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The Burden of Healthcare-Associated Infections in Southeast Asia: A Systematic Literature Review and Meta-analysis

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A systematic literature review and meta-analysis of the burden of healthcare-associated infections (HAIs) in Southeast Asia was performed on 41 studies out of the initially identified 14 089 records. The pooled prevalence of overall HAIs was 9.0% (95% confidence interval [CI], 7.2%–10.8%), whereas the pooled incidence density of HAI was 20 cases per 1000 intensive care unit–days. The pooled incidence density of ventilator-associated pneumonia, central line–associated bloodstream infection, and catheter-associated urinary tract infection was 14.7 per 1000 ventilator-days (95% CI, 11.7–17.7), 4.7 per 1000 catheter-days (95% CI, 2.9–6.5), and 8.9 per 1000 catheter-days (95% CI, 6.2–11.7), respectively. The pooled incidence of surgical site infection was 7.8% (95% CI, 6.3%–9.3%). The attributed mortality and excess length of stay in hospitals of infected patients ranged from 7% to 46% and 5 to 21 days, respectively.

Keywords. healthcare-associated infections; systematic literature review; meta-analysis; Southeast Asia; epidemiology.

Healthcare-associated infections (HAIs) are a burden to the healthcare system in terms of costs to payers and providers, and inefficiencies in hospital capacity and operations [1, 2]. Furthermore, infected patients and healthcare workers suffer the consequences of decreased quality of life and sometimes death [3]. HAIs are unnecessary adverse events as they are preventable with proper healthcare worker behavior and compliance with evidence-based infection prevention procedures and guidelines [4].

Initiatives in developed countries, such as the United States and Australia, have leveraged the use of national HAI surveillance data to improve patient safety by enforcing hospital participation through monetary penalties (eg, the US National Healthcare Safety Network and the Centers for Medicare and Medicaid Services' value-based purchasing programs [5]) or accreditation (eg, Australia's National Safety and Quality Health Service Standards program [6]). Furthermore, both countries also publicly disclose hospital HAI rates through online websites to aid consumer decision making in hospital choice (eg, Hospital Compare for Medicare–certified hospitals in the United States and MyHospital for public and private hospitals in Australia). Hence, based on surveillance data, healthcare policies and programs have been developed with success for the prevention and control of HAIs to improve quality of healthcare [7, 8].

In Asia, national surveillance is a rarity and is usually only addressed in developed nations, such as Taiwan [9], Singapore [10], Japan [11], and Korea [12]. In the past few years, the Asia-Pacific Economic Cooperation's Life Sciences Innovation Forum has raised the issue of the societal burden of HAIs to health ministers of member economies and recommended the need for national surveillance in understanding the burden of HAIs, policies that provide funding and programs to reduce its burden, and collaboration from various public and private organizations [13–15]. In Southeast Asia,

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estimation of the magnitude of the burden of HAIs is not well documented due to limited epidemiological and cost-analysis publications. We performed a systematic literature review and meta-analysis of the burden of HAIs in Southeast Asia to address the apparent paucity of data about the burden of HAIs in the region and to help support the evidence of HAI prevention and control in the region.

METHODS

The literature search was based on a full protocol that was designed prior to data collection. A multistring search strategy was utilized to retrieve published clinical data in full manuscript form. Search terms include *cross-infection* [MeSH Terms], *infection control* [MeSH Terms], *health care associated infection*, *health care-associated infection*, *nosocomial infection*, *hospital acquired infection*, *hospital-acquired infection*, *bloodstream infection**, *nosocomial bacteraemia*, *nosocomial bacteremia*, *nosocomial septicaemia*, *nosocomial septicemia*, *device-associated infection**, *nosocomial urinary tract infection**, *surgical site infection**, *ventilator-associated pneumonia* (VAP), *ventilator associated pneumonia*, *hospital-acquired pneumonia* (HAP), *hospital acquired pneumonia*, *wound infection* [MeSH Terms], *wound infection**, and specific names of countries from the region: Brunei, Burma (Myanmar), Cambodia, East Timor, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. Search terms were based on a similar study [16].

The search terms were used in the following databases: Medline (PubMed); Embase; Cochrane Library (includes Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Cochrane Methodology Register, Database of Abstracts of Reviews of Effects, National Health Service Economic Evaluation Database, and Health Technology Assessment Database); and World Health Organization database–Index Medicus for South-East Asia Region. Limits were set to include studies published in English from 2000 to 2012. Animal studies, reviews, editorials, letters and commentaries, and studies reporting other outcomes were excluded from this systematic review. Eligibility criteria used in this systematic review are presented in the Supplementary Appendix.

The first stage of screening was done through abstract review of citations. Abstracts that did not pass the eligibility criteria were excluded. If abstracts were not available, full-text articles were screened. All research papers that could potentially meet the eligibility criteria were retrieved for full-text review. The second stage of screening was done by applying the eligibility criteria to all full-text research papers. Eligible studies were extracted into data extraction grids by one reviewer and random checks were performed by a second reviewer. Case definitions of VAP, catheter-associated urinary tract infection (CAUTI), and central line–associated bloodstream infection (CLABSI) were based on the criteria used by the authors of the studies included in this systematic review. Studies included in the systematic review were assessed for quality (internal and external validity) based on the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist [17]. Two reviewers independently assessed the quality of studies. Differences in assessment were resolved by consensus. For quality

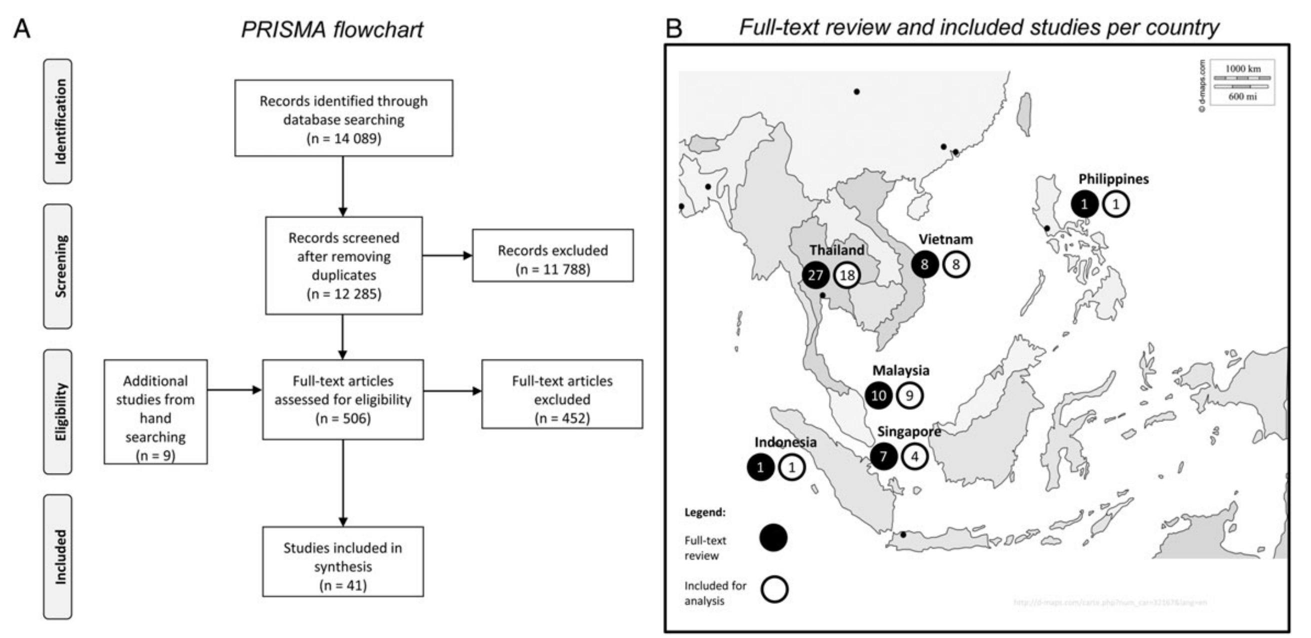

Figure 1. Search strategy. Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

assessment, 3 categories were established: high quality, fulfilled >80% of STROBE criteria; moderate quality, fulfilled 50%–80% of STROBE criteria; low quality, fulfilled <50% of STROBE criteria [18].

Statistical Analysis

Pooling of data was performed in studies that reported the same outcomes and measures of occurrence (ie, prevalence, cumulative incidence, and incidence density). Prevalence was defined as the number of infections per 100 patients who are in the hospital for a given period of time, and proportion of patients with HAI was defined as the number of patients with HAI per 100 patients. Cumulative incidence was defined as the number of new cases per 100 patients over a defined period of time. Incidence density was defined as the number of new infections per 1000 intensive care unit (ICU)–days, ventilator-days, or catheter-days. Data were pooled for (1) prevalence of HAI, (2) proportion of patients with HAI, (3) incidence density of device-associated HAI in adult ICUs, (4) incidence density of VAP, (5) incidence density of CLABSI, (6) incidence density of CAUTI, and (7) cumulative incidence of surgical site infection (SSI). Random-effects meta-analyses were conducted for all pooled data. Pooled estimates were shown in forest plots, along with the corresponding 95% confidence intervals (CIs).

To measure statistical heterogeneity or the extent of variability of outcomes in the studies, I^2 statistic was used. This was interpreted as follows: 0%–40%, might be important; 30%–60%, moderate heterogeneity; 50%–90%, substantial heterogeneity; and 75%–100%, considerable heterogeneity [19]. Heterogeneity χ^2 test was also used to determine if the variation in outcomes was due to chance alone. Sensitivity analysis was performed to determine if the pooled estimate was robust. This was conducted by removing studies of moderate to poor quality in the analysis to see if there were changes in the pooled estimate and if the I^2 improved. This was done only if there were ≥10 pooled estimates.

Meta-regression was performed to investigate the association of the measures of occurrence (dependent variable) and country and year of publication (independent variables). Country and year of publication may pose effect measure modification or confounding as interventions may vary between countries and year when the study was conducted. Meta-regression analysis is suggested to be employed if there are ≥10 studies included in the meta-analysis [19]. The Egger intercept test was used to determine if there is funnel plot asymmetry due to publication bias, among others [20].

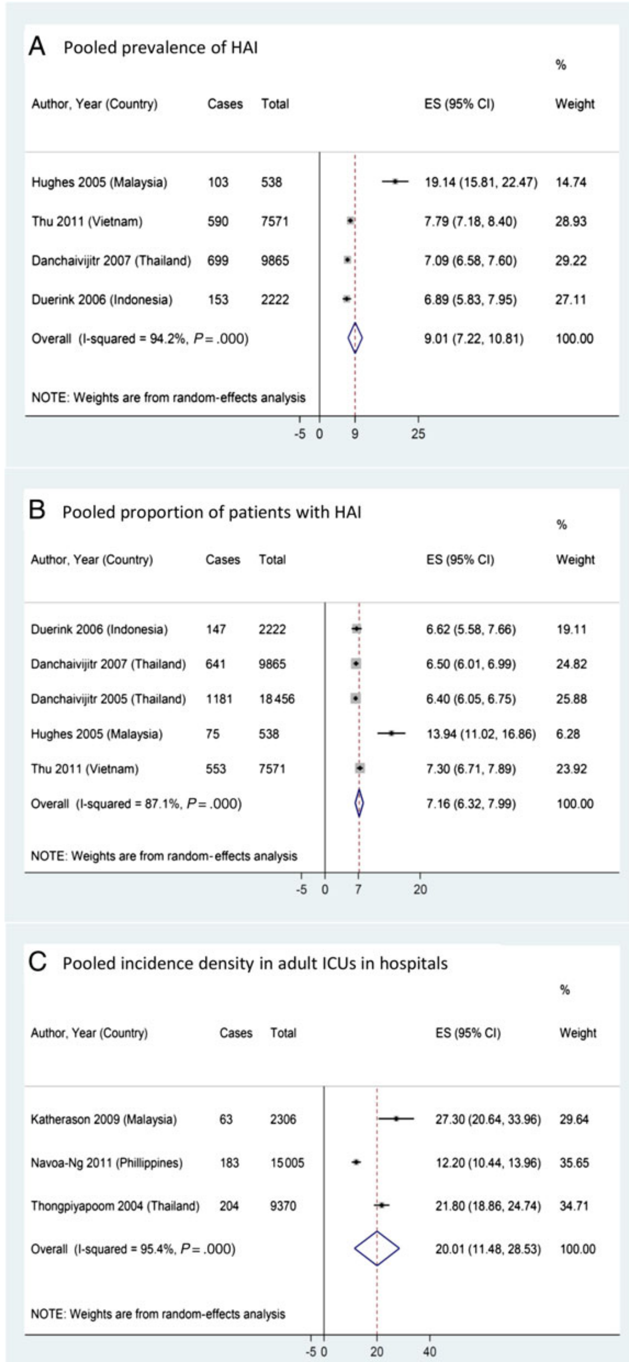

Figure 2. Pooled estimates of healthcare-associated infection (HAI) in Southeast Asian countries, 2000–2012. Abbreviations: CI, confidence interval; ES, effect size; ICU, intensive care unit.

RESULTS

A total of 14 089 records from all databases searched were initially identified. Among these, 1804 were found to be duplicates. Five hundred six potentially relevant studies were assessed for eligibility. The authors looked for studies from all countries in Southeast Asia. However, only studies from countries presented in Figure 1 (ie, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) were found and went through full text review. Forty-one studies met the inclusion criteria and were included in this study [21–61] (Figure 1). Quality assessment based on the STROBE checklist showed that 60% of included studies were of high quality, 30% of included studies were of moderate quality, and 10% were of low quality (Supplementary Appendix). Thirty studies were included in quantitative synthesis and 11 studies were included in qualitative synthesis. Results of random-effects meta-analyses for prevalence of HAI, proportion of patients with HAI, incidence density of HAI (VAP, CLABSI, and CAUTI), and cumulative incidence of SSI are presented in Figures 2 and 3. Four studies [21–24] reported overall prevalence of HAI from hospitals in Southeast Asian countries. The pooled prevalence of HAI was 9.0% (95% CI, 7.2%–10.8%). The I^2 was 94.2% ($\chi^2_{(3)} = 51.5$; $P = .000$), suggesting considerable heterogeneity of pooled studies. The pooled proportion of patients with HAI from 5 studies [21–25] was 7.2% (95% CI, 6.3%–8.0%; $I^2 = 87.1\%$; $\chi^2_{(4)} = 30.9$; $P = .000$). The pooled incidence density of HAI from adult ICUs was 20 cases per 1000 ICU-days (95% CI, 11.5–28.5; $I^2 = 95.4\%$; $\chi^2_{(2)} = 43.09$; $P = .000$). The pooled incidence density of VAP from 5 studies [25–29] was 14.7 per 1000 ventilator-days (95% CI, 11.7–17.7; $I^2 = 85.2\%$; $\chi^2_{(4)} = 27.02$; $P = .000$). For CLABSI, 6 studies [25, 26, 28–31]

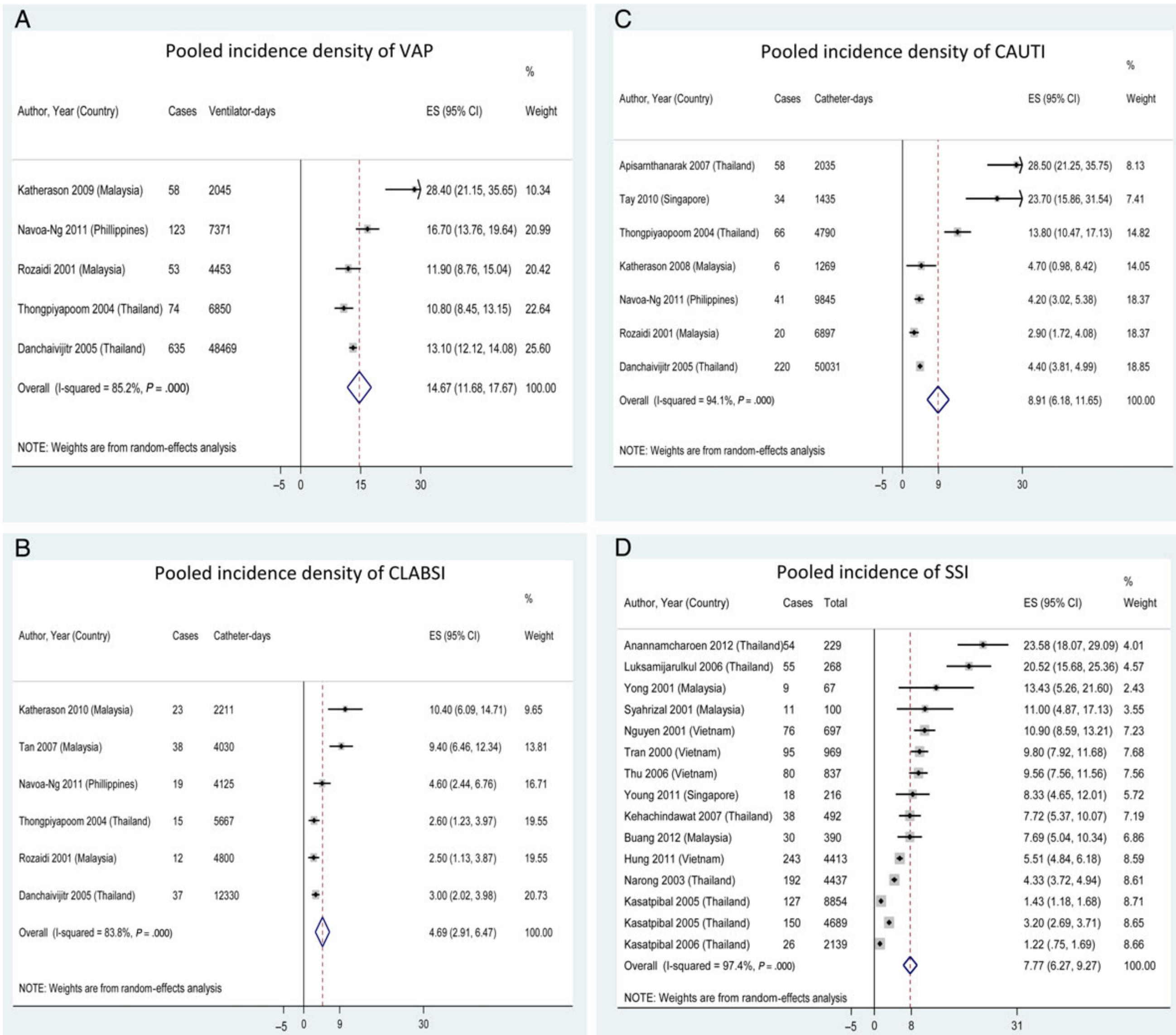

Figure 3. Pooled estimates of healthcare-associated infection in Southeast Asian countries, 2000–2012. Abbreviations: CAUTI, catheter-associated urinary tract infection; CI, confidence interval; CLABSI, central line–associated bloodstream infection; ES, effect size; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

were included to determine the pooled incidence density, which was 4.7 per 1000 catheter-days (95% CI, 2.9–6.5; $I^2 = 83.8$; $\chi^2_{(5)} = 30.9$; $P = .000$), whereas for CAUTI, the pooled incidence density from 7 studies [25, 26, 28, 29, 32–34] was 8.9 per 1000 catheter-days (95% CI, 6.2–11.7; $\chi^2_{(6)} = 102.5$; $I^2 = 94.1$; $P = .000$). The pooled incidence of SSI was 7.8% (95% CI, 6.3%–9.3%; $I^2 = 97.4$; $\chi^2_{(14)} = 539.8$; $P = .000$) based on 15 published articles [26, 32, 35–47].

The pooled estimate of SSI incidence via sensitivity analysis was 8.6% (95% CI, 5.8%–11.4%; $I^2 = 97.5$; $\chi^2_{(7)} = 277.5$; $P < .001$) upon excluding moderate-quality (n = 5) and low-quality (n = 2) studies. The 2 explanatory variables included in the meta-regression models (country where the study was held and year of publication) were not associated with incidence of SSI ($P = .82$ and $P = .70$, respectively). The Egger intercept test suggested an asymmetrical pattern ($P < .001$), which may be indicative of publication bias.

Specific microorganisms that were commonly observed per type of HAI are listed in Table 1. The most common microorganisms identified in included studies for overall HAIs were *Pseudomonas aeruginosa, Klebsiella* species, and *Acinetobacter baumannii*. Several risk factors were also identified from the included studies (Table 2). For overall HAI, use of invasive device or procedures, hospital factors such as ward and length of stay (LOS), diagnosis upon admission, and patient's age were identified as possible risk factors [21, 22]. Common risk factors for SSI include operative factors such as duration of operation and type of surgery, American Society of Anesthesiologists classification, degree of wound contamination, and age of patient [36, 40, 45]. For VAP, aspiration pneumonia, cancer, and leukocytosis were identified as risk factors [27]. Cancer, use of hydrocortisone, duration of infusion of central venous catheter/intravenous catheter, methicillin-resistant *Staphylococcus aureus* (MRSA) infection, and clinical sepsis were identified as risk factors for CLABSI [31].

The attributed mortality in infected patients in hospitals in Southeast Asian countries ranged from 7% to 46% (Figure 4*A*). Danchaivijitr et al [25] reported that of 13.8% of infected patients, 7% died due to HAI from hospitals in Thailand. The crude death rate due to all device-associated infections acquired in ICUs from hospitals in Malaysia [27] was 6.5%. In one hospital from Thailand, 14% of infected patients died due to bloodstream infection [45]. Werarak et al reported a 46% 30-day mortality rate due to pneumonia in a hospital in Thailand [49]. Four percent of neonates admitted to a hospital in Thailand died due to postoperative complications from HAIs [50]. The excess LOS in hospitals due to HAI was between 5 and 21 days (Figure 4*B*). In a study involving 42 hospitals in Thailand, the excess LOS was 12 days due to HAI [25], whereas a study conducted in an adult ICU in Malaysia reported that the hospital LOS increased by 10 days [29] due to infection. Similarly, a study conducted in a neonatal ICU in Thailand reported an increase of 13 days of stay in the hospital due to postoperative complications [50]. Reports of excess LOS due to HAP/VAP from Thailand ranged from 14 to 17 days [51, 52]. For urinary tract infection (UTI), a study done in Singapore

Table 1. Common Microorganisms Extracted From Systematic Review

Type of Infection	Microorganisms	Range, %[a]	Studies
Overall HAIs	*Pseudomonas aeruginosa* *Klebsiella* spp *Acinetobacter baumanni*	13.4–31.5 10–10.9 10.7–23.3	Hughes et al, 2005 (Malaysia) [23]; Thu et al, 2011 (Vietnam) [42]; Danchaivijitr et al, 2007 (Thailand) [24]
ICU	*Acinetobacter* spp *Klebsiella* spp *P. aeruginosa*	18.42–21.13 14.1–44.74 15.8–16.9	Katherason et al, 2008 (Malaysia) [34]; Thongpiyapoom et al, 2004 (Thailand) [26]
SSI	*Escherichia coli* *Pseudomonas* spp *Staphylococcus aureus*	10.3–38.7 12–29.5 11.5–44.4	Anannamcharoen et al, 2012 (Thailand) [35]; Luksamijarulkul et al, 2006 (Thailand) [47]; Yong et al, 2001 (Malaysia) [41]; Syahrizal et al, 2001 (Malaysia) [39]; Thu et al, 2005 (Vietnam) [55]; Young et al, 2011 (Singapore) [43]; Kehachindawat et al, 2007 (Thailand) [38]; Buang et al, 2012 (Malaysia) [44]; Hung et al, 2011 (Vietnam) [40]; Narong et al, 2003 (Thailand) [45]
CAUTI	*Candida* spp *E. coli* *Klebsiella* spp	25–27.8 11.1–36.1 11.1–75	Thongpiyapoom et al, 2004 (Thailand) [26]; Katherason et al, 2008 (Malaysia) [34]; Navoa-Ng et al, 2011 (Philippines) [28]; Rozaidi et al, 2001 (Malaysia) [29]; Narong et al, 2003 (Thailand) [45]
VAP	*Acinetobacter* spp *Pseudomonas* spp *Klebsiella* spp	13.6–42.8 14.8–32.3 14.3–38.7	Katherason et al, 2009 (Malaysia) [27]; Navoa-Ng et al, 2011 (Philippines) [28]; Rozaidi et al, 2001 (Malaysia) [29]; Thongpiyapoom et al, 2004 (Thailand) [26]; Narong et al, 2003 (Thailand) [45]
CLABSI	*Acinetobacter* spp *S. aureus* *Klebsiella* spp	11.1–50 9.1–16.7 9.1–38.9	Katherason et al, 2010 (Malaysia) [31]; Tan et al, 2007 (Malaysia) [30]; Navoa-Ng et al, 2011 (Philippines) [28]; Thongpiyapoom et al, 2004 (Thailand) [26]; Rozaidi et al, 2001 (Malaysia) [29]; Narong et al, 2003 (Thailand) [45]

Abbreviations: CAUTI, catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; HAI, healthcare-associated infection; ICU, intensive care unit; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

[a] Positive bacterial isolates.

Table 2. Risk Factors for Healthcare-Associated Infection From Systematic Review of Literature, 2000–2012

Author, Year	Type	Risk Factors	OR	95% CI
Thu et al, 2011 [22]	HAI	Surgery/invasive procedure		
		Surgery	3.5	2.5–4.7
		Indwelling urinary catheter	2.6	2.2–4.0
		Endotracheal intubation	1.6	1.2–2.2
		Central venous catheter	2.6	1.5–4.6
		Tracheostomy	10.9	4.0–29.3
		Ward		
		Surgery	3.9	2.2–6.7
		Medical	3.5	2.0–6.2
		Pediatric	15.2	8.1–28.5
		ICU	14.0	7.4–26.2
		Primary admission diagnosis		
		Immune system disease	11.1	2.2–54.7
		Cardiovascular disease	2.0	1.5–2.7
Duerink et al, 2006 [21]	HAI	Use of invasive device or procedures	6.2	3.5–11.3
		Fever	5.9	3.5–9.9
		Hospital length of stay >6 days	1.6	1.1–2.4
		Availability of culture results	2.8	1.5–5.1
		Age		
		<1 y	2.0	1.1–3.6
		>60 y	1.7	1.1–2.8
Narong et al, 2003 [45]	SSI	Duration of operation, minutes	1.01	1.00–1.01
		ASA class		
		I	1.0	Reference
		II	2.0	1.32–2.02
		III	3.45	2.11–5.63
		IV	4.4	1.79–10.86
		V	5.99	.47–73.88
		Degree of wound contamination		
		Clean	1.0	Reference
		Clean-contaminated	2.06	1.38–3.07
		Contaminated	5.43	3.56–8.29
		Dirty/infected	9.39	5.46–16.15
Hung et al, 2011 [40]	SSI	Age ≥30 y	1.9	1.3–2.9
		Degree of wound contamination		
		Clean-contaminated	1.7	1.2–2.8
		Contaminated	1.8	1.1–3.2
		Dirty	3.2	1.8–5.7
		Duration of surgery >120 minutes	1.9	1.3–3.4
		Small bowel surgery	4.0	2.1–7.6
Kasatpibal et al, 2005 [36]	SSI	Contaminated wound or dirty/infected wound	5.0	3.3–7.6
		Preoperative stay >6 d	2.3	1.1–4.6
		Emergency operation	2.1	1.4–3.2
		Duration of operation >75th percentile	1.9	1.2–2.9
Katherason et al, 2009 [27]	VAP	Aspiration pneumonia	HR: 4.09	1.24–13.51
		Cancer	HR: 2.51	1.27–4.97
		Leukocytosis	HR: 3.43	1.60–7.37
		Duration of mechanical ventilation	HR: 1.04	1.00–1.08

Table 2 continued.

Author, Year	Type	Risk Factors	OR	95% CI
Katherason et al, 2010 [31]	CLABSI	Cancer	HR: 3.50	1.20–10.2
		Use of hydrocortisone	HR: 5.60	1.82–17.16
		Duration of infusion CVC/IVC	HR: 0.74	.65–.92
		Duration of mechanical ventilation	HR: 1.25	1.07–1.45
		Frequency of change CVC	HR: 0.00	.00–.06
		MRSA in axilla/perineum/throat	HR: 13.5	2.42–75.31
		Clinical sepsis	HR: 13.4	2.51–68.71

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; CLABSI, central line–associated bloodstream infection; CVC/IVC, central venous catheter/intravenous catheter; HAI, healthcare-associated infection; HR, hazard ratio; ICU, intensive care unit; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

reported an increase of 4 days of stay in the hospital due to infection [33], whereas for SSI, the excess LOS ranged from 5 to 21 days [22, 36, 53–55]. Excess cost due to MRSA infection (ie, skin

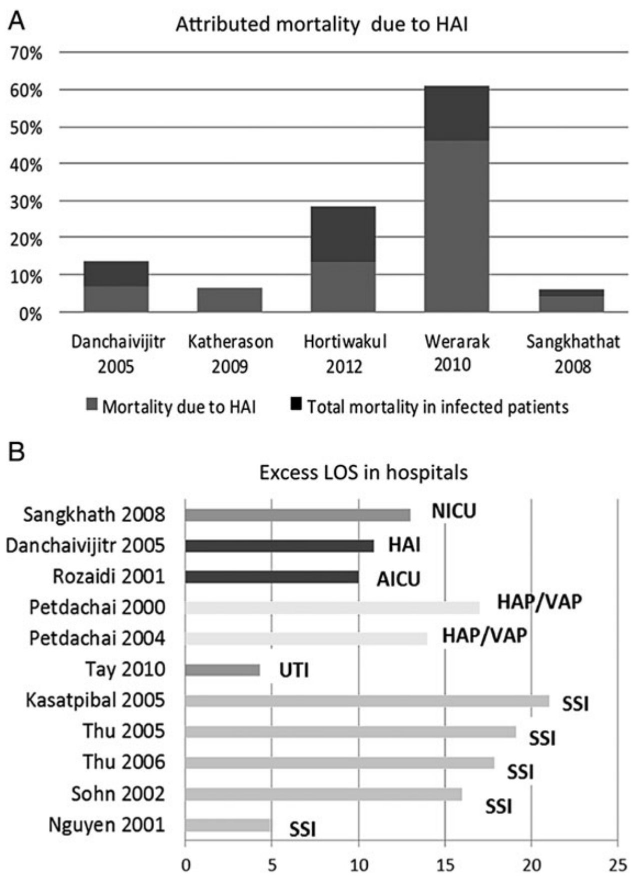

Figure 4. Attributed mortality and excess length of stay (LOS). Abbreviations: AICU, adult intensive care unit; HAI, healthcare-associated infection; HAP/VAP, hospital-acquired pneumonia/ventilator-associated pneumonia; NICU, neonatal intensive care unit; SSI, surgical site infection; UTI, urinary tract infection.

and soft tissue infection, bacteremia, bone/joint infection, pneumonia, UTI, and intracranial infection) reached up to US $13 000 [56] in Singapore, whereas in Vietnam and Thailand, excess cost amounted to US$865 for HAI [57] and US$1091 for SSI [58], respectively (Table 3).

DISCUSSION

The pooled prevalence of overall HAIs in this meta-analysis of studies from Southeast Asia is 9.0% (95% CI, 7.2%–10.8%). This is considerably lower than the reported 15.5% pooled prevalence of HAI in a meta-analysis of studies from developing countries [16]. Similarly, the pooled incidence density of device-associated HAI in adult ICUs in this meta-analysis (20 per 1000 ICU-days) is substantially lower than the pooled incidence density of HAIs in adult ICUs (47.9 per 1000 ICU-days) reported in developing countries [16].

Rosenthal and colleagues [62] reported the aggregated results of incidence densities of device-associated infections from 36 developing countries in Latin America, Asia, Africa, and Europe that utilized International Nosocomial Infection Control Consortium (INICC) surveillance methodology from 2004 to 2009. The VAP incidence density in the INICC report (15.8 per 1000 ventilator-days) is similar to the density reported in this study (14.7 per 1000 ventilator-days) [62]. Both reports showed that VAP has the highest incidence density compared with CAUTI and CLABSI. This is consistent with published studies that utilized INICC methodology from India [63], China [64], Lebanon [65], and Cuba [66]. In general, these studies show varying incidence densities for VAP, CAUTI, and CLABSI. Possible reasons for the differences in incidence densities include variability in case definitions, case-finding methods, and methodological quality of studies. Common microorganisms extracted from studies included in this review were mostly gram-negative bacilli, which is similar to the results of the INICC surveillance study from developing countries [62]. Preventing and controlling

Table 3. Attributed Costs of Healthcare-Associated Infection in Southeast Asian Countries, 2000–2012

Study	Country	Setting	Type	Mean Hospital Costs, US$	Mean Antibiotic Costs, US$	Excess Cost, US$
Ng et al, 2012 [60]	Singapore	2 hospitals	MDR vs non-MDR bacteremia			4959
Pada et al, 2011 [56]	Singapore	2 hospitals	MRSA vs noninfected			13 000
Ha et al, 2012 [57]	Vietnam	1 NICU	HAI			865
Kasatpibal et al, 2005 [37]	Thailand	1 hospital	SSI			1091
Pancharti et al, 2005 [58]						
1 episode				1028	110	
2 episodes				2377	383	
≥3 episodes				4004	595	

Abbreviations: HAI, healthcare-associated infection; MDR, multidrug resistant; MRSA, methicillin-resistant *Staphylococcus aureus*; NICU, neonatal intensive care unit; SSI, surgical site infection.

HAIs in Southeast Asia would therefore lead to reduction of gram-negative multidrug-resistant organism infections in the region. The incidence densities of HAIs from this meta-analysis as well as the other reports from developing countries are 10–20 times higher than those reported in the most recent US National Health Safety Network data on incidence density of device-associated infections [67]. Even in this era of patient safety, the gap between the United States and developing countries such as those in Southeast Asia is still wide, although the HAI rate has declined over time [68]. This may be due to differences in standards of care in infection prevention and control programs, such as the more effective use of bundling implementations in developed countries. More effort in improving infection prevention and control policies and programs, including networking and collaboration between healthcare institutions, is needed in developing countries [69]. The pooled SSI rate (7.8%) reported in this meta-analysis is more than twice that (2.9%) of developing countries surveyed from 2005 to 2010 [62]. Results from this meta-analysis suggest the urgent need for SSI interventions in Southeast Asia. Pooled rates from this meta-analysis can serve as a benchmark for comparison with other studies in the region.

A limitation of our meta-analysis is the heterogeneity observed in all pooled estimates. The heterogeneity levels, however, were comparable to those reported by Allegranzi et al ($I^2 > 97.4\%$) [16]. Variations in case definitions, data collection methodology, and sample size contributes to heterogeneity of pooled estimates. Furthermore, the quality of care provided to patients may also suggest the differences in measures seen in included studies.

Further studies are needed from Southeast Asian countries to obtain a more robust description of the magnitude of HAI. There is a need to enhance the research methodology used to measure the occurrence of HAI inclusive of standardization of case definitions, utilization of active disease surveillance, and inclusion of process surveillance to measure compliance to infection prevention programs. Use of standardized case definitions, as recommended by the World Health Organization, will ensure consistency of data and comparability of results between countries [70]. These standardized definitions should be relevant and appropriate to healthcare facilities in Southeast Asia. Active surveillance has been shown to have higher sensitivity in identifying cases compared with passive surveillance and may contribute to increased staff compliance with prevention programs and subsequent decrease in incidence of HAIs [71]. Surveillance activities should target high-risk areas such as ICUs and surgical wards. Enhancement of basic microbiology services and quality control of antimicrobial susceptibility testing will be beneficial for obtaining valid and reliable HAI surveillance information.

Likewise, there is a need for more publications on economic analysis from the region. Availability of published data will increase awareness among health authorities and may be used to engage policymakers to prioritize infection prevention and control. This will lead to better funding opportunities for prevention and control programs. Use of multimodal interventions or bundles of care may reduce the societal burden of HAI in the region.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online (http://cid.oxfordjournals.org). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyedited. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

Notes

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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