Indicators for an extended length of stay in the emergency service unit of a Thai community hospital: A multi-level analysis

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DOI: ***10-2427/13248***
Accepted on xxx

ABSTRACT

Background: Extended length of stay affects the efficiency of patient care and results in undesirable patient outcomes. This study explores potential indicators for a prolonged length of stay in the emergency unit in a community hospital setting.
Methods: A retrospective cohort study was conducted. Patients who visited the emergency unit during the first half of September 2018 were included. A multivariable multi-level risk regression was used to explore for potential indicators of an extended length of stay in the emergency unit.
Results: A total of 1,160 emergency visits nested within 16 days study period were included for analysis. 126 (10.9%) visits with an extended length of stay (≥4 hours) and 1,034 visits with a length of stay less than 4 hours were identified. Different patient characteristics and characteristics related to emergency unit between groups were explored. Male gender (RR=1.52, 95% CI; 1.05-2.20, p=0.025), elderly patients (RR=1.82, 95% CI; 1.08-3.04, p=0.016), Burmese citizenship (RR=1.72, 95% CI; 1.15-2.59, p=0.009), non-traumatic mode of presentation (RR=2.50, 95% CI; 1.28-4.92, p=0.008), hospital admission as disposition status (RR=2.38, 95% CI; 1.50-3.77, p<0.001), visit on weekends (RR=2.42, 95% CI; 1.12-5.23, p=0.025), and visit during day shifts (RR=5.75, 95% CI; 1.38-23.92, p=0.016) were identified as significant indicators for extended length of stay in the emergency unit.
Conclusion: Indicators for an extended length of stay in the emergency unit of a Thai community hospital were male patients, elderly patients, Burmese citizenship, non-traumatic mode of presentation, hospital admission as disposition status, visit on weekends, and visit during day shifts.

Key words: Emergency Services, Triages, Length of Stay, Crowding

INTRODUCTION

Length of stay is considered a key indicator of emergency unit overcrowding and the quality of emergency medical care [1]. The extended length of stay systematically affects the efficiency of patient care delivery and contributes to delays in patient evaluation [2]. After the timeliness issue was recognized as a critical component of quality health care by the World Health Organization, many countries' healthcare policy shifted to target on reduction in an emergency unit length of stay [3]. England was the first country to take serious action by placing a

4-hour access standard for patients attending emergency units. The standard was later adopted by many countries such as Canada, Australia, and, most recently, Thailand [4]. After implication, the number of patients disposed within 4 hours had noticeably improved, but the mortality-related outcomes were indifferent. Besides, less urgent patients seemed to have more benefit from the policy than more emergent patients [5]. Although the outcomes of time reduction strategy were controversial and inconsistent, it is still supported by most emergency physicians [6].

Other time measurements that reflect different stages of the emergency unit throughout are the time to physician initial assessment or door to diagnostic time, the time to first physician order or door to treatment time, and the time to disposition decision [7]. These time indices give useful, detailed information for policymakers and emergency providers. Unfortunately, they are rarely mentioned in literature compared to the overall length of stay. Several studies had identified indicators of an extended length of stay in the emergency unit. Patient-related factors were older age, lack of insurance support, or a specific type of health insurance, complex complaints, multiple comorbidities, and specific triage categories [8–10]. Emergency service-related factors were exit block, multiple laboratory testing, need for consultation, limited inpatient beds, and the time that the patients visit the emergency units [11,12].

As previously mentioned, there was some evidence concerning emergency unit waiting time and factors associated with an extended length of stay in the emergency unit in Thailand. However, most are reports from university-affiliated hospitals and tertiary care settings, which made the results of this information inapplicable to smaller units of care. Prior risk factor studies have been conducted by conventional single-level regression analysis, which assumes independence of the data. The risk of prolonged length of stay for each visit differed according to the day that the patient visited. Various factors such as the number of patients, the severity of patients, the number of health care workers, the staff workload, including the shift and the day of the week account for the differences. Failure to recognize the possible correlation of the data or clustering effect may lead to underestimation of standard errors of the coefficients, overestimation of the parameter significance level and inflation of type 1 error [13]. This study aimed to explore potential risk factors of an extended length of stay in the emergency unit to provide useful information for advancing emergency medical services in a community setting by using multi-level analysis.

METHODS

Design

The data of a retrospective cohort was analyzed. The study cohort inception was based on Maesai Hospital emergency service unit routine electronic medical records. The Research Ethics Committee of Chiang Rai Provincial Health Office, Ministry of Public Health, Thailand approved the study (49/2018).

Setting

Maesai Hospital, Chiang Rai, Thailand, is an upper medium-sized community hospital, classified as "M2" by the Ministry of Public Health. The emergency service unit serves approximately 4,000 patient visits per month or almost 50,000 in a year. In Thailand, most community hospitals are not yet equipped with physicians specializing in emergency medicine. General practitioners and newly-graduated medical internships are usually assigned to work in the emergency service unit, both in and out of office hours.

Emergency service hours are divided into three 8-hour shifts, which are day shifts (from 08.00 to 16.00), evening shifts (from 16.00 to 24.00) and night shifts (from 24.00 to 08.00). On weekdays, the emergency unit is staffed with two general physicians during day and evening shifts. In night shifts, one physician is available. On weekends, every shift is operated by only one physician. Every day, the numbers of nursing staff for the day, the evening, and the night shift were eight, seven, and three, respectively. Operating theatre is available on weekdays; all the cases that require immediate surgical management need to be referred to the tertiary care hospital.

Study population

All patients who visited Maesai Hospital emergency unit during the first two weeks of September 2018 were included for data analysis, except for patients who were appointed for regular wound dressings, IM or IV drug administrations, and vaccine injections. Records with incomplete data were excluded. The short-interval data was due to the fact that the emergency unit routinely collected patient data and time indices only during that period for root cause analysis and policy management of emergency unit overcrowding.

Data collection

The routine clinical data recorded by the emergency unit staff were used. The data unit were based on patient visits and were grouped as patient factors and emergency unit factors. Patient factors included the patient's baseline characteristics (i.e., gender, age, nationality and type of medical insurance), type of complaints (i.e., trauma, non-trauma), triage categories, and disposition status. There are three primary medical insurance schemes in

Thailand, which included the universal coverage scheme (UCS), civil servant medical benefit scheme (CSMBS), and social security scheme (SSS) [14]. Patients without medical insurance were classified as self-paid. The patient primary chief complaints and diagnosis categories were collected and classified based on ICD-10. The triage categories were based on the Ministry of Public health Emergency Department Triage System, or MOPD-ED Triage, which was developed by the Department of Medical Services, the Ministry of Public Health, Thailand[15]. The MOPH-ED Triage is a 5 categories system which is primarily adapted from the Emergency Severity Index or ESI [16]. Triage nurses triaged patients who presented to the emergency service unit in front of the emergency room. The patients would be assigned into any of the five triage levels depending on their conditions, which are resuscitation, emergency, urgency, semi-urgency, and non-urgency. Patients with a higher level of acuities, such as resuscitation and emergency, are immediately evaluated by the attending physicians. Patients with a lower level of acuity are asked to wait in the observation and waiting area outside of the emergency room. The patient disposition status was categorized into discharge, admission, referral to tertiary hospital, rejection or denial of further treatment, and death.

Emergency unit factors included timing of visit (i.e., weekdays, shift) and emergency unit time indices (i.e., length of stay). The emergency unit timing indices were calculated from the exact time data collected by the emergency unit staff. Five points of time were recorded for each patient visits, first when patients were triaged, second when patients were first assessed by physicians, third when orders of the physician were delivered to patients, forth when physicians determined disposition status of patients and fifth when patients leave the emergency room. Five-time indices were calculated from the differences of each point of time as followed — Time to physician initial assessment (PIA) = time at triage – time at first physician assessment. Time to first physician order (FPO) = time at triage – the time when the first physician orders were delivered. Time to disposition decision (DISP) = time at triage – the time when physician determined patient disposition status. Length of stay (LOS) = time at triage – the time when the patient leaves the emergency room. Time gap after disposition = length of stay – time to disposition decision. LOS is the crucial measurement of the emergency unit patient flow and widely accepted as the indicator of emergency unit overcrowding. All the time indices in this study were presented in minutes.

Extended length of stay

The clinical endpoint for this exploratory analysis is the extended length of stay in the emergency service. In this study, extended length of stay was defined as any patient visit with a total time from patient triage to the time when patient leaves the emergency department more than 240 minutes or 4 hours. Although the cut-off point of extended LOS varies across studies [8,17–19], we chose 4 hour as the study threshold based on emergency room service delivery guideline by the Ministry of Public Health, Thailand, which suggests that most patients should be discharged from the emergency room within the interval of 2 to 4 hours [4].

Potential risk factors

Potential risk factors for an extended length of stay were grouped into patient factors and emergency unit factors. Patient factors included gender, age, nationality, type of complaint, triage categories, and disposition status. The age of the patient was categorized into three groups, children (0 to 14 years old), adults (15 to 59 years old), and elderly (more than 60 years old). Nationality was based on the patient's citizenship, which was Thai, people with citizenship problems (minorities and hill tribes who have gained legal rights to live in Thailand), Burmese, and other foreigners. Types of medical insurance were not included for exploratory analysis due to possible collinearity to nationality. The type of complaint was categorized into trauma and non-trauma. Diagnosis categories based on ICD-10 could not be included in the exploratory model because of the limited sample size and imbalance of clinical endpoints across subcategories. Patient disposition status was divided into discharge, admission to hospital, referral to tertiary care, denial of further treatment, and death. Emergency service factors included were days of the week (i.e., weekday or weekend), and working shifts (i.e., day, evening and night shift), in which the patient visited the emergency unit.

Statistical analysis

Descriptive statistics were used to compare the differences between the group with total time in the emergency unit more than 4 hours and the group with total time less than 4 hours according to types of variables. Frequencies and percentages were used for categorical variables. All of the continuous variables were non-normally distributed and were presented by median and interquartile ranges. Statistics for testing hypothesis of differences between groups were used as appropriate. We used Wilcoxon rank sum test for non-normally distributed continuous variable. Exact probability test was used for categorical variables.

An exploratory analysis was planned to be carried out with generalized linear regression for a binary outcome to estimate the risk ratio. However, we encountered convergence problems during analysis, which was usual for log binomial regression. The analysis was switched to

modified Poisson regression with a robust error variance as suggested in literature [20]. From our dataset, the mean and the variance of the response variable were found to be approximate, which suggests that the use of Poisson distribution was appropriate, and no evidence of overdispersion was identified. In case of any error misspecification, the use of sandwich estimator would result in a robust estimate of variances. All the potential factors were explored in both univariable multivariable analysis. Risk ratios estimated from the Poisson model and their 95% confidence intervals were presented and considered statistically significant if their p-values were less than 0.05.

We further our analysis by using multi-level regression to account for the dependent nature of the data. As the date variable represented variation in emergency personals, resources, and the degree of emergency department crowding, it was considered as an emergency unit-level. All of the patient visits were clustered within the emergency unit-level or the date that the patient visited the emergency unit. A two-level random intercept model with a fixed slope multi-level model was analysed based on a generalized linear model for a binary outcome with the Poisson distribution. The measure of association for fixed effect component was reported in terms of risk ratio (RR) with their 95% confidence intervals and p-values. The random-intercept model or "null" model, with no patient-level or department-level predictor specified, was first inspected for the presence of significant variance based independently on the clustering effect of the department level. Conventionally, intraclass correlation (ICC) or variance partition coefficient (VPC) would be calculated based on the random intercept and residual variances, which would give information on the proportion of the variation in the outcome that is due to between-cluster variation [21]. However, in multi-level regression with Poisson distribution, residual variances could not be directly estimated from the data. Therefore VPC and ICC could not be directly estimated. Alternatives method of computing VPC had been suggested, such as the exact calculation and a simulation-based approach [22]. Larsen et al. introduced the concept of the median odds ratio (MOR) [23] to be used instead of VPC to present the between-cluster variation. This concept was later adapted and subsequently incorporated into another type of regression families such as median hazard rate ratio for multi-level survival analysis [24] and median rate ratio for multi-level Poisson regression [25], based on the same calculation equation.

For the measure of variation or random effect components in this study, the median ratio concept was adopted to represent the emergency unit-level variation instead of VPC. The median risk ratio was estimated based on the random intercept variance of the multivariable multi-level regression with Poisson distribution. It can be interpreted as the likelihood that two random different department-levels or dates would differ in affecting similar patient visits. The median risk ratio of more than 1.20 would suggest substantial cluster-level variation [26,27]. Model precision was assessed using the log-likelihood ratio and Akaike Information Criterion (AIC). The log-likelihood ratio test or LR test was then used to compare the log-likelihood ratio from the maximum likelihood estimation of both multivariable models. To maximize the validity of the model, all available data during the study period were employed. All statistical analyses were executed with Stata statistical software version 15, StataCorp LP, Texas, United States.

RESULTS

A total of 1,160 patient visits were included during the two weeks. These emergency visits were nested within 16 different dates, the 2nd level variable. 126 (10.9%) visits were classified in the group with extended length of stay (LOS >4 hours), the remaining visits (1,034, 89.1%) were in the group with length of stay less than 4 hours (Figure 1). In group with extended length of stay, there were higher proportion of male (61.1% vs. 50.3%, p 0.023), elderly (31.0% vs. 21.6%, p 0.033), Burmese citizenship (38.9% vs. 19.1%, p <0.001), self-paid (40.5% vs. 21.5%, p <0.001), and non-trauma presentation (92.1% vs. 76.8%, p<0.001) compared to the other group. In both groups, around half of the patients were triaged as urgency, followed by semi-urgency and emergency. The groups with an extended length of stay had higher proportions of urgency (52.4% vs. 42.6%) and emergency (10.3% vs 5.0%) patients. More patients were admitted (33.3% vs. 13.2%) and referred (7.1% vs. 5.0%) in extended length of stay group, less were discharged (57.9% vs. 80.9%) (Table 1). The average number of visits per day was 72.5±15.4. The mean number of visits was 68.3±14.6 for weekday and 81.8±14.0 for weekend. The number of patient visiting the emergency unit within each day of observation, together with relevant time indices, the proportion of patients with an extended length of stay were shown in Table 2.

In terms of emergency unit factors, higher proportions of patients in an extended length of stay group visited the emergency unit on weekends (62.7% vs. 33.9%, p<0.001) or during day shifts (62.7% vs. 35.8%, p<0.001). All of the emergency unit time indices differed significantly between groups. Groups with extended waiting time had longer median time to physician initial assessment (27.5 (IQR 5, 102) vs. 15.0 (IQR 7, 31), p<0.001), median time to first physician order 46.0 (IQR 15, 130) vs. 23.0 (IQR 12, 45), p<0.001), median time to patient disposition (280.0 (IQR 241, 342) vs. 48.0 (IQR 22, 95), p<0.001), and median total length of stay (306.0 (IQR 267, 376) vs. 65.0 (IQR 30, 117), p<0.001). The median gaps after disposition decision were also longer in the group with an extended waiting

FIGURE 1. Patient flow diagram

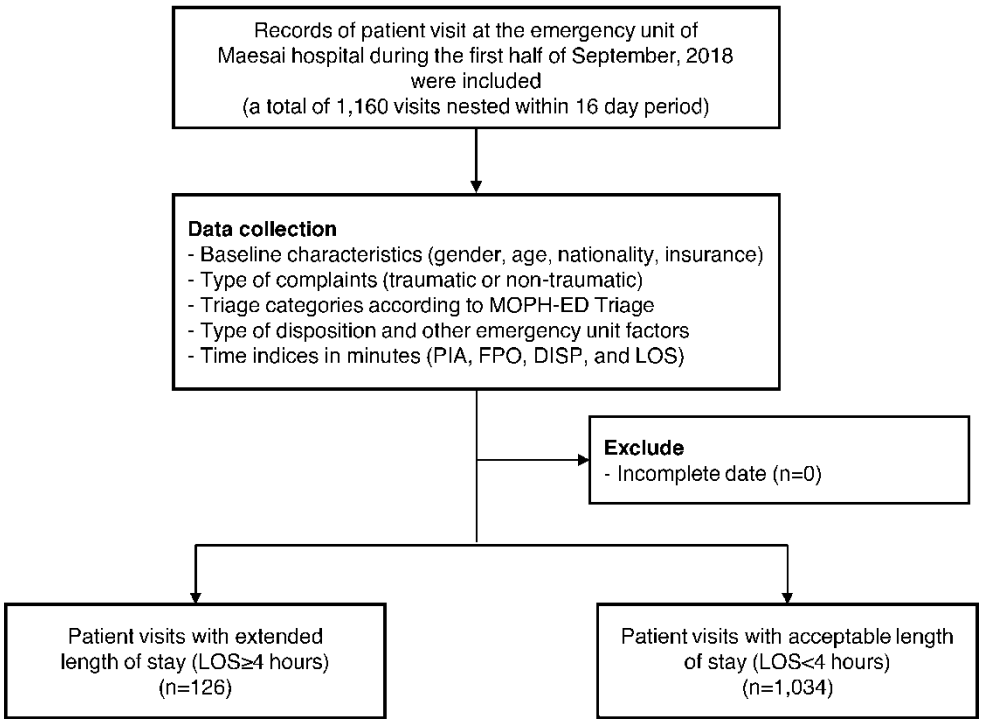
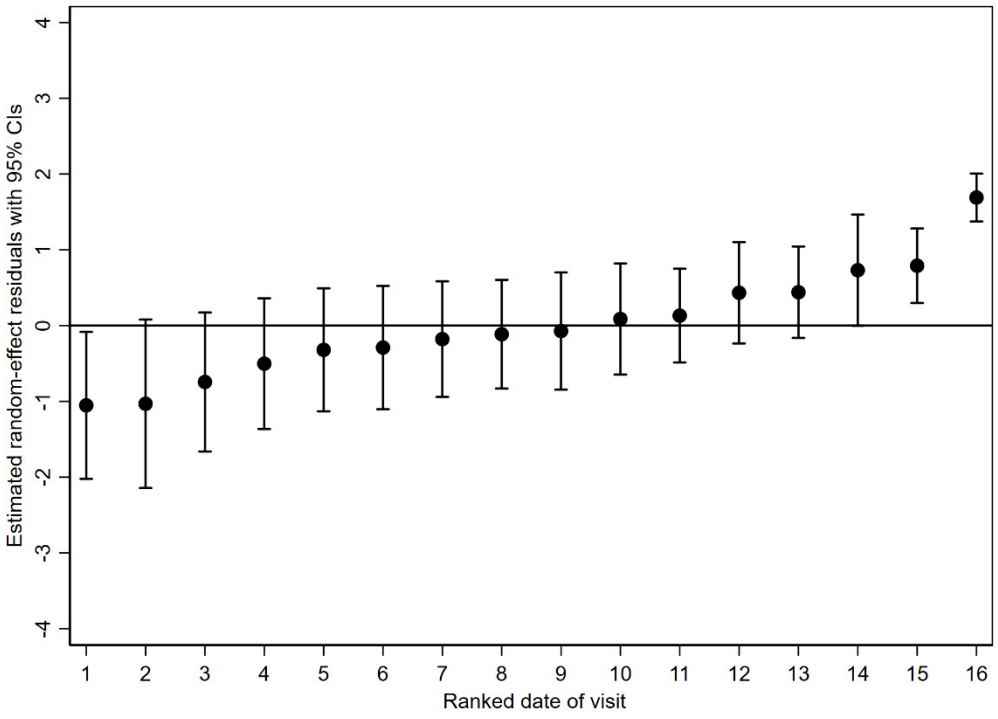


FIGURE 2. Caterpillar plot showing estimated 2nd level variances



time (10.0 (IQR 0, 32) vs. 3.0 (IQR 0, 19), p<0.001).

Based on univariable risk regression model, male gender (RR=1.48, 95% CI: 1.06-2.08, p=0.023), elderly age group (RR=1.83, 95% CI: 1.15-2.91, p=0.011), Burmese citizenship (RR=2.37, 95% CI: 1.66-3.39, p<0.001), non-trauma presentation (RR=3.19, 95% CI: 1.70-5.99, p<0.001), emergency triage level (RR=5.60, 95% CI: 1.66-18.84, p=0.005), urgency triage level (RR=3.65, 95% CI: 1.17-11.35, p=0.025), admission as disposition status (RR=2.94, 95% CI: 2.08-4.14, p<0.001), visit on weekends (RR=2.86, 95% CI: 2.04-4.03, p<0.001), and visit during day shifts (RR=8.36, 95% CI: 2.09-33.43, p=0.003) were significant risk factors for extended length of stay in the emergency unit. In multivariable risk regression model, all of the previously explored risk factors remained statistically significant except for emergency triage level (RR=2.19, 95% CI: 0.69-6.99, p=0.186) and urgency triage level (RR=2.37, 95% CI: 0.87-6.46, p=0.091) (Table 3).

The random intercept or the null mode showed significant variation among different dates of patient visits (p<0.001). The 2nd level residuals were estimated from the null model and presented with a caterpillar plot (Figure 2). The last two ranked dates (the 15th and the 16th) revealed significant heterogeneity of the 2nd level residuals. Both days were weekends, where only one doctor was available for each shift. The median risk ratio of the null model was 2.13 (95% CI: 1.60-3.39, p<0.001), which represented that the likelihood of extended length of stay could increase over two times when the same patient visited the emergency department on the day with higher risk of extended length of stay, regardless of any other predictors. In the multivariable multi-level model, male gender (RR=1.52, 95% CI: 1.05-2.20, p=0.025), elderly age group (RR=1.82, 95% CI: 1.08-3.04, p=0.016), Burmese citizenship (RR=1.72, 95% CI: 1.15-2.59, p=0.009), non-trauma presentation (RR=2.50, 95% CI: 1.28-4.92, p=0.008), admission as disposition status (RR=2.38, 95% CI: 1.50-3.77, p<0.001), visit on weekends (RR=2.42, 95% CI: 1.12-5.23, p=0.025), and visit during day shifts (RR=5.75, 95% CI: 1.38-23.92, p=0.016) were identified as significant risk factors for extended length of stay in the emergency unit (Table 4).

After adjusting for other potential risk factors, the median risk ratio decreased to 1.82 (95% CI: 1.41-2.83, p<0.001). The log-likelihood ratio test between the conventional single-level Poisson regression model and multi-level Poisson-based risk regression model showed statistical differences at p<0.001, with a lower log-likelihood ratio from the multi-level model (Table 5).

DISCUSSION

From the multi-level exploratory analysis, this study identified potential risk factors of an extended length of stay within the emergency unit, which included both patient and emergency unit characters. Many of these risk factors had been consistently identified in literature such as age, gender, payment method, ethnicity, patient complaint, patient acuity ,and requiring admission [8,9,28]. Most studies involved specific characteristics of the patient visiting the emergency unit, only a few described hospital or emergency unit characteristics.

In terms of patient characters, we found that male patients had 1.5 times longer length of stay than female patients in the emergency unit. This was opposed to previous studies that reported inconsistent results. One study reported a higher risk of an extended length of stay in females [28]. One study from Thailand found no significant difference between females and males in terms of waiting time [9]. Another study reported longer in-patient length of stay in male patients, which was explained that men were more tolerable to their illness and tended to delay their visit to the hospital compared to women [29].

The elderly were at merely two times at risk of having extended length of stay compared to children, the reference group. This was because most children who visited the unit were having only minor illnesses such as acute nasopharyngitis and viral gastroenteritis, unlike adult and elderly patients who usually had more serious, complicated illnesses. Older patients also had multiple comorbidities and required more emergency resources, such as laboratory investigations and radiological examinations. This result was consistent with past evidence that the risk of an extended stay in the emergency unit tends to increase with age [30].

We found a higher proportion of Burmese citizens in an extended length of stay group. In our setting, around 20 percent of all patient visits were from Burma; only one western foreigner was included. Previous studies suggested that language barriers and communication problems during the health care process could significantly increase the patient length of stay in emergency units [31,32]. As nationality and health insurance are partly related, this association could partially result from the uninsured status of Burmese patients. The result was concordant with prior studies in the United States which, found longer waiting times among uninsured patients [31,33].

Patients with non-traumatic presentation had a 2.5 times higher risk of an extended length of stay than traumatic patients. Trauma patients usually were rapidly approached by medical staff. An initial evaluation, or primary survey, takes less time in trauma patients than in medical patients. Most trauma patients were minor injuries and could be discharged in a short period without further timely laboratory investigations. Few studies compared the risk between trauma and non-trauma patients; most were separated as a different domain of patients. One study in Canada found that patients with trauma diagnoses had a shorter median length of stay compared to non-trauma diagnoses [34].

TABLE 1.Patient and emergency unit (EU) factors

Parameters	LOS >4 hours (n=126)		LOS ≤4 hours (n=1,034)		P-value
	n	(%)	n	(%)	
Patient factors					
Gender					
Male	77	61.1	520	50.3	0.023
Female	49	38.9	514	49.7	
Age (year, median, IQR)	41.5	19 to 62	34.3	12 to 57	0.043
Age groups					
Elderly	39	31.0	223	21.6	0.033
Adult	60	47.6	504	48.8	
Children	27	21.4	305	29.6	
Health insurance					
Universal coverage	67	53.2	740	71.6	<0.001
CSMB	6	4.7	56	5.4	
Social security scheme	2	1.6	16	1.5	
Self-paid	51	40.5	222	21.5	
Citizenship					
Thai	55	43.6	600	58.0	<0.001
Unidentified	22	17.5	236	22.8	
Burmese	49	38.9	197	19.1	
Others	0	0	1	0.1	
Mode of presentation					
Non-trauma	116	92.1	794	76.8	<0.001
Trauma	10	7.9	240	23.2	
Triage categories					
Resuscitation	1	0.8	15	1.5	0.004
Emergency	13	10.3	52	5.0	
Urgency	66	52.4	440	42.6	
Semi-urgency	43	34.1	446	43.1	
Non-urgency	3	2.4	81	7.8	
Disposition status					
Death	1	0.8	3	0.3	<0.001
Deny treatment	1	0.8	6	0.6	
Refer	9	7.1	52	5.0	
Admission	42	33.3	136	13.2	
Discharge	73	57.9	836	80.9	
EU factors					
Days of week					
Weekends	79	62.7	350	33.9	<0.001
Weekdays	47	37.3	684	66.1	
Shift					
Day	79	62.7	370	35.8	<0.001
Evening	45	35.7	571	55.2	
Night	2	1.6	93	9.0	

Abbreviations: LOS, length of stay; IQR, interquartile range; CSMB, civil servant medical benefit scheme; EU, emergency unit.

TABLE 2. The number of patient visiting the emergency unit within each day of observation, together with relevant time indices, the proportion of patients with an extended length of stay

Date of visit	Day	Total	PIA	FPO	DISP	GAP	LOS	LOS≥4hr	
		n	P50 (IQR)	P50 (IQR)	P50 (IQR)	P50 (IQR)	P50 (IQR)	n	(%)
1-Sep-18	Sun	88	11(3, 49)	23 (11, 62)	225 (82, 315)	0 (0, 3)	228 (86, 315)	40	(45.5)
2-Sep-18	Mon	34	12 (5, 58)	23 (10, 65)	65 (46, 183)	5 (0, 15)	85 (60, 198)	7	(20.6)
3-Sep-18	Tue	78	10 (5, 17)	12 (7 ,25)	37 (12, 81)	5 (1, 16)	48 (17, 115)	2	(2.6)
4-Sep-18	Wed	74	12 (6, 22)	17 (10, 31)	33 (15, 72)	3 (0, 10)	45 (25, 80)	3	(4.1)
5-Sep-18	Thu	88	20 (1, 26)	23 (15, 42)	49 (23, 80)	10 (1, 43)	75 (31, 114)	1	(1.1)
6-Sep-18	Fri	74	13 (6 ,32)	24 (14, 54)	61 (23, 107)	12 (3, 30)	79 (45, 166)	10	(13.5)
7-Sep-18	Sat	95	18 (8, 37)	30 (15, 46)	52 (29, 98)	1 (0, 25)	80 (33, 132)	9	(9.5)
8-Sep-18	Sun	84	26 (11, 129)	31 (17, 104)	81 (27, 162)	0 (0, 7)	88 (31, 177)	6	(7.1)
9-Sep-18	Mon	74	13.5 (7, 24)	20 (11, 35)	35 (14, 100)	2 (0, 30)	63 (27, 134)	4	(5.4)
10-Sep-18	Tue	71	15 (10, 28)	27 (17, 46)	49 (24, 120)	7 (0, 35)	75 (45, 150)	4	(5.6)
11-Sep-18	Wed	76	8 (3, 16)	18 (8, 30)	33 (14, 105)	5 (0, 30)	61 (21, 134)	5	(6.6)
12-Sep-18	Thu	66	19 (12, 45)	29 (16, 60)	55 (25, 99)	1 (0, 25)	70 (29, 120)	5	(7.6)
13-Sep-18	Fri	51	19 (5, 47)	24 (11, 65)	55 (32, 100)	10 (4,28)	90 (45, 147)	0	(0)
14-Sep-18	Sat	58	20 (10, 35)	30 (15, 50)	44 (29, 103)	3 (0, 18)	57 (34, 145)	8	(13.8)
15-Sep-18	Sun	84	26 (10, 57)	34 (20, 76)	71 (27, 159)	1 (0, 11)	81 (32, 175)	16	(19.1)
16-Sep-18	Mon	65	21 (8, 40)	28 (12, 50)	59 (30, 110)	2 (1, 11)	78 (45, 129)	6	(9.2)
Overall			15 (6, 35)	24 (12, 49)	55 (24, 124)	3 (0, 20)	75 (33, 148)		

Abbreviations: PIA, time to physician initial assessment; FPO, time to first physician order; DISP, time to disposition status; GAP, time between disposition decision and the time when the patient leaves the emergency unit; LOS, total length of stay in the emergency unit

Patients requiring admission were significantly at higher risk of lengthy waiting in the emergency unit than other types of disposition. This was the group of patients that were access-blocked. When in-patient beds were fully occupied, the emergency patient outflow was obstructed and resulted in more prolonged waiting. Our final model did not find statistically significant differences among triage categories. However, the tendency of significant was toward urgent and emergent triage categories, which was consistent with previously reported data that the relation was possibly inverted-U or bell-shaped [28]. Length of stay was found to be shortest in patients with the highest or lowest level of acuity, and longest in those in the middle zone such as urgent groups [35], all of these were perfectly reflected in our data.

For emergency unit characters, we explore the effect of different times the patients visited the unit. We found that patients who visited during the dayshifts carried almost six times higher risk than the night shifts, the reference shifts. This was in contrast to the previous study, which found that the length of stay was highest in the evening shifts [9]. However, the study was done in the university hospital setting. In our setting, a large proportion of urgent and emergent patients visited during the day shifts. These patients usually required investigations, imaging, and admission to the hospital. The access to in-patient was blocked until late in the afternoon after the in-patient discharge process finished. On weekends, the median total length of stay almost doubled of that on weekdays, which could be explained by outnumbered staff and resources. It was found that on weekends with only single doctor covering the whole 8-hour shift, the risk of extended length of stay was averagely higher than on the weekdays, despite the constant numbers of nursing staff. The effect of weekend days might be mediated through the number of doctor. To answer this specific concern, a causal mediation analysis is required.

Our study not only measured the total length of stay but other emergency time indices such as time to physician assessment, time to first physician order, and time to disposition decision. We hypothesized that the delay since the first step of patient encounter could sequentially affect the next step along the emergency health care process. However, the identification of possible linear relationships among relevant time indices was beyond the scope of our study. One strength of our study was statistical analysis. We considered the correlation within our observations and used hierarchical modeling or a multi-level model for exploratory purposes, which was rarely seen in medical literature. We also chose generalized linear regression for binary outcome instead of more conventional logistic regression to avoid the overestimation of risk ratios, as our data was a retrospective cohort in design.

TABLE 3. Univariable and multivariable risk regression model

Determinants	Univariable Model				Multivariable Model			
	RR	95% CI		P-value	RR	95% CI		P-value
		Lower	Upper			Lower	Upper	
Patients factors								
Gender								
Male	1.48	1.06	2.08	0.023	1.47	1.07	2.02	0.018
Female	1.00	Ref	Ref		1.00	Ref	Ref	
Age groups								
Elderly	1.83	1.15	2.91	0.011	1.91	1.21	3.01	0.005
Adult	1.31	0.85	2.02	0.225	1.60	1.06	2.42	0.026
Children	1.00	Ref	Ref		1.00	Ref	Ref	
Citizenship								
Burmese	2.37	1.66	3.39	<0.001	1.93	1.34	2.76	<0.001
Unidentified	1.02	0.63	1.63	0.949	1.00	0.63	1.59	0.988
Thai	1.00	Ref	Ref		1.00	Ref	Ref	
Mode of presentation								
Non-trauma	3.19	1.70	5.99	<0.001	2.77	1.46	5.25	0.002
Trauma	1.00	Ref	Ref		1.00	Ref	Ref	
Triage categories								
Resuscitation	1.75	0.19	15.79	0.618	1.23	0.14	11.17	0.853
Emergency	5.60	1.66	18.84	0.005	2.19	0.69	6.99	0.186
Urgency	3.65	1.17	11.35	0.025	2.37	0.87	6.46	0.091
Semi-urgency	2.46	0.78	7.76	0.124	1.86	0.69	5.01	0.222
Non-urgency	1.00	Ref	Ref		1.00	Ref	Ref	
Disposition status								
Death	3.11	0.56	17.25	0.194	2.16	0.22	21.56	0.513
Deny treatment	1.78	0.29	11.07	0.537	1.78	0.30	10.54	0.525
Refer	1.84	0.97	3.49	0.063	1.37	0.61	3.08	0.450
Admission	2.94	2.08	4.14	<0.001	2.29	1.55	3.37	<0.001
Discharge	1.00	Ref	Ref		1.00	Ref	Ref	
EU factors								
Days of week								
Weekends	2.86	2.04	4.03	<0.001	2.70	1.96	3.72	<0.001
Weekdays	1.00	Ref	Ref		1.00	Ref	Ref	
Shift								
Day	8.36	2.09	33.43	0.003	5.89	1.44	24.03	0.013
Evening	3.47	0.86	14.08	0.082	3.36	0.80	14.20	0.099
Night	1.00	Ref	Ref		1.00	Ref	Ref	

Abbreviations: LOS, length of stay; RR, risk ratio; CI, confidence interval; EU, emergency unit.

The major limitation of our study lies within the generalizability of the data as it was collected from a single community hospital. Second, the study interval was short and might not represent the general pattern of patient visits to the emergency department over a more extended period. Third, in terms of study size for multi-level analysis, the data was only available in 16 days. Thus only 16 groups were available for estimation of the 2nd

TABLE 4. Multivariable multi-level risk regression model

Determinants	RR	95% CI		P-value
		Lower	Upper	
Patients factors				
Gender				
Male	1.52	1.05	2.20	0.025
Female	1.00	Ref	Ref	
Age groups				
Elderly	1.82	1.08	3.04	0.016
Adult	1.53	0.95	2.45	0.064
Children	1.00	Ref	Ref	
Nationality				
Burmese citizen	1.72	1.15	2.59	0.009
Unidentified	0.95	0.57	1.58	0.852
Thai citizen	1.00	Ref	Ref	
Mode of presentation				
Non-trauma	2.50	1.28	4.92	0.008
Trauma	1.00	Ref	Ref	
Triage categories				
Resuscitation	1.82	0.16	20.72	0.629
Emergency	2.85	0.75	10.89	0.126
Urgency	2.76	0.83	9.22	0.097
Semi-urgency	2.41	0.74	7.91	0.146
Non-urgency	1.00	Ref	Ref	
Disposition status				
Death	2.60	0.32	20.91	0.368
Deny treatment	2.37	0.31	17.88	0.402
Refer	1.31	0.60	2.88	0.491
Admission	2.38	1.50	3.77	<0.001
Discharge	1.00	Ref	Ref	
EU factors				
Days of week				
Weekends	2.42	1.12	5.23	0.025
Weekdays	1.00	Ref	Ref	
Shift				
Day	5.75	1.38	23.92	0.016
Evening	3.88	0.92	16.28	0.064
Night	1.00	Ref	Ref	

Abbreviations: LOS, length of stay; RR, risk ratio; CI, confidence interval; EU, emergency unit.

level variances. According to the previous simulation study, a multi-level study with a group size smaller than 30, the standard error could be underestimated (too small) by more than 15%. However, the estimated regression coefficients were reported to be unbiased even in a small study with ten groups of five units [36]. Finally, we did not follow up and compare the patient clinical outcomes between both groups, which could confirm the clinical impact of emergency unit overcrowding.

The result from our study could be implicated in 2 different levels, the unit or policy level and the individual or patient level. For policymakers, the risk at the unit level

TABLE 5. Random effect components of multi-level model

Determinants	Random Intercept Model				Multivariable Model			
	Statistic	95% CI		P-value	Statistic	95% CI		P-value
		Lower	Upper			Lower	Upper	
Random effect component								
Area variance	0.63	0.24	1.63		0.40	0.13	1.19	
Median risk ratio	2.13	1.60	3.39	<0.001	1.82	1.41	2.83	<0.001
Log-likelihood	-374.59				-330.93			
AIC	753.19				701.86			

Abbreviations: CI, confidence interval; AIC, Akaike information criterion.

showed possible flaws in the patient care process during the weekends and on the day shift. Efforts might be done to increase numbers of staff, specifically doctor, and resources to fit the requirements and improve patient outcomes, whereas in individual-level our data could be further developed into a predictive model which health care professionals could use to monitor for patients who might require close attention to prevent the occurrence of extended length of stay [28].

CONCLUSION

Risk factors of an extended length of stay in the emergency unit of a Thai community hospital were male gender, elderly age group, Burmese citizenship, non-trauma presentations, admission as disposition status, visit on weekends, and visit during day shifts.

Acknowledgments

The authors wish to acknowledge contribution of all the medical and nursing staff of the Emergency Unit at Maesai Hospital for data collection. Also, the authors wish to grant special appreciation to Dr. Sirisak Nanta, the director of Maesai Hospital for his approval of the research conduct and to Mrs. Pimpa Weerakham and Ms. Kanokporn Jaewison for their collaboration in cleaning and reviewing data for time indices.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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