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The impact of COVID-19 on health care–associated infections in intensive care units in low- and middle-income countries: International Nosocomial Infection Control Consortium (INICC) findings

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ABSTRACT

Background: This study examines the impact of the COVID-19 pandemic on health care–associated infection (HAI) incidence in low- and middle-income countries (LMICs).
Methods: Patients from 7 LMICs were followed up during hospital intensive care unit (ICU) stays from January 2019 to May 2020. HAI rates were calculated using the International Nosocomial Infection Control Consortium (INICC) Surveillance Online System applying the Centers for Disease Control and Prevention's National Healthcare Safety Network (CDC-NHSN) criteria. Pre–COVID-19 rates for 2019 were compared with COVID-19 era rates for 2020 for central line–associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator-associated events (VAEs), mortality, and length of stay (LOS).
Results: A total of 7,775 patients were followed up for 49,506 bed days. The 2019 to 2020 rate comparisons were 2.54 and 4.73 CLABSIs per 1,000 central line days (risk ratio [RR] = 1.85, $p = .0006$), 9.71 and 12.58 VAEs per 1,000 mechanical ventilator days (RR = 1.29, $p = .10$), and 1.64 and 1.43 CAUTIs per 1,000 urinary catheter days (RR = 1.14; $p = .69$). Mortality rates were 15.2% and 23.2% for 2019 and 2020 (RR = 1.42; $p < .0001$), respectively. Mean LOS for 2019 and 2020 were 6.02 and 7.54 days (RR = 1.21, $p < .0001$), respectively.

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Discussion: This study documents an increase in HAI rates in 7 LMICs during the first 5 months of the COVID-19 pandemic and highlights the need to reprioritize and return to conventional infection prevention practices.

Introduction

Before the appearance and worldwide spread of the COVID-19 pandemic, a pervasive decrease in health care–associated infection (HAI) incidence had been observed across hospitals in the United States (Weiner-Lastinger et al., 2021b). Throughout 2020, as COVID-19 swept across the United States in multiple waves of infections, regions experienced steep surges in cases and hospitalizations (Ripa et al., 2021). Some studies specifically noted the occurrence of secondary infections in patients with COVID-19 (Ripa et al., 2021). In addition, single-site studies observed signs of increases in select HAIs in the United States as early as the spring of 2020 (Fakih et al., 2021; LeRose et al., 2021; McMullen et al., 2020).

During the second quarter of 2020, as United States hospitals nationwide responded to the influx of COVID-19 cases, increasing standardized infection ratios (SIRs) were detected (Weiner-Lastinger et al., 2021b). Initial increases in the SIRs were observed for central line–associated bloodstream infections (CLABSIs), methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia, and ventilator-associated events (VAEs) (Weiner-Lastinger et al., 2021b).

Compared with the prepandemic rates observed throughout 2019, the third and fourth quarters of 2020 were notable for significant increases in SIRs associated with CLABSIs, VAEs, MRSA bacteremia, and catheter-associated urinary tract infections (CAUTIs) (Weiner-Lastinger et al., 2021b). When comparing 2020, the first year of COVID-19 hospitalizations throughout the United States to the prepandemic experience of 2019, the upward trend in SIRs across all HAI types was most pronounced for CLABSIs (Weiner-Lastinger et al., 2021b). According to the National Healthcare Safety Network (NHSN), increasing rates for CLABSIs were noted in the earliest months of the pandemic (Patel et al., 2021). Elevated CLABSI incidence during the COVID-19 pandemic in the context of the likely impact of hospital COVID-19 prevention activities on central line (CL) insertion and maintenance practices has been repeatedly documented (Fakih et al., 2021; LeRose et al., 2021; McMullen et al., 2020).

Potential contributors to increased risks for device-associated infection during the COVID-19 pandemic in 2020 included longer patient length of stay (LOS), increased numbers of comorbidities, elevated patient acuity levels, and longer durations of device use (Weiner-Lastinger et al., 2021b). Increased reliance on acute-care hospitals (ACHs) during the pandemic may also have increased HAI risks in several ways, including altered staffing patterns and practices, increased critical care capacity, and modified use of personal protective equipment (Rebmann et al., 2021; Weiner-Lastinger et al., 2021a).

The International Nosocomial Infection Control Consortium (INICC) is the largest international HAI surveillance system. INICC surveillance is used by hospitals in multiple low- and middle-income countries (LMICs) (Rosenthal, 2016; Rosenthal et al., 2008). INICC data are used to update HAI rates and measure the impact of infection prevention interventions (Rosenthal et al., 2021; Rosenthal et al., 2013b). For almost 2 decades, from 2002 through 2019, the INICC's LMIC members have seen significant reductions in the rates of CLABSI, VAE, and CAUTI, related to their adoption and application of INICC online platforms and prevention methods (Rosenthal et al., 2013a; Rosenthal et al., 2010; Rosenthal et al., 2014; Rosenthal et al., 2012a; Rosenthal et al., 2012b; Rosenthal et al., 2012c; Rosenthal et al., 2012d; Rosenthal et al., 2012e; Rosenthal et al., 2012f).

Given the likelihood for COVID-19 response activities to impact HAI risks and practices, the INICC team analyzed HAI incidence, comparing prepandemic rates from 2019 to pandemic-era rates in 2020 to explore potential changes.

Methods

Data were collected using the INICC Surveillance Online System (ISOS) platform (Rosenthal, 2016; Rosenthal et al., 2008). ISOS applies NHSN criteria, developed by the Centers for Disease Control and Prevention (CDC), for the calculation of HAI rates and device use ratios (DURs) (CDC/NHSN, 2019; Emori et al., 1991). HAI definitions include both laboratory and clinical criteria (CDC/NHSN, 2019; Emori et al., 1991).

Acute-care hospital patients from 7 LMICs that report to the INICC (India, Mongolia, Jordan, Lebanon, Palestine, Egypt, and Turkey) were followed up from intensive care unit (ICU) admission to discharge. Infection preventionists collected data on HAIs occurring in all patients admitted to the ICU. The corresponding denominator data, consisting of specific device days, were collected and validated.

Rates of CLABSIs, VAEs, CAUTIs, and mortality, along with LOSs, were computed from analyses of compiled individual patient data. INICC methods include daily data collection for all patients, data on the use of invasive devices, confirmation that CDC-NHSN criteria for diagnosed HAIs are met in each case, along with a check of numerators and denominators (Rosenthal, 2016; Rosenthal et al., 2008).

Using INICC data, HAI incidence rates were calculated and compared for 2019 (prepandemic year) and the first 5 months of 2020 (pandemic year).

Data analyses were conducted using SPSS for Windows Version 16.0 (SPSS Inc., IBM Corp., Chicago, Illinois), ISOS® (Buenos Aires, Argentina) (Rosenthal, 2016; Rosenthal et al., 2008), and EpiInfo® version 6.04b (CDC, Atlanta, Georgia).

To compare hospitalization type and gender among both periods, we applied a test of homogeneity, Pearson's chi-squared test, with Yates' continuity correction. To compare age among both periods, we applied 2 sample *t*-test, for 2 independent groups. To compare mechanical ventilator days, CL days, urinary catheter (UC) days, and peripheral catheter days among both periods, we applied 2 sample *t*-test for 2 independent groups. Data for ICUs were not stratified by type or size of the hospital.

Results

A total of 7,775 patients admitted to ICUs in hospitals in 7 LMICs were followed up from admission to discharge from the ICU, totaling 49,506 bed days of observation. In the prepandemic period, from January 1, 2019, to December 31, 2019, a total of 5,997 patients were hospitalized in ICUs for a total of 36,106 bed days. In the pandemic period, from January 1, 2020, to May 31, 2020, a total of 1,778 admitted patients were hospitalized for 13,400 bed days. The average LOS was 6.02 days in 2019 and 7.54 days in 2020, reflecting a significant 21% increase in LOS (RR = 1.21; 95% confidence interval [CI]: 1.15-1.27; $p < .0001$).

In the prepandemic period of 2019, a total of 36,652 CL days were reported. A total of 93 CLABSIs were acquired, yielding a rate of 2.54 CLABSIs per 1,000 CL days.

During 2020, 9,515 CL days were reported. A total of 45 CLABSIs were acquired, yielding a rate of 4.73 CLABSIs per 1,000 CL days. This represented a significant 85% increase in the rate of CLABSIs from 2019 to 2020 (RR = 1.85; 95% CI: 1.30-2.65; $p = .0006$) (Table 1).

In the prepandemic period of 2019, 13,801 mechanical ventilation (MV) days were reported. In addition, 134 VAEs were acquired, yielding a rate of 9.71 VAEs per 1,000 MV days. During 2020, 4,611 MV days were reported; 58 VAEs were acquired, yielding a rate of 12.58 VAEs per 1,000 MV days. This represented a marginally significant 29% increase in the rate of VAEs from 2019 to 2020 (RR = 1.29; 95% CI: 0.95-1.75; $p = .10$) (Table 1).

In the prepandemic period of 2019, 24,919 UC days were reported; 41 CAUTIs were acquired, yielding a rate of 1.64 CAUTIs per 1,000 UC days. During 2020, 7,653 UC days were reported; 11 CAUTIs were acquired, yielding a rate of 1.43 CAUTIs per 1,000 UC days. No significant change in the rate of CAUTIs was observed between 2019 and 2020 (RR = 1.14; 95% CI: 0.58-2.22; $p = .69$) (Table 1).

In 2019, 5,997 patients were admitted to the ICU, of whom 916 died, resulting in a mortality rate of 15.2%. In 2020, 1,778 patients were admitted to the ICU, of whom 413 died, resulting in a mortality rate of 23.2%. This represented a significant 42% increase in mortality from 2019 to 2020 (RR = 1.42; 95% CI: 1.27-1.58; $p < .0001$) (Table 2).

In the prepandemic period of 2019, the average LOS of patients was 6.02 days, and in 2020, the average LOS of patients was 7.54 days. This represented a significant 21% increase in average LOS from 2019 to 2020 (RR = 1.21; 95% CI: 1.15-1.27; $p < .001$) (Table 3).

Comparing both periods to identify confounders, we found that during 2020, patients were significantly younger, and mechanical ventilator and UC use was significantly longer. In contrast, hospitalization type, gender, CL days, and peripheral catheter days were similar (Table 4).

Discussion

This is the first international report comparing HAI, mortality rates, and LOS among patients hospitalized in ICUs in multiple LMICs in 2019, before the COVID-19 pandemic, and in 2020, during the first 5 months of the pandemic. Data reported here provide an international picture of how patient safety, generally, and incidence rates of HAIs, specifically, may have been affected by the COVID-19 pandemic.

Before the arrival of COVID-19, decreasing HAI incidence rates had been observed in LMICs (Rosenthal et al., 2013a, Rosenthal et al., 2010; Rosenthal et al., 2014; Rosenthal et al., 2012a; Rosenthal et al., 2012b; Rosenthal et al., 2012c; Rosenthal et al., 2012d; Rosenthal et al., 2012e; Rosenthal et al., 2012f), as well as in hospitals in the United States.

Findings reported here for 7 LMICs corroborate analyses conducted in US hospitals, showing sharp increases in CLABSI rates (highest among all HAI types) during the pandemic. These complementary findings suggest that COVID-19 prevention activities may have affected CL insertion and maintenance practices, as previously

Table 1
Comparison of pooled HAI rates per 1,000 device days and relative risk in ICUs of 7 INICC hospitals from LMICs in 2019 and 2020.

	2019			2020					
HAI type	Device days, n	HAIs, n	HAI rate	Device days, n	HAIs, n	HAI rate	RR[a]	95% CI[a]	P-value
CLAB[a]	36,652 CL[a] days	93 CLABs	2.54 CLAB per 1,000 CL days	9,515 CL days	45 CLABs	4.73 CLAB per 1,000 CL days	1.85	1.30-2.65	.0006
VAE[a]	13,801 MV[a] days	134 VAEs	9.71 VAE per 1,000 MV days	4,611 MV days	58 VAEs	12.58 VAE per 1,000 MV days	1.29	0.95-1.75	.10
CAUTI[a]	24,919 UC[a] days	41 CAUTIs	1.64 CAUTI per 1,000 UC days	7,653 UC days	11 CAUTIs	1.43 CAUTI per 1,000 UC days	1.14	0.58-2.22	.69

Acute care hospitals were located in India, Mongolia, Jordan, Turkey, Egypt, Palestine, and Lebanon.
CAUTI = catheter associated urinary tract infection; CI = confidence interval; CL = central line; CLAB = central line–associated bloodstream infection; HAI = health care–associated infection; ICU = intensive care unit; INICC = International Nosocomial Infection Control Consortium; LMIC = low- and medium-income country; MV = mechanical ventilator; RR = relative risk; UC = urinary catheter; VAE = ventilator-associated event.

Table 2
Pooled means and relative risk of the crude mortality of patients admitted to the ICU in 2019 and 2020.

2019			2020					
Number of patients, n	Number of deaths, n	Mortality rate, %	Number of patients, n	Number of deaths, n	Mortality rate, %	RR[a]	95% CI[a]	P-value
5,997	916	15.2	1,778	413	23.2	1.42	1.27-1.58	<.0001

CI = confidence interval; ICU = intensive care unit; RR = relative risk.

Table 3
Pooled means and relative risk of the ALOS of patients admitted to the ICU in 2019 and 2020.

2019			2020					
Number of patients, n	Bed days, n	ALOS, n	Number of patients, n	Bed days, n	ALOS, n	RR[a]	95% CI[a]	P-value
5,997	36,106	6.02	1,778	13,400	7.54	1.21	1.15-1.27	<.001

ALOS = average length of stay; CI = confidence interval; ICU = intensive care unit; RR = relative risk.

Table 4
Confounding variables.

Patient characteristics	2019	2020			p-Value	Test
Age	Mean 44.49911	Mean 35.31041	Mean difference 9.1887	95% CI 7.9617-10.4157	.0	*t* statistic = 14.682 degrees of freedom = 3994
Mechanical ventilator days, average use,	Mean 4.637427	Mean 6.024773	Mean difference 1.3874	95% CI 0.9298-1.845	.0	*t* statistic = −5.9463 degrees of freedom= 1711.5
Central line days, average use,	Mean 8.150607	Mean 8.301244	Mean difference 0.1506	95% CI 0.3438-0.6451	.5503	*t* statistic = −0.59733 degrees of freedom= 2928.4
Urinary catheter days, average use,	Mean 5.162639	Mean 5.624106	Mean difference 0.4614	95% CI 0.1485-0.7745	.0039	*t* statistic = −2.8908 degrees of freedom = 2877.2
Peripheral catheter days, average use,	Mean 5.713647	Mean 5.79456	Mean difference 0.0809	95% CI 0.3232-0.485	.6947	*t* statistic = −0.39259 degrees of freedom = 2711.4
Hospitalization type						
Medical	51.8%	51.8%				
Surgical	48.2%	48.2%		.9806	$\chi^2 = 0.00058997$ degrees of freedom = 1	
Gender						
Female	37.7%	38.02%				
Male	62.3%	61.98%		.8469	$\chi^2 = 0.037295$ degrees of freedom = 1	

CI = confidence interval.

documented in multiple studies (Fakih et al., 2021; LeRose et al., 2021; McMullen et al., 2020; Patel et al., 2021).

It is likely that COVID cases in 2020 who were populating the hospital ICUs were associated with longer mean LOS, multiple comorbidities, elevated patient acuity levels, and longer durations of device use, which are all factors that could have increased risks for HAIs during the pandemic (Fakih et al., 2021; LeRose et al., 2021; McMullen et al., 2020).

Moreover, several studies identified an increased risk of ventilator-associated conditions in critically ill patients with COVID-19 (Fakih et al., 2021; LeRose et al., 2021; Maes et al., 2021; McMullen et al., 2020). The characteristic worsening of respiratory status in some patients with COVID-19 increased the number of hospitalized patients in 2020 who required ventilation, and an increase in patients' average duration of ventilation, both of which could have contributed to an increased risk of VAEs. Further support for this reasoning comes from CDC analyses spanning many states that experienced high rates of COVID-19 hospital admissions, showing significant increases in rates of both CLABSIs and VAEs during 2020 compared with the 2019 prepandemic rates of these HAIs (Sapiano et al., 2021).

Increase in CLABSI rates during 2020 was not influenced by hospitalization type, age, or gender because hospitalization type and gender were similar in both periods, and the patients were younger during 2020. In addition, increase of CLABSI rates was not associated with increased vascular catheter device use because CL and peripheral catheter device use were similar in both periods.

UC use and CAUTI rates were similar in both periods, meaning that UC use did not have any influence on rates. Mechanical ventilator use was significantly higher during 2020, but VAE rates were not significantly higher.

This study has several limitations. First, analyses were limited to hospitals that reported data for both 2019 and 2020. New hospitals and units that opened in 2020 in response to COVID-19 were not included. Many LMIC hospitals and health care centers ceased their HAI surveillance during 2020, the first year of the pandemic, because of the extreme workload demands associated with caring for the surge of patients with COVID-19, coupled with marked reductions in staffing. Thus, these analyses are limited to a group of hospitals in just 7 LMICs. Thus, the findings of this study cannot be generalized to represent the patterns of HAIs across a broader spectrum of LMICs. Furthermore, we focused solely on ACHs for these analyses, and we cannot extend our findings to other care settings for patients with COVID-19, including critical access and long-term facilities. Finally, we did not analyze if the observed significant excess LOS was the cause or the consequence of HAIs.

Conclusions

To our knowledge, this study is the first to provide a comprehensive look at the impact of COVID-19 on HAI incidence in LMICs. Significant increases were observed in overall mortality, CLABSIs, and mean LOS, along with a marginally significant increase in VAEs.

The COVID-19 pandemic's first year—2020—marked an unprecedented time for hospitals, many of which were simultaneously challenged to confront an overwhelming patient caseload, deep and acute staffing shortages, austere care regimens, crisis standards of care, and rationing of life-saving devices and therapies, all of which impinged on the capabilities to maintain optimal infection prevention and control practices.

Regular review of HAI surveillance data is critical for hospitals to rapidly detect any upward inflections in HAI rates, identify gaps in prevention practices, and implement effective interventions. Infection prevention programs should urgently reprioritize infection prevention practices in their facilities. Health care systems must improve contingency planning to foster resiliency and withstand future public health emergencies.

Disclosures

All authors report no conflicts of interest related to this article. Every hospital's institutional review board agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it only identifiable to the infection control team.

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Authors' Contributions

Zhilin Jin and Ruijie Yin were involved in the statistical analysis, critical revision for important intellectual content, and final approval of the manuscript.

Victor D. Rosenthal was responsible for study conception and design, drafting of the manuscript, software development, technical support, report generation, data validation, data assembly, data interpretation, epidemiologic and statistical analysis, critical revision of the manuscript for important intellectual content, and final approval of the manuscript.

Sheila Nainan Myatra, Jigeeshu Vasishtha Divatia, Sanjay Biswas, Anjana Shrivastava, Majeda Alruieh, Omar Ayyad, Ariungerel Bat-Erdene, Ider Bat-Erdene, Batsaikhan Narankhuu, Debkishore Gupta, Subhranshu Mandal, Sankar Sengupta, Hala Joudi, Ibrahim Omeis, Hala Mounir Agha, Amr Fathallala, El Hossein Mohamed, Irem Yesiler, Mehmet Oral, Menekse Ozcelik, Yatin Mehta, Smita Sarma, Souranshu Chatterjee, Souad Belkebir, Alaa Kanaa, and Rawan Jeetawi were involved in the provision of study patients, in critical revision of the manuscript for important intellectual content, and final approval of the manuscript.

Samantha A. Mclaughlin, James M. Shultz, and Gonzalo Bearman were involved in the critical revision of the manuscript for important intellectual content and final approval of the manuscript.

Ethical approval

I have read and complied with the policy of the Journal on ethical consent as stated in the Guide to Authors.

The use of the protocol, methods, criteria, definitions, and software were approved by the Ethics Committee of the Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, India. Document number: AA No. 178736.

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