National Survey of Practices to Prevent Methicillin-Resistant *Staphylococcus aureus* and Multidrug-Resistant *Acinetobacter baumannii* in Thailand

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Background. We evaluated the extent to which hospital characteristics, infection control practices, and compliance with prevention bundles impacted multidrug-resistant organism (MDRO) infections in Thai hospitals.

Methods. From 1 January 2014 to 30 November 2014, we surveyed all Thai hospitals with an intensive care unit and ≥250 beds. Infection control practices for methicillin-resistant *Staphylococcus aureus* (MRSA) and multidrug-resistant *Acinetobacter baumannii* (MDR-AB) were assessed. Linear regression was used to examine associations between hospital characteristics and prevention bundle compliance and changes in MDRO infection rates.

Results. A total of 212 of 245 (86.5%) eligible hospitals responded. Most hospitals regularly used several fundamental infection control practices for MRSA and MDR-AB (ie, contact precautions, private room/cohorting, hand hygiene, environmental cleaning, and antibiotic stewardship); advanced infection control practices (ie, active surveillance, chlorhexidine bathing, decolonization for MRSA, and hydrogen peroxide vaporizer for MDR-AB) were used less commonly. Facilities with ≥75% compliance with the MRSA prevention bundle experienced a 17.4% reduction in MRSA rates ($P = .03$). Although the presence of environmental cleaning services (41.3% reduction, $P = .01$) and a microbiology laboratory (82.8% reduction, $P = .02$) were among characteristics associated with decreases in MDR-AB rates, greater compliance with the MDR-AB prevention bundle did not lead to reductions in MDR-AB rates.

Conclusions. Although fundamental MRSA and MDR-AB control practices are used regularly in most Thai hospitals, compliance with more comprehensive bundled prevention approaches is suboptimal. Improving compliance with bundled infection prevention approaches and promoting the integration of certain hospital factors into infection control efforts may help reduce MDRO infections in Thai hospitals.

Keywords. national survey; multidrug-resistant; MRSA; *Acinetobacter baumannii*; Thailand.

Multidrug-resistant gram-positive and gram-negative pathogens are increasing worldwide and pose a major challenge for healthcare institutions [1–4]. In Southeast Asia, methicillin-resistant *Staphylococcus aureus* (MRSA) is the major resistant gram-positive pathogen, while multidrug-resistant *Acinetobacter baumannii* (MDR-AB) has become the most common resistant gram-negative pathogen in several patient populations [5, 6]. In Thailand, the National Antimicrobial Resistance Surveillance Thailand program established a national commitment to multidrug-resistant organism (MDRO) surveillance and patient safety over the past decade [7–10]. The hospital prevalence of MRSA in Thailand has been estimated to be 26% for colonization and infection, with higher estimates (65%) among intensive care unit (ICU) patients [7, 8].

Infection control interventions such as contact precautions, patient cohorting, hand hygiene, environmental cleaning, and the presence of an antimicrobial stewardship program are considered essential to prevent the spread of these resistant pathogens [11, 12]. Assessing the efficacy of individual and bundled infection control measures and determining predictors of increased compliance with these practices can add to our knowledge of infection prevention and inform policy to help prevent these resistant pathogens. We therefore conducted a national survey in Thailand to evaluate the impact of infection prevention practices used to prevent MRSA and MDR-AB, and to investigate the extent to which compliance with prevention practices impacts these pathogens.

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METHODS

Survey Instrument

From 1 January 2014 to 30 November 2014, we surveyed all hospitals in Thailand with an ICU and at least 250 hospitals

beds (n = 245). The list of hospitals that met our inclusion criteria was obtained from the Ministry of Public Health of Thailand. The survey instrument was first developed by Krein et al and Saint et al [13–15]. The survey was translated into Thai by an experienced hospital epidemiologist (A. A.). The survey assessed facility-wide, personnel, and infection control program characteristics. Infection control practices specific to MDROs inclusive of MRSA and MDR-AB were assessed.

The lead infection preventionist for each hospital was interviewed to determine the frequency of various infection prevention practices being used as well as the level of compliance to MRSA and MDR-AB prevention practices. Infection preventionists were asked about the frequency with which their hospital utilized the infection-specific prevention practices on a 5-point Likert scale for 5 fundamental (ie, contact precautions, private room/cohorting, hand hygiene, environmental cleaning, and antibiotic stewardship) and 4 advanced (ie, active surveillance for MRSA and MDR-AB, chlorhexidine bathing, decolonization for MRSA, and hydrogen peroxide vaporizer for MDR-AB) infection control measures. Responses of 4 (almost always) or 5 (always) were coded as "regular use" and the dichotomized variables were used in all analyses. For the compliance questions, infection preventionists were asked how often their hospital complied with the given practices, alone and as a bundle (scaled as 1 = "100%" to 6 = "No monitoring compliance"). Responses of 1 or 2 (75%–99%) were coded as high bundle compliance for all analyses. For MRSA, the bundled practices consisted of hand hygiene, contact isolation, antibiotic stewardship, patient cohorting, and at least 1 of the following: active surveillance, decolonization with mupirocin, chlorhexidine gluconate bathing, or environmental cleaning. For MDR-AB, the bundled practices consisted of hand hygiene, contact isolation, antibiotic stewardship, patient cohorting, and at least 1 of the following: active surveillance, environmental cleaning, chlorhexidine gluconate bathing, or hydrogen peroxide vaporizer. Hospitals reported annual aggregate infection rates for MRSA and MDR-AB at 2 time points (12 months before and 12 months after the implementation of specific infection control practices) as the number of cases per 1000 patient-days.

Trained research nurses used the survey instrument to interview the lead infection preventionist at each hospital. Three training sessions were held to instruct the 5 research nurses on the survey and data collection procedures. The survey instrument was pilot tested in 10 hospitals to ensure the validity, reliability, and acceptability of the survey results by 5 research nurses; 100% interrater agreement in the responses captured was observed in the pilot test. The study was approved by the Institutional Review Board at Thammasat University.

Statistical Analysis

Descriptive statistics are given for all pertinent survey questions. Multivariable logistic regression was used to determine significant associations between hospital characteristics and regular use of MRSA and MDR-AB infection prevention practices. Multivariable linear regression models were used to assess the associations between high compliance with the MRSA and MDR-AB prevention bundles and relative reductions in the respective infection rates. Hospital characteristics considered included type of ownership, number of acute care beds, affiliation with a medical school, presence of hospitalists, involvement in a collaborative to reduce hospital infections, support of the infection control program from leadership, presence of a hospital epidemiologist, total full-time equivalent of all infection preventionists, and whether the lead infection preventionist is certified in infection control. Additionally, whether or not the hospital has an infectious diseases physician, presence of environmental cleaning services, facilities maintenance department, or microbiology laboratory were also included as covariates if they were statistically significant in a bivariable model. Multivariable linear regression models were used to assess relative reductions in MRSA and MDR-AB rates. In addition to the questions mentioned above, the relative reduction models were additionally adjusted for selected infection prevention practices. All models were adjusted for whether or not the hospital has an established surveillance system for monitoring infection rates. All analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

Of the 245 eligible hospitals, 212 (86.5%) responded to our survey. General hospital and infection control characteristics are shown in Table 1. Nearly 97% of hospitals reported having hospitalists, 94.8% had a microbiology laboratory, and 92.5% had an infection preventionist who was certified in infection control. Approximately half of all hospitals were affiliated with a medical school (52.4%), had infection disease specialists (50.9%), and were involved in a healthcare-associated infection (HAI) collaborative (49.5%).

The percentages of regular use of fundamental and advanced infection control measures for patients infected with MRSA and MDR-AB are shown in Table 2. The majority of hospitals regularly used contact precautions (77.4%), private rooms or cohorting (72.2%), appropriate hand hygiene (84.0%), and environmental cleaning of patients' room and surroundings (85.4%). In this national cohort, overall use of an antibiotic stewardship program was observed in more than half of the hospitals surveyed (54.2%). Only 37.3% of facilities regularly used active surveillance cultures for colonization of MRSA and 22.6% regularly decolonized the nose and skin of patients colonized with MRSA prior to surgery. Fewer hospitals regularly used active surveillance culturing (36.3%), chlorhexidine bathing for the patients infected with MDR-AB (31.1%), or hydrogen peroxide room disinfection system of the MDR-AB–infected patients' room and surroundings for terminal disinfection (21.2%).

Table 1. Respondent Hospital Characteristics (n = 212)

Characteristic	No. (%)
Region	
Northern	14 (6.6)
Southern	20 (9.4)
Central	106 (50.0)
Northeastern	36 (17.0)
Eastern	22 (10.4)
Western	14 (6.6)
Facility ownership	
Private	44 (20.8)
Government-owned	148 (69.8)
Military	20 (9.4)
Total No. of acute care hospital beds (including ICU), mean ± SD	545.9 ± 468.5
Medical school affiliation	111 (52.4)
Infectious diseases specialist(s)	108 (50.9)
Environmental cleaning services	130 (61.3)
Facilities maintenance department	144 (67.9)
Microbiology laboratory	201 (94.8)
Hospitalists	205 (96.7)
HAI collaborative	105 (49.5)
Good/excellent support of infection control program	135 (63.7)
Hospital epidemiologist	83 (39.2)
Total FTE for all infection preventionists, mean ± SD	3.5 ± 3.4
Lead infection preventionist certified in infection control	196 (92.5)
Antibiotic stewardship[a]	115 (54.2)

Data are shown as No. (%) unless otherwise indicated.Abbreviations: FTE, full-time equivalent; HAI, healthcare-associated infection; ICU, intensive care unit.[a]For prevention of multidrug-resistant *Acinetobacter baumannii*.

The odds ratios and 95% confidence intervals for select characteristics associated with MDRO prevention practices are also presented in Table 2. For MRSA, involvement in an HAI collaborative, leadership support of infection control, and the presence of a facilities maintenance department were all significantly associated with increased active surveillance cultures for colonization. Leadership support of infection control was significantly associated with increased regular use of the following 5 MDR-AB infection prevention practices: contact precautions, private rooms or cohorting of patients, hand hygiene, environmental cleaning of infected patients' room and surroundings, and chlorhexidine bathing.

Compliance rates for MRSA and MDR-AB prevention practices were very similar. Nearly two-thirds of responding hospitals reported ≥75% compliance using hand hygiene (65.6% for MRSA, 64.2% for MDR-AB). More than 60% of hospitals reported compliance with hand hygiene and contact isolation in patients with MRSA (62.3%) or MDR-AB (61.3%). Compliance with antibiotic stewardship (45.8% for both MRSA and MDR-AB) and patient cohorting (40.1% for MRSA, 42% for MDR-AB) was lower. Nearly 40% of hospitals reported at least 75% compliance for the MRSA (37.0%) and MDR-AB (38.7%) prevention bundles.

Multivariable model results for changes in MRSA and MDR-AB infection rates are presented in Tables 3 and 4, respectively. Facilities with ≥75% compliance with the prevention bundle for MRSA experienced on average a 17.4% reduction in MRSA rates (P = .03). Involvement in a collaborative to reduce HAI was also associated with a reduction in MRSA rates (18.9%, P = .01). Although several individual factors were associated with changes in MDR-AB rates (presence of environmental cleaning services [41.3% reduction, P = .01], facilities maintenance department [33.3% reduction, P = .04], and microbiology laboratory [82.8% reduction, P = .02]), achieving high compliance with the prevention bundle for MDR-AB was not significantly associated with MDR-AB reductions.

DISCUSSION

Several important findings emerged from this national survey in Thailand. First, although most hospitals reported regular use of fundamental infection control measures to reduce MRSA and MDR-AB transmission, advanced infection control measures were less commonly performed. Second, we noticed that compliance with prevention bundles—consisting of fundamental and advanced infection control measures—to contain both MRSA and MDR-AB was less than optimal. This is especially important as infection prevention interventions have been reported effective only when compliance is high [16, 17]. Third, hospitals reporting high compliance with the prevention bundle for MRSA were more successful at reducing MRSA. Additionally, hospitals with better infection control infrastructure and support were more likely to reduce MDR-AB. Taken together, these findings suggest the need for continued education and process surveillance to ensure compliance with infection control measures to prevent MDRO infections in Thailand.

A previous study, using similar methodology, conducted by Apisarnthanarak and colleagues found that medical school affiliation and participating in an HAI collaborative were associated with infection control policies to prevent MRSA, and having a physician as the head of infection control, strong leadership support of the infection control program, participating in a collaborative effort to reduce hospital infections, and a strong organizational safety culture were associated with infection control policies to prevent MDR-AB [18]. In the current study, we identified a similar rate of implementing fundamental infection control measures with slight improvement in advanced infection control measure implementation. Our current findings confirm that leadership support of infection control programs and participation in a collaborative effort to reduce hospital infections remains crucial for MRSA and MDR-AB prevention. We also found that the lead infection preventionist being certified in infection control was associated with increased compliance to advanced infection control practices to prevent MDR-AB. This could be partly explained by the governmental Thai curriculum created in 2000 intended to provide formal training for postgraduate physicians who plan to head infection control. Whether this advanced training could impact competency of

Table 2. Characteristics Significantly Associated With Regular Use of Specific Methicillin-Resistant *Staphylococcus aureus* and Multidrug-Resistant *Acinetobacter baumannii* Prevention Practices

Characteristic	OR	(95% CI)	*P* Value	Infection Prevention Practice	Regular Use
Practices specific to MRSA prevention					
Medical school affiliation	0.35	(.17–.73)	.005	Active surveillance cultures	37.30%
Facilities maintenance department	8.40	(3.44–20.52)	<.0001		
HAI collaborative	2.35	(1.16–4.73)	.02		
Good/excellent support of infection control program	2.09	(1.04–4.20)	.04		
Facilities maintenance department	2.82	(1.07–7.41)	.04	Decolonization of the nose and skin in colonized patients prior to surgical procedure	22.60%
HAI collaborative	2.46	(1.12–5.37)	.02		
Practices specific to MDR-AB prevention					
Facilities maintenance department	2.39	(1.06–5.37)	.04	Contact precautions while caring for infected patients	77.40%
Good/excellent support of infection control program	2.20	(1.09–4.46)	.03		
Lead infection preventionist certified in infection control	4.19	(1.26–13.96)	.02		
Type of ownership				Private rooms or cohorting of infected patients	72.20%
Private	4.22	(1.38–12.93)	.01		
Government-owned		Ref			
Military	2.11	(.61–7.33)	.24		
Good/excellent support of infection control program	2.37	(1.22–4.61)	.01		
Lead infection preventionist certified in infection control	3.41	(1.11–11.41)	.05		
Involved with a collaborative effort to reduce HAI	2.86	(1.13–7.22)	.03	Appropriate hand hygiene	84.00%
Good/excellent support of infection control program	3.33	(1.46–7.62)	.004		
Lead infection preventionist certified in infection control	5.74	(1.43–23.05)	.01	Antibiotic stewardship program	54.20%
Good/excellent support of infection control program	3.97	(1.70–9.27)	.001	Environmental cleaning of infected patients' room and surroundings	85.40%
Good/excellent support of infection control program	2.21	(1.10–4.46)	.03	Chlorhexidine bathing for infected patients	31.10%
None				Hydrogen peroxide vaporization of infected patients' room and surroundings	21.20%
Medical school affiliation	0.36	(.17–.74)	.01	Active surveillance cultures	36.30%
Facilities maintenance department	3.63	(1.57–8.43)	.003		
HAI collaborative	2.50	(1.24–5.03)	.01		

Abbreviations: CI, confidence interval; HAI, healthcare-associated infection; MDR-AB, multidrug-resistant *Acinetobacter baumannii*; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio.

healthcare epidemiology programs in resource-limited settings should be further assessed [19–21].

Increasing compliance levels for utilizing infection control measures has been emphasized as a key component for success-ful outcomes in several guidelines for MDRO prevention efforts [22–24]. However, the optimal compliance level for success-ful MDRO control is unknown. In this survey, we found that compliance rates for the various MRSA and MDR-AB prevention practices were very similar and ranged from approximately 40% to >75%. Not surprisingly, advanced infection control measures had a lower compliance rate than fundamental measures. Of interest, facilities with ≥75% compliance with fundamental infection control measures plus either active surveillance, decolonization with mupirocin, chlorhexidine bathing, or environmental

Table 3. Rates of Methicillin-Resistant *Staphylococcus aureus*—Multivariable Regression

Characteristic	Estimate	(95% CI)	*P* Value
Type of ownership			
Government-owned		Ref	
Private	–0.0158	(–.2122 to .1807)	.87
Military	–0.1358	(–.3902 to .1186)	.30
No. of acute care beds	0.0001	(–.0002 to .0003)	.62
Medical school affiliation	–0.115	(–.2699 to .04)	.15
Hospitalists	0.2999	(–.1151 to .715)	.16
HAI collaborative	–0.1889	(–.3397 to –.0381)	.01
Good/excellent support of infection control program	–0.1077	(–.2628 to .0474)	.17
Hospital epidemiologist	0.257	(.103–.411)	.001
Total FTE for all infection preventionists	–0.0176	(–.0426 to. 0074)	.17
Lead infection preventionist certified in infection control	–0.0325	(–.3072 to .2421)	.82
Gram-positive bacteria bundle: hand hygiene + contact isolation + antibiotic stewardship + patient cohorting + at least 1 of the following: active surveillance, decolonization with mupirocin, chlorhexidine gluconate bathing, or environmental cleaning	–0.1737	(–.3279 to –.0195)	.03

Abbreviations: CI, confidence interval; FTE, full-time equivalent; HAI, healthcare-associated infection.

Table 4. Rates of Multidrug-Resistant *Acinetobacter baumannii*—Multivariable Regression

Characteristic	Estimate	(95% CI)	*P* Value
Type of ownership			
Government-owned		Ref	
Private	–0.0042	(–.3871 to .3786)	.98
Military	0.4359	(–.0389 to .9108)	.07
No. of acute care beds	0.0003	(–.0001 to .0007)	.10
Medical school affiliation	0.128	(–.1806 to .4365)	.42
Environmental cleaning service	–0.4126	(–.7353 to –.09)	.01
Facilities maintenance department	–0.3331	(–.651 to –.0153)	.04
Microbiology laboratory	–0.828	(–1.4996 to –.1565)	.02
Hospitalists	0.4603	(–.3563 to 1.277)	.27
HAI collaborative	–0.11	(–.4141 to .1941)	.48
Good/excellent support of infection control program	0.1502	(–.1409 to .4412)	.31
Hospital epidemiologist	–0.134	(–.4252 to .1572)	.37
Total FTE for all infection preventionists	–0.0267	(–.0747 to .0214)	.28
Lead infection preventionist certified in infection control	0.0767	(–.4493 to .6028)	.77
Gram-negative bacteria bundle: hand hygiene + contact isolation + antibiotic stewardship + patient cohorting + at least 1 of active surveillance, environmental cleaning, chlorhexidine gluconate bathing, or hydrogen peroxide vaporizer	–0.1572	(–.4534 to .1389)	.30

Abbreviations: CI, confidence interval; FTE, full-time equivalent; HAI, healthcare-associated infection.

cleaning for MRSA prevention experienced on average a 17.4% reduction in MRSA rates over a year, while having sophisticated infrastructure facility factors (eg, environmental cleaning services, facilities maintenance department division, microbiology laboratory) were associated with MDR-AB rate reductions. These findings imply the need to have high-level compliance for both fundamental and advanced infection control measures for successful MRSA containment, while environmental cleaning is seemingly crucial for the control of MDR-AB. As prior studies have demonstrated the potential roles of airborne and waterborne transmission in MDR-AB infections [25–28], hospitals better equipped to limit these transmission routes due to better facility infrastructure and resources (eg, having a facilities maintenance department division and microbiology laboratory) will likely achieve better infection control for MDR-AB than hospitals with limited resources.

Our study has several important limitations. First, because the response rate was <100%, our results are susceptible to nonresponse bias. Although we achieved a very high response rate, our findings may not be generalizable to all hospitals in Thailand. Second, as we relied on self-reported data from the lead infection preventionist to determine the frequency of various infection control practices being used, there is a potential for response bias. Third, MDRO infection rates at 2 time points were based on reported estimates from the lead infection preventionist at each hospital. Absent longitudinal infection rate data, reported rates in our study are prone to response bias. Finally, we did not have access to (and thus could not adjust for) patient-level or hospital case-mix data. As such, our regression adjustments could be biased because of unmeasured confounding, and our results can only be interpreted as providing evidence for associations rather than causal mechanisms.

Despite these limitations, our study identified several areas of focus for quality improvement efforts for MDRO infection prevention in Thai hospitals. Key quality improvement targets include education in implementing bundled prevention approaches that include advanced infection control measures. Continued government support for formal training on infection prevention for postgraduate physicians who become lead infection preventionists, enhancement of facility factors and safety structure, and infection control compliance level monitoring for both fundamental and advanced infection control measures are essential components to help reduce the burden of MRSA and MDR-AB in Thai hospitals.

Notes

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