

Original Article

**ASSESSMENT OF HEAVY METALS IN DUST SAMPLES AND HYGIENE PRACTICES
AMONG STONE QUARRY WORKERS IN GUSAU, ZAMFARA STATE, NORTHWEST
NIGERIA.**

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ABSTRACT

Background: Chemical hazards produced in the process of quarrying stones include heavy metals like lead, nickel, cadmium and some of them can cause heavy metal poisoning in humans. This study assessed the heavy metals levels in dust samples and hygiene practices in stone quarries in Gusau metropolis.

Methods: In this study, a cross-sectional study was conducted among quarry workers in Gusau metropolis between August and September 2022. Systematic sampling technique was used to select 307 respondents. Data was collected using interviewer-administered questionnaire (ODK) and analysed using IBM SPSS version 25. Dust samples were collected in the quarries (quarry and administrative areas) and sent for heavy metal analysis in National Research Institute and Chemical Technology (NARICT), Zaria.

Results: The heavy metals levels in dust in the work and administrative areas were all below the maximum permissible level. Over two-thirds, 209 (68.1%) of the respondents take bath always, one-third, 92 (30.0%) of the respondents take bath sometimes and six (1.9%) of the respondents never take bath both before and after work. Almost all the respondents 302 (98.4%) had never used a uniform in the quarry, although, five (1.6%) of them designated some clothing as uniform sometimes. Only about one-sixth, 47 (15.3%) of the respondents avoid food or drink at work areas.

Conclusions: This study revealed tolerable levels of all the heavy metals assessed in the workplaces but, poor hygiene practices among the quarry workers in Gusau. The quarry employers should ensure periodic training and education of the workers on good hygiene practices.

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INTRODUCTION

The quarry workplaces have numerous hazards including chemical, physical, and ergonomic.¹ The chemical hazards in the quarries include heavy metals like lead, chromium, copper etc.^{1, 2} Workers are exposed to hazards everyday as part of their job duties and these hazards predispose them to occupational diseases and poisonings.¹ Due to intensified quarry activities in the nation, huge amounts of heavy metals may be released into the environment.³

They accumulate in land and water and subsequently, they may reach harmful concentrations in the plants and animals.³ Exposure to potentially harmful metals like lead and Cadmium could adversely affect human health⁴. It is recognized that plants grown in areas near quarry sites absorb heavy metals.³

When man consumes these crops, there is accumulation of the metals in the body system and such accumulation may reach very harmful levels.⁵

This is the main cause of heavy metal poisoning in man.³

Moreover, heavy metals like Copper and Zinc are needed for normal plant growth, but higher concentrations of these metals

Cd (5.5 mg/kg), Pb (386 mg/kg), Cu (703 mg/kg), and Zn (1100 mg/ kg).¹⁰ Another study conducted for the assessment of heavy metal pollution in Soils in the vicinity of Durumi quarry site in Mpape, Abuja Nigeria, found concentration levels of Cr, Cu, Cd, Zn, Mn, Ni, Pb and Fe (24.90 mg/kg, 31.78 mg/kg, 22.27 mg/kg, 18.82 mg/kg, 6.41 mg/kg, 16.26 mg/kg, 3.55 mg/kg and 169.33 mg/kg respectively

might lead to toxic levels and inhibition of plant growth.³ The inhalation of dust is associated with respiratory symptoms, while dust deposition on body surfaces can cause skin and eye morbidities.³ Route of exposure to heavy metals includes inhalation, dermal contact and ingestion of the metal.⁶ Arsenic is one of the most toxic metals present in the air, water, and soil.⁷

Ingestion of excessive quantities of inorganic Arsenic can cause, nervous system disruption, anaemia, liver enlargement, and skin decolouration.⁸

Lead (Pb) concentrations in soil samples varied inconsistently between 4.56mg/kg and 22.53mg/kg at a soil depth of 0.0-5.0cm.⁹

There is no known safe blood lead concentration; even blood lead concentrations as low as 5µg/dL, may be associated with decreased intelligence in children, behavioural difficulties and learning problems.⁶

Lead exposure also causes anaemia, hypertension, renal impairment, and toxicity to the reproductive organs.⁶

In a study carried out in South China, the soil samples collected from the mining area revealed the highest concentrations of

Safety workplace has been precedence since the era of industrial development and is a priority to the United Nations (UN). It is recognized as a basic human right in the UN Universal Declaration of Human Rights, 1948.¹¹ Efforts to improve hygiene practices among quarry workers can significantly reduce the risk of heavy metals inhalation, ingestion or absorption. A cross-sectional study carried out in India reported that 89.94% of stone quarry workers take their baths daily, and 10.0% of them do not take their baths daily.¹ In another study conducted in Ebonyi state, Nigeria quarry workers' observation of basic hygiene revealed that workers, 54 (13.8%) bathed before leaving the workplace for home, changed into clean clothes, 162 (41.3%) before going home, washed their hands, 338 (86.2%) before taking their meals and/or before snuffing or smoking. And only 2 (0.5%) of the workers received one form of training or the other.¹²

Quarry workers may have an idea about their exposure to dust however may not be aware of the heavy metals composition of the dust they come in contact with or its concentration. They may be exposed to a concentration that can cause poisoning in them but may do nothing if unaware of the heavy metal hazards. Therefore, this study assessed heavy metal composition of the

dust. Similarly, hygiene practices among quarry workers are important measures to prevent exposure to heavy metal-containing dust however; this practice is often neglected despite being simple to conduct. Consequently, this study also assessed hygiene practices among the workers. In addition, over a decade ago, Zamfara state experienced lead poisoning.¹³ Hence, this study assessed the levels of heavy metals in dust to prevent another potential outbreak of heavy metal poisoning.¹³

METHODOLOGY

Study Area

The study was conducted in Gusau metropolis, Zamfara State, Nigeria. Agriculture and gold mining are the major occupations of the people of the state and the major agricultural products include millet, maize, rice, and beans.¹⁴ Irrigation farming for cereals and legumes gave rise to its slogan "farming is our pride".^{15, 14} Other occupations are stone quarrying, cotton ginnery, trading etc. Gusau LGA has a population of 528,400, an area of 3,364 km and a population of 383,162 as of the 2006 census (See Figure 4).¹⁵

Study Design

This was a cross-sectional study design among manual stone quarry workers in Gusau metropolis conducted between May and July 2022.

Sample Size Determination

The minimum sample size for the hygiene practice respondent was calculated using Cochran formula for descriptive studies $n = \frac{Z^2 pq}{d^2}$.¹⁶ A minimum sample size of 350 was obtained based on the prevalence (p) from a previous study of 64.9% = 0.649.¹⁷ Adjusting for 10% non-response rate, an optimum sample size of 307 was attained. This study was carried out in Gusau metropolis which has three quarries. All the quarries were included in the study because two of the three quarries had numbers of workers less than the sample size. Then, respondents were selected from each of the three quarries by proportionate allocation of workers. A systematic sampling technique was finally used to select the 307 respondents from the quarries.

Data Collection

Dust sample collection was done by the principal researcher in the three quarries. Each of the three quarries was divided into two sections (i.e., quarrying and

administrative areas) making up a total of six areas. The six dust samples collected were sent to NARICT, Zaria for analysis and the findings were reported accordingly. A total of nine heavy metals were analysed from each of the dust samples. A structured interviewer-administered questionnaire, developed from similar studies was used to collect data on hygiene practice.^{1, 12} The questionnaire was validated and pretested and was administered to the respondents at their workplaces using ODK software installed in the Android phones of the researchers.

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of the Ministry of Health of Zamfara State (ZSHREC01122021). Permission was sought from the heads of all the quarries. Informed consent was obtained from the study respondents after explaining the purpose of the study, the right to accept or refuse participation, and the guaranteeing of confidentiality.

RESULT

The values of Lead (Pb) were similar between the quarry work and administrative areas of each of the sites but were not detected in the administrative area of site B (<0.01). The level of chromium was similar between the quarry work (0.15 mg/kg) and administrative (0.17 mg/kg) areas of site A, however, it

was not detected in site B and site C quarry and administrative areas. The levels of other heavy metals were also similar between the quarry and administrative areas of each of the sites. The levels of all the analysed heavy metals were below the maximum permissible level in the dust (Table 1).

Table 1: Heavy metal levels in dust samples in the quarry and administrative areas

Heavy metal (Element/ Compd.)	<u>Site A (Samaru)</u>		<u>Site B (Damba)</u>		<u>Site C (Lalan)</u>		Maximum permissible level (mg/kg)¹⁸⁻²⁰
	Quarry Area (mg/kg)	Admin Area (mg/kg)	Quarry Area (mg/kg)	Admin Area (mg/kg)	Quarry Area (mg/kg)	Admin Area (mg/kg)	
K	1.19	1.01	1.36	1.09	1.14	1.07	80
Fe	0.32	0.86	1.24	1.42	0.65	0.54	50,000
Zn	1.35	1.20	1.37	1.20	1.29	1.11	300
Cd	1.67	1.42	1.12	1.32	1.59	1.20	3
Ni	1.36	1.21	0.99	1.13	1.31	1.10	50
Pb	0.01	0.14	0.09	<0.01	0.30	0.31	100
Cr	0.15	0.17	<0.01	<0.01	<0.01	<0.01	100
Cu	1.58	1.16	1.48	1.42	1.52	1.45	100
Mn	0.09	0.07	0.15	0.10	0.16	0.17	2000

About one-third, 92 (30.0%) of the respondents take their baths before and after work occasionally and six (1.9%) of the respondents never take baths both before and after work. Almost all the respondents 302 (98.4%) had never used a uniform in the quarry, however, five

(1.6%) of them designated some clothing as uniform sometimes. Only about one-sixth of the respondents avoid eating and drinking in the quarry working areas (Figure 1).

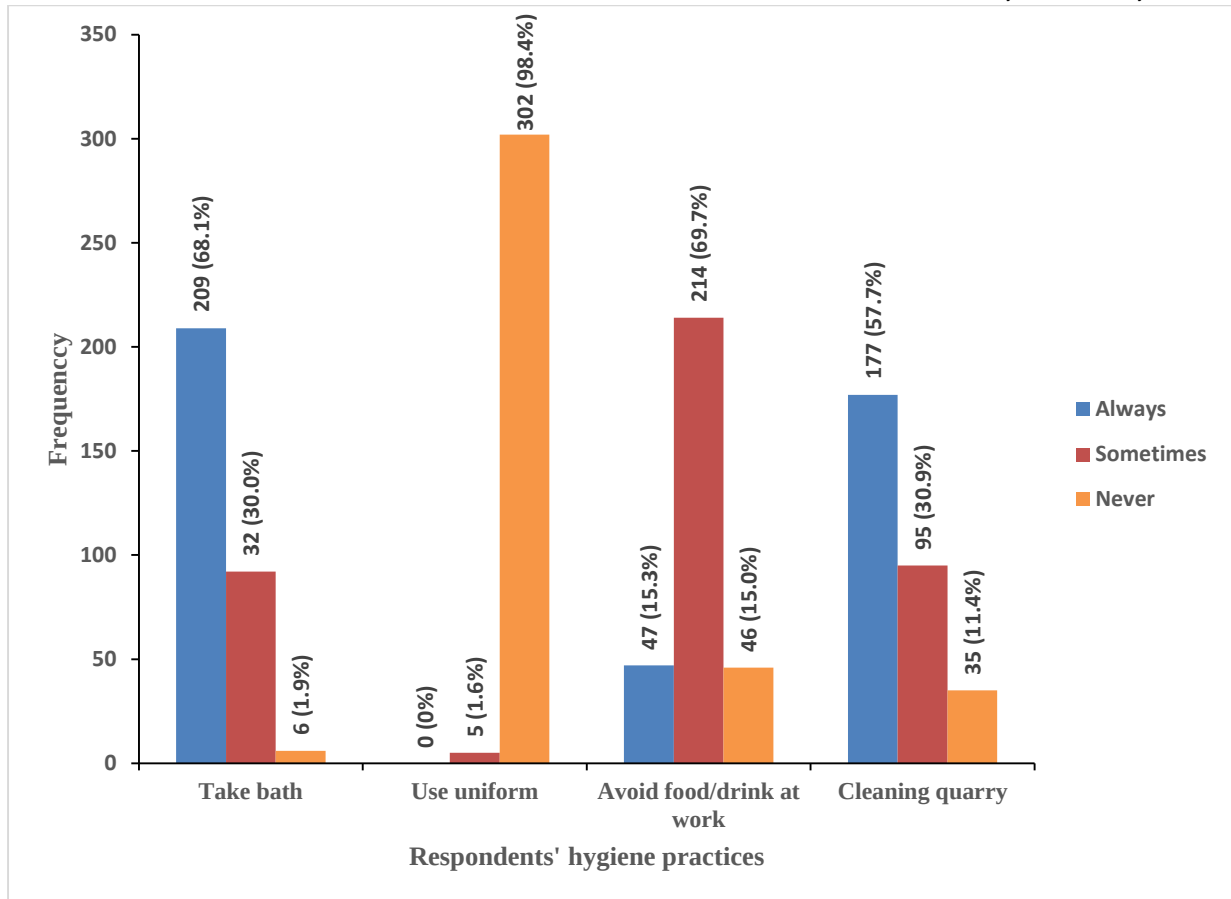
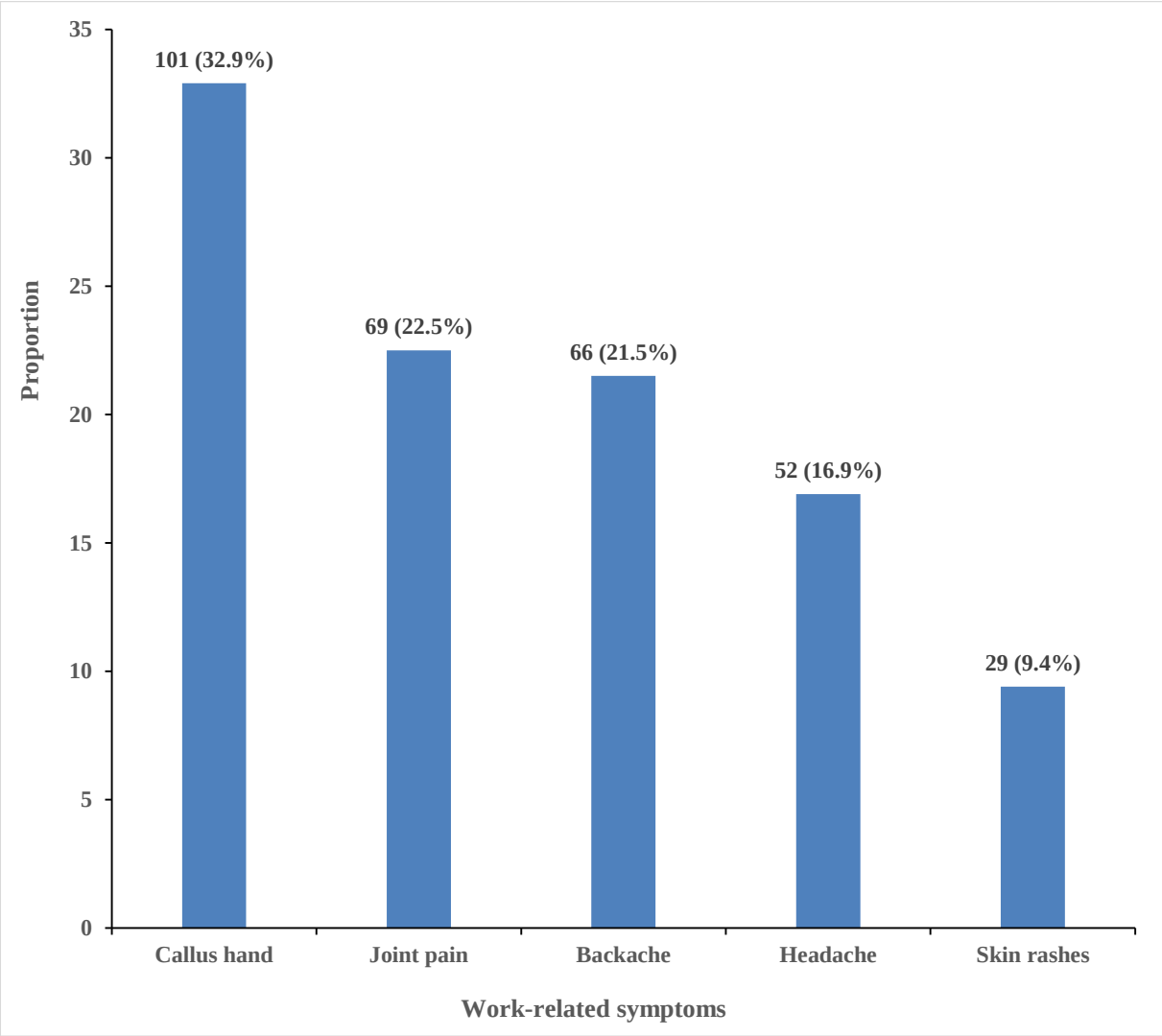


Figure 1: Respondents' hygiene practices in the quarry

Almost a third of the respondents 101 (32.9%) had callus hands, while 69 (22.5%) and 66 (21.5%) of the respondents experienced joint pain and backache

respectively. Headaches were reported by 52 (16.9%) of the respondents, while 29 (9.4%) of them experienced skin rashes (Figure 2).



Multiple responses.

Figure 2: Work-related symptoms experienced by the respondents

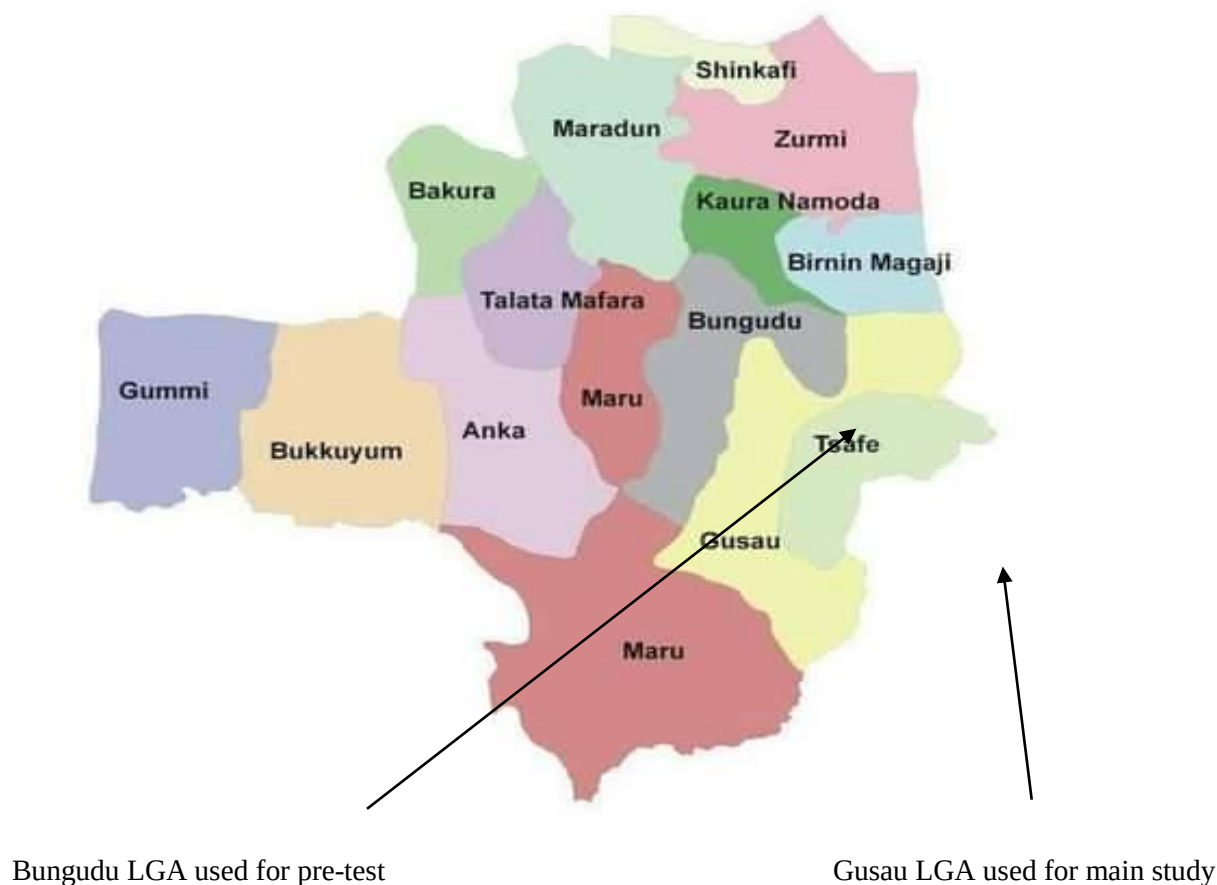


Figure 3: Map of Zamfara state showing Gusau LGA

DISCUSSION

The levels of lead in dust samples at all the quarries (work and administrative areas) were similar and below the WHO/FAO maximum permissible level (100mg/kg).¹⁸

The levels of all other heavy metals in dust samples at all the quarries were also similar and below the WHO/FAO maximum permissible level.¹⁸ The soil

(7.539.2 ppm, mean 21.9ppm); Zn (12.0-89.0 ppm, mean 52.5pp

lead levels in this study were far below the safe soil lead threshold limit of 400 mg/kg set by the USEPA and 100 mg/kg set by the WHO/FAO.^{21, 22} The values of the heavy metals found in this study is similar to what was reported by a survey conducted in Akamkpa, South-eastern Nigeria, with range of values: Fe (0.08-0.62 ppm, mean 0.24ppm); Cu (4.9-18.1 ppm with mean 12.03ppm); Pb

.²³ However, a study conducted in Queensland, Australia reported a range of values markedly higher than what was found in our study with Cd (0.7-12.5 ppm); Cu (31-12,100 ppm); Pb (8-5770 ppm); Zn (26-11,100 ppm), values exceeding Australian residential health investigation guidelines.²⁴ An acceptable level of 400 mg/kg of lead in soil is the suggested “safe” level that would contribute no more than 5 µ/dl (0.005 mg/kg) to the total blood lead of individuals.²¹ Since lead and other heavy metals cannot build up in the blood to toxic levels, both the employees working in these quarries and the communities around them are safe.

According to this study, about one-third of the respondents take bath occasionally before and after work. Nearly all of the respondents said they had never worn uniforms in the quarry. Only about one-sixth of the respondents avoid eating or drinking in the quarry. This is in contrast to the finding of a study in Ebonyi state Southeast, Nigeria which reported that 13.8% of workers bathed before leaving the worksite for home, 41.3% changed into clean clothes before going home and 86.2% washed their hands before taking their meals.¹² The gender disparity of the respondents in the Ebonyi study, who were

Limitations of this study

predominantly female (84.7%) may be the cause of the difference in hygiene practice.¹² Workers who did not take bath before leaving quarries may have continuous dust absorption via the skin or ingestion via the mouth. They may also expose their relation to the dust hazard. Therefore, many of the workers may be absorbing the dust through the skin unnoticed. Callus hands, joint pain, backache, headache and skin rashes were some of the work-related morbidities reported by the respondents. These morbidities could be a result of awkward work positions, heavy lifting, worn-out working tools and poor design and organization of the workplace. Previous studies among quarry workers also reported a high prevalence of musculoskeletal pains among quarry workers.²⁵

Conclusion

This study revealed tolerable levels of all the heavy metals assessed in the workplaces but, poor hygiene practices among the quarry workers in Gusau. The quarry employers should ensure periodic training and education of the workers on good hygiene practices.

A limitation of this study is that it partly depends on information from the study respondents to estimate hygiene practices. This may be prone to recall bias due to self-reporting of hygiene practices. This was minimized by making the data collection process confidential and ensuring that the respondents were adequately informed on the purpose of the research.

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Authors' contributions: SA conceptualized the study, and contributed to data collection, analysis and manuscript writing. RMO, KAU and AY contributed to designing the study, research instrument and preparation of the final draft of the manuscript. AHS, DMZ and AAA contributed to designing the study and data collection. BMB, AMD and BFL contributed to the review of literature, data analysis and interpretation BMM, AA and AOS contributed to the review of the literature and preparation of the final draft of the manuscript. All the authors were involved in the writing of the manuscript at the draft and the revision stages, and have thoroughly read and approved the final version.

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