Frequency of Admittance and Probability of Inpatient Treatment: 
Experience of Emergency Department, Hospital Universiti Kebangsaan 
Malaysia

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Abstract: - Recently, the number of Emergency Department (ED) visits in Malaysia has climbed dramatically and as a result causing overcrowding in such department. Overcrowding occurs when all rooms, stretchers and chairs in the ED are full with sick people waiting for a long period of time to receive emergency care. The main factors contributing to this state of affair are the increasing number of unexpected patients, the lack of staffs and the lack of inpatient beds. Overcrowding has a significant negative effect on the patient’s safety, comfort and satisfaction in addition to depicting the inability of emergency staffs to care for patients. Based on past studies, statistics have shown that the number of patients frequently admitted to the ED were patients injured in road accidents. This study aims to develop two models for solving overcrowding in the ED. The first will be applied to estimate the frequency of admittance and its relationship to the contributing factors, whereas the latter will be employed to estimate the probability of receiving inpatient treatment once the patients are already admitted to the ED. The samples are collected from the experience of the Emergency Department, Hospital Universiti Kebangsaan Malaysia (HUKM) and they are analyzed using regression models. Poisson regression is used for the first model whereby the factors considered are the patient’s age, gender, race and admittance date. The result may be utilized by the hospital management to predict the frequency of admittance based on the contributing factors. Logistic regression is utilized in the second model to identify the probability of receiving inpatient treatment after being admitted to the ED. The result may be employed by the hospital management to prepare and provide sufficient emergency beds and staffs especially for inpatient treatment. The contributing factors studied in the second model are the same as the first model.

Key-Words: - Admittance frequency, inpatient probability, Emergency Department, Poisson regression, logistic regression.

1 Introduction

Recently, the number of Emergency Department (ED) visits in Malaysian government hospitals has climbed dramatically and as a result causing overcrowding in such department. Patients admitted to the ED of government hospitals often have to lie on gurneys or sit on chairs filling every available space including the hallways while waiting for triage process and inpatient treatment. In the triage process, patients will be checked and determined whether their problem are critical, urgent or routine. The main reasons for overcrowding in the ED of government hospitals are seasonal illnesses and frequent visits by the poor and uninsureds who have nowhere else to turn except to the “safety net” provided by such departments.

The volume of emergency patients and the number of admissions per day is often unpredictable. Hospitals usually do not prepare for the next day’s volume and admission to the ED. A number of recent studies show a direct and strong correlation between the number of admitted patients being boarded in the ED and crowding, making it clear beyond question that this is the number one reason for overcrowding. Among the consequences of overcrowding are sick people having to wait too long to receive emergency care which (American College of Emergency Physicians [1]):

- has a significant negative effect on the patient’s safety, comfort and satisfaction,
- increases the total length of stay in hospital, further worsening access to the emergency care,
- increases walkouts because the longer people wait, the more people will leave prior to care,
- increases medical errors since the emergency staff must simultaneously care for inpatients and focus on new emergencies coming in the door, and
• increases patient mortality and medical negligence claims, which increases health care costs for everyone.

The most common reasons for ED visits are abdominal pain, chest pain, asthma, chronic disease and fever. The most frequent diagnoses are contusions (bruising), acute upper respiratory infections, and open wounds. Injury, poisoning and adverse effects of medical care (such as an allergic drug reaction or complication of surgery) account for more than a third of all visits. According to World Health Organization (W.H.O), injury was responsible for 9% cause of death all around the world in 2001 which is nearly 5.1 million deaths, and in the United States, injury was one of the main reasons of prenataal death (Peden et al. [2]).

In Malaysia, injury became one of the main reasons why people are admitted to the hospital and the number one cause of death. The number of patients admitted to the government hospital has increased from 156,073 cases in 1999 to 163,837 in 2001. It contributes for 10% of all entries. Research carried out by the Ministry of Health in Malaysia showed that the common location of injury are road injury (42%), house injury (29%), work injury (18%), recreation park injury (7%) and school injury (4%) (YB Dato’ Chua Jui Meng [3], Mohamad Nizam Mustafa [4]). According to W.H.O, 48% of all inpatient beds in the ED of developed countries in year 2004 were full with road injury patients. The average number of road accident cases in Malaysia is constantly increasing by 9.7% per year and this scenario automatically increases the number of patients admitted to the ED (Polis Diraja Malaysia [5]).

Several studies have been carried out on solving crowding in the ED. Mayou and Bryant [6] studied the effects of road accidents on patients after one month and in the United States, injury was one of the main reasons of prenatal death (Peden et al. [2]).

This study aims to develop two models for solving overcrowding in the ED. The first model estimates the frequency of ED admittance and its relationship to the contributing factors, whereas the latter estimates the probability of inpatient or outpatient treatment once the patients are already admitted to the ED. The results may be used by the hospital management to prepare and provide sufficient emergency beds and staffs especially for inpatient treatment.

2 Methodology

2.1 Data

The data consists of patients admitted to the Emergency Department, Hospital Universiti Kebangsaan Malaysia due to injuries of road accidents in year 2006. Medical records containing information on patient’s demographic background are available and they are categorized into binary data. The categories are:

- age (1-12 years, 13-24 years, 25-40 years, 41-60 years & 61+ years)
- gender (male and female)
- race (Malay, Chinese, Indian and others)
- admittance date (Jan-March, Apr-June, July-Sept, Oct-Dec)

The independent or explanatory variables for the regression model are represented by the patient’s demographic background. The intercept, i.e. the basic class, chosen for the regression model is represented by the following categories; age 1-12 years, male, Malay and admitted in Jan-March.

2.2 Poisson Regression Model

Poisson regression model is applied to estimate the frequency of patient’s admittance to the ED. The dependent variable is represented by the number of patients admitted whereas the explanatory variables are represented by the patients’ demographic background as mentioned above. The regression parameters are estimated through maximum likelihood estimation and the significance of the regression parameters are tested using chi-squares and p-values. The best model is chosen by comparing the models’ deviances. In particular, deviance can be used to compare the fit of two models by taking the differences in the deviances (Dunteman & Ho [8], Dobson [9]).

2.3 Logistic Regression Model

Logistic regression model is applied to estimate the probability of inpatient treatment once the patient is
already admitted to the ED. Dichotomous data is used for the dependent variable (zero-one data for outpatient-inpatient treatment) whereas the explanatory variables are represented by the patients’ demographic background as mentioned above. The regression parameters are also estimated using maximum likelihood estimation and the significance of the regression parameters are tested using chi-squares and $p$-values. The best model is chosen also by comparing the models’ deviances.

### 3 Results and Discussions

A total of 152 patients visited the ED of HUKM during the study period, of which 75 patients were treated as inpatients whereas the rest were treated as outpatients. Table 1 shows the characteristics of patients admitted to the ED. Note that the majority of patients admitted were male (82%), age 13 to 24 years (50%), Malay (62%) and admitted between January and March (38%). A total of 160 ($5 \times 2 \times 4 \times 4$) classes are developed from the categories of patients.

#### Table 1 Categories of patients

<table>
<thead>
<tr>
<th>Category</th>
<th>Class</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1-12 years</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>13-24 years</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>25-40 years</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>41-60 years</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>61+ years</td>
<td>12</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>28</td>
</tr>
<tr>
<td>Race</td>
<td>Malay</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Indian</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>11</td>
</tr>
<tr>
<td>Admittance date</td>
<td>Jan-Mar</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Apr-June</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Jul-Sept</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Oct-Dec</td>
<td>35</td>
</tr>
</tbody>
</table>

The explanatory variables for the regression model are represented as:

- $x_{i0} = \begin{cases} 1, \text{ age } 1\text{-}12\text{ years} \\ 0, \text{ else} \end{cases}$
- $x_{i1} = \begin{cases} 1, \text{ age } 13\text{-}24\text{ years} \\ 0, \text{ else} \end{cases}$
- $x_{i2} = \begin{cases} 1, \text{ age } 25\text{-}40\text{ years} \\ 0, \text{ else} \end{cases}$
- $x_{i3} = \begin{cases} 1, \text{ age } 41\text{-}60\text{ years} \\ 0, \text{ else} \end{cases}$
- $x_{i4} = \begin{cases} 1, \text{ age } 61+\text{ years} \\ 0, \text{ else} \end{cases}$
- $x_{i5} = \begin{cases} 1, \text{ female} \\ 0, \text{ male} \end{cases}$
- $x_{i6} = \begin{cases} 1, \text{ Chinese} \\ 0, \text{ else} \end{cases}$
- $x_{i7} = \begin{cases} 1, \text{ Indian} \\ 0, \text{ else} \end{cases}$
- $x_{i8} = \begin{cases} 1, \text{ other races} \\ 0, \text{ else} \end{cases}$
- $x_{i9} = \begin{cases} 1, \text{ admitted in Apr\text{-}June} \\ 0, \text{ else} \end{cases}$
- $x_{i10} = \begin{cases} 1, \text{ admitted in Jul\text{-}Sept} \\ 0, \text{ else} \end{cases}$
- $x_{i11} = \begin{cases} 1, \text{ admitted in Oct\text{-}Dis} \\ 0, \text{ else} \end{cases}$

Table 2 shows the significant factors chosen for the best model of Poisson and logistic regressions. Age, gender, race and admittance date are considered as significant factors for the Poisson model whereas age and race are considered as significant factors for the logistic model.

#### Table 2 Significant Factors for Poisson and Logistic regression models

<table>
<thead>
<tr>
<th>Regression model</th>
<th>Significant factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson</td>
<td>Age, gender, race, admittance date</td>
</tr>
<tr>
<td>Logistic</td>
<td>Age, race</td>
</tr>
</tbody>
</table>

Based on the best Poisson regression model, the frequency of admittance to the ED for class $i$, $i = 1,2,...,160$, can be estimated as,

$$E(Y_i) = \exp(0.7x_{i0} + 1.8x_{i1} + 0.7x_{i2} - 1.0x_{i3} - 0.4x_{i4} - 1.3x_{i5} - 1.1x_{i6} - 0.3x_{i7})$$

where $E(Y_i)$ denotes the expected number of patient in class $i$, $x_{i0}$ the intercept (age 1-12 years, male, Malay, admittance in Oct-Mar), $x_{i1}$ the categorical variable for age 13-24 years, $x_{i2}$ the categorical variable for age 25 years and above, $x_{i3}$ the categorical variable for female, $x_{i4}$ the categorical variable for Indian, $x_{i5}$ the categorical variable for Chinese, $x_{i6}$ the categorical variable for other races, and $x_{i7}$ the categorical variable for admittance in Apr-Sept.
Table 3 shows the regression parameters, standard errors, chi-squares and $p$-values of the best Poisson regression model. Insignificant categorical variables are combined with other categorical variables to provide significant effects. All of the regression parameters are significant at 0.10 level. Patients of age 13 years and above, male gender and Malay race have positive relationship with the frequency of admittance. In addition, the frequency of admittance is higher in October until March.

![Table 3 Parameter estimates for Poisson regression model]

Based on the best logistic regression model, the probability of receiving inpatient treatment once admitted to the ED for class $i$, $i = 1, 2, ..., 160$, can be estimated as,

$$
\frac{\pi_i}{1 - \pi_i} = \exp\left(-0.42x_{i0} + 1.01x_{i1} + 2.75x_{i2} + 1.20x_{i3}\right)
$$

(2)

where $\frac{\pi_i}{1 - \pi_i}$ denotes the probability of receiving inpatient treatment in class $i$, $x_{i0}$ the intercept (age 1-40 years, Malay, Chinese and Indian races), $x_{i1}$ the categorical variable for age 41-60 years, $x_{i2}$ the categorical variable for age 61+ years, and $x_{i3}$ the categorical variable for other races.

Table 4 shows the regression parameters, standard errors, chi-squares and $p$-values of the best logistic regression model. Insignificant categorical variables are also combined with other categorical variables to provide significant effects. All of the regression parameters are significant at 0.10 level. The probability of receiving inpatient treatment once already admitted to the ED increases with patients of age 41 and above and patients of other races.

![Table 4 Parameter estimates for logistic regression model]

4 Conclusion

This study developed two models for solving overcrowding in the Emergency Department (ED). The first model estimates the frequency of ED’s admittance and its relationship to the contributing factors, whereas the second model estimates the probability of inpatient treatment once the patients are already admitted to the ED. Poisson regression is applied to the first model whereby the factors considered are the patient’s age, gender, race and admittance date. Logistic regression is utilized in the second model and the factors considered are the same as the first model.

Based on the model developed, the frequency of admittance to the ED of Hospital Universiti Kebangsaan Malaysia (HUKM) is influenced by patients of age 13 years above. This finding is consistent with the result displayed on the website of Polis Diraja Malaysia [5] which states that more than 50% of road accident deaths in Malaysia is contributed by the deaths of adults aging from 15 to 44 years. The frequency of admittance is also influenced by patients of male gender and Malay race, confirming the report of Malaysian government police which states that the number of motorcycle accident cases is extremely large compared to other road users. In Malaysia, a large number of motorcyclists are male and Malay citizens. The frequency of admittance is also higher in October until March, indicating that a larger number of road accidents occurred during festival seasons and school holidays which took place around these months.

Based on the model developed for the probability of receiving inpatient treatment after being admitted to the ED of HUKM, patients of age 41 years and above have higher probability of being treated as inpatient. This finding is consistent with the results of Roberts [10] which stated that individuals aging 65 years and older visited the ED at a higher rate compared to other age groups in the United States. From 1993 to 2003, the visit rate per 100 person for individuals aging 65 years and older increased faster than any other groups, increasing 26% during the 11 years of study (compared with little change for those younger than 21 years). There are no definite reasons for the increase in inpatient treatment at
HUKM for patients aging 41 years and older. One possible reason is that in Malaysia, citizens under welfare, government staffs and pensioners are eligible for receiving free treatment whereas elderly citizens and students in government schools are eligible for receiving minimal charges.

The results also show that patients of other races (mostly migration workers) have higher probability of receiving inpatient treatment in HUKM. One possible reason is that government hospitals in Malaysia are fully subsidized by the government and therefore offering cheaper medical costs and expenses.

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References: