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Effect of advanced age and vital signs on admission from an emergency department observation unit

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Abstract

Objectives—The primary objective was to determine the relationship between advanced age and need for admission from an emergency department (ED) observation unit. The secondary objective was to determine the relationship between initial ED vital signs and admission.

Methods—We conducted a prospective, observational cohort study of ED patients placed in an ED-based observation unit. Multivariable penalized maximum likelihood logistic regression was used to identify independent predictors of need for hospital admission. Age was examined continuously and at a cutoff of 65 years. Vital signs were examined continuously and at commonly accepted cutoffs. We additionally controlled for demographics, co-morbid conditions, laboratory values, and observation protocol.

Results—Three hundred patients were enrolled, 12% (n=35) 65 years old and 11% (n=33) requiring admission. Admission rates were 2.9% (95% confidence interval [CI], 0.07-14.9%) in older adults and 12.1% (95% CI, 8.4-16.6%) in younger adults. In multivariable analysis, age was not associated with admission (odds ratio [OR] 0.30, 95% CI 0.05-1.67). Predictors of admission included: systolic pressure 180 mmHg (OR 4.19, 95% CI 1.08-16.30), log Charlson co-morbidity score (OR 2.93, 95% CI 1.57-5.46), and white blood cell count 14,000/mm³ (OR 11.35, 95% CI 3.42-37.72).

Conclusions—Among patients placed in an ED observation unit, age 65 years is not associated with need for admission. Older adults can successfully be discharged from these units. Systolic pressure 180 mmHg was the only predictive vital sign. In determining appropriateness of patients selected for an ED observation unit, advanced age should not be an automatic disqualifying criterion.

Keywords

elder; aged; observation; emergency; admission

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INTRODUCTION

Short stay observation units affiliated with hospital emergency departments (EDs) are becoming increasingly common. Their goal is to provide a brief period for diagnostic and therapeutic interventions to aid physicians in making the decision whether to admit or discharge the patient. Disposition of ED patients to these units has been proven to be appropriate for a number of conditions.¹⁻⁷ Although a percentage of patients are expected to fail observation status and require hospital admission, patients who ultimately require hospital admission would ideally be identified in the ED rather than after an observation unit stay.⁸ Several authors have identified factors, such as comorbid conditions and ED laboratory parameters, which may be predictive of need for admission among observation unit patients.^{5,9,10} These studies have generally examined specific observation protocols, but are not generalizable to the broad population of patients seen in the observation unit.

One important potential predictor of admission is advanced age. There are greater than 19 million yearly ED visits by adults 65 and over in the US, and these older adults are admitted to the hospital at a higher rate than younger patients.^{11,12} As a result, there is a need to identify the patterns of care for these patients in an observation unit. One study has found that elders were more likely to be admitted than younger patients from an observation unit (26% versus 18%).⁸ However, this study did not control for comorbidities, protocol type, or other potential predictive factors. Others have examined age as it pertains to specific observation protocols, but not the entire observation unit population.¹³ It is therefore unknown if age is independently predictive of admission from an observation unit.

Abnormal vital signs may also represent a differentiating factor to predict the need for admission from an observation unit. Vital signs are part of the Emergency Severity Index triage classification which has been shown to predict admission in older ED patients.^{14,15} However, they have not been well studied in the specific observation unit population.

The goal of this study was to better investigate the relationship between both age and vital signs and the patterns of disposition from an ED observation unit. Our primary objective was to determine the relationship between advanced age and odds of admission from an observation unit. Our secondary objective was to determine if initial ED vital signs are predictive of the need for admission.

METHODS

Study design and setting

This was a prospective, observational cohort study conducted in a twenty bed observation unit affiliated with and adjacent to the ED of a tertiary-care Level 1 trauma center which sees approximately 72,000 patients yearly. The study took place from 7/2010 through 3/2011 and was approved by the hospital's institutional review board. The observation unit is staffed by three attending physicians (one emergency/internal medicine, one emergency medicine, and one internal medicine trained) for 8 to 10 hours per day and has around-the-clock nurse practitioner coverage. The unit treats an average of 475 patients per month on over 30 clinical protocols. Length of stay ranges from 6 to 24 hours (average of 16 hours) with occasional patients remaining for 24-48 hours. Transfer to the observation unit is at the discretion of the ED attending physician with the acceptance of the observation unit provider staff.

Study population and protocol

All patients 18 years of age on an observation unit protocol were potentially eligible to participate. Pregnant women and trauma patients were excluded. A convenience sample of patients was enrolled on shifts when a research assistant was available between 8AM and midnight, seven days per week. Not every eligible patient was approached during the enrollment window, and not every shift was covered with a research assistant. Upon enrollment, study personnel administered a patient survey gathering patient data such as demographics and medical history. Additional study data was gathered by review of the ED electronic medical record including ED vital signs, ED laboratory values, observation protocol, and ultimate disposition.

The patient survey was administered by either one author (EH) or by undergraduate research assistants. All personnel underwent one hour of training on the survey instrument. Research assistants were blinded to study hypotheses. The chart review was performed by one author (EH) who was not blinded to study hypotheses. There was both a standardized survey instrument and standardized abstraction form with predefined variables.

Measurements

The primary outcome variable was disposition which was defined as either admission to the hospital or discharge from the observation unit. Age was examined both as a continuous variable and divided between adult and older adult (age ≥ 65 years). The 33 possible observation unit protocols were initially grouped into five diagnostic categories: cardiac (rule out myocardial infarction, syncope, congestive heart failure, hypertensive urgency, and supraventricular tachycardia), infectious disease (cellulitis, pneumonia, and genitourinary infections), pain-related (abdominal pain, nephrolithiasis, and back pain), neurologic (headache, pseudotumor cerebri, transient ischemic attack, and vertigo), and other (dehydration, general observation, pulmonary protocols, endocrine protocols, and other assorted protocols). During data analysis these five categories were combined into three categories as described in the Results section. Race was divided into white and non-white. Medical co-morbidities were recorded individually and the Charlson co-morbidity (CCM) score was calculated.¹⁶ Immunosuppression was defined as the presence of: HIV/AIDS, multiple myeloma, systemic steroid use (past 30 days), malignancy, organ transplant, or current use of immunosuppressive medication.

Initial ED vital signs were examined as continuous variables. They were also dichotomized at cutpoints chosen from common clinical usage. A fever was defined as temperature $\geq 38.0^{\circ}\text{C}$, tachycardia as a pulse ≥ 100 beats per minute, tachypnea as a respiratory rate ≥ 24 breaths per minute, and hypotension as a systolic blood pressure <90 mmHg. Additional potentially useful cutoffs were identified through construction of smoothed plots of each vital sign versus the primary outcome variable.

Recorded laboratory values included white blood cell (WBC) count, hemoglobin, platelet count, and creatinine. Due to the acuity level of the patients and the variety of clinical conditions present, one or more of these studies was not obtained in many patients, making interpretation as continuous variables problematic. Therefore, laboratory values were dichotomized at common clinical cutpoints. Abnormal values included: WBC count $\geq 14,000/\text{mm}^3$, hemoglobin <10 g/dL, platelets $<150,000/\text{mm}^3$, and serum creatinine ≥ 2 mg/dL. For purposes of the multivariable analysis and to allow use of the complete dataset, patients who did not have particular lab tests ordered were assumed to have normal values. This was felt appropriate as lab testing in these cases was not felt necessary by the treating clinician and did not influence disposition decision. The use of multiple imputation analysis

for laboratory variables was not considered appropriate due to the obviously nonrandom nature of the missing values.

Data Analysis

All data analysis was completed using Stata version 11 (STATACorp, College Station, TX). Variables were reported as proportions for dichotomous variables and median with interquartile range for continuous variables. Comparisons were considered significant at p values <0.05 . There was only one outcome event (hospital admission) in the age ≥ 65 group which was the primary independent variable of interest. The presence of such quasi-complete separation in logistic regression models can result in bias of odds ratio estimates away from one. To avoid biased estimates, we analyzed the data using penalized maximum likelihood logistic regression with the Stata command *firthlogit*,¹⁷⁻¹⁹ which reduces bias by penalizing the calculated log likelihood. Significance was tested using the penalized likelihood ratio test.¹⁸ Continuous variables were tested for linearity in the logit using Lowess smoothed plots and fractional polynomial analysis (in unadjusted, non-penalized models).

Independent variables were first entered into a series of unadjusted models with disposition as the dependent variable. Variables with unadjusted p values <0.20 were then entered into a multivariable model. Age ≥ 65 years was retained in all models. Variables were examined for collinearity, and rational choices were made regarding inclusion in the model. An initial full model was created with all candidate independent variables. To address possible sample size concerns, another model was then created by removing selected nonsignificant variables at the $p=0.05$ level through a manual, rational process.

Sensitivity analyses were performed by repeating the multivariable analysis in standard logistic regression and in exact logistic regression. Goodness of fit and discrimination are not available for *firthlogit* but were calculated in the standard logistic regression models using the Hosmer-Lemeshow test and area under the receiver operating characteristic curve (AUROC) respectively. In the exact model, we substituted the dichotomous variable abnormal CCM score for the continuous CCM score, as required by this technique. We also tested age as a continuous variable in the original models. Finally, we substituted variables initially found to be collinear into the original models.

The initial study sample size of 300 patients was based on an estimated admission rate of 20% with 10% of patients aged 65 and over. Given that the admission rate was lower than expected, we report power calculations for the comparison between proportion admitted in the two age groups assuming a 10% admission rate and a change in admission proportion from 10% to 20%, which was a priori considered clinically significant. Power was calculated using a 2 sided test with an alpha of 0.05.

RESULTS

A total of 396 screened subjects met enrollment criteria and were approached for consent. Ninety-six declined to participate, leaving 300 subjects enrolled. Characteristics of the study subjects are demonstrated in Table 1. Twelve percent ($n=35$) of the study population were elders ≥ 65 years of age. Eleven percent ($n=33$) of the population was admitted, including 32 of 265 patients <65 years of age (12.1%) and 1 of 35 elders (2.9%). Older adults had a greater comorbidity burden and were more likely to be on a cardiac protocol than younger adults. The only missing data was the lack of any recorded temperatures in three patients. They were assigned the study average temperature.

Due to the lower than expected admission rate, the power of the study to detect a difference in proportion admitted in each age group was lower than originally planned. We used the number of subjects and the proportions admitted in each age group in our study sample for the power calculations. The power to detect a significant difference between age groups in the admission rates we obtained in the study (2.9% and 12.1%) was only 0.15. However, the study had adequate power to detect clinically significant increases in admission among older adults. Power was 0.90 to detect a difference in proportion admitted among older adults from a hypothesized 20% compared to the 3% we found. Additionally, power was 0.81 to detect an increase in proportion admitted from 10% in younger adults to 30% in older adults.

Results of the unadjusted analyses are shown in Table 2. After initial examination of the odds ratios for protocol type, we combined cardiac (odds ratio [OR] = 1.00, 95% CI 0.35-2.81)($p=1.000$) and neurologic (OR = 1.06, 95% CI 0.24-4.59)($p=0.938$) protocols with the referent “other” protocol group. Examination of the smoothed plot of systolic blood pressure revealed increased admission rates both at the predefined cutoff of <90 mmHg and at an additional cutoff at 180 mmHg.

Variables with univariate p values <0.200 included age ≥ 65 , protocol category, CCM score, diabetes mellitus, immunosuppression, initial temperature, presence of fever, systolic blood pressure ≥ 180 mmHg, and elevated WBC count. In the multivariable models, the variables measuring medical history – CCM score, diabetes mellitus, and immunosuppression – were collinear. To achieve a complete overview of medical comorbidity, we retained CCM score for our primary multivariable models. However, in the fractional polynomial analysis, CCM score was not linear in the logit and it was therefore log transformed. Collinearity was also found between the continuous temperature and the dichotomous fever variable, so fever was not tested in the primary model.

An initial full multivariable model was created from these identified predictors (Table 3). Age ≥ 65 trended towards a decreased odds of admission (OR=0.30) in this model but was not significant. As the inclusion of seven variables for 34 outcome events in the full model is at the limit of recommended events per variable in multivariable analysis,²⁰ a reduced model was created (Table 3). Age ≥ 65 continued to show a trend towards reduced odds of admission (OR=0.28), but remained nonsignificant. Results for the remaining variables in this reduced model were similar to the full model. There were no interactions in either model.

In the sensitivity analyses, the same variables were significant in both standard and exact logistic regression as in the primary analysis. Age ≥ 65 remained nonsignificant in both standard (OR 0.19, 95% CI 0.02-1.51) ($p=0.117$) and exact (OR 0.21, 95% CI 0.00-1.43) ($p=0.1672$) multivariable logistic regression. There was no evidence of lack of fit of either the full ($p=0.1470$) or reduced ($p=0.9295$) models in standard logistic regression. Discrimination was good for full (AUROC 0.79) and reduced (AUROC 0.77) models. In the initial penalized models, when substituting age as a continuous variable, it remained nonsignificant (OR 0.98, 95% CI 0.95-1.01)($p=0.200$). Among the collinear variables, when substituting for the logCCM score, diabetes mellitus was significant (OR 3.06, 95% CI 1.36-6.87)($p=0.008$), but immunosuppression was not (OR 1.89, 95% CI 0.84-4.28) ($p=0.129$).

DISCUSSION

We found that only 2.9% (95% CI, 0.07-14.9%) of older adults were admitted from an ED observation unit as compared to 12.1% (95% CI, 8.4-16.6%) of adults. This finding supports

the contention that the ED observation unit is an appropriate environment for placing selected older adults.

Results of prior studies in this area have been mixed. In a large cohort of observation unit patients, Ross et al found in 2003 that elders actually had higher rates of admission than younger adults (26.1% versus 18.5%).⁸ They did however conclude that elders were appropriately placed in the unit as they had an admission rate lower than a predefined 30% threshold. Although they considered protocol type, they did not adjust for other demographics, medical comorbidities, vital signs, or laboratory abnormalities. We therefore felt it appropriate to expand the analysis controlling for these variables. Our overall admission rate was lower than in Ross et al which may point to differences in patient selection policies, maturation of the observation unit concept, or other unmeasured differences in practice between the two sites.

Additional prior studies have supported our conclusions. Chan et al studied all patients placed in an ED observation unit in Australia and found that there was no relationship between age and admission after controlling for multiple confounders.²¹ However, Chan examined age only as a continuous variable and the distribution of ages in the study population was not reported. In studies limited to specific observation unit protocols, advanced age has not been associated with increased odds of admission.^{6,9,13}

Sample size and power to detect a difference is a concern in our study. The initial power calculation assumed an overall admission rate of 20%. Given the study data, our concern is to avoid Type II error, i.e. failing to detect a difference where one exists. Most clinically relevant would be failure to detect an increased rate of admission among older adults. We think an increased rate of admission among older adults is unlikely for several reasons. First, the point estimate and CIs for admission of older adults was 2.9% (95% CI, 0.07-14.9%) compared to 12.1% (95% CI, 8.4-16.6%) in adults. We therefore are 95% confident that the unadjusted admission rate in our population of older adults is less than 15%. Second, the although power to detect a difference in these point estimates was low, the power was adequate to detect a clinically significant difference from a 10% admission rate in younger adults to a 30% admission rate in older adults. Finally, the odds ratio in the adjusted analysis, although nonsignificant and with confidence intervals encompassing one, trended towards decreased rather than increased odds of admission for older adults.

As selection of patients for the observation unit in our study was at the discretion of the ED and observation unit staff, it could be argued that only less ill or uncomplicated elders were placed in the unit. Assessment of patient severity is complicated by the large variety of observation unit protocols, but possible measures of severity include vital sign abnormalities, co-morbidity burden, and laboratory abnormalities. In our cohort, abnormal vital signs and laboratory values were similar between the two age groups. The exception was tachycardia which was more common in younger adults. However, elders had a much greater overall comorbidity burden than younger adults. Overall, these facts suggest that elders in our observation unit had similar severity of illness to younger adults.

An additional difference between elders and younger adults was in distribution of protocol type. These differences may be due to different proportions of presenting complaints in different age groups, differences in risk stratification for these presenting complaints (e.g., younger adults with chest pain are less likely to undergo a cardiac work-up), or differences in admission patterns based on age (e.g., older adults with infection may be more likely to be admitted). We are unable to determine which of these factors, if any, affected initial decision to place in the observation unit. However, we did adjust for protocol type in the multivariable analyses to control for potential confounding.

Abnormal vital signs might also predict admission from the observation unit but have not previously been well studied. We found that initial temperature, heart rate, and respiratory rate were not predictive of admission. The lack of a relationship is not surprising as patients with severely abnormal vital signs would likely be admitted rather than placed in an observation unit.

Systolic blood pressure was also not predictive of admission when examined continuously. However, graphical analysis identified a cutpoint at blood pressures ≥ 180 mmHg where admission rates increased. Although constituting only 5% of the population, 26.7% of the 15 patients with systolic ≥ 180 mmHg were admitted, more than double the overall cohort rate. As a result, severely elevated systolic blood pressure could be considered as a relative contraindication to placement into an observation unit. Others have not identified this cutpoint at ≥ 180 mmHg, likely due to confining their analysis of blood pressure to a continuous variable.⁹

We also examined protocol type, comorbidities, and laboratory studies as potential predictors of admission. Protocol type was not associated with admission, a finding consistent with the findings of Chan et al.²¹ Comorbidity burden and elevated WBC count were associated with admission. A larger sample would be required to determine what specific comorbidities are most contributory.

The study was limited by the fact that we only enrolled patients after initial transfer to the observation unit. This study therefore cannot be used as a guide for initial disposition decision of patients during their ED stay. Rather, it demonstrates characteristics of patients who are likely to fail observation care after being placed in observation status. We have a large, well-established observation unit, and the patterns seen in this single center study may not apply to other settings with different observation referral patterns. It would be appropriate to study the ED population directly to account for potential differentiation of patients selected for the observation unit based on age.

The admission rate in the study cohort was 11%, but our overall observation unit admission rate is closer to 20%. There are several potential explanations for this finding. First, a proportion of patients are placed in observation status, but upon initial evaluation by observation unit staff, they are felt to be more appropriate for admission. Although, such patients are refused for observation level of care and immediately admitted, due to the mechanics of our electronic medical record, they appear among the observation unit population, increasing its admission rate. It may also be that patients were less willing to participate if they were more ill. Finally, the shift distribution of study personnel may have resulted in missing patients admitted when the observation unit doctor first came on their shift at 7 AM. It is unclear what effect including these patients may have had on study outcomes. We were able to confirm that we did not preferentially enroll patients on specific protocols as our distribution of protocols mirrored that of the observation unit overall for the study time period.

One consequence of the lower admission rate was a less than expected number of outcome events. We have already discussed concerns over study power above. Due to the quasi-complete separation for the age variable, we used penalized logistic regression which prevents bias, but may be overly conservative.^{18,19} The Wald confidence intervals provided in Tables 2 and 3 are the only ones available in Stata using the *firthlogit* command. These may be inaccurate for variables with small numbers of outcome events (e.g., age ≥ 65) as their likelihood profile may be asymmetric. The CIs for age should therefore be interpreted with caution. However, the penalized likelihood ratio tests' *p* values are valid measures, and conclusions regarding significance of age ≥ 65 are considered valid. Although there are less

than the traditional 10 events per independent variable in the models, recent work indicates that 5-9 events per variable provides similar error rates and bias in logistic regression as 10 events per variable.²⁰ To confirm our findings, we also constructed the reduced model. Finally, the assumption that laboratory studies which were not ordered were normal, although reasonable to make, may have attenuated the effect of abnormal values on admission. As a result, we would exercise caution in concluding that laboratory parameters were not associated with admission.

We conclude that among patients placed in an ED observation unit, older adults are admitted 2.9% ((95% CI, 0.07-14.9%) of the time as compared to an admission rate of 12.1% (95% CI, 8.4-16.6%) of adults. In both adjusted and unadjusted analysis, advanced age was not significantly associated with admission and demonstrated a trend towards decreased odds of admission. The study was underpowered to detect a difference in these analyses, however. Older adults can successfully be cared for in these units. Initial temperature, respiratory rate, and pulse were not predictive of admission, but extremely elevated blood pressure was predictive.

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Table 1
Characteristics of 300 subjects in an emergency department observation unit

Variable	Entire population (n=300)		Age <65 years (n=265)		Age ≥65 years (n=35)	
	Frequency (n)	Percent or Median(IQ range)	Frequency (n)	Percent or Median(IQ range)	Frequency (n)	Percent or Median(IQ range)
Demographics						
Age (continuous)(years)	–	44 (32-54)	–	42 (31-51)	–	68 (66-75)
Age 65 years	35	12 %	NA	NA	NA	NA
Female gender	185	62 %	161	61 %	24	69 %
Non-white race	78	26 %	71	27 %	7	20 %
Hispanic ethnicity	3	1 %	3	1.1 %	0	0 %
Nursing home resident	0	0 %	0	0 %	0	0 %
Co-morbid conditions						
Charlson co-morbidity score (continuous)	–	1 (0-2)				
Charlson co-morbidity score 4	44	15 %	33	12 %	11	31 %
Diabetes mellitus	65	22 %	55	21 %	10	29 %
Immunosuppression	80	27 %	68	26 %	12	34 %
Initial vital signs						
Temperature °C (median, IQ range)	–	36.7 (36.6-36.9)	–	36.7 (36.6-36.9)	–	36.7 (36.5-37.0)
Pulse (median, IQ range)	–	85 (75-96)	–	86 (76-98)	–	78 (70-88)
Respiratory rate (median, IQ range)	–	16 (16-18)	–	16 (16-18)	–	16 (16-18)
Systolic blood pressure (median, IQ range)	–	138 (123-154)	–	136 (122-154)	–	147 (129-158)
Temperature 38.0°C	12	4 %	9	3 %	0	0 %
Tachycardia (100 beats per minute)	62	21 %	60	23 %	2	6 %
Tachypnea (24 breaths per minute)	6	2 %	6	2.3 %	0	0 %
Systolic blood pressure 180mmHg	15	5 %	14	5 %	1	3 %
Hypotension (<90 mmHg)	2	1 %	2	1 %	0	0 %
Laboratory values						
White blood cell count 14,000/mm ³	18	6 %	17	6 %	1	3 %
Hemoglobin <10 g/dL	9	3 %	8	3 %	1	3 %
Platelets <150,000/mm ³	12	4 %	10	4 %	2	6 %

Variable	Entire population (n=300)		Age <65 years (n=265)		Age ≥65 years (n=35)	
	Frequency (n)	Percent or Median(IQ range)	Frequency (n)	Percent or Median(IQ range)	Frequency (n)	Percent or Median(IQ range)
Creatinine 2 mg/dL	4	1 %	3	1 %	1	3 %
Observation protocol						
Cardiac	118	39 %	99	37 %	19	54 %
Infectious disease	47	16 %	43	16 %	4	11 %
Neurologic	28	9 %	23	9 %	5	14 %
Pain	48	16 %	47	18 %	1	3 %
Other	59	20 %	53	20 %	6	17 %
Disposition						
Admission	33	11 %	32	12 %	1	3 %

Abbreviations: IQ=interquartile; mmHg=millimeters mercury

Table 2
Univariate predictors of admission among emergency department observation unit patients using penalized log likelihood logistic regression

Variable	Odds Ratio	<i>p</i> value*	Wald 95% confidence interval†
Demographics			
Age 65	0.31	0.109	0.06-1.67
Female	1.08	0.834	0.51-2.27
Nonwhite	1.30	0.513	0.60-2.83
Co-morbid conditions			
Charlson co-morbidity score	1.21	0.028	1.03-1.42
Log of Charlson co-morbidity score	2.09	0.006	1.23-3.55
Diabetes	2.70	0.012	1.28-5.72
Cancer	1.31	0.602	0.49-3.48
Immunosuppression	1.46	0.330	0.68-3.12
Initial vital signs			
Temperature	1.52	0.029	1.09-2.13
Pulse	1.00	0.648	0.98-1.02
Respiratory rate	1.05	0.439	0.92-1.21
Systolic blood pressure	1.01	0.351	0.99-1.02
Temperature 38.0°C	4.92	0.036	1.27-19.09
Tachycardia (100 beats per minute)	1.30	0.536	0.57-3.00
Tachypnea (24 breaths per minute)	2.20	0.435	0.35-13.90
Systolic blood pressure <90	1.58	0.779	0.07-33.72
Systolic blood pressure 180	3.40	0.056	1.07-10.79
Laboratory values			
White blood cell count 14,000/mm ³	8.17	<0.001	3.03-22.03
Hemoglobin <10 g/dL	2.76	0.216	0.63-12.09
Creatinine 2 mg/dL	3.49	0.253	0.50-24.44
Platelets <150,000/mm ³	0.30	0.326	0.018-5.27
Observation protocol			
Cardiac/neurologic/other	referent	0.033	
Infectious disease	2.40		1.06-5.44
Pain	0.46		0.12-1.78

* P values are based on the penalized likelihood ratio test

† Confidence intervals are based on Wald intervals which may be inaccurate for variables with small numbers of outcome events.

Table 3
Multivariable analysis of predictors of admission among emergency department observation unit patients using penalized log likelihood logistic regression

Variable	Full model			Reduced model		
	Odds Ratio	<i>p</i> -value [*]	95% Confidence Interval [†]	Odds Ratio	<i>p</i> -value [*]	95% Confidence Interval [†]
Age 65 years	0.30	0.111	0.05-1.67	0.28	0.091	0.05-1.57
Log of Charlson co-morbidity score	2.93	<0.001	1.57-5.46	2.91	<0.001	1.59-5.30
Initial temperature	1.17	0.503	0.64-2.11	-	-	-
Systolic blood pressure 180 mmHg	4.19	0.058	1.08-16.30	5.20	0.016	1.52-17.79
White blood cell count 14,000/mm ³	11.35	<0.001	3.42-37.72	14.00	<0.001	4.48-43.44
Observation protocol		0.254			-	
Infectious disease protocol	1.71		0.64-4.55	-	-	-
Pain protocol	0.50		0.12-2.14	-	-	-

^{*} *P* values are based on the penalized likelihood ratio test

[†] Confidence intervals are based on Wald intervals which may be inaccurate for variables with small numbers of outcome events.