Nasal Colonization as a Risk Factor for Staphylococcal Infection: a Systematic Review and Meta-Analysis

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Abstract: *Staphylococcus aureus* (S. *aureus)* is a gram-positive bacterium found in clinical and community settings across the world. It is a major cause of both nosocomial and community-acquired staphylococcal infections. Nasal carriage rates of *S. aureus* and Methicillin resistant *Staphylococcus aureus* (MRSA) among hospital and non-hospital centres have been reported in several Nigerian studies. Nevertheless, most of these studies presented local data, and no systematic study has been performed. Only 41 studies were included in this meta-analysis out of which only 24 studies reported MRSA colonization rates. The Meta-analysis of included studies reveals the pooled random effects estimate of nasal carriage of *S. aureus* and MRSA in Nigeria to be 41.5% (95% CI: 36.3-46.9) and 36.4% (95% CI: 27.7- 46.1), respectively. The high level of heterogeneity *(S. aureus,* 94% and MRSA, 92%) found in this study cannot be explained by chance, but by differences in study populations, methodology and geographical regions. Although not all infections* are causally related to persistent *S. aureus* and MRSA carriages, there is sufficient data to show that colonization by MRSA may act as a reservoir that can subsequently develop into an infection, once immunity wanes or immune defenses are breached. Therefore, proper screening and decolonization strategies should be nationally employed.

Key words: *Staphylococcus aurous,* Nigeria, Meta-Analyses, Nasal carriage, Systematic review.

Introduction

Staphylococcus aureus (*S. aureus*) is a Gram-positive bacterium found in clinical and community settings across the world. It is a major cause of both nosocomialand community-acquired staphylococcal infections (Gordon and Lowy, 2008).The primary colonization site of *S. aureus* is the anterior nares. Approximately 20–30% of individuals are persistent carriers of *S. aureus*, around 30% are intermittent carriers, and 40–50% were found to be non-carriers(Farnsworth *et al.*, 2017). Carriers of *S. aureus* are likely to suffer from a clinical infection than non-carrier (Ayepola *et al.*, 2018).

The nares provide a niche where *S. aureus* can obscure itself from host defences.Its ability to colonize the nares is enhanced when a protein located on the bacterial surface, called clumping factor B (ClfB), recognizes a protein called loricrin (a major component of the cells inside the nose). The binding of ClfB to loricrin allows the bacterium to bind to the surface of the squamous epithelial cells in the *stratum corneum* (Olsen, 2013; Farnsworth *et al.*, 2017).

The nasal vestibule is the anterior part of the nasal cavity. It is enclosed by the cartilages of nose and lined by the same epithelial lining like the skin therefore not surprising that *S. aureus* finds this site inhabitable. Being colonized predisposes an individual towards becoming infected (Hanssen *et al.*, 2017).

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As an adaptable microbe and a recurrent invader of human, *S. aureus* colonizes the anterior nares of individuals in both community and hospital environment (Assis *et al.*, 2017). Community and healthcare associated *S. aureus* infection has been on the rise since the last decade. Incomplete or ineffective hygienic practices and a high prevalence of *S. aureus* are two risk factors that establishes detectable human carriers in both hospital and community settings(Morris *et al.*, 2017).

Methicillin-resistant *Staphylococcus aureus* (MRSA) are resistant to β-lactam antibiotics. They were identified shortly after methicillin was introduced into clinical practice(Harkins *et al.*, 2017).In past times, MRSA was mainly a found in Health-care settings butrecently, MRSA strains are being gradually isolated from the community as well (Dadashi *et al.*, 2017).

Theoccurrence of methicillin-resistant *S. aureus* (MRSA) in surgical site and blood stream infections and pneumonia is on the rise. MRSA are considered to bewide spread in many communities throughout the world and are now responsible for approximately 40–60% of health care-associated infections.(Calfee, 2017)

Healthcare and community associated *S. aureus* are major global health problems. Nasal carriage rates of *S. aureus* and MRSA among hospital and non-hospital centres have beenreported in several Nigerian studies. Nevertheless, most of these studiespresented local data, and no systematic study has been performed. Despite the fact that susceptibility testing of *S. aureus* isolates and screening of patients for colonization with MRSA are important tools to limit the spread of this

organism, accurate and updated data describing the pooled prevalence of *S. aureus* and MRSA are crucial for the development of national policies to control MRSA infection in Nigeria.

The aim of this study is toreveal thepooled prevalence of nasal carriage of *Staphylococcus aureus* and MRSA among hospital and non-hospital population during the last 14 years (2003–2018) using asystematic review and meta-analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Materials and Methods

Study design

This was a systematic review and meta-analysis of the prevalence of the nasal carriage of *S. aureus* and MRSA among Nigerians. This study was conducted according to the protocols of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (*PRISMA, 2009*) guidelines.

Search Strategies

Anelectronicsearchofpublishedstudiesin *African Journals Online (AJOL), Medline (via Pub* Med), Google Scholar, Science domain International, Research gate, and other databases from the years 2003 to 2018 was performed using the following search terms: *Staphylococcus aureus* or *S. aureus* and methicillin-resistant *Staphylococcus aureus* or MRSA and nasal carriage. The aforementioned keywords were also used in combination with individual states in Nigeria. Studies that reported the prevalence of MRSA in human anterior nares was considered. The titles and abstracts were screened by two independent reviewers for possible inclusion. There view was restricted to studies conducted in Nigeria and assessed the prevalence or incidence of *S. aureus* or MRSA in the nasal passages. Suitable articles were selected based on their: title, abstract, and full-text publication.

Selection of studies

The criteria for the inclusion and exclusion of the studies were established by the investigators before the literature was reviewed;

Inclusion criteria

Studies with the following characteristics were included: astandardmethodhadtobeused todetect*S. aureus* and MRSA, studies addressing the *S. aureus* nasal carriage in human, reported data on the prevalence of MRSA studies carried out in Nigeria.

Exclusion criteria

Studies that had one or more of the following characteristics were excluded: studies using nonstandard methods, duplicate and overlapping studies, studies carried out incountries otherthan Nigeria, studies that did not evaluate nasal carriage of S. *aureus*, studies that did not report S. *Aureus* prevalence, non-human studies, review articles, meta-analysis or systematic reviews, as well as articles *available only in abstract form.*

Data Extraction and Definitions

The following details were extracted from each study: the first author's name, year of publication, year of study, study center, sample size, number of S. *aureus* and MRSA. All data were independentlyextracted from the included studies by two reviewers, and the results were reviewed by a third reviewer. In consistencies between the reviewers were resolved by a consensus.

Assessment of Study Quality

The quality of the included studies was independently assessed using the Joanna Briggs Institute Checklist for Studies Reporting Prevalence Data(Martin, 2017). The prevalence checklist consists of nine (9) inquiries in which the reviewers answered questions on the selected articles on an individual basis according to the evidence. The Yes answer to each question got a point; evidently, the scores ranged from *zero to nine. Afterwards, studies that attained greater* than 5 points were included in this study.

2.8 Statistical Analysis

Meta-analysis was performed using the ComprehensiveMeta-Analysis® (Bio-statVersion 3) software. The data were pooled using random-effects model (REM). Were ported the amount of residual heterogeneity by using the I^2 statistics. In order to assess any possible publication bias; the Begg rank correlation and Egger weighted regression methods in combination with a funnelplot was used. Ninety five confidence percent level ($p < 0.05$) was considered indicative of statistically significant publication bias. Zotero desktop® (version 5.0.44) referencing software was used to collate the search results and removeduplicates.The I^2 values (25%, 50%, and above 75%) were assigned adjectives of low, moderate, and high values respectively. Map of distribution of *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* (MRSA) based on Longitude and Latitude) was generated with Tableau®professional edition (version 10.4). The study flow diagram (PRISMA) was sketched with Review manager® (Rev-man version 5.3.5).

Results

From September 2003 to March 2018 (174 months), forty-one (41) published articles that matched inclusion criteria were selected for meta-analysis: in total, 1,028 studies were identified. Of these, 3 articles remained after the duplicates were removed. By screening the titles and abstracts, 306 studies were excluded because they were not relevant. Of the remaining 88 articles, only 41 studies were included in

this meta-analysis out of which only 24 studies reported MRSA colonization rates.

The study selection process and reasons for exclusions are shown in Figure 1, and the main characteristics of the selected studies are described in Table 1. Based on the 41 selected articles, the pooled prevalence of *S. aureus* and MRSA were 41.5% (95% CI: 36.3-46.9) and 36.4% (95% CI: 27.7- 46.1), respectively, as shown in Table 2. Heterogeneity between studies (I^2=94, p = 0.015 for *S. aureus* and I^2= 92, p = 0.007 for MRSA) were found to be high, so a random effects model was used for the meta-analysis.

Figures 2, 4 and 6 displays the stratified analysis according to study centers (*S. aureus*), Health status (MRSA) and geopolitical zones (*S. aureus*) of included studies respectively. The distribution of MRSA infections in different parts of Nigeria is shown in Figure.7. Study duration of included studies varied between 5 and 24 months.

Subgroup analysis of the prevalence of *S. aureus* in different Geopolitical Zones shows the North-Central with the highest prevalence (50.8%) and the North-East with the lowest (27.4). In contrast to the high prevalence observed in the North-East, there were more studies published in the South-South region (17) of the country.

The prevalence of MRSA varied as regards Health status in the subgroup analysis as shown in Figure 4., it ranged from 31.7% (CI: 11.4- 62.6) to 38.1% (CI: 22.5- 56.6) in unhealthy and unclear groups, respectively in 24 studies.

Discussion

To the best of our knowledge, this study is the first to systematically investigate nasal carriage rate of S. *aureus* and MRSA in Nigeria.

The Meta-analysis of included studiesreveals the pooled random effects estimate of nasal carriage of *S. aureus* and MRSA in Nigeria to be 41.5% (95% CI: 36.3-46.9)and 36.4% (95% CI: 27.7- 46.1), respectively. These results reflect a higher colonization rate than that previously reported by Emaneini *et al.*, 2017 who reported colonization rates of 22.7% (95% CI: 19.3-26.6) and 32.8% (95% CI: 26.0-40.4) in Iran. A Publishedstudy inEthiopia, by Shibabaw*et al.*, 2013. reported that the prevalence of *S. aureus* among Ethiopian health care workers was 28.8% and among these 44.1% was MRSA (Shibabaw *et al.*, 2013). Nasal carriage of S. aureus and MRSA is a multifactorial process that differs noticeably among countries, which may reflect methodological differences (sampling technique, sample size, culture techniques) and differences in infection control policies, among other factors (Dongxin *et al.*, 2014).

Interestingly the Meta-view of the subgroup analysis shows thelowest carriage rate of MRSA in the unhealthy population 31.7% (CI: 11.4- 62.6) compared to the healthy (36.4%–CI: 25.6- 48.7) and unclear groups (38.1%–CI: 22.5- 56.6).This may be due to the fact that the unhealthy group of people may have been exposed to antibiotics which could have reduced the nasal population of MRSA(Leibler *et al.*, 2017). Conversely, Self-medication, overprescribing or unregulated use of antibiotics in developing countries such as Nigeria is common and may have contributed to the surge in MRSA prevalence among the healthy group (Belkina, 2017). Also substandard antibiotics and patientnoncompliance to antibiotic treatment regimens (Belkina, 2017). It has been shown that patients with recent nosocomial acquisition of MRSA may act as a reservoir(Leung *et al.*, 2017). Although it is not well known whether or not the prior presence of an S. aureus strain predisposes to or protects against colonization by a new strain. However, it has been demonstrated previously that carriers can change their nasal strain over time while staying healthy as phenotypically persistent carriers(Ghasemzadeh-Moghaddam *et al.*, 2015). The pooled random effects estimate of *Staphylococcus aureus* carriage was higher among non-hospital participants (47.2%–CI: 39.3-55.3) than the hospital participants (39.1%–CI: 25.0-55.4).The reason for this rate is not clear, however a potential explanation may be attributed toprior healthcare contact wherethey were exposedto colonization. The half-life of *S. aureus* colonization is approximately 40 months (Grothe *et al.*, 2014). Thus, it is rational to suspect that colonized patients who are discharged from a hospital remain a substantial risk for *S. aureus* dissemination to the community, and may be responsible for the rates observed among the non-hospital population inthis study.

In regional perspective, a higher pooled prevalence rate was observed in the north-central than any other geopolitical zone.It canbe speculatedthe paucity of published literature on the nasal carriage of *S. aureus* among hospital and non-hospital population in this part of the country may have contributed to the over estimated rates. Another major factor that could drive regional *S. aureus* dissemination could be the ineffective of infection prevention control measures which could be attributed to short comings, which mainly relate to cost-effectiveness and labour(Halim *et al.*, 2016).

Ideally, a meta-analysis combines the results of several studies that are highly comparable in design, intervention, and patient population but naturally, studies brought together in a meta-analysis will differ, and this is also called 'heterogeneity(von Hippel, 2015). The high level of heterogeneity (*S. aureus*, 94% and MRSA, 92%) found in this studycannot be explained by chance, but bydifferences in study populations, methodology and geographical regions. Moreover, different methods of S. aureus or MRSA identification and history of antibiotic usage in the included literature might also be the cause of such heterogeneity(Costelloe *et al.*, 2010).

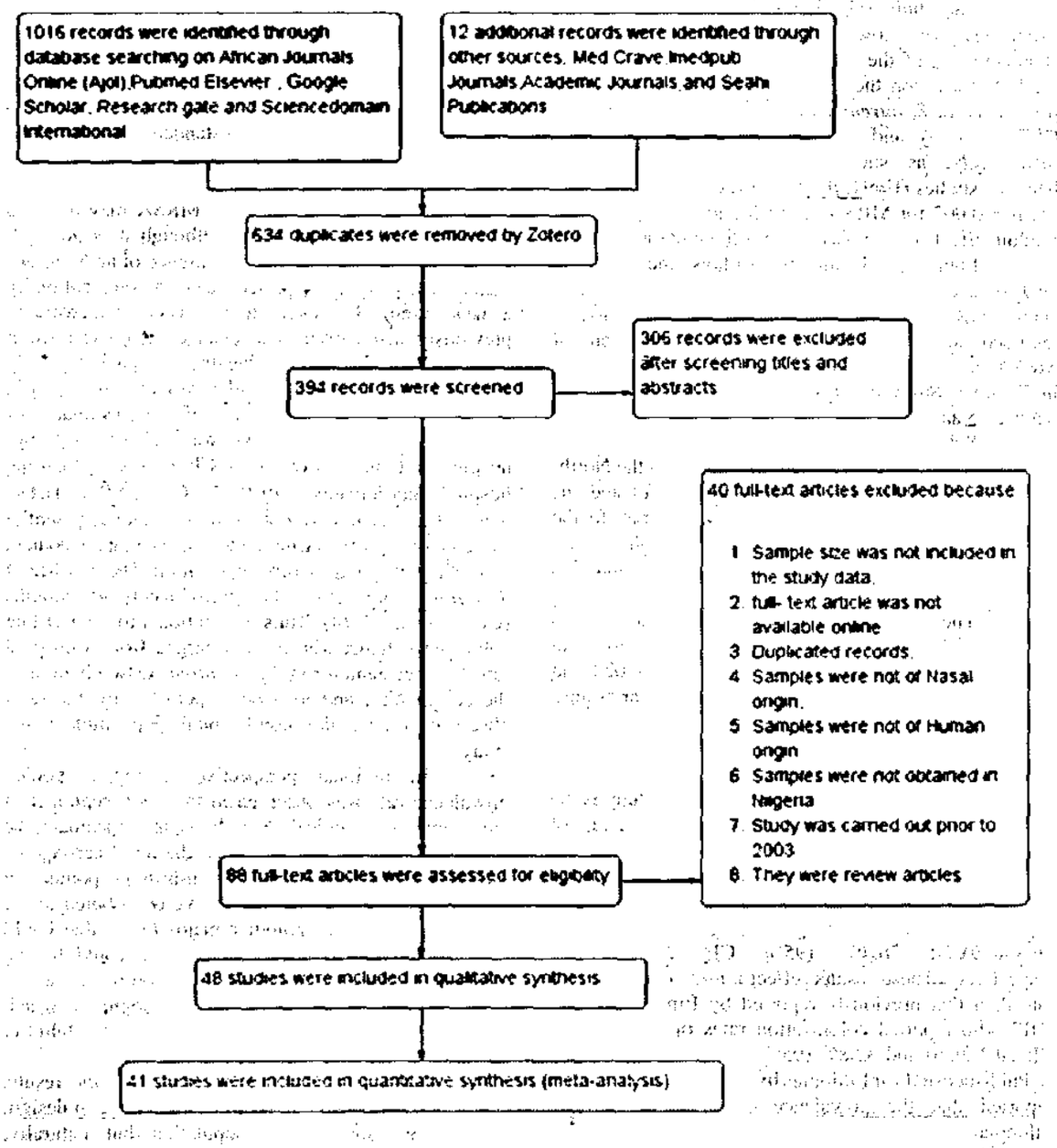

Figure 1: Study flow diagram of literature search of *Staphylococcus aureus*. *MRSA*. methicillin-resistant.

Table 1 Characteristics of studies included in the meta-analysis

Study	State	Study period (m/y)	Study center/health status	Sample size	*S.aureus*(n)	MRSA(n)	Quality
Onanuga and Temedie ., 2011	Bayelsa	02/09 to 07/09	Non-hospital/Healthy	120	40	10	6
Akerele et al., 2015	Edo	NA	Non-hospital/Unclear	200	99	22	7
Onolitola et al., 2006	Kaduna	NA	Non-hospital/Healthy	50	50	36	8
Ike, et al 2016	Anambra	NA	Non-hospital/unclear	261	81	33	7
Otokunefor et al., 2017	Rivers	NA	Non-hospital/Unclear	140	46	NA	7
Eke et al., 2015	Edo	NA	Non-hospital/Unclear	100	60	NA	8
Nmema., 2017	Ondo	NA	Non-hospital/Healthy	40	17	NA	7
Omololu et al., 2017	Osun	NA	Non-hospital/Unclear	35	13	NA	8
Nsofor et al., 2015	Imo	03/13 to 06/13	Non-hospital/Unclear	270	152	NA	8
Ohagim et al., 2018	Akwalbom	04/16 to10/16	Hospital/Unclear	200	102	22	6
Ayepola., et al, 2018	Ogun	NA	Non-hospital/Unclear	277	157	143	8
Ugwu et al., 2016	Delta	NA	Non-hospital/Healthy	300	218	56	6
Akinjogunla et al., 2014	Akwalbom	NA	Non-hospital/Unclear	120	84	30	8
Onyeagwara, et al., 2014	Edo	07/12 to 09/12	Hospital/Unclear	50	25	10	8
Abdu and Lamikanra 2016	Bayelsa	NA	Non-hospital/Healthy	400	91	NA	6
Adesida et al., 2016	Lagos	NA	Hospital/Unhealthy	230	50	10	7
Okwu et al., 2012	Edo	NA	Non-hospital/Unclear	120	22	13	8
Nworie et al., 2013	Ebonyi	NA	Non-hospital/Unclear	87	20	3	7
Olalekan et al., 2012	Lagos	12/08 and 08/10	Hospital/Unhealthy	744	202	26	7
O'Malley et al., 2014	Lagos	06/12 and 07/12	Hospital/Unclear	23	14	6	8

Adesida et al., 2007	Lagos	NA	Hospital/Unclear	185	26	0	8
Akortha and Ikenebomeh., 2010	Edo	NA	Hospital/Unhealthy	52	20	NA	6
Isibor and Otabor et al., 2014	Edo	NA	Non-hospital and hospital/Unclear	100	32	NA	7
Edem et al., 2013	Akwaibom	NA	Hospital/Healthy	30	17	6	8
Abdulaziz and Olayinka ., 2016	Kaduna	01/14 to 11/ 14	Hospital/Healthy	427	81	10	6
Egwuatu et al., 2013	Lagos	NA	Hospital/Healthy	250	89	34	8
Job et al., 2018	Rivers	NA	Hospital/Unhealthy	217	82	54	8
Obiazi et al., 2007	Edo	12/05 and 11/06	Hospital/Unhealthy	80	7	NA	6
Moses et al., 2017	Akwaibom	NA	Hospital /Unhealthy	130	41	16	7
Chigbu and Ezeronye., 2003	Abia	NA	Non-hospital and hospital/Unclear	50	24	NA	6
Gulani et al., 2016	Borno	NA	Non-hospital/Unclear	37	11	5	6
Ahmad et al., 2016	Kano	NA	Hospital/Unhealthy	15	8	NA	6
Fadeyi et al., 2010	Kwara	12/09 and 02/10	Hospital/Healthy	198	104	40	6
Umar et al. ,2015	Kaduna	NA	Hospital/Unclear	13	13	NA	6
Uwaezuoke and Aririatu 2014	Imo	NA	Hospital/Unhealthy	29	16	NA	6
Anie et al. ,2017	Delta	NA	Non-hospital/Healthy	300	164	47	7
Ugwu et al., 2013	Enugu	07/08 and 08/08	Non-hospital/Healthy	100	53	NA	7
Ineta et al., 2013	Enugu	NA	Non-hospital/Unclear	60	50	NA	6
Ajoke et al. 2012	Plateau	NA	Non-hospital/Healthy	200	98	62	6
Muhammad., et al. 2014	Borno	NA	Non-hospital/Healthy	120	32	NA	7
Ugwu et al., 2015	Anambra	04/13 to 05/13	Non-hospital/Healthy	100	68	NA	6

Table 2: Meta-analysis of Pooled prevalence of *Staphylococcus aureus* and MRSA

Subgroups		Studies (no)	Pooled Prevalence	n/N	I^2	p -value	Begg's test	Egger's test	
								t-value	*p*-value
	S. aureus	41	41.5 (CI: 36.3-46.9)	2579 / 6460	94	0.015	0.3	0.9	0.18
	MRSA	24	36.4(CI: 27.7-46.1)	694 / 1877	92	0.007			
Study center(*S.aureus*)	Hospital	17	36.5(CI: 29.3-44.4)	897 / 2873	92	0.001	0.3	0.9	0.18
	Non-hospital	22	47.2(CI: 39.3-55.3)	1626/3434	95	0.498			
	Non-hospital and hospital	2	39.1 (CI: 25.0-55.4)	56/150	72	0.188			
Health status (MRSA)	Healthy	9	36.4(CI: 25.6-48.7)	301 / 861	90	0.031	0.4	0.18	0.4
	Unhealthy	4	31.7(CI: 11.4-62.6)	106 / 375	95	0.24			
	Unclear	11	38.1(CI: 22.5- 56.6)	287 / 641	92	0.206			
Geopolitical Zone(*S.aureus*)	South-South	17	41.3(CI: 32.8-50.5)	1150 / 2659	94.7	0.06	0.3	0.9	0.18
	South-East	8	52.1(CI: 39.0-65.0)	464 / 957	92.7	0.75			
	South-West	8	34.7(CI: 24.5-46.4)	568 / 1784	94.5	0.011			
	North-West	4	30.1 (CI: 28.1-96.5)	152 / 505	91.8	0.275			
	North-East	2	27.4(CI: 21.0-39.4)	43 / 157	0	0.00			
	North-Central	2	50.8(CI: 45.8-55.6)	202 / 398	0	0.764			

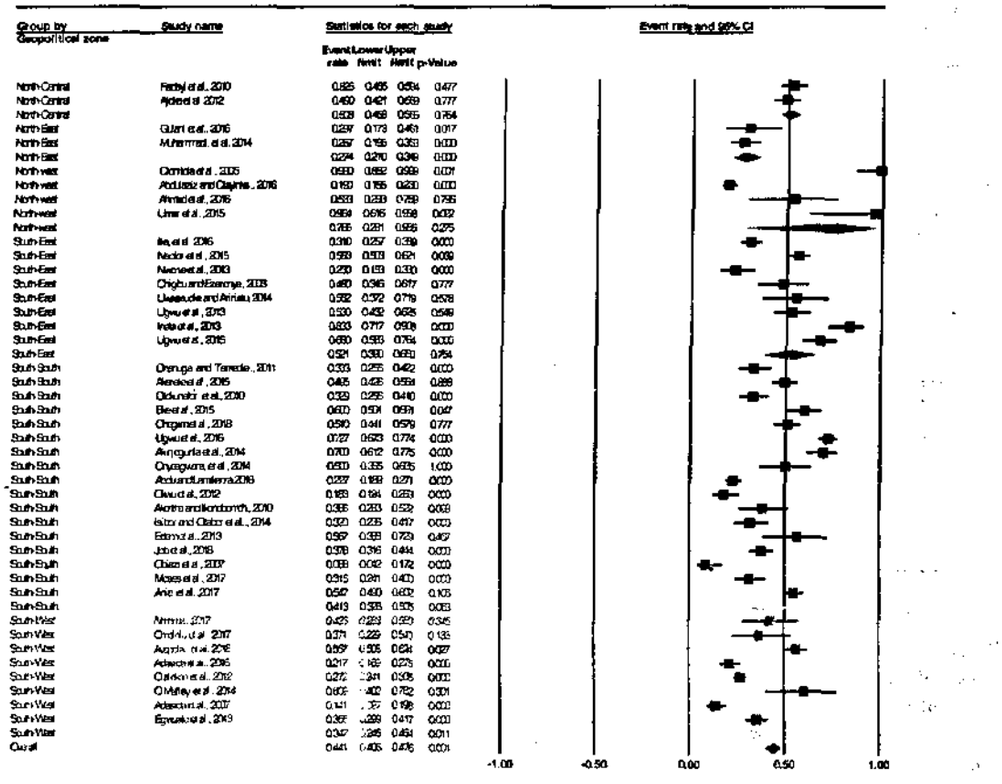

FIGURE 2 - Forest plot of prevalence of *S. aureus* in Hospital and non–hospital centers in Nigerian. (The squares represent the point estimates of individual studies with their 95% confidence intervals and the size of the square denotes the weight given to each study in the meta-analysis. The diamond represents the overall result and 95% confidence interval of the random effect meta-analysis. Vertical line: null value). 95% CI: 95% confidence interval.

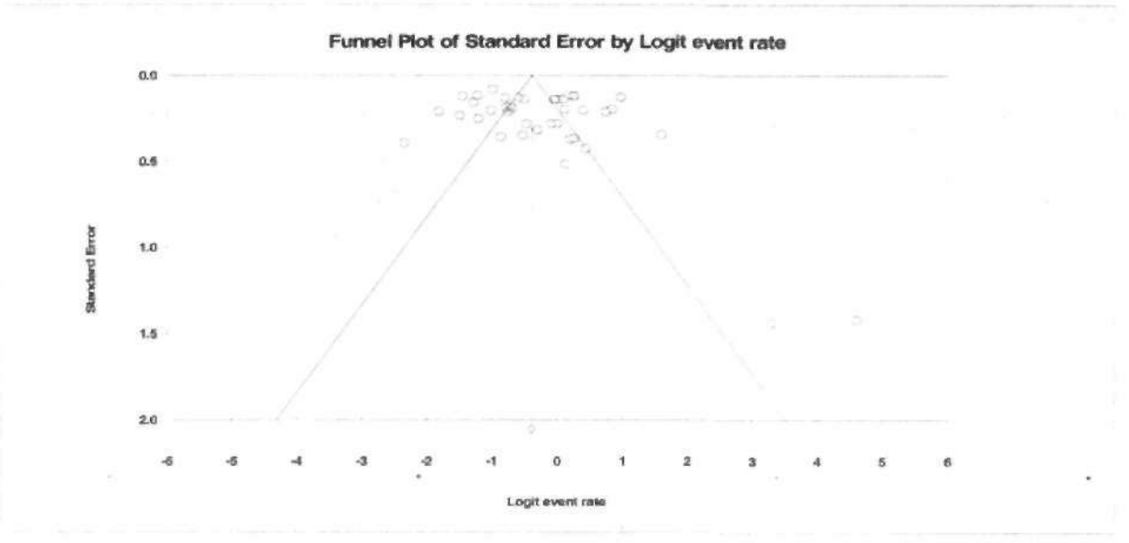

FIGURE 3: Funnel plot of prevalence of *Staphylococcus aureus* Nigeria.

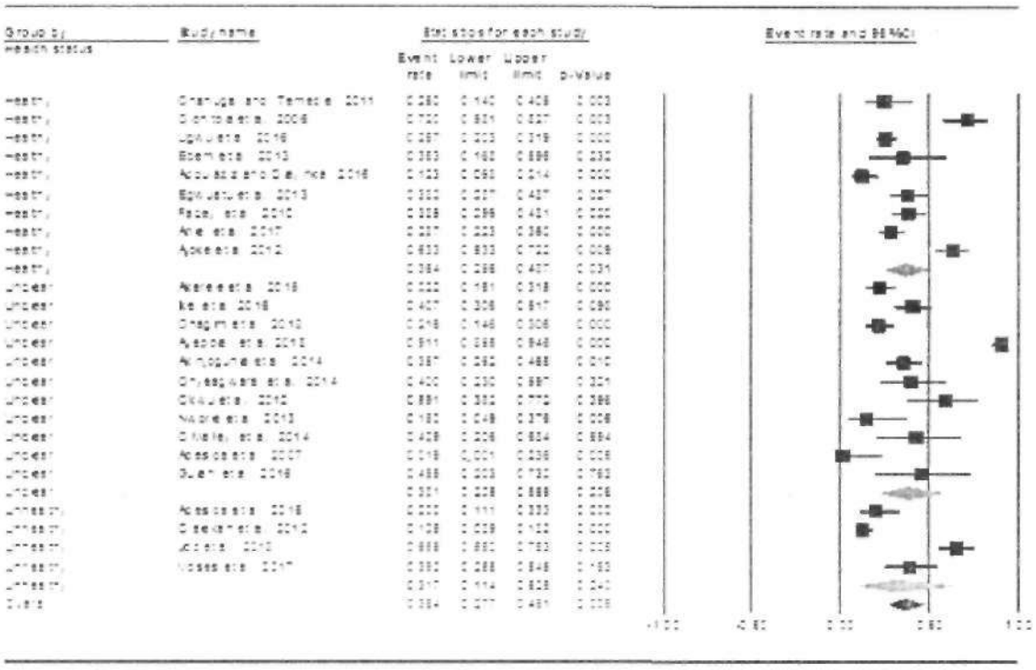

FIGURE 4 - Forest plot of prevalence of MRSA (methicillin resistant *Staphylococcus aureus*) in accordance with the health status of the study population. (The squares represent the point estimates of individual studies with their 95% confidence intervals and the size of the square represents the weight given to each study in the meta-analysis. The diamond signifies the overall result and 95% confidence interval of the random effect meta-analysis. Vertical line: null value). 95% CI: 95% confidence interval.

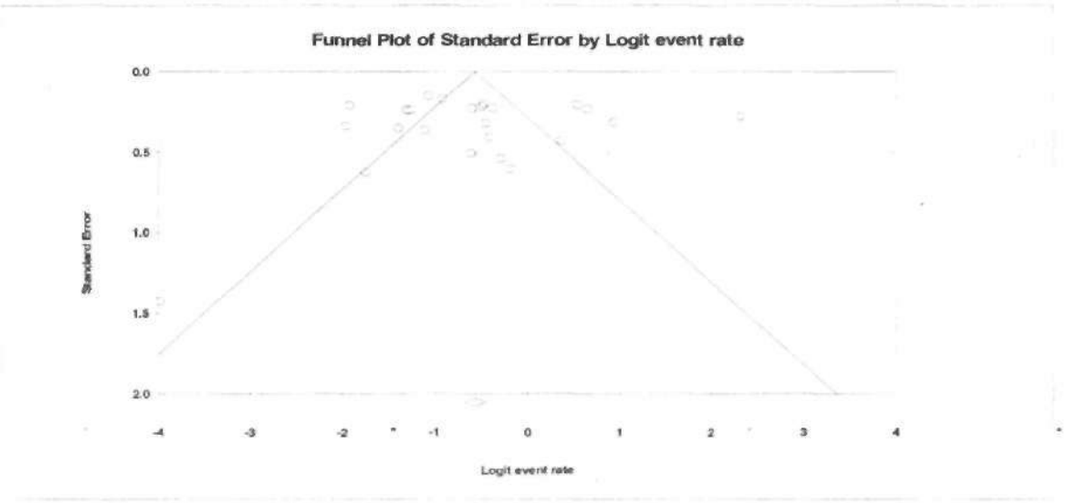

FIGURE5: Funnel plot on meta-analysis of the prevalence ofmethicillin resistant *Staphylococcus aureus* (MRSA) in Nigeria.

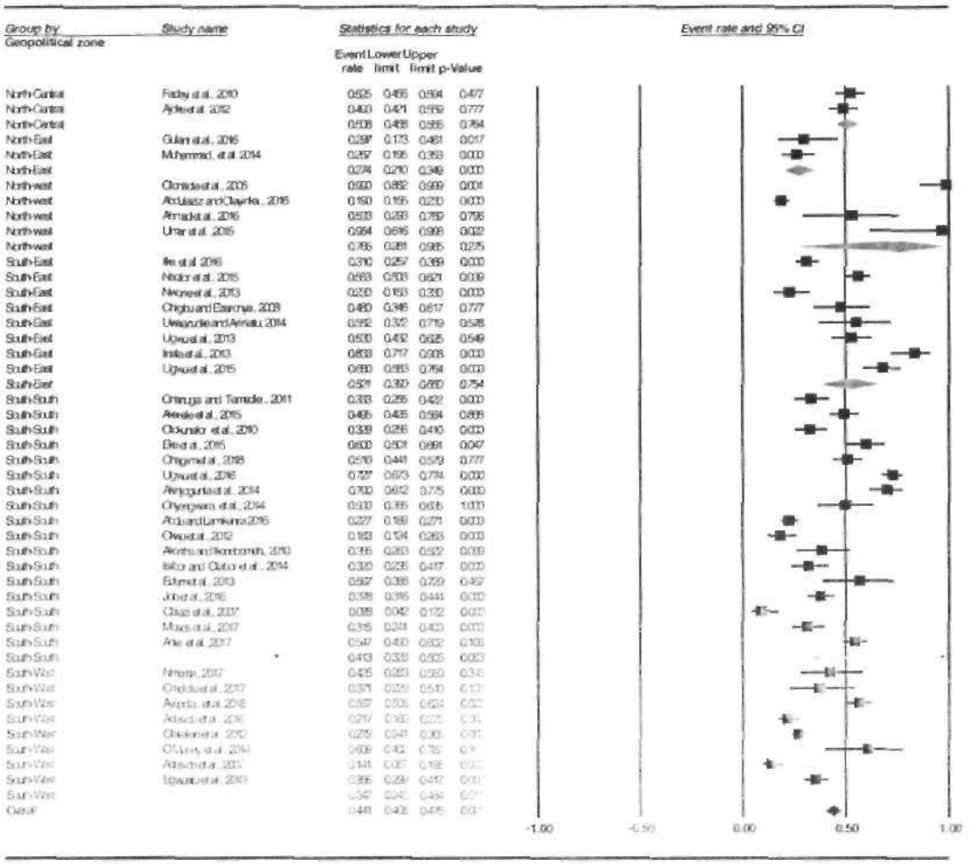

FIGURE 6 - Forest plot of prevalence of *Staphylococcus aureus*in accordance with the geopolitical zones of the study population. (The squares denotes the point estimates of individual studies with their 95% confidence intervals and the size of the square signifies the weight given to each study in the meta-analysis. The diamond represents the overall result and 95% confidence interval of the random effect meta-analysis. Vertical line: null value). 95% CI: 95% confidence interval.

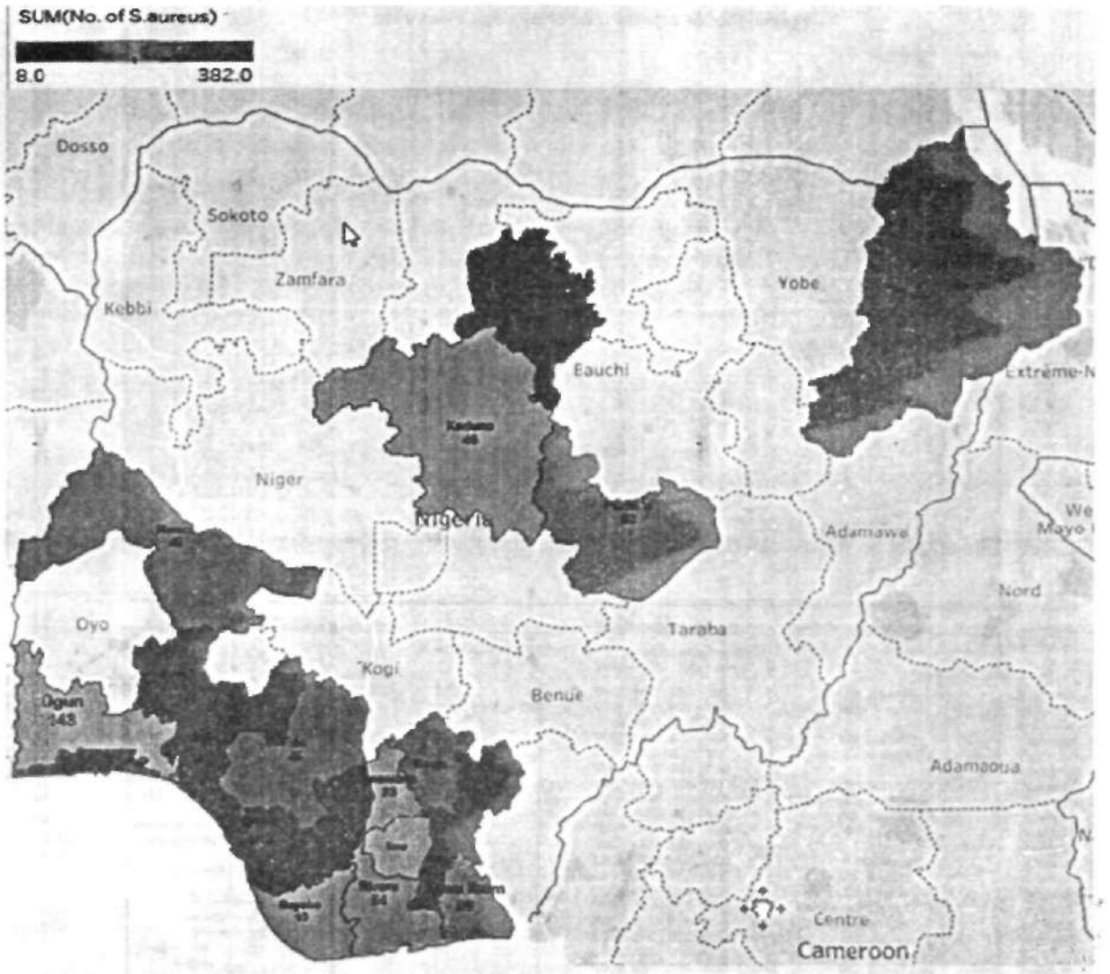

FIGURE 7: Map of distribution of *Staphylococcus aureus* and methicillin-resistant Staphylococcus *aureus* (MRSA) based on Longitude (generated) and Latitude (generated). Color shows sum of No. of S.*aureus*. Size shows sum of No. of MRSA. The marks are labeled by State and sum of No. of MRSA.

Table 3: Sensitivity analysis of Studies on colonization rates of *S.aureus*

Study	Point prevalence	lower limit	upper limit	P-value
All studies	41.5%	0.367	0.487	0.017
All except Onanuga and Temedie.,2011	42.9%	0.369	0.491	0.025
All except Akerele *et al.*,2015	42.5%	0.365	0.487	0.018
All except Olonitola *et al.*,2006	41.9%	0.361	0.479	0.008
All except Ike, *et al* .,2016	43.0%	0.370	0.492	0.028
All except Otokunefor *et al.*,2010	42.9%	0.369	0.491	0.025
All except Eke *et al.*, 2015	42.2%	0.363	0.483	0.012
All except Omololu *et al.*, 2017	42.8%	0.368	0.489	0.021
All except Nsofor *et al.*, 2015	42.2%	0.363	0.484	0.014
All except Ohagim *et al.*, 2018	42.4%	0.364	0.486	0.017
All except Ayepola., *et al*, 2018	42.2%	0.363	0.484	0.014
All except Ugwu *et al.*, 2016	41.6%	0.361	0.473	0.004
All except Akinjogunla *et al.*,2014	41.8%	0.360	0.478	0.008
All except Onyeagwara, *et al.*,2014	42.4%	0.365	0.486	0.016
All except Abdu and Lamikanra 2016	43.3%	0.374	0.493	0.029
All except Adesida *et al.*, 2016	43.3%	0.374	0.494	0.031
All except Okwu *et al.*, 2012	43.4%	0.375	0.495	0.033
All except Nworie *et al.*, 2013	43.2%	0.373	0.493	0.029
All except Olalekan *et al.*, 2012	43.1%	0.371	0.493	0.031
All except O'Malley *et al.*, 2014	42.2%	0.364	0.483	0.014
All except Adesida *et al.*, 2007	43.6%	0.378	0.496	0.036
All except Akortha and Ikenebomeh.,2010	42.7%	0.368	0.489	0.021
All except Isibor and Otabor *et al.*,2014	42.9%	0.370	0.491	0.025
All except Edem *et al.*, 2013	42.3%	0.364	0.484	0.014
All except Abdulaziz and Olayinka.,2016	43.4%	0.376	0.493	0.029
All except Egwuatu *et al.*,2013	42.9%	0.368	0.491	0.025
All except Job *et al.*, 2018	42.8%	0.368	0.491	0.024
All except Obiazi *et al.*, 2007	43.7%	0.379	0.498	0.042
All except Moses *et al.*, 2017	43.0%	0.370	0.491	0.026
All except Chigbu and Ezeronye., 2003	42.5%	0.366	0.486	0.017
All except Gulani *et al.*, 2016	43.0%	0.370	0.491	0.025
All except Ahmad *et al.*, 2016	42.4%	0.365	0.485	0.015
All except Fadeyi *et al.*, 2010	42.4%	0.364	0.486	0.016
All except Umar *et al.* ,2015	42.1%	0.363	0.481	0.010
All except Uwaezuoke and Aririatu,2014	42.3%	0.364	0.485	0.014
All except Anie *et al.* ,2017	42.3%	0.363	0.485	0.015
All except Ugwu *et al.*, 2013	42.4%	0.364	0.485	0.015
All except Ineta *et al.*, 2013	41.5%	0.357	0.474	0.005
All except Ajoke *et al.* 2012	42.5%	0.365	0.487	0.018
All except Muhammad *et al.*.2014	43.1%	0.372	0.493	0.028
All except Ugwu *et al.*.2015	41.9%	0.361	0.479	0.008

Table 4: Sensitivity Analysis of Studies on colonization rates of MRSA

Study	Point prevalence	lower limit	upper limit	P-value
All studies	36.4%	0.279	0.463	0.007
All except Onanuga and Temedie., 2011	37.2%	0.281	0.472	0.013
All except Akerele *et al.*, 2015	37.4%	0.282	0.475	0.015
All except Olonitola *et al.*, 2006	35.1%	0.266	0.447	0.003
All except Ike, *et al* 2016	36.4%	0.272	0.466	0.009
All except Ohagim *et al.*, 2018	37.4%	0.283	0.475	0.015
All except Ayepola., *et al*, 2018	33.8%	0.268	0.417	0.000
All except Ugwu *et al.*, 2016	37.1%	0.278	0.475	0.016
All except Akinjogunla *et al.*, 2014	36.6%	0.274	0.468	0.011
All except Onyeagwara, *et al.*, 2014	36.4%	0.275	0.465	0.008
All except Adesida *et al.*, 2016	37.5%	0.284	0.475	0.015
All except Okwu *et al.*, 2012	35.7%	0.269	0.456	0.005
All except Nworie *et al.*, 2013	37.6%	0.286	0.475	0.015
All except Olalekan *et al.*, 2012	38.2%	0.295	0.479	0.017
All except O'Malley *et al.*, 2014	36.4%	0.275	0.463	0.008
All except Adesida *et al.*, 2007	37.8%	0.289	0.476	0.015
All except Edem *et al.*, 2013	36.6%	0.277	0.466	0.009
All except Abdulaziz and Olayinka., 2016	38.1%	0.291	0.480	0.019
All except Egwuatu *et al.*, 2013	36.5%	0.273	0.467	0.010
All except Job *et al.*, 2018	35.3%	0.267	0.449	0.003
All except Moses *et al.*, 2017	36.5%	0.275	0.466	0.009
All except Gulani *et al.*, 2016	36.3%	0.274	0.462	0.007
All except Fadeyi *et al.*, 2010	36.5%	0.272	0.468	0.011
All except Anie *et al.* ,2017	36.9%	0.276	0.473	0.014
All exceptAjoke *et al.* 2012	35.4%	0.268	0.451	0.004

To examine this heterogeneity and the effect of each study on the overall result, we tested the sensitivity of our results to the exclusion of each study by carrying out sensitivity analysis. The analysis showed only slight changes in the pooled rates of both *S aureus* and MRSA colonization ratesafter sequentially omitting an individual study, suggesting that our results were stable.Plainly, theimpact of each study (outlier; large or small) on the combine effect was low. In other words, results showed that no single study was responsible for all the heterogeneity.

In the meta-view above study representations (line, box and diamond) that trace the line of no effect (null-line) was measured as not statistically significant. Overall, there was a statistically significant relationship between the nasal colonization of *S. aureus* and the occurrence of MRSA. Furthermore, a significant relationship was also observed between *S. aureus* nasal colonization and participants in hospital setting. Conversely despite higher carriage rates observed among non-hospital participants the metaview did not confirm a statistically significant relationship.

Conclusions

Managing colonization with*S. aureus* and MRSA continueto be a problem, especially in health-care institutions. Colonization is associated with an increased risk of infection and, thereby, increased morbidity and mortality. Findings in this systematic review have shown that the pooled prevalence rate of S. *aureus*is41.6% and that there is a 36.4% likelihood that a person colonized by *S. aureus* will harbour MRSA in Nigeria.This study also confirms a high nasal carriage rateof *S. aureus* and MRS Ain Nigeria.

Nasal colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) is asignificantstride in the pathogenesis of active infection and is a key issue in the spread of MRSA infection. Adequate data on the epidemiology of the nasal carriage of *S. aureus* and MRSA in Nigeria are limited, with reports from only 20 of the 36 states in the country included in the study. The extreme paucity of published data in the Northern geopolitical zone of this country draw attention to the need for moreeffort in monitoring and publication S. *aureus* and MRS Anasal epidemiological studies.

This study had several limitations. First, the study could not fully assess the prevalence of S. *aureus*

and MRSA among Nigerians because literature in some regions of the country were not available and could have influenced the results. Secondly, we only considered published articles in the current meta-analysis; thus, the potential for publication bias should be considered as it invariably has an effect on review findings. Finally, the studies included in the review rarely reported on the negative outcomes of nasal colonization experienced by the populace which could haveaided in the appreciation of the proportion of the population that were non-carriers.

With this meta-analysis we have demonstrated that the setting (hospital or non-hospital), geopolitical zone and health status of participants are risk factors in the epidemiology of *S. aureus* and MRSA in Nigeria despite the likelihood of selection and publication bias.

Although not all infections are causally related to persistent *S. aureus* and MRSA carriages, there is sufficient data to show that colonization by MRSA may act as a reservoir that can subsequently develop into an infection, once immunity wanes or immune defenses are breached. Therefore, proper screening and decolonization strategies should be nationally employed.

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