JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Emerging Problems in Infectious Diseases

The prevalence of hospital-acquired infections in Southeast Asia (1990-2022)

Lucky Poh Wah Goh[1], Hartinie Marbawi[1], Shu Meng Goh[2], Abdul Kahar bin Abdul Asis[2], Jualang Azlan Gansau[1]

[1] Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, Kota Kinabalu, Sabah, Malaysia
[2] Sabah State Health Department, Rumah Persekutuan, Jalan Mat Salleh, Kota Kinabalu, Sabah, Malaysia

Abstract

Introduction: Hospital-acquired infections (HAIs) have continually affected the quality of hospital care. Despite medical interventions by healthcare personnel and improved healthcare facilities, the rates of morbidity and mortality due to HAIs is increasing. However, a systematic review of HAIs is lacking. Therefore, this systematic review aims to determine the prevalence rate, types, as well as causes of HAIs in Southeast Asian countries.

Methodology: A systematic literature search was conducted on PubMed, Cochrane library, World Health Organization database–Index Medicus for South-East Asia Region (WHO-IMSEAR), and Google Scholar databases. The search period was from 1st January 1990 until 12th May 2022. The prevalence of HAIs and subgroups were calculated using MetaXL software.

Results: The database search retrieved 3879 non-duplicate articles. After applying exclusion criteria, 31 articles with a total number of 47666 subjects were included and a total of 7658 cases of HAIs were recorded. The overall prevalence of HAIs in Southeast Asia was 21.6 % (95% CI: 15.5 – 29.1%) with heterogeneity statistics of I^2 = 100%. Indonesia had the highest prevalence rate of 30.4% whereas Singapore had the lowest prevalence rate at 8.4%.

Conclusions: This study revealed that the overall prevalence of HAIs was relatively high and the prevalence rate of each country was associated with socioeconomic status. Measures should be taken to examine and control the rates of HAIs in countries with high HAI prevalence.

Key words: hospital-acquired; nosocomial; infections; Southeast Asia.

J Infect Dev Ctries 2023; 17(2):139-146. doi:10.3855/jidc.17135

(Received 20 July 2022 – Accepted 15 December 2022)

Introduction

Hospital-acquired infections (HAIs) impact a significant proportion of people in our world. In developed countries, these infections account for 7% of all infections and in developing countries they account for 10% of all infections [1]. The World Health Organization (WHO) estimates that approximately 15% of hospitalized patients get HAIs [1]. HAIs are also known as nosocomial infections or health-care-associated infections. An infection is said to be hospital-acquired if it was neither present nor incubating in the patient during patient admission to the hospital.[2]. The major infections which are acquired in hospitals include ventilator associated pneumonia [3], bloodstream infection [4], urinary tract infection [5], surgical site infection [6], skin and soft tissue infection [7], respiratory tract infection [8], tuberculosis [9], gastrointestinal infections and cardiovascular infections [10].

HAIs are caused by different microorganisms such as fungi, bacteria, parasites, or viruses. The major causative microorganisms in Southeast Asia are *Acinetobacter* spp. [11], *Pseudomonas aeruginosa* [12], *Klebsiella pneumoniae* [13], and *Staphylococcus aureus* [14]. All patients can get infected by nosocomial infections but some patients are at a higher risk of contracting the infections than others. Such high-risk patients include: patients with increasing age, patients with comorbid conditions, patients with longer hospital stays, and patients with more invasive equipment and procedures [15].

HAIs have impacted morbidity and mortality rates significantly across the world. HAIs also lead to an increase in the economic burden. In the United States, $28.4 billion are used to curb medical costs associated with HAIs treatments. In addition, $12.4 billion are lost due to loss of productivity and early deaths [10]. In some underdeveloped regions, the risks of acquiring

hospital infection are higher compared to developed regions due to the different rates of HAIs occurrences.

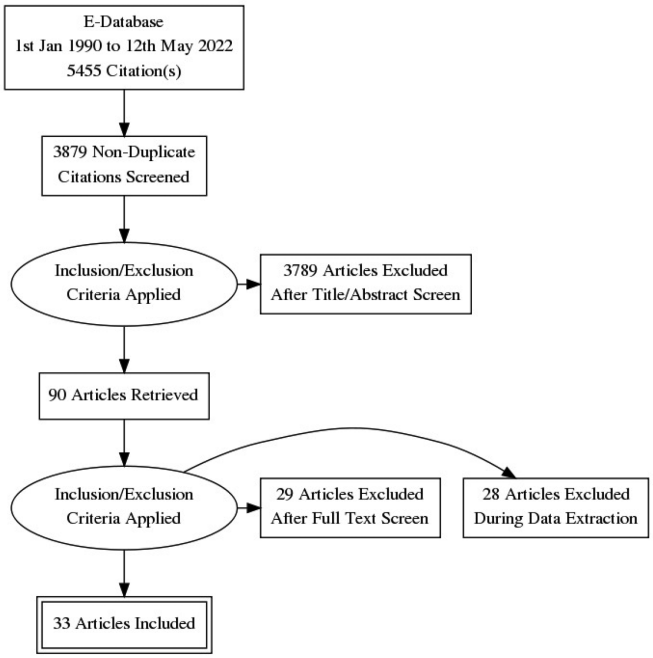
In the Asia-Pacific region, it is estimated that the risks are 2-25 times higher compared to developed countries [16]. Southeast Asia is composed of 11 countries namely; Brunei, Burma Cambodia Timor-Leste Indonesia Laos Malaysia, Philippines, Singapore Thailand, and Vietnam [17]. Most of these countries are still developing and thus do not have prolonged and well-documented HAI surveillance compared to developed countries such as Australia and USA. A systematic review on healthcare-associated infections in Southeast Asia was therefore conducted to determine the rates of infections across the region and the impact on the population in a particular region. The review used causative microorganisms of the HAIs as factors to determine the current and arising infections.

Methodology

Search criteria and information sources

This systematic review was performed according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [18]. The studies included were dated between 1st January 1990 and 12th May 2022. The databases used to search for potential studies were PubMed, Cochrane library, World Health Organization database–Index Medicus for South-East Asia Region (WHO-IMSEAR), and Google scholar. The search string for each respective database were as follows. PubMed: ("cross infection"[Majr]) AND "Asia, Southeastern/statistics and numerical data"[Mesh]), Cochrane Library: ("cross infection" OR "hospital-acquired infection" AND "Southeast Asia" OR "Brunei" OR "Burma" OR "Myanmar" OR "Cambodia" OR "Timor-Leste" OR "Indonesia" OR "Laos" OR "Malaysia" OR "Philippines" OR "Singapore" OR "Thailand" OR "Vietnam"), WHO-IMSEAR: ("cross infection" OR "hospital-acquired infection" OR "nosocomial infection" OR "healthcare associated infection"), Google Scholar: ("hospital acquired infection" OR "nosocomial infection" OR "hospital infection" OR “cross infection” AND south east Asia OR "Brunei" OR "Burma" OR "Myanmar" OR "Cambodia" OR "Timor-Leste" OR "Indonesia" OR "Laos" OR "Malaysia" OR "Philippines" OR "Singapore" OR "Thailand" OR "Vietnam”).

Figure 1. Study filtering and selection flow diagram.



A total of 5455 articles were searched. After the filtering, selection and screening process a total to 33 articles were included in the study.

The inclusion criteria were: 1) cross-sectional studies, cohort studies, case-control studies, retrospective studies; 2) full-text available; 3) studies published in English; 4) studies in the Southeast Asian region; 5) population-based articles which report on the prevalence of nosocomial infections. The exclusion criteria were systematic reviews, meta-analyses, case reports, case studies, clinical trials, reviews, letters to the editor or author, studies reporting on animal infections, and studies that lacked prevalence calculations.

At first, the studies were screened for any potential duplicates. Then, the titles and abstracts were screened for relevance. Subsequently, the inclusion or exclusion criteria were further applied to screen for potential articles following the criteria as stated above. Finally, the data from the articles were extracted for further analysis.

Statistical analysis

The I^2 index (represented as percentage) and Q-test (represented as a *p* value) was used to investigate heterogeneity between studies. High heterogeneity was defined with I^2 value of > 75% and Q-test with a *p* value < 0.1 [19,20]. The prevalence of each study with a 95% confidence interval (95% CI) that contributed to the analysis was illustrated using a forest plot. Subgroup analysis was also performed according to several study characteristics. Funnel plots, Egger’s tests of asymmetry, and Begg’s test were performed to identify any bias within the results [21,22].

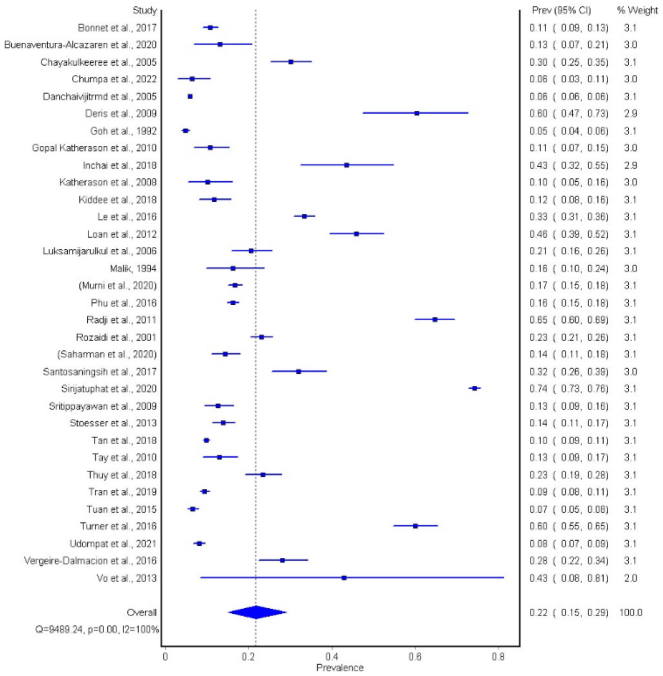
Quality appraisal

The studies were deemed to be of high quality if they provided observational population statistics on health-care-associated infections, HAIs rate of the population, and quality HAIs data on the subject matter. Studies providing only quantified data with minimal qualitative data on the affected population were classified as medium-quality studies. Studies that had minimal quantitative data or only qualitative data on the population being studied were deemed to be low-quality studies.

Results

Study search and filtering were performed according to PRISMA guidelines (Figure 1). A total of 5455 studies were identified from the databases. The studies were screened and 1576 duplicates were excluded. The remaining 3879 studies underwent title, abstract and keywords screening to further exclude 3789 studies. Full-texts of the remaining 90 studies were read in full to ascertain the eligibility of articles based on the inclusion and exclusion criteria. A total of 29 articles were excluded in the initial full-text screen. During data extraction, 28 articles were further excluded due to the unavailability of data.

Figure 2. The forest plot and overall prevalence of hospital acquired infections (HAIs).



The prevalence rate of HAIs in all studies were computed and plotted in the forest plot. The box and line represent the prevalence rate and 95% CI for each study, respectively. The filled diamond shaped represents the overall prevalence rate and the 95% CI.

Table 1. Characteristics of included studies.

Author	Year	Region	Hospital type	Participant number	Gender	HAIs rate	Infection type	Bacteria	Quality
Bonnet *et al.* [23]	2017	Cambodia	Private	1187	Male (567), Female (611)	0.108	Non-tuberculosis mycobacteria (NTM) disease	mycobacteria	High
Buenaventura-Alcazaren *et al.* [7]	2020	Philippines	Public	92	Male (41) female (51)	0.13	MRSA infections such as skin and soft tissue infection	Methicillin-Resistant *Staphylococcus aureus* (MRSA)	High
Chayakulkeeree *et al.* [24]	2005	Thailand	Public	346	Male (83), Female (263)	0.301	Gram-negative bacilli (GNB) such as *E. Coli*, *K. pneumoniae*	extended-spectrum beta-lactamase (ESBL)	Medium
Chumpa *et al.* [25]	2022	Thailand	Public	158	Male (84), female (74)	0.063	Latent tuberculosis infection	*Mycobacterium tuberculosis*	High
Danchaivijitrmd *et al.* [11]	2005	Thailand	Public and private	18456	Male (9136), Female (9320)	0.06	Low respiratory, urinary, skin and soft tissue, gastrointestinal, and surgical infections	*E. coli*, *Acinetobacter* spp., MRSA, *Enterococci* and *Klebsiella* spp.,	High
Deris *et al.* [4]	2009	Malaysia	Public	58	Male (33), female	0.611	bloodstream infection (BSI), skin and soft tissue, wound and infection, *pneumonia* meningitis, urinary tract infection, and implant-related infection	*Acinetobacter* spp.	High
Goh *et al.* [26]	1992	Singapore	Public	1965	Male (1120), female (845)	0.048	typhoid	*Salmonella typhi*	Medium
Gopal Katherason *et al.* [13]	2010	Malaysia	Public and private	215	Male (156), female (59)	0.107	Nosocomial bacteremia	*Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter* spp. Methicillin-resistant *Staphylococcus aureus*, Methicillin-resistant-*Staphylococcus epidermis* (MRSE), *Enterococcus* species, and *Enterobacter* species.	High
Inchai *et al.* [9]	2018	Thailand	Public	76	Male (25), female (51)	0.434	Tuberculosis	*Mycobacterium*	Medium
Katherason *et al.* [27]	2008	Malaysia	Private/Public	128	Male (96), female (32)	0.102	ventilator-associated pneumonia (VAP), nosocomial pneumonia, nosocomial urinary tract infection	*Acinetobacter* spp, *Klebsiella pneumonia*, *Pseudomonas aeroginosa*	High
Kiddee *et al.* [12]	2018	Thailand	Public	275	Male (149), female (126)	0.116	Carbapenem-resistant (CR) Gram-negative bacteria infection	Carbapenem-resistant (CR) Gram-negative bacteria (GNB), such as *Acinetobacter baumannii*, Enterobacteriaceae, and *Pseudomonas aeruginosa*	High
Le *et al.* [28]	2016	Vietnam	Public and private	1363	Male (812), female (551)	0.333	Carbapenem-resistant (CR) Gram-negative bacteria infection	*Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii*	High
Loan *et al.* [14]	2012	Vietnam	Public	229	Male (183), female (96)	0.46	Wound infection, gastrointestinal infection, urinary tract infection, bacteremia, and pneumonia.	*Pseudomonas aeruginosa*, *Acinetobacter* spp., *Klebsiella* spp., *Streptococcus pneumoniae*, *Haemophilus influenzae*	High

Table 1 (continued). Characteristics of included studies.

Author	Year	Region	Hospital type	Participant number	Gender	HAIs rate	Infection type	Bacteria	Quality
Luksamijarulkul *et al.* [16]	2006	Thailand	Public	268	Male (175), female (93)	0.205	surgical infection	*Acinetobacter* spp., *Staphylococcus aureus*, *Streptococcus* group D, *Pseudomonas aeruginosa*, *Escherichia coli*, MRSA, alpha *streptococcus*, *morganella merganii*, and *Proteus valgaris*	High
Malik [29]	1994	Malaysia	Public	111	Male (54), female (57)	0.162	septicemia, Meconium Aspiration Syndrome. (MAS), skin infection, pneumonia, and omphalitis	*Staphylococcus aureus*, *Staphylococcus epidermidis*, *Klebsiella species*, and group A *Streptococcus*.	Medium
Murni *et al.* [30]	2020	Indonesia	Public	1885	Male (943), female (942)	0.167	Respiratory tract infection, urinary tract infection, cardiovascular infection, skin and soft tissue infection, and surgery infection	*Klebsiella pneumoniae* and *Pseudomonas aeruginosa*	High
Phu *et al*. [31]	2016	Vietnam	Public	2618	Male (1656), female (962)	0.162	pneumonia, bloodstream infection, gastrointestinal infection, surgical site infection, skin and soft tissue infection, central nervous system infection, and urinary tract infection	*Acinetobacter baumannii*, P*seudomonas aeruginosa*, and *Klebsiella pneumoniae*	High
Radji *et al*. [32]	2011	Indonesia	Public	385	Male (1656), female (962)	0.647	pneumonia, gastrointestinal infection, skin and soft tissue infection, n and urinary tract infection	*Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *E. Coli* and *Staphylococcus epidermidis*	High
Rozaidi *et al.* [33]	2001	Malaysia	Public	988	Male (588), female (400)	0.231	Lower respiratory tract infection, pneumonia, skin infection, bloodstream infections, urinary tract infection, central venous, primary bacteraemia, surgical infection, and gastro-intestinal infection.	*Acinetobacter* sp., S*trenot-rophomonas* sp, *Viridans streptococci*, P*seudomonas* sp. and *Klebsiella* sp.	High
Saharman *et al*. [34]	2020	Indonesia	Public	412	Male (214), female (198)	0.143	multidrug-resistant Gram-negative bacilli infections	*Klebsiella pneumoniae*	Medium
Santosaningsih *et al*. [35]	2017	Indonesia	Public	197	Male (155), female (42)	0.318	bloodstream infection, surgical site infection and pneumonia	methicillin-resistant *Staphylococcus aureus* (MRSA)	High
Sirijatuphat *et al*. [36]	2020	Thailand	Public	3545	N/A	0.742	urinary tract infection	*E. coli*, *S. agalactiae*, *P. aeruginosa*, *E. faecium*, *P. mirabilis*, *E. faecalis*, *K. pneumoniae* and *A. baumannii*	Medium
Sritippayawan *et al.* [37]	2009	Thailand	Public	347	Male (278), female (69)	0.127	catheter-related bloodstream infection (CR-BSI), ventilator-associated pneumonia (VAP), and catheter-related urinary tract infection (CR-UTI)	*Stenotrophomonas maltophilia*, *Acinetobacter* spp., vancomycin-resistant *Enterococci*, *Enterobacteriaceae*, and P*seudomonas*	High
Stoesser *et al.* [38]	2013	Cambodia	Public	613	N/A	0.138	Ventilator-associated pneumonia, skin/soft tissue infection, urinary tract infection, hospital-acquired pneumonia, urinary tract infection, gastroenteritis, and bacteraemia	*Staphylococcus aureus* and multi-drug resistant-Gram negative bacilli	Medium
Tan *et al*. [39]	2018	Singapore	Public	5357	Male (2876), female (2481)	0.098	VRE infections such as bloodstream infections, urinary tract infections and surgical site infections	Vancomycin-resistant *Enterococci* bacteria	High
Tay *et al*. [5]	2010	Singapore	Public	256	Male (166), female (90)	0.129	urinary tract infection	*Candida* spp., *E. coli*, *Klebsiella* spp., *Citrobacter koseri*, *Pseudomonas aeruginosa*, A*cinetobacter baumannii* complex, and *enterococcus*	High
Thuy *et al*. [40]	2018	Vietnam	Public	364	Male (242), female (122)	0.234	bloodstream infection (BSI), pneumonia, and urinary tract infection (UTI)	*Staphylococcus aureus*, *Pseudomonas* spp., *Escherichia coli*, *Klebsiella* spp. and *Acinetobacter* spp.	High
Tran *et al.* [41]	2019	Vietnam	Public	2233	N/A	0.094	Sepsis HAI, pneumonia HAI, central venous catheter infections, and premature ventricular contractions.	*K. pneumoniae*, *Enterobacter* spp and *E. coli*	Medium
Tuan *et al*. [8]	2015	Vietnam	Public	1439	N/A	0.066	Respiratory tract infection, urinary tract infection, cardiovascular infection, skin and soft tissue infection, and surgery infection	Human respiratory syncytial virus (RSV)	Medium
Turner *et al.* [42]	2016	Cambodia	Private	333	N/A	0.6	antimicrobial-resistant Gram-negative infections	*K. pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter* spp., and *E. coli*	Low
Udompat *et al*. [3]	2021	Thailand	Public	1536	N/A	0.081	Ventilator acquired pneumonia	*Acinetobacter baumannii*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *E. coli*, and *Pseudomonas aeruginosa*.	Medium
Vergeire-Dalmacion *et al*. [43]	2016	Philippines	Public	224	Male (111), female (113)	0.28	Pneumonia, line-related infection. Surgical wound infection, gastroenteritis, upper respiratory tract infection, bloodstream infection, meningitis, conjunctivitis, sepsis, cellulitis, necrotizing enterocolitis, peritoneal shunt infection, and bronchiolitis.	*E. coli*, S*taphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*.	High
Vo *et al*. [44]	2013	Vietnam	Public	7	Male (5), female (2)	0.43	Cholera	*Vibrio cholerae*	Low

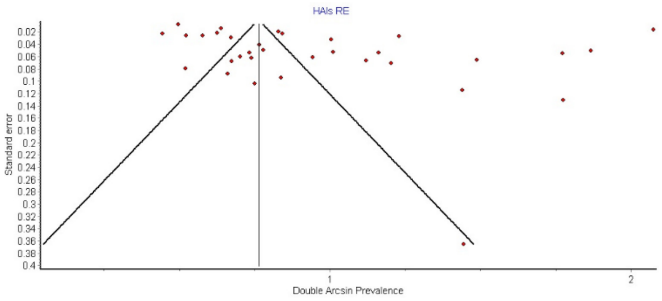
The table summarizes the author, year of publication, study region, hospital type, participants number, gender, hospital acquired infections (HAIs) rate, infection type, bacteria and quality of the studies.

The articles that did not report observational population studies in Southeast Asian countries and the rate of HAI were also excluded. Finally, 33 articles were included in this meta-analysis. These include 21 high quality studies, 10 medium quality studies and 2 low quality studies.

Data extraction and analysis

Variables from studies that are included in this meta-analysis were tabulated in a descriptor table and illustrated (Figure 2 & Table 1). There was a total of 47,666 subjects included in this study with different types of infections that were caused by different bacteria. Overall and subgroup analysis according to year, countries, quality of studies, gender, and hospital type are shown in Table 2. There was no difference in the prevalence rate of HAI for studies before 2015 and after 2015, at 22% and 21%, respectively. Intriguingly, Indonesia had the highest prevalence rate of HAI at 30.4%, whereas Singapore had the lowest at 8.3%. The prevalence of HAIs in male (22.6%) was higher when compared to female (19.5%). The Egger's and Begg's test were observed to be statistically significant at p value < 0.05. The funnel plot did not show significant symmetry (Figure 3).

Figure 3. Funnel plot for bias analysis.



Bias analysis was performed using the funnel plot.

Discussion

Hospital-acquired infections (HAI) is a major threat to the well-being of hospitalized patients. In this systematic review, the prevalence of HAIs in Southeast Asian countries was observed to be high at 22% (95% CI, 0.15-0.29). The WHO reported that the worldwide HAIs rate is between 7% - 22% [45]. Further data revealed that the prevalence rate of HAI in Southeast Asian countries is at the higher end of the worldwide scale. This poses a significant risk to public health in Southeast Asia where there is a high transmission rate. Hence, urgent interventions are required to be taken to reduce the rate of HAI to a lower risk level.

Studies included in this systematic review involved patients from public hospitals, private hospitals or both, with different proportions of males and females. Through the analysis of different HAI-causing pathogens, it was found that specific microorganisms have a stronghold on HAIs in Southeast Asia and also across other HAIs in other regions of the world. These are *Escherichia coli* [6,7,11,13,36], *Acinetobacter* spp. [4,6,11-13,31,33,37,40,42], *Pseudomonas aeruginosa* [5,6,12,14,27,28,30,31,40,42], *Staphylococcus aureus*

Table 2. Overall and Subgroup analysis of prevalence of HAIs.

Subgroup(s)	Prevalence rate (95% CI)	Proportions (%)
Overall prevalence	0.216 (0.150 – 0.291)	100
Year		
≤ 2014	0.220 (0.143 – 0.307)	44.7
> 2014	0.211 (0.112 – 0.324)	55.2
Geographical region		
Thailand	0.209 (0.030 – 0.432)	33.5
Vietnam	0.218 (0.127 – 0.320)	20.5
Malaysia	0.216 (0.113 – 0.334)	15.0
Indonesia	0.304 (0.093 – 0.543)	12.2
Singapore	0.083 (0.045 – 0.133)	9.2
Cambodia	0.257 (0.027 – 0.541)	9.2
Quality of study		
High	0.223 (0.169 – 0.284)	69.3
Medium	0.195 (0.029 – 0.403)	30.6
Gender		
Male and Female	0.226 (0.147 – 0.314)	84.5
Not Specified (N/A)	0.166 (0.070 – 0.281)	15.4
Hospital type		
Public	0.217 (0.138 – 0.306)	84.5
Private	0.214 (0.059 – 0.397)	15.4

The table shows the prevalence rate of overall and subgroups (year of publication, geographical region, quality of study, gender, and hospital type).

[6,13,14,28,29,35,37,40], and *Klebsiella pneumoniae* [13,14,28,31]. Clinicians should take note of the infection risks associated with these microorganisms and find initiatives to cut down the high rates recorded.

Well-documented and detailed data on HAIs in developing countries is lacking as compared to western regions. However, this systematic review and meta-analysis were able to screen 3879 studies and finally included 33 studies. Monitoring HAIs is expensive and time consuming. Therefore, it becomes difficult to collect comprehensive data and this contributes to the low management of HAIs and fewer reports are published. Therefore, to fully assess HAIs across Southeast Asia, further observational studies with diverse and well-classified sampling criteria are required.

Conclusions

Through a statistical and qualitative analysis of data from the included studies, HAI rates in Southeast Asian countries were found to be significantly higher. Even though constant increase of health standards occurs annually, more efforts are required to examine and control cross infections in hospitals. HAI mortality and morbidity rates should be recalculated with extensive studies and awareness programs organized for healthcare workers to carry out the necessary precautions and initiatives in controlling HAIs.

References

1. Khan HA, Baig FK, Mehboob R (2017) Nosocomial infections: epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine 7: 478–482.
2. Monegro AF, Muppidi V, Regunath H (2022) Hospital acquired infections. Cambridge Handbook of Psychology, Health and Medicine, Second Edition: 736–738.
3. Udompat P, Rongmuang D, Hershow RC (2021) Modifiable risk factors of ventilator-associated pneumonia in non-intensive care unit versus intensive care unit. J Infect Dev Ctries 15: 1471–1480. doi: 10.3855/jidc.14190.
4. Deris ZZ, Harun A, Omar M, Johari MR (2009) The prevalence and risk factors of nosocomial *Acinetobacter* blood stream infections in tertiary teaching hospital in north-eastern Malaysia. Trop Biomed 26: 123–129.
5. Tay MKX, Lee JYC, Wee IYJ, Oh HML (2010) Evaluation of intensive care unit-acquired urinary tract infections in Singapore. Ann Acad Med Singap 39: 460–465.
6. Luksamijarulkul P, Parikumsil N, Poomsuwan V, Konkeaw W (2006) Nosocomial surgical site infection among Photharam Hospital patients with surgery: incidence, risk factors and development of risk screening form. J Med Assoc Thai 89: 81–85.
7. Buenaventura-Alcazaren FA, dela Tonga A, Ong-Lim A, Destura R v (2020) Prevalence and molecular characteristics of MRSA nasal carriage among hospital care workers in a tertiary hospital in the Philippines. J Microbiol Immunol Infect 53: 739–745.
8. Tuan TA, Thanh TT, Hai N thi T, Tinh LBB, Kim LtN, Do LAH, B'Krong NtTC, Tham NT, Hang VtTH, Merson L, Farrar J, Thuong TC, Jong MD, Schultsz C, Doorn HRv (2015) Characterization of hospital and community-acquired respiratory syncytial virus in children with severe lower respiratory tract infections in Ho Chi Minh City, Vietnam, 2010. Influenza Other Respir Viruses 9: 110–119.
9. Inchai J, Liwsrisakun C, Bumroongkit C, Euathrongchit J, Tajarernmuang P, Pothirat C (2018) Tuberculosis among healthcare workers at Chiang Mai University Hospital, Thailand: clinical and microbiological characteristics and treatment outcomes. Jpn J Infect Dis 71: 214–219.
10. CDC (n.d.) Types of healthcare-associated infections | HAI | Available: https://www.cdc.gov/hai/infectiontypes.html. Accessed: 31 May 2022.
11. Danchaivijitrmd S, Dhiraputra C, Santiprasitkul S, Judaeng T (2005) Prevalence and impacts of nosocomial infection in Thailand 2001. J Med Assoc Thai 88: 1–9.
12. Kiddee A, Assawatheptawee K, Na-udom A, Treebupachatsakul P, Wangteeraprasert A, Walsh TR, Niumsup PR (2018) Risk factors for gastrointestinal colonization and acquisition of carbapenem-resistant Gram-negative bacteria among patients in intensive care units in Thailand. Antimicrob Agents Chemother 62: e00341.
13. Gopal Katherason S, Naing L, Jaalam K, Kamarul Imran Musa K, Nik Abdullah NM, Aiyar S, Bhojwani K, Harussani N, Rahman AA, Ismail A (2010) Prospective surveillance of nosocomial device-associated bacteremia in three adult intensive units in Malaysia. Trop Biomed 27: 308–316.
14. Loan HT, Parry J, Nga NTN, Yen LM, Binh NT, Thuy TTD, Duong NM, Campbell JI, Thwaites L, Farrat JJ, Parry CM (2012) Semi-recumbent body position fails to prevent healthcare-associated pneumonia in Vietnamese patients with severe tetanus. Trans R Soc Trop Med Hyg 106: 90–97.

15. Cheung J (n.d.) Nosocomial Infection: what is it, causes, prevention, and more | osmosis. Available: https://www.osmosis.org/answers/nosocomial-infection. Accessed: 31 May 2022.
16. Apisarnthanarak A, Mundy LM, Tantawichien T, Leelarasamee A (2017) Infection prevention and control in Asia: current evidence and future milestones. Clin Infect Dis 64: S49–S50.
17. Barbara A (2019) Introduction to Southeast Asia. Asia Society. Available: https://asiasociety.org/education/introduction-southeast-asia. Accessed: 31 May 2022.
18. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow C, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hrobjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuiness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372: n71.
19. DerSimonian R, Laird N (1986) Meta-analysis in clinical trials. Control Clin Trials 7: 177–188.
20. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327: 557–560.
21. Egger M, Smith GD, Schneider M, Minder C (1997) Bias in meta-analysis detected by a simple, graphical test. BMJ 315: 629–634.
22. Light R, Richard J, Light R, Pillemer D (1984) Summing up: the science of reviewing research. Available: https://books.google.com/books?hl=en&lr=&id=qel3lAm4K6gC&oi=fnd&pg=PA1&ots=8-EzXZ3VDY&sig=htKOtqN2xRNNHvAFd3FpxCKd32w. Accessed: 31 May 2022.
23. Bonnet M, Chamroeun San K, Pho Y, Sok C, Dousset JP, Brant W, Hurtado N, Eam KK, Ardizzoni E, Heng S, Godreuil S, Yew W-W, Hewison C (2017) Nontuberculous mycobacteria infections at a provincial reference hospital, Cambodia. Emerg Infect Dis 23: 1139–1147.
24. Chayakulkeeree M, Junsriwong P, Keerasuntonpong A, Tribuddharat C, Thamlikitkul V (2002) Epidemiology of extended-spectrum beta-lactamase producing Gram-negative bacilli at Siriraj Hospital, Thailand, 2003. Southeast Asian J Trop Med Public Health 36: 1503–1509.
25. Chumpa N, Kawkitinarong K, Wongpiyabovorn J, Paitoonpong L, Suwanpimolkul G (2022) Prevalence of latent tuberculosis infection among pre-clinical and clinical medical students using QuantiFERON-TB gold plus and tuberculin skin test at a teaching hospital in Thailand: a cross-sectional study. J Infect Public Health 15: 400–405.
26. Goh KT, Teo SH, Tay L, Monteiro EHA (1992) Epidemiology and control of an outbreak of typhoid in a psychiatric institution. Epidemiol Infect 108: 221–230.
27. Katherason SG, Naing L, Jaalam K, Ismail A (2008) Baseline assessment of intensive care-acquired nosocomial infection surveillance in three adult intensive care units in Malaysia. J Infect Dev Ctries 2: 364–368. doi: 10.3855/jidc.198.
28. Le NK, Hf W, Vu PD, Khu DTK, Le HT, Hoang BTN, Vo VT, Lam YM, Vu DTV, Nguyen TT, Thai TQ, Nilsson LE, Rydell U, Nguyen KV, Nadjm B, Clarkson L, Hanberger H, Larsson M (2016) High prevalence of hospital-acquired infections caused by Gram-negative carbapenem resistant strains in Vietnamese pediatric ICUs: a multi-centre point prevalence survey. Medicine 95.
29. Malik AS (1994) Prelabour rupture of membranes and neonatal morbidity in level II nursery in Kelantan. Med J Malaysia 49: 12–16.
30. Murni IK, Duke T, Kinney S, Daley AJ, Laksanawati IS, Nurnaningsih, Rusmawatiningtyas D, Wirawan MT, Soenarto (2020) Multifaceted interventions for healthcare-associated infections and rational use of antibiotics in a low-to-middle-income country: can they be sustained? PloS One 15: e0234233.
31. Phu VD, Wertheim HFL, Larsson M, Nadjm B, Dinh QD, Nilsson LE, Rydell U, Le TTD, Trinh SH, Pham HM, Tran CT, Doan HTH, Tran NT, Le ND, Huynh NV, Tran TP, Tran BD, Nguyen ST, Pham TTN, Dang TQ, Nguyen CVVm Lam YM, Thwaites G, Nguyen KV, Hanberger H (2016) Burden of hospital acquired infections and antimicrobial use in Vietnamese adult intensive care units. PLoS One 11: e0147544.
32. Radji M, Fauziah S, Aribinuko N (2011) Antibiotic sensitivity pattern of bacterial pathogens in the intensive care unit of Fatmawati Hospital, Indonesia. Asian Pac J Trop Biomed 1: 39-42.
33. Rozaidi SW, Sukro J, Dan A (2001) The incidence of nosocomial infection in the intensive care unit, Hospital Universiti Kebangsaan Malaysia: ICU-acquired nosocomial infection surveillance program 1998-1999. Med J Malaysia 56: 207–222.
34. Saharman YR, Karuniawati A, Sedono R, Aditianingsih D, Goessens WHF, Klaassen CHW, Verbrugh HA, Severin JA. (2020) Clinical impact of endemic NDM-producing *Klebsiella pneumoniae* in intensive care units of the national referral hospital in Jakarta, Indonesia. Antimicrob Resist Infect Control 9: 1–14.
35. Santosaningsih D, Santoso S, Verbrugh HA, Severin JA (2017) Risk factors for methicillin-resistant *Staphylococcus aureus* carriage among patients at admission to the surgical ward in a resource-limited hospital in Indonesia. Am J Trop Med Hyg 97: 1310.
36. Sirijatuphat R, Pongsuttiyakorn S, Supapueng O, Kiratisin P, Thamlikitkul V (2020) Implementation of global antimicrobial resistance surveillance system (GLASS) in patients with bacteriuria. J Glob Antimicrob Resist 20: 60–67.
37. Sritippayawan S, Sri-Singh K, Prapphal N, Samransamruajkit R, Deerojanawong J (2009) Multidrug-resistant hospital-associated infections in a pediatric intensive care unit: a cross-sectional survey in a Thai university hospital. Int J Infect Dis 13: 506–512.
38. Stoesser N, Emary K, Soklin S, Peng KA, Sophal S, Chhomrath C, Day NPJ, Limmathurotsakul D, Nget P, Pangnarith Y, Sona S, Kumar V, Moore CE, Chanpheaktra N, Parry CM (2013) The value of intermittent point-prevalence surveys of healthcare-associated infections for evaluating infection control interventions at Angkor Hospital for Children, Siem Reap, Cambodia. Trans R Soc Trop Med Hyg 107: 248–253.
39. Tan D, Htun HL, Koh J, Kanagasabai K, Lim JW, Hon PY, Ang B, Chow A (2018) Comparative epidemiology of vancomycin-resistant enterococci colonization in an acute-care hospital and its affiliated intermediate- and long-term care facilities in Singapore. Antimicrob Agents Chemoth 62: e01507-18.
40. Thuy DB, Campbell J, Hoang Nhat LT, VanMinh Hoang N, van Hao N, Baker S, Geskus RB, Thwaites GE, Chau NVV, Thwaites CL (2018) Hospital-acquired colonization and

infections in a Vietnamese intensive care unit. PLoS One 13: e0203600.
41. Tran DM, Larsson M, Olson L, Hoang NTB, Le NK, Khu DTK, Nguyen HD, Vu TV, Trinh TH, Le TQ, Phan PTT, Nguyen BG, Pham NH, Mai BH, Nguyen TV, Nguyen PTK, Le ND, Huynh TM, Thu LTA, Thanh TC, Berglund B, Nilsson LE, Bornefall E, Song LH, Hanberger H (2019) High prevalence of colonisation with carbapenem-resistant Enterobacteriaceae among patients admitted to Vietnamese hospitals: risk factors and burden of disease. J Infect 79: 115–122.
42. Turner P, Pol S, Soeng S, Sar P, Neou L, Chea P, Day NP, Cooper BS, Turner C (2016) High prevalence of antimicrobial-resistant Gram-negative colonization in hospitalized Cambodian infants. Pediatr Infect Dis J 35: 856–861.
43. Vergeire-Dalmacion GR, Itable JR, Baja ES (2016) Hospital-acquired infection in public hospital buildings in the Philippines: is the type of ventilation increasing the risk? J Infect Dev Ctries 10: 1236–1242. doi: 10.3855/jidc.8295.
44. Vo TH, Le NH, Nuorti JP, Phan LT, Tran Minh NN (2013) A cluster of cholera among patients in a Vietnamese district hospital in 2010. J Infect Dev Ctries 7: 910–913. doi: 10.3855/jidc.3503.
45. Kilpatrick C, Allegranzi B, Pittet D, Kilpatrick C (2011) WHO first global patient safety challenge: clean care is safer care, contributing to the training of health-care workers around the globe. International Journal of Infection Control 7: 6515.

Corresponding author

Professor Dr. Jualang Azlan Gansau, PhD
Dean of the Faculty of Science and Natural Resources,
Universiti Malaysia Sabah, Jalan UMS,
88400 Kota Kinabalu, Sabah,
Malaysia.
Tel: +60-88320000
Fax: +60-88435324
Email: azlanajg@ums.edu.my

Conflict of interests: No conflict of interests is declared.