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The Impact of COVID-19 on Healthcare-Associated Infections

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Summary: COVID-19 surges adversely impact healthcare-associated infection rates and clusters of infections within hospitals, emphasizing the need for balancing COVID-related demands with routine hospital infection prevention.

Abstract

Background: The profound changes wrought by COVID-19 on routine hospital operations may have influenced performance on hospital measures, including healthcare-associated infections (HAIs). We aimed to evaluate the association between COVID-19 surges and HAI and cluster rates.

Methods: In 148 HCA Healthcare-affiliated hospitals, 3/1/2020-9/30/2020, and a subset of hospitals with microbiology and cluster data through 12/31/2020, we evaluated the association between COVID-19 surges and HAIs, hospital-onset pathogens, and cluster rates using negative binomial mixed models. To account for local variation in COVID-19 pandemic surge timing, we included the number of discharges with a laboratory-confirmed COVID-19 diagnosis per staffed bed per month.

Results: Central line-associated blood stream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), and methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia increased as COVID-19 burden increased. There were 60% (95% CI, 23-108%) more CLABSI, 43% (95% CI, 8-90%) more CAUTI, and 44% (95% CI, 10-88%) more cases of MRSA bacteremia than expected over 7 months based on predicted HAIs had there not been COVID-19 cases. *Clostridioides difficile* infection was not significantly associated with COVID-19 burden. Microbiology data from 81 of the hospitals corroborated the findings. Notably, rates of hospital-onset bloodstream infections and multidrug resistant organisms, including MRSA, vancomycin-resistant enterococcus and Gram-negative organisms were each significantly associated with COVID-19 surges. Finally, clusters of hospital-onset pathogens increased as the COVID-19 burden increased.

Conclusion: COVID-19 surges adversely impact HAI rates and clusters of infections within hospitals, emphasizing the need for balancing COVID-related demands with routine hospital infection prevention.

Keywords: COVID-19; Healthcare-Associated Infections (HAI); Central Line-Associated Blood Stream Infection (CLABSI); Catheter-Associated Urinary Tract Infection (CAUTI)

Introduction

The COVID-19 pandemic placed extraordinary demands on the healthcare system, resulting in modifications in routine patient care practices that could have the potential to either increase or decrease risks for healthcare-associated infections (HAIs). Negative impacts may have resulted when usual efforts to monitor and prevent HAIs were redirected to the COVID-19 response. Enhanced isolation practices and the burden of increased personal protective equipment (PPE) requirements may have led to reduced focus on routine HAI prevention activities such as central line and urinary catheter care. Earlier studies suggest that these shifts in activities and supplies could be associated with an increase in HAI rates.[1,2]

Simultaneously, infection prevention and control practices became more visible in healthcare systems. Hand hygiene was emphasized both inside and outside of healthcare facilities.[3] Training on donning and doffing of personal protective equipment was enhanced, and many hospitals saw increased compliance with contact precautions. It is possible that increased attention to standard infection prevention practices and the use of personal protective equipment impacted HAI rates in a beneficial direction, particularly the spread of multidrug resistant organisms (MDROs).[4,5]

Increased attention to infection prevention practices may have balanced the additional pandemic-related burden on infection prevention resources. Understanding whether and how COVID-19 impacted HAI rates is essential to guide resources, policies, and practices during the next stages of the COVID-19 response.

Methods

Study population and setting:

We conducted a prospective cohort study in 148 HCA Healthcare-affiliated hospitals. HAI events were assessed by the hospitals' infection preventionists on all patients admitted between March 1, 2020 and September 30, 2020. Hospital-onset bloodstream infections (BSI) and MDRO events were assessed in 81 hospitals with microbiology data available between March 1, 2020 and December 31, 2020. We used a spatial and temporal scan statistic to identify clusters in 40 of those hospitals (Figure 1).[6-9] The 40 hospitals were a random sample of the 81 hospitals, balanced on hospital and intensive care unit census, average comorbidity count, length of stay and historical cluster data.[10] This study was approved by the Harvard Pilgrim Health Care institutional review board, and HCA Healthcare-affiliated hospitals and collaborating institutions delegated review.

Data sources and events:

Central line-associated blood stream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia, and *Clostridioides difficile* infection (CDI) reported by participating hospitals to the Centers for Disease Control and Prevention's (CDC) National Healthcare Safety Network (NHSN) were identified.[11] To validate the analyses based on NHSN data, microbiology data in a subset of the hospitals were used to identify any hospital-onset bloodstream infections (BSI) or MDRO-positive clinical cultures. MRSA bacteremia and CDI were reported directly to NHSN based on microbiology data and are thus not validated. Hospital-onset BSI was defined as a positive blood culture obtained on hospital day 3 or later and in an inpatient location. If the organism was on the NHSN list of common commensal organisms [12], we required 2 cultures of the same organism on the same or consecutive days. Hospital-onset MDROs were defined as clinical cultures growing an MDRO organism based on the CDC criteria [13] and obtained from any body site on hospital day 3 or later, excluding surveillance cultures. The

MDRO analysis was also separated into MRSA, vancomycin-resistant enterococcus (VRE) and Gram-negative bacteria.

In 40 hospitals, we identified clustering of organisms based on hospitals' microbiology data. Clusters were defined by statistically significant increases in organisms collected on hospital day 3 or later from a single ward or clinically related wards compared to a 2 year baseline time period.[6] Identification of clusters was based on matching of species and antimicrobial resistance profile when available. We used a statistically-based cluster detection tool, WHONET-SaTScan, to identify clusters, and parameters were based upon prior studies.[6,14] Statistical significance was measured using a recurrence interval, which estimates the likelihood that the cluster signal would occur by chance.[15] We used a threshold recurrence interval of 200 days, meaning that a cluster of this type of organism with the observed number and distribution of cases would be expected to occur by chance less than once per every 200 days.

For each facility and month, the number of COVID-19 patients per staffed bed was calculated by dividing the number of cases discharged from the facility with SARS-CoV-2, confirmed by polymerase chain reaction, per month by the number of beds the facility was approved to service. As we included COVID-19 patients discharged from facilities rather than admitted, we did not include lag time in the analysis. Covariates included hospital size as a categorical variable (small <200 beds, medium 200 to <300 beds, and large ≥300 beds). CLABSI and CAUTI models included the expected count as an offset, while MRSA bacteremia and CDI models included patient days as a covariate. We also evaluated chronologic calendar month to account for changes in process over time and use of contact precautions for MRSA and VRE in the models.

Statistical analysis

We used negative binomial mixed models to account for within-hospital correlation across the repeated measures over time. Different models were developed for each event type. The data for the models included the monthly number of discharges of COVID-19 patients per staffed bed as the predictor. Results are presented as the relative rate in the event per 0.1 increase in the monthly discharges per staffed bed. Excess cases of HAIs were calculated as the difference between the observed number of events and the predicted number from the model, had there been 0 COVID-19 discharges across the study period. Facility level parameters limited to hospital size were included in the models. All statistical analyses were performed in SAS version 9.4.

Role of the funding source

This study was funded by the CDC Prevention Epicenter Program. The funder had no role in the design or conduct of the study; collection, management, analysis or interpretation of the data; preparation, review or approval of the manuscript; or decision to submit the manuscript for publication.

Results

The 148 hospitals ranged in size from 34 to 1013 beds and were located in 17 states. The hospitals had a total of 1,024,160 discharges between March 1, 2020 and September 30, 2020 (Table 1). They included 60 small facilities, 40 medium facilities and 48 large facilities.

Increased relative rates of CLABSI, CAUTI and MRSA bacteremia reported to NHSN were associated with increasing monthly COVID-19 discharges (Table 2). For each 0.1 increase in the monthly number of discharges of COVID-19 patients per staffed bed, there was a relative increase of 1.14 (95% CI, 1.09 to 1.19) for CLABSI, 1.09 (95% CI, 1.04 to 1.15) for CAUTI, and 1.09 (95% CI, 1.04 to 1.14) for MRSA bacteremia (Figure 2a-c). Larger hospital size

was independently associated with a greater number of HAI events. Over 7 months, there were 60% (95% CI, 23 to 108%) more CLABSI, 43% (95% CI, 8 to 90%) more CAUTI, and 44% (95% CI, 10 to 88%) more cases of MRSA bacteremia than were expected based on the predicted number across the 148 hospitals. CDI relative rates, however, were not associated with increased monthly rates of COVID-19 discharges, 0.97 (95% CI, 0.93 to 1.02) (Figure 2d).

When evaluating microbiology data from the subset of 81 hospitals, there was a greater absolute number of hospital-onset BSIs and MDRO-positive cultures associated with an increase in the number of COVID-19 hospitalizations. Per 0.1 increase in the monthly number of discharges of COVID-19 patients per staffed bed, the relative rate was 1.05 (95% CI, 1.03 to 1.07) for hospital-onset BSIs and 1.05 (95% CI, 1.04 to 1.07) for any hospital-onset MDRO. Specific MDRO rates included a relative increase of 1.06 (95% CI, 1.04 to 1.08) for hospital-onset MRSA, 1.04 (95% CI, 1.01 to 1.08) for hospital-onset VRE, and 1.06 (95% CI, 1.04 to 1.08) for hospital-onset multidrug resistant Gram-negative bacteria (Table 2). Hospital size was also independently associated with BSI and MDRO events. Chronologic calendar month and use of contact precautions for MRSA and VRE were not found to be statistically significant and were not included in the final model. Over 10 months, 882,835 discharges experienced an additional 24% (95% CI, 2 to 51%) of hospital-onset BSIs and 24% (95% CI, 3 to 49%) of hospital-onset MDROs than predicted, including 30% (95% CI, 4 to 63%) hospital-onset MRSA, 44% (95% CI, 3 to 102%) hospital-onset VRE, and 27% (95% CI, 4 to 55%) hospital-onset multidrug resistant Gram-negative organisms, that were temporally associated with COVID-19 surges.

Spatio-temporal scanning in 40 hospitals identified 101 clusters with a mean size of 3.8 isolates. Increased relative rates of clusters of hospital-onset pathogens were associated with increasing monthly rates of COVID-19 discharges per staffed bed. For each increase of 0.1 in the monthly number of discharges of COVID-19 patients per staffed bed, there was a

relative increase of 1.09 (95% CI, 1.01 to 1.18) in the occurrence of clusters (Table 2, Figure 3). The cluster isolates accounted for 16% of the excess BSI cases and 36% of the excess MDRO cases.

Discussion

This analysis of prospectively collected HAI and microbiology data in geographically diverse US hospitals confirmed that elevated HAI rates were temporally associated with increases in hospitalized COVID-19 patients. Furthermore, the number of clusters of hospital-onset pathogens increased during COVID-19 surges, suggesting increased healthcare-associated transmission as one possible mechanism to account for increases in HAIs. As the facilities included here represent a sample of hospitals across the United States with varying local pandemic pressures, this analysis supports the hypothesis that certain HAI rates are being adversely affected by the pandemic response. This highlights the critical importance of identifying strategies to ensure the sustainability of routine infection prevention programs even during periods of public health crises that require diversion of healthcare resources.

In the HCA Healthcare system and many other hospitals, HAI rates had been steadily declining prior to the COVID-19 pandemic.[16] Efforts in hospitals to reach zero HAIs focused attention on surveillance and infection prevention process measures.[17] However, as health systems were strained by COVID-19, HAI rates increased, demonstrating how community pandemic control impacts other patients beyond those infected by the pandemic pathogen. This study's finding that the number of clusters significantly increased is consistent with recent case reports of outbreaks during COVID-19 surges or on COVID-19 specialty units.[18,19] The additional burden of COVID-19 care, disrupting routine practice, may have contributed to the clustering of infections, including both lapses in routine infection prevention practice as well as transmission of healthcare-associated pathogens. Additionally, during COVID-19 surges, many elective admissions were canceled, resulting in higher acuity patient populations.[20]

As our analysis and others have shown, CDI rates were stable or decreased during the COVID-19 pandemic.[21] Barrier precautions and increased training on donning and doffing of PPE to prevent COVID-19 transmission might have led to reductions in the carriage of *Clostridioides difficile*. This may have been particularly important for reducing transmission of *Clostridioides difficile* spores which are often resistant to alcohol-based hand sanitizer and may survive on surfaces for extended periods of time. Alternatively, rates of CDI may lag due to the delayed consequences of changes in antimicrobial stewardship or changes in testing practices.

Limitations of this study include use of NHSN-reported HAI events. Variations in surveillance and reporting may affect NHSN HAI data, especially when infection prevention activities are constrained. Some facilities may have been challenged, leading to reduced reporting whereas other facilities may have noted heightened vigilance leading to increased reporting. However, this study supplements NHSN reported events dependent on adjudication, such as CLABSI or CAUTI, with microbiology-based analyses that minimize the potential impact of reduced infection preventionist effort available for HAI surveillance. Additionally, HAI rates may have been impacted by dynamic changes in the overall risk of HAIs within the inpatient population given the marked increase in acuity and decrease in elective admissions.

Although the per-patient risk of a hospital-onset infection remained very low, HAI rates increased during COVID-19 surges. Further research is necessary to elucidate the specific ways in which the COVID-19 burden is affecting HAI rates, but our results identify a need to build capacity in infection prevention and control. As hospitals and healthcare systems prepare for the next stages of the pandemic and recovery, this study emphasizes the need to remain focused on routine infection prevention.

NOTES

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References

1. McMullen KM, Smith BA, Rebmann T. Impact of SARS-CoV-2 on hospital acquired infection rates in the United States: Predictions and early results. American journal of infection control, 2020;48(11):1409-11.
2. Fakih MG, Bufalino A, Sturm L , et al. Coronavirus disease 2019 (COVID-19) pandemic, central-line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infection (CAUTI): The urgent need to refocus on hardwiring prevention efforts. Infect Control Hosp Epidemiol, 2021;1-6. doi: 10.1017/ice.2021.70.
3. Moore LD, Robbins G, Quinn J, Arbogast JW. The impact of COVID-19 pandemic on hand hygiene performance in hospitals. Am J Infect Control, 2021;49(1):30-3.
4. Wee LEI, Conceicao EP, Tan JY, et al. Unintended consequences of infection prevention and control measures during COVID-19 pandemic. American journal of infection control, 2021;49(4):469-477.
5. Tsang KK, Mertz D, O'Neill C, Khan S. Silver linings of the coronavirus disease 2019 (COVID-19) pandemic from an infection prevention and control perspective. Infection control and hospital epidemiology, 2020:1-2. doi:10.1017/ice.2020.1310.
6. Huang SS, Yokoe DS, Stelling J, et al. Automated detection of infectious disease outbreaks in hospitals: a retrospective cohort study. PLoS Med, 2010;7(2):e1000238.
7. Kulldorff M, Heffernan R, Hartman J, Assuncao R, Mostashari F. A space-time permutation scan statistic for disease outbreak detection. PLoS Med, 2005;2(3):e59.
8. Kulldorff M, Athas WF, Feurer EJ, Miller BA, Key CR. Evaluating cluster alarms: a space-time scan statistic and brain cancer in Los Alamos, New Mexico. Am J Public Health, 1998;88(9):1377-80.
9. Kulldorff M. Prospective time periodic geographical disease surveillance using a scan statistic. J Roy Stat Soc, 2001;164(1):61-72.
10. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity Measures for Use with Administrative Data. Medical Care, 1998;36(1):8-27.

11. Centers for Disease Control and Prevention. The NHSN Standardized Infection Ratio (SIR). February 2021. Accessed at https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf on 26 April 2021.

12. Centers for Disease Control and Prevention. Common commensals. Accessed at https://www.cdc.gov/nhsn/xls/master-organism-com-commensals-lists.xlsx on 13 April 2021.

13. Centers for Disease Control and Prevention. Multidrug-resistant organism & *Clostridioides difficile* infection (MDRO/CDI) Module. January 2021. Accessed at https://www.cdc.gov/nhsn/pdfs/pscmanual/12pscmdro_cdadcurrent.pdf on 13 April 2021.

14. Baker MA, Yokoe DS, Stelling J, et al. Automated outbreak detection of hospital-associated pathogens: Value to infection prevention programs. Infect Control Hosp Epidemiol, 2020;41(9):1016-21.

15. Kleinman K, Lazarus R, Platt R**.** A generalized linear mixed models approach for detecting incident clusters of disease in small areas, with an application to biological terrorism. Am J Epidemiol, 2004;159(3):217-24.

16. Centers for Disease Control and Prevention. Healthcare-associated infections. 20 November 2020. Accessed at https://www.cdc.gov/hai/data/portal/index.html on 8 January 2021.

17. Safdar N, Anderson DJ, Braun BI, et al. The evolving landscape of healthcare-associated infections: recent advances in prevention and a road map for research. Infect Control Hosp Epidemiol, 2014;35(5):480-93.

18. Prestel C, Anderson E, Forsberg K, et al. Candida auris Outbreak in a COVID-19 Specialty Care Unit - Florida, July-August 2020. MMWR Morb Mortal Wkly Rep, 2021;70(2):56-7.

19. Perez S, Innes GK, Walters MS, et al. Increase in Hospital-Acquired Carbapenem-Resistant Acinetobacter baumannii Infection and Colonization in an Acute Care Hospital During a Surge in COVID-19 Admissions - New Jersey, February-July 2020.

MMWR Morb Mortal Wkly Rep, 2020;69(48):1827-31.

20. Lyall MJ, Lone NI**.** Higher clinical acuity and 7-day hospital mortality in non-COVID-19 acute medical admissions: prospective observational study. Emerg Med J, 2021;emermed-2020-210030. doi:10.1136/emermed-2020-210030.

21. Bentivegna E, Alessio G, Spuntarelli V, et al. Impact of COVID-19 prevention measures on risk of health care-associated Clostridium difficile infection. American Journal of Infection Control, 2021;49(5):640-642. doi:10.1016/j.ajic.2020.09.010.

Table 1: Characteristics of the hospitals included in the analysis

	Number of Discharges in 148 NHSN facilities (N=1,024,160)		Number of Discharges in 81 Facilities with Microbiology Data (N=882,835)	
Patient Characteristic	**N**	**%**	**N**	**%**
Age at admission				
Mean	50		51	
Median (IQR)	55 (31.0-72.0)		56 (31.0-72.0)	
Age Categorized				
0-17	125,613	12.3%	108,961	12.3%
18-44	270,397	26.4%	224,274	25.4%
45-54	103,017	10.1%	88,142	10.0%
55-64	152,037	14.8%	132,238	15.0%
65-74	165,925	16.2%	147,004	16.7%
75-84	132,897	13.0%	118,009	13.4%
≥85	74,265	7.3%	64,197	7.3%
Age >65				
Yes	373,087	36.4%	329,210	37.3%
Male				
Yes	459,221	44.8%	394,537	44.7%
Race Categorized				
Asian	19,829	1.9%	16,037	1.8%
Asian Indian	8,383	0.8%	6,278	0.7%
American Indian/ Alaska Native	1,461	0.1%	1,502	0.2%
Black	163,049	15.9%	131,504	14.9%
Hawaiian/Pacific Islander	1,253	0.1%	930	0.1%
White	692,422	67.6%	606,548	68.7%
Other	118,170	11.5%	101,493	11.5%
Unknown	19,593	1.9%	18,543	2.1%
Hispanic/Latino				
Yes	181,966	17.8%	136,414	15.5%
Length of Stay				
Mean	6		6	
Median (IQR)	4 (3.0-6.0)		4 (3.0-6.0)	
Staffed Beds				
Mean	344		363	
Median (IQR)	313 (231-417)		315 (231-425)	
Elixhauser Count				
Mean	3		3	
Median (IQR)	2 (1.0-4.0)		2 (1.0-4.0)	

Table 2: Effect of an increase in number of COVID-19 discharges on HAIs and hospital-onset pathogens

EVENT	EFFECT	TOTAL	MEDIAN (INTERQUARTILE RANGE)	RELATIVE RATE (95% CI)	P VALUE
CLABSI	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	440	0 (0 - 1)	1.14 (1.09, 1.19)	<0.001
	beds <200			Ref	.
	beds 200-299			2.14 (1.42, 3.23)	<0.001
	beds ≥300			2.43 (1.66, 3.56)	<0.001
CAUTI	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	282	0 (0 - 0)	1.09 (1.04, 1.15)	0.001
	beds <200			Ref	.
	beds 200-299			2.13 (1.39, 3.28)	0.001
	beds ≥300			1.91 (1.27, 2.87)	0.002
CDI	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	658	0 (0 - 1)	0.97 (0.93, 1.02)	0.247
	beds <200			Ref	.
	beds 200-299			3.37 (2.29, 4.96)	<0.001
	beds ≥300			3.17 (2.00, 5.01)	<0.001
MRSA BSI	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	298	0 (0 - 0)	1.09 (1.04, 1.14)	0.001
	beds <200			Ref	.
	beds 200-299			2.05 (1.28, 3.28)	0.003
	beds ≥300			2.18 (1.26, 3.76)	0.005
BSI	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	2911	2 (1 - 5)	1.05 (1.03, 1.07)	<0.001
	beds <200			Ref	.
	beds 200-299			3.19 (2.37, 4.30)	<0.001
	beds ≥300			7.03 (5.29, 9.34)	<0.001

MDRO	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	5097	5 (2 - 9)	1.05 (1.04, 1.07)	<0.001
	beds <200			Ref	.
	beds 200-299			3.01 (2.31, 3.93)	<0.001
	beds ≥300			5.44 (4.21, 7.03)	<0.001
MRSA	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	1944	2 (0 - 3)	1.06 (1.04, 1.08)	<0.001
	beds <200			Ref	.
	beds 200-299			2.79 (2.02, 3.87)	<0.001
	beds ≥300			4.44 (3.25, 6.07)	<0.001
VRE	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	583	0 (0 - 1)	1.04 (1.01, 1.08)	0.016
	beds <200			Ref	.
	beds 200-299			2.88 (1.75, 4.75)	<0.001
	beds ≥300			5.05 (3.13, 8.13)	<0.001
GNR	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	2849	2 (1 - 5)	1.06 (1.04, 1.08)	<0.001
	beds <200			Ref	.
	beds 200-299			3.16 (2.35, 4.26)	<0.001
	beds ≥300			6.29 (4.73, 8.37)	<0.001
Clusters	Per 0.1 increase in the monthly number of COVID-19 discharges per staffed bed	101	0 (0 - 0)	1.09 (1.01, 1.18)	0.02
	beds <200			Ref	.
	beds 200-299			1.55 (0.74, 3.27)	0/25
	beds ≥300			3.17 (1.63, 6.17)	<0.001

FIGURE LEGENDS

Figure 1. Hospitals included in the analyses

The NHSN infection analysis included 148 hospitals. In 81 hospitals, microbiology data was available and included in the BSI and MDRO analyses. A convenience subset of those hospitals was included in the cluster analysis (40 hospitals).

Figure 2. Predicted mean HAI rates as COVID-19 discharges increase

Predicted mean HAI rate by increasing monthly COVID-19 discharges. Panel a. CLABSI, Panel b. CAUTI, Panel c. MRSA Bacteremia, Panel d. CDI. Data are stratified by small, medium and large hospitals.

Figure 3. Monthly comparison of COVID discharges to clusters

COVID-19 discharges and the number of clusters of hospital-onset pathogens are correlated throughout the pandemic.

Figure 1

1.

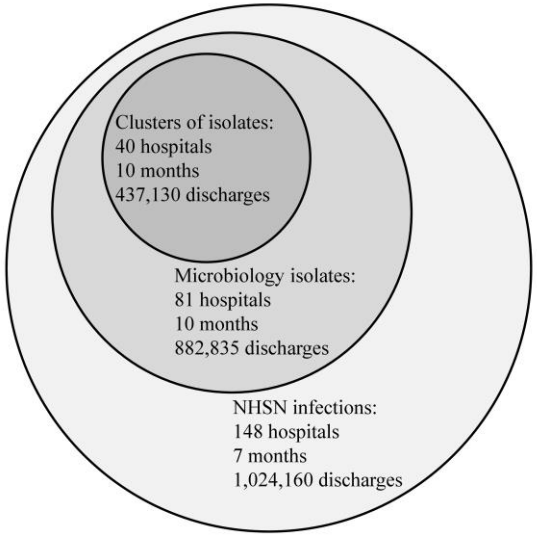

Figure 2

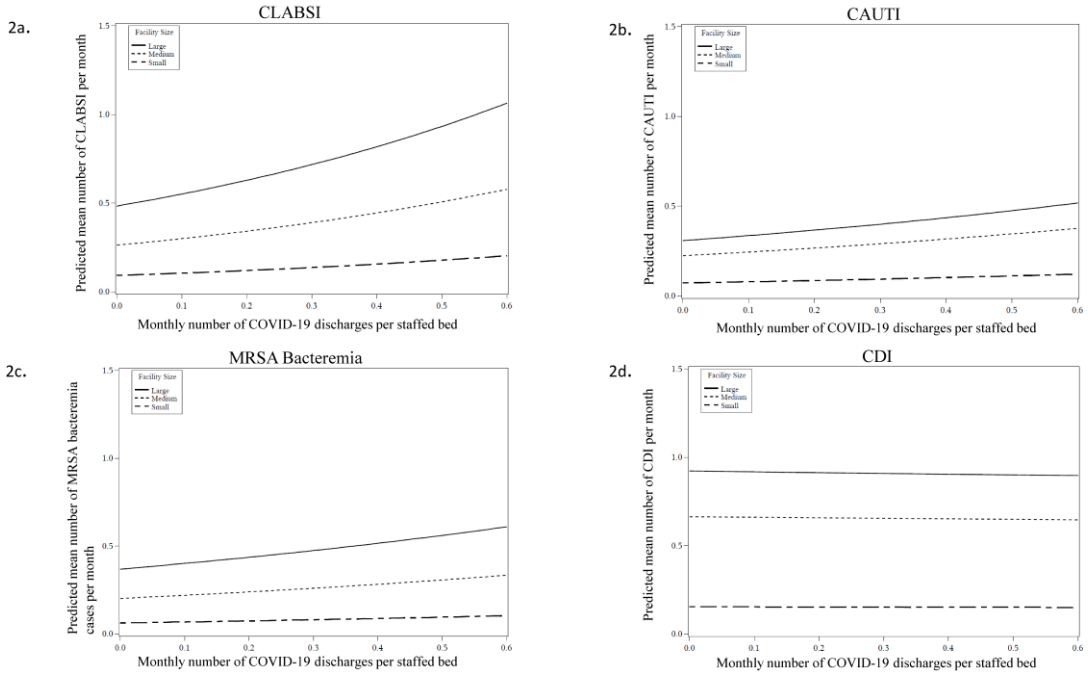

Figure 3

3.