Brief Report

Variation in a novel antipseudomonal antimicrobial consumption metric across hospital inpatient units at a Veterans Affairs hospital: A retrospective cohort study

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A novel antimicrobial consumption metric designed to identify the proportion of carbapenem consumption (PoCC) among broad-spectrum antipseudomonal antimicrobials has been shown to vary significantly by US Census Bureau region. This retrospective surveillance study identified significant total PoCC variability (27%; $P = .001$) across 8 inpatient units from January 2017 through June 2018. This metric may be useful in identifying and comparing inpatient units that may be overusing antipseudomonal carbapenems.
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The Centers for Disease Control and Prevention includes antimicrobial consumption tracking as part of the core elements of antibiotic stewardship programs (ASPs).[1] Meaningful, actionable antimicrobial consumption metrics that simplify interpretation for frontline providers and ASPs are needed, particularly as the incidence of infections with carbapenem-resistant organisms (CROs) is rising in the United States.[2] This is due to a number of factors; however, selective pressure secondary to inappropriate use of carbapenems has been linked to carbapenem resistance, and infections caused by CROs are associated with high mortality rates (32%-44%).[3-6] Carbapenems are often used empirically to cover for the possibility of infection due to *Pseudomonas aeruginosa* (PSAR) even when more narrow-spectrum agents such as cefepime and piperacillin-tazobactam (PT) could be utilized.[7] ASP interventions targeting inappropriate carbapenem use have been found to reduce resistance in various organisms, including PSAR and *Acinetobacter* spp.[3,5,8-10]

A novel antimicrobial consumption metric aimed at identifying the proportion of carbapenem consumption (PoCC) among broad-spectrum antipseudomonal antimicrobials has been shown to vary significantly among academic medical centers by US Census Bureau region after adjusting for patient mix.[9] Applying the benchmarks previously

identified, this metric is tracked and reported at our institution to identify inpatient units with potential carbapenem overuse. The purpose of this study was to determine if the PoCC metric varies across individual inpatient units at a Veterans Affairs medical center (VAMC).

METHODS

This surveillance study was conducted at a 399-bed, tertiary care VAMC in Richmond, VA. The medical center has a mature ASP that utilizes TheraDoc (Premier Inc; Charlotte, NC) for prospective audit and feedback, and it has a rigorous antibiotic restriction policy that requires ASP approval for approximately 30 antimicrobials (including carbapenems and cefepime). The ASP began reporting to the Centers for Disease Control and Prevention's National Health and Safety Network antibiotic use option in April 2017. Antimicrobial use data reported as antimicrobial days of therapy (DOT) per 1000 days present (DP) aggregated by month were extracted from the antibiotic use option from January 2017 through June 2018 for antipseudomonal beta-lactams on formulary,[2] including meropenem, imipenem/cilastatin, cefepime, ceftazidime, and PT. The PoCC metric was calculated using the following formula:

$$\frac{(\text{carbapenem DOT per 1000 DP})}{(\text{carbapenems} + \text{cefepime} + \text{ceftazidime} + \text{PT DOT per 1000 DP})}$$

A linear mixed model with a fixed time effect, a random unit effect, and a first-order autoregressive correlation structure was used to

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assess the variability of PoCC among patient care units while accounting for repeated measurements within units over time. Analysis was completed using SAS 9.4 (SAS Institute Inc; Cary, NC).

RESULTS

Eight units were included: 1 surgical intensive care unit (ICU), 1 medical ICU, 3 medical wards, 1 surgical ward, and 2 spinal cord injury (SCI) units. Antimicrobial consumption data were included from January 2017 through June of 2018. The mean DOT per 1000 DP per unit per month were 130.8 for PT, 48.9 for meropenem, 7.4 for cefepime, 2.1 for ceftazidime, and 0.6 for imipenem/cilastatin. Mean PoCC values ranged from 0.18 to 0.42 (Table 1). Twenty-seven percent of total PoCC variability was attributable to variability across the inpatient units (variance component, 0.008; standard error [SE], 0.005; 95% confidence interval [CI], 0.003-0.052; $P = .001$). There was significant correlation between measurements within units ($r = 0.23$; SE, 0.10; 95% CI, 0.04-0.43; $P = .019$) but not a significant effect on PoCC due to time ($P = .376$). The units with the highest mean PoCC scores were the 2 SCI units (0.42 and 0.34) and the surgical ICU (0.35).

DISCUSSION

This is one of the first studies to describe the variability of a novel antipseudomonal consumption metric across a variety of inpatient units, and, as far as we know, it is the first study to describe the PoCC within a VA hospital. Mean PoCC scores varied significantly across inpatient units over 16 months after adjusting for time. The SCI units had the highest mean PoCC, indicating a greater proportion of carbapenem use among the broad-spectrum antipseudomonal beta-lactam agents compared to other inpatient units. The SCI units are composed of a complex population of patients that suffer from recurrent infections due to decubitus ulcers, catheter-associated urinary tract infections, and osteomyelitis, and they have higher rates of carbapenem resistance compared to other units. According to our most recent antibiogram (all isolates included), PSAR isolates from the SCI units were more resistant to meropenem (n = 91, 69% susceptible) compared to the facility-wide aggregate data (n = 320, 82% susceptible).

Table 1
PoCC metric by unit

Unit	Mean PoCC	Standard deviation	Minimum/maximum*
Spinal cord unit 1	0.42	0.20	0.03/0.85
Spinal cord unit 2	0.34	0.24	0.06/0.91
Surgical ward	0.18	0.06	0.05/0.28
Medical/telemetry ward	0.18	0.10	0.01/0.43
Medical ward 1	0.18	0.13	0.00/0.48
Medical ward 2	0.20	0.09	0.04/0.35
Medical intensive care unit	0.24	0.11	0.08/0.42
Surgical intensive care unit	0.35	0.12	0.16/0.58

PoCC, proportion of carbapenem consumption.
*Minimum and maximum PoCC score calculated per month.

Further investigation is needed to determine if inappropriate carbapenem use in the SCI units corresponds to high PoCC scores. The mean PoCC (0.26) was relatively high across all units when compared to a previously described PoCC benchmark of 0.17 for the Middle Atlantic region.[9]

There are several limitations to this study. As a single-center study at a VAMC, these data may not be generalizable across other medical centers. Without patient-level data, it is not possible to determine the clinical appropriateness of the agents used. Aztreonam was not included in the PoCC metric, as it is primarily used at our facility as an alternative agent for penicillin-allergic patients as opposed to a first-line antipseudomonal agent. Applying the PoCC metric at a local facility should account for the most commonly utilized antipseudomonal beta-lactam agents. The PoCC metric focuses on potential overuse of carbapenems and does not reflect overuse of broad-spectrum agents in general, which is also a significant stewardship challenge.

Prolonged carbapenem exposure favors the development and selection of CROs, and ASP interventions targeting carbapenem use have been shown to decrease carbapenem resistance rates.[6,9,10] With rising rates of CROs, ASPs must be able to identify potential carbapenem overuse. Our study revealed significant variation in the PoCC metric across inpatient units after adjusting for time. The PoCC metric may serve as a tool for ASPs to identify inpatient units that could be overusing carbapenems and prioritize investigations into appropriateness of use.

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