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Identifying hospital-level predictors for antibiotic use: a Global Point Prevalence Survey study among Belgian, Philippine and South African hospitals

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Introduction: Understanding determinants that influence antibiotic use is crucial for developing effective stewardship interventions that optimize the use of antibiotics and ultimately mitigate the burden of antibiotic resistance. This study aims to find hospital-level predictors of antibiotic use among hospitals worldwide.

Methods: Antibiotic use data were collected from hospitals that participated in 2022–23 in the Global Point Prevalence Survey (Global-PPS) basic inpatient and Healthcare-Associated Infection (HAI) modules from three countries with high participation degrees: Belgium, the Philippines and South Africa. A linear mixed model was applied to predict hospital-level prevalence, considering all variables from the Global-PPS as potential predictors. Stepwise forward and backward selection modelling were conducted to identify the best-fitting models per country separately.

Results: In total, data from 138 hospitals were retrieved, including 19 Belgian, 55 Philippine and 64 South African hospitals. No predictors were shared across the three countries, such as hospital type, proportion of occupied medical beds and proportion of available guidelines. However, the proportions of admitted patients with certain invasive devices were significant predictors for increased odds of hospital-wide antibiotic prescribing, despite the type of invasive device varying between countries.

Conclusions: Factors related to the patient mix, including the proportion of patients with an invasive device, are associated with increased odds of antibiotic prescribing at hospital level. Considering substantial differences in predictors associated with country-specific patient populations and hospital characteristics, more research is needed to explore additional determinants, such as healthcare system and broader contextual factors that may influence hospital-level antibiotic prevalence.

Introduction

Antibiotic resistance is a globally recognized major healthcare threat, with over one million associated deaths in 2021 only,[1] and is mostly attributed to the misuse and overuse of antibiotics worldwide. Understanding the factors that drive antibiotic use is crucial for developing effective interventions that might optimize the use of antibiotics and ultimately mitigate the burden of antibiotic resistance.

Previously identified factors associated with increased antibiotic use among admitted patients include several patient characteristics, such as male sex,[2–5] racial groups,[5] age group[6] and religion,[6] as well as age group of the prescriber.[7] Identified factors related to the healthcare system and setting include the availability of clinical guidelines,[6] several financial and economic factors,[6,8] health and transport infrastructure,[6] and relative humidity.[6]

Notably, there is a lack of studies identifying organization-level predictors of antibiotic use, such as hospital characteristics like patient mix. Such factors can also be useful for hospitals to estimate and compare their antibiotic prescribing patterns with those of other institutions. However, large heterogeneity in antibiotic prescribing patterns,[9] and the wide variety in data collection techniques, may influence these organization-level predictors of antibiotic use. Therefore, this study aims to find predictors for antibiotic prescribing among hospitals of three different countries: Belgium, the Philippines and South Africa, taking their heterogeneity into consideration.

Methods

Included data

Cross-sectional antibiotic prescribing data were gathered from the Global Point Prevalence Survey (Global-PPS) inpatient dataset. We selected hospitals that had participated in the basic inpatient with the optional Healthcare-Associated Infection (HAI) module, which collects more detailed information on the use of invasive devices for all admitted inpatients and risk factors for antibiotic prescribing for those on at least one antibiotic. Furthermore, we restricted inclusion to hospitals from countries where at least 10 hospitals had participated in the years under review to maximize statistical power. Consequently, we retained 19 hospitals from Belgium, 55 from the Philippines (both year 2022), and 64 from South Africa (year 2023) (Table 1). The inpatient protocol and data collection templates are described in Appendices I and II.

Model development

A linear mixed model[11] was applied to predict hospital-level prevalence of antibiotics (ATC code J01) per country separately with hospital as a random effect to correct for the association of the measurements within hospitals. The logit-transformed prevalence was chosen as primary outcome of the model to limit the prevalence between 0 and 1, since it was defined as a proportion. An alternative way of modelling, such as logistic regression, was not possible as detailed information of the patients without antimicrobial use was not included in the Global-PPS protocol.

All available variables collected in the Global-PPS dataset were considered as candidate predictors, apart from treatment regimen and prophylaxis type (medical or surgical) (Appendix III). We retained the proportion of patients receiving antibiotics with a community-acquired infection (CAI) or HAI as predictors, even though they were derived from the same underlying variable as the prophylaxis types, because both factors are not necessarily direct characteristics of the treatment but might represent important characteristics of the patient mix and hence influence overall antibiotic prescribing at hospital-level.

All predictors were calculated at hospital- or ward-level (Appendix III). Hospital-level variables included level of care ('hospital type'), teaching status, presence of certain ward types, total number of surveyed beds and bed occupancy rate, while ward-level variables include detailed information on the admitted patients, such as proportion of patients receiving targeted antibiotic treatment, patients with at least one invasive device, patients with multiple morbidities, etc. (Table 1 and Appendix III).

Candidate predictors were included in the first step of the analysis if the proportion/prevalence was non-missing. Predictors were excluded if there was more than 50% missingness, or if the predictor was highly correlated with another variable, defined as having a Pearson 's or Spearman's correlation of 0.95 or higher. From the two highly correlated predictors, the easiest interpretable one was selected.

A final model was built for each country separately by forward model selection and backward extraction. In forward model selection, starting with a univariate linear mixed model, predictors were added one by one to the model, beginning with the predictor that had the lowest *P* value. Predictors were added to the forward model using likelihood ratio tests with a significance level of 20%.

In backward extraction, the predictors were excluded one by one from the model obtained from forward selection, starting with the least influential predictor, until all remaining model predictors were significant at level 5%. The likelihood ratio test was applied to determine significance.

To facilitate interpretation of the regression coefficients, we exponentiated the coefficients of the final model, which included all selected predictors, to compute odds ratios (ORs). These represent the relative change in the odds of hospital-wide antibiotic utilization associated with a one-unit increase in each predictor, conditioned on the other predictors. For predictors expressed as proportions, we additionally computed ORs for 10% increments, calculated as OR^0.1. These increments were chosen to facilitate clinical interpretation, since 100% increments for proportional predictors are clinically improbable and generate extreme, difficult-to-interpret estimates. All analyses were carried out in R (version 4.3.1).

Results

In total, 138 hospitals participating in 2022 and 2023 were included, of which 19 Belgian hospitals, 55 Philippine hospitals and 64 South African hospitals (Table 1). Data were merged at hospital level for hospitals that had participated multiple times within one year. One (0.7%) hospital declined participation in this study.

Belgian model

Most Belgian hospitals included in this study were general hospitals (94.7%). In total, 4722 admitted patients and 1407 patients treated with an antibiotic were surveyed (Table 1). Most patients were admitted to adult wards (93.3%) (Table 1). Peripheral vascular catheters were inserted in 45.5% of the admitted patients, and urinary catheters in 14.5% (Table 1). Among patients treated with an antibiotic, 50.3% were male, 34.7% underwent a surgical procedure during their current admission, 22.3% had an HAI, and 19.0% had ultimately or rapidly fatal disease according to the McCabe score (Table 1). For most antibiotic prescriptions, guidelines were available (94.4%), a reason for the treatment was documented (89.7%) and a stop/review date was recorded (55.1%) (Table 1).

Our final model including 19 Belgian hospitals indicated that a 10% increase in the proportion of admitted patients with a urinary catheter was associated with a 35% increase in the odds of hospital-wide antibiotic utilization (OR = 1.35, 95% CI: 1.24–1.46), compared to a 21% increase in these odds per 10% increase in the proportion of treated patients with a previous non-ICU admission (OR = 1.21, 95% CI: 1.07–1.38), and a 31% decrease in the odds per 10% increase in the proportion of antibiotic prescriptions with existing guidelines (OR = 0.69, 95% CI: 0.51–0.93) (Table 2 and Figure 1).

Table 1. Hospital and patient characteristics used in the linear mixed model to identify important predictors for antibiotic use in Belgian, Philippine and South African hospitals

Characteristics	Belgium	Philippines	South Africa
N hospitals	19	55	64
N surveys (Basic + HAI module)[a]	19	100	68
Years	2022	2022	2023
N admitted patients	4722	20131	10875
N antibiotic prescriptions	1603	15074	4816
N patients treated with antibiotics	1407	10384	3482
Antibiotic prevalence	29.8%	51.6%	32.0%
N adults treated with antibiotics	1323	7333	2277
N children treated with antibiotics	80	1971	819
N neonates treated with antibiotics	4	1080	386
Mean age of treated patients in years (SD)	66.1 (22.6)	36.1 (26.5)	31.0 (25.1)
Median age of treated patients in years (IQR)	72 (58–83)	35 (12–58)	31 (3–50)
Top 5 most common comorbidities among patients treated with antibiotics (*n*, %)	Diabetes mellitus 261 (19.7)	Diabetes mellitus 1232 (16.8)	AIDS/HIV 445 (19.5)
	Haematological or solid cancer 230 (17.4)	Chronic Renal Disease 693 (9.5)	Diabetes mellitus 277 (12.2)
	Chronic lung disease 217 (16.4)	Haematological or solid cancer 598 (8.2)	Haematological or solid cancer 153 (6.7)
	Chronic neurological conditions 206 (15.6)	Chronic lung diseases 447 (6.1)	Tuberculosis 124 (5.4)
	Chronic renal disease 164 (12.4)	Tuberculosis 277 (3.8)	Chronic renal disease 105 (4.6)
Candidate predictors			
N teaching hospitals (%)	5 (26.3)	31 (56.4)	30 (46.9)
N primary or secondary ('general') hospitals (%)	18 (94.7)	11 (20.0)	44 (68.8)
N tertiary hospitals (%)	1 (5.3)	40 (72.7)	18 (28.1)
N infectious diseases hospital (%)	0 (0.0)	2 (3.6)	0 (0.0)
N other hospitals (%)	0 (0.0)	2 (3.6)	2 (3.1)
N hospitals with ICU, transplant or ID ward (%)	17 (89.5)	53 (96.4)	39 (60.9)
N hospitals with obstetrics or gynaecology ward (%)	10 (52.6)	24 (43.6)	34 (53.1)
N hospitals with haemato-oncology ward (%)	7 (36.8)	13 (23.6)	7 (10.9)
N hospitals with long-term care, geriatric, or rehabilitation wards (%)	15 (78.9)	1 (1.8)	0 (0.0)
N beds (median, IQR)	336 (196–402.5)	424 (223.5–729)	147.5 (76.75–261.75)
N surgical beds (median, IQR)	77 (52.5–92)	113 (37–208.5)	34.5 (10.5–90.5)
N medical beds (median, IQR)	206 (138.5–300)	281 (137.5–437)	84 (49.25–167.25)
N ICU beds (median, IQR)	12 (10.5–18.5)	51 (24–104)	5.5 (0.0–28.0)
N occupied beds (median, IQR)	66 (52–89.5)	140 (66.5–276.0)	35.5 (20.25–69.25)
N occupied surgical beds (median, IQR)	0 (0–2.5)	0 (0–8)	0 (0–0)
N occupied medical beds (median, IQR)	45 (29.5–59)	101 (53–180)	25 (10.75–40.5)
N occupied ICU beds (median, IQR)	4 (2–6.5)	18 (9–37.5)	3 (0–13)
N admitted adult patients (%)	4404 (93.3)	15256 (75.8)	8285 (76.2)
N admitted paediatric patients (%)	251 (5.3)	3207 (15.9)	1540
N admitted neonatal patients (%)	67 (1.4)	1668 (8.3)	1050

Patients with… among all admitted patients				
Urinary catheter	*N* patients (%)	683 (14.5)	2888 (14.3)	1646 (15.1)
	Median (IQR)	7 (1–15)	4 (0–15)	3 (0–9)
Peripheral vascular catheter	*N* patients (%)	2149 (45.5)	14 302 (71.0)	4592 (42.2)
	Median (IQR)	18 (5.5–34)	29 (9–73)	13 (5–29)
Central vascular catheter	*N* patients (%)	367 (7.8)	1377 (6.8)	539 (5.0)
	Median (IQR)	4 (1–7.5)	1 (0–4)	0 (0–3)
Non-invasive mechanical ventilation	*N* patients (%)	44 (0.9)	935 (4.6)	274 (2.5)
	Median (IQR)	0 (0–1)	1 (0–4)	0 (0–1)
Invasive respiratory endotracheal intubation	*N* patients (%)	60 (1.2)	1059 (5.3)	319 (2.9)
	Median (IQR)	0 (0–1)	1 (0–5)	0 (0–1)
Inserted tubes and drains	*N* patients (%)	348 (7.4)	1921 (9.5)	556 (5.1)
	Median (IQR)	2 (0.5–7)	3 (0–9)	0 (0–2)
Number of patients with… among all patients receiving antibiotics (%)				
Treatment based on biomarker[b]		137 (58.1)	—	—
Targeted antibiotic treatment		464 (33.0)	1269 (12.2)	446 (12.8)
Community-acquired infections		834 (59.3)	4949 (47.7)	1865 (53.6)
Healthcare-associated infections		315 (22.3)	1893 (18.2)	768 (22.1)
Previous ICU hospitalization		25 (1.7)	211 (2.0)	174 (5.0)
Previous non-ICU hospitalization		402 (28.6)	1418 (13.7)	798 (22.9)
Ultimately/rapidly fatal disease (McCabe score)[10]		267 (19.0)	1806 (17.4)	537 (15.4)
Surgical procedures during current admission		489 (34.7)	2901 (27.9)	947 (27.2)
Previous antibiotic use		364 (25.9)	1430 (13.8)	757 (21.7)
Male patients		707 (50.3)	5097 (49.1)	1697 (48.7)
Multiple comorbidities		327 (23.2)	741 (7.1)	266 (7.6)
Number of antibiotic prescriptions with… (%)				
Existing guidelines among antibiotic prescriptions[c]		1566 (94.4)	14 505 (96.2)	4430 (92.0)
Documented reason for prescription[c]		1405 (89.7)	11 841 (78.6)	3977 (82.6)
Recorded stop/review date[c]		863 (55.1)	8233 (54.6)	1779 (36.9)

[a]Hospitals participated in maximum 3 surveys per year.
[b]Biomarker data are excluded from analyses for the Philippines and South Africa due to the amount of missing data.
[c]Unknown values are excluded from the analyses.

Table 2. Relative change in the odds of hospital-wide antibiotic utilization associated with a one-unit and 10% increase in each predictor from a linear mixed model among 19 Belgian hospitals

Predictor	*N* (%)	Coefficient (95% CI)	Relative change in odds (95% CI)	Relative change in odds for 10% increments (95% CI)	*P* value[a]
Proportion of antibiotic prescriptions with existing guidelines	1566 (94.4)	−3.72 (−6.72 to 0.69)	0.02 (0.00–0.50)	0.69 (0.51–0.93)	0.020
Proportion of patients with a previous hospital (non-ICU) admission among patients receiving antibiotics	402 (28.6)	1.94 (0.66–3.21)	6.94 (1.94–24.84)	1.21 (1.07–1.38)	0.003
Proportion of admitted patients with a urinary catheter	683 (14.5)	2.97 (2.14–3.81)	19.47 (8.47–45.27)	1.35 (1.24–1.46)	0.000

[a]Applies to both relative changes in odds.

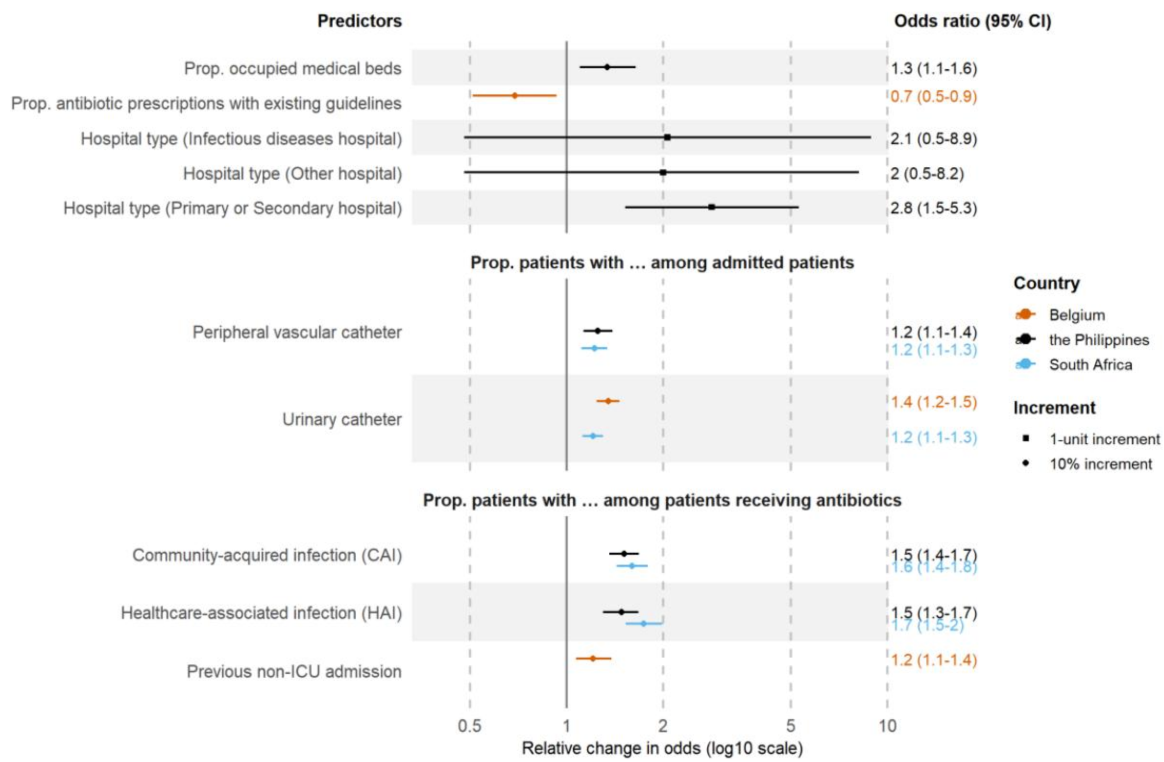

Figure 1. Relative change in the odds of hospital-wide antibiotic utilization associated with a one-unit and 10% increase in each predictor from a linear mixed model among 138 Belgian, Philippine and South African hospitals. Values are presented on a logarithmic scale (base 10). Abbreviations: Prop. = proportion.

Philippine model

Most Philippine hospitals were tertiary hospitals (72.7%) (Table 1). A total of 20 131 admitted patients and 10 384 patients treated with an antibiotic were surveyed. A majority of patients were admitted to adult wards (75.8%) (Table 1). Peripheral vascular catheters (71.0%) and urinary catheters (14.3%) were frequently inserted in admitted patients. Among patients treated with an antibiotic, 49.1% were male, 27.9% underwent a surgical procedure during their current admission, 17.4% had an ultimately or rapidly fatal disease (McCabe score), 13.8% had previously received antibiotics, and 18.2% had an HAI (Table 1). For many antibiotic prescriptions, guidelines were available (96.2%), a reason for the treatment was recorded (78.6%), and a stop/review date was documented (54.6%) (Table 1).

In the final model containing data from 55 Philippine hospitals, a 10% increase in the proportion of patients with a CAI among those receiving antibiotics was associated with a 51% increase in the odds of hospital-wide antibiotic utilization (OR = 1.51, 95% CI: 1.36–1.68) (Table 3 and Figure 1). This increase in odds was 48% per 10% increase in the proportion of patients

Table 3. Relative change in the odds of hospital-wide antibiotic utilization associated with a one-unit and 10% increase in each predictor from a linear mixed model among 55 Philippine hospitals

Predictor	*N* (%)	Coefficient (95% CI)	Relative change in odds (95% CI)	Relative change in odds for 10% increments (95% CI)	*P* value[a]
Hospital type (Primary or Secondary hospital)	11 (20.0)	1.04 (0.42–1.67)	2.83 (1.52–5.29)	—	0.002
Hospital type (Infectious diseases hospital)	2 (3.6)	0.72 (−0.74–2.18)	2.06 (0.48–8.87)	—	**0.330**
Hospital type (Other hospital)	2 (3.6)	0.69 (−0.73–2.10)	2.00 (0.48–8.15)	—	**0.331**
Proportion occupied medical beds	45 (29.5–59)	2.95 (1.00–4.97)	19.20 (2.71–142.72)	1.34 (1.10–1.64)	0.004
Proportion of patients with … among patients receiving antibiotics					
Community-acquired infections as indication	4949 (47.7%)	4.14 (3.11–5.17)	62.78 (22.38–175.67)	1.51 (1.36–1.68)	0.000
Healthcare-associated infections as indication	1893 (18.2%)	3.91 (2.66–5.14)	49.87 (14.30–171.20)	1.48 (1.30–1.67)	0.000
Proportion of admitted patients with … among all admitted patients					
Peripheral vascular catheter	14 302 (71.0%)	2.25 (1.20–3.29)	9.49 (3.33–26.89)	1.25 (1.13–1.39)	0.000

[a]Applies to both relative changes in odds.

Table 4. Relative change in the odds of hospital-wide antibiotic utilization associated with a one-unit and 10% increase in each predictor from a linear mixed model among 64 South African hospitals

Predictor	*N (%)*	Coefficient (95% CI)	Relative change in odds (95% CI)	Relative change in odds for 10% increments (95% CI)	*P* value[a]
Proportion of patients with … among patients receiving antibiotics					
Community-acquired infections as indication	1865 (53.6)	4.70 (3.60–5.81)	110.3 (36.53–333.03)	1.60 (1.43–1.79)	0.000
Healthcare-associated infections as indication	768 (22.1)	5.54 (4.25–6.83)	225.21 (69.97–929.09)	1.74 (1.53–1.98)	0.000
Proportion of patients with … among admitted patients					
Urinary catheter	1646 (15.1)	1.88 (1.16–2.61)	6.57 (3.18–13.58)	1.21 (1.12–1.30)	0.000
Peripheral vascular catheter	4592 (42.2%)	1.97 (1.00–2.94)	7.17 (2.73–18.88)	1.22 (1.11–1.34)	0.000

[a]Applies to both relative changes in odds.

with a HAI (OR = 1.48, 95% CI: 1.30–1.67), 34% for the proportion of occupied medical beds (OR = 1.34, 95% CI: 1.10–1.64), and 25% for the proportion of admitted patients with a peripheral vascular catheter (OR = 1.25, 95% CI: 1.13–1.39) (Table 3). Compared to tertiary care hospitals, primary or secondary hospital types was associated with a 2.8-fold increase in the odds of hospital-wide antibiotic utilization (OR = 2.83, 95% CI: 1.52–5.29), while infectious disease and other hospital types showed no significant change in these odds (Table 3).

South African model

A total of 10 875 admitted patients and 4816 patients treated with an antibiotic were surveyed, mostly from general hospitals (68.8%) (Table 1). Many admitted patients stayed in adult wards (76.2%) and had a peripheral vascular catheter (42.2%) and a urinary catheter (15.1%). Among patients treated with an antibiotic, 48.7% were male, 27.2% underwent a surgical procedure during current admission, 21.7% previously received antibiotics, 22.1% had an HAI, and 15.4% had an ultimately or rapidly fatal disease according to the McCabe score (Table 1). Guidelines were available for 92.0% of all antibiotic prescriptions, a reason for the treatment was recorded for 82.6%, and the stop/review date was recorded for 36.9% (Table 1).

In the final model for South Africa, including 64 hospitals, a 10% increase in the proportion of patients with an HAI among those receiving antibiotics was associated with a 74% increase in the odds of hospital-wide antibiotic utilization (OR = 1.74, 95% CI: 1.53–1.98) (Table 4 and Figure 1). This increase in odds was 60% per 10% increase in the proportion of patients treated for a CAI (OR = 1.60, 95% CI: 1.43–1.79), 22% for the proportion of admitted patients with a peripheral vascular catheter (OR = 1.22, 95% CI: 1.11–1.34), and 21% for the proportion of admitted patients with a urinary catheter (OR = 1.21, 95% CI: 1.12–1.34) (Table 4).

The estimates of the linear mixed model and the type III ANOVA tests for all three countries are included in the supplementary materials (Appendices IV and V) (available as Supplementary data at *JAC-AMR* Online).

Discussion

While many point prevalence studies have described local, national, or cross-country antibiotic prescribing patterns, few have explored the underlying determinants that drive these practices, particularly across multiple countries. This study, therefore, investigated predictors for hospital-wide antibiotic utilization among 138 hospitals in Belgium, the Philippines and South Africa.

From the Global-PPS dataset, we identified no common predictors associated with increased odds of hospital-wide antibiotic utilization across all three countries, although higher proportions of admitted patients with invasive devices seemed key factors. These and other factors related to the patient mix were associated with increased odds of hospital-wide antibiotic utilization in this study: in Belgium, key factors include higher proportions of admitted patients with a urinary catheter and patients with a previous non-ICU admission among those who received antibiotics. In both the Philippines and South Africa, identified predictors include higher proportions of patients treated for a CAI or HAI, as well as increased proportions of admitted patients with a peripheral vascular catheter. In South Africa, elevated proportions of admitted patients with urinary catheters were additionally associated with greater odds of hospital-wide antibiotic utilization.

These findings are not surprising, as antibiotics are frequently prescribed in patients with invasive devices,[12,13] CAIs[14] or HAIs.[15,16] These predictors might reflect a greater case complexity in wards with higher antibiotic prevalences, which is consistent with previous research that found a correlation between in-hospital antibiotic use and chronic use of urinary catheters,[2] and between in-hospital antibiotic use and case mix index.[17,18] Nevertheless, invasive devices like peripheral vascular catheters are commonly used to administer (parenteral) antibiotics,[19,20] or may be used concurrently with antibiotic treatments to manage ongoing infections, which may alternatively explain the increased odds of antibiotic use. Notwithstanding, we advise caution when interpreting the association between increased odds of hospital-wide antibiotic use and elevated proportions of patients receiving antibiotics for a CAI or HAI, as this might reflect an association between antibiotic prevalence and therapeutic prescribing rather than with characteristics of the patient mix.

Other factors related to the patient mix of a hospital were not associated with antibiotic use, though this could be attributed to the smaller number of specific cases included in the model, such as the proportion of admitted patients with a central vascular catheter, an invasive respiratory endotracheal intubation, tubes and drains and non-invasive mechanical ventilation. While the proportion of patients receiving antibiotics with ultimately or rapidly fatal disease (according to the McCabe score), multiple comorbidities, a surgical procedure during current admission, or sex were not identified as predictors for hospital-level antibiotic use in these models, previous studies have reported increases in antibiotic use associated with chronic use of central venous catheters,[2] prior antibiotic use,[3,4] previous hospitalization,[3] comorbidities,[3,4] and male sex.[2–5] One explanation is the difference in setting and study design, as these studies were conducted solely in high-income countries using logistic or negative binomial mixed regression applied on longitudinal cohort data.[2–5] However, considering we use cross-sectional data, it is possible that we lacked sufficient power to identify all important predictors for hospital-wide antibiotic utilization.

This study additionally identified several hospital-level predictors. In Belgium, a higher proportion of existing guidelines among all antibiotic prescriptions was associated with decreased odds of hospital antibiotic utilization. The Infectiology Guide of the Belgian Society for Infectiology and Clinical Microbiology is nationally widely adopted,[21] and also serves as a reference for the harmonization of local antibiotic guidelines which were supported financially through the HOST projects conducted between 2021 and 2025.[22,23] In line with previous research that has established the importance of antibiotic guideline implementation,[24] this finding suggests that the availability of guidelines curbs (unnecessary) antibiotic use in hospitals and highlights the need for freely available national guidelines for in-hospital antibiotic use in Belgium.

In the Philippines, elevated proportions of occupied medical beds were associated with significant increases in the odds of hospital antibiotic utilization. A study investigating 16 Swiss long-term care facilities described a similar finding: they reported a positive association between the number of occupied beds and antibiotic use.[25] This might suggest that higher occupancy rates, which potentially reflect higher patient turnover, influence antibiotic use. This effect might be direct, for instance when antibiotics are prescribed to treat HAIs transmitted in crowded wards,[26] or indirect, through increased time pressure on healthcare staff.[27] The influence of overcrowding in hospitals on the decrease in infection, prevention and control (IPC) and antimicrobial stewardship (AMS) measures has additionally been observed during the COVID-19 pandemic.[28]

Additionally, primary or secondary hospital status was associated with increased odds of antibiotic utilization compared to tertiary hospitals in the Philippine model. Evidence from the literature is mixed: while some studies report higher antimicrobial use patterns among primary care hospitals and decreased antibiotic use among hospitals with a university affiliation,[12,29] other studies found no notable differences between hospital types.[30,31]

Interestingly, apart from hospital type, the availability of clinical guidelines, and number and occupancy rate of medical beds, other ward- and hospital-level factors were not associated with significant changes in odds of antibiotic utilization, such as the teaching status and the presence of haemato-oncology wards and of long-term care, geriatric or rehabilitation wards. Limited power may have obscured some key determinants of hospital-level antibiotic use.

These findings have several implications. First, the association between hospital-wide antibiotic use and elevated proportions of patients with HAIs or invasive devices underscores the importance of IPC measures, to reduce the transmission or incidence of HAIs and ultimately curb antibiotic use. Second, the considerable heterogeneity in the predictors for antibiotic prescribing between the three countries suggests that, with the current data, a uniform model cannot be developed. There may be a need to broaden certain predictors to reduce the variability between countries and enhance robustness, e.g. by combining all invasive devices into one variable. Moreover, other factors may play a role in the hospital's antibiotic utilization. A recent systematic review identified gender, education level and health status of patients, as well as the work experience of prescribing physicians, as significant factors for hospital antibiotic prescribing.[32] Furthermore, it seems that AMS programmes are additionally associated with reduced antibiotic use in inpatient and outpatient care.[33] This suggests hospital-level structure and process indicators on AMS are important in surveillance activities.

Although future research could consider more variables in the prediction modelling, for instance by incorporating variables from additional healthcare-related or socio-economic databases into the model, we believe that integrating prediction modelling in feedback from surveillance studies on antibiotic use deserves greater emphasis, to optimize comparison with similar hospitals and ultimately facilitate integration of antibiotic stewardship recommendations. Therefore, future work should involve refining and integrating prediction models in antibiotic surveillance feedback reports.

An important strength of this study was exploring the potential of point prevalence use data for identifying hospital-level predictors for antibiotic use to ultimately enhance comparability of point prevalence data between hospitals from different settings. We used a stepwise method for variable selection to consider the association between predictors and prevent loss of information.

Other strengths of this study were the use of a large database containing detailed data on antibiotic prescribing worldwide. Furthermore, the standardized method for data collection allowed for comparison between heterogeneous settings.

Limitations to this study include the lack of detailed patient data for patients who did not receive an antimicrobial prescription. While this is inherent to the Global-PPS design, it impairs the prediction of antibiotic prescribing at patient-level in this study and potentially biases the prevalence of patients with certain comorbidities or indications. This limitation was mitigated by computing the prediction at ward- and hospital-level, which provides insightful estimates for stewardship efforts, and by limiting the prevalence of patients with certain comorbidities or indications to the patients who received antibiotic treatment. Moreover, we lack accurate information on the severity of infections, which is likely an important predictor for hospital-wide antibiotic use.

Next, the results may not be fully generalizable to the inpatient care settings in Belgium, the Philippines and South Africa, due to the use of cross-sectional data across hospitals and networks that participated on voluntary basis in Belgium (19.4% of the total 103 hospitals in 2022),[34] the Philippines (approximately 4.6% of at least 1200 licensed hospitals in 2022),[35] and South Africa (11.7% of the total 544 hospitals in 2023).[36] This could result in non-response bias. Furthermore, clustering at hospital- or ward-level could influence the results, although this effect was mitigated by modelling hospitals as a random effect. Clustering could be further influenced by measurement bias, although we tried to minimize this effect by using a simple protocol with automated data validation checks during data entry, and by providing regular online training webinars with the opportunity to ask any questions during or after the training.

In addition, a limitation of this study was the lack of information on important known predictors for antibiotic use, including country-wide burden of antibiotic resistance, health economic status, hospitals' resources and capacities, seasonality, and broader contextual factors. The use of cross-sectional data rather than longitudinal data was an additional limitation. Including these broader contextual factors from detailed, longitudinal data, was out of the scope of this study: we aimed to find important predictors from a point prevalence study that hospitals could use to recognize whether they are at higher risk of antibiotic prescribing within their hospital or ward.

Conclusion

In this study, we have explored the use of point prevalence data to identify important predictors for antibiotic prescribing practices. Among all potential predictors, only the proportion of invasive device utilization emerged as a shared key determinant of hospital-wide antibiotic prescribing across the three countries. Although the data were collected cross-sectionally and are not nationally representative for the three countries, the findings nonetheless offer valuable insights for future study. The observed variation in antibiotic prescribing predictors across the three countries underscores the need for deeper research to achieve more precise findings. Incorporating additional healthcare-related or socio-economic databases into the model could potentially yield more clinically relevant results at country level.

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Supplementary data

Appendices I–V available as Supplementary data at *JAC-AMR* Online.

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Transparency declarations

The authors declare no conflicts of interest.

Author contributions

A.I., A.B., A.V., I.P., E.V. and N.B. were involved in the study concept and design. R.B., J.G., M.D.L.R., R.M., H.F. and S.M. were involved in the data collection. A.I. and A.B. conducted the analyses, and all authors interpreted the findings. A.B. drafted the manuscript, which all authors critically revised. All authors approved the current version for submission.

Ethical declarations

This study is a part of the Global-PPS project. Ethical approval was granted by the Ethical Committee of the University Hospital of Antwerp for the Global-PPS project (project ID 5805, 9/1/2024).

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