



Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief Report

Seasonal differences in central line–associated bloodstream infection incidence rates in a Central European setting: Results from prospective surveillance



Peter W. Schreiber MD^{a,*}, Mesida Dunic RN^a, Aline Wolfensberger MD^a, Lauren Clack PhD^a, Christian Falk^b, Hugo Sax MD^a, Stefan P. Kuster MD, MSc^a

^a Division of Infectious Diseases and Hospital Epidemiology and University of Zurich, University Hospital Zurich, Zurich, Switzerland

^b Information and Communication Technology, University Hospital Zurich, Zurich, Switzerland

Key Words:

CLABSI
Seasonality
Surveillance
Hospital-acquired infections

Using prospectively collected surveillance data at a tertiary care hospital in Central Europe, we investigated seasonal differences in central line–associated bloodstream infection incidence. Central line–associated bloodstream infection incidence rates were highest during the third quarter over an observation period of 24 months. Investigating influence of meteorological parameters identified a significant correlation with precipitation ($r = 0.460$, $P = .023$).

© 2019 Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.

Seasonal variations in incidence of a broad spectrum of infectious diseases have been described. Seasonality has been reported for certain bacterial,¹ viral,² and even parasitic infections.³ For example, in Central Europe, influenza typically peaks between November and April.⁴ For several infections showing a seasonal pattern in incidence, these variations have been associated with environmental changes, such as temperature, humidity, rainfall, or wind.^{1,5} However, no data are published on the seasonal pattern of central line–associated bloodstream infection (CLABSI) incidence. Identification of seasonal peaks could optimize allocation of infection prevention efforts. In periods with higher incidence, an intensification in hygienic measures could be triggered. Similar to other infectious diseases showing seasonal patterns, we were also interested in the question whether there is an association between incidence rates and meteorological variables. At our hospital, a semiautomatic surveillance of CLABSI had been established in the beginning of 2016. We used these prospectively collected data to address the question of seasonality for CLABSI and investigated correlation with environmental factors, which were collected at a public meteorological station located near to the hospital.

METHODS

Setting

This study was conducted at the University Hospital Zurich, Switzerland, a 900-bed tertiary care teaching center with approximately 40,000 admissions per year, featuring all medical specialties except pediatrics and orthopedics.

Surveillance of CLABSI

In January 2016, a semiautomatic surveillance system for CLABSI incidence was implemented. Source data including presence of a central venous catheter, length of hospitalization, and microbial results of blood cultures are continuously extracted from our patient data management system into Caradigm Intelligence Platform (CIP). CIP acts as a platform for data aggregation, and within CIP aggregated data can be subjected to an algorithm applying the Centers for Disease Control and Prevention CLABSI definitions,⁶ resulting in a list of individuals with possible CLABSI. This list is then checked by a specialized infection control nurse to exclude positive blood cultures resulting from contamination or secondary bacteremia originating from another site of infection. For the current study, we used validated CLABSI data encompassing 2 years (2016 and 2017), which were used to calculate incidence rates (IR) (CLABSI per 1000 catheter days) for quarters January–March, April–June, July–September, and October–December. In addition to

* Address correspondence to Peter W. Schreiber, MD, Division of Infectious Diseases and Hospital Epidemiology, University Hospital Zurich, Raemistrasse 100, HAL 14, B4, 8091 Zurich, Switzerland.

E-mail address: peterwerner.schreiber@usz.ch (P.W. Schreiber).

Conflicts of interest: None to report.

analysis of single years, we also used pooled data from 2016 and 2017. As chlorhexidine digluconate bathing in intensive care and intermediate care units was widely implemented in the fourth quarter of 2017, which likely influenced CLABSI rates, we performed an additional analysis with exclusion of the fourth quarter of 2017 to confirm our findings.

Meteorological data

For investigation of correlations between environmental influences and CLABSI incidence the variables temperature, humidity, precipitation, wind force, and global radiation were obtained from a public meteorological station (Stadt Zürich, Sicherheitsdepartement, Wetterstation Mythenquai, <https://www.tecson-data.ch/zurich/mythenquai/>). This public meteorological station is located near to the University Hospital Zurich with an air-line distance of approximately 2.5 km (1.6 miles). Meteorological variables were repeatedly determined every 10 minutes. For our analyses, we downloaded daily averages, which were used to calculate monthly and quarterly averages. We did not perform an outlier exclusion.

Statistical analysis

R (version 3.2.3; R Foundation for Statistical Computing, Vienna, Austria) was employed for statistical analyses. Incidence rates were calculated by dividing the number of CLABSI by the number of catheter days in the corresponding time period and reported as CLABSI per 1000 catheter days. Catheter use was assessed by dividing the number of catheter days by the number of patient days. In general, 2-sided tests were used; P values $\leq .05$ were considered statistically significant. Comparisons of rates were performed with the R package `rateratio.test` (version 1.0-2, <https://cran.r-project.org/web/packages/rateratio.test/rateratio.test.pdf2014>), which enables comparison of rates of 2 Poisson counts with given time at risk for each count. For investigation of linear relationships between 2 variables, we applied the Spearman rank correlation, which does not assume normal distribution of data. For correlation analyses, monthly data for CLABSI incidence and meteorological data were used.

RESULTS

Seasonality of CLABSI incidence

Over a period of 24 months, the highest incidence rates for CLABSI were observed in the third quarter of both years, that is, 2016 and 2017 (Fig 1). In 2016, the CLABSI rate in the third quarter did not differ significantly from other quarters, whereas in 2017 the CLABSI rate in the third quarter (IR, 1.73; 95% confidence interval [CI], 1.17–2.46) tended to be higher compared to all other seasons (IR, 1.02; 95% CI, 0.76–1.35; $P = .056$) and especially the second quarter (IR, 0.49; 95% CI, 0.24–0.91; $P = .002$). Pooled data from both years confirmed the increased CLABSI rate in the third quarter (IR, 1.88; 95% CI, 1.44–2.42; other quarters IR, 1.33; 95% CI, 1.11–1.58; $P = .047$). Notably, no significant difference in central venous catheter use was detectable between the third (rate [R], 0.198; 95% CI, 0.196–0.200) and other quarters (R, 0.200; 95% CI, 0.199–0.201; $P = .169$).

Correlation of meteorological variables and incidence of CLABSI

Linear correlation did not detect a statistically significant association between temperature ($r = 0.224$; $P = .291$), relative humidity ($r = -0.070$; $P = .743$), wind force ($r = -0.074$; $P = .731$), and global radiation ($r = 0.121$; $P = .572$). We found a significantly positive correlation between precipitation and CLABSI incidence ($r = 0.460$; $P = .023$) (Fig 2).

DISCUSSION

Using prospectively collected data on CLABSI incidence at a tertiary care hospital in Central Europe, we identified a seasonal pattern with peak incidence in the third quarter of the years 2016 and 2017. Investigation of environmental factors suggests a correlation between precipitation and incidence of CLABSI.

Seasonality in incidence of infectious diseases can sometimes be supported by biologically plausible hypotheses taking periodic environmental changes into consideration. Common hypotheses include improved survival conditions of pathogens and changes in immune status of the host during seasons with increased incidence.⁷ For

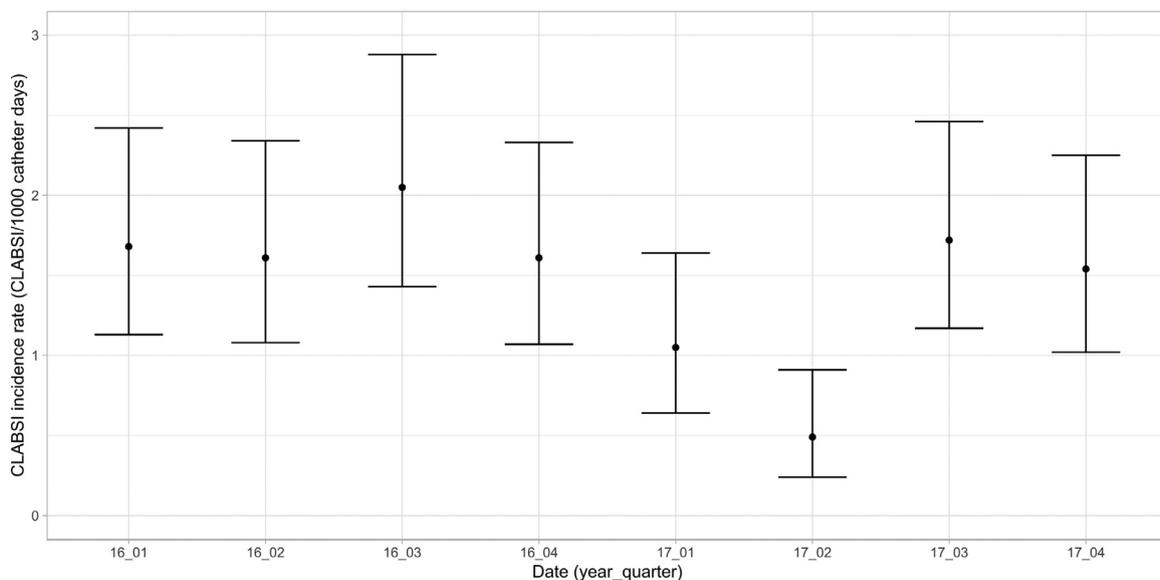


Fig 1. Seasonal variations in CLABSI incidence. The x-axis indicates the date (year_quarter). The y-axis displays the quarterly incidence rate of CLABSI. Dots correspond to pooled means and error bars to 95% confidence intervals for each quarter. CLABSI, central line-associated bloodstream infection.

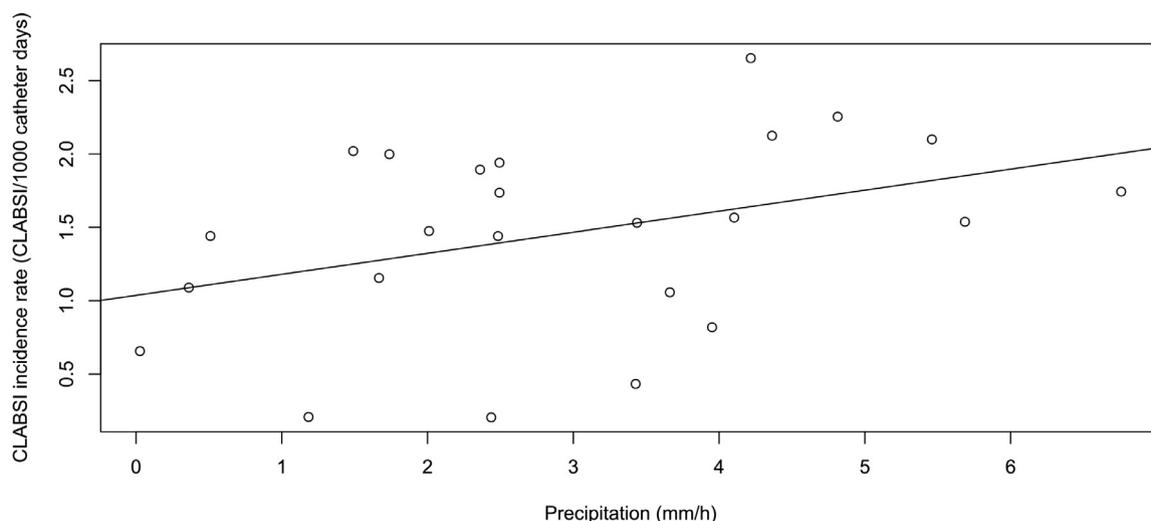


Fig 2. Correlation between precipitation and CLABSI incidence. The x-axis indicates monthly precipitation. The y-axis displays the monthly incidence rate of CLABSI. Line was generated using linear regression. CLABSI, central line–associated bloodstream infection.

example, wintertime seasonality of norovirus outbreaks has been attributed to improved durability of this virus in cold water. Most CLABSI are caused by bacteria and the vast majority of patients suffering from a CLABSI are treated as inpatients; exposure to changes in precipitation seems marginal for both bacteria and patients. As predisposing factors for reduced immune responses by the host, vitamin D deficiency and reduced production of melatonin during periods of reduced sunlight exposure has been considered.² However, in our study setting, sunlight exposure in the third quarter is expected to be higher than in the first or fourth quarter. Nevertheless, for certain pathogens, such as *Legionella* spp⁸ or diarrheal diseases,⁵ an association with rainfall has been reported. *Staphylococcus* spp is a frequent pathogen in CLABSI. Recently, an increase in detection of staphylococci in room air during summer in Northern Europe was described⁹ and a positive correlation between methicillin-resistant *Staphylococcus aureus* colonization and precipitation was reported, which, however, lost significance in a multivariable model.¹⁰ It can be hypothesized that variations in microbial burden of air and colonization of patients might be at the cause of the observed seasonality, but we did neither air sampling for microbial cultures nor routine screening of patients for colonization.

We were able to confirm our findings in sensitivity analyses, which excluded the fourth quarter of 2017. In the fourth quarter of 2017, chlorhexidine digluconate bathing was widely implemented on the intensive and intermediate care units, which is expected to lower the rate of CLABSI.^{11,12} In these analyses, incidence rates were highest in the third quarter, which reached statistical significance for the year 2017, and found a marginally significant correlation between precipitation and CLABSI incidence (data not shown).

The major strength of our study is the standardized and semiautomatic surveillance for CLABSI. Limitations are the single-center design and the length of the analyzed surveillance period limited to 24 months. Furthermore, we did not analyze the pathogens causing CLABSI in the current study.

CONCLUSIONS

Prospective surveillance identified highest incidence rates of CLABSI in the third quarters of 2 consecutive years. Future multicenter

studies are desirable to confirm seasonality of CLABSI incidence and the potential association with precipitation.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.ajic.2019.02.011>.

References

- Joshi YP, Kim EH, Cheong HK. The influence of climatic factors on the development of hemorrhagic fever with renal syndrome and leptospirosis during the peak season in Korea: an ecologic study. *BMC Infect Dis* 2017;17:406.
- Lofgren E, Fefferman NH, Naumov YN, Gorski J, Naumova EN. Influenza seasonality: underlying causes and modeling theories. *J Virol* 2007;81:5429–36.
- Ferrao JL, Mendes JM, Painho M, Zacarias S. Malaria mortality characterization and the relationship between malaria mortality and climate in Chimio, Mozambique. *Malar J* 2017;16:212.
- Hedge J, Lamagni T, Moore G, Walker J, Crook D, Chand M. *Mycobacterium chimera* isolates from heater-cooler units, United Kingdom. *Emerg Infect Dis* 2017;23:1227.
- Carlton EJ, Eisenberg JN, Goldstick J, Cevallos W, Trostle J, Levy K. Heavy rainfall events and diarrhea incidence: the role of social and environmental factors. *Am J Epidemiol* 2014;179:344–52.
- Centers for Disease Control and Prevention. Device-associated module BSI, bloodstream infection event (central line-associated bloodstream infection and noncentral line-associated bloodstream infection). Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf; 2019. Accessed March 8, 2019.
- Fisman D. Seasonality of viral infections: mechanisms and unknowns. *Clin Microbiol Infect* 2012;18:946–54.
- Hicks LA, Rose CE Jr, Fields BS, Drees ML, Engel JP, Jenkins PR, et al. Increased rainfall is associated with increased risk for legionellosis. *Epidemiol Infect* 2007;135:811–7.
- Madsen AM, Moslehi-Jenabian S, Islam MZ, Frankel M, Spilak M, Frederiksen MW. Concentrations of *Staphylococcus* species in indoor air as associated with other bacteria, season, relative humidity, air change rate, and *S. aureus*-positive occupants. *Environ Res* 2018;160:282–91.
- Blanco N, Perencevich E, Li SS, Morgan DJ, Pineles L, Johnson JK, et al. Effect of meteorological factors and geographic location on methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci colonization in the US. *PLoS One* 2017;12:e0178254.
- Bleasdale SC, Trick WE, Gonzalez IM, Lyles RD, Hayden MK, Weinstein RA. Effectiveness of chlorhexidine bathing to reduce catheter-associated bloodstream infections in medical intensive care unit patients. *Arch Intern Med* 2007;167:2073–9.
- Afonso E, Blot K, Blot S. Prevention of hospital-acquired bloodstream infections through chlorhexidine gluconate-impregnated washcloth bathing in intensive care units: a systematic review and meta-analysis of randomised crossover trials. *Euro Surveill* 2016;21. pii: 30400.