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Antibiotic Resistance in *Staphylococcus aureus* at a Jamaican Hospital: A comparison of the Pre-pandemic and Pandemic Periods

Shari-Jo Knight[1], Camille-Ann Thoms Rodriguez[1,2], Niel McKnight[1,2], Maxine Gossell-Williams[1]

ABSTRACT

Objective

To compare antibiotic resistance patterns in patterns of methicillin-susceptible Staphylococcus aureus (MSSA) and methicillin-resistant Staphylococcus aureus (MRSA) isolates collected before and during the COVID-19 pandemic at a tertiary care hospital in Jamaica.

Methods

A retrospective analysis of antibiotic susceptibility data was conducted by extracting demographic and antibiogram information from the laboratory information system at the University Hospital of the West Indies. The analysis included comparisons between deduplicated cases of S. aureus isolated during the pre-pandemic period (March 10, 2016, to May 5, 2019) and the pandemic period (March 10, 2020, to May 5, 2023). Significant differences in the demographic proportions of cases and their resistance rates to first-line and second-line antibiotics were identified using the independent t-test, chi-square test and Fisher's exact test ($p < 0.05$).

Results

Of 2649 de-duplicated cases of S. aureus infections that were identified across the pre-pandemic (n=1541) and pandemic period (n=1108), the MRSA rates remained at 6.2%. There was no significant difference in susceptibility to other first-line agents (clindamycin, erythromycin and gentamicin) and second line agents (rifampin, minocycline, trimethoprim-sulfamethoxazole and linezolid) between the pre-pandemic and pandemic periods. Although only 8 isolates were tested against linezolid, of significance there was no reported resistance to this drug.

Conclusion

The COVID-19 pandemic didn't significantly change the antibiotic resistance of S. aureus (including MRSA) in this setting, unlike in other areas. These findings, when compared to other healthcare settings, highlight the variable impact of the pandemic on MRSA rates, influenced by differences in healthcare responses and infection control measures. Nonetheless, the projected regional predilection to progressively increasing disease outbreaks by the Caribbean Public Health Agency (CARPHA) is a specific risk for increasing AMR, and in addition to universal risks, underscores the importance of surveillance studies like these which could help to inform AMR mitigation measures.

Key-words: infection control, MRSA, antibiogram, COVID-19, Caribbean/West Indies.

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2*Corresponding author Shari-Jo Knight, Maxine Gossell-Williams[1], Department of Basic Medical Sciences, University of the West Indies, S. Knight: sharijothomas@gmail.com, C. Thoms Rodriguez: camille.thomsrodriguez@uwimona.edu.jm, Maxine Gossell-Williams,Kingston, Jamaica; Camille-Ann Thoms Rodriguez[1,2], Niel McKnight[1,2], Department of Basic Medical Sciences, University of the West Indies, Kingston, Jamaica,[2]Department of Microbiology, University Hospital of the West Indies, Kingston, Jamaica, M. Gossell-Williams: maxine.gossell@uwimona.edu.jm, N. Mcknight: niel.mcknight@uwi.edu

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INTRODUCTION

Antimicrobial resistance (AMR) is a critical global health issue, intensified by the misuse and overuse of antibiotics. Global organizations such as the World Health Organization (WHO) (1) have established initiatives to combat AMR, emphasizing infection prevention, appropriate antimicrobial use, and increased surveillance and education. However, AMR persists due to factors like inappropriate prescribing practices, lax regulations, and the decline in new antibiotic development. The COVID-19 pandemic has exacerbated these challenges, straining healthcare systems and potentially increasing AMR due to heightened antibiotic use and disrupted infection control strategies (2). Amid these changes, both increases and decreases in AMR rates have been observed, with varying impacts across different regions (2,3,4). For instance, some hospitals (4) reported enhanced infection prevention measures, leading to decreased MRSA rates, while others saw increased broad-spectrum antibiotic use, potentially elevating resistance levels (5). Methicillin-Resistant *Staphylococcus aureus* (MRSA) exemplifies the AMR crisis due to its adaptability and virulence. MRSA is a major cause of both hospital and community-acquired infections. Its resistance mechanism involves the *mecA* gene, which confers resistance to methicillin and other β-lactam antibiotics (6). The widespread impact of MRSA is evident globally, with significant mortality rates, especially in resource-limited settings. Studies show a mixed impact of the COVID-19 pandemic on MRSA rates. Some regions, such as Brazil (7) and Greece (8), reported increases in MRSA infections during the pandemic, while others, like Japan (2) and Singapore (9), observed decreases due to enhanced infection control practices. These findings highlight the variable impact of the pandemic on MRSA rates, influenced by differences in healthcare responses and infection control measures. In Jamaica, data on AMR, particularly MRSA, is limited and sporadic. Historical studies from the University Hospital of the West Indies (UHWI) indicate fluctuating MRSA prevalence (10, 11, 12) with the most recent trends showing an increase (13). This highlights the need for consistent monitoring and comprehensive data to accurately assess MRSA trends in Jamaica. Given the significant health burden posed by MRSA, particularly in regions with limited surveillance and regulation, comprehensive studies are urgently needed to understand the rate and distribution of drug resistance among *Staphylococcus aureus* isolates in low-income healthcare settings. This data is essential for developing targeted interventions and improving antibiotic stewardship, ultimately mitigating the threat of AMR on a national and global scale. This study aims to fill the gap in Jamaican-specific data by comparing the rate, distribution, and drug resistance patterns of MRSA and methicillin-susceptible *Staphylococcus aureus* (MSSA) isolates from the UHWI before and during the COVID-19 pandemic. The UHWI, being one of the main referral centres for the island, has a robust Microbiology department making it a key centre for surveillance. By addressing this gap, the study seeks to provide essential data for developing effective interventions and improving antibiotic stewardship in Jamaica.

Methods

Study Design

This retrospective, observational study investigates the clinical distribution and resistance profile of *S. aureus* isolates at the University Hospital of the West Indies (UHWI) before and during the COVID-19 pandemic. The pandemic period spans from March 10, 2020, to May 5, 2023, reflecting the official dates of onset and conclusion of the pandemic in Jamaica. The pre-pandemic period (March 10, 2016 - May 5, 2019) was established to mirror the pandemic period in specific calendar days and analyze the temporal changes in distribution and drug susceptibility. This choice deliberately excluded the transition period of May 6, 2019 - March 9, 2020, controlling for the typical seasonal fluctuations in patients' healthcare-seeking

behaviour and the concomitant responses by the healthcare system. Additionally, the exclusion of the transition period mitigated potential confounding data because of adjustments to clinical practices and shifts in healthcare utilizatioAn immediately preceding the pandemic period.

Study Setting

The study was conducted at the UHWI, a 579-bed, tertiary-level academic hospital in St. Andrew, Jamaica. The hospital serves the local community and the wider Jamaican population through referrals and inter-hospital transfers. UHWI has a robust Microbiology department, infectious disease services, and a comprehensive antibiotic formulary, making it a key referral center for Jamaica and the Caribbean, especially during the COVID-19 pandemic.

Data Source

Data was obtained from the UHWI Microbiology Department's laboratory database. The database included antibiogram data, clinical information, and demographics for each case of *S. aureus* infection. Isolates underwent routine testing for identification and drug resistance using Kirby-Bauer Disk Diffusion and E-test methods, following CLSI guidelines (14). Among the antibiotics tested were oxacillin/cefoxitin, gentamicin, clindamycin, erythromycin, trimethoprim-sulfamethoxazole, linezolid, minocycline and rifampin. Molecular diagnostics to detect the mecA gene in MRSA isolates was not typically available and therefore was not widely performed at the UHWI during the study periods, thereby limiting the scope of this study to a comparison of phenotypic drug resistance characteristics while excluding variation analysis of *S. aureus* strains.

Study Population and Sampling

The study included all non-duplicate isolates from clinical specimens at UHWI, covering medical and surgical ward admissions, outpatient cases, and accident and emergency department cases. The inclusion criteria ensured that only the first isolate per patient per hospitalization period (≤ 90 days) was incorporated, with cases categorized by sample type and falling within the specified study periods. Consecutive non-probability sampling was used, including all eligible cases within the study periods, eliminating the need for complex randomization techniques and reducing selection bias.

Data Collection and Processing

Data extracted from the laboratory database included patient information (date of birth, sex, age), sample information (collection date, specimen type, ward), and antibiotic information (zone size, susceptibility). Data were anonymized and filtered according to inclusion and exclusion criteria. The cleaning process included removing duplicates, handling missing data, correcting inconsistencies, and standardizing date formats. The cleaned dataset was validated by cross-checking with the laboratory database and reviewed by secondary research team members. Preliminary statistical analyses were performed to verify data reliability.

Statistical Analysis

Categorical variables in demographics, sample information and antibiotic susceptibilities were summarized using proportions. The age of patients was described by calculating means and standard deviations for each study period. Age groups were categorized as infants (<1 year), young children (1-14 years), adolescents and young adults (15-44 years), middle-aged adults (45-64 years), and older adults (≥65 years). Relationships between pre-pandemic and pandemic data were analyzed using Fisher's exact test and Pearson's chi-square ($\chi 2$), with statistical significance set at $p<0.05$. A comparison of patients' mean age per period was conducted using an independent samples t-test.

All antibiotics selected for analysis contained greater than 30 isolates per period, the threshold recommended by CLSI for cumulative

antibiogram preparation (15).

Ethical Considerations

The study was approved by the Institutional Review Board of The University of the West Indies (Mona Campus) and the Mona Campus Research Ethics Committee (MCREC). The requirement for written informed consent was waived due to the retrospective nature of the study.

Results

Demographic Information of Source of the Isolates: Pre-pandemic and Pandemic Samples

A total of 2649 cases of *S. aureus* infections were identified, with 1541 cases in the pre-pandemic period and 1108 during the pandemic (Table 1). Specimens included wounds, pus, blood, sputum, and urine from various wards at UHWI. The mean age of patients with *S. aureus* infections was 43±24 years for the pandemic period compared to 41±23 years for pre-pandemic period. The distribution of both males and females for both periods were comparable as demonstrated in Table 1. For the pandemic period, *S. aureus* infections increased in the Accident and Emergency Department (74.2% to 79.5%) but decreased in the ICU (3.6% to 1.4%) and pediatric wards (10.8% to 8.3%) ($P<0.05$).

Distribution of Sample Types

Wound swabs predominated in both periods (59.4% pre-pandemic, 56.5% pandemic). There was a decrease in respiratory specimens (9.6% to 0.8%) and an increase in blood samples (16.1% to 26.3%) ($p<0.05$). Significant fluctuations were observed in sample types across different wards ($p<0.001$). In the ICU, respiratory samples were predominant pre-pandemic (58.9%), while blood samples increased during the pandemic (33.3%). There was an increase in blood specimens during the pandemic from the Accident and Emergency department (18.0% pre-pandemic versus 30.1% during the pandemic). From the pediatric wards, eye swabs increased during the pandemic (64.1% vs. 40.7% pre-pandemic).

Table 1:Characteristics of Patients and S. aureus Isolates Pre-pandemic and During the Pandemic

Characteristics	Pre-pandemic[a]	Pandemic[a]	*p*-value[b]
	n (%)	n (%)	
Age (in years)	41 (24)	43 (23)	<0.05*
Sex[c]	1531 (100.0)	1103 (100.0)	.874
Male	838 (54.7)	608 (55.1)	
Female	693 (45.3)	495 (44.9)	
Ward	1541 (100.0)	1108 (100.0)	<0.001
Accident & Emergency	1144 (74.2)	881 (79.5)	
Pediatrics	167 (10.8)	92 (8.3)	
Surgery	67 (4.3)	35 (3.2)	
Intensive Care Unit (ICU)	56 (3.6)	15 (1.4)	
Other	45 (2.9)	24 (2.2)	
Medicine	26 (1.7)	34 (3.1)	
Obstetrics & Gynecology	18 (1.2)	14 (1.3)	
Private Wing (TTW)	18 (1.2)	13 (1.2)	
Specimen Type	1541 (100.0)	1108 (100.0)	<0.001
Wound	845 (54.8)	569 (51.4)	
Blood	248 (16.1)	291 (26.3)	

Respiratory	148 (9.6)	9 (0.8)
Eye	114 (7.4)	79 (7.1)
Tissue	70 (4.5)	57 (5.1)
Urine	49 (3.2)	54 (4.9)
Other	67 (4.3)	49 (4.4)

[a]Categorical variables are expressed in frequencies and proportions; age in years is summarized as mean and standard deviation.)
[b]Chi-square test was used for all categorical variables while an independent samples t-test was applied for mean ages. *t(2647) = -2.592, *p* = .005.
[c]Data were missing on Sex for 10 *S. aureus* isolates in the pre-pandemic period and 5 in the pandemic period.

Antibiotic Susceptibility

The study analyzed susceptibility to oxacillin, clindamycin, erythromycin, gentamicin, linezolid, rifampin, minocycline, and trimethoprim-sulfamethoxazole. Oxacillin resistance remained stable at 6.2% in the pre-pandemic period (95% CI: 5.0% to 7.4%) and 6.2 % in the pandemic period (95% CI: 4.8% to 7.6%) . Erythromycin showed the highest resistance rates in both periods at 18.1% [95% CI: 16.1% to 20.0%] during the pre-pandemic period and 19.3% during the pandemic [95% CI: 16.8% to 21.8%]), followed by clindamycin at 9.4% (95% CI: 7.9% to 10.9%) and 10.9% [95% CI: 8.9% to 12.9%), respectively. When comparing pandemic and pre-pandemic resistance patterns for both MSSA and MRSA, some differences were observed, however, these differences were not statistically significant (p > 0.05). For MSSA, clindamycin resistance increased slightly (6.6% to 8.8%), while MRSA showed a decrease (53.7% to 43.9%). Gentamicin resistance in MSSA decreased (1.1% to 0.6%), while MRSA resistance increased (11.3% to 14.8%).

Due to limited data, linezolid resistance could not be fully assessed. Rifampin resistance remained 0% for MSSA in both periods, with a slight increase for MRSA (4.8% to 6.8%). Minocycline resistance in MSSA decreased significantly (10.0% to 0%) and also for MRSA (8.5% to 2.1%). SXT resistance in MSSA decreased (1.9% to 0%) and slightly decreased for MRSA (12.5% to 10.2%). The overall trend indicated decreased resistance for most antibiotics during the pandemic.

As shown in Figure 1, resistance rates for all drugs were higher for MRSA than MSSA. During the pre-pandemic and pandemic periods, significant association was identified between MRSA and resistance to clindamycin (*P*<0.01), erythromycin (*P*<0.01), gentamicin (*P*<0.01), trimethoprim-sulfamethoxazole (pre-pandemic, *P* = 0.03; pandemic, *P* = 0.029).

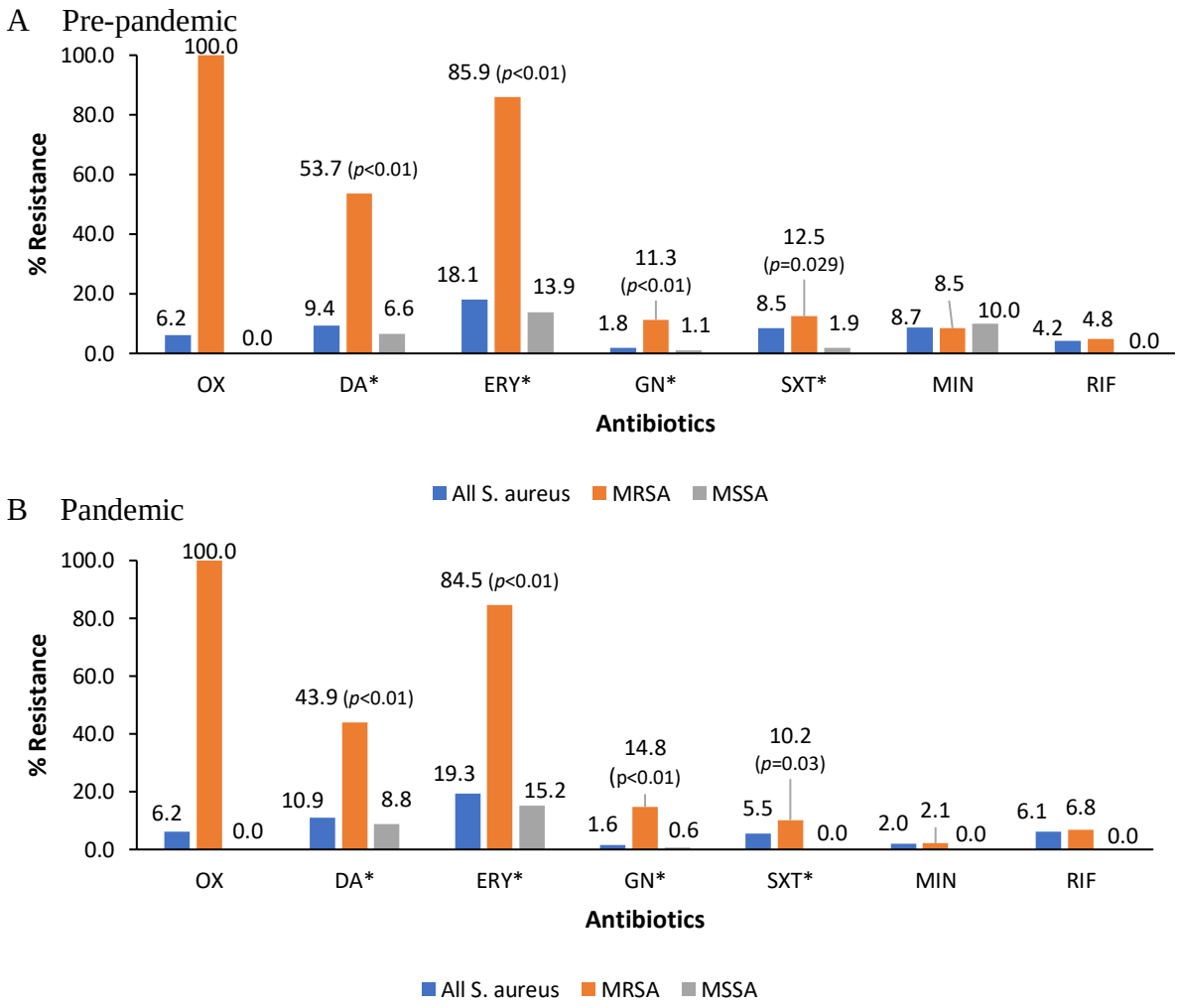
Table 2 Antibiogram of S. aureus During Pre-Pandemic and Pandemic Periods at the UHWI

Antibiotics	Pre-pandemic Period		Pandemic Period		χ^2	p-value[a]
	Sensitive No. (%)	Resistant No. (%)	Sensitive No. (%)	Resistant No. (%)		
1st line						
Oxacillin	1445 (93.8)	96 (6.2)	1039 (93.8)	69 (6.2)	.000	.998
Clindamycin	1248 (90.6)	129 (9.4)	842 (89.1)	103 (10.9)	1.461	.227
Erythromycin	1201 (81.9)	265 (18.1)	794 (80.7)	190 (19.3)	.591	.442
Gentamicin	972 (98.2)	18 (1.8)	815 (98.4)	13 (1.6)	.166	.684
2nd line						
SXT	130 (91.5)	12 (8.5)	104 (94.5)	6 (5.5)	.839	.360

Rifampin	92 (95.8)	4 (4.2)	62 (93.9)	4 (6.1)	.299[c]	.717[c]
Minocycline	84 (91.3)	8 (8.7)	50 (98.0)	1 (2.0)	2.524[c]	.158[c]
Linezolid[b]	4 (100.0)	0	4 (100.0)	0	-	-

[a] *Chi square test to 95% confidence*
[b] *Statistical analysis could not be completed due to the small sample size.*
[c] *Fisher's Exact test*
SXT,trimethoprim-sulfamethoxazole

Figure 1: Antibiotic Resistance Profiles of *S. aureus* Isolates Overall, MRSA, and MSSA Isolates Pre-Pandemic and During the Pandemic



OX, oxacillin, DA, clindamycin; ERY, erythromycin; GN, gentamicin; RIF, rifampin; MIN, minocycline; SXT, trimethoprim-sulfamethoxazole
Note. Chi-square test was performed for DA, ERY and GN (P<0.01); Fisher's exact test for SXT (P<0.05)

DISCUSSION

Prevalence and Trends of MRSA

The prevalence of MRSA has been a major concern in healthcare settings globally (16). The results from this study at the University Hospital of the West Indies (UHWI) reflect a nuanced

picture consistent with global trends. During the pre-pandemic period, the MRSA prevalence at UHWI was stable, with 6.2% resistance to oxacillin, which is lower than the global range reported in the literature (27.8% to 87.2%).

Despite the stable resistance rates observed at UHWI, global trends show a more mixed picture, with some regions experiencing a decline and others an increase in MRSA rates. For instance, developed countries like the United States and several European nations have reported decreasing MRSA rates due to effective infection prevention and control measures (17,18). Conversely, developing countries generally exhibit sustained or increasing MRSA prevalence (19, 20, 21).

Impact of COVID-19 Pandemic on MRSA Rates

The pandemic period introduced several changes in clinical practices and patient demographics at UHWI, which may have influenced MRSA prevalence and resistance patterns. Patients with COVID-19 were cohorted with enhanced droplet precautions, and airborne precautions where necessary. Gloves and gowns were routinely worn during patient reviews. Though not measured, compliance with transmission based precautions appeared to increase, likely due to concern for personal well-being. Compliance with hand washing and cleaning of equipment after use also increased. Hospital personnel paid increased attention to the cleaning of the environment and waste management during the pandemic. Infection control strategies geared toward MRSA, including the implementation of contact precautions (and where necessary droplet precautions) continued across the hospital in spite of the pandemic. Personal protective equipment (PPE) shortages did not include gloves and gowns and where there were mask restrictions (due to attempts at minimizing wastage), staff were willing to procure their own. Screening and treatment for colonization continued along with other measures. These practices are thought to be contributory to positive outcomes seen in regard to MRSA rates. There were other changes too. Notably, there was a higher mean age of patients with *S. aureus* infections during the pandemic than pre-pandemic (from 41 to 43 years) and a shift towards older age groups. The pandemic also saw a significant reduction in young children with *S. aureus* infections and a slight increase in middle-aged and older adults. This increase in *S. aureus* infections in older adults is not entirely surprising given the documented observation that other outbreaks, especially that of COVID-19, are associated with increased rates of AMR infections, however, for our study there was no increase in those *S. aureus* strains that were methicillin resistant. (22,23). COVID-19 disproportionately affected persons over 40 in the Jamaican context, supporting the age group-specific observations (24). This shift can also be attributed to the altered healthcare-seeking behavior and prioritization of certain patient groups during the pandemic. It is not clear however how this shift could have affected MRSA rates.

The literature indicates that the impact of COVID-19 on MRSA rates varies by region and healthcare setting. Some studies report increased MRSA rates due to disruptions in routine infection control practices and increased antibiotic use for COVID-19 patients (25, 26). However, others, like studies from Japan and Singapore, report a decrease in MRSA rates due to enhanced infection control measures implemented during the pandemic (27, 28).

At UHWI, MRSA resistance patterns remained relatively stable during the pandemic, indicating that the infection control measures may have been effective in mitigating potential increases in MRSA rates. Despite PPE shortages worldwide, attempts were made to ensure the judicious use of what was available and minimized wastage. The MRSA rates at UHWI have remained remarkably low for many years (10, 11, 12, 13) compared to other countries, which may be due to consistency in IPC strategies and stewardship efforts. Perhaps further study is warranted to detect whether strain variation could have also accounted for

some of the differences seen.

Antibiotic Susceptibility

Antibiotic resistance patterns observed at UHWI were consistent with broader global trends (15). Erythromycin exhibited the highest resistance rates among the antibiotics tested, both pre-pandemic and during the pandemic (18.1% and 19.3%, respectively). Clindamycin resistance also increased slightly during the pandemic. These findings underscore the need for continued vigilance in antibiotic stewardship programs to prevent further escalation of resistance.

The stability in oxacillin resistance rates at UHWI is noteworthy, given the fluctuations reported in other regions. For example, some developed countries have seen significant reductions in MRSA prevalence due to stringent infection control and antibiotic stewardship efforts (17, 18). In contrast, the overall stability in MRSA rates at UHWI suggests that while the hospital's measures were effective in preventing an increase, there is still room for improvement to achieve reductions similar to those seen in other regions.

Sample and Ward Distribution

The study highlighted changes in the distribution of *S. aureus* isolates among different wards and sample types at UHWI. During the pandemic, there was a notable increase in isolates from the Accident and Emergency Department and a decrease in those from the ICU and pediatric wards. These changes likely reflect the shifts in hospital admissions and the focus on treating COVID-19 patients. The reduction in respiratory samples and the increase in blood samples also align with the precautionary measures taken during the pandemic to minimize aerosol-generating procedures.

Conclusion and Future Directions

These findings provide valuable insights into the impact of the COVID-19 pandemic on MRSA prevalence and resistance patterns in a Caribbean healthcare setting. They contribute to data available on surveillance for multidrug resistant organisms like MRSA in the Caribbean, which have public health significance. Surveillance data can be useful in informing policies and guidelines that are geared towards AMR mitigation strategies. The stable resistance rates suggest that the infection control measures implemented during the pandemic were effective to some extent, but there remains a need for continuous monitoring and enhancement of antimicrobial stewardship programs. The regional predilection to progressively frequent and severe disease events (29) is a specific risk for increasing AMR, and in addition to universal risks, underscores the importance of developing AMR mitigation policies. To date, less than five countries within the CARICOM-10 countries have national action plans for AMR and so the work is ongoing. Future research should focus on expanding the surveillance of MRSA and other resistant pathogens across different healthcare settings across the Caribbean to obtain a more comprehensive understanding of AMR trends. Additionally, investigating the long-term impact of the pandemic on antibiotic resistance and exploring innovative strategies for infection prevention and control will be crucial in managing AMR effectively.

Limitations

The single-center design may limit generalizability with limited extrapolation nationally and regionally. The gap between study periods prevents analysis of trends during the interim. Missing clinical characteristics and the absence of molecular diagnostic data limit the understanding of disease patterns, treatment efficacy, and resistance trends. Finally, for susceptibility testing only a subset of isolates were tested against each antibiotic, therefore antibiogram results may be biased. Future studies should aim to include multiple centres across the Caribbean that incorporate molecular analyses and more expanded susceptibility testing in order to give a more robust report, one that is more generalizable for the Caribbean region.

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Appendix A

Table A – Sample Extraction Sheet for *S. aureus* Isolates Cases During the Pre-Pandemic and Pandemic Periods

Study #	Sex	Date of Birth	Age	Ward	Date Collected	Specimen Type	MRSA? (Yes/No)	Antibiotic Susceptibility Profile			
								OX Zone Size	OX Susceptibility Interpretation (S/I/R)	SXT Zone Size	SXT Susceptibility Interpretation (S/I/R)
3C	F	01/02/2003	21	AE	25/09/2019	Wound	Yes	0	R	3	R

Note: Broken lines indicate an extension of the table both vertically and horizontally. The columns that extend to the left include zone sizes and susceptibility interpretations for other antibiotics that were tested against S. aureus isolates during the pre-pandemic and pandemic periods. The rows that extend downwards would encompass individual cases of S. aureus isolates included in the study.