Journal of Quality Measurement and Analysis *JQMA* 18(2) 2022, 75-85
e-ISSN: 2600-8602 *http://www.ukm.my/jqma*

MODELING THE LENGTH OF HOSPITAL STAY FOR COPD AND PNEUMONIA PATIENTS IN MALAYSIA FOR 2019

(Pemodelan Tempoh Penghospitalan bagi Pesakit Copd dan Pneumonia di Malaysia untuk Tahun 2019)

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ABSTRACT

Respiratory diseases are among the leading causes of hospitalizations and deaths in Malaysia. Chronic respiratory illness will have an impact on every aspect of a patient's life, including physical and mental health, social life, finances, and employment. When a patient requires ongoing medical treatment, especially if it is for an extended period of time, the patient's economic burden increases. As a result, understanding the factors that influence the cost of respiratory disease treatment is critical, particularly in terms of financial implications. One of the factors influencing the cost of respiratory disease treatment is the length of hospitalization. As a result, the estimated duration of hospitalization is based on the duration of treatment of inpatients with pneumonia and chronic obstructive pulmonary disease (COPD) in all Malaysian Ministry of Health Malaysia hospitals in the five states with the highest number of hospital admissions, namely Selangor, Sabah, Sarawak, Johor, and Perak. From 1 January 2019 to 31 December 2019, 135 147 patients with COPD and pneumonia were included in the study. The negative binomial regression analysis indicated that age, gender, race, hospital discharge status, and state all had a significant effect on the length of hospitalization.

Keywords: length of stay; COPD; pneumonia; negative binomial regression

ABSTRAK

Gangguan respiratori adalah antara penyakit yang mencatatkan kemasukan ke hospital dan kematian tinggi di Malaysia. Penyakit respiratori yang kronik akan mempengaruhi setiap aspek kehidupan bagi seseorang pesakit tidak kira dari segi kesihatan fizikal atau mental, kehidupan sosial, kewangan mahupun pekerjaan. Beban ekonomi pesakit semakin meningkat apabila pesakit memerlukan rawatan perubatan yang berterusan terutamanya jika ia melibatkan jangka masa yang panjang. Sehubungan dengan itu, memahami faktor yang mempengaruhi kos rawatan penyakit respiratori adalah penting untuk mengatasi implikasi penyakit tersebut khususnya implikasi kewangan. Tempoh penghospitalan merupakan satu daripada faktor yang mempengaruhi kos rawatan bagi penyakit respiratori. Justeru itu, anggaran tempoh penghospitalan dibuat berdasarkan tempoh rawatan pesakit dalaman yang mengidap pneumonia dan penyakit pulmonari obstruktif kronik (COPD) di semua hospital Kementerian Kesihatan Malaysia di lima buah negeri yang mencatatkan bilangan kemasukan ke hospital yang tertinggi iaitu Selangor, Sabah, Sarawak, Johor, dan Perak. Sampel kajian melibatkan 135 147 pesakit yang didiagnosis mengidap COPD dan pneumonia dari 1 Januari 2019 sehingga 31 Disember 2019. Hasil daripada analisis regresi binomial negatif yang dilakukan, didapati bahawa umur, jantina, bangsa, status discaj dari hospital dan negeri mempunyai kesan yang signifikan ke atas tempoh penghospitalan.

Kata kunci: tempoh penghospitalan; COPD; pneumonia; regresi binomial negatif

1. Introduction

Respiratory disease is a condition that affects the lungs as well as other parts of the respiratory system. According to the Soriano *et al*. (2020), 544.9 million people were infected with chronic

respiratory diseases worldwide in 2017, a 39.8 percent increase since 1990. Furthermore, chronic respiratory diseases were responsible for 3.9 million deaths in 2017. Furthermore, chronic respiratory diseases have resulted in 112.3 million years of total life adjustment for disability (DALY), a 13.3 percent increase since 1990 (Soriano *et al*. 2020). In Malaysia, respiratory diseases are one of the top three causes of hospitalisation and death (Kementerian Kesihatan Malaysia 2021). Respiratory diseases were the second most common reason for admission to public and private hospitals in 2020 (9.67 percent) (Kementerian Kesihatan Malaysia 2021). In the same year, the percentage of deaths due to respiratory diseases was 19.69% in public hospitals and 12.03% in private hospitals.

Chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pneumonia, asthma, and lung cancer are examples of respiratory diseases. Asthma, allergic rhinitis, COPD, and inflammatory sinusitis are among the respiratory diseases with the highest global morbidity and mortality rates (Bousquet & Kaltaev 2007). COPD is the most common chronic respiratory disease, with a global prevalence of 3.9 percent, followed by asthma (3.6 percent). The prevalence of asthma in children and adults was estimated to be 8.9 percent to 13 percent (Ahad & Ming Khoo 2017; Pearce *et al*. 2007) and 6.3 percent (Chan *et al*. 2015), respectively, while the prevalence of COPD was reported to be 3.4 percent to 6.5 percent (Loh *et al*. 2016; Lim *et al*. 2015).

COPD is defined as a disease that is both preventable and treatable, with some significant extrapulmonary effects that may contribute to patient severity (Ismail & Mohamad 2010). It is a severe chronic disease with persistent airflow restriction. COPD symptoms include chronic bronchitis and emphysema. It has the potential to obstruct airflow and cause breathing problems. COPD has been identified as a leading cause of morbidity and mortality worldwide (Lopez *et al*. 2006), with a significantly increasing economic and social burden (Viegi *et al*. 2007) for both patients and healthcare systems. COPD is currently the fifth leading cause of death worldwide, but it is expected to rise to the third by 2030 (Vogelmeier *et al*. 2017). COPD is expected to be the fifth leading cause of disability in Malaysia in 2020, after ischemic heart disease, major depression, traffic accidents, and cerebrovascular disease. Furthermore, COPD is the most common comorbidity among pneumonia patients (Restrepo *et al*. 2018). In addition, pneumonia is a type of acute respiratory infection affecting the lungs. Pneumonia patients' alveoli are clogged with pus and fluid, making breathing difficult and oxygen intake limited. According to Williams *et al*. (2018), pneumonia caused over 1.1 million hospitalizations and 50 000 deaths in 2010 in the United States. Pneumonia is the leading cause of death in children worldwide. According to the World Health Organization (2021), pneumonia accounted for 14% of all child deaths under the age of five in 2019, killing 740,180 children. In Malaysia, pneumonia (12.2 percent) was the second leading cause of death in 2019, trailing only ischemic heart disease (15.0 percent) (Jabatan Perangkaan Malaysia 2020). The number of pneumonia-related deaths increased from 11.8 percent to 12.2 percent between 2018 and 2019 (Jabatan Perangkaan Malaysia 2020).

Chronic respiratory illness will have an impact on every aspect of a patient's life, including physical and mental health, social life, finances, and employment. Hospitalized COPD patients were found to have a lower quality of life, higher hospital costs, higher mortality, and a longer hospital stay (Holguin *et al*. 2005; Soler-Cataluña *et al*. 2005; Gutiérrez Villegas 2021). Length of stay (LOS) is defined as the number of days between admission and discharge from an inpatient care facility. The length of time patients spend in hospital beds is known to be a good representation of the amount of resources utilized, such as bed capacity, staffing, and equipment (Carter & Potts 2014). LOS is commonly used as a key performance measure (Gonçalves-Bradley *et al*. 2016) to assess the quality of care (Thomas *et al*. 1997; Lingsma *et al*. 2018) and demand for medical services (Baniasadi *et al*. 2019). According to Dang-Tan *et al*. (2017) and Li *et al*. (2018), LOS has been an important estimator of medical resources and hospitalisation

costs for COPD patients'. According to Celli & Barnes (2007), some studies have determined that hospitalisation costs represent 40–57% of total direct costs generated by patients with COPD, and this percentage may be as high as 63% in severe patients. Thus, hospitalisation duration was the most important factor in determining treatment costs, and reducing the full-day hospitalisation period was found to reduce total treatment costs by 3% or less on average (Taheri *et al*. 2000). The average direct cost per annual patient for COPD management in Malaysia is USD 506.92 (Rehman *et al*. 2021). Having a better understanding of LOS also provides an opportunity to reduce the length of time patients stay in the hospital. As a result, the purpose of this study is to determine the effects of patients' demographic and clinical factors on LOS for COPD and pneumonia.

2. Material and Methods

The goal of this study was to identify the factors that influence the length of hospitalization for COPD and pneumonia patients in the five Malaysian states with the highest number of hospital admissions in 2019: Selangor, Sabah, Sarawak, Johor, and Perak. This study included a total of 135,147 COPD and pneumonia patients. The data on patient demographics and clinical factors from January to December 2019 were obtained from the Malaysian Ministry of Health. The length of stay – LOS (in days) in the hospital was the dependent variable studied. As independent variables, demographic characteristics such as gender, age, state, race, and clinical characteristics such as hospital discharge status were used. The patients' ages were classified into seven age groups using a conditional inference decision tree in *R* Studio with CTREE.

Based on previous research, a negative binomial regression model was used to assess the impact of demographic, clinical, and comorbid factors on LOS in COPD patients (Inabnit *et al*. 2018; Li *et al*. 2021), as well as demographic and clinical factors in cancer patients (Feliciana Silva *et al*. 2020) and congestive heart failure (Joshi *et al*. 2004). As a result, in this study, the same model is used to estimate LOS in the hospital for COPD and pneumonia patients. The parameters for this model were estimated using *R* software's glm function and the maximum likelihood estimation (MLE) method. The generalised linear model (GLM) is made up of a linear predictor, also known as a linear regressor function (McCullagh & Nelder 1989):

$$\eta_i = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_p X_{pi} \tag{1}$$

The link function defines the connection between the random and systematic components:

$$\begin{aligned} &\mu_i = E\left(Y_i\right) \\ &g\left(\mu_i\right) = \eta_i = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_p X_{pi} \\ &g^{-1}\left(\eta_i\right) = \mu_i \\ &Y = g^{-1}\left(\eta_i\right) + \varepsilon \\ &\ln \mu_i = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_p X_{pi} \end{aligned} \tag{2}$$

with μ_i is LOS for COPD and pneumonia patients and $X_{1i}, X_{2i} \ldots X_{pi}$ represents the demographic and clinical variables such as gender, age, state, race, and clinical characteristics such as hospital discharge status. Thus, by combining all the estimated parameters into (2), the model equations for the predicted LOS of COPD and pneumonia patients are as follows, respectively:

$$\ln(\mu_i)_C = \beta_0 + \beta_1 X_{10} + \beta_2 X_{20} + \beta_3 X_{21} + \beta_4 X_{22} + \beta_5 X_{23} + \beta_6 X_{24} + \beta_7 X_{25} + \beta_8 X_{30} + \beta_9 X_{31} + \beta_{10} X_{32} + \beta_{11} X_{33} + \beta_{12} X_{40} + \beta_{13} X_{41} + \beta_{14} X_{50}$$

$$\ln(\mu_i)_P = \beta_0 + \beta_1 X_{10} + \beta_2 X_{20} + \beta_3 X_{21} + \beta_4 X_{22} + \beta_5 X_{23} + \beta_6 X_{24} + \beta_7 X_{25} + \beta_8 X_{30} + \beta_9 X_{31} + \beta_{10} X_{32} + \beta_{11} X_{33} + \beta_{12} X_{40} + \beta_{13} X_{41} + \beta_{14} X_{50}$$

The following assumptions must be met by the generalised linear model:

(1) the correlation between the independent variables is low,
(2) the relationship between the dependent variable and the independent variable is nonlinear,
(3) the error does not follow the normal distribution,
(4) the homogeneity of variance does not need to be satisfied, and
(5) the dependent variables are not normally distributed.

Given that the variable LOS is a count variable that is clearly not normally distributed, only a few count regression models could be used. To determine the best type of GLMs to use in this study, model evaluation was performed. R software was used to run five different regression models: normal regression, Poisson regression, negative binomial regression (NB), zero-inflated Poisson regression (ZIP), and zero-inflated negative binomial regression (ZIP) (ZINB). The best model will be chosen using log-likelihood, Akaike Information Criteria (AIC), AIC weight, and Bayesian Information Criteria (BIC).

According to Table 1, the NB model's AIC and BIC values are lower than those of the Poisson model, indicating that the NB model fits the data slightly better than the Poisson model. Furthermore, because the LOS dispersion was insufficient for the Poisson's distribution, we chose the NB model, which has a parameter that controls data over or under dispersion. Furthermore, because the LOS dispersion was insufficient for the Poisson's distribution, we chose the NB model, which has a parameter that controls data over or under dispersion. The AIC values and AIC weight for the pneumonia model favour the ZINB and NB models over the other three models. The NB model is more parsimonious because the ZINB model requires twice as many parameters as the NB model (Beaujean & Grant 2016). According to the findings, the NB model is the best model to use in this study.

Table 1: Model selection

	Normal	Poisson	Negative binomial (NB)	Zero-inflated Poisson (ZIP)	Zero-inflated negative binomial (ZINB)
COPD					
Log likelihood	-112 726.5	-105 505.0	-64 307.3	-105 244.2	-64 307.3
Degree of freedom	16	15	16	30	31
Deviance	10 325 819.0	135 444.4	24 918.8	-	-
AIC	225 485.0	211 039.9	128 646.6	210 548.4	128 676.6
AIC weight	0	0	1	0	< 0.001
BIC	225 615.3	211 162.1	128 776.9	210 792.8	128 929.1
Pneumonia					
Log likelihood	-407 919.1	-377 471.0	-271 768.0	-373 766.1	-271 467.2
Degree of freedom	16	15	16	30	31
Deviance	10 937 122.0	426 722.2	105 817.2	-	-
AIC	815 870.1	754 971.9	543 568.0	747 592.2	542 996.3
AIC weight	0	0	< 0.001	0	1
BIC	816 023.8	755 116.0	543 721.7	747 880.4	543 294.1

3. Results and Discussion

Table 2 summarises the study population's demographic and clinical characteristics. Among the 135,147 patients, there were 25,499 COPD patients (18.87 percent), with pneumonia patients accounting for the remaining 109,648. (81.13 percent). Figure 1 shows a conditional inference decision tree in R Studio with CTREE that was used to categorise the patients' ages into seven age groups. This study also discovered that men have a higher prevalence of COPD and pneumonia than women, with rates of 57.8 percent, particularly among those aged 56 to 83 (37.15 percent). The average age of COPD patients was 63.91 years, while the average age of pneumonia patients was 30.17 years. COPD patients range in age from 56 to 83 years old and are comprised of 15,023 males and 3,848 females. Among the 15,023 male COPD patients aged 56 to 83, there were 9,817 (7.26 percent) Malay, 3,686 (2.73 percent) Chinese, and 1,520 (1.12 percent) Indians.

Table 2: Patients' frequency based on categorical variables

	COPD		Pneumonia	
	Number of patients (%)		Number of patients (%)	
Total	25 499 (18.87)		109 648 (81.13)	
Gender	Male	Female	Male	Female
Total	19 652 (14.54)	5 847 (4.33)	58 469 (43.26)	51 179 (37.87)
Age				
≤ 1	215 (0.16)	81 (0.06)	19 538 (14.46)	12 870 (9.52)
Malay	197 (0.15)	75 (0.06)	18 008 (13.32)	11 831 (8.75)
Chinese	12 (0.01)	2 (0.00)	988 (0.73)	634 (0.47)
Indian	6 (0.00)	4 (0.00)	542 (0.40)	405 (0.30)
2 – 10	203 (0.15)	141 (0.10)	13 111 (9.70)	11 538 (8.54)
Malay	179 (0.13)	129 (0.10)	11 395 (8.43)	9 932 (7.35)
Chinese	18 (0.01)	8 (0.01)	996 (0.74)	942 (0.70)
Indian	6 (0.00)	4 (0.00)	720 (0.53)	664 (0.49)
11 – 18	93 (0.07)	56 (0.04)	907 (0.67)	797 (0.59)
Malay	61 (0.05)	44 (0.03)	699 (0.52)	577 (0.43)
Chinese	12 (0.01)	4 (0.00)	119 (0.09)	110 (0.08)
Indian	20 (0.01)	8 (0.01)	89 (0.07)	110 (0.08)
19 – 39	564 (0.42)	587 (0.43)	3 199 (2.37)	3 519 (2.60)
Malay	408 (0.30)	431 (0.32)	2 328 (1.72)	2 741 (2.03)
Chinese	49 (0.04)	60 (0.04)	407 (0.30)	357 (0.26)
Indian	107 (0.08)	96 (0.07)	464 (0.34)	421 (0.31)
40 – 55	2 665 (1.97)	632 (0.47)	4 770 (3.53)	3 962 (2.93)
Malay	1 871 (1.38)	416 (0.31)	3 170 (2.53)	2 814 (2.08)
Chinese	327 (0.24)	111 (0.08)	876 (0.65)	505 (0.37)
Indian	467 (0.35)	105 (0.08)	724 (0.54)	643 (0.48)
56 – 83	15 023 (11.12)	3 848 (2.85)	15 360 (11.37)	15 972 (11.82)
Malay	9 817 (7.26)	2 325 (1.72)	9 084 (6.72)	10 405 (7.70)
Chinese	3 686 (2.73)	843 (0.62)	4 656 (3.45)	3 617 (2.68)
Indian	1 520 (1.12)	680 (0.50)	1 620 (1.20)	1 950 (1.44)
≥ 84	889 (0.66)	502 (0.37)	1 584 (1.17)	2 521 (1.87)
Malay	415 (0.31)	185 (0.14)	612 (0.45)	982 (0.73)
Chinese	386 (0.29)	255 (0.19)	861 (0.64)	1 343 (0.99)
Indian	88 (0.07)	62 (0.05)	111 (0.08)	196 (0.15)

Pneumonia was most common in children aged one year and below, with 19,538 male patients and 12,870 female patients. Among the 19,538 (14.46 percent) male patients for pneumonia cases aged one year and under, there were 18,008 (13.32 percent) Malay patients, 988 (0.73 percent) Chinese, and 542 (0.40 percent) Indians.

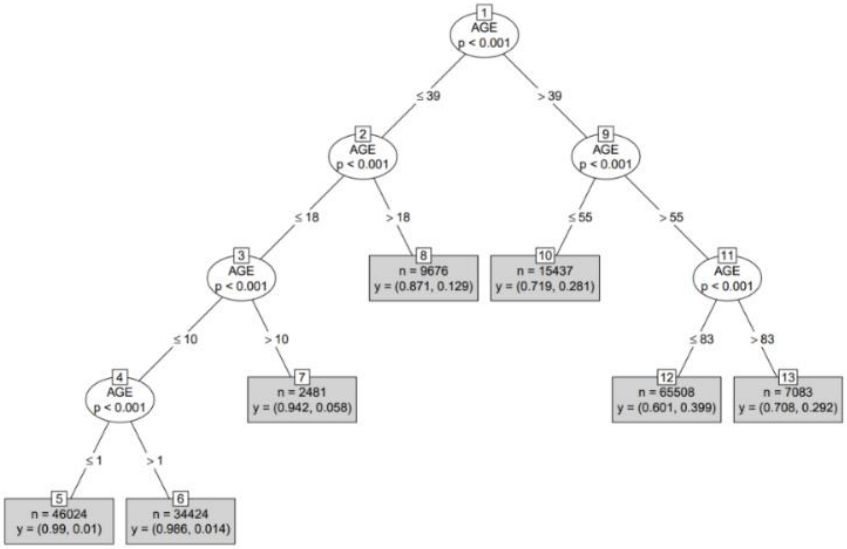

Figure 1: Conditional inference decision tree

Overall, the mean LOS for COPD and pneumonia patients was around four days, with a three-day median LOS (IQR 2.00 - 5.00). Although the average LOS is not clearly distinguishable by gender, there is a notable difference in the standard deviation values. In terms of age, patients aged one year and below had the longest LOS of nearly nine days.

Table 3: Descriptive analysis of length of stay (LOS) in hospital by categorical variables

	Length of Stay			
	COPD		Pneumonia	
Average	4.38		4.45	
Median	3.00		3.00	
Inter quartile range (IQR)	2.00 – 5.00		2.00 – 5.00	
Variable	Mean	Std. deviation	Mean	Std. deviation
Gender				
Male	4.33	22.15	4.53	9.98
Female	4.54	10.95	4.35	10.29
Age				
≤ 1	8.88	28.79	3.96	5.84
2 - 10	3.93	4.80	2.83	4.57
11 - 18	3.72	4.04	4.07	4.78
19 - 39	3.60	11.48	5.08	8.36
40 - 55	3.84	4.87	5.68	8.38
56 - 83	4.42	21.50	5.57	11.40
≥ 84	4.93	28.52	5.86	32.01

The results of negative binomial regression, which was used to assess the influence of explanatory variables on the LOS of COPD and pneumonia patients, are shown in Table 4. Gender, age, state, race, and hospital discharge status all had a significant impact on LOS. The negative binomial regression coefficient is interpreted as follows: for a one-unit change in the independent variable, the difference in the logs of expected LOS counts is expected to change by the respective regression coefficient, assuming that all other independent variables in the model remain constant. The female indicator variable, for example, represents the expected

difference in log LOS between female patients and the control group (male). The equations for both models are shown below.

Model for COPD:

$$\ln(\mu_i)_C = 2.194 + 0.028X_{10} - 0.840X_{20} - 0.916X_{21} - 0.844X_{22} - 0.703X_{23} - 0.639X_{24} + 0.108X_{30} + 0.057X_{31} - 0.124X_{32} - 0.137X_{33} + 0.118X_{40} + 0.136X_{41} + 0.324X_{50}$$

Model for pneumonia:

$$\ln(\mu_i)_P = 1.465 - 0.043X_{10} - 0.326X_{20} + 0.179X_{21} + 0.288X_{22} + 0.259X_{23} + 0.255X_{24} - 0.036X_{30} 0.065X_{31} - 0.173X_{32} - 0.174X_{33} + 0.109X_{40} + 0.081X_{41} + 0.470X_{50}$$

Table 4: Estimation of parameters for negative binomial regression model

Variable	COPD			Pneumonia		
	Estimated Coefficients β	Std. Error	*p*-Value	Estimated Coefficients β	Std. Error	*p*-Value
Intercept	2.194	0.049	< 0.001***	1.465	0.006	< 0.001***
Gender						
Female	0.028	0.014	0.041*	-0.043	0.005	< 0.001***
Age						
2 - 10	-0.840	0.068	< 0.001***	-0.326	0.007	< 0.001***
11 - 39	-0.916	0.055	< 0.001***	0.179	0.010	< 0.001***
40 - 55	-0.844	0.051	< 0.001***	0.288	0.010	< 0.001***
56 - 83	-0.703	0.049	< 0.001***	0.259	0.007	< 0.001***
≥ 84	-0.639	0.054	< 0.001***	0.255	0.014	< 0.001***
State						
Sabah	0.108	0.039	0.006**	-0.036	0.016	0.026*
Sarawak	0.057	0.021	0.007**	-0.065	0.010	< 0.001***
Johor	-0.124	0.014	< 0.001***	-0.173	0.006	< 0.001***
Perak	-0.137	0.016	< 0.001***	-0.174	0.007	< 0.001***
Race						
Chinese	0.118	0.014	< 0.001***	0.109	0.008	< 0.001***
India	0.136	0.018	< 0.001***	0.081	0.010	< 0.001***
Discharge Status						
Dead	0.324	0.032	< 0.001***	0.470	0.010	< 0.001***

***, **, and * denote that the parameters are significant at the 0.001, 0.01, and 0.05 significance levels, respectively.

Table 5 shows the results as log-ratios, the Incident Rate Ratios (IRR). The following examples demonstrate the results. A COPD patient's IRR in Sabah is 1.11:1. This means that the incident rate for a COPD patient in Sabah is 1.11 times that of the control group (Selangor). This patient will be hospitalised for 11% longer than a COPD patient in Selangor. Meanwhile, the IRR for a pneumonia patient in Perak is 0.84:1. This patient will only be in the hospital for 84% of the time that a Selangor pneumonia patient would be. Table 5 also shows how each variable influences *Y*. An example is used to describe the model and the effects of each variable on LOS. Patient A is a 60-year-old man suffering from pneumonia. He was originally from Johor and died in a hospital. To calculate the patient's LOS, use the following formula:

$$\ln(\mu_i)_P = 1.465 - 0.043(0) - 0.326(0) + 0.179(0) + 0.288(0) + 0.259(1) + 0.255(0) - 0.036(0) 0.065(0) - 0.173(1) - 0.174(0) + 0.109(0) + 0.081(0) + 0.470(1)$$

As a result, patient A's estimated LOS is 7.55 days. A female patient will only stay 96% of the time that a male patient will. The female's LOS would be reduced by 0.3 days to 7.25 days if she was admitted with the same admission and discharge characteristics as patient A.

Table 5: Effects of variables on LOS

Variable	COPD			Pneumonia		
	β	IRR	Changes on Y (%)	β	IRR	Changes on Y (%)
Intercept	2.194	8.968	-	1.465	4.330	-
Gender						
Female	0.028	1.028	2.8	-0.043	0.958	-4.2
Age						
2 - 10	-0.840	0.432	-56.8	-0.326	0.722	-27.8
11 - 39	-0.916	0.400	-60.0	0.179	1.195	19.5
40 - 55	-0.844	0.430	-57.0	0.288	1.334	33.4
56 - 83	-0.703	0.495	-50.5	0.259	1.296	29.6
≥ 84	-0.639	0.528	-47.2	0.255	1.290	29.0
State						
Sabah	0.108	1.114	11.4	-0.036	0.965	-3.5
Sarawak	0.057	1.059	5.9	-0.065	0.937	-6.3
Johor	-0.124	0.884	-11.6	-0.173	0.841	-15.9
Perak	-0.137	0.872	-12.8	-0.174	0.840	-16.0
Race						
Chinese	0.118	1.125	12.5	0.109	1.115	11.5
India	0.136	1.146	14.6	0.081	1.084	8.4
Discharge status						
Dead	0.324	1.383	38.3	0.470	1.600	60.0

The factors associated with the length of hospital stay of COPD and pneumonia patients were investigated in this study. In our study population, we found a predominance of male patients, elderly (aged 56 to 83), Selangor residents, Malay patients, and patients with a discharge status of alive. Furthermore, we discovered that several factors, including gender, patient age, state, race, and discharge status, were related to length of stay. For COPD patients, age has the greatest influence on LOS, whereas for pneumonia patients, the discharge status from the hospital has the greatest influence on LOS.

The gender of patients was found to have a significant influence on the LOS of COPD and pneumonia patients in this study. These findings are supported by de-Miguel-Díez *et al*. (2021) and Almirall *et al*. (2017), who discovered that gender is a risk factor that contributes to both the increase and decrease of LOS. Female COPD patients will have a 2.8 percent increase in LOS, while female pneumonia patients will have a 4.2 percent decrease in LOS. Furthermore, men were more likely than women to be hospitalised for COPD and pneumonia. This study's findings are consistent with those of Rodríguez *et al*. (2009), who discovered that the overall incidence per 1000 people per year in the United Kingdom was 1.22 in males and 0.93 in females. In a previous study, Afonso *et al*. (2011) discovered that the incidence of COPD was 1.5 times higher in men than in women.

This study also discovered that patient age has a significant impact on LOS. With 18 871 (13.96 percent) COPD patients and 31 332 (23.18 percent) pneumonia patients, the age group 56 to 83 years old had the highest number of patients. According to the reports from Department of Statistics Malaysia (Jabatan Perangkaan Malaysia 2019; 2021), the Malaysian population aged 65 and above increased from 6.5 percent in 2018 to 6.7 percent in 2019 and is now 7.4 percent in 2021. As the patient ages, his or her lung function deteriorates gradually, affecting the patient's LOS (Li *et al*. 2021).

In this study, LOS for COPD patients aged 56 to 83 years will be reduced by approximately 50.5 percent. Patients with pneumonia in the same age group, on the other hand, will have a

higher LOS of 29.6 percent. As a result, patients with pneumonia aged 56 to 83 years have a longer LOS than COPD patients. A large percentage change also indicated that, when compared to other factors, age was the determining factor that had the greatest impact on patients' LOS in this study.

Furthermore, the mortality status of COPD and pneumonia patients has a significant effect on LOS. COPD patients who die, for example, are expected to spend more time in the hospital (38.3 percent) than patients who recover. This could be due to comorbidities in COPD patients. According to Sin *et al*. (2006), lung cancer and cardiovascular disease are the leading causes of death in the mild or moderate stage of COPD, while respiratory failure is the leading cause of death in the advanced stage of COPD. Three-quarters of COPD patients have three or more comorbidities, including respiratory infections (47%), heart problems (30%), and diabetes (33%) (Freeborne *et al*. 2000). As a result, the number of comorbidities is associated with an increase in LOS, confirming that comorbidities are important predictors of prolonged hospitalisation (Alqahtani *et al*. 2020; Inabnit *et al*. 2018).

Furthermore, this study discovered that the LOS rate for pneumonia patients was 1.6 times higher in dying patients than in cured patients. This study's findings are supported by Zhang *et al.* (2018), that more than 85 percent of pneumonia patients died in the hospital. Furthermore, increasing age has been identified as a predictor of pneumonia patient mortality in many studies, particularly among patients 65 and older (Fine *et al*. 1997; Lim *et al*. 2003; Sligl *et al*. 2010). In this study, patients aged 56 to 83 years old had the highest number of deaths, with 4 924 patients dying from pneumonia out of a total of 7 249 people. Finally, these findings are consistent with those of Zhang *et al*. (2018), who discovered that pneumonia is common and deadly among the elderly.

4. Conclusions

The study's findings confirmed that gender, age, state, race, and hospital discharge status all have an impact on patients' LOS in both COPD and pneumonia cases. Female gender, Chinese or Indian ethnicity, and death are among the covariates linked to a longer LOS in COPD patients. There are significant differences in LOS between Peninsular Malaysia and East Malaysia when it comes to the patient's condition. In summary, the length of stay for COPD and pneumonia patients varies depending on demographic and clinical factors. The model's implementation is expected to improve inpatient hospitalization management in the future.

Acknowledgement

We gratefully acknowledge the Health Informatics Center, Planning Division, Ministry of Health Malaysia for providing the data for this study.

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Received: 27 April 2022
Accepted: 13 July 2022

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