



Assessing the Potential for MRSA and VRSA Transmission among Food Handlers in Dhamar: A Critical Need for Intervention

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Abstract

Scientific background: Food handlers carrying *Staphylococcus aureus* on their noses mainly contribute to food contamination. Antibiotic resistance in *S. aureus* represents a significant public health concern. The drug of choice, Vancomycin, has become more popular as the rate of MRSA has increased. Consequently, VRSA has begun to emerge. This study aimed to assess the distribution of *S. aureus* nasal carriage and its antibiotic susceptibility patterns among food handlers at Dhamar restaurants in Yemen. **Method:** A cross-sectional study was conducted in Dhamar City, Yemen, between January and February 2023, collecting nasal swabs from 100 food handlers. Standard bacteriological techniques were applied to inoculate the collected swabs on mannitol salt agar to identify and isolate *S. aureus*. Researchers used the Kirby-Bauer disk diffusion method to test the antimicrobial susceptibility of methicillin and Vancomycin. **Results:** *S. aureus* colonized 44 (44%) of the 100 nasal food handlers working in Dhamar, Yemeni restaurants. Among the 44 *S. aureus* isolates, 6 (13.6%) were resistant to Vancomycin (VRSA), and 23 (52.3%) were resistant to methicillin (MRSA). A correlation was not observed between the nasal carriage rate of *S. aureus* and specific food handler variables. **In conclusion,** the high nasal carriage of *S. aureus*, including MRSA and VRSA, among food handlers poses significant risks to consumers, underscoring the need for strict policies, routine screening, and effective management to ensure food safety and control resistant bacteria.

Keywords: *S. aureus*; MRSA; VRSA; Nasal carriage

1. Introduction

Staphylococcus aureus is a Gram-positive bacterium that is often part of the normal human flora, especially in the anterior nares. It is an opportunistic pathogen widely recognized for its virulence factors, which cause a wide range of diseases, from mild symptoms to serious infections such as endocarditis and sepsis [1, 2]. As a major cause of both nosocomial and community-acquired infections, *S. aureus* represents a significant public health concern worldwide, with high morbidity and mortality rates [3, 4]. A significant concern with *S. aureus* is the production of enterotoxins, which are linked to food poisoning [5]. This risk is particularly pronounced among food handlers, who may inadvertently transmit the bacteria through respiratory secretions or manual contact, leading to gastrointestinal intoxication [6, 7].

The rise of methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant *S. aureus* (VRSA) highlights growing alarm about drug resistance in *S. aureus*. Once the go-to therapy, penicillins are no longer effective because *S. aureus* produces penicillinases, leading to resistance [8, 9]. The mortality rate of Methicillin-resistant *S. aureus* bacteremia (MRSA) is high [10], and its prevalence has steadily increased globally. In hospitals in Germany and Austria, MRSA was found in 20% and 10% of clinical isolates, respectively [11], the other study by Ahmed OB. (2020) found that the prevalence of MRSA among Sudanese food handlers was high [12]. In line with this, a study conducted in central Iran by Fooladvand S. *et al.* (2019) revealed a high prevalence of enterotoxin-positive and methicillin-resistant *S. aureus* among food handlers [13].

In addition to MRSA, VRSA represents an alarming development, as Vancomycin, a last-line treatment for Gram-positive bacterial infections, is

increasingly resistant [14, 15]. Consequently, *VRSA* poses a major global public health [16]. A study in Qena City, Egypt, by El-Zamkan, M. A. et al. (2019) found that food handlers transmit *MRSA* and *VRSA* to hospitalized patients [17].

As a result, the presence of *S. aureus* among food handlers remains a persistent public health concern. Asymptomatic workers are sources of staphylococcal food poisoning via contaminated food through respiratory secretions or manual contact, which leads to gastrointestinal intoxication [7]. In support of this, the study by El-Shenawy M. et al. (2014) highlighted the possibility that food handlers' skin may become colonized with enterotoxigenic strains of *S. aureus*, increasing the risk of food contamination [18]. Similarly, the study in Jimma Town, Southwest Ethiopia, by Beyene G. et al. (2019) found that the percent isolation of *S. aureus* from the nose and hands was 8.3% (nose) and 11.3% [19] (hands), respectively [19]. Another study found that the prevalence of *S. aureus* in the nose, hands, and both (nose and hands) was 19.8%, 11.1%, and 6.2%, respectively [20]. Strict hygienic measures and high standards of food handlers' hygiene are important for preventing the transmission of *MRSA* and *VRSA* [21, 22].

The widespread occurrence of endemic diseases in Yemen reflects its status as a developing country. Key contributing factors include population overcrowding, limited provision of safe drinking water, ineffective waste management, inadequate hygiene practices, and deficient environmental sanitation [23-25]. A lack of governmental oversight, reliance on poorly trained staff, and unhygienic food practices may increase the risk of staphylococcal food poisoning. As data on nasal carriage and antimicrobial resistance of *S.aureus* among Yemeni food handlers are scarce, this study provides the first assessment of these factors among restaurant workers in Dhamar city, Yemen.

2. Materials and Methods

2.1 Study area and period

A cross-sectional study was conducted among restaurant food handlers in Dhamar, Yemen, from January to February 2023 to determine the distribution of nasal *S. aureus* colonization and its susceptibility to methicillin and Vancomycin. Using random sampling, 100 food handlers involved in meal preparation, serving, and utensil cleaning in various restaurants were recruited as study participants.

2.2 Sociodemographic data and swab specimen collection

Data on each food handler's social and demographic characteristics (age, sex, occupation, and educational level) were collected using a pre-designed questionnaire. A nasal specimen was obtained using a sterile swab moistened with saline solution. The tips were inserted 1-2 cm inside each nostril's anterior nares, rotated six times, and transported to the Medical Laboratory of the Thamar University Institute for Continuous Education, Thamar University.

2.3 S. aureus isolation and identification

The nasal swab specimens were inoculated on Mannitol Salt Agar (LAB M, UK) [26]. Each plate was incubated for 24 hours under aerobic conditions at 37°C [27]. Researchers followed standard procedures after isolating a pure colony, including Gram staining. Using standard protocols, confirmatory biochemical tests, such as the coagulase tube and catalase tests, were performed to identify suspected *S. aureus* [28, 29].

2.4. Antimicrobial susceptibility testing of S. aureus

Susceptibility testing was performed on Mueller-Hinton agar (LAB M, UK) using the Kirby-Bauer agar disc diffusion method, as recommended, according to the guidelines of the Clinical and Laboratory Standards Institute [26, 29]. Researchers tested the following antibiotics: Methicillin (MET, 5 µg) and Vancomycin (30 µg) (HiMedia Comp., India). Disks were used to assess resistance in *S. aureus* isolates. The resistance and sensitivity results were analyzed according to the Clinical and Laboratory Standards Institute (CLSI) protocol. Isolates showing resistance or intermediate to Vancomycin were classified as "presumptive *VRSA*".

2.5. Data analysis procedures

The data were analyzed using Version 20 of the Statistical Package for the Social Sciences (SPSS). Chi-Square tests (Crosstabs), frequencies, and percentages were employed in the analysis. A p-value threshold of ≤ 0.05 was applied to determine statistical significance.

2. Results and Discussion

The majority of employees at the restaurant in Dhamar, Yemen, as shown in Table 1, are male (98% of the workforce), and 76% of the workers

are under 35. Contrasting with Beyene et al. (2019), who found that 65.7% of the participants were female [19]. This gender disparity may be attributed to cultural and traditional norms that discourage women from working in restaurants or public spaces. The most common roles are cooks (37%) and waiters (22%), while 33% fall into the unspecified "Others" category. Education levels are generally low: 42% have only primary education, 13% are illiterate, and just 6% hold a university degree. The findings suggest that food handling jobs require minimal formal education, attract a young workforce, and have limited female participation. This highlights potential areas for workforce development, gender inclusion, and clarifying job roles.

Table 1: Distribution of Sociodemographic Characteristics of Food Handlers Working in Restaurants in Dhamar, Yemen (January–February 2023).

Characteristics	Category	Frequency (n = 100)	Percentage (%)
Sex	Male	98	98.0
	Female	2	2.0
Age (years)	15-25	41	41.0
	26-35	35	35.0
	36-45	16	16.0
	>45	8	8.0
Job Category	cook	37	37.0
	Assistant Cook	8	8.0
	Waiter	22	22.0
	Others (e.g., cleaners, cashiers...)	33	33.0
Educational Status	Literature	13	13.0
	Read and Write only	9	9.0
	Primary	42	42.0
	Secondary	30	30.0
	University	6	6.0

Figure 1 shows that *S. aureus* contamination among food handlers in Dhamar is 44%, representing a significant risk to food safety. This rate is notably higher than rates reported in Sana'a, Yemen (18.6%) [25], and in other regions, such as Kerbala, Iraq (30.1%) [30], Jimma, Ethiopia (28.7%) [19], and Sanliurfa, Turkey (23.1%) [31]. The discrepancy may stem from variations in hygiene practices, educational background, working conditions, and regulatory enforcement across different locations. These findings underscore a significant public health concern and emphasize the urgent need for targeted food safety interventions. Implementing hygiene training programs, enforcing stricter food safety regulations, and conducting routine health screenings are essential to reducing bacterial contamination and minimizing foodborne illness outbreaks. Additionally, promoting education among food handlers and raising awareness of hygiene best practices could significantly improve compliance with food safety standards. Beyond hygiene, addressing workforce challenges—such as gender inclusivity, job role clarity, and employment conditions—could contribute to a more regulated and professionalized food service sector, ultimately strengthening public health protection.

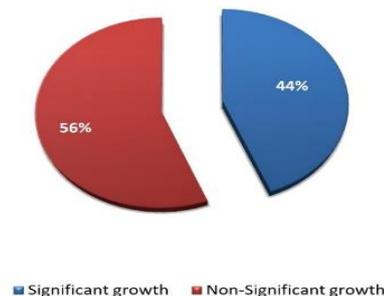


Figure 1: *S. aureus* carriage rate among nasal food handlers in Dhamar city, 2023.

Table 2: Association of Sociodemographic Characteristics with Nasal Carriage of *S. aureus* Among Food Handlers in Dhamar City, Yemen, from January to February 2023.

Characteristics		Significant Growth (No, %)	Non-Significant Growth (No, %)	P-value
Sex	Male	43 (%)	55 (%)	0.689
	Female	1 (%)	1 (%)	
Age	15-25	15 (%)	26 (%)	0.061
	26-35	16 (%)	19 (%)	
	36-45	6 (%)	10 (%)	
	>45	7 (%)	1 (%)	
Job Category	Cook	17 (%)	20 (%)	0.805
	Assistant Cook	3 (%)	5 (%)	
	Waiter	8 (%)	14 (%)	
	Others (e.g., cleaners, cashiers...)	16 (%)	17 (%)	
Educational Status	Literature	8 (%)	5 (%)	0.443
	Read and Write Only	3 (%)	6 (%)	
	Primary	20 (%)	22 (%)	
	Secondary	10 (%)	20 (%)	
	University	3 (%)	3 (%)	

Table 2 indicates no significant correlation between sociodemographic factors and nasal carriage of *S. aureus* among food handlers in Dhamar City. The study may not have sufficient power to detect smaller associations, so more research with larger sample sizes is needed to examine other factors, such as health or sanitary conditions. In this study, a significant portion had only primary education (42%) or were illiterate (13%), which may limit their understanding of hygiene and food safety regulations.

Table 3: Susceptibility pattern of *S. aureus* to methicillin and Vancomycin.

Antimicrobial agent	Resistance (No. %)	Intermediate (No. %)	Sensitive (No. %)
Methicillin	23 (52.3%)	2 (4.5%)	19 (43.2%)
Vancomycin	6 (13.6%)	6 (13.6%)	32 (72.8%)

The study revealed a high prevalence of *MRSA*, with 52.3% of *S. aureus* isolates showing methicillin resistance. This indicates a significant public health concern due to the difficulty in treating *MRSA* infections with standard antibiotics. This resistance underscores the urgent need for enhanced infection control measures, particularly in food-handling environments, where bacterial transmission can cause foodborne illnesses. Poor sanitation, improper handwashing, and inadequate handling of contaminated surfaces may facilitate the spread of *MRSA* among food handlers.

Globally, *S. aureus* has become increasingly resistant to vancomycin and β -lactam antibiotics, making it one of the most dangerous bacteria [32-34]. Several studies have identified *MRSA* as a causative agent of community-acquired infections worldwide [35-38]. The *MRSA* prevalence in this study (52.3%) is higher than reported in other countries, such as Egypt (32%) [39], Ghana (28%) [40], Nigeria (9.43%) [41], and Iran (38.14% and 31.31%) [42, 43], but lower than the study in Sana'a, Yemen (66.7%) [25]. The higher *MRSA* percentage in the present study may be attributed to antibiotic overuse and misuse, poor infection control practices, and limited healthcare infrastructure. Given these findings, it is crucial to implement strict antimicrobial stewardship, routine screening for *MRSA*, and

comprehensive hygiene training programs to control its spread and ensure public health safety.

As seen in Table 3, identifying 13.6% of isolates with reduced susceptibility to Vancomycin and 13.6% exhibiting intermediate resistance raises significant public health concerns. These isolates should be considered as showing 'presumptive *VRSA*,' and the need for confirmatory testing is crucial to validate these findings. Although 72.8% of isolates remain sensitive, resistance detection indicates a potential risk of treatment failure, particularly in severe infections, since Vancomycin is one of the primary treatment options for *MRSA* infections. The emergence of resistance further limits available therapeutic strategies and poses a significant challenge to infection control efforts [44-46].

Globally, *VRSA* prevalence has risen dramatically, with data from Scopus, Embase, PubMed, and Web of Science showing a 3.5-fold increase between 2006 and 2020 [16]. Before 2006, *VRSA* prevalence was 2%, rising to 5% from 2006 to 2014 and further increasing to 7% between 2015 and 2020, reflecting the growing challenge of antibiotic resistance. In this study, the *VRSA* prevalence (13.6%) is comparable to rates reported in Egypt (13.8%) [47]. However, it is notably higher than in Ethiopia (7%) [19] and Iran (0%) [43]. The high rate of *VRSA* in Yemen may be linked to the high rate of *MRSA*, poor surveillance systems, and the wrong use of antibiotics, all of which could lead to antibiotic resistance. Nonetheless, additional research is required to validate these associations.

The detection of *VRSA* among food handlers also poses a significant risk of transmission to food products and consumers, increasing concerns over foodborne infections. Strict antimicrobial stewardship, enhanced monitoring, and stronger infection control measures must be implemented to prevent the further spread of *VRSA*. Addressing inappropriate antibiotic use, improving hygiene practices, and reinforcing infection prevention strategies are essential to curbing *VRSA* transmission and safeguarding public health.

3. Conclusions

The study reveals a high prevalence of *S. aureus* among food handlers in Dhamar, including *MRSA* (52.3%) and presumptive *VRSA* (13.6%), posing a significant food safety risk. Contributing factors include poor hygiene, low levels of education, and antibiotic misuse. To mitigate these risks, strengthening hygiene training, enforcing food safety regulations, promoting antimicrobial stewardship, and conducting regular health screenings are crucial for protecting public health.

Ethical Approval

Before this research project could be carried out, the Public Health and Population Office, Dhamar Branch, and the Institute for Continuous Education at Tamar University gave their approval. Data were gathered after each food handler provided written consent.

Subject Consent

Verbally informed consent was obtained from the parents or legal guardians of all participating children after a full explanation of the study's purpose and procedures. Participation was voluntary, and consent was reaffirmed before data collection. All collected data were anonymized and used solely for research purposes.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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