)	1,650 (47)	2,443 (49)	3,477 (52)	21,216 (64)
PCP provider (n, %)						
Yes	129,345 (67)	445 (21)	658 (19)	821 (17)	1,014 (15)	3,621 (11)
No	64,925 (33)	1,641 (79)	2,860 (81)	4,136 (83)	5,701 (85)	29,736 (89)
Homeless (n, %)						
Yes	16,783 (9)	663 (32)	1,090 (31)	1,386 (28)	1,694 (25)	1,719 (5)
No	177,487 (91)	1,423 (68)	2,428 (69)	3,571 (72)	5,021 (75)	31,638 (95)
Means of arrival (n, %)						
Healthcare-assisted	51,181 (27)	802 (39)	1,268 (36)	1,682 (34)	2,106 (31)	5,449 (16)
Others	141,688 (73)	1,278 (61)	2,242 (64)	3,264 (66)	4,597 (69)	27,840 (84)
Any insurance (n, %)						
Yes	99,827 (51)	1,757 (84)	2,942 (84)	4,112 (83)	5,515 (82)	28,774 (86)
No	94,268 (49)	329 (16)	576 (16)	845 (17)	1,200 (18)	4,579 (14)
ESI level (n, %)						
ESI (1,2,3)	150,277 (78)	1,606 (77)	2,654 (76)	3,740 (76)	5,062 (75)	27,621 (83)
ESI (4,5)	43,423 (22)	477 (23)	859 (24)	1,211 (24)	1,646 (25)	5,680 (17)
Last vitals upon discharge (n, %)						
Normal	23,338 (13)	235 (12)	389 (12)	547 (12)	739 (11)	4,287 (13)
Abnormal	162,312 (87)	1,739 (88)	2,968 (88)	4,190 (88)	5,690 (89)	28,172 (87)
Any chronic conditions (n, %)						
Yes	91,194 (47)	1,338 (64)	2,277 (65)	3,161 (64)	4,224 (63)	18,649 (56)

No	103,076 (53)	748 (36)	1,241 (35)	1,796 (36)	2,491 (37)	14,708 (44)
Prescriptions upon discharge (n, %)						
Yes	129,198 (67)	1,177 (56)	2,086 (59)	3,050 (62)	4,322 (64)	22,356 (67)
No	65,072 (34)	909 (44)	1,432 (41)	1,907 (38)	2,393 (36)	11,001 (33)
Length of ED stay (n, %)						
Equal or longer than 4-hours	127,708 (66)	808 (39)	1,364 (39)	1,907 (38)	2,550 (38)	13, 964 (42)
Less than 4-hours	66,538 (34)	1,277 (61)	2,153 (61)	3,049 (62)	4,164 (62)	19,393 (58)

Derivation of SHOUT Scoring Systems for Diversity of Discharge Failure Models

Nine independent variables predicting discharge failures were: 1) homelessness; 2) PCP status; 3) Male sex; 4) history of chronic diseases; 5) lack of insurance; 6) low level of acuity (ESI 4-5); 7) White race/ethnicity; 8) arriving by health-assisted transportation; and 9) abnormal vital signs at discharge. These factors were incorporated into the SHOUT scores for discharge failure models (Table 2). These scores were applied back to the derivation data yielding good discriminations indicating the feasibility of using SHOUT scores for the initial screening of different discharge failure models (Table 3).

Table 2. SHOUT Scoring System for Different Discharge Failure Models

	Broad	Restricted (3-day)	Restricted (7-day)	Restricted (14-day)	Restricted (30-day)
Sex					
Female	0	0	0	0	0
Male	2	1	1	1	1
Race/Ethnicity					
Non-Hispanic White	1	1	1	1	1.5
Others	0	0	0	0	0
PCP provider assigned					
Yes	21	0	0	0	0
No	0	6	6	11	15.5
Homeless					
Yes	7	5	5	7	9
No	0	0	0	0	0
Means of arrival					
Health-care assisted	6	1	1	1.5	1.5
Others	0	0	0	0	0
Any insurance					
Yes	0	3	3	4	5
No	10.5	0	0	0	0
Last vital signs upon discharge					
Abnormal		1	1	1	1.5
Normal		0	0	0	0
ESI level					
ESI (1,2,3)	0	0	0	0	0
ESI (4, 5)	1.5	1	1	2	3

History of chronic conditions					
Yes	0	1	1	1.5	2
No	1	0	0	0	0
Score Range	0-50	0-20	0-20	0-30	0-40
Predicted Discharge Failure	≥9	≥9	≥9	≥14	≥20

Table 3. Predictive Performance of Different Discharge Failure Models in Derivation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.83 (0.83-0.84)	80%	71%	2.77	0.28
Restricted (3-days)	0.79 (0.78-0.80)	86%	60%	2.14	0.24
Restricted (7-days)	0.79 (0.79-0.80)	86%	60%	2.17	0.23
Restricted (14-days)	0.79 (0.78-0.80)	84%	61%	2.18	0.25
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.21	0.29

Validation of SHOUT Scoring System for Discharge Failure Models

SHOUT scores were again applied back to the study validation data using different discharge failure models. First, AUC comparisons of SHOUT scores predicting patients with restricted discharge failure within 3-days, 7-days, 14-days, and 30-days were performed. Similar AUCs predicted patients with short-term restricted discharge failure in this cohort (Table 4). Secondly, when the SHOUT score was applied to patients with broad discharge failures, higher AUC (0.84, 95% CI 0.84-0.84) yielded a sensitivity of 80%, specificity of 72%, positive likelihood of 2.85, and negative likelihood of 0.27 (Table 4).

Table 4. Predictive Performance of Different Discharge Failure Models in Validation Study

Outcome	AUC (95% CI)	Sensitivity	Specificity	LR(+)	LR(-)
Broad	0.84 (0.84-0.84)	80%	72%	2.85	0.27
Restricted (3-days)	0.79 (0.78-0.80)	85%	60%	2.13	0.25
Restricted (7-days)	0.80 (0.79-0.80)	87%	61%	2.20	0.22
Restricted (14-days)	0.79 (0.78-0.80)	85%	62%	2.21	0.24
Restricted (30-days)	0.79 (0.78-0.79)	82%	63%	2.22	0.29

Discussion

Timely arrangement of post-ED follow-up is critical to ensure patient safety, monitor patient disease progression, and adjust management properly [2,20]. The SHOUT scoring system was derived and internally validated to differentiate patients with different discharge failure models and shown to be broadly applicable among the types of discharge failure patients. In this study, we categorized patients as either having broad discharge failure potential or having short-term restricted discharge failure. Our study findings add some evidence to the literature pool on capable of early recognizing different ED discharge

failure patients, thus could provide the potential to implement interventions earlier to prevent discharge failures.

It is reported that providing a follow-up appointment prior to the patient departing the ED can significantly increase follow-up care [21]. However, making real-time PCP appointments among all ED discharged patients might be challenge with limited healthcare resources. Therefore, our study differentiated patients between "broad" and "restricted" discharge failures. Given the uncertainty of ED returns and poor adherence for clinic follow-up, we believe that the restricted discharge failure prediction tool with its higher sensitivity and small patient size can provide better ED administrative value (e.g. capturing more patients and providing real-time patient PCP appointments at patient discharge). Whereas, a broad discharge failure tool with higher specificity and large patient size can better help with healthcare utilization (e.g. capturing more "true" discharge failure patients and limiting the urgent needs for PCP follow-up). Different institutions can choose the one that better fits their own operational needs.

Risks identified in our study to predict patients with discharge failure have also been validated in previous studies to a certain level [3,4,13]. Lack of insurance coverage, lack of a PCP, homelessness, and chronic diseases are most commonly addressed in the literature with different discharge failure models [5,12,14,]. Lacking insurance coverage prevented patients from seeking healthcare follow-up and incentivized patients to use the ED as their medical home, which usually resulted in inappropriate ED utilization [22]. Patients with homelessness and chronic disease conditions more frequently had discharge failures due to the certain association between homeless patients and chronic disease conditions [23]. Studies showed homeless patients had more chronic diseases in comparison to general population [24]. Additionally, homeless patients tended to use ED more often as their medical home resulting in higher inappropriate ED utilization [25]. Our study also showed patients of lower acuity (ESI 4-5), male, and non-Hispanic-White ethnicity had more discharge failure. Similar findings reported that patients with lower acuity, male , and White race/ethnicity had higher inappropriate ED visits and higher 72-hour ED returns [6,15]. However, such findings are controversial in different studies probably due to different study patient populations [26].

Though risks predictive of broad and restricted discharge failure seem similar, three risks had opposite effects on such predictions. Lack of PCP assignment, presence of chronic disease conditions, healthcare insurance coverage seemed to predict restricted discharge failure and protected patients from broad discharge failures. This might be partly due to current study hospital healthcare policies. The study hospital advocates for PCP assignments and clinic follow-up arrangements, provides charity insurance coverage among certain patients (e.g. high psychosocial risks, homeless, low-income residents, etc.), and has developed outreach programs for patients with special needs (e.g. homeless, chronic heart failure outreach programs, etc.) [25,27]. It has been reported that these patients had high risk of short-term ED returns (e.g. 72-h) both in the literature and in our own study [3,14,25]. In addition, such policies are not uncommon across publicly-funded or nonprofit hospitals in the US [28,29]. However, when applied to patients with long-term discharge failure potential, such effects protected against broad discharge failures. This is consistent to other reports in the literature [30]. Therefore, we believe the SHOUT score for broad discharge failure can be used more broadly in a diversity of hospital settings (e.g. charity, public-funded, Veteran Affair, private or community hospitals, etc.). However, the SHOUT score for restricted discharge failure might be limited to public-funded hospitals with similar policies as the study hospital.

This study has several strengths: 1) large sample size was used and applicable to diverse concepts of discharge failures; 2) the LASSO regression model improved the accuracy of identifying independent risks; 3) relatively simple and easy scoring calculations to predict patients with discharge failures; and 4) the SHOUT scoring system is different than other tools reported in the literature with more potential for applying to general population.

Our study has its own limitations. First, with a study design using a single-center, retrospective data analysis, limited and potential incorrect information, and potential patient population selection bias cannot be avoided. In this study, not all patients had EMR data after one-year of post ED discharge which might potentially affect the accuracy of SHOUT scores. In addition, we were unable to capture patient follow-up information if follow up occurred outside of the study hospital system. Secondly, we were not able to include all potential variables that may predict study outcomes. However, ED providers are busy during clinical shifts with limited time to collect pertinent information. We intended to include convenient variables that can be common and easily identified within a short period to make it feasible for any ED. Thirdly, though SHOUT scores can identify patients with potential risk of discharge failure, based on the AUC results, these models have good but not excellent discrimination. Using our recommended cutoff scores yielded fair sensitivities and specificities but not excellent ones. Considering such outcomes are multifactorial with the diversity of patient populations, it is challenging to derive scoring systems with both higher sensitivity/specificity and excellent discrimination. Such scoring systems might only be used as initial screening tools, and further multi-center external validation is warranted.

In summary, **S**creening for **H**ealthcare f**O**llow-**U**p **T**ool (SHOUT) might be used as initial screening to differentiate patients with different discharge failure models. It can be used to identify patients with broad and restricted discharge failure potentials. However, its use might be limited only in publicly-funded or not-for-profit hospitals similar as the study hospital.

Figure legend:

Figure 1 shows the study flow diagram

Figure 2 shows time to next-event curve to determine the probability of subsequent events (ED return vs. clinic follow-up) occurring among discharged patients

Reference List

1. Misky GJ, Wald HL, Coleman EA: **Post-hospitalization transitions: Examining the effects of timing of primary care provider follow-up.** *J Hosp Med* 2010, **5:** 392-397.

2. Schull MJ: **Making aftercare more than an afterthought: patient follow-up after emergency department discharge in Ontario.** *Healthc Q* 2014, **17:** 11-13.

3. Pham JC, Kirsch TD, Hill PM, DeRuggerio K, Hoffmann B: **Seventy-two-hour returns may not be a good indicator of safety in the emergency department: a national study.** *Acad Emerg Med* 2011, **18:** 390-397.

4. Magnusson AR, Hedges JR, Vanko M, McCarten K, Moorhead JC: **Follow-up compliance after emergency department evaluation.** *Ann Emerg Med* 1993, **22:** 560-567.

5. Klinkenberg WD, Calsyn RJ: **The moderating effects of race on return visits to the psychiatric emergency room.** *Psychiatr Serv* 1997, **48:** 942-945.

6. Khan NU, Razzak JA, Saleem AF, Khan UR, Mir MU, Aashiq B: **Unplanned return visit to emergency department: a descriptive study from a tertiary care hospital in a low-income country.** *Eur J Emerg Med* 2011, **18:** 276-278.

7. McCusker J, Cardin S, Bellavance F, Belzile E: **Return to the emergency department among elders: patterns and predictors.** *Acad Emerg Med* 2000, **7:** 249-259.

8. Graf CE, Giannelli SV, Herrmann FR, Sarasin FP, Michel JP, Zekry D *et al.*: **Can we improve the detection of old patients at higher risk for readmission after an emergency department visit?** *J Am Geriatr Soc* 2012, **60:** 1372-1373.

9. Hegney D, Buikstra E, Chamberlain C, March J, McKay M, Cope G *et al.*: **Nurse discharge planning in the emergency department: a Toowoomba, Australia, study.** *J Clin Nurs* 2006, **15:** 1033-1044.

10. Runciman P, Currie CT, Nicol M, Green L, McKay V: **Discharge of elderly people from an accident and emergency department: evaluation of health visitor follow-up.** *J Adv Nurs* 1996, **24:** 711-718.

11. Moons P, De RK, Geyskens K, Sabbe M, Braes T, Flamaing J *et al.*: **Screening for risk of readmission of patients aged 65 years and above after discharge from the emergency department: predictive value of four instruments.** *Eur J Emerg Med* 2007, **14:** 315-323.

12. Boudreaux ED, Clark S, Camargo CA, Jr.: **Telephone follow-up after the emergency department visit: experience with acute asthma. On behalf of the MARC Investigators.** *Ann Emerg Med* 2000, **35:** 555-563.

13. Lamantia MA, Platts-Mills TF, Biese K, Khandelwal C, Forbach C, Cairns CB *et al.*: **Predicting hospital admission and returns to the emergency department for elderly patients.** *Acad Emerg Med* 2010, **17:** 252-259.

14. White D, Kaplan L, Eddy L: **Characteristics of patients who return to the emergency department within 72 hours in one community hospital.** *Adv Emerg Nurs J* 2011, **33:** 344-353.

15. Heng KW, Tham KY, How KY, Foo JS, Lau YH, Li AY: **Recall of discharge advice given to patients with minor head injury presenting to a Singapore emergency department.** *Singapore Med J* 2007, **48:** 1107-1110.

16. Ballard DW, Price M, Fung V, Brand R, Reed ME, Fireman B *et al.*: **Validation of an algorithm for categorizing the severity of hospital emergency department visits.** *Med Care* 2010, **48:** 58-63.

17. Agency for Healthcare Research and Quality . Beta Chronic Condition Indicator (CCI) for ICD-10-CM. 2018. Ref Type: Online Source

18. Friedman J, Hastie T, Tibshirani R: **Regularization Paths for Generalized Linear Models via Coordinate Descent.** *J Stat Softw* 2010, **33:** 1-22.

19. Sullivan LM, Massaro JM, D'Agostino RB, Sr.: **Presentation of multivariate data for clinical use: The Framingham Study risk score functions.** *Stat Med* 2004, **23:** 1631-1660.

20. Schectman JM, Schorling JB, Voss JD: **Appointment adherence and disparities in outcomes among patients with diabetes.** *J Gen Intern Med* 2008, **23:** 1685-1687.

21. Atzema CL, Maclagan LC: **The Transition of Care Between Emergency Department and Primary Care: A Scoping Study.** *Acad Emerg Med* 2017, **24:** 201-215.

22. Gandhi SO, Grant LP, Sabik LM: **Trends in nonemergent use of emergency departments by health insurance status.** *Med Care Res Rev* 2014, **71:** 496-521.

23. McCarthy ML, Hirshon JM, Ruggles RL, Docimo AB, Welinsky M, Bessman ES: **Referral of medically uninsured emergency department patients to primary care.** *Acad Emerg Med* 2002, **9:** 639-642.

24. Wiersma P, Epperson S, Terp S, LaCourse S, Finton B, Drenzek C *et al*.: **Episodic illness, chronic disease, and health care use among homeless persons in Metropolitan Atlanta, Georgia, 2007.** *South Med J* 2010, **103:** 18-24.

25. Wang H, Nejtek VA, Zieger D, Robinson RD, Schrader CD, Phariss C *et al*.: **The role of charity care and primary care physician assignment on ED use in homeless patients.** *Am J Emerg Med* 2015, **33:** 1006-1011.

26. Goldman RD, Ong M, Macpherson A: **Unscheduled return visits to the pediatric emergency department-one-year experience.** *Pediatr Emerg Care* 2006, **22:** 545-549.

27. Nejtek VA, Aryal S, Talari D, Wang H, O'Neill L: **A pilot mobile integrated healthcare program for frequent utilizers of emergency department services.** *Am J Emerg Med* 2017, **35:** 1702-1705.

28. Mercer T, Bae J, Kipnes J, Velazquez M, Thomas S, Setji N: **The highest utilizers of care: individualized care plans to coordinate care, improve healthcare service utilization, and reduce costs at an academic tertiary care center.** *J Hosp Med* 2015, **10:** 419-424.

29. Gingold DB, Pierre-Mathieu R, Cole B, Miller AC, Khaldun JS: **Impact of the Affordable Care Act Medicaid expansion on emergency department high utilizers with ambulatory care sensitive conditions: A cross-sectional study.** *Am J Emerg Med* 2017, **35:** 737-742.

30. Yeatts KB, Lippmann SJ, Waller AE, Hassmiller LK, Travers D, Weinberger M *et al*.: **Population-based burden of COPD-related visits in the ED: return ED visits, hospital admissions, and comorbidity risks.** *Chest* 2013, **144:** 784-793.

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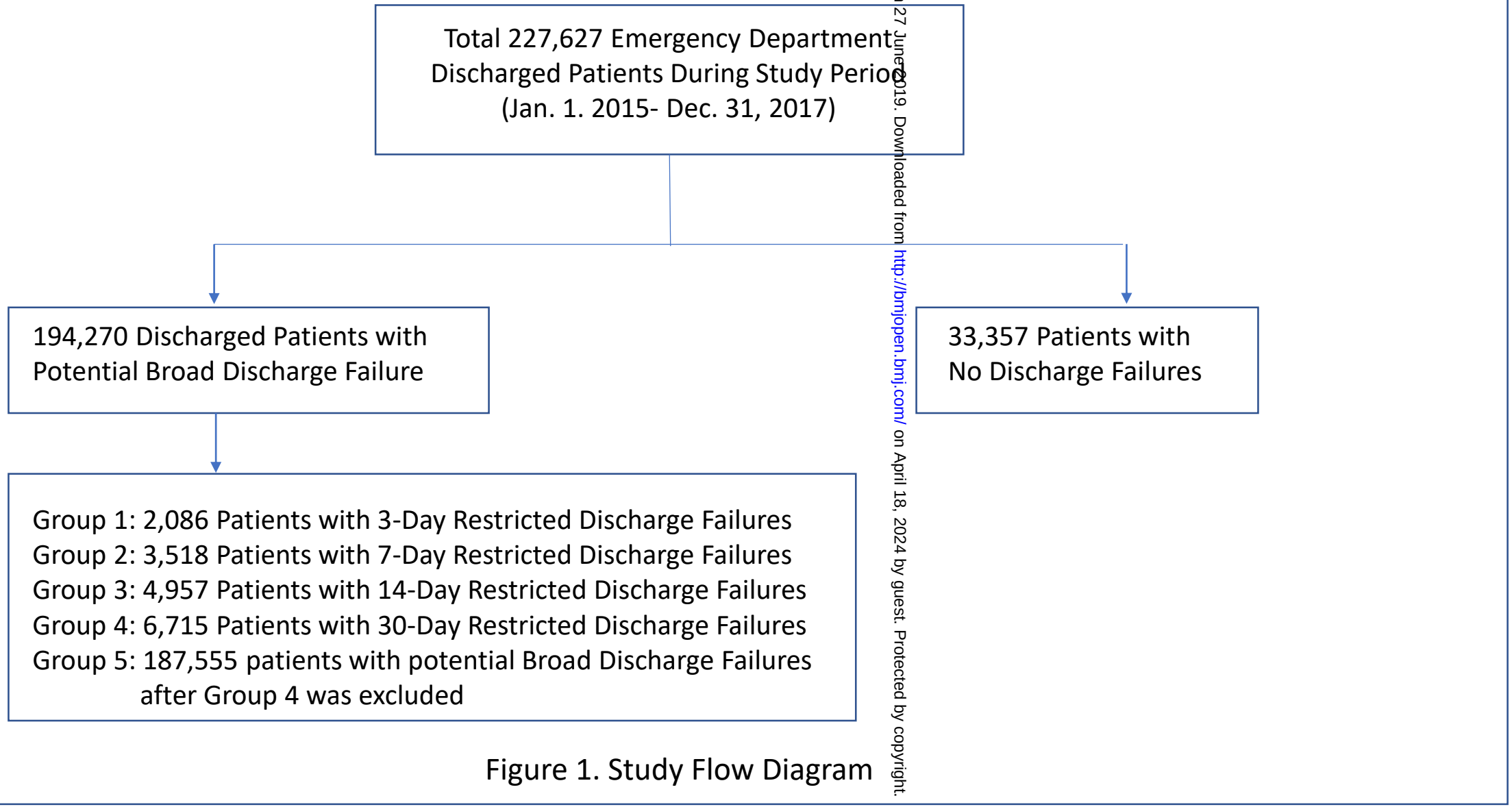

Figure 1. Study Flow Diagram

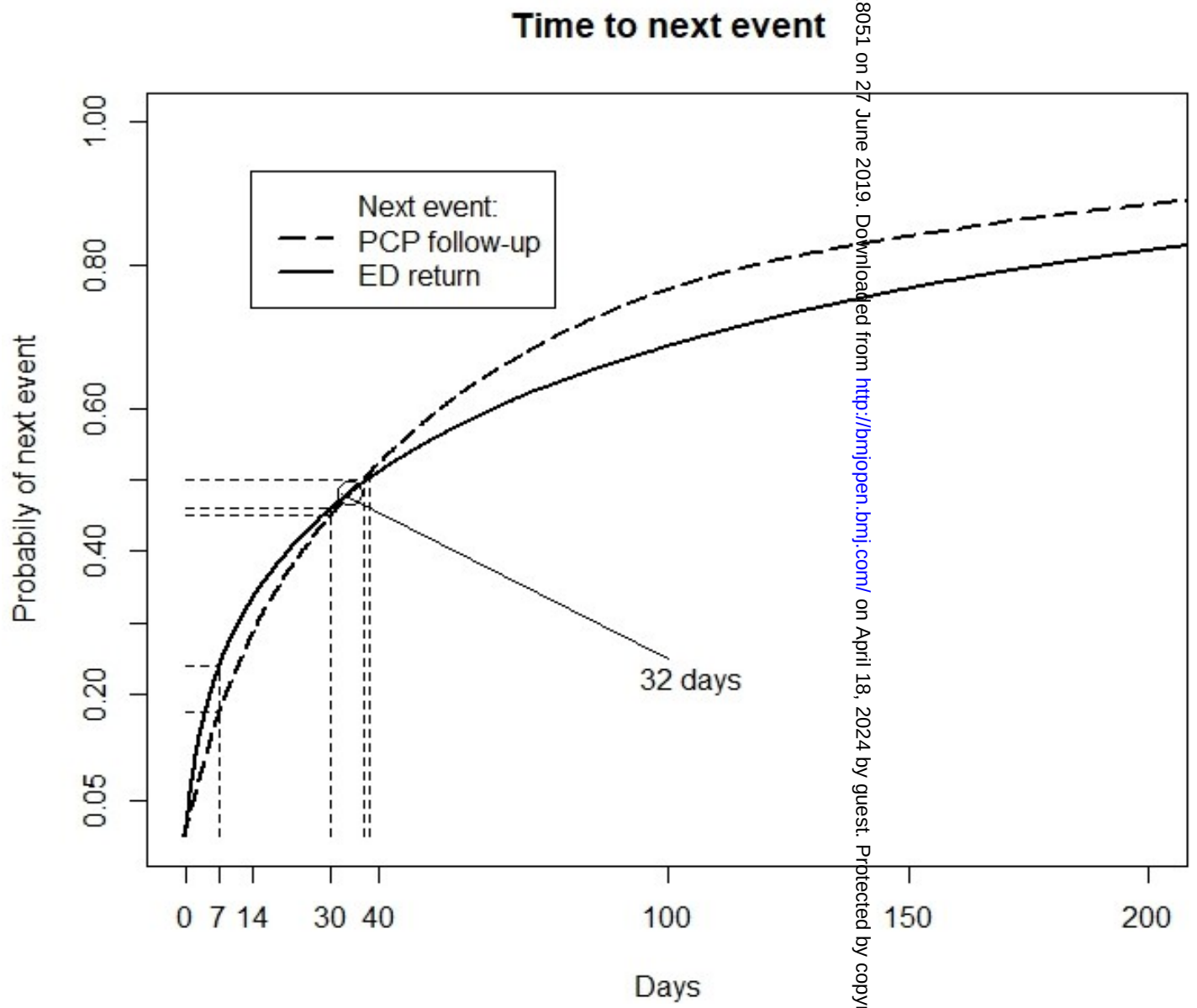

Figure 2. Time to Next-Event Curve to Determine the Probability of Subsequent Events (ED Return vs. Clinic Follow-up) Occurred Among Study Discharged Patients

Supplemental Table 1. General Information of Uncertain Discharge Failure Patients

Uncertain Discharge Failure Patients (N=102,787)	
a. Category of Uncertain Discharge Failures (N, %)	
1)patients who had neither subsequent ED nor clinical visits	84,049 (82)
2) patients had no subsequent ED visits and their clinic visits were longer than one year from the index ED visit;	1,398 (1.4)
3) patients ED returns and clinical visits fell on the same day;	299 (0.3)
4) patients had subsequent clinical visits earlier than ED returns and their ED returns were within 30-days from the index ED discharge;	2,295 (2.2)
5) patients had ED returns earlier than subsequent clinical visits and their ED utilizations considered emergent;	9,640 (9.4)
6) patients had ED returns beyond 30-days from the index ED discharge and their ED visits were earlier than their clinical visits	5,106 (5)
b. Patient General Characteristics	
Gender (Male)---yes, n (%)	50,830 (49)
Race --- n (%)	
None-Hispanic Caucasian	33,100 (32)
Others	69,687 (68)
Homeless --- yes, n (%)	4,992 (4.9)
Chronic Disease Conditions --- yes, n (%)	43,435 (42)
No Insurance --- n (%)	52,049 (51)
Primary Care Physician Assignment --- yes, n (%)	71,182 (69)
ESI (4-5) low level of acuity --- yes, n (%)	21,664 (21)

Supplemental Table 2. Number of Study Missing Variables

	Total Sample Size (N=227,627)
Gender, n (%)	8 (0.004)
Race, n (%)	0
Homeless, n (%)	0
Mode of Arrival, n(%)	1469 (0.6)
Chronic Disease Conditions, n (%)	0
Insurance, n (%)	179 (0.08)
Primary Care Physician Assignment, n (%)	0
ESI level of acuity, n (%)	626 (0.3)
Prescriptions, n (%)	0
Prolonged ED Length of Stay, n (%)	24 (0.01)
Abnormal vital signs, n(%)	9518 (4.2)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	4-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	6

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	4-6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.