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Point prevalence survey of antibiotic use among hospitalized patients across 41 hospitals in Thailand

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Objectives: To describe the antibiotic use among hospitalized patients in Thailand.

Methods: A standardized cross-sectional point prevalence survey (PPS) modified from the WHO PPS protocol was conducted in 41 selected hospitals in Thailand. All inpatients who received an antibiotic at 9 a.m. on the survey date were enrolled. The total number of inpatients on that day was the denominator.

Results: Between March and May 2021, a total of 8958 inpatients were enumerated; 4745 inpatients received antibiotics on the day of the survey and there were 6619 prescriptions of antibiotics. The prevalence of antibiotic use was 53.0% (95% CI 51.1%–54.0%), ranging from 14.3% to 73.4%. The antibiotic use was highest among adults aged >65 years (57.1%; 95% CI 55.3%–58.9%). From 6619 antibiotics prescribed, 68.6% were used to treat infection, 26.7% for prophylaxis and 4.7% for other or unknown indications. Overall, the top three commonly used antibiotics were third-generation cephalosporins (1993; 30.1%), followed by first-generation cephalosporins (737; 11.1%) and carbapenems (703; 10.6%). The most frequently used antibiotics for community-acquired infections were third-generation cephalosporins (36.8%), followed by β-lactam/β-lactamase inhibitors (11.8%) and carbapenems (11.3%) whereas for the patients with hospital-acquired infections, the most common antibiotics used were carbapenems (32.7%), followed by β-lactam/β-lactamase inhibitors (15.7%), third-generation cephalosporins (11.7%) and colistin (11.7%). The first-generation cephalosporins were the most commonly used antibiotics (37.7%) for surgical prophylaxis. Seventy percent of the patients received surgical prophylaxis for more than 1 day post surgery.

Conclusions: The prevalence of antibiotic use among hospitalized patients in Thailand is high and one-quarter of these antibiotics were used for prophylaxis. The majority of surgical prophylaxis was inappropriately used for a long duration post operation. Therefore, it is recommended that local guidelines should be developed and implemented.

Introduction

Overuse and inappropriate use of antibiotics are among key factors leading to antimicrobial resistance (AMR)—a major global health challenge.[1] In Thailand, the antibiotic-resistant infections resulted in at least 3.24 million additional days of hospitalizations and 38 481 deaths in 2010.[2] To strengthen antibiotic stewardship, international organizations and countries are committed to establishing antibiotic use surveillance systems.[3,4] A set of standardized methods for surveillance of antibiotic use based on point prevalence surveys (PPS) has been well established. Surveillance data are essential evidence that can be used to improve antibiotic stewardship. The survey collects data pertaining to prevalence of use, indications for treatment and prophylaxis, antibiotics classes and inappropriate use. PPS of antibiotics use is a standardized tool for monitoring these parameters over time.[5] The EU and the USA have developed and carried out their own surveys using PPS.[3,6] WHO also developed a similar tool that meets the needs of low-resource countries while maintaining comparability with data collected from high-income countries.[7] The WHO guideline was launched in 2018.

A systematic review reported a significantly higher prevalence of antibiotic use in non-European hospitals compared with European hospitals.[8] This PPS of antibiotic use aims to provide a comprehensive data on the use of antibiotics and valuable insight into quality prescriptions and indications of use.[9] PPS evidence supports improvement of antibiotic stewardship; the surveillance of hospital-acquired infections (HAIs) informs the need to improve infection prevention and control, which are the foundations to tackle AMR in healthcare facilities.

Data on the prevalence of antibiotic use and antibiotic prescription pattern in Thailand are limited, even though Thailand has conducted several rounds of PPS of HAIs;[10–13] however, none of the surveys collected data on antibiotic use. Hence, this study aimed to estimate the prevalence and antibiotic prescription pattern among hospitalized patients in Thailand using the WHO PPS methods. The experiences gained from using the WHO tool can be applied for future regular monitoring of antibiotic use in healthcare facilities and improve antibiotic stewardship in the hospitals.

Methods

Study design

This cross-sectional survey used the standardized WHO PPS protocol in 41 hospitals in Thailand.[7] The Thai version of the PPS protocol and user manual were developed through a series of technical consultations with the stakeholders on the PPS methodology. Modified versions of the WHO PPS forms were used to collect data (see Table S1, available as Supplementary data at *JAC-AMR* Online). The PPS was conducted between March and May 2021. The study received approval from the Ethics Committee, Institute for the Development of Human Research Protection, Ministry of Public Health, Thailand (IHRP no. 095/2563). Informed consent was not required because the survey did not directly contact the patient. The patient's identification was encrypted to maintain anonymity.

The sample size was estimated using the following information. In 2020, there were a total of 157072 beds in 1421 public and private hospitals, an average of 110 beds per hospital. We assumed that the prevalence of antibiotic use in hospitalized patients was 50% and the precision was ±5% at the national level, and the design effect corresponding to an average hospital size of 110 beds (range 80–140 beds) was 10.1.[7,14] Based on these values, we calculated the sample size to be 3871 beds. An average hospital size was 110 beds, which indicated that at least 35 (3871/110) hospitals should be included in the survey. Since random sampling was not feasible, we used convenience sampling, as suggested by the WHO protocol. Various types of hospitals were approached to participate in the survey.

Settings and participants

Based on the WHO PPS protocol,[7] we categorized the hospitals into three groups: primary, secondary and tertiary hospitals. All of the hospitals that were located in all 13 public health regions were approached to join the study, including Bangkok (see Table S2). All inpatient wards at the sample hospitals were included in the survey. The survey of each ward was completed on 1 day that was not at the weekend or a public holiday. In addition, surgical wards were not enumerated on the day following the weekend or public holidays in order to capture the duration of surgical prophylaxis (SP) use.[7] Data were collected at each sampled hospital within 3 weeks after enrolment into the study.

We used the following criteria for recruiting inpatients for enumeration: (a) in hospitals with <500 inpatient beds, all eligible patients were enumerated; (b) in hospitals with 500–800 inpatient beds, one out of two patients per ward were systematically randomized and enumerated; and (c) in hospitals with >800 inpatient beds, one out of three patients per ward were enumerated through systematic random sampling. Furthermore, the systematic random sampling using the admission number was applied for selecting surveyed patients at each ward. We included inpatient wards in our survey. However, we excluded emergency departments and day surgery wards.

Training and data collection

Two healthcare professionals (i.e. infectious disease physicians, pharmacists, infection control nurses etc.) from each hospital were appointed and trained on how to apply the WHO PPS methodology. A 2 day online training course (COVID-19 did not allow face-to-face training) in Thai was arranged to provide the team with an opportunity to review, comment on the data verification, and use different case scenarios in order to ensure that the quality of the data collected for this survey was not compromised.

Data were recorded in a paper-based worksheet prior to entering them into an online spreadsheet. The PPS was concluded in 1 day in small hospitals with 30–60 beds, whereas in larger hospitals with more than 60 beds, the data were collected in three consecutive weeks. The survey team collected the basic information from the medical records as well as treatment and management of infectious diseases regardless of whether these patients were on antibiotic treatment on the survey date.

All inpatients who received an antibiotic at 9 a.m. on the survey date were enumerated as numerators; the denominators were the total number of inpatients on that day. We collected the following patient data: age, gender, use of ventilator, prescribed antibiotics, start date, generic name, route of administration, dose, reason for use, indications for community-acquired infections (CAIs), HAIs, SP, medical prophylaxis (MP) and type of treatment received (empirical, definitive treatment and prophylactic). If the therapy was definitive treatment, the causative organism was recorded, if available. The survey team immediately validated all records after data collection.

Definitions

Age groups were classified into neonates (aged <1 month), children (aged 1 month to 15 years), adults (aged 15–65 years) and elderly (aged >65 years).

Wards were categorized by type: medicine, surgery, obstetrics and gynaecology (OB/GYN), paediatrics, neonatal, ICU, neonatal ICU (NICU), mixed wards and high-risk wards. High-risk wards are defined as wards that have patients who are on many antibiotics due to their clinical conditions. These patients were from the haematology/oncology unit, burns unit, transplantation unit, generalized or specialized infectious disease ward. Paediatric wards included paediatric medical and surgical wards. ICU included adult ICU (AICU) and paediatric ICU (PICU). Mixed wards were defined as wards for adult medicine and surgery conditions.

Antibiotics in this survey include any antibiotics administered via IV, oral or intramuscular routes. On the other hand, topical antibiotic agents, antifungals and antivirals were excluded. Third-generation cephalosporins (i.e. ceftriaxone, cefotaxime and ceftazidime), β-lactam/β-lactamase inhibitors (BLBIs) (i.e. amoxicillin/clavulanic acid and piperacillin/tazobactam), carbapenems and other antibiotics were used by inpatients in the sampled hospitals. Antibiotic prescription was classified as either monotherapy or combination therapy (i.e. use of more than one antibiotic). If an antibiotic susceptibility test had been done, the resistant phenotypes based on CLSI 2021[15] were recorded (Table S3).

We reviewed the medical records and categorized the hospitalized patients into CAIs and HAIs, which were classified based on the date of onset of the infection after admission. Infections categorized as HAIs were defined as: (a) onset date was beyond Day 3; (b) onset date was on Day 1 or Day 2, and the patient was transferred from another hospital; and (c) onset date was on Day 1 or Day 2, and the patient was discharged from the hospital within 48 h (same hospital or another one).[7]

Statistical analysis

The prevalence rates of antibiotic prescriptions were defined as percentage, including 95% CI, of total inpatients who were receiving antibiotics on the survey date. We analysed the most commonly prescribed antibiotics and the reasons for use, categorized by ward type. Paired sample *t*-test and independent sample *t*-test were used where appropriate. Statistical analyses were performed using Stata version 15.1 (StataCorp LLC, College Station, TX, USA). Statistical significance was defined as a *P* value of <0.05.

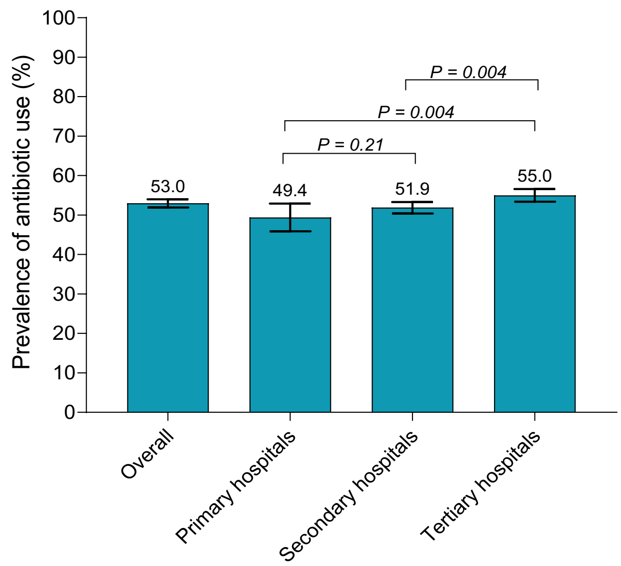

Figure 1. Prevalence of antibiotic use categorized according to the levels of the hospitals (overall *P* value <0.001).

Results

Forty-one hospitals participated in the study: 11 primary hospitals, 19 secondary hospitals and 11 tertiary care hospitals. In these 41 participating hospitals, the average bed size was 391 (range 28–1030 beds), with bed occupancy rate of 65.6% (range 25.0%–96.3%), and provided services to 30 669 inpatients in 2020. Antibiotic stewardship was available among 78% of the participating hospitals with various interventions (e.g. education, clinical guideline and antibiotic restriction).

Prevalence of antibiotic use

Out of 8958 inpatients enumerated, 4745 inpatients received antibiotics on the survey date. The prevalence of antibiotic use was 53.0% (95% CI 51.1%–54.0%). The prevalence of antibiotic use ranged from 14.3% to 73.4%. The prevalence of antibiotic use significantly increased according to the level of the hospital (overall *P* value 0.001) (Figure 1). The prevalence of antibiotic use by age group was 32.5% (95% CI 29.2%–36.0%) in neonates, 54.9% (95% CI 50.8%–58.9%) in children, 26.8% (95% CI 25.6%–28.1%) in adults aged 15 to 65 years, and 57.1% (95% CI 55.3%–58.9%) in the elderly patients aged >65 years. The top five types of wards with high prevalence of antibiotics used were: 76.7% in AICU and PICU, 59.6% in surgery, 53.3% in NICU, 52.0% in medicine and 50.6% in mixed wards (Table 1).

The use of antibiotics by indication showed a clear gradient across the three hospital levels (Table 2). There was a higher proportion of empirical and a lower proportion of definitive treatment in primary hospitals compared with the secondary hospitals. The prevalence of CAIs and HAIs was higher in the secondary hospitals compared with the tertiary hospitals. However, there was a similar proportion of prophylactic use across all three levels of the hospitals.

Characteristics of antibiotic use

From 4745 patients on antibiotics, 1645 patients (34.7%) received combination antibiotics. The top three common antibiotic combinations were ceftriaxone plus metronidazole (18.4%), followed by ceftriaxone plus clindamycin (10.4%), and ampicillin plus gentamicin (7.5%). A total of 6619 antibiotics were prescribed to these 4745 patients; 4538 (68.6%) patients were treated for infection, 1768 (26.7%) patients received the antibiotics for prophylaxis, and 313 (4.7%) patients received antibiotics for other or unknown indications.

Overall, the most commonly used antibiotics were third-generation cephalosporins (1993; 30.1%), followed by first-generation cephalosporins (737; 11.1%), carbapenems (703; 10.6%) and BLBIs (688; 10.4%) (Figure 2). The proportion of antibiotic used as categorized by the WHO AWaRe (Access, Watch, Reserve) list[16,17] is shown in Figure 3. Out of 6619 prescribed antibiotics, 47.0% belonged to the Access group, 47.3% belonged to the Watch group, and 5.7% belonged to the Reserve group.

Antibiotic use was stratified by ward type and is shown in Table 3. The most commonly used antibiotics in medicine, surgery, paediatrics, mixed and high-risk wards were third-generation cephalosporins. The majority of the patients in the OB/GYN ward received first-generation cephalosporins. In the adult wards and PICU, carbapenems were the most commonly prescribed antibiotics. In the neonatal wards, the most commonly prescribed antibiotics were penicillins and aminoglycosides. Antibiotic use was stratified by indication (Figure 4). This survey was conducted during the COVID-19 pandemic (March–May 2021). From 757 surveyed wards, 21 wards (2.8%) used antibiotics to treat COVID-19. It should be noted that <1% (77/8958) of the patients had COVID-19, yet 29.9% of them (23/77) received antibiotics.

Antibiotics for therapeutic use

From a total of 3165 therapeutic indications, 4538 patients received antibiotics (some cases received more than one antibiotic). The most common use for the antibiotics was for the

Table 1. Prevalence of antibiotic use stratified by ward types in Thailand in 2021

Ward type	Patients (*n*)	Number of patients on antibiotics (%)	Antibiotic combination (%)	Prescriptions (*n*)	Definitive treatment (%)	Parenteral administration (%)
Surgery	2756	1643 (59.6)	613 (22.2)	2323	193 (8.3)	2111 (90.9)
Medicine	2741	1425 (52.0)	411 (15.0)	1907	443 (23.2)	1746 (91.6)
Mixed[a]	1012	512 (50.6)	143 (14.1)	675	87 (12.9)	572 (84.7)
OB/GYN	833	236 (28.3)	49 (5.9)	286	9 (3.2)	202 (70.6)
AICU/PICU	614	471 (76.7)	178 (29.0)	678	242 (35.7)	653 (96.3)
Paediatrics	461	227 (49.2)	88 (19.1)	329	26 (7.9)	284 (86.3)
NICU	225	120 (53.3)	98 (43.6)	236	13 (5.5)	235 (99.6)
Neonates	209	71 (34.0)	54 (25.8)	127	6 (4.7)	127 (100)
High risk[b]	107	40 (37.4)	11 (10.3)	58	9 (15.5)	51 (87.9)

[a]Mixed wards were defined as wards with mixed adult medicine and surgical wards.
[b]High-risk units were defined as units or wards that utilized high amounts of antibiotics due to the type of care they provide.

Table 2. Antibiotic use, % (*n*/*N*), by indication and type of treatment stratified by the level of the hospitals

	Therapeutic use (*n*=4538)					
	CAIs (*n*=3984)		HAIs (*n*=554)			
Hospital level	Empirical (*n*=3314)	Definitive (*n*=670)	Empirical (*n*=278)	Definitive (*n*=276)	Prophylactic use (*n*=1768)	Unknown/others (*n*=313)
Primary (*n*=681)	91.3 (422/462)	8.7 (40/462)	75.0 (9/12)	25.0 (3/12)	28.1 (191/681)	2.3 (16/681)
Secondary (*n*=3121)	86.7 (1731/1997)	13.3 (266/1997)	52.1 (123/236)	47.9 (113/236)	24.0 (750/3121)	4.5 (138/3121)
Tertiary (*n*=2817)	76.1 (1161/1525)	23.9 (364/1525)	47.7 (146/306)	52.3 (160/306)	29.4 (827/2817)	5.6 (159/2817)
Overall (*n*=6619)	83.2 (3314/3984)	16.8 (670/3984)	50.2 (278/554)	49.8 (276/554)		

treatment of respiratory tract infections (1092; 34.5%) followed by gastrointestinal tract infections (403; 12.7%) and sepsis (376; 11.9%) (Table 4). From a total of 4538 patients who used the antibiotics for therapeutic use, empirical treatment accounted for 79.2%, while definitive treatment was 20.8%.

The three most common antibiotic uses for CAIs were third-generation cephalosporins (36.8%) followed by BLBIs (11.8%) and carbapenems (11.3%), whereas the three most common antibiotic uses for HAIs were carbapenems (32.7%) followed by BLBIs (15.7%) and third-generation cephalosporins (11.7%) and colistin (11.7%) (Figure 4).

Antibiotics for surgical prophylaxis

The top three sites for surgical prophylaxis were: (1) skin, soft tissue, bone and joint (47.1%); (2) gastrointestinal tract (23.2%); and (3) gynaecology and obstetrics sites (12.7%). The three most common antibiotics used for surgical prophylaxis were first-generation cephalosporins (37.7%) followed by third-generation cephalosporins (20.1%) and metronidazole (11.8%). It is inappropriate to use surgical prophylaxis for more than 1 day;[18] 70.3% of the patients in this study received prophylaxis for more than 1 day after surgery. The durations of surgical prophylaxis used by surgical sites are shown in Figure 5.

Prevalence of antibiotic use in HAIs

On the survey date, out of 8958 hospitalized patients, 385 were diagnosed with HAIs and received antibiotics for treatment. The overall HAI prevalence was 4.3% (385/8958; 95% CI 3.9%–4.7%, range 0%–14%). HAI prevalence significantly increased according to the level of the hospital with an overall *P* value of <0.001 (Figure 6).

Microbiology and resistance profiles

Among 2408 patients who received antibiotics for treatment, a total of 3895 clinical specimens were collected for culture and susceptibility analysis. The types of specimens collected are

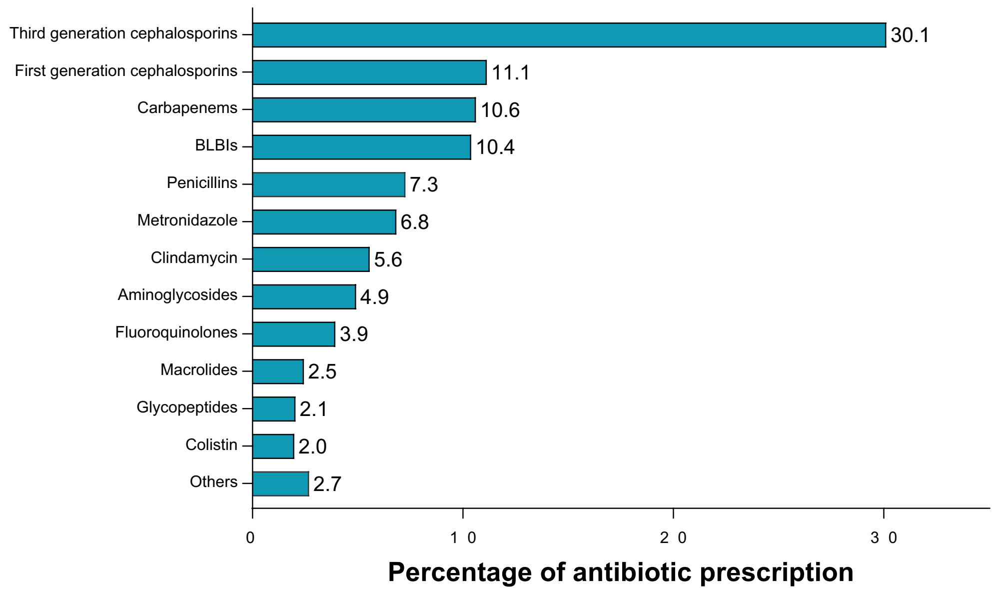

Figure 2. Percentages of 6619 antibiotic prescriptions.

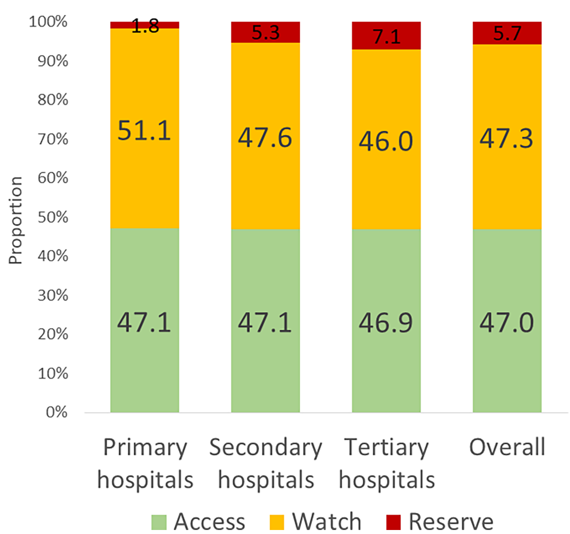

Figure 3. Proportional consumption (%) of antibiotic by WHO AWaRe classification stratified by the level of the hospitals.

shown in Table 5. There were 1284 microbiologically confirmed infections. The five most common microorganisms identified were *Escherichia coli* (267; 20.8%), followed by *Acinetobacter baumannii* (206; 16.0%), *Klebsiella pneumoniae* (198; 15.4%), *Pseudomonas aeruginosa* (105; 8.2%) and *Staphylococcus aureus* (68; 5.1%). The overall antimicrobial-resistant organisms among eight priority pathogens listed in the Thailand National Strategic Plan on Antimicrobial Resistance[19] are shown in Table 6. Forty-three percent of the *E. coli* were resistant to ceftriaxone, whereas 25.3% of the *K. pneumoniae* were resistant to ceftriaxone. Sixteen percent of carbapenem-resistant Enterobacteriaceae (CRE) were detected in *E. coli* and *K. pneumoniae* isolates. Most of the *A. baumannii* isolates were resistant to carbapenems (80.6%), while a total of 31.4% of the *P. aeruginosa* isolates were resistant to carbapenems.

Discussion

In this study, more than half (53.0%) of the hospitalized patients received at least one antibiotic. This is comparable to a prior study conducted in Thailand[13] in 2018, which reported a prevalence of antibiotic use to be 51.5% (range 8%–89%). Recent global PPS studies reported that the prevalence of antibiotic use varied across countries, with the highest prevalence in Africa (50%, range 27%–74%), whereas the prevalence of antibiotic use in Eastern Europe was 28%, 39% in North America, and 37% in East and South Asia (range 29%–78%).[3,20] In Asia, the highest antibiotic-prescribing country was China (75%) in 2012,[21] and in 2020, it was Laos PDR (71%).[22] The prevalence of antibiotic use varied across different countries due to factors such as CAI and HAI rates, resistance patterns, lack of standard treatment guidelines and adherence by clinicians, and lack of effective feedback to the clinicians pertaining to antibiotic use.[8,23]

According to the WHO AWaRe list, 47.0% of the antibiotics were from the Access group, 47.3% were from the Watch group, and 5.7% were from the Reserve group. Monitoring the use of the Watch and Reserve list provides good feedback and evidence for strengthening the antibiotic stewardship in each hospital. The WHO has set a goal to increase, at the national level, the proportion of antibiotic consumption in the Access group to at least 60% and to reduce the use of antibiotics from the Watch and Reserve groups.[24,25] Unfortunately, this target is for primary healthcare facilities. Thus, there is a need to define specific targets for other types of hospitals.

Respiratory tract infections were the most frequent reason for prescribing antibiotics. This finding is comparable to previous reports from Thailand[14] as well as the global PPS.[3,8] In our survey,

Table 3. Antibiotic use, *n* (%), according to the ward type

	Ward type									
Antibiotics	Surgery (*n*=2323)	Medicine (*n*=1907)	OB/GYN (*n*=286)	AICU/ PICU (*n*=678)	NICU (*n*=236)	Neonates (*n*=127)	Paediatrics (*n*=329)	Mixed (*n*=675)	High risk (*n*=58)	Overall (*N*=6619)
First-generation cephalosporins	487 (21.0)	41 (2.2)	89 (31.1)	27 (4.0)	3 (1.3)	0 (0.0)	10 (3.0)	79 (11.7)	1 (1.7)	737 (11.1)
Third-generation cephalosporins	615 (26.5)	773 (40.5)	49 (17.1)	148 (21.8)	23 (9.8)	17 (13.4)	137 (41.6)	207 (30.7)	24 (41.4)	1993 (30.1)
Aminoglycosides	93 (4.0)	31 (1.6)	9 (3.2)	14 (2.1)	71 (30.1)	48 (37.8)	38 (11.6)	21 (3.1)	1 (1.7)	326 (4.9)
BLBIs	181 (7.8)	299 (15.7)	16 (5.6)	97 (14.3)	2 (0.9)	2 (1.6)	16 (4.9)	65 (9.6)	10 (17.2)	688 (10.4)
Carbapenems	165 (7.1)	234 (12.3)	3 (1.1)	180 (26.6)	32 (13.6)	10 (7.9)	17 (5.2)	55 (8.2)	7 (12.1)	703 (10.6)
Clindamycin	171 (7.4)	94 (4.9)	23 (8.0)	28 (4.1)	0 (0.0)	0 (0.0)	8 (2.4)	41 (6.1)	4 (6.9)	369 (5.6)
Colistin	14 (0.6)	44 (2.3)	0 (0.0)	50 (7.4)	9 (3.8)	0 (0.0)	3 (0.9)	10 (1.5)	2 (3.5)	132 (2.0)
Fluoroquinolones	119 (5.1)	67 (3.5)	4 (1.4)	27 (4.0)	0 (0.0)	0 (0.0)	4 (1.2)	38 (5.6)	2 (3.5)	261 (3.9)
Glycopeptides	30 (1.3)	45 (2.4)	3 (1.1)	23 (3.4)	16 (6.8)	1 (0.8)	3 (0.9)	13 (1.9)	2 (3.5)	136 (2.1)
Macrolides	6 (0.3)	93 (4.9)	2 (0.7)	20 (3.0)	1 (0.4)	0 (0.0)	17 (5.2)	22 (3.3)	1 (1.7)	162 (2.5)
Metronidazole	277 (11.9)	70 (3.7)	20 (7.0)	26 (3.8)	0 (0.0)	1 (0.8)	15 (4.6)	44 (6.5)	0 (0.0)	453 (6.8)
Penicillins	111 (4.8)	63 (3.3)	56 (19.6)	12 (1.8)	79 (33.5)	48 (37.8)	57 (17.3)	54 (8.0)	1 (1.7)	481 (7.3)
Others	54 (2.3)	53 (2.8)	12 (4.2)	26 (3.8)	0 (0)	0 (0)	4 (1.2)	26 (3.9)	3 (5.2)	178 (2.7)

Mixed wards were defined as wards with mixed adult medicine and surgical wards.
High-risk units were defined as units or wards that utilized high amounts of antibiotics due to the type of care they provide.

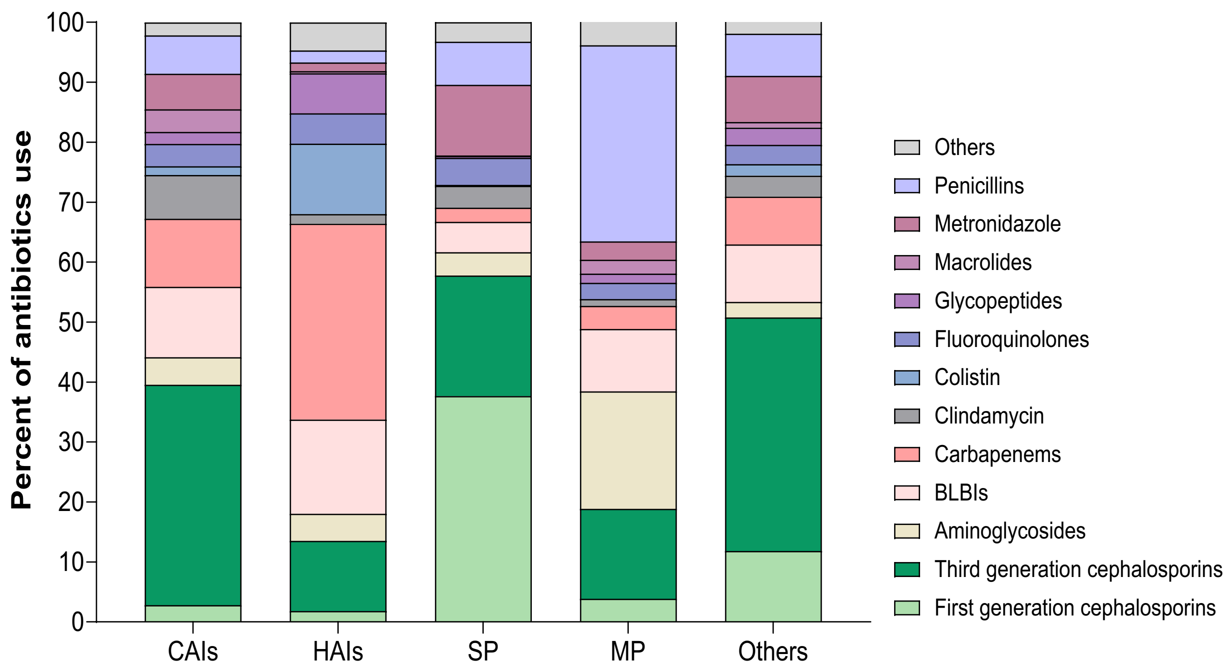

Figure 4. Proportion of antibiotic use stratified by indication.

the most frequently prescribed antibiotics were third-generation cephalosporins; this was similar to reports from Asia, Latin America and southern and eastern Europe.[3] Carbapenems were the most commonly used antibiotics for HAIs because the clinicians were concerned about AMR pathogens. Also, carbapenems were used in patients with unstable and critical conditions. There is a high rate of carbapenem use because there is an increased rate of antimicrobial-resistant Gram-negative organisms reported in Thailand, with a sharp increase in CRE nationwide.[26]

Table 4. Diagnosis or sites of infections for antibiotic treatment

CAI diagnosis (*n* = 2780)	*n* (%)	HAI diagnosis (*n* = 385)	*n* (%)
Lower respiratory tract infections	793 (28.5)	Respiratory tract infections	198 (51.7)
Gastrointestinal tract infections	392 (14.1)	Urinary tract infections	67 (17.5)
Sepsis	360 (12.9)	Surgical site infections	33 (8.6)
Skin and soft tissue infections	347 (12.5)	Bloodstream infections	30 (7.8)
Urinary tract infections	321 (11.6)	Skin and soft tissue infections	18 (4.7)
Upper respiratory tract infections	101 (3.6)	Sepsis	16 (4.2)
Fever of unknown origin	98 (3.5)	Gastrointestinal tract infections	11 (2.9)
Bone and joint infections	75 (2.7)	Fever of unknown origin	7 (1.8)
Bacteraemia	65 (2.3)	Others	5 (1.3)
CNS infections	55 (2.0)		
Obstetric/genital infections	33 (1.2)		
Febrile neutropenia	21 (0.8)		
Others	47 (1.7)		
Unknown	72 (2.6)		

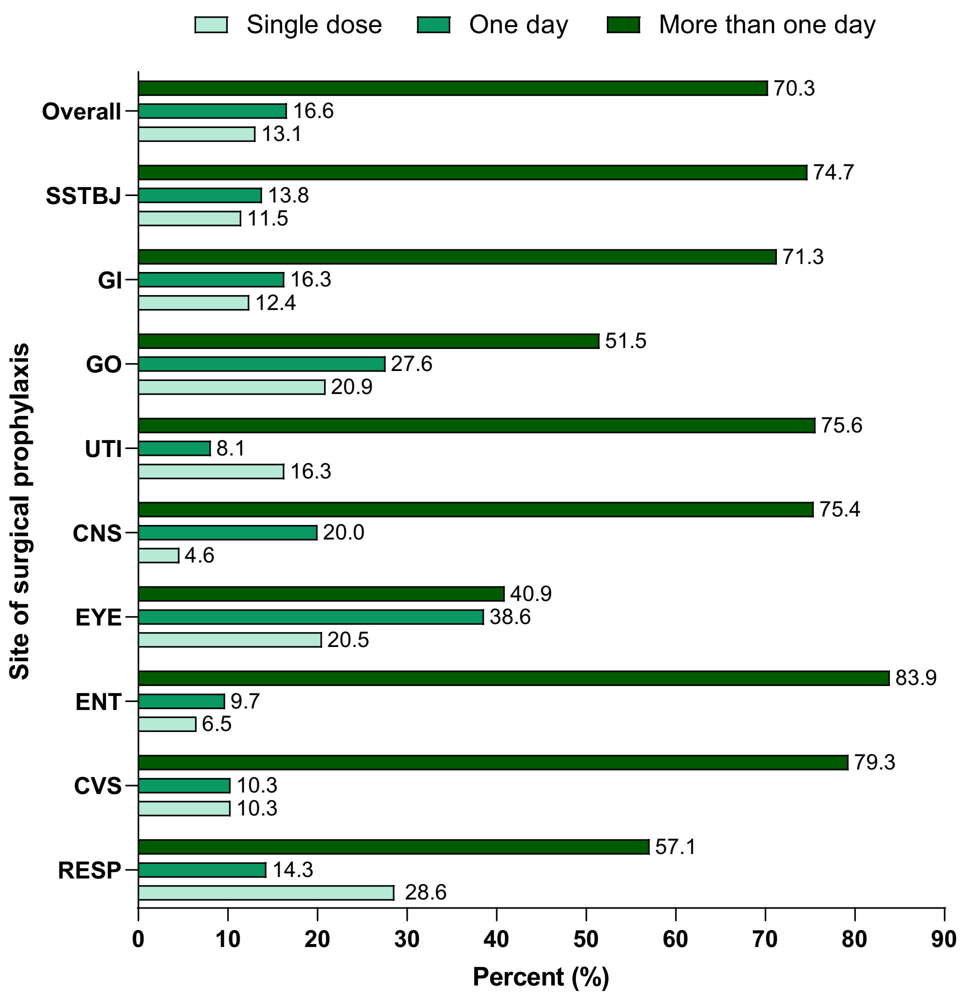

Figure 5. Duration of antibiotic use for surgical prophylaxis. SSTBJ, skin, soft tissue, bone and joint; GI, gastrointestinal tract; GO, gynaecology and obstetrics; UTI, urinary tract; EYE, ophthalmic; ENT, otolaryngology; CVS, cardiovascular system; RESP, respiratory tract.

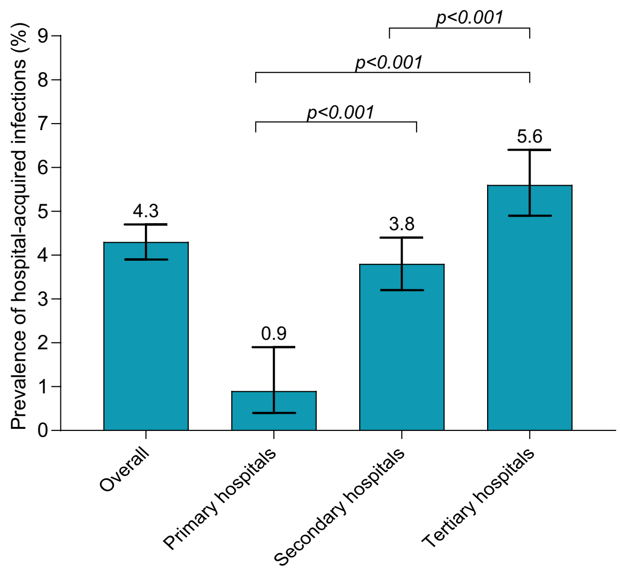

Figure 6. Prevalence of HAIs and 95% CI according to the level of the hospitals (overall *P* value <0.001).

Table 5. Microbiological data of 3895 clinical specimens

Specimens (*N* = 3895)	*n* (%)
Blood	1468 (37.7)
Sputum	1089 (28.0)
Urine	838 (21.5)
Wound	233 (6.0)
Sterile fluids	156 (4.0)
Other	111 (2.9)
Results	
Positive culture	1284 (33.0) (95% CI: 30.8–33.7)
Negative culture	1818 (46.7)
No report at the time of PPS conduct	793 (20.3)
AMR, *n* (%)	602/1284 (46.9) (95% CI: 44.1–49.7)
CAIs	390/936 (41.7) (95% CI: 38.5–44.9)
HAIs	212/348 (60.9) (95% CI: 55.9–66.4)

Table 6. Percentage of AMR among eight targeted pathogens reported in the Thai National Strategic Plan on Antimicrobial Resistance

	Percentage (*n*/*N*) of isolates with drug resistance
Ceftriaxone-resistant *E. coli*	42.7 (114/267)
Ceftriaxone-resistant *K. pneumoniae*	25.3 (50/198)
CRE[a]	16.3 (76/465)
Carbapenem-resistant *A. baumannii* (CRAB)	80.6 (175/217)
Carbapenem-resistant *P. aeruginosa* (CRPA)	31.4 (33/105)
Drug-resistant *Streptococcus pneumoniae* (DRSP)	30.0 (3/10)
MRSA	20.6 (14/68)
VRE	1.6 (1/62)

[a]Included only *E. coli* and *K. pneumoniae*.

In this study, the use of carbapenems ranked third for CAIs. It is inappropriate to use carbapenems because this can lead to the emergence of MDR organisms.[27] The definitive treatment of CAIs using meropenem in this study can be replaced by a narrow-spectrum choice because 33% (27/82) of the cases did not have resistant pathogens. The high rates of Enterobacterales resistant to a third-generation cephalosporin[26] in CAIs are due to the high rates of carbapenem use. It has been reported that there is a higher burden of drug-resistant Gram-negative organisms in Asia compared with Western countries.[22,28] In addition to antibiotic stewardship, infection prevention and control measures should be emphasized to control AMR.

There is a higher proportion of empirical treatment in primary hospitals compared with the secondary and tertiary hospitals. On the other hand, there is a higher proportion of definitive treatment in tertiary hospital compared with the primary and secondary hospitals. The reason for this difference is that there are more general physicians in the primary hospitals and more specialists in the tertiary hospitals. In addition, the laboratory capacity to do culture and drug susceptibility testing is limited in primary hospitals. As a result of this, we recommend that there should be a scale-up of the laboratory's diagnostic testing to support and guide antibiotic prescribing practices.[20]

A study showed that there was an increased use of antibiotics, especially in COVID-19 patients who were critically ill and developed severe complications from nosocomial bacterial pathogens.[29] Aside from that, it has been reported that there is an increased use of empirical antibiotics for bacterial coinfection, even in COVID-19 patients with mild symptoms.[30,31] Our study was conducted between March and May 2021; there were 133 841 cumulative COVID-19 cases nationwide during this period.[32] In this study conducted during the COVID-19 pandemic, COVID-19 infections accounted for less than 1% of the total enumerated cases, and one-third of them received antibiotics. Given the small number of COVID-19 cases in this study, it is less likely that the results of antibiotic use by COVID-19 patients will affect the overall prevalence of antibiotic use.

This survey found inappropriate use of surgical prophylaxis. Seventy percent of the patients received prophylaxis for more than 1 day post operation. The prolonged use of surgical prophylaxis is common in other countries.[3,33,34] Inappropriate prolonged use of prophylaxis in this study (54%) is higher than in Europe.[35] In contrast, a previous study reported that the use of perioperative surgical prophylaxis for more than 24 h ranged from 29.1% (UK) to 92.3% (Romania) in Europe; 70% of the 30 participating countries had more than half of the surgical operations surveyed and reported prolonged use of prophylaxis for more than 24 h post surgery. Such practice correlates with the cultural anthropological dimension of uncertainty avoidance.[36] In the context of uncertainties, evidence and practice guidelines can improve such inappropriate practices. Prolonged surgical prophylaxis is not only ineffective for postoperative infections but it increases the risk of side effects and AMR.[37]

Most of the PPS were conducted in upper-middle and high-income countries.[8] The WHO PPS tool meets the needs of resource-constrained countries.[7] Regular monitoring of antibiotic use in hospitals provides evidence for strengthening antibiotic stewardship; comparison across hospitals can lead to the strengthening of antibiotic stewardship in a larger number of healthcare facilities.[8] PPS should integrate antibiotic use and HAIs in order to optimize the use of the resources.[4]

As a good practice, we reported results and provided online educational training to all participating hospitals to improve their antibiotic stewardship. Furthermore, we found that WHO PPS methodology was practical and easy to use. We plan to conduct nationwide PPS on antibiotic use combined with PPS HAIs every 2–3 years in the same setting, and recruit more hospitals to increase the representativeness at the national level. The prevalence of antibiotic use and HAIs are key indicators for monitoring the progress of antibiotics stewardship, and infection prevention and control of AMR.[38] This study strengthens the technical and survey capacity among focal points in participating hospitals; these capacities can be deployed for future PPS.

The strength of this study was its ability to ascertain the patterns of antibiotic use and empower the hospital team to do their own regular monitoring. A few limitations were identified. First, the findings from this study cannot represent the country's prevalence of antibiotic use, even though one-quarter of the total number of large hospitals across Thailand participated in this study. This is one of the limitations of convenience sampling. Also, this study did not include private hospitals. Second, this cross-sectional PPS was done at one timepoint and may not be representative for the entire nation. Last, the appropriateness of antibiotic prescription was not evaluated by this study. Even though the majority of the hospitals have local antimicrobial guidelines available, the data on guideline compliance are scarce because there is a lack of documentation for the antibiotic use, which can lead to the differences in the surveyors' opinions of which antibiotic uses are and are not appropriate.

In conclusion, the prevalence and patterns of antibiotic use in Thailand were identified using the WHO PPS method. The findings from the study could be used as benchmarks for improving antibiotic prescription in the future. The WHO PPS is a simple, practical and feasible tool that can assess the prevalence and patterns of antibiotic use in inpatients in low- and middle-income countries. Regular PPS is encouraged to monitor antibiotic use and combat AMR.

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Transparency declarations

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Conceptualization: S.A., L.C., A.K., V. Thienthong, S.U., W.K. and V. Tangcharoensathien; data curation: S.A., L.C., A.K., V. Thienthong and S.U.; formal analysis: S.A. and J.S.; methodology: V.M., W.M., and V. Tangcharoensathien; project administration: V. Thienthong, W.K. and O.R.; supervision: V.M., W.M. and V. Tangcharoensathien; validation: O.R. and J.S.; writing—original draft: S.A.; writing—review and editing: L.C., A.K., S.U., J.S., V.M., W.M. and V. Tangcharoensathien. All authors have read and agreed to the published version of the manuscript.

Supplementary data

Tables S1 to S3 are available as Supplementary data at *JAC-AMR* Online.

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