

## Original Article

# Demographics, Disease Severity, and Per Patient Cost of melioidosis in East Coast and Northern Malaysia: A Hospital-based Retrospective Cohort Study from 2019 to 2023

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### Abstract:

**Objectives:** To examine the demographics, disease severity, hospital stay duration, intensive care unit (ICU) stay, and per-patient cost (PPC) of melioidosis cases in Eastern and Northern Malaysia.

**Methods:** A total of 502 patients in six hospitals in Eastern and Northern Malaysia were included in the study. Descriptive statistics were used to analyze patient demographics, disease severity, comorbidities, length of stay (LOS), and ICU stay. One-way ANOVA and Kruskal-Wallis tests were applied to compare LOS and ICU stay based on comorbidities. Pearson chi-square test was used to identify the association between comorbidities and severity.

**Results:** LOS and ICU duration were significantly influenced by comorbidity burden ( $P < 0.001$ ). Patients with three or more comorbidities had the longest LOS (mean  $\pm$  SD = 38.0  $\pm$  39.4 days) and ICU stays (median  $\pm$  IQR = 1.0  $\pm$  19.0 day) compared to those without comorbidities (LOS mean  $\pm$  SD = 17.9  $\pm$  17.8 days; ICU median  $\pm$  IQR = 0.0  $\pm$  0.00 day). Hospitals' PPC for melioidosis differed from 2017 to 2020. Costs varied at Hospital Sultanah Nur Zahirah but increased dramatically at Hospital Raja Perempuan Zainab II.

**Conclusions:** Melioidosis remains a severe disease with a substantial healthcare burden, especially among patients with multiple comorbidities. Disease severity, sex, and comorbidity count significantly affect hospital and ICU stay durations. The findings highlight the need for early risk identification and targeted resource allocation to improve patient outcomes and manage hospital costs effectively.

**Keywords:** Melioidosis; Disease severity; Hospital costs; Length of stay; ICU stay; Malaysia; Patient demographics; Comorbidities.

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### Introduction

Melioidosis is an infectious disease caused by the Gram-negative bacterium *Burkholderia (B.) pseudomallei*. The disease was first identified in 1911 when the bacterium is commonly found in the rhizosphere<sup>1</sup> and surface groundwater in many tropical and subtropical regions, where it can infect humans and various animals<sup>2</sup>. Infections naturally acquired by humans and animals occur through exposure to *B. pseudomallei* via broken skin, inhalation, or ingestion<sup>3</sup>. Environmental factors like tropical storms and certain occupations, such as rice farming, forestry, and fishing<sup>1</sup>, can increase the risk of exposure. *B. pseudomallei* infection can be acute, chronic, or latent, but it often leads

to subclinical diseases, as most immunocompetent individuals can recover from the infection<sup>4</sup>. Only those who develop clinical symptoms, whether acute or chronic, are diagnosed with melioidosis<sup>2</sup>.

The death rate from melioidosis in countries where the disease is common is still high, leading to significant economic costs and loss of productivity. Proper treatment during the early stage of the disease and continuous therapy to eliminate the bacteria is crucial. Hospital costs have become a significant issue. Studies show that 28 melioidosis patients (32.9%) needed ICU care at a teaching hospital in Kuala Lumpur between 1988 and 2010<sup>6</sup>, and 27 patients (20.3%) required ICU care at Singapore General Hospital from 1996 to 2002. ICU admissions increase the overall cost of treatment<sup>7</sup>. The length of hospital stay also affects medical costs, an important factor in predicting future expenses. Similar to a study in Sabah, the annual incidence of culture-confirmed melioidosis is estimated at 4.97 per 100,000 people<sup>7</sup>.

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A study in Kedah, Malaysia, highlights the financial strain on patients and the healthcare system and reported the overall mean direct medical cost for melioidosis amounted to US \$233.61, focusing solely on healthcare expenses during hospital admission<sup>9</sup>. Understanding these costs is crucial for developing strategies to alleviate the economic impact of the disease<sup>9</sup>. In comparison, a study conducted in Thailand found that the annual cost of bacteremic melioidosis hospitalizations from a societal perspective, which includes both direct medical and indirect non-medical costs, was \$152 159 in Sa Kaeo and \$465 303 in Nakhon Phanom. The average cost per fatal case in these regions was \$14 182 and \$14 858, respectively. These figures illustrate the broader financial toll that melioidosis can have on affected communities<sup>7</sup>.

The primary objective of this study is to analyze the patient characteristics, treatment outcomes, and per-patient costs associated with melioidosis using data from six hospitals between 2019 and 2023. The study examined the patient demographics, such as age, sex, race, and severity of the disease, to better understand how these factors influence hospitalizations due to melioidosis. It will also explore trends of hospital admissions due to melioidosis across different years and states. The results also compared the mean length of stay (LOS) and ICU stay based on comorbidities and disease severity.

## Methods

### *Data sources*

A retrospective cohort study design was applied in this study. The general data were collected from the Health Informatics Centre, Ministry of Health. Meanwhile, the per-patient cost data was obtained from the Casemix Unit, the subunit of hospital financing, Ministry of Health, Malaysia. The per-patient cost represented the total cost of treating a patient with melioidosis in the hospital. Two key factors are considered to determine this cost: the Base Rate and the Case Group Weight (CGW). The Base Rate means the average cost of treating a patient, calculated by dividing the hospital's total expenses by the number of patients treated in a year. CGW shows the complexity of the patient's condition, considering factors like severity and the amount of care needed. The per-patient cost is determined by multiplying the Base Rate by the CGW, representing the total hospitalization cost.

### *Study site and population*

This study focused on all types of melioidosis patients admitted to hospitals in Eastern and Northern Malaysia (Hospital Sultanah Bahiyah in Alor Setar, Hospital Tuanku Fauziah in Kangar, Hospital Raja Permaisuri Bainun in Kedah, Hospital Tengku Ampuan Afzan in Kangar, Hospital Sultanah Zahirah in Kuala Terengganu, and Hospital Raja Perempuan Zainab II in Kota Bharu). Data of 502 melioidosis

patients admitted to these hospitals from 2019-2023 covered demographics, disease severity, LOS, ICU stay, comorbidities, and discharge outcomes were included in the study.

The diagnosis of the patients was based on positive culture for *B. pseudomallei* or positive PCR or a four-fold rise in serological titre, as stated in the Ministry of Health Infectious Disease Case Definition<sup>10</sup>. In this study, the severity of melioidosis was categorized into three levels based on the presence of comorbidities and complications in the patient. Severity 1 was classified based on patients without comorbidities and complications, severity 2 on those with comorbidities and complications, and severity 3 on those with major comorbidities and complications. Comorbidities were classified into four categories based on the number of diagnosed conditions: no comorbidity, one comorbidity, two comorbidities, and three or more comorbidities. ICU stay durations were categorized into five groups based on the number of days spent in the ICU: 0 day, 1-6 days, 7-13 days, 14-20 days, and 21+ days. Otherwise, the per-patient cost data from 2017-2020 were extracted from these six hospitals.

### *Statistical analysis*

The data were analyzed using descriptive statistics to summarize the baseline characteristics of melioidosis patients. Age was presented as mean with standard deviations (SD), while LOS and ICU stay were presented as median with interquartile range (IQR). Categorical variables, including sex, race, discharge status, comorbidities, ICU stay in categorical and disease severity, were reported as frequencies and percentages. A one-way ANOVA was used to compare the LOS across different numbers of comorbidities. The Kruskal-Wallis test was used to compare the ICU stay across different numbers of comorbidities since the data were not normally distributed. Pearson *Chi*-square test was applied to identify the association between the number of comorbidities and severity levels. Statistical significance was determined with a *P*-value of < 0.05. All statistical analyses were performed using IBM SPSS 29.0.

### *Ethics approval*

This study was approved by The Medical Research and Ethics Committee Ministry of Health Malaysia with the registered number NMRR ID-23-03666-DMZ(IIR) issued on 26<sup>th</sup> February 2024. This study does not put anyone at risk. The patient's name was not collected and was replaced with unique IDs to protect patients' privacy, which was in line with ethical guidelines. The obtained data were handled carefully and kept confidential.

## Results

Table I shows the baseline characteristics of 502 melioidosis patients admitted to six East Coast and Northern Malaysia hospitals between 2019 and 2023. Regarding demographics, the mean±SD age of patients was (47.3±18.2) years, with

73.3% (368/502) of the male patient and 85.9% Malay (431/502).

Based on the hospital distribution, the highest number of melioidosis patients was reported at Hospital Sultanah Nur Zahirah in Kuala Terengganu (28.5%, 143/502), followed by Hospital Sultanah Bahiyah in Alor Setar (22.9%, 115/502). The lowest admissions occurred at Hospital Tuanku Fauziah in Perlis (4.6%, 23/502). The yearly trends show that 2020 had the highest number of admissions, with 148 patients (29.5%), followed by a decline in 2022 (17.1%, 86/502) and an increase again in 2023 (25.7%, 129/502).

The most common comorbidity was diabetes mellitus, affecting 19.7% (n=99) of patients, followed by kidney disease (n=65, 12.9%). The least common comorbidity was

hypertension, affecting only 1.6% (n=8) of patients. In terms of disease severity, the majority of patients had severity 3 of melioidosis (n=200, 39.8%), followed by severity 1 (n=152, 30.3%) and severity 2 (n=150, 29.2%). The median length of hospital stay was 18.0 days, with an IQR of 24.0, while the median ICU stay was 0.0 days, with an IQR of 0.0 days. This indicates that most of the patient did not require ICU care. Based on the categorization of the ICU stay into five group show that the majority of patients, 10.6% (n=53) stayed for 1-6 days. A smaller proportion, 3.0% (n=15) stayed for 7-13 days and 1.4% (n=7) stayed for 14-20 days. Only 1.0% (n=5) stayed for 21+ days. As for the patient outcomes, most patients were discharged well (n=377, 75.1%), while 9.6% died, and 11.2% were transferred to other facilities. A small percentage (4.2%) were discharged against medical advice.

**Table I.** Baseline characteristics of melioidosis patients admitted to six hospitals in Malaysia from 2019-2023 (n=502).

Variables	n (%)	Variables	n (%)
Age, years	47.3±18.2 <sup>a</sup>	Severity	
Sex		1	152(30.3)
Female	132 (26.3)	2	150(29.9)
Male	368 (73.3)	3	200(39.8)
Unknown-missing data	2 (0.4)	Comorbidities	
Race		Diabetes mellitus	99(19.7)
Malay	431 (85.9)	Kidney disease	65(12.9)
Chinese	17 (3.4)	Anaemia	24(4.8)
Indian	23 (4.6)	Hypertension	8(1.6)
Others	14 (2.8)	None	124(24.7)
Not citizen	6 (1.2)	Other	182(36.3)
Native of the peninsula	11 (2.2)	No. of comorbidities	
Hospital name		None	124(24.7)
Hospital Raja Perempuan Zainab II,Kota Bharu	59 (11.8)	1	332(66.1)
Hospital Raja Permaisuri Bainun,Ipoh	48 (9.6)	2	32(6.4)
Hospital Sultanah Bahiyah, Alor Setar	115 (22.9)	3 or more	14(2.8)
Hospital Sultanah Nur Zahirah, Kuala Terengganu	143 (28.5)	Length of hospital stay, days	18.0(24.0) <sup>b</sup>
Hospital Tengku Ampuan Afzan, Kuantan	114 (22.7)	Length of ICU stay, days	0.0(0.0) <sup>b</sup>
Hospital Tuanku Fauziah, Kangar	23 (4.6)	0 day	422(84.0)
Year		1-6 days	53(10.6)
2019	13(2.6)	7-13 days	15(3.0)
2020	148 (29.5)	14-20 days	7(1.4)
2021	126 (25.1)	21+ days	5(1.0)
2022	86 (17.1)	Patient's outcome	
2023	129 (25.7)	DAMA	21 (4.2)
		Death	48 (9.6)
		Discharged well	377 (75.1)
		Transfer	56(11.2)

Data were expressed as n (%) unless stated otherwise. <sup>a</sup>Mean±SD) was reported; the normality assumption was met.

<sup>b</sup>Median (IQR) was reported; the normality assumption was not met.

DAMA: discharged against medical advice.

The mean age of patients slightly decreased, from 48 years in 2020 to 45 years in 2023, as shown in Table II. Sex distribution remained stable, with male patients consistently being the majority, and the racial composition was the majority Malay, slightly fluctuating across the years.

The highest number of patients was recorded at Hospital Sultanah Nur Zahirah in Kuala Terengganu, especially in 2022, with (n=40, 46.5%). The number of admissions peaked in 2020 with 148 patients (29.5%), then decreased steadily in 2021 and dropped to its lowest in 2022. However, admissions increased again in 2023 to (n=129, 25.7%). Severity 3 decreased over the year, from (n=62, 41.9%) in 2020 to (n=46, 35.7%) in 2023.

From 2020 to 2023, diabetes mellitus remained the most common comorbidity, though its prevalence decreased from (n=35, 23.6%) in 2020 to (n=16, 12.4%) in 2023. Kidney disease stayed stable, affecting around 13%-14% of patients yearly. Anaemia and hypertension were less common, with hypertension almost absent by 2023. Most patients had one comorbidity, with a decrease in the proportion of patients with multiple comorbidities over time. The length of stay varied significantly, with 2021 having the shortest mean(SD) hospital stay at 17.6(15.9) days and 2019 with the longest at 30.2(12.5) days. Regarding discharge outcomes, most patients were discharged well, with the highest percentage in 2022 (n=70, 81.4%). The death rate peaked in 2021 (n=20, 15.9%), while the percentage of patients discharged against medical advice was lowest in 2023 (n=3, 2.3%).

**Table II.** Comparison of baseline characteristics of melioidosis patients admitted to six hospitals in Malaysia based on year (n=502).

Variables	2019	2020	2021	2022	2023	
Age, years	48.1±16.7 <sup>a</sup>	47.8±17.7 <sup>a</sup>	47.4±20.8 <sup>a</sup>	45.7±18.9 <sup>a</sup>	48.1±16.7 <sup>a</sup>	
Sex	Female	0(0.0)	46 (31.1)	35 (27.8)	17 (19.8)	34 (26.4)
	Male	13(100.0)	102 (68.9)	90 (71.4))	68 (79.1)	95 (73.6)
	Unknown	0(0.0)	0(0.0)	1 (0.8)	1 (1.2)	0 (0.0)
Race	Malay	12(92.3)	130(87.8)	106(84.1)	77 (89.5)	106 (82.2)
	Chinese	0(0.0)	3(2.0)	5(4.0)	1 (1.2)	8 (6.2)
	Indian	0(0.0)	5(3.4)	7(5.6)	4 (4.7)	7 (5.4)
	Not citizen	0(0.0)	0(0.0)	3(2.4)	1 (1.2)	2 (1.6)
	Others	1(7.7)	5(3.4)	3(2.4)	1 (1.2)	4 (3.1)
	Native of the peninsula	0(0.0)	5(3.4)	2(1.6)	2 (2.3)	2 (1.6)
	Hospital name					
Hospital Raja Perempuan Zainab II, Kota Bharu	0(0.0)	24(16.2)	11(8.7)	5(5.8)	19(14.7)	
Hospital Raja Permaisuri Bainun, Ipoh	0(0.0)	14(9.5)	10(7.9)	12(14.0)	12(9.3)	
Hospital Sultanah Bahiyah, Alor Setar	3(23.1)	39(26.4)	29(23.0)	12(14.0)	32(24.8)	
Hospital Sultanah Nur Zahirah, Kuala Terengganu	6(46.2)	34 (23.0)	37(29.4)	40(46.5)	26(20.2)	
Hospital Tengku Ampuan Afzan, Kuantan	3(23.1)	25 (16.9)	38(30.2)	17(19.8)	31(24.0)	
Hospital Tuanku Fauziah, Kangar	1(7.7)	12 (8.1)	1(0.8)	0(0.0)	9(7.0)	
Comorbidities	Diabetes mellitus	6(46.2)	35(23.6)	25(19.8)	17(19.8)	16(12.4)
	Kidney disease	3(23.1)	20(13.5)	15(11.9)	9(10.5)	18(14.0)
	Anaemia	1(7.7)	4(2.7)	10(7.9)	7(8.1)	2(1.6)
	Hypertension	1(7.7)	4(2.7)	3(2.4)	0(0.0)	0(0.0)
	None	0(0.0)	27(18.2)	43(34.1)	19(22.1)	35(27.1)
	Other	2(15.4)	58(39.2)	30(23.8)	34(39.5)	58(45.0)
No. of comorbidities	None	0(0.0)	27(18.2)	42(33.3)	20(23.3)	35(27.1)
	1	12(92.3)	104(70.3)	78(61.9)	60(69.8)	78(60.5)
	2	1(7.7)	13(8.8)	3(2.4)	4(4.7)	11(8.5)
	3 or more	0(0.0)	4(2.7)	3(2.4)	2(2.3)	5(3.9)
Severity	1	3(23.1)	40(27.0)	37(29.4)	28(32.6)	44(34.1)
	2	7(53.8)	46(31.1)	36(28.6)	22(25.6)	39(30.2)
	3	3(23.1)	62(41.9)	51(42.1)	36(41.9)	46(35.7)
Length of hospital stay, days	30.2±12.6 <sup>a</sup>	21.3±17.7 <sup>a</sup>	17.6±15.9 <sup>a</sup>	26.7±23.3 <sup>a</sup>	23.7±16.6 <sup>a</sup>	
Length of ICU stay, days	0.0(0) <sup>b</sup>	0.0(0) <sup>b</sup>	0.0(0) <sup>b</sup>	17.0(0) <sup>b</sup>	0.0(0) <sup>b</sup>	
Patient's outcome	DAMA	1(7.7)	8 (5.4)	5 (4.0)	4 (4.7)	3 (2.3)
	Death	0(0.0)	10 (6.8)	20 (15.9)	5 (5.8)	13(10.1)
	Discharged well	12(92.3)	103 (69.6)	89 (70.6)	70 (81.4)	103(79.8)
	Transfer	0(0.0)	27 (18.2)	12 (9.5)	7 (8.1)	10 (7.8)

Data were expressed as n (%) unless stated otherwise: <sup>a</sup>Mean±SD) was reported; normality assumption met.

<sup>b</sup>Median(IQR) was reported; normality assumption was not met. DAMA: discharged against medical advice.

**Table III.** Comparison of length of stay and ICU stay across different numbers of comorbidity (n=502).

No. of comorbidities	Length of stay		ICU stay	
	Patients with comorbidities (mean±SD)	P-value <sup>a</sup>	Patients with comorbidities (median±IQR)	P-value <sup>b</sup>
None	17.9±17.8)	<0.001	0.0±0.0	<0.001
1	22.4±16.5)		0.0±0.0	
2	29.3±17.8)		0.0±13.0	
3 or more	38.0±39.4)		1.0±19.0	

<sup>a</sup>One-way ANOVA was applied. Post-hoc analysis with the **Tukey test** shows significant differences in LOS across the comorbidity groups. For LOS, None significantly differed from 1 comorbidity ( $P<0.001$ ), one comorbidity differed significantly from 2 comorbidities ( $P<0.001$ ), and two comorbidities significantly differed from 3 or more comorbidities ( $P<0.001$ ).

<sup>b</sup>Kruskal-Wallis was applied as the data was not normally distributed

Table III compares **LOS** and **ICU stay** across different comorbidity groups. A significant mean difference was observed for LOS between the comorbidities groups ( $P<0.001$ ). The results showed that patients with **no comorbidities** had the shortest LOS (mean=17.85; SD=17.812), while those with **three or more comorbidities** had the longest (mean=38.00; SD=39.425). Patients with **more comorbidities** tended to have longer ICU stays, particularly those with **three or more comorbidities** (median=1.0; IQR=19.0) compared to patients with none, 1 and 2 comorbidities. The difference between these groups was statistically significant, with  $P<0.001$ .

There was an association between the number of comorbidities and severity ( $P<0.001$ ) (Table IV). Most patients with no comorbidities are in severity 1 (n=47, 30.9%), while those with one comorbidity are primarily in

severity 2 (n=116, 77.3%) and severity 3 (n=119, 59.5%). Patients with three or more comorbidities tend to be in severity 3 (n=9, 4.5%).

Table V shows that from 2017 to 2020, the PPC for treating melioidosis showed varying trends across hospitals. Hospital Raja Perempuan Zainab II, Kota Bharu, demonstrated a significant increase in PPC, rising from USD 942.2 in 2017 to USD 1,410.9 in 2020, indicating an upward trend in treatment costs over time. Other hospitals, such as Hospital Sultanah Nur Zahirah Kuala Terengganu, also showed fluctuations in PPC, with a noticeable increase in 2020 (USD 1,125.6). Hospital Raja Permaisuri Bainun, Ipoh, and Hospital Sultanah Bahiyah, Alor Setar, showed decreased PPC for the upcoming year, with unavailable values in the dataset in 2017 and 2020. The PPC highlights the complexity of cost patterns across different regions and hospitals.

**Table IV.** Association between the number of comorbidities and severity levels (n=502).

No. of comorbidities	Severity 1	Severity 2	Severity 3	P- value <sup>a</sup>
None	47(30.9)	28(18.7)	49(24.5)	<0.001
1	97(63.8)	116(77.3)	119(59.5)	
2	8(5.3)	1(0.7)	23(11.5)	
3 or more	0(0)	5(3.3)	9(4.5)	

<sup>a</sup>Pearson *chi*-square test applied; less than 20% of expected count<5. Data are expressed as n (%).

**Table VI.** Per patient cost in 5 hospitals from 2017-2020 (USD).

Hospitals	2017	2018	2019	2020
Hospital Raja Perempuan Zainab II, Kota Bharu	942.2	1,041.6	1,006.6	1,410.9
Hospital Raja Permaisuri Bainun, Ipoh	Unavailable	1,355.6	1,235.2	Unavailable
Hospital Sultanah Bahiyah, Alor Setar	1,377.7	1,228.7	Unavailable	Unavailable
Hospital Sultanah Nur Zahirah, Kuala Terengganu	1,024.4	1,046.6	827.3	1,125.6
Hospital Tuanku Fauziah, Kangar	Unavailable	Unavailable	1,436.3	Unavailable

## Discussion

This study provides valuable insights into the baseline characteristics of melioidosis patients admitted to six hospitals in Malaysia from 2019 to 2023. The results highlight several important factors: age, sex, race, disease severity, comorbidities, length of stay, ICU care, and discharge outcomes.

In this study, the mean age of melioidosis patients was 47 years, slightly decreasing from 47 years in 2020 to 45 years in 2023. Age and sex are closely linked to the risk of melioidosis, especially for those working outdoors. Most individuals exposed to melioidosis through outdoor work are between 45 and 54 years old, with men being the majority, particularly those in agriculture or other labor-intensive jobs<sup>12</sup>. These occupations often involve frequent contact with soil and water contaminated by *B. pseudomallei*, increasing the risk of infection<sup>13</sup>. Additionally, older workers are more vulnerable to severe disease due to weaker immune systems and existing health conditions, leading to more extended hospital stays and higher treatment costs<sup>14</sup>.

The racial distribution of this study closely mirrored the ethnic demographics of Malaysia, with the majority of patients being Malay. While past studies haven't focused on how the Malay population is involved in agriculture-related melioidosis patients, our analysis shows that over the years, the majority of patients have been among Malays. Farming which is more common among Malays, farming may put them at greater risk of exposure to *B. pseudomallei*, the bacteria responsible for melioidosis<sup>15</sup>. Since Malays are the largest ethnic group in Malaysia<sup>16</sup>, it's not surprising that they make up the majority of patients in our study.

Terengganu had the highest number of patients, which reflects local environmental factors such as tropical storms or other seasonal weather patterns that increase exposure to *B. pseudomallei*<sup>17</sup>. Rainfall plays an important role in the spread of melioidosis. Studies show that regions with clearly defined wet and dry seasons, such as northern Australia<sup>12</sup> and northeast Thailand<sup>18</sup>, are more prone to the spread of melioidosis. In addition, a survey in Alor Setar, Kedah, found that the highest number of patients and deaths occurred during the wettest months. This suggests that heavy rainfall or flooding could still significantly increase exposure to the bacteria, even though Malaysia does not experience distinct wet and dry seasons<sup>4</sup>. Flooding caused by the rain can carry the bacteria into water sources and over agricultural land, increasing the risk of exposure for farmers<sup>19</sup>. People working in agriculture often come into contact with contaminated soil and water through cuts on their skin, inhalation of bacteria, or using untreated water in their work<sup>13</sup>.

This study also shows that the severity of the disease directly impacted both the LOS and the ICU stay. Patients in the severity 3 group had longer hospital stays and ICU admissions<sup>20</sup>. Severe melioidosis weakens the body's immune system, making recovery much slower. In severe cases, especially severity 3, the infection can spread through the body and cause septicemia, which puts too much pressure on the immune system. The condition leads to inflammation, tissue damage, and organ failure, requiring longer hospital stays and intensive care to stabilize the patient. Conditions like diabetes, which are common in melioidosis patients, further weaken the immune system, making it harder for the body to fight the infection and recover<sup>21</sup>. This emphasizes the critical need for early diagnosis and timely treatment to reduce the severity of the disease and, consequently, reduce hospitalization costs<sup>22</sup>.

Additionally, this study found that the average ICU stay was relatively short across the patient population, with a mean of 1.08 days. However, patients in the severity 3 group required significantly longer ICU stays. These patients need help with breathing through mechanical ventilation, support for failing organs, and close monitoring to manage life-threatening conditions<sup>23</sup>. Severe cases can also lead to problems like acute respiratory distress syndrome, which takes time and specialized care to treat<sup>24</sup>. The need for intensive care in severe cases further drives up the overall costs of treatment<sup>7</sup>. Based on the study conducted in Kedah and Perlis from 2014 to 2017 reported that a total of 50.11% (227/453) of the patients died at the hospital, and a majority (86.75%, 393/453) of patients were bacteremic<sup>25</sup>. The presence of additional comorbidities significantly impacts the LOS and ICU stay, as evidenced by the extended stays in patients with more than one comorbidity. This finding mirrors a study in Saudi Arabia<sup>26</sup>, which reported a similar trend in the relationship between the number of comorbidities and hospitalization duration.

The discharge result shows that the majority of patients were discharged well. However, a smaller percentage of patients either passed away or were transferred to other facilities. This indicates that discharge outcomes are closely linked to the severity of the disease. Patients with severity 1 melioidosis were more frequently discharged well, while those with severe cases had higher rates of transfers and deaths. This aligns with evidence showing that severe melioidosis often requires prolonged and intensive care, resulting in more extended hospital stays and ICU stays compared to those with milder cases<sup>20</sup>. A study in Thailand found that the mortality rate of melioidosis was 44.7%, measured from 2014 to 2017<sup>27</sup>.

The cost of treating melioidosis patients in Malaysia varies between hospitals and years. Compared with other countries, Malaysia's cost of treating melioidosis patients is much lower than that of developed countries. In Thailand, the average cost per fatal case was USD 14,182 and USD 14,858 in Sa Kaeo and Nakhon Phanom, respectively<sup>7</sup>. The differences in costs between Malaysian hospitals could be due to factors like the severity of the cases, the availability of resources, or how the hospitals operate.

One of the limitations of this study was that it relied on retrospective data, meaning the information was gathered from records, resulting in limited variables that could be included in the analysis, as only the initially available data was used. As a result, the study may have overlooked potentially important factors, such as the patient's lifestyle or specific treatments, which could have influenced the results. Another limitation was the incomplete data regarding the cost per patient. Due to missing a few financial records, it was impossible to determine each patient's treatment cost fully. This data gap could have affected the accuracy of cost-related conclusions.

In conclusion, this study shows/demonstrates important findings on the demographics of melioidosis patients, showing that the majority of patients are middle-aged males, particularly within the Malay population. This demographic information highlights the need for targeted healthcare strategies for these groups to improve prevention and treatment outcomes. Additionally, this study proves that comorbidities significantly affect the severity of melioidosis, with patients having more comorbidities requiring longer hospital stays and more intensive care. The results of this study also show that an increase in comorbidities leads to longer hospital and ICU stays, which aligns with previous research, highlighting the importance of managing comorbidities to improve patient outcomes.

However, this study's limitations, including the retrospective data and incomplete cost records, suggest that future research should focus on gathering more comprehensive data, especially regarding the economic burden of treating melioidosis patients with comorbidities.

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