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Assessing the burden of pneumonia using administrative data from Malaysia, Indonesia, and the Philippines

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SUMMARY

Objectives: To describe the incidence, mortality, cost, and length of stay (LOS) of hospitalized community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP) in three Southeast Asian countries: Malaysia, Indonesia, and the Philippines.

Methods: Using Casemix system data from contributing hospitals, patients with International Classification of Diseases 10th revision (ICD-10) codes identifying pneumonia were categorized into CAP or HAP using a logical algorithm. The incidence among hospitalized patients, case fatality rates (CFR), mean LOS, and cost of admission were calculated. The population incidence was calculated based on Malaysian data.

Results: For every 100 000 discharges, CAP and HAP incidences were 14 245 and 5615 cases, respectively, in the Philippines, 4205 and 2187, respectively, in Malaysia, and 988 and 538, respectively, in Indonesia. The impact was greatest in the young and the elderly. The CFR varied from 1.4% to 4.2% for CAP and from 9.1% and 25.5% for HAP. The mean LOS was 6.1–8.6 days for CAP and 6.9–10.2 days for HAP. The cost of hospitalization was between USD 254 and USD 1208 for CAP and between USD 275 and USD 1482 for HAP.

Conclusions: The burden of CAP and HAP is high. Results varied between the three countries, likely due to differences in socio-economic conditions, health system differences, and ICD-coding practices.

1. Introduction

Pneumonia is a significant problem worldwide and remains one of the major causes of death among children younger than 5 years old.[1,2] In 2010, it was estimated that there were 120 million episodes of pneumonia globally, and 1.3 million episodes led to death among children in this age group in 2011.[3,4] The elderly and adults with pre-existing medical conditions are also at increased risk of pneumonia. These include people with chronic heart, lung, or liver disease, people living with HIV, and those who have had transplants or are taking immunosuppressive drugs.[5]

Hospitalizations for pneumonia may be classified based on the location of prior exposure and can be categorized as hospital-acquired or community-acquired. In contrast to community-acquired pneumonia (CAP), hospital-acquired pneumonia (HAP) occurs more than 48 h after a hospital admission without any

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antecedent signs at the time of admission.[6,7] By pathogen, HAP and CAP differ. Pathogens causing CAP are commonly *Streptococcus pneumoniae*, *Mycoplasma pneumoniae*, *Chlamydophila pneumoniae*, *Legionella pneumophila*, *Haemophilus influenzae* type B, and respiratory syncytial virus (RSV).[8,9] In some countries in the Asia Pacific, *Klebsiella pneumoniae* is also a common CAP pathogen.[9] Common HAP-causing pathogens include *Pseudomonas aeruginosa*, *Escherichia coli*, *K. pneumoniae*, and *Acinetobacter* species, while *Staphylococcus aureus* is an increasing problem.[7] HAP-causing bacteria are considered to be more virulent since many are likely to be multidrug-resistant.[5–7] The rates of morbidity and mortality also tend to differ between CAP and HAP. Hence, being able to differentiate between CAP and HAP is of interest to clinicians and researchers.

Few studies have compared the incidences of the two pneumonia types. One such study was conducted in the region of Lazio in Italy and explored the incidences of CAP, HAP, and AIDS-related pneumonia using hospital information system data.[10] The annual incidence rates of the three pneumonia types were found to be 159, 75, and 7.4 per 100 000 population, respectively; meanwhile, the fatality rates were 9.4%, 29.3%, and 11.2%, respectively.

Few studies from the Asia-Pacific region have reported pneumonia incidence. Most studies have tended to focus on the causative organisms, antibiotic resistance, or risk factors.[9,11] Furthermore, few countries have reported incidence rates.[12] Among the estimates available is one from Thailand, which reported incidence as being between 177 and 580 per 100 000 population.[13,14] In another study performed in central Vietnam, the incidence of CAP was estimated at 0.81 per 1000 population.[15] In Singapore, a national study showed that the incidence of pneumococcal pneumonia was approximately 4.5 per 100 000 in those aged 15–64 years.[16] No study has explored the difference in incidence of CAP and HAP in Southeast Asian countries.

Information on cost or the economic burden is relatively limited and does not discuss these two pneumonia categories. A study of pneumonia admission costs in Singapore estimated a cost of USD 1294 for a hospital admission of 6.4 days and USD 3456 for a hospital admission of 10 days.[17] In the Philippines, it was estimated that the cost of hospitalization with moderate-risk CAP was between USD 852 and 2678.[18] On the other hand, the cost of pneumonia in rural Thailand was reported to be lower, varying from USD 490 to 628.[13] Within the wider Asian region, the cost per hospital admission was reported to be USD 3221 among elderly patients in Taiwan, while the total annual burden in the elderly was USD 1 897 137.[19] Also in Taiwan, a study by Wu et al. found that the cost of pneumococcal pneumonia hospitalization in older adults aged 50 years and above was between NT$ 153 000 and 178 000 (USD 5109–5952) and the total annual cost was greater than NT$ 3.6 billion (USD 112 023 220).[20]

In developed countries, administrative databases have been used widely to understand disease patterns and burden of disease. Such studies have been performed in the USA and Europe where administrative databases are readily available and are well-established.[21–27] In Asia, research using administrative databases is less common, except in South Korea, Taiwan, and Japan.[27,28] Although administrative data are not initially collected for research, they can provide useful information in a less resource-intensive manner by eliminating the need for primary data collection.[27] Two such studies exploring pneumonia are the studies mentioned above by Wu et al.,[20] and Low et al.,[16] performed in Taiwan and Singapore, respectively.

Although research using administrative databases is still new in Southeast Asia, pockets of data exist that can be used for epidemiological research.[27,28] One of these sources of data is the administrative system developed by the United Nations University International Institute for Global Health (UNU-IIGH) and the National University of Malaysia.[27,29,30] The system, called Casemix, has been in use at the medical center of the National University of Malaysia since 2002 and was implemented in a second Malaysian academic center in 2012. Meanwhile, the Casemix system has been used on a larger scale in Indonesia and the Philippines,[31] since 2008 and 2009, respectively, to support the implementation of their social insurance systems. Hospital discharge data are coded using the International Classification of Diseases 10th revision (ICD-10) and diagnosis-related groups (DRGs). The system contains costs of ambulatory services, in-patient services, daycare surgery, and other services. In Indonesia and the Philippines, it is used for hospital reimbursement by the relevant social health insurance authorities in each country. Social insurance has not been implemented in Malaysia; the Casemix system is used in two hospitals for budgeting and academic purposes in this country.

The objectives of this study were to describe the incidence, mortality, and resource utilization associated with hospitalized pneumonia in Malaysia, Indonesia, and the Philippines using Casemix data, as well as to better understand the differences between CAP and HAP. It was aimed to elucidate the incidences of CAP and HAP among hospitalized patients, as well as to ascertain the differences in cost, length of stay (LOS), and prevalence of comorbidities between CAP and HAP.

2. Methods

Casemix system data from hospitals in Malaysia, Indonesia, and the Philippines that were contributing to the dataset at the time of the study were utilized. In Indonesia, hospitals began to use the system in January 2014 to implement social insurance for citizens in the lower socio-economic groups. In the Philippines, coverage of hospitals was limited at the time of the study and was made possible through collaboration between UNU-IIGH, the National University of Malaysia, the Department of Health of the Philippines, and the Ministry of Health of Indonesia. The available dataset for this study consisted of data from 42 anonymized

Table 1
ICD-10 codes used to identify cases of pneumonia

Definition	ICD-10 code
Influenza due to identified influenza virus	J10.0, J10.1, J10.8
Influenza, virus not identified	J11.0, J11.1, J11.8
Viral pneumonia, not elsewhere classified	J12.0, J12.1, J12.2, J12.3, J12.8, J12.9
Pneumonia due to *Streptococcus pneumoniae*	J13
Pneumonia due to *Haemophilus influenzae*	J14
Bacterial pneumonia, not elsewhere classified	J15.0, J15.1, J15.2, J15.3, J15.4, J15.5, J15.6, J15.7, J15.8, J15.9
Pneumonia due to other infectious organisms, not elsewhere classified	J16.0, J16.8
Pneumonia in disease classified elsewhere	J17.0, J17.1, J17.2, J17.3, J17.8
Pneumonia, organism unspecified	J18.0, J18.1, J18.2, J18.8, J18.9

ICD, International Classification of Diseases.

Table 2
ICD-10 codes used to identify comorbidities

Definition	ICD-10 code
Diabetes	E10.0–E10.9, E11.0–E11.9, E12.0–E12.9, E13.0–E13.9, E14.0–E14.9
Lung disease	I26.0, I27.0, I27.8, I27.9, I28.0, I28.8, I28.9, J40, J41.0, J41.1, J41.8, J43.0, J43.1, J43.2, J43.8, J43.9, J44.0, J44.1, J44.8, J44.9, J45.0, J45.1, J45.8, J45.9, J46, J47, J61, J62.0, J62.8, J63.0, J63.1, J63.2, J63.3, J63.4, J63.5, J63.8, J66.0, J66.1, J66.2, J66.8, J67.0, J67.1, J67.2, J67.3, J67.4, J67.5, J67.6, J67.7, J67.8, J67.9, J68.4, J70.1, J70.3
Chronic liver disease	B18.0, B18.1, B18.2, B18.8, B18.9, E52, F10, G62.1, I42.6, I85.0, I85.9, I86.4, I98.2, K29.2, K70.0, K70.3, K70.9, K71.1, K71.3–K71.5, K71.7, K72.0, K72.1, K72.9, K73.0, K73.1, K73.2, K73.8, K73.9 K74.0, K74.1, K74.2, K74.3, K74.4, K74.5, K74.6, K76.0, K76.2–K76.9, T51.0, T51.1, T51.2, T51.3, T51.8, T51.9, Z50.2, Z71.4, Z72.1, Z94.4
Immunodeficiency	B20.0, B20.1, B20.2, B20.3, B20.4, B20.5, B20.6, B20.7, B20.8, B20.9, B21.0, B21.2, B21.3, B21.7, B21.8, B21.9, B22.0, B22.1, B22.2, B22.7, B24, C81.0– C85.9, C88.0–C96.9, C90.0, C90.2, C77.0– C80.9, C00.0–C26.9, C30.0–C34.9, C37–C41.9, C43.0, C45.9–C58, C60.0–C76.8, C97, Q89.01, Q89.09
Cardiovascular disease	A52.0, I09.9, I10, I05.0–I08.9, I09.1, I09.8, I11.0–I13.9, I11.0, I13.0, I13.2, I15.0, I15.1, I15.2, I15.8, I15.9, I25.5, I34.0–I39.8, I42.0, I42.5–I42.9, I43.0, I143.1, I143.2, I143.8, I44.1–I44.3, I45.6, I45.9, I47.0–I49.9, I50.0, I70.0, I71.9, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, P29.0, R00.0, R00.1, R00.8, T82.1, Q23.0–Q23.3, Z45.0, Z95.0, Z95.2–Z95.4, Z95.8, Z95.9
Renal disease	I12.0, I13.1, N18.1, N18.2, N18.3, N18.3, N18.4, N18.5, N18.9, N25.0, Z49.0–Z49.2, Z94.0, Z99.2

ICD, International Classification of Diseases.

private and public hospitals in Indonesia, 18 hospitals in the Philippines, and two academic hospitals in Malaysia that used the Casemix system. The latest updated data from a single year were used (2011 for Malaysia and 2010 for Indonesia and the Philippines). In total, there were 58 075, 134 500, and 50 791 hospitalized patient records from Malaysia, Indonesia, and the Philippines, respectively. All patient records were de-identified.

Pneumonia cases were identified by ICD-10 codes J10–J18 (Table 1). Patients were further categorized into CAP and HAP using a simplified algorithm based on concepts similar to those used in previous studies.[10,32] Patients were categorized as having CAP if they had (1) a primary diagnosis of pneumonia, or (2) a secondary diagnosis of pneumonia with a respiratory condition as the primary diagnosis. Meanwhile, patients were categorized as having HAP if they had pneumonia in any of the secondary diagnosis fields with a non-respiratory primary diagnosis. Comorbidities recorded during the admission were also identified (Table 2). Patients were placed into the CAP or HAP category based on the above algorithm, then a descriptive analysis was performed to calculate the incidence of CAP and HAP among the total number of hospital discharges. Finally, for Malaysia, the population incidence rate was estimated based on the catchment population of the hospitals contributing the data. It was not possible to ascertain the catchment populations for hospitals in the Philippines and Indonesia, therefore population incidence rates were not calculated.

Finally, CAP and HAP admissions were compared in terms of cost per admission, mean LOS, case fatality rate (CFR), and prevalence of comorbidities. To enable cost comparisons between countries, average costs of admission were converted from local currency units (Malaysian Ringgits, Indonesian Rupiah, and Philippine Pesos) to USD based on the conversion rate in June 2013. Since the implementation of the Casemix system was new in Indonesia and the Philippines, stakeholder discussions were held to better understand the reasons for the patterns seen and whether they reflected experience in practice. The stakeholders attending were those involved in the implementation of the Casemix system, including representatives of the health insurance agencies and ministries of health, and clinical experts from each country.

3. Results

Pneumonia was diagnosed in a large proportion of hospitalized patients in the Philippines (19.9%) and a moderate proportion in Malaysia (6.4%), but was diagnosed in a relatively low proportion in Indonesia (1.5%) (Table 3). This corresponded to an incidence rate among hospitalized patients of 14 245 CAP cases and 5615 HAP cases per 100 000 discharges in the Philippines, 4205 CAP and 2187 HAP cases per 100 000 discharges in Malaysia, and 988 CAP and 538 HAP cases per 100 000 discharges in Indonesia. The proportion of CAP cases was approximately two times higher than the proportion of HAP cases in Malaysia and Indonesia, and three times higher in the Philippines (Table 3). The proportions of CAP and HAP cases among all hospital discharges were high in the Philippines (14.2% and 5.6%, respectively). On the other hand, the proportions of CAP and HAP were the lowest in Indonesia (1.0% and 0.5%, respectively). The proportion of deaths was higher in HAP compared to CAP: 25.5% vs. 4.2% in Malaysia, 11.3% vs. 1.8% in Indonesia, and 9.1% vs. 1.4% in the Philippines.

For Malaysia and the Philippines, the incidence of CAP per 100 000 discharges plotted against age group showed a perceptible U-shaped curve compared to HAP, indicating a greater impact of CAP on the youngest and the oldest age groups (Figure 1). This pattern was most apparent for the data from the Philippines. This U-shaped pattern was less apparent for Indonesia, as there were no cases of CAP recorded within the age group 85 years and above. The population incidence rate based on the catchment area of the Malaysian hospitals was 159 per 100 000 for CAP and 83 per

Table 3
Incidence per 100 000 discharges and case fatality rates among hospitalized patients in participating hospitals in the selected year

	Malaysia discharges			Indonesia discharges			Philippines discharges		
Item	CAP	HAP	Total	CAP	HAP	Total	CAP	HAP	Total
No. of discharges (*n*)	-	-	58 075	-	-	134 500	-	-	50 791
No. of pneumonia cases (*n*)	2442	1270	3712	1329	723	2052	7235	2852	10 087
Incidence per 100 000 discharges	4205	2187	6392	988	538	1526	14 245	5615	19 860
No. of deaths (*n*)	102	324	426	24	82	106	100	260	360
Proportion of pneumonia cases among discharged population (%)	4.2	2.2	6.4	1.0	0.5	1.5	14.2	5.6	19.9
CFR among pneumonia cases (%)	4.2	25.5	11.5	1.8	11.3	5.2	1.4	9.1	3.6

CAP, community-acquired pneumonia; HAP, hospital-acquired pneumonia; CFR, case fatality rate.

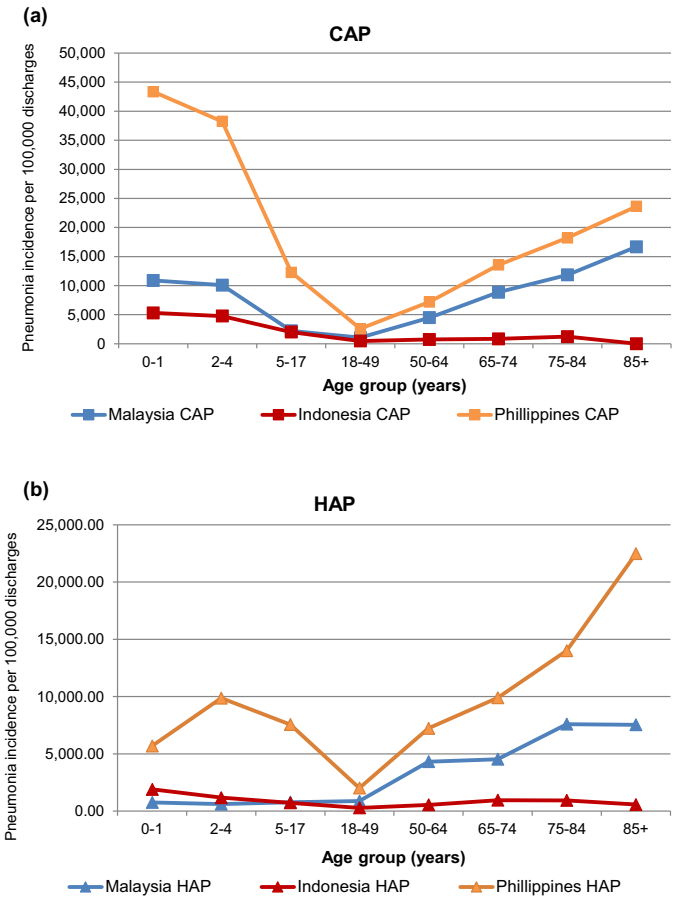

Figure 1. (a) Pneumonia CAP incidence per 100,000 discharges in Malaysia, Indonesia and Philippines according to age group. (b) Pneumonia HAP incidence per 100,000 discharges in Malaysia, Indonesia and Philippines according to age group.

100 000 population for HAP (Table 4). It was also estimated that the CAP incidence was 496 per 100 000 among children below 5 years of age, 64 per 100 000 for patients aged between 5 and 64 years, and 1305 per 100 000 for patients aged 65 years and older. The estimated incidence of HAP was 33 per 100 000 among children below 5 years of age, 53 per 100 000 for patients aged 5 to 64 years, and 717 per 100 000 for patients aged 65 years and older (Table 4, Figure 2).

Figure 3 shows the CFR among HAP and CAP admissions across age categories. Despite the incidence of CAP being highest in the youngest and oldest age groups, the older age groups tended to have higher CFRs related to pneumonia. This was most apparent for the Philippines data. Overall, 48.6% of cases occurred in adults over 18 years of age, whereas 84% of deaths occurred in the same age group (data not shown). The CFR was higher in HAP cases compared to CAP cases in all three countries.

Table 4
Estimated incidence rate of community-acquired pneumonia and hospital-acquired pneumonia based on two participating hospitals in Malaysia (per 100 000 population)

Age group, years	CAP	HAP	All pneumonia
Overall	159	83	242
<5	496	33	529
5–64	64	53	116
≥65	1305	717	2021

CAP, community-acquired pneumonia; HAP, hospital-acquired pneumonia.

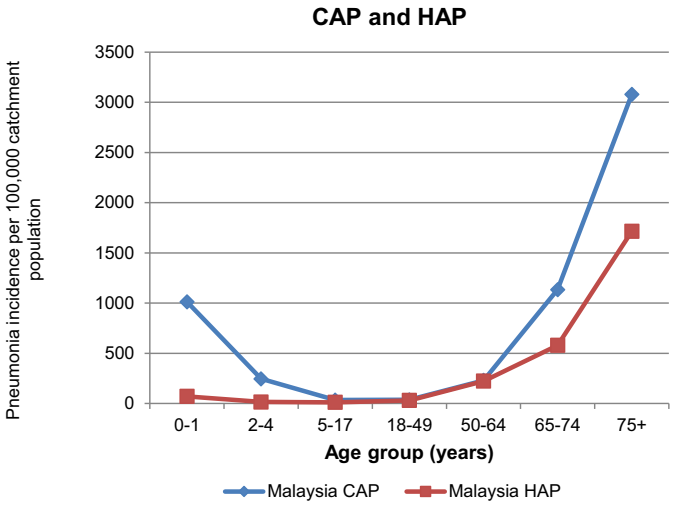

Figure 2. Pneumonia CAP and HAP incidence per 100,000 catchment population in Malaysia according to age group.

Comorbidities among patients with CAP and HAP pneumonia differed according to age group in each country (**Supplementary Material**, Figures S1–S3). In all three countries, the most common comorbidity among CAP cases was lung disease in young patients. However, lung disease, cardiovascular disease, and diabetes were more frequent in the older age groups. For HAP patients, the prevalence of lung disease was even more prominent among the younger age groups, while in the older age groups cardiovascular disease and lung disease were once again common. For both types of pneumonia, there was a dip in comorbidities seen in the oldest age group.

In terms of admission costs, the total average cost per admission for pneumonia was lowest in the Philippines (USD 254.3) and highest in Malaysia (USD 1177.5) (Table 5). The average cost per admission was slightly higher for HAP compared to CAP in each country (Table 5). Due to the greater proportion of CAP cases compared to HAP cases, it was estimated that CAP admissions cost the hospitals more than HAP admissions. The total estimated costs incurred for patients included in this dataset were USD 2.2 million (CAP) and USD 1.9 million (HAP) in Malaysia, USD 1.6 million (CAP) and USD 1.0 million (HAP) in Indonesia, and USD 1.8 million (CAP) and USD 0.8 million (HAP) in the Philippines.

The overall average LOS was longer for the pneumonia admissions in Malaysia (9.2 days) compared to Indonesia (8.0 days) and the Philippines (6.6 days). Comparing LOS between CAP and HAP, the results showed that HAP admissions were longer than CAP admissions in Malaysia (10.2 days vs. 8.6 days) and in Indonesia (7.9 days vs. 6.1 days). However, in the Philippines, admission lengths were approximately the same: 6.2 days for CAP and 6.9 days for HAP (Table 5).

4. Discussion

4.1. Comparison among countries

There were similarities as well as differences between the three countries. One similarity was the U-shaped trend seen for CAP incidence across age groups, although the pattern was less prominent for Indonesia. This indicates a high incidence in young children and the elderly and a low incidence in young and middle-aged adults. This pattern has been described in previous studies.[33–36] In all three countries, the proportion of CAP cases was higher than the proportion of HAP cases; the highest ratio was seen in the Philippines with a three-fold higher rate of CAP. On the other hand,

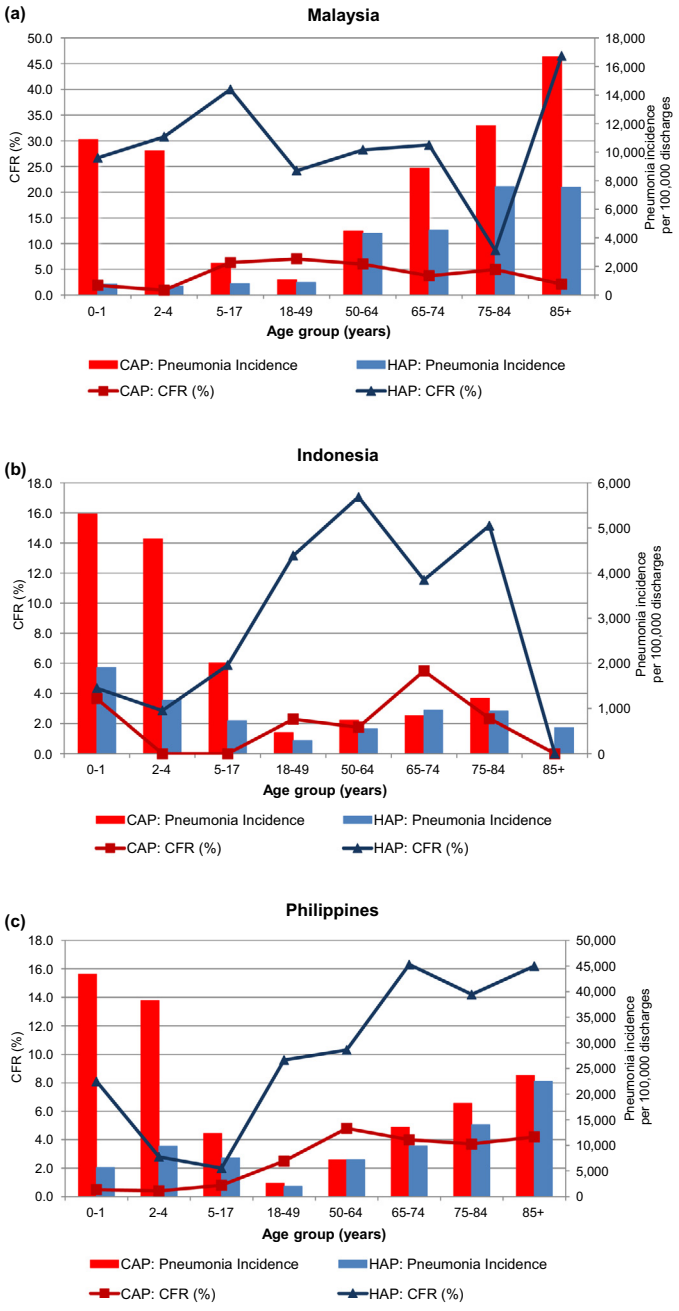

Figure 3. (a) Pneumonia incidence per 100,000 discharges according to age groups in Malaysia. (b) Pneumonia incidence per 100,000 discharges according to age groups for Indonesia. (c) Pneumonia incidence per 100,000 discharges according to age groups in Philippines.

the CFR rate was higher among HAP cases in all three countries. Similarly, LOS was higher for HAP than CAP in Malaysia and Indonesia, but was almost the same duration for the two types of pneumonia in the Philippines.

4.2. Explanations for the patterns seen

Some of the differences seen may be attributed to differences in the individual country health systems and the implementation of the Casemix system in the contributing hospitals. For instance, the overall rate of pneumonia was very high in the Philippines but very low in Indonesia. Also, the difference in CFR observed in CAP and HAP varied quite markedly. The difference was most marked in Malaysia (4.2% for CAP and 25.5% for HAP), followed by Indonesia and the Philippines (Table 3).

Stakeholder meetings helped in gaining a better understanding of the patterns seen. Stakeholders from Indonesia were concerned about the low incidence rate reported for that country, which did not reflect their clinical experience in hospitals; they estimated that approximately 10% of all discharges could be pneumonia-related. The stakeholders believed that there may have been under-reporting of pneumonia cases due to hospital preferences for a higher rate-paying claim. Another explanation is that the newly launched social insurance scheme covered patients from the lower socio-economic groups who, due to family resource constraints and cultural perceptions, did not bring their very elderly family members to the hospital for treatment.

Stakeholders from the Philippines were concerned about the low cost per admission reflected in the results of the study. The stakeholders explained that the low cost may be due in part to the relatively low official salaries of physicians and other hospital employees. However, patients are often charged additional fees for medical costs that are not covered by the social insurance system and this additional fee is not recorded. The cost per admission was estimated by the group to be approximately 40% higher than that found in the study. The estimation of out-of-pocket fees brings the estimate of the cost per pneumonia admission to USD 356. Despite this higher amount, the cost per admission was still lower than those for Malaysia and Indonesia and lower than that reported in a recent study by Tumanan-Mendoza et al. (which reported a cost of USD 852–2678 for moderate-risk CAP).[18] It should be noted that the results of Tumanan given here were based on the societal perspective used in that study. For Malaysia, there was a notably higher CFR for both CAP and HAP compared to Indonesia and the Philippines. This was likely due to the hospitals in Malaysia that contributed the data being tertiary academic referral centers. As such, patients may have been more ill and may have had a greater prevalence of comorbidities than those hospitalized in Indonesia and the Philippines.

4.3. Comorbidities

The prevalence of comorbidities found in this study was similar to those reported in previous studies that have shown patients with comorbidities to be at greater risk of both CAP and HAP.[9,34,37,38] Among the most frequently reported comorbidities were lung disease, cardiovascular disease, and diabetes mellitus. The data on comorbidities were extracted from pneumonia cases only and thus may reflect the general pattern of comorbidities. A future study to ascertain the rates of pneumonia among patients

Table 5
Length of stay and cost among hospitalized patients in participating hospitals

	Malaysia discharges			Indonesia discharges			Philippines discharges		
Item	CAP	HAP	Total	CAP	HAP	Total	CAP	HAP	Total
LOS (mean days)	8.6	10.2	9.2	6.1	7.9	8.0	6.2	6.9	6.6
Cost per admission (mean USD)	927	1482	1178	1208	1373	1104	254	275	254
Estimated cost overall (USD)	2 263 734	1 882 140	4 372 736	1 605 432	992 679	2 265 408	1 837 690	784 300	2 562 098

CAP, community-acquired pneumonia; HAP, hospital-acquired pneumonia; LOS, length of stay; USD, US dollars.

Table 6
Incidence of community-acquired pneumonia from previous studies

Study	Study period	Country	Type of data used	Age (years)	Incidence
Low et al., 2007[16]	1995–2004	Singapore	Discharge diagnosis of pneumococcal disease based on ICD-9 codes from the central claims processing system	All	Pneumococcal pneumonia: 4.53 per 100 000
Olsen et al., 2006[13]	2002–2003	Sa Kaeo, Thailand	Hospital admissions with pneumonia	0–75+	Pneumonia: 177–580 per 100 000
Kanlayanaphotporn et al., 2004[14]	1999–2001	Sa Kaeo, Thailand	Electronic surveillance data	Overall	Pneumonia: 211 per 100 000
Takahashi et al., 2013[15]	2009–2010	Khánh Hòa, Central Vietnam	Adults aged 15 years and above with lower respiratory tract infection	Overall	CAP: 0.81 per 1000
Scott et al., 2004[41]	2000–2002	New Zealand	Hospital data of adults aged 15 years and older	≤15	CAP: 859 per 100 000
Giorgi Rossi et al., 2004[10]	1997–1999	Lazio, Italy	Hospital information system of the Lazio region	Overall	CAP: 158 per 100 000
Monge et al., 2001[42]	1995–1996	Spain	CAP identified using national surveillance system for hospital data	Overall	CAP: 160 per 100 000
Jokinen et al., 1993[34]	1981–1982	Kuopio, Finland	CAP; reported by physicians, pathologists, autopsy and registry	Overall	CAP: 11.6 per 1000
Aljunid et al., 2011	2011, current study	Malaysia	Casemix data from two academic centers	Overall	CAP: 159 per 100 000 HAP: 83 per 100 000

ICD, International Classification of Diseases; CAP, community-acquired pneumonia.

with and without comorbidities would be helpful to better understand the impact of comorbidities.

4.4. Study limitations

There were several limitations to this study. The first is related to the administrative dataset used. The Casemix system is relatively new and was used in different healthcare system settings in the three countries studied. Other differences may be due to actual underlying differences in costs, practices, and cultural factors. Unlike Indonesia and the Philippines, only two hospitals provided data for Malaysia. The types of hospitals included were also different: the contributing hospitals in Indonesia and the Philippines were private and public hospitals funded by social insurance, whereas the hospitals in Malaysia were government-funded academic hospitals.

In terms of methodology, the use of an administrative dataset in combination with a simple algorithm may not reflect the incidence as accurately as a prospective study or chart review method. However, previous studies that have compared this method to chart review still found it to be helpful in epidemiology studies.[32,39] The incidence of pneumonia among hospitalized patients is higher than the incidence in the general population, as indicated by the additional population incidence that was calculated for Malaysia. The population incidence rates of CAP and HAP for the two Malaysian hospitals, at 159 per 100 000 and 83 per 100 000, respectively, appear to be comparable to rates in other countries as reported in previous studies (Table 6).[10,13–16,29,34,41,42] Unfortunately, it was not possible to ascertain the catchment populations for the hospitals in Indonesia and the Philippines and therefore it was not possible to estimate the population incidence for these two countries.

4.5. General administrative data limitations

Aside from the limitations of the current dataset, there are also biases inherent in the use of administrative databases. As noted by Giorgi Rossi et al., capturing disease occurrence in a database depends on a sequence of events beginning when the patient perceives an illness and then presents him/herself to the emergency room – steps that may be influenced by psycho-social circumstances.[10] Furthermore, the quality of the data entered into the system is an important factor; the actual cause of illness as assessed by the physician should be recorded, without reinterpretation at the point of data entry. In addition, as has been mentioned in previous publications using administrative and coded data, the differences observed in terms of disease rates may be affected by the differences in criteria adopted by hospitals in determining the admission code,[40] and by the frequency at which coders use the codes incorrectly.[39] These factors may have had an impact on the present study. These issues may be resolved as the systems become more established and as audits are performed as part of the regular administrative processes to ensure accuracy; this is done in developed countries where these systems are now well-established.[43,44]

4.6. Conclusions

The results of this study show that there are differences in disease burden between CAP and HAP, similar to the results of previous studies performed in other countries.[10,19,32,39] In all three countries, CAP was found to be a frequent cause of hospitalization in children under 5 years of age and those above the age of 50 years. Although the cost per admission and the LOS for HAP tended to be higher, the overall cost attributed to CAP was found to be greater, due to the greater prevalence of CAP. The population incidence rate calculated for Malaysia is consistent with the findings of earlier studies. Despite the acknowledged limitations, it is believed that this study contributes to the existing body of knowledge on pneumonia. This study is also one of the first to use administrative data and a logical algorithm to find differences between CAP and HAP patterns in Southeast Asia. As the system becomes more established and regular audits are made, the Casemix dataset could be used in the future to provide greater clarity on pneumonia patterns in the region. Meanwhile, other data owners, such as social insurance providers and medical providers, should be encouraged to share data with researchers for the purpose of increasing knowledge of disease epidemiology in their respective countries.[27] A better understanding of the burden of pneumonia and other diseases in Southeast Asia could help in planning preventive strategies and improving clinical management.

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Author contributions: Conceptualized and designed the study: SA and CR. Wrote the manuscript: SA. Operationalized the study: SA, SMA. Obtained data from multiple countries and sites: SMA, AMN, RM. Analyzed the data NM, AA. Provided country inputs and organized stakeholder discussions in Indonesia and the Philippines: DRV, JE, BW, KK. Reviewed the paper: All. All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijid.2016.05.021.

References

1. World Health Organization. World health statistics 2013. Geneva: WHO; 2013.
2. Bhutta ZA, Das JK, Walker N, Rizvi A, Campbell H, Rudan I, et al. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? *Lancet* 2013;**381**:1417–29.
3. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. *Bull World Health Organ* 2008;**86**:408–16.
4. Walker CL, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, et al. Global burden of childhood pneumonia and diarrhoea. *Lancet* 2013;**381**:1405–16.
5. Anand N, Kollef MH. The alphabet soup of pneumonia: CAP, HAP, HCAP, NHAP, and VAP. *Semin Respir Crit Care Med* 2009;**30**:3–9.
6. Kieninger AN, Lipsett PA. Hospital-acquired pneumonia: pathophysiology, diagnosis, and treatment. *Surg Clin North Am* 2009;**89**:439–61. ix.
7. American Thoracic Society, Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. *Am J Respir Crit Care Med* 2005;**171**:388–416.
8. Tong N. Update on 2004 background paper 6.22 pneumonia. In: Priority medicines for Europe and the world "A public health approach to innovation". Geneva: WHO; 2013.
9. Song JH, Thamlikitkul V, Hsueh PR. Clinical and economic burden of community-acquired pneumonia amongst adults in the Asia-Pacific region. *Int J Antimicrob Agents* 2011;**38**:108–17.
10. Giorgi Rossi P, Agabiti N, Faustini A, Ancona C, Tancioni V, Forastiere F, et al. The burden of hospitalised pneumonia in Lazio, Italy, 1997–1999. *Int J Tuberc Lung Dis* 2004;**8**:528–36.
11. Peto L, Nadjm B, Horby P, Ngan TT, van Doorn R, Van Kinh N, et al. The bacterial aetiology of adult community-acquired pneumonia in Asia: a systematic review. *Trans R Soc Trop Med Hyg* 2014;**108**:326–37.
12. Chawla R. Epidemiology, etiology, and diagnosis of hospital-acquired pneumonia and ventilator-associated pneumonia in Asian countries. *Am J Infect Control* 2008;**36**:S93–100.
13. Olsen SJ, Laosiritaworn Y, Siasiriwattana S, Chunsuttiwat S, Dowell SF. The incidence of pneumonia in rural Thailand. *Int J Infect Dis* 2006;**10**:439–45.
14. Kanlayanaphotporn J, Brady MA, Chantate P, Chantra S, Siasiriwattana S, Dowell SF, et al. Pneumonia surveillance in Thailand: current practice and future needs. *Southeast Asian J Trop Med Public Health* 2004;**35**:711–6.
15. Takahashi K, Suzuki M, Minh le N, Anh NH, Huong LT, Son TV, et al. The incidence and aetiology of hospitalised community-acquired pneumonia among Vietnamese adults: a prospective surveillance in Central Vietnam. *BMC Infect Dis* 2013;**13**:296.
16. Low S, Chan FL, Cutter J, Ma S, Goh KT, Chew SK. A national study of the epidemiology of pneumococcal disease among hospitalised patients in Singapore: 1995 to 2004. *Singapore Med J* 2007;**48**:824–9.
17. Lee KH, Chin NK, Tan WC, Lim TK. Hospitalised low-risk community-acquired pneumonia: outcome and potential for cost-savings. *Ann Acad Med Singapore* 1999;**28**:389–91.
18. Tumanan-Mendoza BA, Mendoza VL, Punzalan FE, Reganit PF, Bacolcol SA. Economic burden of community-acquired pneumonia among adults in the Philippines: its equity and policy implications in the case rate payments of the Philippine Health Insurance Corporation. *Value in Health Regional Issues* 2015;**6**:118–25.
19. Chen YH, Yang GY, Loh CH, Liou SH, Su WL, Lin SH, et al. Cost benefits of targeting the pneumococcal vaccination program to the elderly population in Taiwan. *Am J Infect Control* 2006;**34**:597–9.
20. Wu DB, Roberts CS, Huang YC, Chien L, Fang CH, Chang CJ. A retrospective study to assess the epidemiological and economic burden of pneumococcal diseases in adults aged 50 years and older in Taiwan. *J Med Econ* 2014;**17**:312–9.
21. Aylin P, Bottle A, Majeed A. Use of administrative data or clinical databases as predictors of risk of death in hospital: comparison of models. *BMJ* 2007;**334**:1044.
22. Claster S, Termuhlen A, Schrager SM, Wolfson JA, Iverson E. Pitfalls of using administrative data sets to describe clinical outcomes in sickle cell disease. *Pediatr Blood Cancer* 2013;**60**:1936–9.
23. Ng B, Aslam F, Petersen NJ, Yu HJ, Suarez-Almazor ME. Identification of rheumatoid arthritis patients using an administrative database: a Veterans Affairs study. *Arthritis Care Res (Hoboken)* 2012;**64**:1490–6.
24. Ray WA, Griffin MR. Use of Medicaid data for pharmacoepidemiology. *Am J Epidemiol* 1989;**129**:837–49.
25. Ayanian JZ. Using administrative data to assess health care outcomes. *Eur Heart J* 1999;**20**:1689–91.
26. Schneeweiss S, Avorn J. A review of uses of health care utilization databases for epidemiologic research on therapeutics. *J Clin Epidemiol* 2005;**58**:323–37.
27. Milea D, Azmi S, Reginald P, Verpillat P, Francois C. A review of accessibility of administrative healthcare databases in the Asia-Pacific region. *Journal of Market Access & Health Policy* 2015;**3**:28076. http://dx.doi.org/10.3402/jmahp.v3.28076
28. Aljunid SM, Srithamrongsawat S, Chen W, Bae SJ, Pwu RF, Ikeda S, et al. Health-care data collecting, sharing, and using in Thailand, China mainland, South Korea, Taiwan, Japan, and Malaysia. *Value Health* 2012;**15**:S132–8.
29. Aljunid S, Hamzah S, Mutalib S, Nur A, Shafie N, Sulong S. The UNU-CBGs: development and deployment of a real international open source Casemix grouper for resource challenged countries. *BMC Health Services Research* 2011;**11**:A4.
30. About us. Casemix Solutions. Available at: http://www.casemix.com.my/web/about-us/ (accessed September 7, 2015).
31. Tangcharoensathien V, Patcharanarumol W, Ir P, Aljunid SM, Mukti AG, Akkhavong K, et al. Health-financing reforms in Southeast Asia: challenges in achieving universal coverage. *Lancet* 2011;**377**:863–73.
32. Yu O, Nelson JC, Bounds L, Jackson LA. Classification algorithms to improve the accuracy of identifying patients hospitalized with community-acquired pneumonia using administrative data. *Epidemiol Infect* 2011;**139**:1296–306.
33. Ho PL, Chiu SS, Cheung CH, Lee R, Tsai TF, Lau YL. Invasive pneumococcal disease burden in Hong Kong children. *Pediatr Infect Dis J* 2006;**25**:454–5.
34. Jokinen C, Heiskanen L, Juvonen H, Kallinen S, Karkola K, Korppi M, et al. Incidence of community-acquired pneumonia in the population of four municipalities in eastern Finland. *Am J Epidemiol* 1993;**137**:977–88.
35. McIntyre P, Gilmour R, Watson M. Differences in the epidemiology of invasive pneumococcal disease, metropolitan NSW, 1997–2001. *N S W Public Health Bull* 2003;**14**:85–9.
36. Melegaro A, Edmunds WJ, Pebody R, Miller E, George R. The current burden of pneumococcal disease in England and Wales. *J Infect* 2006;**52**:37–48.
37. Kollef MH, Shorr A, Tabak YP, Gupta V, Liu LZ, Johannes RS. Epidemiology and outcomes of health-care-associated pneumonia: results from a large US database of culture-positive pneumonia. *Chest* 2005;**128**:3854–62.
38. Almirall J, Bolibar I, Balanzo X, Gonzalez CA. Risk factors for community-acquired pneumonia in adults: a population-based case–control study. *Eur Respir J* 1999;**13**:349–55.
39. Whittle J, Fine MJ, Joyce DZ, Lave JR, Young WW, Hough LJ, et al. Community-acquired pneumonia: can it be defined with claims data? *Am J Med Qual* 1997;**12**:187–93.
40. McMahon Jr LF, Wolfe RA, Tedeschi PJ. Variation in hospital admissions among small areas. A comparison of Maine and Michigan. *Med Care* 1989;**27**:623–31.
41. Scott G, Scott H, Turley M, Baker M. Economic cost of community-acquired pneumonia in New Zealand adults. *N Z Med J* 2004;**117**:U933.
42. Monge V, San-Martin VM, Gonzalez A. The burden of community-acquired pneumonia in Spain. *Eur J Public Health* 2001;**11**:362–4.
43. Berthelsen CL. Evaluation of coding data quality of the HCUP national inpatient sample. *Top Health Inf Manage* 2000;**21**:10–23.
44. Hsia DC, Ahern CA, Ritchie BP, Moscoe LM, Krushat WM. Medicare reimbursement accuracy under the prospective payment system, 1985 to 1988. *JAMA* 1992;**268**:896–9.