Impact of the COVID-19 pandemic on the incidence and mortality of hospital-onset bloodstream infection: a cohort study

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ABSTRACT

The COVID-19 pandemic burdens hospitals, but consequences for quality of care outcomes such as healthcare-associated infections are largely unknown. This cohort included all adult hospital episodes (n=186 945) at an academic centre between January 2018 and January 2021. Data were collected from the hospitals' electronic health record data repository. Hospital-onset bloodstream infection (HOB) was defined as any positive blood culture obtained ≥ 48 hours after admission classified based on microbiological and hospital administrative data. Subgroup analyses were performed with exclusion of potential contaminant bacteria. The cohort was divided into three groups: controls (prepandemic period), non-COVID-19 (pandemic period) and COVID-19 (pandemic period) based on either PCR-confirmed SARS-CoV-2 infections from respiratory samples or International Classification of Diseases 10th Revision diagnoses U071 and U72 at discharge. Adjusted incidence rate ratios (aIRR) and risk of death in patients with HOB were compared between the prepandemic and pandemic periods using Poisson and logistic regression. The incidence of HOB was increased for the COVID-19 group compared with the prepandemic period (aIRR 3.34, 95% CI 2.97 to 3.75). In the non-COVID-19 group, the incidence was slightly increased compared with prepandemic levels (aIRR 1.20, 95% CI 1.08 to 1.32), but the difference decreased when excluding potential contaminant bacteria (aIRR 1.15, 95% CI 1.00 to 1.31, p=0.04). The risk of dying increased for both the COVID-19 group (adjusted odds ratio (aOR) 2.44, 95% CI 1.75 to 3.38) and the non-COVID-19 group (aOR 1.63, 95% CI 1.22 to 2.16) compared with the prepandemic controls. These findings were consistent also when excluding potential contaminants. In summary, we observed a higher incidence of HOB during the COVID-19 pandemic, and the mortality risk associated with HOB was greater, compared with the prepandemic period. Results call for specific attention to quality of care during the pandemic.

INTRODUCTION

The COVID-19 pandemic has put stress on the healthcare system and healthcare workers, but the consequences for quality of care outcomes in entire hospital

populations are not well studied.¹ One such outcome measure is hospital-onset bloodstream infection (HOB), which is closely related to central line-associated bloodstream infections, but also reflects bacteraemia secondary to other healthcare-associated infections.^{2 3} HOB rate is an objective measure and has been suggested as an indicator of changes in healthcare delivery.^{4–7} We aimed to compare the incidence and mortality of HOB before and after the emergence of COVID-19.

METHODS

The cohort included all patients ≥ 18 years admitted to an academic centre in a large metropolitan area in Sweden between January 2018 and January 2021. Data were collected from the hospitals' electronic health record data repository, which includes complete microbiological, hospital administrative and mortality data for all patients.

Exposure to COVID-19 was defined as PCR-confirmed SARS-CoV-2 infections from respiratory samples or International Classification of Diseases 10th Revision diagnoses U071 (COVID-19, virus identified) and U72 (COVID-19, virus not identified) at discharge. In accordance with previously published criteria, HOB was defined as any positive blood culture obtained ≥ 48 hours after admission.² To account for therapeutic failure of community-onset infections, pathogens cultured in blood before 48 hours were not classified as HOB if recurring again after 48 hours. HOB was collected for all wards and only the first episode per admission was counted. Subgroup analyses were performed with exclusion of

potential contaminant bacteria to identify HOB caused by predominantly primary bacteraemia or bacteraemia due to other underlying healthcare-associated infections. Contaminants were identified using the full list of common commensals from the Centers for Disease Control and Prevention/National Healthcare Safety Network Patient Safety Component Manual (version 2021).⁸

Based on the local emergence of COVID-19 admissions around 1 March 2020, the cohort was divided into groups: controls (prepandemic period), non-COVID-19 (pandemic period) and COVID-19 (pandemic period). Monthly incidence rates of HOB were calculated. Adjusted incidence rate ratios (aIRR) were compared between the before-and-after periods using Poisson regression controlling for age, sex, Charlson Comorbidity Index and urgent versus planned admission. Person-time was defined as length of stay until either discharge, death or HOB, excluding the first 48 hours of admission when outcome criteria could not be fulfilled to avoid immortal time bias.⁹ Risk of 30-day mortality of HOB was compared between the before-and-after periods using logistic regression, presented as odds ratio adjusted (aOR) for the variables described above. In addition to controlling for seasonal factors using historical controls, aIRR and aOR were compared between the non-COVID-19 group and the COVID-19 group to account for unmeasured factors unique to the pandemic period. Statistical analyses were done in R V.4.1.0.

RESULTS

The study included 133 193 episodes in the prepandemic control group, 48 791 episodes in the pandemic non-COVID-19 group and 4961 episodes in the COVID-19 group (online supplemental figure 1).

Patient characteristics are presented in online supplemental table 1. Patients with COVID-19 had more intensive care unit (ICU) admissions (15%, 95% CI 14% to 16% vs 3%, 95% CI 3% to 4%), longer hospital stay (median 6 days, 95% CI 3 to 13 vs 3 days, 95% CI 1 to 5) and higher 30-day mortality (12%, 95% CI 11% to 13% vs 4%, 95% CI 3% to 4%) than the remaining hospital population.

Increased monthly incidence of HOB correlated with the first and second COVID-19 waves (online supplemental figure 2). The incidence of HOB was increased for the COVID-19 group compared with the prepandemic period (aIRR 3.34, 95% CI 2.97 to 3.75) (table 1). In the non-COVID-19 group, HOB incidence was slightly increased compared with prepandemic levels (aIRR 1.20, 95% CI 1.08 to 1.32), but the difference decreased when excluding potential contaminants (aIRR 1.15, 95% CI 1.00 to 1.31, $p=0.04$). The risk of dying increased for both the COVID-19 group (aOR 2.44, 95% CI 1.75 to 3.38) and the non-COVID-19 group (aOR 1.63, 95% CI 1.22 to 2.16) compared with the prepandemic controls (table 1). These findings were consistent also when excluding potential contaminants. The aIRR for HOB was 2.69 (95% CI 2.34 to 3.08) and the aOR for mortality of HOB was 1.53 (95% CI 1.05 to 2.22) when comparing the COVID-19 group to the non-COVID-19 group during the pandemic period.

DISCUSSION

In this analysis of 186 945 hospital episodes before and after the emergence of COVID-19, incidence of HOB increased in the after period. The surge in incidence tailed the waves of the epidemic and was mainly driven by patients with COVID-19, which had more than doubled incidence. These findings indicate

Table 1 Differences in incidence and mortality of hospital-onset bloodstream infection after emergence of COVID-19

Variable	HOB all pathogens			HOB excluding all possible contaminants*		
	Controls	Non-COVID-19	COVID-19	Controls	Non-COVID-19	COVID-19
Group						
Time period	January 2018 to February 2020	March 2020 to January 2021	March 2020 to January 2021	January 2018 to February 2020	March 2020 to January 2021	March 2020 to January 2021
Person-time at risk (days)	393 503	130 578	33 805	404 245	134 644	38 972
HOB (n)	1370	552	369	757	292	181
Incidence rate Number of outcomes/1000 days at risk (95% CI)	3.48 (3.30 to 3.67)	4.23 (3.88 to 4.60)	10.92 (9.83 to 12.09)	1.87 (1.74 to 2.01)	2.17 (1.93 to 2.43)	4.64 (3.99 to 5.37)
Crude IRR (95% CI)	Ref	1.21 (1.10 to 1.34)	3.14 (2.79 to 3.51)	Ref	1.16 (1.01 to 1.32)	2.48 (2.10 to 2.91)
Adjusted IRR† (95% CI)	Ref	1.20 (1.08 to 1.32)	3.34 (2.97 to 3.75)	Ref	1.15 (1.00 to 1.31)‡	2.66 (2.25 to 3.13)
30-day mortality, n (%)	161 (12)	96 (17)	74 (20)	101 (13)	60 (21)	42 (23)
Crude OR (95% CI)	Ref	1.59 (1.20 to 2.08)	1.89 (1.39 to 2.55)	Ref	1.68 (1.18 to 2.39)	1.97 (1.31 to 2.93)
Adjusted OR§ (95% CI)	Ref	1.63 (1.22 to 2.16)	2.44 (1.75 to 3.38)	Ref	1.73 (1.19 to 2.49)	2.51 (1.61 to 3.90)

*Contaminants were identified using the organism list from National Healthcare Safety Network (NHSN) Patient Safety Component Manual (version 2021) provided by the Centers for Disease Control and Prevention.

†Poisson regression adjusted for age, sex, Charlson Comorbidity Index and urgent versus planned admission.

‡Statistically significant ($p=0.04$).

§Logistic regression adjusted for age, sex, Charlson Comorbidity Index and urgent versus planned admission.

HOB, hospital-onset bloodstream infection; IRR, incidence rate ratio.

that the COVID-19 pandemic exacerbates the rates of healthcare-associated infections, and its associated mortality, which may signal a need for quality of care improvements.

Bacterial coinfections in COVID-19 are fairly uncommon.^{10 11} Despite this, we noted that the pandemic substantially impacted the incidence of HOB on a hospital level, but patients without COVID-19 only represented a minor portion of the increase. Our results are in agreement with a prior study showing an increased risk of HOB in ICU patients with COVID-19 compared with controls.¹² The reasons for these findings are unclear, but factors such as inexperienced healthcare workers, high workload, material shortage and use of protective clothing may contribute. Explanations could also be intrinsic to the COVID-19 illness itself, or its treatment, and the degree of preventability of HOB in this new setting needs to be further assessed.

Patients with COVID-19 and HOB were recently shown to have worse clinical outcome compared with controls.¹³ In this study, HOB mortality increased for all patients during the pandemic, irrespective of COVID-19 status. Indeed, the increased mortality risk in the COVID-19 group is expected given the higher baseline mortality, but effects related to delayed antibiotic treatment are also plausible. Explaining the greater HOB mortality for the non-COVID-19 group during the pandemic is more difficult and several factors may contribute. Even though patients' characteristics and incidence rates among controls and patients without COVID-19 were similar, unmeasured population differences may be present. Moreover, the pandemic may affect quality of care factors associated with increased mortality such as inappropriate antimicrobial treatment, inadequate source control or fewer infectious disease consultations.^{14–16}

Our study has limitations. First, the findings should be confirmed in other settings. Second, restricting analyses to the first HOB episode per admission likely underestimated the incidence of HOB. Third, there may be unmeasured confounders, such as socioeconomic factors, which were not controlled for due to lack of data.

CONCLUSIONS

We observed a higher incidence of HOB during the COVID-19 pandemic, and the mortality risk associated with HOB was greater, compared with the prepandemic period. Results call for specific attention to quality of care during the pandemic.

Contributors Concept and design: JKV, PN. Acquisition, analysis or interpretation of data: JKV, PH, FH, SDvdW, PN. Drafting of the manuscript: JKV, PH. Critical revision of the manuscript for important intellectual content: JKV, PH, FH, SDvdW, PN. Statistical analysis: JKV, PH.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The study was approved by the Ethical Review Authority and the Regional Ethical Review Board in Stockholm with a waiver of informed consent (Dnr 2018/1030-31, COVID-19 research amendment Dnr 2020-01385). Since this is a retrospective study including more than 150 000 participants, with mortality as an important outcome, informed consent was not possible to collect without biasing the results and the research ethics committee gave their approval to the study with a waiver of consent from participants. The study had no impact on the care that individual participants were receiving.

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