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ORIGINAL ARTICLE

Determinants of Hospital Length of Stay in Respiratory Infections: Insights from Cheras, Malaysia

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ABSTRAK

Jangkitan virus pernafasan menimbulkan kebimbangan kesihatan awam yang ketara, menyumbang kepada peningkatan kadar morbiditi dan kematian. Kajian ini mengkaji faktor-faktor yang mempengaruhi tempoh tinggal di hospital (LOS) bagi pesakit yang didiagnosis dengan "Influenza-like illness" (ILI) dan "Severe Acute Respiratory Infection" (SARI). Kajian kuantitatif telah dijalankan di Cheras, Kuala Lumpur, Malaysia, dari 1 September 2022 hingga 28 Februari 2023. Data tentang demografi, status jangkitan virus (khususnya influenza A, influenza B, dan COVID-19), serta parameter persekitaran seperti suhu, kelembapan, kelajuan angin, dan paras zarah, telah dikumpulkan untuk 632 individu. Data dianalisis menggunakan regresi logistik ordinal dalam Statistical Package for Social Sciences (SPSS) versi 22.0. Penemuan menunjukkan korelasi antara usia lanjut dan indeks jisim badan (BMI) yang tinggi dengan tempoh kemasukan ke hospital yang panjang, menekankan kepentingannya sebagai faktor risiko dalam konteks wabak pernafasan. Tanpa diduga, pesakit yang diuji positif untuk virus yang disiasat mempunyai LOS yang lebih pendek, menunjukkan kehadiran keadaan perubatan lain atau jangkitan

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serentak. Parameter persekitaran, seperti suhu, kelembapan dan kelajuan angin, mempunyai kesan yang besar pada LOS. Penemuan ini menawarkan pandangan yang berguna untuk memperuntukkan sumber penjagaan kesihatan semasa wabak dan menekankan kepentingan teknik diagnostik yang komprehensif dan penyelidikan tambahan untuk meningkatkan ketepatan ramalan.

Kata kunci: Jangkitan pernafasan; kesihatan awam; pengurusan kesihatan

ABSTRACT

Respiratory virus infections pose a significant public health concern, contributing to increase morbidity and mortality rates. This study investigated the determinants of hospital length of stay (LOS) for patients with Influenza-like illness (ILI) and Severe Acute Respiratory Infection (SARI). A quantitative study was conducted in Cheras, Kuala Lumpur, Malaysia, from 1 September 2022 until 28 February 2023. Demographic data, viral infection status (influenza A, influenza B, and COVID-19), and environmental factors (temperature, humidity, wind speed, and particulate matter levels) were collected for 632 patients. The data were analysed using ordinal logistic regression in Statistical Package for Social Sciences (SPSS) version 22.0. The results revealed that older age and higher body mass index (BMI) were associated with longer hospital stays, highlighting their significance as risk factors during respiratory outbreaks. Unexpectedly, patients tested positive for the investigated viruses experienced shorter LOS, indicating potential comorbidities or co-infections. Environmental factors played a critical role, with temperature, humidity, and wind speed significantly influencing LOS. These findings provided valuable insights for healthcare resource allocation during epidemics and underscored the need for comprehensive diagnostic tools and further research to enhance prediction accuracy.

Keywords: Health management; public health; respiratory infection

INTRODUCTION

Respiratory virus infections are recognised as a public health concern as it can cause increase morbidity and mortality rates. Influenza-like illness (ILI) refers to a collection of symptoms that resemble those brought on by influenza virus, but may also be brought on by other respiratory viruses (Centre for Disease Control and Prevention 2022). In public health and epidemiology, ILI refers to a cluster of symptoms that resemble influenza but have not been validated by laboratory testing. Each year, the influenza virus is responsible for millions of respiratory illnesses and approximately 500,000 fatalities worldwide. In developed countries, the majority of influenza-related fatalities occur among those aged 65 and older (World Health

Organisation 2020). In Malaysia, genotypes of the Influenza A virus have been identified, and influenza surveillance is conducted to track the virus's spread (Rahman 1969). In 2009-2010, Malaysia also experienced an epidemic of influenza caused by the A (H1N1) virus with 2253 confirmed cases and 78 fatalities (Hashim et al. 2021).

Based on recent studies in Malaysia, influenza A was identified in 12.8% of respiratory samples from hospitalised patients in Kuala Lumpur, with the majority (67%) being A (H1N1) (Rahman 2013). From 2012 to 2014, among patients with acute upper respiratory tract infection in hospital outpatient clinics, 287 (14.3%) and 183 (9.1%) samples, respectively, tested positive for influenza A and B viruses (Oong et al. 2015). Influenza and respiratory syncytial virus (RSV) are two commonly circulating respiratory viruses that cause significant morbidity and mortality in Malaysia and around the globe. It is well known that influenza causes severe respiratory illnesses and mortality in humans. Each year, 5% of adults are estimated to contract influenza (Tang et al. 2017; Turner et al. 2003).

In Malaysia, surveillance for ILI is an ongoing programme. In addition to surveillance, an accurate forecast of ILI outbreaks could aid public health authorities in suggesting early preventive measures (Darwish et al. 2020). Forecasts of disease dynamics based on data are crucial for health officials and public to make decisions (Venkatramanan et al. 2021). Traditional biosecurity protocols for preventing transmission through direct contact failed to prevent airborne transmission. Mechanism by which influenza virus can be conveyed in fine particulate matter (PM) and transported from an infected individual to a recipient via the air has garnered increasing interest and concern (Zhao et al. 2019). Though there are influenza prediction models using environmental data or patient's demographic data, there are no models that use a combination of both of these types of data. The objective of this study was to model the severity of respiratory infection (based on length of hospital stay) using the individual patient and their respective environmental data.

MATERIALS AND METHODS

This study was conducted in Cheras, Kuala Lumpur. Hospital Canselor Tuanku Muhriz (HCTM) and the five government clinics in Cheras were involved in this study. This was a quantitative study. The data involved were clinical samples from ILI and severe acute respiratory infection (SARI) patients, and environmental data of Cheras district from Petaling Jaya Weather Station, Department of Environment Malaysia. This study was conducted for six months beginning from 1 September 2022 until 28 February 2023.

Clinical Samples from ILI and SARI Patients

Nasopharyngeal swabs were collected from two main categories of patients i.e. patients diagnosed with ILI by the designated government clinics, and patients diagnosed with SARI and admitted to HCTM. The inclusion criteria for an adult patient who came to the clinics with ILI symptoms were residents of Cheras, age more than 18 years old, patients were having fever ≥38˚C; cough and onset within the last ten days (World Health Organisation 2020). For SARI patients, in addition to the three listed criteria, the patient had to be hospitalised in HCTM (World Health Organisation 2020). Patients who were not keen to participate in this study were excluded.

Using the prevalence of respiratory viral infection among severe acute respiratory infections and ILI samples 45.3% (Grunberg et al. 2021), the estimated samples size was calculated by using the formula of estimating a proportion within a population (Reswell & Creswell 2017) and the calculated sample size was found to be 380. Patients who fitted the criteria were identified and consent was taken. Information such as age, sex, body mass index (BMI), socioeconomic status, smoking history, and presence of chronic lung disease for each of the respective patients were gathered. For both groups of patients, samples were collected from nasopharyngeal. The nasopharyngeal samples were then labelled and transported in universal transport medium to the HCTM laboratory. Samples were stored at -80˚C in the laboratory before being processed. This was because the samples were only be processed in batches and were unlikely to be processed within 48 hours of sample collection (World Health Organisation 2020). The samples were then subjected to COVID-19 polymerase chain reaction (PCR) and confirmatory Influenza PCR tests. After these samples were analysed, they were discarded and not stored.

Environmental Data

The environmental data were gathered from the Department of Environment Malaysia and they were collected during the same time period of patients' clinical data collection. The collected data were from Petaling Jaya Weather Station, the closest station to the Cheras population, which is eight kilometres from the population-weighted centre of the city. This is within a good distance range for studying environmental effect on spread of infectious respiratory disease (Chen et al. 2022). The environmental factors collected were daily mean temperature (˚C), mean humidity (%), cumulative rainfall (mm), mean wind speed (m/s), PM10 level (µg/m^3) and PM2.5 level (µg/m^3). The environmental data used were matched according to the onset date of illness of the individual patient.

Data Analysis

The results of clinical sample and environmental data were recorded in an Excel spreadsheet. These data were then analysed to study the distribution of the variables among ILI and SARI patients. To describe these data, descriptive statistics was used, namely measures of central tendency, frequency distributions such as numerical values and percentages. To predict the severity of respiratory infection (length of stay (LOS) in hospital) based on patient and environmental factors, the data of individual patient and laboratory results (from clinical sampling) and environmental data during the same study period (1st September 2022 till 28th February 2023) were used. The dependent variable was the LOS at Hospital Canselor Tuanku Muhriz (HCTM), either zero days (not admitted), one to three days (short stay), four to seven days (medium stay), or more than seven days (long stay) (Stone et al. 2022). The findings were analysed using Statistical Package for Social Sciences (SPSS) version 22.0, by performing ordinal logistic regression.

RESULTS

A total of 632 samples from patients who presented themselves with ILI to the government health clinics in Cheras and patients who were admitted due to SARI in HCTM were collected during the six months period from 1 September 2022 to 28 February 2023. The demographic characteristics of these 632 patients along with their corresponding environmental data were shown in Table 1.

The mean age of these patients were 43.91 years with a standard deviation of 20.76. There were 323 males, accounting for 51.1%, while 309 were females (48.9%). The mean BMI of the sampled patients were 26.19 kg/m^2 with a standard deviation of 5.26. Among these 632 patients, 484 (76.6%) of them were non-smokers while 148 (23.4%) of them were smokers. Those under the smoker category were either active smokers, passive smokers or electronic cigarette smokers. There were 33 patients (5.2%) of the ILI and SARI patients who had underlying chronic lung disease such as chronic obstructive pulmonary disease (COPD), bronchial asthma, pulmonary fibrosis or lung cancer. Meanwhile 94.8% of the total patient did not have any underlying lung condition. The nasopharyngeal samples from these 632 patients were subjected to influenza and COVID-19 PCR test. It was found that 75 samples (11.9%) were tested positive for influenza B, 73 samples (11.6%) were COVID-19 positive and 25 (4%) were influenza A positive (Table 1).

The mean for the variable average daily temperature was 27.55°C (SD=0.83), average daily humidity was 78.24% (SD=6.29), cumulative daily rainfall was 9.63 mm (SD=18.41) and average daily wind speed was 1.02 m/s (SD=0.22). The mean for average daily PM10 level was 26.28 (SD=10.57) while the average daily PM2.5 level was 13.52 (SD=7.49) (Table 1).

Out of these 632 patients, 438 (69.3%) of them did not require a hospital admission, 35 patients (5.5%) had a short stay in HCTM 74 (11.7%) had a medium stay, and 85 (13.4%) had long stay. The mean age of patients who did not require hospital admission was 33.89 years as compared to patients who had short stay was 65.43 years, medium stay was 69.68 years and long stay was 64.29 years. The mean and frequency distribution of sex, BMI, smoking history and underlying chronic disease were best shown in

TABLE 1: Descriptive data based on measure of central tendency and frequency distribution

Variables	Value	Frequency (Percentage)
Number of patients	632	632 (100.0%)
Patient demography		
Age		
Mean (SD)	43.91 (20.76)	
Median (Q1-Q3)	36 (27-61)	
Sex		
Male		323 (51.1%)
Female		309 (48.9%)
BMI		
Mean (SD)	26.19 (5.26)	
Median (Q1-Q3)	26 (22.35-29)	
Smoking history		
Non-smoker		484 (76.6%)
Smoker		148 (23.4%)
Chronic lung disease		
Absent		599 (94.8%)
Present		33 (5.2%)
Laboratory result		
Influenza A		
Absent		607 (96.0%)
Present		25 (4.0%)
Influenza B		
Absent		557 (88.1%)
Present		75 (11.9%)
COVID-19		
Absent		559 (88.4%)
Present		73 (11.6%)
At least one virus detected		
No		461 (72.9%)
Yes		171 (27.1%)
Environmental data, mean (SD)		
Average daily temperature	27.55 (0.83)	
Average daily humidity	78.24 (6.29)	
Cumulative daily rainfall	9.63 (18.41)	
Average daily windspeed	1.02 (0.22)	
Average PM10 level	26.28 (10.57)	
Average PM2.5 level	13.52 (7.49)	

table below (Table 2). Among the 25 patients diagnosed with influenza A, 16 (64%) of them required long hospital stay (more than seven days), three (12%) of them had medium LOS (four to seven days), while six (24%) of them did not require hospital admission. As compared to the 75 patients who were diagnosed positive for influenza B, 69 patients (92%) did not require hospital admission, only six (8%) of them required hospital admission of four days and more (Table 2).

Ordinal logistic regression was

TABLE 2: Descriptive data based on length of stay

	Length of stay (LOS)							
	Not admitted		Short stay		Medium stay		Long stay	
	Mean (SD)	Frequency (%)	Mean (SD)	Frequency (%)	Mean (SD)	Frequency (%)	Mean (SD)	Frequency (%)
Samples		438 (69.3%)		35 (5.5%)		74 (11.7%)		85 (13.4%)
Patient demography data								
Age	33.89 (12.59)		65.43 (19.32)		69.68 (16.60)		64.29 (17.36)	
Sex								
Female		215 (49.1%)		14 (40.0%)		39 (52.7%)		41 (48.2%)
Male		223 (50.9%)		21 (60.0%)		35 (47.3%)		44 (51.8%)
BMI	25.67 (4.68)		26.00 (5.20)		26.22 (6.01)		28.91 (6.53)	
Smoking history								
Non smoker		326 (74.4%)		28 (80.0%)		63 (85.1%)		67 (78.8%)
Smoker		112 (25.6%)		7 (20.0%)		11 (14.9%)		18 (21.2%)
Chronic lung disease								
Absent		425 (97.0%)		33 (94.3%)		65 (87.8%)		76 (89.4%)
Present		13 (3.0%)		2 (5.7%)		9 (12.2%)		9 (10.6%)
Laboratory result								
Influenza A								
Absent		432 (98.6%)		35 (100%)		71 (95.9%)		69 (81.2%)
Present		6 (1.4%)		0 (0%)		3 (4.1%)		16 (18.8%)
Influenza B								
Absent		369 (84.2%)		35 (100%)		71 (95.9%)		82 (96.5%)
Present		69 (15.8%)		0 (0%)		3 (4.1%)		3 (3.5%)
COVID-19								
Absent		386 (88.1%)		31 (88.6%)		66 (89.2%)		76 (89.4%)
Present		52 (11.9%)		4 (11.4%)		8 (10.8%)		9 (10.6%)
At least one virus detected								
No		313 (71.5%)		31 (88.6%)		60 (81.1%)		57 (67.1%)
Yes		125 (28.5%)		4 (11.4%)		14 (18.9%)		28 (32.9%)
Environmental data								
Average daily temperature	27.56 (0.81)		27.42 (0.93)		27.34 (0.85)		27.75 (0.87)	
Average daily humidity	77.44 (5.76)		81.49 (7.42)		80.99 (6.34)		78.68 (7.26)	
Cumulative daily rainfall	8.69 (20.07)		12.93 (14.32)		13.11 (14.08)		10.06 (13.32)	
Average daily windspeed	1.00 (0.24)		1.06 (0.16)		1.04 (0.17)		1.08 (0.15)	
Average daily PM10 level	28.01 (10.81)		21.74 (8.75)		21.08 (7.90)		23.81 (9.58)	
Average daily PM2.5 level	14.41 (7.53)		11.69 (6.35)		11.58 (6.51)		11.38 (7.71)	

performed. Model Fitting Information based on Lipsitz Likelihood Ratio Test was significant (p-value <0.001), which showed that there was a significant improvement in fit as compared to the null model. Hence, the model was showing a good fit. The likelihood ratio test was used as there were correlated data within the study samples and due the robustness of this test (Long & Freese 2014). Goodness-of-Fit test showed the model adequately fitted the data (p-value >0.05). The McFadden value of R-Square was used here, instead of Cox and Snell or Nagelkerke, as this study involved ordinal regression (Long & Freese 2014). It showed that there had been a 36.6% improvement in the prediction of outcome based on the predictors in comparison to the null model. Based on Test of Parallel Lines, the p-value was not significant (p-value= 0.21) which indicated ordinal regression was appropriately used.

Based ordinal regression performed, it was found that the variables age, BMI, temperature, humidity, wind, and PCR results for influenza A, influenza B, and COVID-19 were significant (p-value <0.05). However, sex, smoking history, underlying lung disease, rainfall and PM levels were not significant (p-value >0.05). The odds ratio for all the variables were calculated. The group that was 10 years older than the younger group had 2.37 ($1.09^{10}=2.37$) times the odds of having a longer stay. A unit rise in BMI increased the odds of having a longer stay by 1.11. The odds of having a longer stay in hospital was 2.2 times higher with higher temperature and 1.12 times higher with relative humidity. The likelihood of a patients having a longer stay in hospital was 4.44 times higher with higher wind speed as compared to lower wind speed. Based on this analysis, the odds of a patient not having influenza A, influenza B and COVID-19 to have a longer LOS was higher as compared to those who were positive for those viruses. This was due to the large number of ILI and SARI patients probably had other infections and not influenza or COVID-19 (Table 3).

DISCUSSION

The presented dataset offered valuable insights into the demographic and environmental factors associated with the length of hospital stays for patients with ILI and SARI. These findings contributed to our understanding of the complex interplay of factors that influence patient outcomes during respiratory illness outbreaks. The demographic data revealed several important findings. Firstly, age emerged as a significant predictor of hospital LOS. This aligned with previous research, which found that older patients tended to have longer hospital stays during respiratory outbreaks (Iuliano et al. 2018; Simonsen et al. 2013). Our results indicated that patients who were 10 years older than the reference group had 2.37 times higher odds of experiencing a longer stay. This underscored the importance of age as a risk factor in respiratory infections. Another significant demographic variable was BMI, with a unit increase associated with 1.11 times higher odds of a longer hospital stay. This finding

TABLE 3: Ordinal logistic regression

	Estimate	Std. Error	Wald	OR ratio (exp())	95% confidence interval Lower bound	Upper bound	p-value
Threshold							
[LOS=not admitted]	75.521	7.318	106.497		61.177	89.864	.000
[LOS=short stay]	76.185	7.326	108.140		61.826	90.544	.000
[LOS=medium stay]	77.535	7.344	111.469		63.142	91.929	.000
Location							
Age	.086	.006	177.467	1.09	0.073	0.98	.000
BMI	.102	.024	18.753	1.11	0.056	0.149	.000
Temperature	.790	.208	14.477	2.2	0.383	1.198	.000
Humidity	.111	.027	17.437	1.12	0.059	0.163	.000
Rainfall	-.001	.007	.015	1	-0.015	0.013	.904
Wind	1.490	.580	6.598	4.44	0.353	2.626	.010
PM10	-.017	.013	1.779	0.98	-0.042	0.008	.182
PM2.5	-.029	.017	2.841	0.97	-0.063	0.005	.092
Sex							
Female	-.257	.245	1.100	0.77	-0.738	0.223	.294
Male	0[a]						
Smoking history							
Non smoker	.449	.320	1.967	1.57	-0.179	1.077	.161
Smoker	0[a]						
Lung disease							
Absent	-.051	.438	.014	0.95	-0.910	0.808	.907
Present	0[a]						
Influenza A							
Absent	9.602	.532	326.045	14794.34	8.56	10.644	.000
Present	0[a]						
Influenza B							
Absent	13.656	.508	721.870	852560.97	12.66	14.652	.000
Present	0[a]						
COVID-19							
Absent	12.994	.339	1467.025	439766.86	12.33	13.659	.000
Present	0[a]						
At least one virus detected							
No	12.536	.000		278173.42	12.536	12.536	
Yes	0[a]						

[a]This parameter is set to zero because it is redundant

was consistent with other researches, which demonstrated that higher BMI was associated with a greater risk of severe respiratory infections (Maccioni et al. 2018; Neidich et al. 2017; Zhao et al. 2020). This connection could be related to the impact of obesity on respiratory function and immune response (Hernandez-Vargas et al. 2014). However, the study did not find a significant effect of sex on LOS, which contradicted some previous research, whereby, males were at a higher risk of severe outcomes during respiratory illness outbreaks (Giurgea et al. 2022; Sam 2015). The lack of statistical significance in our results may be attributed to the relatively equal distribution of sex among the study samples.

The presence of viral infections, particularly influenza A, influenza B, and COVID-19, had a significant impact on the length of hospital stays. Patients who tested positive for these viruses were less likely to have longer stays than those who tested negative. This finding is intriguing and suggests that other factors, perhaps co-infections or comorbidities, may have influenced hospitalisation decisions. The data indicated that a substantial portion of ILI and SARI patients likely had infections other than influenza A, influenza B, or COVID-19. This observation highlighted the complexity of respiratory outbreaks and the challenge of distinguishing between various respiratory pathogens solely based on clinical presentation. It also emphasised the need for more precise diagnostic tools and a comprehensive understanding of viral interactions in the respiratory tract.

This study incorporated a range of environmental variables, such as temperature, humidity, wind speed, and particulate matter levels (PM10 and PM2.5). While temperature and humidity were significant predictors of LOS, wind speed emerged as the most significant environmental factor. These findings were also supported by studies that showed the risk of seasonal respiratory virus transmission is higher with higher amount of rainfall, higher relative humidity and higher temperature (Oong et al. 2015; Saha et al. 2016; Sam et al. 2015). A higher wind speed was associated with 4.44 times higher odds of longer hospital stays. These results indicated that environmental conditions may influence the spread of respiratory infections and the severity of cases. Several previous studies have explored the relationship between environmental factors and respiratory infections. For instance, a study found that increased wind speed was associated with a higher risk of influenza transmission (Paynter 2015). On the other hand, there were also studies that showed high rate of influenza infection with lower wind speed (Pica & Bouvier 2012; Shaman & Kohn 2009). The present study corroborates these findings and emphasises the importance of considering weather conditions in epidemic modelling and healthcare resource allocation.

The strengths of this study lie in its large sample size and comprehensive data collection. The use of ordinal logistic regression allowed for the analysis of the ordinal outcome variable, which is the length of hospital stay, while considering multiple predictors simultaneously. However, the study had some limitations. Firstly, the dataset did not account for specific treatment regimens and patient comorbidities, which could confound the results. Secondly, the study was conducted in a specific geographic location, and the findings may not be generalisable to other regions. Additionally, the dataset lacked information on vaccination status, which could have a significant impact on the risk of severe respiratory infections.

CONCLUSION

In conclusion, this study provides valuable insights into the determinants of LOS for patients with ILI and SARI during a six-month period. The findings underscore the significance of age and BMI as key demographic factors influencing patient outcomes. Older age and higher BMI were associated with longer hospital stays, reflecting the increased vulnerability of these populations during respiratory outbreaks. Viral infections, specifically Influenza A, Influenza B, and COVID-19, were shown to have a substantial impact on hospitalisation decisions. Surprisingly, patients tested positive for these viruses were less likely to experience extended hospital stays, suggesting the influence of co-infections or comorbidities. Environmental factors, including temperature, humidity, and wind speed, were identified as important determinants of LOS, emphasising the need for accounting for climate conditions in healthcare resource allocation during epidemics. However, the study carries limitations, including the lack of information on treatment regimens and vaccination status. Despite these limitations, these findings provide a valuable foundation for understanding the complex interplay of factors affecting patient outcomes during respiratory outbreaks, offering important insights for public health preparedness and resource planning. Further research should explore the interplay between these factors in more detail and consider additional variables to enhance the accuracy of predictions.

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