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Letter to the Editor

Weather, climate control, and imipenem-resistance in *Acinetobacter baumannii*: an ecological approach

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To the Editor—The incidence of healthcare-associated infections (HCAIs) caused by gram-negative bacilli (GNB) increases in summer[1] and has been associated to outside environmental temperature[2] and low latitudes.[3] Evidence has been consistent for temperate[4] and, to a lesser extent, tropical climates.[5] The factors underlying this phenomenon and implications for infection control are not clear.

One of the causal hypotheses proposes that environmental reservoirs outside healthcare settings increase in warmer periods and that microorganisms are somehow carried into hospitals.[4,6] This hypothesis is based on the following findings: (1) seasonality and meteorological dependence occur even in hospitals with complete climate control[4]; (2) polyclonal increase of *Acinetobacter baumannii* during summer, suggesting sources other than cross transmission[7]; (3) seasonality for overall but not for multidrug-resistant *A. baumannii*, implying a possible community-associated source.[8]

We designed an ecological study aimed at testing premises that are central to the hypothesis that there are differences in seasonal pattern and influence of weather on the incidence of *A. baumannii* HCAIs according to climatization of hospital units or to imipenem resistance. The study was conducted in a teaching hospital in inner Brazil (Hospital Estadual Bauru, 335 beds). In that hospital, intensive care units (ICUs) have climate control, but all the other hospital wards are not climatized.

We obtained data from records of patient with cultures positive for *A. baumannii* from 2006 through 2017. Clinical cultures collected after the day 3 of admission were included (ie, the 3-midnight rule).[9] We included only the first culture positive for *A. baumannii* for each subject. Monthly incidence was calculated for overall *A. baumannii* and for subgroups based on unit of admission, specimen, and resistance to imipenem.

Monthly meteorological parameters (ie, average temperature, average relative humidity, and aggregated rainfall) were collected from a nearby meteorological station (Institute of Meteorological Research, State University of São Paulo, City of Bauru, São Paulo State, Brazil).

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We tested time series for seasonality using Box-Jenkins models and autocorrelation plots.[10] The association with weather was tested using Poisson regression. Meteorological parameters were dichotomized, based on the 75th percentile of monthly values (temperature, 24.7°C [76.5°F]; relative humidity, 79.6%; rainfall, 163.6 mm). Analyses were performed using NCSS 9 software (LLC, Kaysville, UT) and SPSS version 20 software (IBM, Armonk, NY).

We identified 1,207 patients with HCAIs due to *A. baumannii*. The overall incidence was 12.99 per 10,000 patient days: 67.12 for ICUs and 5.11 for noncritical wards. The imipenem resistance rate was 78.9%.

Time series of incidence rates (either of overall *A. baumannii* or of subgroups) tested negative for seasonality. The results of our analysis of association with weather are presented in Table 1. We found a significant positive association with temperature for overall *A. baumannii*. The analyses of subgroups identified stronger associations with temperature for ICUs, isolates from blood cultures, and those that were imipenem resistant.

The absence of seasonality in Box-Jenkins models may be due to the poorly defined pattern of seasons in the tropical climate. The area where the study hospital is located has a mostly warm and humid period (usually October through March, including summer and spring), with lower temperatures in the rest of the year. However, this pattern is irregular, and brief increases in environmental temperature often occur, even during fall and winter.

A different picture emerges when we consider associations of outside temperature and the incidence of *A. baumannii*. This association was stronger in the following conditions: positive blood cultures, ICUs, and imipenem-resistant strains. The recovery of *A. baumannii* from blood cultures may be interpreted either as a sign of "true infection" (as opposed to colonization) or as a marker of the invasiveness of strains. Either way, our findings reinforce the impact of temperature on the incidence of HCAIs caused by this agent.

While the severity of critical patients is an obvious risk factor for acquisition of *A. baumannii*, the causes underlying the impact of the outside temperature on its incidence in ICUs are not straightforward. We are even less certain why we found greater association of temperature with imipenem-resistant strains. Notably, this finding is contrary to the picture described by

Table 1. Poisson Regression Model for Impact of Monthly Meteorological Parameters on the Incidence of Healthcare-Associated Infections Caused by *Acinetobacter baumannii*

		RR (95% CI)[b]		
Culture Site/Unit of Admission	Incidence[a]	Temperature	Humidity	Rainfall
Overall *Acinetobacter baumannii*				
Total clinical cultures	12.99	**1.09 (1.02–1.16)**	0.97 (0.91–1.05)	0.93 (0.77–1.01)
Clinical cultures (ICUs)	67.12	1.06 (0.98–1.15)	1.04 (0.95–1.14)	0.95 (0.87–1.04)
Clinical Cultures (noncritical wards)	5.11	1.10 (0.98–1.23)	0.89 (0.78–1.02)	0.96 (0.80–1.04)
Blood cultures	2.43	**1.26 (1.09–1.46)**	0.89 (0.74–1.06)	0.87 (0.73–1.05)
Blood cultures (ICUs)	14.05	**1.23 (1.04–1.46)**	1.03 (0.84–1.26)	0.88 (0.71–1.08)
Blood cultures (noncritical wards)	0.74	1.27 (0.96–1.69)	**0.53 (0.33–0.86)**	0.88 (0.61–1.28)
Imipenem-resistant *A. baumannii*				
Total clinical cultures	10.25	**1.18 (1.11–1.27)**	1.00 (0.92–1.09)	0.90 (0.82–0.97)
Clinical cultures (ICUs)	56.13	**1.16 (1.06–1.26)**	1.08 (0.97–1.18)	0.90 (0.82–1.01)
Clinical Cultures (noncritical wards)	3.57	**1.20 (1.06–1.37)**	0.90 (0.77–1.05)	0.89 (0.76–1.04)
Blood cultures	1.82	**1.38 (1.17–1.62)**	0.94 (0.77–1.15)	0.86 (0.70–1.06)
Blood cultures (ICUs)	11.09	**1.34 (1.11–1.60)**	1.07 (0.85–1.33)	0.83 (0.65–1.06)
Boold cultures (noncritical wards)	0.47	**1.43 (1.03–2.02)**	0.62 (0.37–1.04)	1.01 (0.66–1.55)

Note. RR, rate ratio; CI, confidence interval; ICUs, intensive care units.
[a]Incidence in cases per 10,000 patient days.
[b]Meteorological values were dichotomized at the 75th percentile of monthly values (temperature, 24.7°C [76.5°F]; relative humidity, 79.6%; rainfall, 163.6 mm). Statistically significant associations ($P < .05$) are presented in boldface.

Fukuta et al.[8] Because infections caused by imipenem-resistant isolates (which are most likely healthcare-associated) increase in warmer months, we cannot infer that reservoirs in the outside environment are implicated in this phenomenon. On the other hand, increases in incidence according to outside temperature, even among patients admitted to units with complete climate control, are unlikely to be due to inanimate reservoirs within those units. Finally, because greater incidence of the pathogen of interest was not associated with any particular month or season, we can rule out the hypothesis that understaffing due to summer vacations would lead to greater transmission of nosocomial pathogens.[4,6]

We should approach our findings in terms of implications for research and implications for practice. Studies focusing on changes in healthcare work processes (eg, adherence to hand hygiene, conformities in isolation precautions) in different periods of the year or under different weather conditions should be conducted. Also, research including molecular strain typing could help determine whether there is increased cross transmission of *A. baumannii* (as well as other GNB) in periods of higher outside temperature. The obvious implication for practice is the requirement of intensifying infection control measures during warm months. Other recommendations may arise from continuing research.

The phenomenon of seasonality and meteorological determination of HCAIs caused by GNB remains puzzling. Still, from our perspective, it should not be regarded as mere curiosity. Instead, its elucidation may provide novel opportunities for infection prevention and control.

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References

1. Perencevich EN, McGregor JC, Shardell M, *et al*. Summer peaks in the incidences of gram-negative bacterial infection among hospitalized patients. *Infect Control Hosp Epidemiol* 2008;29:1124–1131.
2. Schwab F, Gastmeier P, Meyer E. The warmer the weather, the more gram-negative bacteria—impact of temperature on clinical isolates in intensive care units. *PLoS One* 2014;9:e91105.
3. Fisman D, Patrozou E, Carmeli Y, *et al*. Geographical variability in the likelihood of bloodstream infections due to gram-negative bacteria: correlation with proximity to the equator and health care expenditure. *PLoS One* 2014;9:e114548.
4. Richet H. Seasonality in gram-negative and healthcare-associated infections. *Clin Microbiol Infect* 2012;18:934–940.
5. Fortaleza CM, Caldeira SM, Moreira RG, *et al*. Tropical healthcare epidemiology: weather determinants of the etiology of bloodstream infections in a Brazilian hospital. *Infect Control Hosp Epidemiol* 2014;35:85–88.
6. Eber MR, Shardell M, Schweizer ML, Laxminarayan R, Perencevich EN. Seasonal and temperature-associated increases in gram-negative bacterial bloodstream infections among hospitalized patients. *PLoS One* 2011;6:e25298.

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7. Christie C, Mazon D, Hierholzer W Jr, Patterson JE. Molecular heterogeneity of *Acinetobacter baumannii* isolates during seasonal increase in prevalence. *Infect Control Hosp Epidemiol* 1995;16:590–594.
8. Fukuta Y, Clarke LG, Shields RK, Wagener MM, Pasculle AW, Doi Y. Lack of seasonality in the occurrence of multidrug-*resistant Acinectobacter baumannii* complex. *Infect Control Hosp Epidemiol* 2012;33:1051–1052.
9. Cohen AL, Calfee D, Fridkin SK, *et al*. Recommendations for metrics for multidrug-resistant organisms in healthcare settings: SHEA/HICPAC position paper. *Infect Control Hosp Epidemiol* 2008;29:901–913.
10. Box GE, Jenkins GM, Reinsel CG. Time series analysis: forecasting and control. Hoboken NJ: Wiley; 2015.

Dissemination of *Acinetobacter baumannii* OXA-23 in old and new intensive care units without transfer of colonized patients

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To the Editor—The contamination of the environment and the hands of health professionals, transfer of patients, and movements of health professionals between hospitals are all possible routes for the dissemination of *Acinetobacter baumannii*.[1–3] In our region during 2004–2008, an endemic carbapenem-resistant *A. baumannii* (CRAb) was detected.[4] Later, it was verified (2011–2014), with a change in the dissemination mode of this microorganism (ie, the endemic situation to polyclonal dissemination).[5] However, the routes of spread of *A. baumannii* have not yet been established.

In this study, we analyzed the effect of constructing a new ICU in a Brazilian hospital on the dissemination of *A. baumannii*. In the first 6 months, 22 clinical isolates were collected from an old ICU (12 beds), and in the next 6 months, 26 clinical isolates were collected from a newly installed ICU (24 beds).

In the new ICU, the presence of *A. baumannii* in the environment was investigated for a period of up to 15 days before and 15 days after patient admission to the unit. The samples were collected from bedside table, antiseptic dispenser, cardiac monitor, infusion pump, and bedrail, using sterile swabs moistened with sterile saline solution. Each swab was then used to inoculate a MacConkey agar plate.

The identification and antimicrobial susceptibility of bacterial isolates were assessed using a BD Phoenix system (Becton, Dickinson and Company, Franklin Lakes, NJ, USA). The minimum inhibitory concentrations of imipenem, meropenem, and polymyxin B were confirmed using the agar-dilution method.[6]

A multiplex PCR assay was performed to detect the presence of MBL genes (bla_{IMP}, bla_{VIM}, bla_{GIM}, bla_{SPM}, and bla_{SIM}) and oxacillinase genes (bla_{OXA23}, bla_{OXA24}, bla_{OXA51}, and bla_{OXA58}).[7,8]

Molecular typing was performed with enterobacterial repetitive intergenic consensus-polymerase chain reaction (ERIC-PCR) assays. Computer-assisted analysis was performed with BioNumerics version 6.5 software (Applied Maths, Sint-Martens-Latem, Belgium) with Dice correlation coefficient ≥ 0.93.[9]

In total, 48 *A. baumannii* were isolated. The clinical and colonization isolates were obtained from tracheal aspirates (n = 26), urine (n = 6), blood (n = 5), cerebrospinal fluid (n = 1), wound secretion (n = 1), and nasal swabs (n = 4), oral swabs (n = 4), and axillar swabs (n = 1). During the study period, no patient infected or colonized with *A. baumannii* was transferred from the old to the new ICU, and no *A. baumannii* isolates were detected in the environment of the new ICU.

Of the 48 isolates, 65% and 50% were resistant to imipenem and meropenem, respectively. The most effective of the antibiotics tested was polymyxin B (100% sensitivity), followed by tetracycline (73%) and tobramycin (52%). Comparing the isolates of *A. baumannii* from the 2 ICUs revealed an increase in resistance to imipenem in the isolates from the new unit (from 50% to 69%).

All isolates carried bla_{OXA51}, and 29 (60%) also carried bla_{OXA23} (14 isolates from the old ICU and 15 isolates from the new unit). No strain was identified as a producer of MBL, OXA-58 or OXA-24.

The findings that 60% of the *A. baumannii* isolates showed the bla_{OXA23} gene and that 11 (38%) were susceptible to carbapenems can be explained. The expression of resistance depends not only on the presence of the bla_{OXA23} gene but also on its association with an insertion sequence, such as IS*Aba1*, which enhances the expression of the bla_{OXA23} gene. These findings are worrisome because this insertion sequence may be inserted into a plasmid that has a high capacity for mobilization and dissemination.[10]

Molecular typing by ERIC-PCR of the 48 *A. baumannii* isolates detected 17 different clusters (Fig. 1, A–Q). Two clusters were detected in both ICUs (I and J). Cluster J was detected in a patient admitted to the old ICU (negative for bla_{OXA23}) and in another patient admitted to the new ICU (positive for bla_{OXA23}). Cluster I was detected in 10 patients (5 in the old and 5 in the new ICU). This cluster was identical to the endemic CRAb detected in our region.[5]

The old ICU showed no distinct clusters, and the new ICU had 10 clusters. The most common clusters were B, I, and H, which comprised ~50% (23 of 48) of all *A. baumannii* isolates. Clusters B and H were isolated only in the new ICU, while cluster I was detected in both units. All clusters showed at least 1 isolate carrying bla_{OXA23}.

Molecular typing revealed a certain degree of clonal diversity, and despite the construction of the new ICU, several *A. baumannii*–producing OXA-23 coexist, making control more

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