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Prevalence and Risk Factors for Methicillin-Resistant *Staphylococcus aureus* Carriage among Healthcare Workers in a Tertiary Health Facility in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) colonized healthcare workers (HCWs) constitute massive threat to the well-being of hospitalized patients due to their ability to transmit this multidrug-resistant (MDR) bacteria strain in hospital settings.
Aim: To determine the prevalence of MRSA carriage/colonization among HCWs, to identify risk-factors associated with colonization/carriage, and to determine the antibiotic resistance pattern of isolates.
Study Design: A cross-sectional study.
Materials and Methods: A total of 333 randomly selected consenting HCWs from most hospital care units were studied. Data on demographic characteristics and infection control practices were obtained from participants with the aid of questionnaire. Swabs of the anterior nares and hands of participants were cultured on oxacillin-containing mannitol salt agar (MSA), *S. aureus* was

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identified using convectional criteria and MRSA was identified by cefoxitin disc diffusion technique. Antibiotic susceptibility testing was carried out on all isolated MRSA.
Results: The carriage rate of MRSA was high (21.3%). Isolation was significantly higher among; males compared to females (*P*=.035), staff of critical care units compared to other care units (*P*=.049), among doctors and nurses compared to other HCWs (*P*=.0031). Poor handwashing practices (*P*<.001), presence of wound or skin infection (*P*<.001) and recent antibiotic use (P=.006) were associated with higher isolation rate. Isolation rate was higher from the nose (15.0%) than from the hands (6.3%). Isolates demonstrated low resistance to clindamycin (16.9%) and ciprofloxacin (16.9%). No isolate was resistant to vancomycin.
Conclusion: In this study; colonization of HCWs by MRSA was high, a male doctor or nurse from critical care unit, with poor handwashing practices, wound or skin infection, and recent antibiotic use had a higher risk of MRSA carriage/colonization. No MRSA isolated was resistant to vancomycin. Improved infection control policies and practices are needed to curtail this trend in hospital settings.

Keywords: Antibiotic resistance; healthcare workers; infection control; MRSA colonization/carriage.

1. INTRODUCTION

Staphylococcus aureus is one of the most common bacteria causes of human infections, it is a Gram-positive, catalase-positive and coagulase-positive bacterium [1]. Some strains of this bacterium have acquired a mobile genetic element called staphylococcal chromosome cassette (SCCmec) containing the *mecA* gene encoding the penicillin binding protein-2a (PBP2a) which has a low affinity for beta-lactam antibiotic thus conferring resistance to most β - lactam antibiotics [2]. These strains, called the methicillin-resistant *Staphylococcus aureus* (MRSA) has become endemic worldwide and have been associated with varying human infections ranging from mild skin infections to some more severe infections such as osteomyelitis, pneumonia, endocarditis, deep seated abscesses and toxic shock syndrome [3,4]. These strains are resistant to an array of antibiotics other than the β-lactams, thus posing serious challenge to the management of infections, with attendant higher cost of treatment, prolonged hospital stay, increased morbidity and mortality [5].

MRSA is the most commonly identified multidrug-resistant pathogen in most hospitals worldwide [6]. In Europe, MRSA constituted between 0.5% to 50% of *S. aureus* isolated from infected patients in 2011 with a pooled mean rate of 17%, while in the United States, MRSA approached almost 60% of isolated *S. aureus* in 2003 with an average resistance of about 50% between the periods of 1998 and 2002 [7]. In 2001 at Ilorin, Nigeria, MRSA prevalence rate of 34% was reported in a hospital study involving patients with varying infections [8]. Other studies in Nigeria have also indicated that MRSA is a common cause of infection in our environment [9,10].

Nosocomial transmission of MRSA is aided by healthcare workers (HCWs) who are carriers of the organism in their anterior nares and the hands. A carrier of MRSA is one who has the organism colonizing the anterior nares (nose), the sputum, open wound or the skin without any disease associated with the organism. The carrier HCWs transmit the MRSA to patients directly by contact through colonized hands and through sneezing by way of aerosolization from colonized anterior nares [11].

The risk factors associated with the nasal carriage of MRSA among HCWs include: staying in long-term care units, prolonged antibiotic therapy, recent hospitalization, surgical intervention, presence of skin or soft tissue infections, and chronic underlying disease [12]. The need for mass screening of HCWs for MRSA comes with potential advantages and disadvantages, in addition to ethical issues and such step had been widely debated [13]. In some developed regions of Europe with low MRSA prevalence, HCWs are screened for MRSA only after contact with patient infected with MRSA, while screening of HCWs is only recommended in situations such as epidemiological outbreaks in some other regions [14]. No protocol for screening of HCWs is available in our region. Meanwhile, screening and eradication of MRSA from colonized HCWs have been documented as important components of infection control measure against this pathogen.

Most guidelines recommended the use of mupirocin ointment for the decolonization of

nasal carriage of MRSA. Other measures include the use of antiseptic solution for washing and shampooing and use of hexachlorophene powder for perineal carriers [15]. There is also the need to exclude colonized HCWs from work until there is evidence of complete eradication of the organism from the colonized part of the body or healing of their wound or skin infection as the case may be.

To control the spread of MRSA in our health care facility, it is important that we determine the extent of the problem and examine the associated risk factors, which will help in formulating our hospital infection control policy.

There is currently no available infection control policy against the carriage and transmission of MRSA by HCWs in our centre and the burden of the colonization of HCWs is unknown, thus necessitating this study which intended to determine the prevalence of nasal and hand carriage of MRSA among the HCWs, to examine the associated risk factors for this carriage, to determine the antibiotic resistance pattern of the isolated MRSA, and to make suggestions on infection control measures against this pathogen.

2. METHODS

2.1 Study Location

This cross sectional study was carried out from January 2020 to December 2020 at Federal Teaching Hospital, Ido-Ekiti, in the South western Nigeria. It is a 300 bedded tertiary care centre which serves its locality and also serves as a referral centre for neighboring states.

2.2 Study Population and Sampling

A total of 333 randomly selected consenting healthcare workers (doctors, nurses, health attendants and other non-clinical staff) from all the major care units of the hospital were included in this study.

2.3 Data Collection

Data was collected with the aid of questionnaire survey and laboratory methods.

2.3.1 Questionnaire survey

A pretested questionnaire including demographic data, past and present work locations in the hospital, number of years spent in the unit, handwashing practices, presence of any wound/sore or skin infections, recent use of antibiotics (<3 months of the survey) was administered to all respondent for the purpose of comparing the carriage rate of MRSA with infection control practices.

Handwashing practices were graded into percentages based on the answers given to different questions on handwashing. Correct answer per question was awarded 1 point, incorrect answer or no response/indifference was awarded 0. The maximum point obtainable was 16. All points scored by each participant were added together and placed over 16 and then converted to percentages. Score less than 70% was recorded as poor handwashing practice and scores from 70% and above were recorded as good handwashing practice.

2.3.2 Laboratory methods

Swabs of both anterior nares of participants were taken using a sterile swab stick moistened with sterile physiological saline and transported immediately to the Medical Microbiology Laboratory of the hospital for immediate inoculation onto oxacillin-containing mannitol salt agar (MSA) (Oxoid^{TM}). Swabs of the palm and web spaces of the hands were also taken with another moist swab stick for immediate inoculation onto oxacillin-containing MSA (Oxoid^{TM}) in the laboratory. Swab from the hands were taken at least an hour after the last handwashing by the participants. The MSA agar plates were incubated aerobically at 35^{o}C for up to seven days. Inoculated plates were screened for typical *Staphylococcus* spp colonies at 24, 48, 72 and 96 hours. Identification of *S. aureus* was based on convectional criteria including colonial morphology, Gram stain reaction, positive catalase, coagulase (tube) and DNAse tests [16].

Methicillin-resistance was confirmed by cefoxitin disk-diffusion technique using the Clinical and Laboratory Standard Institute (CLSI) criteria [17]. A member of staff was considered a carrier when MRSA was detected at one or both sites studied.

All isolated MRSA were tested against penicillin (10 µg), erythromycin (15 µg), chloramphenicol (30 µg), cotrimoxazole (25 µg), cefuroxime (30 µg), ceftriaxone (30 µg), gentamycin (10 µg), amoxicillin/clavulanate (30 µg), ciprofloxacin (5 µg), clindamycin (2µg), linezolid (30 µg) and quinupristin/dalfopristin (15 µg) using the modified Kirby-Bauer disc diffusion technique on

Muellar Hinton Agar (Oxoid™) and incubated at 35°C for 18-24 h. The result was interpreted following the CLSI criteria [17]. All antibiotic discs were from Oxoid™, ThermoFisher Scientific™ US. Resistance of isolated MRSA strains to vancomycin was tested using the E-test.

2.4 Data Analysis

Data entry was done using Microsoft Excel version 2017 and analysis was done using SPSS software version 20. The results were presented in tables and figure. Fisher's exact test was used in the case of small number. Statistical significance was accepted at $P<0.05$.

3. RESULTS

3.1 Distribution of Participants

Of the total 333 participants recruited into this study, 72 (21.6%) were doctors and 131 (39.3%) were nurses. A total of 62 (18.6%) were staff of surgical wards, 50 (15.0%) were from renal dialysis unit and 49 (14.7%) were from medical wards (Table 1).

3.2 Demographic Characteristics of Participants Versus MRSA Isolation Rate

A total of 129 (38.7%) respondents were between the age range 30-39%, while only 33 (9.9) were older than 50 years. The mean age of the distribution was 36.054±9.808 years. Most respondents were females (69.4%), while up to 135 (40.5%) of respondents were staff of the critical care units of the hospital.

A total of 71 (21.3%) of respondents had MRSA colonization in the anterior nares or hands or both, making an overall isolation rate of 21.3%. Isolation of MRSA from respondents was highest among age range 18-29 years (23.6%) and was lowest among age range 30-39 years; no significant difference was seen in isolation rates in different age-groups. There was a higher isolation rate of MRSA among staff that have spent more than five years (22.2%) compared to those that have spent less than 5 years (20.6%) in their units, but the difference was not statistically significant (P=.73).

There was a significantly higher rate of MRSA isolation among male respondents (28.4%) compared to the female respondents (18.2%), $\chi2$=4.43, P=.035, OR=1.79. Isolation was higher among clinical staff; doctors (36.1%), nurses 20.6%) compared to the non-clinical staff (11.1%), P=.003, $\chi2$=13.85, df=3, this is statistically significant. Also, MRSA was isolated at higher rates among the staff of critical care units compared to the staff of other hospital care units. ($\chi2$=3.87, P=.049, OR=1.69), this is statistically significant (Table 2).

3.3 Infection Control-related Factors Versus MRSA Isolation Rate

There was a significantly higher isolation rate of MRSA among respondents with poor handwashing practices (37.5%) compared to those with good handwashing practices (16.9%), $\chi2$ =14.33. P<.001, OR=0.34. Isolation of MRSA was significantly higher among respondents with wound or skin infections (50.0%) at the time of the survey compared to those without wound or

Table 1. Distribution of participants in different care units

Unit	Doctor n(%)	Nurse n(%)	Attendant n(%)	Non-Clinical staff n(%)	Total n(%)
Critical care units					
NICU	11 (15.3)	15 (11.5)	12 (10.7)	2 (11.1)	40 (12.0)
ICU	7 (9.7)	18 (13.7)	18 (16.1)	2 (11.1)	45 (13.5)
Renal Dialysis Unit	12 (16.7)	21 (16.0)	14 (12.5)	3 (16.7)	50 (15.0)
Other care units					
Medical ward	11 (15.3)	19 (14.5)	17 (15.2)	2 (11.1)	49 (14.7)
Surgical ward	14 (19.4)	24 (18.3)	22 (19.6)	2 (11.1)	62 (18.6)
Gynecology ward	5 (6.9)	8 (6.1)	8 (7.1)	3 (16.7)	24 (7.2)
Maternity ward	4 (5.6)	9 (6.9)	7 (6.3)	1 (5.6)	21 (6.3)
Pediatric ward	8 (11.1)	17 (13.0)	14 (12.5)	3 (16.7)	42 (12.6)
Total	72 (21.6)	131 (39.3)	112 (33.6)	18 (5.4)	333 (100.0)

Table 2. Relationship of demographic characteristics of participant with MRSA isolation

Parameter	Number n(%)	MRSA isolated n(%)	χ2 value	*P*-value
Age (years)			0.58	.9
18-29	89(26.7)	21(23.6)		
30-39	129 (38.7)	25(19.4)		
40-49	82(24.6)	18 (22.0))		
≥50	33(9.9)	7(21.2))		
Mean age=36.054±9.808 years				
Gender			4.43	.035
Male	102 (30.6)	29(28.4))		
Female	231 (69.4)	42 (18.2))		
Number of years spent in unit			0.12	.73
<5 years	189 (56.8)	39 (20.6)		
>5 years	144 (43.2)	32(22.2))		
Profession				
Doctor	72(21.6)	26 (36.1)	13.85	.0031
Nurses	131 (39.3)	27(20.6)		
Health Attendant	112 (33.6)	16(14.3)		
Non-clinical staff	18(5.4)	2 (11.1)		
Unit			3.87	0.049
Critical care units	135 (40.5)	36 (26.7)		
Other units	198 (59.5)	35 (17.7)		
Total	333 (100.0)	71 (21.3)		

Table 3. Relationship between infection control-related factors and isolation of MRSA

Parameter	Number n(%)	MRSA isolated n(%)	χ2 value	*P*-value
Handwashing practice			14.33	<.001
Good	261 (78.4)	44 (16.9)		
Poor	72(21.6)	27 (37.5)		
Presence of wound or skin infection			14.99	<.001
No	305(91.6)	57 (18.7)		
Yes	28(8.4)	14(50.0)		
Recent use of antibiotics			7.65	.006
No	272(81.7)	50(18.4)		
Yes	61(18.3)	21(34.4)		
Total	333 (100.0%)	71 (21.3)		

Skin infection (18.7%), χ2=14.99, *P*<.001, OR=0.23. Also, there was a significantly higher isolation rate of MRSA among respondents with history of recent use of antibiotics (34.4%) compared to those without such history (18.4%), χ2=7.65. *P*=.006, OR=0.43 (Table 3).

3.4 Site distribution of isolates

Isolation rate of MRSA was higher from the anterior nares of respondents (15.0%) than from the hands (6.3%). Isolation of MRSA was seen in both the anterior nares and the hands of 13 (3.9%) of the respondents (Table 4).

3.5 Antibiotic Resistance Pattern of Isolated MRSA

None (0.0%) of the isolated MRSA was resistant to vancomycin, linezolid, quinupristin/dalfopristin tested. Favorable resistant pattern was also seen against clindamycin (16.9%) and ciprofloxacin (16.9%), however, all (100%) isolated MRSA were resistant to penicillin (Fig. 1).

Table 4. Site distribution of isolates

Site	Frequency n=333 (%)
Anterior nare	50 (15.0)
Hand	21 (6.3)
Hand and Anterior nare	13(3.9)
Total	71 (21.3)

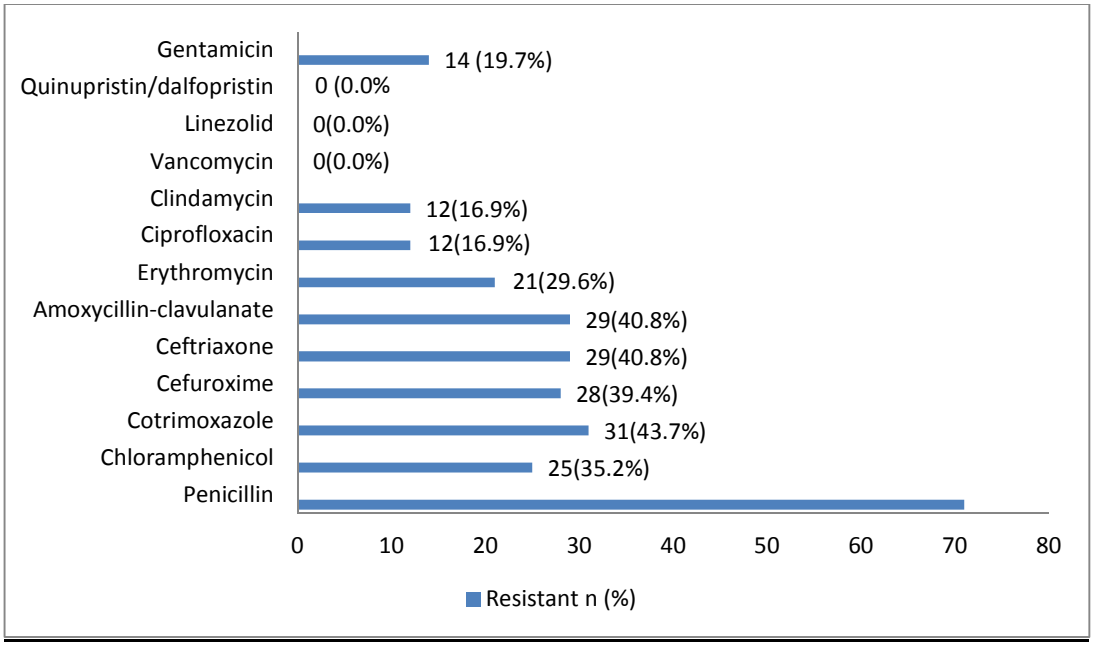

Fig. 1. Resistance pattern of the isolated MRSA to antibiotics tested

4. DISCUSSION

A high isolation rate (21.3%) of MRSA from the nose and hands of HCWs in this study is similar to the findings of Aila *et al* in Gaza who reported that 25.5% of HCWs were carriers of MRSA [18]. A higher isolation rate was reported by Fadeyi *et al* in Ilorin, Nigeria, [19] while lower rates were reported by other authors; Egwuatu *et al* in Lagos, Nigeria (13.6%), Malini et alin Bangalore (10%), Singh *et al* in Bhubaneswar (7.5%), Khanal *et al* in Nepal (3.4%) and Joachim *et al* in Tanzania (15.6%), [20-24].

Variation in isolation rates from different studies might not be unconnected to the varying level of adherence to infection control policies existent in different facilities. The differences in the study design in different studies, such as the sample size, sampling sites and the methods of MRSA detection, may also partly account for the disparity in the carriage rates; studies which screened only for nasal carriage will most likely record lower isolation rate.

In this study, both the hands and the nose were screened for MRSA in each respondent which may have aided higher isolation rate. The level of adherence to infection control policies is low in our setting and may have contributed to the high carriage rate of MRSA among HCWs seen in this study. High carriage rate of MRSA among HCWs was well documented as a harbinger of epidemics of MRSA. It is known that colonized HCWs are the agent of transmission of hospital pathogens to the patient, thus a high level carriage of MRSA among HCWs in our study and its likelihood of transmission to patients comes with unpalatable consequences due to the multidrug resistant nature of MRSA and the tendency to increase the cost of treatment, prolong the duration of hospital stay, increase the morbidity and mortality for patients infected with this strain [5].

This calls for urgent awakening of the infection control program of the hospital and its responsibility of formulating policies to curtail this unpleasant trend.

Isolation was higher in this study from the anterior nares of the respondents than from the hands. Similar findings were reported in previous studies; Fadeyi *et al*, nose (39.6%) and hand (26.3%), Malini *et al*, nose [(8.0%) and hand (2.0%) [19,21]. Hand colonization by microorganisms including MRSA tends to be transient due to handwashing for various reasons including non-clinical issues such as; before and after feeding, but colonization of the anterior nare tends to be persistent until treated.

The profession, care unit and gender of the respondents were found to be associated with carriage rate of MRSA in this study but longer length of stay in service was not found to be associated. Socio-demographic characteristics such as age, gender, length of healthcare service and profession have been reported by previous studies to influence the carriage of *S. aureus* [25,26].

Being a doctor or a nurse was seen as a risk factor for MRSA colonization in this study. Isolation of MRSA from the nose and hands of doctors and nurses were higher compared to those of non-clinical staff and the health attendants. Egwuatu *et al* [20], like in this study isolated MRSA more from doctors than from other HCWs, while some other studies reported higher isolation rate of MRSA among nursing staff compared to other HCWs; Dulon *et al* [27] found the risk for nursing staff of being colonized with MRSA almost two times higher than for doctors and three-times higher than for other HCWs, while Fadeyi *et al*, Singh *et al*, and Khanal *et al* all reported higher isolation rate of MRSA among nurses compared to other HCWs [19,22,23]. However, other study did not see any association between profession and MRSA carriage rate [28].

This disparity in findings may be a result of differences in study designs employed in various studies. Doctors and nurses by the virtue of their more frequent close contact with patients are predisposed to colonization by hospital pathogens of which MRSA is among the most common.

It is surprising however, that the carriage rate of MRSA was lower among the health attendants in this study compared to doctors and nurses. Health attendants were not included in most previous studies, thus, there was paucity of data on the MRSA colonization rate among them, but we expected that in this category of HCWs who are in regular contact with patients, patients' excretions and surroundings, it will be more logical to isolate MRSA at a higher rate among them compared to doctors and nurses who rarely come in contact with excretion of patients, however, health attendants are known to do most of the cleaning works in all care units, and this might have helped in reducing contamination and hence the colonization of their hands with this pathogen.

This study showed that working in a critical care unit was associated with higher MRSA carriage risk. Working in a critical care unit may be associated with higher contact with multidrug resistant bacterial strains especially when there is poor infection control practice among HCWs. High carriage rate of MRSA among the staff of critical care units portends grave danger considering the impact which this multidrug resistant pathogen can have on critically ill patients who are more likely to have increased mortality when infected with this strain.

Being a male HCW was associated with a higher chance of MRSA colonization in this study. This finding is similar to that of Al-Humaidan *et al* in Saudi Arabia [25] and Shibabaw *et al* in Ethiopia [29] but in contrast with findings of Gebreyesus *et al* in North Ethiopia [30] where females HCWs are more likely to be colonized by MRSA. Meanwhile, Joachim *et al* [24] did not find any association between gender of respondents and carriage rate of MRSA.

Relationship between gender and MRSA colonization rate only seems to vary with different healthcare settings, and no gender factor has been previously used to explain predilection for MRSA colonization.

Poor handwashing practices, presence of wound or skin infection and recent antibiotic use (within 3 months of survey) among respondents were all found to be associated with higher carriage of MRSA in this study. All these risk factors, in addition to recent hospitalization, stay in long-term care units, surgical intervention, and chronic underlying diseases have been associated with increased colonization with MRSA among HCWs [12].

Proper handwashing among HCWs is the single most important, easy and economical means of reducing transmission of pathogens in the hospital setting and is recommended as an infection control measure to be instituted among

all HCWs in our setting [31]. Formulation of infection control policy which considers treatment and temporary removal from work of HCWs with florid wound or skin infections, which cannot be easily covered, will go a long way in reducing transmission of MRSA in most healthcare settings including ours. Also, screening and eradication of MRSA from colonized HCW is recommended as an important infection control measure against this pathogen.

The resistant pattern demonstrated by the isolated MRSA can be described as favorable since none was resistant to the vancomycin, linezolid and quinupristin/dalfopristin which are the recommended drug of choice in the treatment of infections due to MRSA [32]. This pattern showed that infections caused by MRSA strains in our setting can be comfortably treated using vancomycin. Also, minimal resistance to clindamycin and ciprofloxacin seen in this study meant that these drugs can be tried in non-critically ill patients infected with MRSA in our centre. Varying reports of resistance to vancomycin which is the first line drug for treating infections due to MRSA have been documented [33]. Infections due to vancomycin-resistant *S. aureus* (VRSA) strains are treated using linezolid and quinupristin/dalfopristin [32]

5. CONCLUSION

In this study among HCWs, being a male, doctor or nurse, working in a critical care unit, with wound or skin infection, poor handwashing practice, and use of antibiotics were found to be risk factors for colonization by MRSA. None of the isolated MRSA was resistant to vancomycin. Improved infection control policies and practices against carriage and transmission of MRSA in hospital setting will reduce transmission of MRSA and associated consequences within healthcare settings [34].

6. LIMITATIONS OF THE STUDY

We were unable to carry out the molecular characterization of the isolated MRSA to determine the clonal relatedness of strains isolated from the nose and hands especially among respondents who had MRSA isolated from both the hands and the nose.

CONSENT AND ETHICAL APPROVAL

Ethical approval (Protocol number: ERC/2020/01/24/410A) for the work was obtained from the Ethic and Research committee of the hospital. Written informed consent was obtained from all participants prior to administration of questionnaire and sample collection.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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