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GENDER MICROAGGRESSIONS: PREVALENCE AND IMPACT ON FEMALE HEALTHCARE PROFESSIONALS IN NIGERIA

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ABSTRACT

Background: Gendered microaggressions, subtle but pervasive forms of discrimination, impede the professional growth of female healthcare professionals, especially in male-dominated environments. These behaviors undermine gender inclusivity, contribute to psychological distress, and hinder the potential for innovation and sustainable development in healthcare. While well-documented in other sectors, research exploring their impact in Nigeria's healthcare system is limited.

Aim of Study: The aim of the study was to evaluate the prevalence of gendered microaggressions among female healthcare professionals in Nigeria, examine their perceptions, and analyze the relationship between microaggressions, burnout, and job satisfaction.

Materials and Methods: A cross-sectional study recruited 111 female healthcare professionals from hospitals in Ogbomoso, Nigeria. The Sexist Microaggression Experience Stress Scale, Maslach Burnout Inventory, and a job satisfaction measure were used. Descriptive statistics (mean, standard

deviation, frequency) summarized the data, while ANOVA, Spearman rank correlation, and multiple regression analyzed relationships with an alpha level of 0.05.

Results: The study found a high prevalence of gendered microaggressions (mean score 28.02±4.72), high burnout levels (mean score 19.61±8.34) and reduced job satisfaction (mean score 2.64±1.06). Spearman's correlation revealed that gendered microaggressions were positively correlated with burnout (rho=0.420, p<0.001) and negatively correlated with job satisfaction (rho=-0.247, p=0.009). ANOVA identified significant differences in gendered microaggressions across job roles (p=0.003), although no significant differences were observed across ethnicities (p=0.305).

Conclusion: Gendered microaggressions are a major contributor to burnout and job dissatisfaction among female healthcare professionals, undermining their well-being and professional growth. To promote innovation and sustainable development within the healthcare sector, it is essential to address these gendered barriers.

Keywords: Microaggressions, Female Healthcare Professionals, Burnout, Job Satisfaction

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INTRODUCTION

Microaggressions, as defined by Sue *et al.* [1] and further explored by Diehl *et al.*[2], are subtle yet pervasive actions—such as slights, insults, invalidations, or offensive behaviours—that impact individuals daily. While these behaviours often arise from seemingly innocent interactions with well-meaning individuals, they carry significant consequences, particularly for historically marginalized groups, including women. Microaggressions are rooted in various forms of discrimination, including racial, sexual orientation, and gender biases[3], all of which undermine the goal of building inclusive and innovative societies.

In the context of gender, microaggressions play a critical role in perpetuating inequality. Women often face verbal, behavioral, or environmental microaggressions that communicate sexist attitudes[4]. These behaviors range from assumptions of inferiority to ignoring women's contributions, which erodes the workplace culture and limits opportunities for innovation. Gender microaggressions differ from traditional sexism because they encompass various manifestations, acknowledging subtle sexism alongside more overt forms[5]. They include biases like intellectual inferiority, second-class citizenship, denial of sexism, and the invisibility of women's efforts, both in media and society[6].

Gender inclusivity is not only a matter of justice but also a cornerstone of innovation and sustainable development. Studies indicate that diverse, inclusive teams perform better in complex environments because they bring a wider range of perspectives, enabling creative problem-solving. Yet, microaggressions undermine inclusivity by reinforcing stereotypes and hindering women's participation in innovation-driven fields. For example, assumptions that women advance because of their gender rather than their qualifications—or a focus on physical appearance rather than professional

contributions—prevent women from fully engaging in leadership and decision-making roles[3]. Addressing these barriers is essential for fostering a culture of inclusivity and innovation, as it ensures that all individuals, regardless of gender, can contribute their skills and insights toward sustainable development.

The healthcare sector, a critical area for achieving sustainable development goals (SDGs), is not immune to microaggressions. Research has demonstrated that implicit bias affects healthcare environments, influencing diagnostic and treatment decisions[7]. Gender microaggressions within healthcare further impede women's ability to innovate and lead, which is essential for advancing global health systems. Studies reveal that female healthcare professionals frequently experience gender-based microaggressions, including underestimation of their abilities, which leads to burnout and discourages their participation in higher-level decision-making[8]. Furthermore, female healthcare workers often receive lower patient satisfaction ratings despite providing objectively superior care[9,10]. This gender bias not only affects women's careers but also hinders healthcare innovation, as it restricts the full engagement of half the workforce. Therefore, addressing gender microaggressions is vital for creating an equitable healthcare environment that supports innovation, efficiency, and sustainability. The promotion of gender inclusivity is essential for sustainable development, particularly in sectors like healthcare, where innovation can save lives. Unfortunately, numerous studies highlight the prevalence of gender microaggressions in professional settings, including academic and healthcare environments. These subtle forms of discrimination have negative psychological effects on recipients, such as anger, confusion, and depression[3]. In healthcare, gender biases perpetuate a hostile work environment, reinforcing stereotypes and inhibiting innovation and sustainability. Recent research has highlighted the persistence of microaggressions in the workplace, including in STEM fields, where sexual objectification and gender biases are rampant[11]. Female surgeons and anesthesiologists, for instance, report frequent encounters with gender microaggressions that contribute to burnout and career dissatisfaction[12]. Moreover, gender bias is exacerbated by other factors such as age, socioeconomic background, and hierarchical rank, further limiting opportunities for women in healthcare[13].

As such, these barriers obstruct efforts toward achieving SDG 5, which focuses on gender equality, and SDG 3, which aims for good health and well-being. Despite global attention to gender equality, there is a lack of research addressing the prevalence of gender microaggressions among female healthcare professionals in Nigeria. This gap limits efforts to build inclusive, innovative, and sustainable health systems in the country. Therefore, this study explored the prevalence of gendered microaggressions experienced by female healthcare professionals in Ogbomoso, Oyo State, Nigeria and its relationship with burnout levels and job satisfaction.

MATERIALS AND METHODS

This cross-sectional study involved 111 female healthcare professionals from selected hospitals in Ogbomoso, Oyo State, Nigeria. Ogbomoso is a town, about 04 km North East of Ibadan, the largest city in West Africa. The Bowen University Teaching Hospital Health Research and Ethics Committee (BUTH-HREC) verified and approved the study (BUTH/REC-2135). Female healthcare professionals

between the ages of 18 and 65 years were included in the study. Those who had worked for less than six months were excluded from the study. Informed consent was obtained from the participants after the aim of the study had been explained to them. The sample size was calculated using G*Power 3.1.9.7. A sample size of 111 had a 95% power of detecting a change of 0.3 at an alpha level of 0.05.

Instruments

Sexist Microaggression Experience Stress Scale (SMESS): The Sexist Microaggressions Scale (SMESS) is a self-report questionnaire comprising 44 items that assess the frequency (SMESS-F) and stressfulness (SMESS-S) of sexist microaggressions. Respondents rate each item using a 4-point Likert scale, with higher scores indicating more frequent occurrence and/or greater impact of sexist microaggressions. This study utilized two components of the SMESS: Theme 1 (Leaving Gender at the Door) and Theme 2 (Assumptions of Inferiority). These components (section B) contained 11 items. Each item is rated on a scale from 1 to 4, with higher scores indicating a higher frequency or intensity of gender microaggressions experienced. The scores obtainable range from 11–44.

Maslach Burnout Inventory The Maslach Burnout Inventory (MBI) is a widely accepted and rigorously validated tool that measures burnout levels. Specifically, the MBI-Human Services Survey (MBI-HSS) is designed for individuals engaged in professions requiring significant interpersonal interaction, such as those within the healthcare field. Comprising three distinct subscales—emotional exhaustion (EE), depersonalization (DP), and personal achievement (PA)—each subscale is assessed independently. Established benchmarks categorizing burnout levels as "low," "average," or "high" were applied to interpret the data outcomes, with similar findings reported by Maslach and Leiter[15]. Test-retest reliability was assessed over various time intervals, ranging from a few weeks to one year. Scores exhibited higher reliability in the shorter periods (ranging from 0.60 to 0.82) compared to the longer time frame (ranging from 0.54 to 0.60). This study utilized one subscale of the Maslach Burnout Inventory (emotional exhaustion), which comprises seven items. Each item is rated on a scale from 0 to 6, with higher scores indicating higher levels of burnout. Scores obtainable range from 0–42.

Job Satisfaction (Single-Item Measure) This was used to assess the levels of job satisfaction. Responses are coded on a scale from 1 to 5, with higher scores indicating higher levels of job satisfaction. Scores obtainable range from 1–5.

Data Analysis

Descriptive statistics of frequency counts, percentages, ranges, means, and standard deviation were used to summarize the participants' sociodemographic data and the prevalence of gendered microaggressions, levels of burnout, and job satisfaction among female healthcare professionals.

The relationships among the variables (prevalence of gendered microaggressions, burnout, job satisfaction, and age) were assessed using the Spearman Correlation Coefficient. Analysis of variance (ANOVA) was used to assess the variation in the prevalence of gendered microaggressions, burnout, and job satisfaction across different job roles and ethnicities. The alpha level was set at 0.05.

RESULTS

Sociodemographic Profile

A total of 111 female healthcare professionals (38.86 ± 7.70 years) participated in the study. They had an average of 10.13 ± 6.82 years of

experience. Seventy-three (65.8%) respondents were married, and majority of the respondents, 80 (72.1%), identified as belonging to the Yoruba ethnic group. Most respondents, 103 (92.8%), were clinical staff members. Among them, 44 (39.6%) were nurses, 26 (23.4%) were physiotherapists, 23 (20.7%) were physicians, 7 (7.2%) were surgeons and 10 (9.0) were residents, with majority of them working in a hospital (71.2%). Additionally, more than half of the respondents (51.4%) indicated that they had received formal training or education on gender sensitivity in the workplace. Furthermore, majority (61.3%) had reported that they had sought support or counseling for work-related stress or burnout in the past year. More information on the sociodemographic profile can be viewed in Table 1.

Gendered Microaggressions

The mean SMESS score was recorded as 28.02±4.72. A total of 49 (44.1%) of respondents indicated that they 'often' attempted to overcompensate for being female in healthcare settings. Similarly, 46 (41.4%) respondents reported 'often' trying to appear assertive at work to avoid being dismissed due to their gender. A total of 34 (30.6%) respondents 'often' tried to hide their emotions at work to avoid appearing overly emotional, while 35 (31.5%) admitted to 'occasionally' dressing in ways considered less feminine, such as choosing trousers over skirts, at their workplace. Additionally, 45 (40.5%) respondents reported that someone 'often' assumed a male was responsible for work they had actually completed. A total of 40 (36.0%) respondents noted that a male colleague 'often' ignored or dismissed their contributions. Another 42 (37.8%) respondents observed that more complex tasks were 'often' assigned to males in healthcare settings. A significant 47 (42.3%) respondents revealed that they were 'occasionally' passed over for an important project or promotion in favour of a male colleague, despite being qualified. Detailed information can be viewed in Table 2.

Emotional Exhaustion (Maslach Burnout Inventory)

The mean Maslach Burnout Inventory score of the respondents was recorded at 19.61±8.34. A total of 89 (80.1%) respondents reported feeling emotionally drained from their work once a month or less to everyday. In addition, 20 (18.0%) respondents indicated that working with people all day long requires significant effort a few times a month. Another 31 (27.9%) respondents mentioned that a few times a month, they feel like their work is breaking them down, while 30 (27.0%) respondents stated they experience frustration with their work a few times a year or less. Furthermore, majority (87, 63.3%) of the respondents reported that once a month or less to everyday, they feel they work too hard at their job. A total of 26 (23.4%) respondents shared that a few times a year or less, working in direct contact with people causes them too much stress. Additionally, more than half of the respondents (64, 57.6%) indicated that a few times a month, they feel like they are at the end of their rope. Table 3 shows more information on this.

Job satisfaction

The mean Job satisfaction score of the respondent was 2.64± 1.06. Only 19.8% (22) of the respondents were either satisfied or very satisfied with their job. This can be seen in Table 4.

Relationship among gendered microaggressions, job satisfaction and levels of burnout

A spearman correlation test was conducted to examine the relationship between gendered microaggressions, levels of burnouts and job satisfaction among the respondents. The findings showed that there was a positive significant relationship between gendered

microaggressions and the levels of burnout among the respondents (rho=0.420, p=<0.001). There was also a negative significant relationship between gendered microaggressions and job satisfaction among the respondents (rho=-0.247, p=0.009). In addition, there was a negative significant relationship between the levels of burnout and job satisfaction among the respondents (rho=-0.419, p=<0.001) as shown in Table 5.

ANOVA comparing the variation in gendered microaggressions among the job roles and ethnicity of the respondents

ANOVA test was done to examine the variation in gendered micro-aggressions among the job roles and ethnicity of the respondents. The findings revealed there was a significant difference between gendered micro-aggressions and job roles (p=0.003) but no significant difference between the micro-aggressions and the ethnicity of the respondents(p=0.305) as shown in Table 6.

Table 1: Sociodemographic data of the respondents

Variable	**Category**	**frequency**	**Percentages**
Marital status	Single	31	27.9
	Married	73	65.8
	Divorced	6	5.4
	Widowed	1	0.9
Ethnicity	Hausa	6	5.4
	Igbo	25	22.5
	Yoruba	80	72.1
Staff	Clinical	103	92.8
	Non-clinical	8	7.2
Type of health facility	Hospital	79	71.2
	Clinic	21	18.9
	Private practice	11	9.9
Have you received any formal training or education on gender sensitivity in the workplace?	Yes	57	51.4
	No	54	48.6
Have you sought support or counseling for work-related stress or burnout in the past year?	Yes	68	61.3
	No	43	38.7

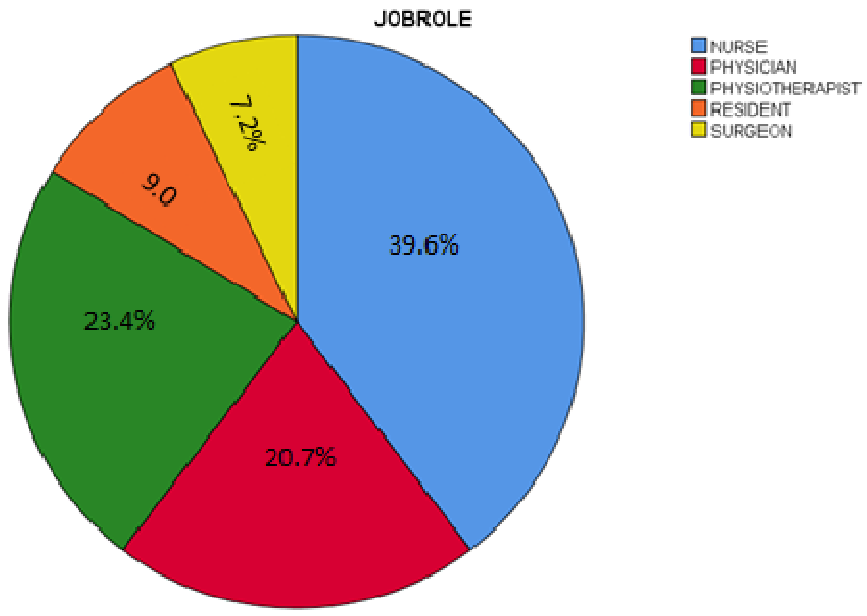

Fig 1: Pie chart showing the job role of the respondents

Table 2: Descriptive statistics of Gender Microaggression

Questions	Almost never	Occasionally	Often	Almost always
You have attempted to 'overcompensate' for being female in healthcare settings	13(11.7%)	32(28.8%)	49(44.1%)	17(15.3%)
You have attempted to appear assertive at work so that your colleagues do not dismiss you because you are a female healthcare professional	8(7.2%)	33(29.7%)	46(41.4%)	24(21.6%)
You have attempted to hide your emotions at work in order to not appear too emotional at your workplace	20(18.0%)	29(26.1%)	34(30.6%)	28(25.2%)
You have intentionally dressed in ways considered less feminine (swapping a skirt for pants, etc.) at your workplace	25(22.5%)	35(31.5%)	27(24.3%)	24(21.6%)
Someone has assumed a male was responsible for work you actually did at your workplace	23(20.7%)	24(21.6%)	45(40.5%)	19(17.1%)
A male has ignored or dismissed your contribution at work	18(16.2%)	32(28.8%)	40(36.0%)	21(18.9%)
You have been in a healthcare setting where the more complicated tasks were assigned to males	18(16.2%)	29(26.1%)	42(37.8%)	22(19.8%)
You have been passed over for an important project or promotion for which you were qualified, and the role was given to a male instead at your workplace	22(19.8%)	47(42.3%)	20(18.0%)	22(19.8%)
A male has spoken for you at work	22(19.8%)	38(34.2%)	33(29.7%)	18(16.2%)
A male peer or coworker was the only member praised for group work you contributed to at your workplace	23(20.7%)	37(33.3%)	40(36.0%)	11(9.9%)
You have been in a group at work where a male automatically assumed the leadership role	18(16.2%)	31(27.9%)	34(30.6%)	28(25.2%)

Table 3: Descriptive statistics of the Emotional Exhaustion (Maslach Burnout Inventory)

Questions	Never	A few times a year or less	Once a month or less	A few times a month	Once a week	A few times a week	Everyday
I feel emotionally drained from my work	4(3.6%)	18(16.2%)	26(23.4%)	18(16.2%)	20(18.0%)	19(17.1%)	6(5.4%)
Working with people all day long requires a great deal of effort	6(5.4%)	17(15.3%)	12(10.8%)	20(18.0%)	16(14.4%)	21(18.9%)	19(17.1%)
I feel like my work is breaking me down	7(6.3%)	16(14.4%)	26(23.4%)	31(27.9%)	8(7.2%)	18(16.2%)	5(4.5%)
I feel frustrated by my work	7(6.3%)	30(27.0%)	24(21.6%)	21(18.9%)	11(9.9%)	9(8.1%)	9(8.1%)
I feel I work too hard at my job	5(4.5%)	19(17.1%)	25(22.5%)	15(13.5%)	13(11.7%)	18(16.2%)	16(14.4%)
It stresses me too much to work in direct contact with people	14(12.6 %)	26(23.4%)	20(18.0%)	24(21.6%)	12(10.8%)	10(9.0%)	5(4.5%)
I feel like I am at the end of my rope	25(22.5 %)	22(19.8%)	13(11.7%)	27(24.3%)	12(10.8%)	6(5.4%)	6(5.4%)

Table 4: Descriptive statistics of the Job satisfaction

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Job satisfaction	17(15.3%)	33(29.7%)	39(35.1%)	17(15.3%)	5(4.5%)

Table 5: Spearman correlation showing the relationship among age, gendered microaggressions, job satisfaction and levels of burnout

Variable	rho	p
Gendered microaggression & levels of burnout	0.420	<0.001*
Gendered microaggressions & job satisfaction	-0.247	0.009*
Levels of burnout & job satisfaction	-0.419	<0.001*
Age & Job satisfaction	-0.158	0.099
Age & Gendered microaggressions	0.137	0.150
Age & level of burnout	0.012	0.902

Significance $p \leq 0.05$

Table 6: ANOVA comparing the variation in gendered microaggressions among the job roles and ethnicity of the respondents

Variable		Sum of squares	Mean square	F	P
Gendered micro-aggressions & job roles	Between groups	334.166	83.542	4.185	0.003
	Within groups	2115.798	19.960		
	Total	2449.964			
Gendered micro-aggressions & ethnicity	Between groups	53.283	26.642	1.201	0.305
	Within groups	2396.681	22.191		
	Total	2449.964			

Significant at $p<0.05$

DISCUSSION

The sociodemographic profile of the female healthcare professionals highlights a homogenous sample, with majority identifying as Yoruba, and a workforce largely comprising clinical staff especially nurses. This profile is consistent with previous research indicating that healthcare professions, particularly nursing, are dominated by women globally. However, the representation of physicians and surgeons in the sample suggests that while women are making inroads into traditionally male-dominated fields, gender disparities remain[12].

Despite strides in gender inclusivity, with 51.4% having received gender sensitivity training, the continued disparities in representation highlight that there is much work to be done in achieving true gender inclusivity in healthcare, which is critical for fostering sustainable development. The inclusion of more women in decision-making and leadership roles within healthcare is not only a matter of gender equity but also ties into the larger sustainable development goals (SDGs), particularly SDG 5 (Gender Equality) and SDG 3 (Good Health and Well-being). Studies have shown that more diverse healthcare teams are better equipped to innovate and address the needs of diverse populations[17]. By integrating women into traditionally male-dominated roles and breaking down these barriers, healthcare systems can become more innovative and responsive to a broader range of societal health needs.

The high mean SMESS score (28.02 ± 4.72) indicates widespread experiences of gendered microaggressions among the respondents, such as having their work credited to male colleagues or being overlooked for promotions. These subtle yet pervasive forms of gender bias can stifle innovation, as they create hostile work environments that undermine the confidence, contributions, and upward mobility of female professionals. When women are marginalized or their contributions are not recognized, the healthcare sector loses out on diverse perspectives essential for innovation. Gender microaggressions have been

shown to reduce job satisfaction and emotional well-being, with lasting effects on professional performance and creativity[4]. Creating a more inclusive work environment where women feel valued and respected can foster greater collaboration and innovation, which is key for advancing healthcare solutions that address diverse patient needs. For healthcare systems to thrive and innovate, tackling these gendered biases is crucial[14].

The emotional exhaustion reported by 80.1% of the respondents underscores the unsustainable nature of the current work environments. Emotional exhaustion is not only detrimental to individual well-being but also affects the broader healthcare system's sustainability. Burnout is linked to increased turnover rates, reduced job satisfaction, and absenteeism, which hinders the capacity of healthcare systems to meet population demands[7]]. The negative correlation between burnout and job satisfaction further emphasizes the need for policies that address work-life balance, fair wages, and mental health support. These findings are consistent with those of Maslach and Leiter[15] and Settles *et al.*[18], who also found a strong correlation between experiences of discrimination and higher burnout rates among women in the workforce.

Sustainable development in healthcare requires retaining skilled professionals by ensuring supportive environments that address burnout, which is especially pressing for women who often bear additional caregiving responsibilities outside of work[16]. Policies that promote gender inclusivity, equitable workloads, and mental health support systems are vital for the long-term sustainability of the healthcare workforce.

The low levels of job satisfaction reflect the dissatisfaction many women feel in healthcare, particularly due to gender bias and the emotional toll of microaggressions. The negative relationship between gendered microaggressions and job satisfaction suggests that addressing gender inequalities in the workplace is crucial for enhancing overall job satisfaction. Promoting gender equality can lead to more fulfilled and motivated professionals, contributing to a more efficient and effective healthcare system.

CONCLUSION

The findings from this study highlight a pressing issue regarding gender inclusivity in the healthcare sector, revealing a high prevalence of gendered microaggressions among female healthcare professionals in Ogbomoso. These microaggressions are associated with significant negative effects on job satisfaction and a positive correlation with burnout, underscoring the urgent need for systemic changes within the workplace to promote gender equity.

RECOMMENDATIONS

To effectively address microaggressions in the workplace, healthcare institutions should adopt a multi-pronged approach. First, regular gender sensitivity training should be implemented to raise awareness among staff and reduce the occurrence of subtle discriminatory behaviors. Equally important is the establishment of confidential reporting mechanisms that provide victims with safe channels to report incidents without fear of retaliation. Institutions must also ensure equal opportunities for leadership by promoting women based on merit rather than gender, thereby fostering a culture of fairness and professional growth. In addition, access to mental health support, including counseling services and stress management programs, should be

prioritized for employees who experience workplace discrimination. Finally, organizations should actively foster inclusive work environments by developing and periodically reviewing policies that promote diversity and inclusion, ensuring their effectiveness in creating a supportive and respectful workplace culture.

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Conflicts of interest
There is no conflict of interest

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COMPARATIVE EFFECTS OF GROUNDNUT OIL AND PALM OIL ON LIPID PROFILE OF ADULT WISTAR RATS

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ABSTRACT

BACKGROUND: The consumption of groundnut oil and palm oil have become common in our daily diets. These oils are edible vegetable oils widely consumed globally and are composed of saturated and unsaturated fatty acids. While these oils are often promoted for their perceived health benefits, emerging research suggests potential implications for lipid profiles. They are said to be pro-atherogenic and can be responsible for cardiovascular complications.

AIM: This study was aimed to assess the comparative effects of groundnut oil and palm oil on lipid profile of Wistar Rats.

MATERIALS AND METHODS: Fifteen (15) Adults Wistar rats weighing between 90-100g were procured for this study. They were divided into three (3) groups of five (5) rats each. All the animals were given rat chow and normal saline *ad libitum*. The Control group (Group 1) was given rat chow and normal saline only. The Sample groups; Group 2 was administered with 100mg/kg of groundnut oil while Group 3 was given 100mg/kg of palm oil for 21 days. The weight of the animals before and after the administration were recorded.

RESULTS: Increase in body weight was seen across all the groups (both control and sample). The average body weights of

the control group, Group 2 and Group 3 were 110, 115 and 119 grams respectively which indicates that the sample groups were significantly different when compared with the control group ($P<0.05$). That of sample group 2 indicates a statistically significant difference in relation to sample group 3 ($P<0.05$). The Control group (Group 1) had the lowest cholesterol level (70.01±0.03 mg/dl) while the rats administered groundnut oil (Group 2) had the highest cholesterol level (100.07±0.17 mg/dl). The cholesterol level of the rats administered with palm oil (Group 3) was (85.50±0.07 mg/dl). The Control group had the highest value for HDL (110.78±0.06 mg/dl), followed by Group 3 (89.66±0.02 mg/dl) while Group 2 had the least HDL level (80.50±0.06 mg/dl). The triglyceride and LDL levels were highest in Group 3 (100.92±0.02 mg/dl and 90.78±0.04 mg/dl respectively), followed by Group 2 (80.87±0.07 mg/dl and 80.70±0.06 mg/dl respectively). Group 1 had the lowest triglyceride and LDL levels (70.80±0.00 mg/dl and 72.48±0.48 mg/dl respectively).

CONCLUSION: Groundnut oil was seen to increase the lipid profile more than the palm oil. Excessive intake of these vegetable oils should be avoided to prevent elevated lipid profile which may predispose an individual to cardiovascular diseases.

Keywords: *Palm oil, Groundnut oil, Body weight, Lipid profile, cardiovascular diseases.*

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INTRODUCTION

Palm oil, extracted from *Elaeis guineensis* oil palm fruit, is the most widely consumed vegetable oil accounting for about 35% of global vegetable oil consumption [1]. Apart from the phytonutrients called minors (vitamin E, carotenoids), it is composed of 50% unsaturated fatty acids and 50% saturated fatty acids, of which 44% is palmitic acid [2], making it an oil which is known to be pro-atherogenic and which would be responsible for cardiovascular complications [3,4,5,6]. Groundnut oil, also known as peanut oil, is a popular oil derived from the seeds of the groundnut plant (*Arachis hypogaea*). It is widely consumed worldwide due to its excellent flavor, high smoke point, and various health benefits. The production of groundnut oil involves several stages, including harvesting, cleaning, shelling, pressing, refining, and packaging.

Globally, there is a constant rise in cardiovascular disease cases. About 60% of all deaths in 2005 were related to these diseases, 80% of which occurred in developing countries [7,8]. Several studies attribute the increased risk of cardiovascular disease to high serum cholesterol and its fractions [9]. This cholesterol is derived mostly from edible fats and oils including groundnut oil and palm oil, which is the most cited. Cholesterol is a waxy, fat-like substance made in the liver, and found in the blood and in all cells of the body. Cholesterol is important for good health and is needed for making cell walls, tissues, hormones, vitamin D, and bile acid. Low-density lipoprotein (LDL), also referred to as ‘bad cholesterol’ is a type of lipoprotein in the blood that carries cholesterol to cells

throughout the body. While cholesterol itself is vital for bodily functions, high levels of LDL cholesterol can contribute to plaque buildup in arteries, increasing the risk of heart disease and stroke. High-density lipoprotein (HDL), often called 'good cholesterol' is a type of lipoprotein that helps remove excess cholesterol from the body. Indeed, Tholstrup *et al*. (2011) reported that palm oil significantly increased Low Density Lipoprotein (LDL) cholesterol when compared with groundnut oil. However, this oil is common in African and Asian food habits, mainly in rural areas where it is used in raw form [11,12,13,14]. A study was conducted with 2240 healthy subjects aged 18 years and above to verify the effect of palm oil consumption on anthropometric parameters (weight and height). It was found that the regular and normal consumption of palm oil by this population did not increase the weight of the subjects consuming it [15]. In addition, several studies have also shown the health benefits of palm oil consumption [16]. In Côte d'Ivoire, changes in lipid profile in farm chickens fed with groundnut oil and palm oil which had a cholesterol-lowering effect was studied. The study indicated that consumption of these oils decreased serum levels of triglycerides and LDL cholesterol but increased HDL cholesterol [17]. Another study carried out on 120 subjects suffering from ischemic heart disease reported no disturbance of lipid and lipoprotein parameters with these subjects who consumed palm oil after four weeks [17]. Several studies on the benefits of palm oil have been carried out for the most part in hypertensive, obese, diabetic, cancerous subjects or suffering from ischemic cardiopathies [17], but not with healthy subjects. Knowing that some apparently healthy subjects have an apprehension about palm oil, it became imperative to study the impact of palm oil and groundnut oil consumption on healthy Wistar rats in order to see whether or not there are lipid and lipoprotein anomalies related to their consumption.

The consumption of groundnut oil and palm oil, have become common in conventional diets. While these oils are often promoted for their perceived health benefits, emerging research suggests potential implications for lipid profiles. Several studies have indicated a relationship between groundnut oil consumption and adverse lipid profiles, including elevated levels of low-density lipoprotein cholesterol (LDL-C) and triglycerides (TAG), and decreased high-density lipoprotein cholesterol (HDL-C). Again, a recent meta-analysis study by Mancini *et al*. (2015) found a significant association between palm oil intake and increased LDL-C levels. Some studies reported adverse effects of groundnut oil consumption on TG levels. Studies have shown in a Chinese population, that the consumption of certain fats and oils were associated with an increased risk of type 2 diabetes [18]. Many clinicians usually discouraged patients with type 2 diabetes from consuming fats and oils or at least limit their consumption. Certain vegetable oils have shown to have positive effect on diabetes management. Indeed, fish oil supplementation have proven to improve insulin sensitivity in rat study [19]. Olive oil also is a vegetable oil that has been scientifically proven to have least dyslipidaemic and atherogenic effect [20]. However, conflicting evidence exists, with some studies suggesting neutral or even beneficial effects on lipid profiles. Understanding the nuanced effects of

groundnut oils on lipid metabolism is crucial for informing dietary recommendations, mitigating cardiovascular risk factors and improving public health outcomes. Further research employing rigorous methodologies is warranted to elucidate these effects comprehensively. This study aims to assess the effects of groundnut oil and palm oil on the body weight and lipid profile of Wistar Rats.

MATERIALS AND METHODS

Experimental Animals

This study was conducted at the laboratories of the Department of Medical Laboratory Science and that of the Department of Anatomy, Presco Campus of Ebonyi State University, Abakaliki, Ebonyi State, Nigeria. Fifteen (15) Adult Wistar rats weighing between 90-100g were procured from the Veterinary Department, University of Nigeria, Nsukka, Enugu state, Nigeria. The rats were housed in the laboratory steel cages for one week for acclimatization under normal laboratory conditions before the commencement of the study. They were allowed to have access to rat chow and water *ad libitum*. All the animals received good care according to the criteria of the Investigations and Ethics Committee of the Community Laws governing the use of experimental animals. An ethical approval with the number EBSU/1704/02/001 was obtained from the Ethics Committee of the Department of Anatomy, Faculty of Basic Medical Sciences, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria. Palm oil and groundnut oil used for this research were purchased from St Margret Umahi International market, Abakaliki, Ebonyi State, Nigeria.

Experimental design

Fifteen (15) adults Wistar Rats were randomly assigned into three groups of five rats each. The Control group (Group 1) received feed and water only, Group 2 received 100mg/kg of groundnut oil, while Group 3 animals were given 100mg/kg of palm oil daily. The experiment was carried out within the period of 21 days.

Sample collection

Procedures for ocular puncture

The blood samples were collected through ocular puncture with the animals under chloroform anaesthesia. This method allows the use of heparinized capillary which was broken into two and inserted into one of the eyes of the rats. The choice of the heparinized tube is to prevent clotting of the blood in the capillary during blood collection. Blood samples were collected into lithium heparin bottles after which samples were centrifuged at 2000 revolution per minute for 5 minutes and the plasma was isolated into plain bottles and stored refrigerated until analyses were carried out at Divine Chemicals and Analytical Laboratory Nsukka, Enugu State, Nigeria.

Determination of Lipid Profile

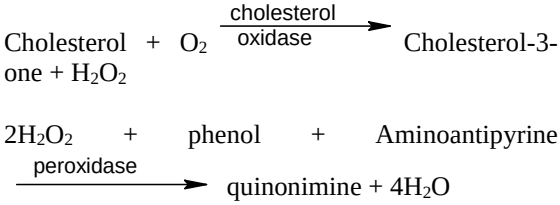
Determination of serum cholesterol (CHOL)

This was done using CHOD-PAP method.

Principle

The cholesterol was determined after enzymatic hydrolysis and oxidation. The indicator quinonimine was formed from hydrogen peroxide and 4-aminoantipyrine in the presence of phenol and peroxidase.

$$\text{Cholesterol ester} + H_2O \xrightarrow[\text{esterase}]{\text{cholesterol}} \text{Cholesterol} + \text{Fatty acids}$$



Procedure

Ten microliters (10µl) of distilled water were added into test tube for water blank, 10 µl of the standard reagent was added into test tube and 10 µl of the sample was added into each test tube. Then, 1000 µl of reagent R1 was added into each test tube and mixed. It was then incubated for 10 minutes at 37 ^{0}C. The absorbance of all the cuvettes was read and recorded at 546 nm.

Determination of serum triglycerides (TAG)

This was done according to the method of Tietz (1976).

Procedure

Five microliters (5µl) of distilled water were added into test tube, 5 µl of the standard reagent was added into another test tube and 5 µl of the sample was added into another test tube. Then, 500 µl reagent R1 was added into each test tube and mixed. This was incubated for 5 minutes at 37 ^{0}C. The absorbance of all the cuvettes was read and recorded at 546 nm.

TAG (mmol/l) = (change in Abs sample/ change in Abs standard) x standard conc

Determination of the serum high density lipoproteins (HDL)

High density lipoproteins (HDL) - cholesterol concentration was determined by the method of Albers *et al* (1978) using Randox kit.

Procedure

The 100 µl of the serum and standard was pipetted inside the centrifuge tube which was immediately accompanied with the addition of 500 µl of the diluted precipitation reagent (R1) to the centrifuge tube. The contents were mixed and allowed to stand for 10 minutes at 25 ^{0}C, then centrifuged for 15 minutes at 3500 rpm. The cholesterol concentration of the supernatant was determined after centrifugation. Into three test tubes labeled test sample supernatant, standard and blank were added 50 µl of sample supernatant, 50 µl of standard and 50 µl distilled water respectively. Then, 500 µl each CHOL reagent solution was added in the test tubes and mix, incubate for 10 min at 25 ^{0}C. Read the absorbance at 500 nm after 60 minutes.

HDL (mg/dl) = (change in Abs sample/ change in Abs standard) x conc of standard

Determination of the serum low density lipoproteins (LDL)

LDL-Cholesterol can be determined as the difference between total cholesterol and the cholesterol content of the supernatant after precipitation of the LDL fraction by polyvinyl sulphate (pvs) in the presence of polyethyleneglycol monomethyl ether.

LDL = total cholesterol – HDL/5 – tg

Statistical Analysis:

Data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 20, windows 10. The results were expressed as Mean ± Standard Error of Mean (SEM). Data obtained from this study were further analyzed using one-way Analysis of Variance (ANOVA) and

Post Hoc Tests which was used to compare means.

RESULTS

Effects of Groundnut oil and Palm oil on the body weight and Lipid Profile of Wistar Rats

The average body weights of the control group, Group 2 and Group 3 were 110, 115 and 119 respectively. The Control group (Group 1) had the lowest cholesterol level (70.01±0.03 mg/dl) while the rats administered groundnut oil (Group 2) had the highest cholesterol level (100.07±0.17 mg/dl). The cholesterol level of the rats administered with palm oil (Group 3) was (85.50±0.07 mg/dl). The Control group had the highest value for HDL (110.78±0.06 mg/dl), followed by Group 3 (89.66±0.02 mg/dl) while Group 2 had the least HDL level (80.50±0.06 mg/dl).

The triglyceride and LDL levels were highest in Group 3 (100.92±0.02 mg/dl and 90.78±0.04 mg/dl respectively), followed by Group 2 (80.87±0.07 mg/dl and 80.70±0.06 mg/dl respectively). Group 1 had the lowest triglyceride and LDL levels (70.80±0.00 mg/dl and 72.48±0.48 mg/dl respectively).

Table 1: Effect of Groundnut and Palm oils on the body weight

Groups	Weight (g)
1	110
2	115
3	119

Table 2: Effects of Groundnut oil on lipid profile of Wistar Rats

Lipids	Amount (mg/dl)
Cholesterol	2.07±0.17
HDL	0.50±0.06
TAG	0.87±0.07
LDL	0.70±0.06

Table 3: Effects of Palm oil on the Lipid profile of Wistar Rats

Lipids	**Amount (mg/dl)**
Cholesterol	1.50±0.07
HDL	0.66±0.02
TAG	0.92±0.02
LDL	0.78±0.04

Table 4: Effects of Groundnut oil and Palm oil on Lipid Profile of Wistar Rats

	Cholesterol mg/dl	**HDL mg/dl**	**TAG mg/dl**	**LDL mg/dl**
Group 1	70.01±0.03	110.78±0.06	70.80±0.00	72.48±0.48
Group 2	100.07±0.17[a]	80.50±0.06[a]	80.87±0.07[a]	80.70±0.06[a]
Group 3	85.50±0.07[b, c]	89.66±0.02[b, c]	100.92±0.02[b, c]	90.87±0.04[b, c]

Values are expressed as Mean ± SEM, n = 15.

a = shows that Group 1 is significantly different from Group 2 at $p<0.05$;

b = shows that Group 1 is significantly different from Group 3 at $p<0.05$;

c = shows that Group 2 is significantly different from Group 3 at $p<0.05$;

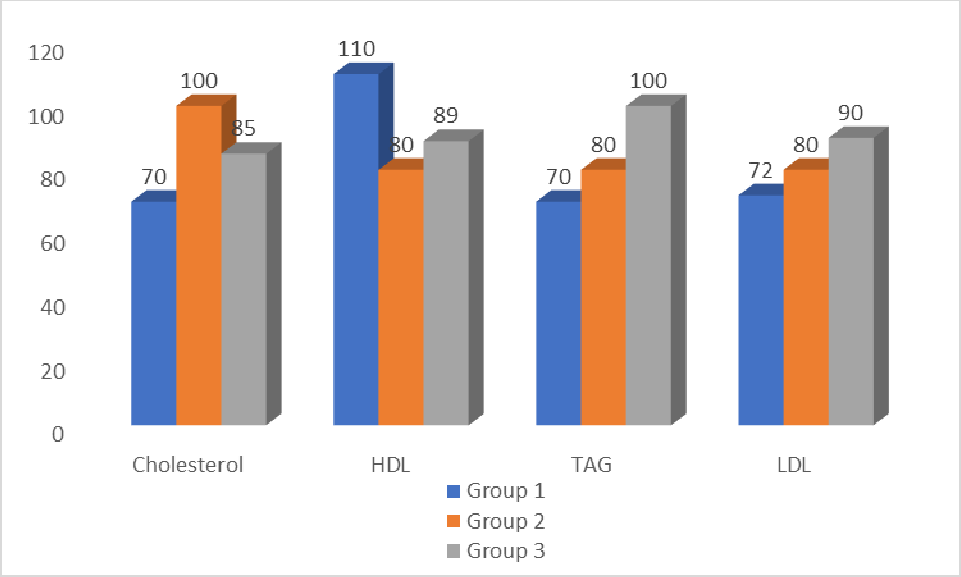


Fig. 1: Effects of Groundnut oil and Palm oil on Lipid Profile of Wistar Rats

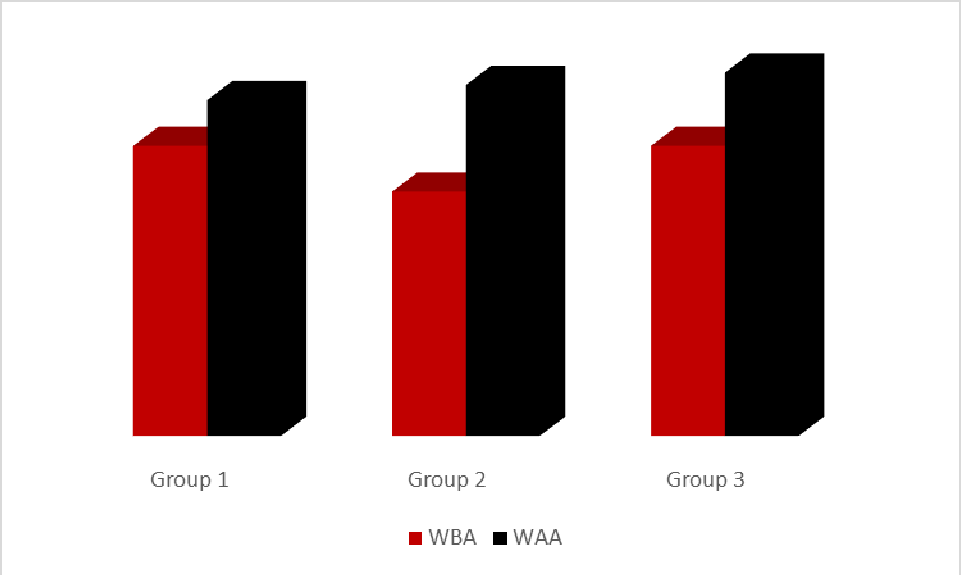


Fig. 2: Effects of Groundnut oil and Palm oil on the Body Weight of Wistar Rats

Key:
WBA= Weight before administration
WAA=Weight after administration

DISCUSSION

The nutritional and health benefits of both groundnut and palm oils as edible vegetable oils have been well documented [23,2]. In this study, increase in body weight was seen across all the groups (both control and sample). The body weights of the sample groups were significantly different when compared with the control group ($P<0.05$). That of sample group 2 indicates a statistically significant difference in relation to sample group 3 ($P<0.05$). These changes indicates that these oils may influence increased body weight. This maybe as a result of lipid cholesterol and calories present in these oils. The body can easily store excess calories from oil as fat, further contributing to weight gain. The highest body weight increase was seen with the palm oil-administered sample group.

The cholesterol level is highest in sample group 2 administered with groundnut oil followed by sample group 3. This indicates that groundnut oil has more cholesterol content when compared with palm oil; and this may be as a result of different reasons which include method of processing resulting in presence of high saturated and trans fats in the groundnut oil and also activation of the enzyme HMG- CoA (3-hydroxy-3-methyl glutaryl- coA) activity which is a key enzyme in cholesterol biosynthesis and an increase in VLDL, LDL. HMG- CoA synthesizes in vivo cholesterol [24]. These oils have abundance of saturated fats which can increase cholesterol level. This high cholesterol level results in increase in too many lipids (fats) in the blood leading to hyperlipidemia (hypercholesterolemia) which may lead to atherosclerosis and eventual heart diseases. Similarly, triglyceride is higher in palm oil-administered sample group when compared to that of the sample group administered with groundnut oil. Increased triglyceride level, especially with the combination of other factors like low HDL and high LDL cholesterol, can increase the risk of heart disease [25].

The HDL (good cholesterol) is lower in sample group 2 administered with groundnut oil than that of sample group 3 administered with palm oil. This indicates that groundnut oil has higher lipid content more than palm oil. The increased HDL levels are associated with a lower risk of cardiovascular disease. A reduction in the level of HDL cholesterol could be due to the stimulation of Lecithin cholesterol acyl transferase (LCAT) which induces the esterification and sequestration of cholesterol in HDL molecules, or by the stimulation of cholesterol ester transfer protein (CETP) which assures the transfer of cholesterol esters from HDL to chylomicrons, VLDL and LDL, thereby increasing the plasma level of the latter [26,27].

The LDL (bad cholesterol) is found to be higher in sample group administered with palm oil than the sample group administered with groundnut oil. This shows that palm oil has more ‘bad cholesterol’ and therefore has more tendency of causing several heart complications. The high level of LDL (hypertriglyceridemia) seen in palm oil indicates that the palm oil consumed has high saturated fats. Diets rich in fatty acids increase the atherogenic index by inducing oxidative stress (enzymatic and non-enzymatic) in rats, thus, increases the oxidation of low-density lipoprotein

(LDL) which plays a key role in the genesis of atherosclerosis.

Palm oil has been used in food preparation for over 5,000 years. This oil is consumed in its fresh state and/or at various levels of oxidation. Feeding experiments in various animal species and humans have highlighted controversial evidences on the beneficial and harmful effects of fresh palm oil to health. On one hand, these benefits include reduction in the risk of arterial thrombosis and atherosclerosis, inhibition of cholesterol biosynthesis, platelet aggregation and reduction in blood pressure [28]. The World Health Organization in its report (2005) states that there is convincing evidence that palmitic oil consumption contributes to an increased risk of developing cardiovascular diseases [29]. Past research confined to epidemiological observations, intervention trials and studies on experimental animals and humans have provided vital information on the obvious facts of the dietetic fats on blood pressure (BP). Therefore, the excessive or chronic intake of dietary oils rich in saturated fatty acids could increase the risk of metabolic and cardiovascular diseases [2].

CONCLUSION

Palm oil and groundnut oil are dietary oils with the requisite constituents to increase fats in the blood. This increase in the fat content results to increase in cholesterol level thereby resulting to risks of developing cardiovascular health implications. Consumption of diets rich in fats therefore should be avoided or reduced. Excessive intake of vegetable oils, especially palm oil and groundnut oil should be avoided to prevent elevated lipid profile.

Conflict Of Interest

Authors declared they have no competing interest.

Acknowledgement

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PREVALENCE OF FOOT PAIN AND ASSOCIATED RISK FACTORS AMONG FINAL YEAR CLINICAL STUDENTS AT UNIVERSITY OF BENIN, EDO STATE, NIGERIA

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ABSTRACT

Background: Foot pain is a common musculoskeletal complaint that can interfere with mobility, daily activities, and clinical performance. Clinical students are particularly vulnerable due to prolonged standing, unsuitable footwear, and heavy clinical workloads. Understanding its prevalence and associated risk factors is essential for developing effective preventive strategies and improving students' well-being.

Aim: To determine the prevalence of foot pain and identify the associated risk factors among final-year clinical students at the University of Benin.

Methods: A descriptive cross-sectional study among 208 final-year clinical students of Physiotherapy, Nursing, Radiography, and Medical Laboratory Science. Participants were selected using a proportionate stratified sampling technique. Data were collected using a validated Foot Health Status Questionnaire (FHSQ). Descriptive statistics summarized the data, while inferential tests (Kruskal–Wallis, Mann–Whitney U, Spearman's correlation, and binary logistic regression) were used to assess associations at a significance level of $p < 0.05$.

Results: The prevalence of foot pain was 47.6% among participants, indicating a

moderate to high occurrence. The Kruskal–Wallis test revealed significant differences in foot pain across departments (p=0.019), with nursing students reporting highest scores. Spearman's correlation showed significant relationships between prolonged standing (r = −0.143, p = 0.039), shoe height (r = −0.166, p = 0.017), and shoe fit (r = 0.157, p = 0.024) with foot pain. The Mann–Whitney U test found no significant gender difference (p = 0.555), while the presence of foot defects significantly influenced foot pain (p = 0.045). Logistic regression showed that the overall model was significant (χ^2 = 27.74, p = 0.015), though no single predictor independently explained the outcome.

Conclusion: Nearly half of the clinical students experienced foot pain, largely associated with prolonged standing, poorly fitted footwear, and pre-existing foot defects.

Keywords: Prevalence, foot pain, risk factors, prolonged standing

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INTRODUCTION

The human foot is one of the vital parts of the body as it supports the entire body weight and aids in movement and posture.[1] Yet, it is given the least care and attention.[2] Although musculoskeletal foot problems make up a significant portion of primary care consultations, it appears that only a small percentage of people with foot problems seek medical attention for them.[3] Gates et al[4] defined foot pain as an independent risk factor for a loco-motor disability that causes impaired balance, increased risk of falls, loss of independence, and ultimately affects quality of life. Each region of the foot, including the toes, forefoot, midfoot, and hindfoot, is susceptible to different forms of pain and pathological conditions due to variations in structure and function. It most commonly occurs at the toes or forefoot, followed by the arch or ball, with the heel and hindfoot least frequently affected[3]. There is a significant reported incidence of foot pain that affects everyday life and work quality.[5]

The prevalence of foot pain has been estimated in a few studies. Globally, foot pain prevalence in adults in the general population is estimated to be between 9 and 36%, with a pooled prevalence of 24%. In their lifetime, one in four people may experience foot discomfort, and up to 40% of runners will report foot pain.[6] Data collected from five international cohorts reported a prevalence of 13-36%[3]. According to a systematic review, 14.6% of healthcare workers in Africa reported having ankle/foot pain.[7] Ankle-foot pain significantly impacted surgical nurses in Europe, being the most common work-related musculoskeletal disorder. This resulted in 2.4% of nurses missing work, 1.4% requiring hospitalization, 52.9% experiencing disruptions to their daily work life, and 2.9% changing their workplace. Over half of nurses resorted to medication to manage the pain.[8-10] A study in India showed that the prevalence of musculoskeletal foot pain among medical professionals was 30% of doctors, 30% of physiotherapists, 20% of nurses, and 20% of pharmacists.[11]

Various factors such as increasing age, gender, higher body mass index (BMI),[12] foot pathologies, footwear habits,[13] other

musculoskeletal pain,[14,15] and medical conditions including mental health/depression,[16] inflammatory arthritis (RA), osteoarthritis (OA), and heart disease[15] have been associated with foot pain. A recent study highlighted factors that can increase the risk of foot pain; - Age, Gender, Weight gain, Occupational risk, Sport and exercise, pregnancy, corn and calluses, Heel pain, Bunion, Morton's neuroma, Achilles tendinitis, Bursitis of the heel, Plantar fasciitis, Arch problem, foot injury, Haghind's deformity, hammer toe, ingrown toenails, stress fracture, cosmetic foot surgery.[14]

Clinical students are individuals admitted into the programs of medical laboratory science, physiotherapy, radiography, and nursing. Their program, which is essential to learn clinical skills, requires them to engage in extensive practical training, which predisposes them to prolonged standing, walking long distances within hospital premises, carrying heavy loads, and wearing inappropriate footwear, as well as other risk factors associated with foot pain.[17] Studies have been done to show the prevalence of pain and its associated risk factors among other musculoskeletal regions, particularly the low back[18-21] and neck[22-24] among clinical students. To the best of this researcher's knowledge, there are limited studies that evaluated the prevalence of foot pain and its associated risk factors among clinical students in the University of Benin. Hence, the present study aims to determine the prevalence of foot pain among clinical students and its association with various risk factors.

MATERIAL AND METHODS

This study used a cross-sectional study design to consecutively recruit 208 clinical undergraduates of the School of Basic Medical Sciences, University of Benin, Edo State.

Inclusion criteria were final year clinical students of the school of Basic Medical Sciences, who were willing to participate in this study.

The sample size for this study was determined using Solvin's formula:

$n = N / (1 + N (e)^2)$

Where n is the sample size, N is the total population, and e is the margin of error (0.05).

The total population of final-year clinical students from the four departments of Physiotherapy, Medical Laboratory Science, Nursing, and Radiography was 432. The population distribution was as follows: Physiotherapy (82), Medical Laboratory Science (110), Nursing (148), and Radiography (92). Using the formula, the estimated sample size arrived at was 208..

A proportionate stratified sampling technique was used to ensure that each department was fairly represented in the study. The number of students selected from each department was determined according to their proportion in the total population. This was done by multiplying each department's population by the overall sample size of 208 and dividing by the total population of 432, using the formula:

Sample size for each department = (Department population / Total population) × Overall sample size.

Based on this calculation, 39 students were selected from Physiotherapy, 53 from Medical Laboratory Science, 71 from Nursing, and 44 from Radiography. This method ensured that each department contributed participants in proportion to its size within the total population, making

the sample representative of the study population.

Before the commencement of the study, ethical approval was obtained from the Ethics Research Committee of the College of Medical Sciences, University of Benin, Benin City (REC approval number: CMS/REC/2024/763). Informed consent was obtained from the participants after adequate information on the aims, methods, possible conflict of interest, institutional affiliations of the researcher, the anticipated benefits, the potential risks of the study and the right to refuse to participate was provided to the participants. Data were obtained through a self-administered questionnaire. The questionnaire comprised three sections:

The first section contained the sociodemographic data of the respondents, including age, gender, department, weight, height, and BMI.

The second section contained questions on foot health using the Foot Health Status Questionnaire (FHSQ). The FHSQ was developed in 1998 by Paul Bennett, Carla Patterson, Scott Wearing, and Tony Baglioni. It was initially developed and validated in Australia as a patient outcome measure for foot health. It is a comprehensive, self-administered questionnaire that assesses foot-specific and generic health-related quality of life (HrQoL). For this study, only the foot-specific aspect of the FHSQ was considered. It consists of 13 questions that evaluate four domains: Pain, Function, Footwear, and General Foot Health. Each domain is scored by converting item responses on Likert-type scales to a standardized domain score ranging from 0 to 100, where higher scores indicate better foot health / less pain and lower scores indicate poorer foot health / greater pain. In this study, the foot pain domain was the primary outcome: prevalence of foot pain was determined by participants' affirmative responses to the foot pain items, and severity was described using the continuous FHSQ foot pain domain score (lower scores = greater pain). Other FHSQ domains were used descriptively to contextualize footwear and functional factors. The FHSQ has a high test-retest reliability, ranging from 0.74 to 0.92.[25]

The third section contained questions on the relationship between footwear and foot pain.

Several data quality control measures were implemented. The questionnaire was pretested on 15 students (not included in the main analysis) to assess clarity and feasibility; minor wording adjustments were made accordingly. Data collectors received standardized training on instrument administration and confidentiality protocols. All questionnaires were administered in person under supervision to reduce misunderstanding and to allow immediate resolution of queries. Completed forms were reviewed on site for completeness and consistency; missing or ambiguous responses were queried with respondents where possible. Data were double-entered into a spreadsheet and cross-checked for entry errors prior to export for statistical analysis. Electronic data were stored on a password-protected device, and paper forms were kept in locked storage to ensure confidentiality. These procedures were implemented to enhance reliability, minimize measurement and entry errors, and promote the integrity of the study data.

The anthropometric parameters were measured using appropriate instruments. The self-administered questionnaire was distributed and retrieved by the researcher

on the same day. A response rate of 100% was recorded as all participants completed their questionnaires.

Procedure for Assessment and Measurement

A weighing scale was used to measure the participants' weight. They were instructed to remove their shoes and heavy clothing and to stand on the weighing scale. The researcher observed and documented the values recorded.

A tape measure was used to measure the participants' height. Each participant was asked to remove their shoes, stand with their back and heels against a flat wall while ensuring their head, shoulders, and buttocks touched the wall. The researcher then used a flat object to mark the wall at the top of their head. The distance from the floor to the mark on the wall was measured. The Body Mass Index (BMI) of the participants was calculated using the recorded weight and height values.

The data obtained were analyzed using descriptive statistics such as mean, frequency, and standard deviation. The Kruskal–Wallis test was used to compare foot pain scores across departments, while the Mann–Whitney U test assessed the influence of gender and foot defects. Spearman's correlation was employed to examine the relationships between standing duration, shoe height, shoe fit, and foot pain. Binary logistic regression was used to identify predictors of foot pain. The level of significance was set at $p < 0.05$.

RESULTS

The primary aim of this study was to determine the prevalence of foot pain and the associated risk factors among clinical students in the University of Benin. 208 students were recruited for this study from the departments of Medical Laboratory Science, Nursing, Physiotherapy, and Radiography.

Shown in Table 1 are the socio-demographic characteristics of the respondents. 110 (52.9%) of the respondents were female, and 71 (34.1%) were from the department of Nursing. The age of the respondents ranged between 20 to 29 years, with a mean age of 22.36 (± 2.25) years. The mean values for weight and height were 71.45kg (± 14.22) and 1.71m (± 0.10), respectively. Body mass index ranged from 14.68 to 36.06kg/m^2, with a mean value of 24.66kg/m^2 (± 5.22). 103 (49.5%) had a normal weight.

Table 2 presents the prevalence of foot pain among final-year clinical students at the University of Benin. The overall prevalence was 47.6% (95% CI: 40.8–54.4), indicating that nearly half of the respondents experienced some degree of foot pain.

Table 1: Sociodemographic characteristics of the respondents N = 208

	Frequency	Percentage
Gender		
Male	98	47.1
Female	110	52.9
Department		
Physiotherapy	40	19.2
Medical Lab. Science	53	25.5
Nursing	71	34.1
Radiography	44	21.2
Body Mass Index		
Underweight	23	11.1
Normal weight	103	49.5
Overweight	40	19.2
Obese	42	20.2
	Range	**Mean ± SD**
Age (years)	20-29	22.36 ± 2.25
Weight (kg)	45.0 – 120.0	71.45 ± 14.22
Height (m)	1.50 – 2.26	1.71 ± 0.10
Body Mass Index (kg/m^2)	14.68 – 36.06	24.66 ± 5.22

Table 2: Prevalence of foot pain

			95% CI	
	Frequency	**Percentage**	**Lower**	**Upper**
Present	99	47.6	40.8	54.4
Absent	109	52.4		

Table 3 shows the foot health status among the respondents. The scores of the respondents in the pain domain of the foot health status questionnaire ranged from 0 to 81.25, with a mean score of 21.63 (± 20.23). Foot function scores ranged from 0 to 95, with a mean value of 22.40 (± 21.56). Mean values for the footwear and general health domains were 60.86 (± 26.25) and 31.61 (± 26.49), respectively.

Footwear characteristics among the respondents are presented in Table 4. Corporate shoes were the most commonly used shoe type, worn by 161 (77.4%). 99 (47.6%) commonly wore shoes of moderate/right fit, 122 (58.7%) commonly wore flat shoes. 95 (45.7%) experience discomfort after wearing shoes, 96 (46.2%) usually stand for 1 to 3 hours daily. 126 (60.6%) usually walked for 1 to 3 hours daily. 119 (57.2%) spend 1 to 3

hours daily standing while wearing shoes, 122 (58.7%) spend 1 to 3 hours daily walking while wearing shoes. 12 (5.8%) had foot defects, 8 of which were flat feet. 68 (32.7%) reported experiencing foot pain related to improper posture. 92 (44.2%) reported an occasional frequency of feeling foot pain/discomfort. 8 (3.8%) of the respondents reported experiencing changes in foot health that they attributed to weight gain or loss; these changes included swollen feet after standing for long periods and feelings of foot heaviness.

Shown in Table 5 is the difference in foot pain score among students in different clinical departments. The Kruskal–Wallis test showed a significant difference in foot pain scores among students across clinical departments ($H = 9.94$, $p = 0.019$). $\eta^2_h = 0.034$, indicating a small effect. Post-hoc comparisons with Bonferroni adjustment revealed that Nursing students reported significantly higher foot pain scores than Physiotherapy students ($p = 0.049$), while differences among the other departments were not significant ($p > 0.05$).

Table 3: Foot Health Status among the Respondents

Domains	Range	Mean ± SD
Pain	0 – 81.25	21.63 ± 20.23
Foot Function	0 – 95.0	22.40 ± 21.56
Footwear	0 – 100	60.86 ± 26.25
General Health	0 – 100	31.61 ± 26.49

Table 4: Footwear characteristics among the respondents

	Frequency	Percentage
Commonly used shoe type		
Athletic/sneakers	11	5.3
Boots	3	1.4
Corporate Shoe	161	77.4
Dress Shoes	4	1.9
Sandals/flip-flops	29	13.9
Commonly used fitting		
Loose Fit	28	13.5
Moderate/Right Fit	99	47.6
Fit	74	35.6
Tight Fit	7	3.4
Commonly used shoe height		
Flat (0-1 inch)	122	58.7
Low Heel (1-2 inches)	55	26.4
Mid Heel (2-3 inches)	28	13.5
High Heel (3-4 inches)	3	1.4
Experience discomfort after wearing shoes		
Yes	95	45.7
No	113	54.3
Hours spent standing daily		
Less than 1 hour	26	12.5
1-3 hours	96	46.2
4-6 hours	79	38.0
7-9 hours	7	3.4
Hours spent walking daily		
Less than 1 hour	45	21.6
1-3 hours	126	60.6
4-6 hours	35	16.8
7-9 hours	2	1.0
Time spent standing while wearing shoes		
Less than 1 hour	30	14.4
1-3 hours	119	57.2
4-6 hours	56	26.9
7-9 hours	3	1.4
Time spent walking while wearing shoes		
Less than 1 hour	45	21.6
1-3 hours	122	58.7
4-6 hours	35	16.8
7-9 hours	5	2.4
More than 9 hours	1	0.5
Foot defects		
Yes	12	5.8

No	196	94.2
Specific foot defect		
Flat feet	8	3.8
Hallux valgus	3	1.4
Foot pain/discomfort related to improper posture		
Yes	68	32.7
No	140	67.3
Frequency of foot pain/discomfort		
Never	25	12.0
Rarely	84	40.4
Occasionally	92	44.2
Frequently	7	3.4
Have you experienced any changes in foot health that are attributed to weight gain or loss?		
Yes	8	3.8
No	200	96.2
Specific changes		
Swollen feet after standing for a long	1	0.5
Feet feel heavy	1	0.5

Table 5: Kruskal-Wallis test for differences in foot pain scores among students in different clinical departments

	Median (IQR)	H	df	η^2_h	p
Department					
Physiotherapy	6.25 (23.44)	9.94	208	0.034	0.019
Medical Lab. Science	25 (31.25)				
Nursing	25 (25)				
Radiography	12.5 (29.69)				

Table 5.1 Post-hoc analysis

Sample 1-Sample 2	Test Statistic	Std. Error	p-value[a]
Physiotherapy-Radiography	-10.605	12.963	1.000
Physiotherapy-Nursing	-31.029	11.731	0.049
Physiotherapy-Med. Lab Science	-31.162	12.428	0.073
Radiography-Nursing	20.424	11.385	0.437
Radiography-Med. Lab Science	20.557	12.102	0.536
Nursing-Med. Lab Science	.133	10.771	1.000

[a]Significant value has been adjusted by the Bonferroni correction for multiple tests

Table 6 shows the correlation between selected sociodemographic and footwear characteristics and foot pain score using spearman rho correlation. There was a significant negative relationship between foot pain score and time spent standing (r = -0.143, p = 0.039), shoe height (r = -0.166, p = 0.017). There was a significant positive relationship between shoe fit and foot pain (r = 0.157, p = 0.024).

Table 6: Correlation between selected sociodemographic and footwear characteristics and foot pain score using Spearman's rho correlation

			95% CI	
	R	**p**	**Lower**	**Upper**
BMI * Foot pain	0.076	0.276	-0.065	0.214
Hours spent standing * Foot pain	-0.143	0.039	-0.278	-0.003
Hours spent walking * Foot pain	-0.082	0.237	-0.220	0.058
Shoe height * Foot pain	-0.166	0.017	-0.299	-0.026
Shoe fit * Foot pain	0.157	0.024	0.017	0.291
Age * Foot pain	0.021	0.760	-0.119	0.161
Time spent standing in shoes	0.044	0.526	-0.096	0.183
Time spent walking in shoes	-0.006	0.93	-0.146	0.134

Shown in Table 7 is the influence of gender and foot defects on foot pain score using the Mann-Whitney U test. The presence of foot defects had a significant influence on the foot pain score (t = -1.985, p = 0.045). However, the gender of the students did not influence their foot pain score.

Table 7: Influence of gender and foot defects on foot pain score using the Mann-Whitney U T-test

	Median (IQR)	**U**	**r**	**p-value**
Gender				
Male	18.75 (31.25)	5642	0.04	0.555
Female	25 (31.25)			
Foot Defect				
Yes	31.25 (31.25)	775.5	0.14	0.045
No	18.75 (31.25)			

Presented in Table 8, the binary logistic regression model significantly predicted foot pain prevalence overall (χ^2 = 27.74, p = 0.015). However, none of the individual predictors were independently significant.

The subgroup analysis presented in Table 9 – 12, showed that the binary logistic regression model significantly predicted the prevalence of foot pain among physiotherapy students (χ^2 = 26.458, p = 0.009) and radiography students (χ^2 = 30.895, p = 0.002). Among radiography students, factors of BMI (OR = 1.61, p = 0.016), walking for less than 1 hour (OR = 7.7 x 10^4, p = 0.028) and walking between 1 to 3 hours (OR = 2.2 x 10^4, p = 0.031) were significant predictors of foot pain prevalence.

Table 8: Omnibus test of model coefficients

Omnibus Tests of Model Coefficients			
	Chi-square	**Df**	**Sig.**
Model	27.744	14	0.015

Table 8.1: Binary logistic regression for predictors of foot pain prevalence

	B	**OR**	**95% C.I. for OR**		**p-value**
			Lower	**Upper**	
Age	0.109	1.115	0.976	1.273	0.108
BMI	0.050	1.052	0.994	1.113	0.079
Gender					
Male (vs Female)	-0.087	0.917	0.499	1.684	0.779
Shoe Fit					0.282
Loose fit (vs Tight fit)	0.693	1.999	0.302	13.245	0.473
Moderate/Right fit (vs Tight fit)	1.161	3.193	0.565	18.036	0.189
Shoe Height					0.086
Flat (vs High heel)	21.277	1.74×10^9	0.000	—	0.999
Low Heel (vs High heel)	21.123	1.49×10^9	0.000	—	0.999
Mid Heel (vs High heel)	19.989	4.80×10^8	0.000	—	0.999
Hours spent standing					0.353
Less than 1 hour (vs 7 – 9 hrs)	0.441	1.555	0.249	9.687	0.636
1-3 hours (vs 7 – 9 hrs)	-0.435	0.648	0.125	3.350	0.604
4-6 hours (vs 7 – 9 hrs)	-0.429	0.651	0.126	3.372	0.609
Hours spent walking					0.184
Less than 1 hour (vs 7 – 9 hrs)	-20.654	0.000	0.000	—	0.999
1-3 hours (vs 7 – 9 hrs)	-21.050	0.000	0.000	—	0.999
4-6 hours (vs 7 – 9 hrs)	-21.787	0.000	0.000	—	0.999
Constant	-4.457	0.012	—	—	1.000

Subgroup Analysis

Department = Physiotherapy

Table 9: Omnibus test of model coefficients for physiotherapy students

Omnibus Tests of Model Coefficients			
	Chi-square	**Df**	**Sig.**
Model	26.458	12	0.009

Table 9.1: Binary logistic regression for predictors of foot pain prevalence among physiotherapy students

	B	**OR**	**95% C.I. for OR**		**p-value**
			Lower	**Upper**	
Age	0.208	1.231	0.767	1.975	0.390
BMI	0.151	1.164	0.896	1.512	0.256
Gender					
Male (vs Female)	−1.530	0.216	0.015	3.067	0.258
Shoe Fit					
Loose fit (vs Tight fit)	−19.632	0.000	0.000	—	0.999
Shoe Height					0.399
Flat (vs High heel)	21.725	2.72×10^{9}	0.000	—	1.000
Low heel (vs High heel)	24.188	3.20×10^{10}	0.000	—	1.000
Mid heel (vs High heel)	19.691	3.56×10^{8}	0.000	—	1.000
Hours spent standing					0.666
<1 hour (vs 7 – 9 hrs)	−20.401	0.000	0.000	9.596	0.999
1–3 hours (vs 7 – 9 hrs)	−22.842	0.000	0.000	94.006	0.999
4 – 6 hours (vs 7 – 9 hrs)	−22.014	0.000	0.000		0.999
Hours spent walking					0.705
<1 hour (vs 7 – 9 hrs)	23.080	1.06×10^{10}	0.000	—	0.998
1–3 hours (vs 7 – 9 hrs)	21.952	3.42×10^{9}	0.000	—	0.998
Constant	−30.640	0.000	—	—	0.999

Department = Medical Laboratory Science

Table 10: Omnibus test of model coefficients for medical laboratory science students

Omnibus Tests of Model Coefficients			
	Chi-square	**Df**	**Sig.**
Model	7.836	11	0.728

Table 10.1: Binary logistic regression for predictors of foot pain prevalence among medical laboratory science students

	B	**OR**	**95% C.I. for OR**		**p-value**
			Lower	**Upper**	
Age	0.125	1.133	0.832	1.543	0.427
BMI	0.024	1.025	0.901	1.165	0.711
Gender					
Male (vs Female)	0.284	1.329	0.362	4.880	0.669
Shoe Fit					
Loose fit (vs Tight fit)	0.144	1.155	0.123	10.812	0.9
Shoe Height					0.626
Flat (vs High heel)	0.903	2.468	0.382	15.949	0.343
Low heel (vs High heel)	0.898	2.455	0.274	21.994	0.422
Hours spent standing					0.974
<1 hour (vs 7 – 9 hrs)	1.158	3.184	0.000	—	1.000
1–3 hours (vs 7 – 9 hrs)	21.727	2.73×10^{9}	0.000	—	0.999
4 – 6 hours (vs 7 – 9 hrs)	22.044	3.75×10^{9}	0.000	—	0.999
Hours spent walking					0.420
<1 hour (vs 7 – 9 hrs)	1.684	5.387	0.428	67.866	0.193
1–3 hours (vs 7 – 9 hrs)	0.937	2.552	0.406	16.036	0.318
Constant	−26.940	0.000	—	—	0.999

Department = Nursing

Table 11: Omnibus test of model coefficients for nursing students

Omnibus Tests of Model Coefficients			
	Chi-square	**Df**	**Sig.**
Model	15.6	14	0.335

Table 11.1: Binary logistic regression for predictors of foot pain prevalence among nursing students

Variable	**B**	**OR (Exp(B))**	**95% C.I. for OR**		**p-value**
			Lower	**Upper**	
Age	x	1.094	0.823	1.454	0.537
BMI	0.034	1.034	0.923	1.158	0.336
Gender					
Male (vs Female)	−0.255	0.775	0.252	2.386	0.198
Shoe Fit					0.187
Loose fit (vs Tight fit)	1.020	2.773	0.138	55.577	0.505
Fit (vs Tight fit)	1.990	7.314	0.542	98.713	0.134
Shoe Height					0.976
Flat (vs High heel)	22.490	5.85×10^9	0.000	—	0.999
Low heel (vs High heel)	22.630	6.73×10^9	0.000	—	0.999
Mid heel (vs High heel)	22.125	4.06×10^9	0.000	—	0.999
Time spent standing					0.929
<1 hour (vs 7 – 9 hrs)	−18.348	0.000	—	—	1.000
1–3 hours (vs 7 – 9 hrs)	−18.760	0.000	—	—	1.000
4–6 hours (vs 7 – 9 hrs)	−19.095	0.000	—	—	1.000
Time spent walking					0.764
<1 hour (vs 7 – 9 hrs)	−20.896	0.000	—	—	0.999
1–3 hours (vs 7 – 9 hrs)	−20.765	0.000	—	—	0.999
4–6 hours (vs 7 – 9 hrs)	−19.384	0.000	—	—	0.999
Constant	13.038	4.60×10^5	—	—	1.000

Department = Radiography

Table 12: Omnibus test of model coefficients for radiography students

Omnibus Tests of Model Coefficients			
	Chi-square	**Df**	**Sig.**
Model	30.895	12	0.002

Table 12.1: Binary logistic regression for predictors of foot pain prevalence among radiography students

Variable	**B**	**OR (Exp(B))**	**95% C.I. for OR**		**p-value**
			Lower	**Upper**	
Age	−0.031	0.970	0.614	1.531	0.895
BMI	0.476	1.610	1.091	2.376	0.016
Gender					
Male (vs Female)	6.139	463.48	0.913	2.35×10^5	0.053
Shoe Fit					0.210
Loose fit (vs Tight fit)	5.186	178.79	0.478	6.69×10^4	0.086
Moderate/Right fit (vs Tight fit)	5.502	245.13	0.382	1.57×10^5	0.095
Shoe Height					0.072
Flat (vs High heel)	6.236	510.86	0.901	2.90×10^5	0.054
Low heel (vs High heel)	−0.449	0.638	0.015	27.178	0.815
Time spent standing					0.578
<1 hour (vs 7 – 9 hrs)	20.022	4.96×10^8	—	—	1.000
1–3 hours (vs 7 – 9 hrs)	18.568	1.16×10^8	—	—	1.000
4–6 hours (vs 7 – 9 hrs)	17.467	3.85×10^7	—	—	1.000
Time spent walking					0.087
<1 hour (vs 7 – 9 hrs)	11.253	7.71×10^4	3.33	1.79×10^9	0.028
1–3 hours (vs 7 – 9 hrs)	10.008	2.22×10^4	2.56	1.93×10^8	0.031
Constant	−50.141	0.000	—	—	0.999

DISCUSSION

The purpose of this study was to determine the prevalence of foot pain and its associated risk factors among clinical students at the University of Benin. Foot pain can have a significant impact on daily activities and reduce overall quality of life.[1] The findings of this study showed a 47.6% prevalence of foot pain among participants. This aligns with reports from other developing and African countries, where the prevalence of foot or ankle pain among healthcare professionals and trainees ranges between 40% and 52%. For instance, a study among nurses in Ethiopia reported a 43.7% prevalence of ankle and foot pain,[26] while a related study in the Amhara region of Ethiopia found a 51.8% prevalence.[27] These values are comparable to the present study's results and

emphasize the widespread nature of foot pain in health-related fields.

In contrast, a study among nursing students in Asia reported an even higher prevalence (93.5%) of foot discomfort,[28] possibly due to differences in measurement tools and case definitions. In Nigeria, Ayanniyi and Udofia[29] observed a 51.7% prevalence of musculoskeletal pain among undergraduates, indicating that the current finding of 47.6% for foot pain is consistent with the general burden of musculoskeletal symptoms among Nigerian students.

These consistent findings across regions indicate that foot pain is a common occupational and ergonomic concern among healthcare trainees, particularly those who engage in long hours of standing, walking, and practical rotations. Variations in prevalence may be attributed to differences in study design, population characteristics, and assessment instruments. The moderate-to-high prevalence observed in this study underscores the need for institutional interventions aimed at preventing foot-related disorders among clinical undergraduates.

The inferential analysis revealed several important associations. Prolonged standing showed a significant negative correlation with foot pain, suggesting that extended periods on one's feet increase discomfort. This supports findings by Mazahreh,[30] Choudhary and Chitkara,[31] and Aziz et al.,[32] who reported that long-standing durations contribute to musculoskeletal strain, reduced blood circulation, and increased plantar pressure. Similarly, the correlation between shoe height and foot pain indicated that moderate heel heights may reduce discomfort, consistent with the reports of De-Castro et al.[33] and Wibowo et al.,[34] who found that heel elevation redistributes plantar pressure more evenly.

Shoe fit was also significantly associated with foot pain, indicating that ill-fitting footwear increases discomfort. This aligns with Moes[35] and Buldt and Menz[36], who noted that tight or loose footwear can alter gait, increase pressure points, and reduce comfort. Furthermore, the study found no significant difference in foot pain between male and female students, implying similar exposure to occupational and ergonomic risks. However, the presence of foot defects was significantly linked to foot pain, supporting Szczepanowska-Wołowiec et al.,[37] who reported that structural abnormalities like flatfoot or high arches alter biomechanics and heighten discomfort.

When compared with other inferential studies, the findings of this research are consistent with those of Getie et al. (2021) and Canca-Sanchez et al. (2024). Getie et al. reported that low shoe comfort, prolonged standing, and high physical demand were significant predictors of ankle and foot pain among nurses in Ethiopia[38]. Similarly, Canca-Sanchez et al. identified body mass index (BMI), foot posture, and footwear characteristics as major predictors of foot pain in adults.[39] Both studies reinforce the role of footwear comfort, body composition, and occupational exposure in the development of foot pain, supporting the associations found in the present study.

However, while those studies identified distinct independent predictors through logistic regression, the current study's overall regression model was significant, but individual predictors did not retain statistical independence. This difference may be due to sample size limitations, restricted variability in exposure levels

among students, and the overlapping nature of risk factors such as standing duration, shoe fit, and shoe height. Nonetheless, the pattern observed across these studies confirms that foot pain is multifactorial, often arising from the combined effects of biomechanical, ergonomic, and lifestyle-related factors.

While several associations were statistically significant, it is essential to distinguish statistical from clinical significance. Statistical significance shows that findings such as the relationship between prolonged standing and foot pain are unlikely due to chance. However, clinical significance emphasizes the real-world impact, such as reduced concentration, mobility, and performance among affected students. Hence, even moderate pain levels have practical implications for students' well-being and academic functioning.

Potential confounding variables such as body mass index, physical activity, footwear outside clinical practice, and individual pain thresholds were not controlled in this study. These may have influenced both exposure and outcome variables. Future studies should include multivariate or stratified analyses to enhance internal validity and accuracy.

From a practical perspective, this study highlights the need for ergonomic and preventive interventions in clinical education. Institutions should promote the use of properly fitted footwear, encourage periodic rest breaks, and integrate foot health education into training programs. Such measures can reduce discomfort, improve clinical performance, and enhance overall well-being among students.

Limitations of the Study

Although this study provides valuable insights into the prevalence and associated risk factors of foot pain among final-year clinical students, several limitations should be noted. The use of a cross-sectional research design limits the ability to establish a causal relationship between the identified risk factors and the occurrence of foot pain. The associations observed in this study should therefore be interpreted as correlations rather than cause-and-effect relationships. Additionally, the study relied on self-reported data, which may have introduced recall bias or social desirability bias, as participants might have underreported or overreported their symptoms and exposure levels.

Furthermore, the convenience sampling technique employed could have resulted in selection bias. Participants who were more available or experiencing foot pain may have been more likely to take part in the study, potentially leading to an overestimation of the prevalence. Students who were absent or uninterested during data collection were excluded, which may have affected the representativeness of the findings.

Lastly, because the study was conducted among clinical students within a single institution, its generalizability is limited. Differences in clinical exposure, footwear type, physical activity levels, and academic workload in other institutions or regions could lead to varying outcomes. Future studies should consider adopting a longitudinal or multicenter approach, involving larger, randomly selected samples, to enhance generalizability and strengthen causal inferences.

CONCLUSION

The prevalence of foot pain among final year clinical students at the University of Benin was 47.6%. Prolonged standing, poorly fitted footwear and presence of foot defects were identified as major contributing factors.

Recommendations

1. Footwear Interventions: Clinical students should be encouraged to wear properly fitted and ergonomic footwear with moderate heel heights to reduce foot pain and improve mobility.
2. Standing Management: Institutions should implement policies that limit prolonged standing during clinical rotations by incorporating scheduled rest breaks and ergonomic modifications in clinical areas.
3. Foot Health Education: Foot care and ergonomics should be integrated into the curriculum to improve students' awareness of proper footwear, posture, and preventive strategies for maintaining healthy feet.

Implications for further studies

1. Longitudinal Studies: Future research should investigate the long-term effects of foot pain on the academic performance, mental health, and overall well-being of clinical students to establish causal relationships.
2. Intervention Effectiveness: Studies should assess the effectiveness of interventions such as custom orthotics, foot-strengthening exercises, and ergonomic modifications in reducing foot pain and improving functionality.
3. Foot Defects and Biomechanics: Further research should explore the prevalence and biomechanical impact of various foot defects among clinical students to better understand their contribution to foot pain development.

CONFLICT OF INTEREST:

The authors declare no conflict of Interest in this study.

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ASSESSMENT OF MICROBIAL AND PARASITIC CONTAMINATION ON NIGERIAN CURRENCY NOTES AT NNAMDI AZIKIWE UNIVERSITY, AWKA NIGERIA

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ABSTRACT

Background: The pervasive use of currency notes in daily transactions makes them a potential vector for microbial contamination. Despite this there remains a notable lack of comprehensive studies specifically addressing the extent and types of microbial contamination present on Nigerian currency.

Aim: This study evaluated the bacterial and parasitic contamination of Nigerian currency notes at Nnamdi Azikiwe University, Awka.

Method: A cross-sectional study design was employed for this research. Currency notes were gathered from various locations on campus. A total of 70 samples of Nigerian currency notes were randomly collected. Samples were prepared for bacterial culture by swabbing with sterile saline moistened cotton swabs. Bacteria were cultured on Salmonella Shigella media, incubated, and analyzed for colony characteristics. Remaining samples underwent microscopic examination for protozoan parasites after centrifugation and resuspension.

Result: The identified protozoan parasites included *Entamoeba histolytica*, *Entamoeba coli*, and *Enterobius vermicularis*, with contamination rates of 35.7%, 57.1%, and 7.1%, respectively. Statistical analysis indicated no significant association between parasite species and overall prevalence (P = 0.06). Bacterial isolates included *Klebsiella spp*., *Proteus spp*., and *Escherichia coli*, with prevalence rates of 50%, 25%, and 25%, respectively,

and no significant association between bacterial species and prevalence (P = 0.4). Notably, polymer notes (10 to 50 naira) exhibited a 0.00% contamination rate, while paper notes showed varying prevalence: 35.7% for 100 naira, 28.6% for 200 naira, 14.3% for 500 naira, and 21.4% for 1000 naira. A significant association was found between currency denomination and prevalence (P = 0.01). Furthermore, the physical condition of the notes influenced contamination levels, with mutilated notes demonstrating the highest contamination rate (22.97± 4.51%). However, no significant association (P = 0.2).

Conclusion: The findings underscore the potential health risks posed by contaminated currency and highlight the need for public awareness and hygiene measures

Keywords: Bacterial, Parasitic, Currency note, Contamination

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INTRODUCTION

The proliferation of currency notes as a medium of exchange has long been recognized as a potential vector for microbial and parasitic contamination, raising significant public health concerns. In Nigeria, where cash transactions remain predominant, the role of currency notes in facilitating the transmission of pathogens is particularly alarming. Despite the growing body of literature on the microbial contamination of banknotes globally, there remains a conspicuous gap in research specifically addressing the extent and implications of such contamination within the Nigerian context. Recent studies have highlighted the presence of various pathogens on currency notes in different countries, indicating that these notes can harbor bacteria, viruses, and parasites capable of causing disease[1,2]. For instance, a study conducted in India found that 85% of examined currency notes were contaminated with bacteria, including *Staphylococcus aureus* and *Escherichia coli*, which are known to pose serious health risks [3] . Similarly, research in Brazil revealed that banknotes could serve as reservoirs for parasites such as Giardia lamblia and Entamoeba histolytica [4]. However, despite these findings, there is a notable lack of comprehensive studies focusing on Nigerian currency notes. The unique socio-economic and cultural dynamics of Nigeria, coupled with the high frequency of cash transactions, necessitate an urgent investigation into the microbial and parasitic load on its currency. Previous work has primarily concentrated on urban areas and has not adequately addressed the rural-urban divide or the potential implications for public health [5]. This study aims to fill this critical research gap by evaluating the microbial and parasitic contamination of Nigerian currency notes, thereby providing essential data that can inform public health policies and hygiene practices. Understanding the extent of contamination is vital for mitigating health risks

associated with cash transactions, especially in a country where the informal economy thrives and cash remains king.

MATERIALS AND METHODS

Study Area

The research was conducted at Nnamdi Azikiwe University in Awka, Anambra State, Nigeria, located at geographical coordinates 6° 16' 0" North and 7° 3' 0" East. The university spans over 100 acres, featuring a rich variety of flora and fauna[6]. The area includes several streams, agricultural lands, numerous buildings, and forested regions. Awka is situated within Nigeria's tropical rainforest zone, experiencing two distinct seasons: the wet season from April to October and the dry season from November to March. The average temperature ranges from 28.5º C between June and December to 33º C from January to April [7].

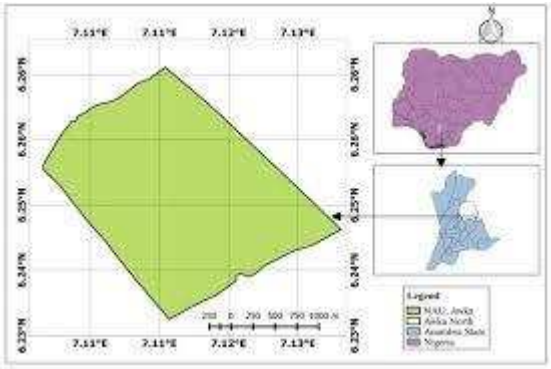

Fig 1: Map of the study area (Nnamdi Azikiwe University)

Sampling Design

A cross-sectional study design was employed for this research. Currency notes were gathered from various locations on campus, including shopping malls, lecture halls, hostels, cyber cafes, and bus stands. A total of 70 samples of Nigerian currency notes were randomly collected, comprising 10 pieces from each denomination (₦10, ₦20, ₦50, ₦100, ₦200, ₦500, and ₦1000) in both polymer and paper forms. A sample size of 70 currency notes was selected based on its adequacy to achieve a reasonable statistical power for detecting significant differences in microbial contamination levels. A sample size of 70 is considered sufficient to provide a robust estimate of the microbial load present on currency notes, given that the study does not involve complex group comparisons but rather a general assessment of contamination levels[8]. The collected notes were categorized based on their physical condition into four groups: mints, clean, dirty, and mutilated dirty, with the mint notes serving as the control group.

Ethical Considerations

The research objectives were clearly explained to the participants, and their verbal consent was secured prior to the collection and exchange of currency notes. The ethical approval for this study was obtained from the Department of Zoology, Nnamdi Azikiwe University, Awka. Currency notes of various denominations were gathered from multiple locations using sterile gloves and forceps to prevent any additional contamination. Notes were placed in sterile, sealed bags immediately after collection and stored at room temperature until analysis

Sample Preparation

The preparation of samples for bacterial culture was done using methods outlined by[9, 10]. This involved individually swabbing each currency note with sterile cotton swabs moistened with sterile saline (0.85% NaCl). The swabbing was conducted systematically across the entire surface of each note to ensure thorough coverage[11]. The swabs were then placed

into sterile tubes containing 1 mL of sterile saline. Bacterial samples were inoculated onto salmonella shigella culture media and incubated at 37°C for 24 hours. Following incubation, the plates were examined for colony morphology, including characteristics such as size, shape, color, and hemolytic properties. Distinct colonies were selected for further identification, which included Gram staining and biochemical tests.

For the identification of protozoan parasites, after isolating bacterial pathogens, the remaining suspension was subjected to microscopic examination[9]. A subsample of the swab suspension from each currency note was centrifuged at 3000 rpm for 10 minutes. The supernatant was discarded, and the pellet was resuspended in 1 mL of sterile phosphate-buffered saline (PBS). A drop of the resuspended sample was placed on a clean glass microscope slide and covered with a coverslip. The sample was then examined under a light microscope at various magnifications (100x, 400x, and 1000x) to identify protozoan cysts and trophozoites.

Statistical Analysis

Descriptive statistics were employed to summarize and provide an overview of the dataset, allowing for a clearer understanding of the distribution and characteristics of the microbial contamination observed on the currency notes. The collected data were analyzed using the Chi-square test to assess the significance of the prevalence of microbial parasites.

RESULT

The result of the study on assessment of microbial and parasitic contamination on Nigerian currency notes is shown below:

Protozoan Parasite Species Detected on Naira Notes Following Parasitological Analysis

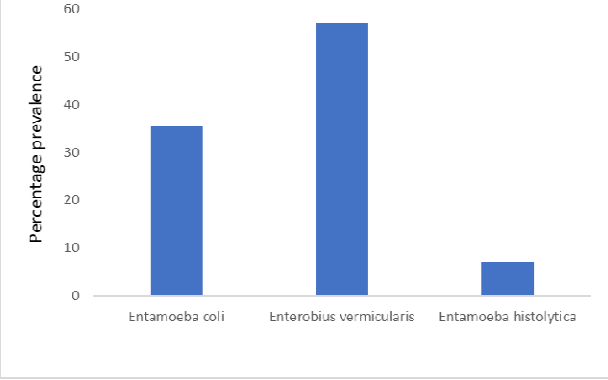

Fig 2: Prevalence of protozoan parasites on naira currency notes

The protozoan parasites identified and isolated in this study included *Entamoeba histolytica*, *Entamoeba coli*, *Enterobius vermicularis*, *Escherichia coli*. Out of the 70 samples analyzed, 35.7% were contaminated with *Entamoeba coli*, 57.1% with *Enterobius vermicularis*, and 7.1% with *Entamoeba histolytica*. The analysis showed no significant correlation between the various parasite species and their prevalence (P = 0.06).

Bacterial Parasite Species Detected on Naira Notes Following Parasitological Analysis

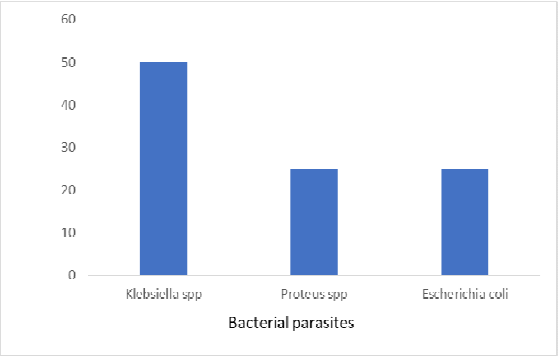

Fig 3: Prevalence of bacterial parasites on naira currency notes

The bacterial pathogens identified and isolated in this research include *Klebsiella spp*., *Escherichia coli*, and *Proteus spp*. Out of the 70 samples examined, 50% were contaminated with *Klebsiella spp*., while 25% showed contamination with Escherichia coli, and another 25% with *Proteus spp*. Statistical analysis indicated no significant correlation between the various bacterial species and their prevalence (P = 0.06).

Parasites prevalence on Naira notes in relation to currency denomination and types of notes

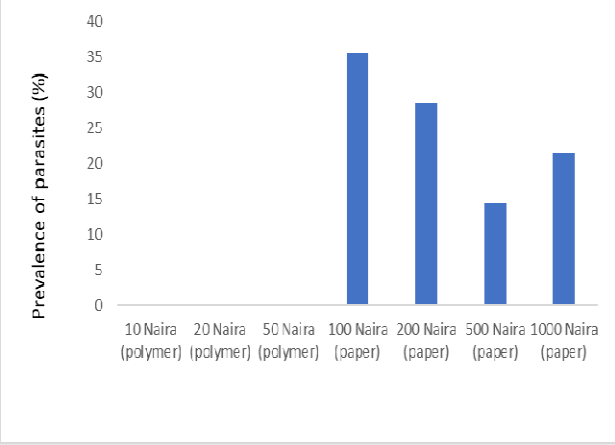

Fig 4: Prevalence of parasites on Naira notes in relation to currency denomination and types of notes

The assessment of microbial contamination indicated that polymer notes (10 to 50 naira) showed no signs of contamination (0.00%). In comparison, paper notes exhibited different levels of contamination: 100-naira notes had a contamination rate of 35.7%, 200-naira notes showed 28.6%, 500-naira notes recorded 14.3%, and 1000-naira notes had a prevalence of 21.4%. A statistically significant relationship was identified between the denomination of naira currency and the prevalence of contamination (P = 0.01).

Parasite species composition and prevalence on naira notes in relation to their physical condition

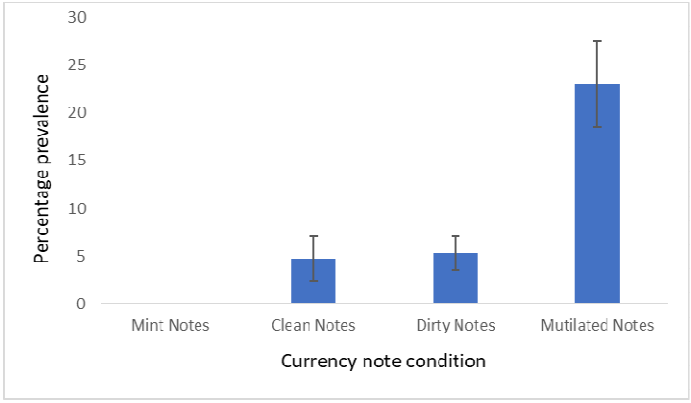

Fig 5: Parasite species prevalence on currency notes in relation to the notes physical condition

Mint notes showed no presence of parasites. Clean notes exhibited a contamination rate of 4.73± 2.37%, while dirty notes had a rate of 5.325± 1.775%. Mutilated naira notes displayed the highest level of contamination at 22.97± 4.51%. Additionally, there was no significant correlation found between the physical

condition of Naira notes and the prevalence of contamination (P=0.2).

DISCUSSION

The results of this study highlight a concerning level of microbial and parasitic contamination on Nigerian currency notes, particularly paper notes, which can serve as vectors for disease transmission. The identification of protozoan parasites such as *Entamoeba histolytica*, *Entamoeba coli*, and *Enterobius vermicularis*, alongside bacterial pathogens like *Klebsiella* spp., *Escherichia coli*, and *Proteus* spp., underscores the potential health risks associated with handling contaminated currency.

The prevalence rates found in this study, with *Entamoeba coli* at 35.7% and *Enterobius vermicularis* at 57.1%, are particularly noteworthy. The higher prevalence of *Enterobius vermicularis*, a common intestinal parasite, suggests that currency notes may act as a reservoir for transmission, especially in populations with limited access to sanitation. Previous studies have reported similar findings, indicating that currency notes can harbor a variety of pathogens, including helminths and protozoa [12, 13]. The lack of a significant association between parasite species and prevalence (P = 0.06) suggests that while multiple parasites are present, their distribution may not be uniform across the samples examined.

The stark contrast in contamination levels between polymer and paper notes is significant. The polymer notes (10 to 50 naira) showed no contamination, while various denominations of paper notes exhibited varying levels of contamination, with the 100-naira notes showing the highest prevalence at 35.7%. This finding aligns with previous research that has indicated that polymer banknotes are less conducive to microbial survival due to their non-porous nature [14]. The significant association between currency denomination and prevalence (P = 0.01) suggests that higher denomination notes may be handled more frequently or kept for longer durations, increasing the likelihood of contamination.

The study also examined the physical condition of the notes, revealing that mutilated and very dirty notes had the highest contamination rates (28.6%). However, the lack of a significant association between the physical condition of the notes and prevalence (P = 0.2) indicates that while dirtiness may correlate with higher contamination, it is not the sole factor influencing the presence of pathogens. This finding is consistent with the work of [15], which found that while dirty notes had higher microbial loads, the relationship was not statistically significant.

The presence of these pathogens on currency notes poses a potential public health risk, particularly in a country like Nigeria, where hygiene practices may vary widely. The transmission of pathogens via currency can contribute to the spread of gastrointestinal diseases and other infections, particularly in vulnerable populations. Public health campaigns emphasizing hand hygiene and the need for regular cleaning of currency notes could be beneficial in mitigating these risks.

CONCLUSION

This study has provided important insights into the microbial and parasitic contamination of Nigerian currency notes. The findings emphasize the need for

further research into effective strategies for decontaminating currency and promoting public health awareness regarding the potential risks associated with handling contaminated money. Continued surveillance of currency contamination and its implications for public health will be crucial in addressing these concerns. While, the limited number of samples used in the study may impact the statistical power of the results and the ability to generalize the result to a broader population. Future research should consider increasing the sampling size. It should also focus on understanding transmission pathways as well as the role of currency in the spread of disease especially during outbreaks.

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PREVALENCE AND PATTERN OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG PRIMARY SCHOOL TEACHERS IN OVIA NORTH EAST, BENIN CITY, EDO STATE, NIGERIA

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ABSTRACT

Background: Work-related Musculo-skeletal disorders are major health challenges for school teachers due to prolonged standing and repetitive tasks. Understanding the prevalence and patterns of musculoskeletal disorders among primary school teachers is essential for developing effective intervention strategies to improve their occupational health and well-being.

Aim: The aim of this study was to determine the prevalence and pattern of work-related musculoskeletal disorders among primary school teachers in Ovia North-East, Benin City, Edo State, Nigeria.

Methods: A cross-sectional descriptive study was conducted among Two hundred and sixty-seven **(**267) primary school teachers in Ovia North-East, Benin City, Edo State, Nigeria. Participants were selected using a consecutive sampling method. Data were collected with a structured self-administered questionnaire comprising sociodemographic/work-related characteristics and an adapted Standardized Nordic Musculoskeletal Questionnaire. Descriptive statistics summarized participants' characteristics and WMSD prevalence, while Chi-square tests assessed associations between variables at a 0.05 significance level.

Results: Among 267 primary school teachers studied, the 12-month prevalence of musculoskeletal pain was highest in the lower back (28.5%), followed by the shoulder (21.7%) and upper back (18.7%). Pain affected work performance in 6.0% of respondents. Job characteristics such as longer teaching hours, poor posture and lack of ergonomic furniture were

significantly associated with higher pain levels ($p<0.05$).

Conclusion: Musculoskeletal pain, particularly in the lower back, shoulder, and upper back, is highly prevalent among primary school teachers. The contributing factors include job-related characteristics such as longer teaching hours, poor posture and inadequate ergonomic support alongside sociodemographic factors like age and years of teaching experience. Improved workplace ergonomics, teacher training on posture, and adequate rest breaks are recommended to reduce the burden of musculoskeletal pain.

Keywords: *Musculo-skeletal Pain, Shoulder pain, Lower back pain, Ergonomics, Teachers.*

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INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are a significant global public health challenge, impacting various occupational groups across different sectors[1]. These disorders encompass a range of conditions affecting muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs. They are commonly associated with repetitive strain, overexertion, and sustained awkward postures, leading to pain, discomfort, and functional impairment[2,3]. The prevalence of WMSDs is notably high among professions that involve repetitive tasks and static postures, such as teaching[4,5].

Primary school teachers are particularly susceptible to WMSDs due to the nature of their job, which requires prolonged standing, repetitive writing on blackboards, handling teaching materials, and maintaining static postures while interacting with students[6]. These activities can lead to the development of musculoskeletal pain and disorders, which can significantly affect their health, productivity, and overall quality of life[7].

Research on prevalence and pattern of work-related musculoskeletal disorders (WMSDs) among primary school teachers is not limited; there are several studies done globally and in Nigeria. A recent systematic review and meta-analysis of 44 articles found that the overall prevalence of MSDs among teachers is about 68.0%, with the highest prevalence in the neck (47.0%) and lower back (47.0%)[5]. In the United Arab Emirates, a study reported a 71.4% prevalence of WMSDs among schoolteachers[2]. In Nigeria Ojukwu et al,[8]. concluded that 70.2% of teachers reported WMSDs while shoulders (62.3%) and neck (57.9%) were most common WMSDs reported.

Ovia North-East, Benin City, Edo State, Nigeria, is home to considerable number of primary school teachers who are integral to the education system in the region. However, the occupational health challenges faced by these teachers, particularly concerning WMSDs, have not been thoroughly investigated. Understanding the prevalence and patterns of WMSDs among primary school teachers in this region is essential for developing effective intervention strategies to improve their occupational health and well-being.

Therefore, this study aimed at investigating the prevalence and pattern of WMSDs among primary school teachers in

Ovia North-East, Benin City, Edo State, Nigeria. By identifying the specific types of musculoskeletal issues prevalent in this group and the associated occupational risk factors, the research will provide valuable insights that can inform the development of tailored interventions to enhance teacher's health and well-being, thereby promoting a more effective educational environment.

MATERIAL AND METHODS

This study employed a cross-sectional descriptive design to determine the prevalence and associated factors of work-related musculoskeletal disorders (WMSDs) among primary school teachers in Ovia North-East Local Government Area, Benin City, Edo State, Nigeria. A total of 267 primary school teachers were consecutively recruited for the study based on accessibility and willingness to participate. Participants were drawn from both public and private primary schools within Ovia North-East, Benin City.

Ethical approval for this study was obtained from the Ministry of Health, Benin City, Edo State (Approval No: HA/737/24/D/1105426). Informed consent was obtained from all participants using a signed consent form. Participation was voluntary, and respondents could withdraw at any time without penalty. Confidentiality and anonymity were maintained throughout the study. No names or identifying information were collected, and each questionnaire was coded with a unique number for analysis purposes.

Inclusion Criteria were:

- Currently employed primary school teachers in Ovia North-East, Benin City, Edo State.
- Teachers with at least one year of teaching experience.
- Teachers who provided informed consent to participate.

Permission was first obtained from the school head teachers. Teachers were approached personally during school hours, and the purpose and procedures of the study were clearly explained. Those who met the inclusion criteria and agreed to participate were given a self-administered structured questionnaire, which was retrieved the same day and some within one week.

Data were collected using a structured, self-administered questionnaire consisting of two main sections: Section A: Sociodemographic and Work-Related Characteristics. This section obtained data on: Personal information (Age, Sex, Marital Status, Level of Education, Years of Teaching Experience, Teaching Level), Work-related factors (Number of Teaching Hours per Day, Class Size, Frequency of Breaks, Use of Teaching Aids), Physical and ergonomic factors (Teaching Posture, Availability of Ergonomic Furniture, Frequency of Lifting Heavy Objects, Comfort Level of Classroom Environment). Section B: Nordic Musculoskeletal Questionnaire (NMQ) The Standardized Nordic Musculoskeletal Questionnaire (NMQ) was used to assess musculoskeletal symptoms across nine body regions. The tool identifies: The prevalence of musculoskeletal symptoms over a defined period, the specific body parts most affected, and the impact of symptoms on work and daily activities. The NMQ was adapted to the Nigerian teaching context to include relevant tasks such as prolonged chalkboard writing, static postures during teaching, and classroom ergonomics.

Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize sociodemographic characteristics and prevalence of musculoskeletal symptoms while Inferential statistics, specifically the Chi-square test (χ^2), were used to determine associations between sociodemographic and occupational factors and the prevalence of WMSDs. The level of significance (α) was set at 0.05.

RESULTS

This research investigated the prevalence and pattern of work-related musculoskeletal disorders among primary school teachers in Ovia North East Benin City, Edo state. The study included a sample of 267 participants selected from 10 primary schools in Ovia North East, Benin city.

Shows in Table 1 is the Sociodemographic Characteristics of Respondents. Majority of the participants were female (82.0%). Most participants were aged between 20–29 years (62.5%), followed by aged 30–39 years (28.5%). Majority were single (69.3%), and 49.1% held an NCE (National Certificate in Education), while 45.3% held a bachelor's degree. Over 64.8% had teaching experience ranging from 0–5 years, and majority (64.0%) taught junior primary classes.

The result revealed that most respondents taught for 6–8 hours daily (66.3%) and handled classes with less than 30 students (63.5%). Nearly equal proportions rated their classrooms as very comfortable (47.2%) or comfortable (46.1%). 40.8% took breaks every two hour, and 64.0% frequently used teaching aids. Ergonomic furniture was always available for 60.7%, and 49.8% primarily taught while standing. Majority (40.4%) reported occasionally lifting materials as part of their teaching activities (see Table 2)

Table 3 shows that, low back pain was the most common musculoskeletal complaint (28.5%) over the past 12 months, followed by shoulder pain (21.7%) and upper back pain (18.7%). Pain affected work for 6.0% of respondents with low back pain and 4.5% for shoulder and upper back pain. Pain persisted in the past 7 days for 25.1% of participants in the lower back region, 15.0% in shoulder and 13.5% for upper back pain. Physician consultations due to pain were highest for lower back pain (6.4%) compared to other body region.

Shown in Table 4 is the results of the test of significance between gender, teachers' classes and prevalence of musculoskeletal pain among the respondents using Mann-Whitney U Test. There was no statistically significant difference ($p>0.05$) in the prevalence of shoulder pain, upper back, and lower back pain between male and female respondents at 12 months. Although slight difference in mean ranks was observed, none of these differences reached statistical significance. A significant difference was found in the prevalence of shoulder pain between those teaching junior and senior primary classes ($p = 0.024$). Other pain regions, including upper back, and lower back, did not show significant differences ($p > 0.05$).

Table 1: Sociodemographic Characteristics of Respondents (N=267)

Variables	Frequency (n)	Percentages (%)
Age		
20- 29	167	62.5
30-39	76	28.5
40- 49	18	6.7
50-59	6	2.2
Gender		
Male	48	18.0
Female	219	82.0
Marital Status		
Single	185	69.3
Married	81	30.3
Divorced	1	0.4
Level of Education		
Nigerian Certificate	131	49.1
In Education		45.3
Bachelor Degree	121	1.9
Master Degree	5	3.7
Senior School	10	
Certificate Exam		
Years of Experience		
0-5	173	64.8
6-11	68	25.5
11-15	19	7.1
16-20	5	1.9
21 above	2	0.7
Teaching Level		
Junior Primary Class	171	64.0
Senior Primary Class	96	36.0

Table 2: Occupational Characteristics of Respondents (N=267)

Variables	Frequency (n)	Percentages (%)
Teaching Hours		
<3 Hours	13	4.9
3-5 Hours	65	24.3
6-8 Hours	177	66.3
>8 Hours	12	4.5
Class Size		
20-29	167	63.5
30-39	76	28.5
40-49	18	6.7
50-59	6	2.2
Classroom Comfort		
Very comfortable	126	47.2
Comfortable	123	46.1
Uncomfortable	17	6.4
Very Uncomfortable	1	0.4
Break Observance		
Every hour	54	20.2
Every 2 hours	109	40.8
Once per day	99	37.1
Rarely	5	1.9
Use of Teaching aids		
Frequently	171	64.0
Occasionally	69	25.8
Rarely	22	8.2
Never	5	1.9
Ergonomic Furniture		
Always Available	162	60.7
Sometimes Available	59	22.1
Rarely Available	21	7.9
Never Available	25	9.4
Teaching Posture		
Standing	133	49.8
Sitting	15	5.6
Combination of Standing and Sitting	119	44.6
Frequency of Lifting		
Frequently	72	27.0
Occasionally	108	40.4
Rarely	54	20.2
Never	33	12.4

Table 3: Prevalence and Pattern of Musculoskeletal Pain among Respondents

Variables	Pain in the last 12 months	Pain Prevented from work in the last 12 months	Seen Physician due to pain in the last 12 months	Had pain in the last 7 days
Neck	47 (17.6)	7 (2.6)	6 (2.2)	15 (5.6)
Shoulder	58 (21.7)	12 (4.5)	7 (2.6)	40 (15.0)
Upper back	50 (18.7)	12 (4.5)	11 (4.1)	36 (13.5)
Lower back	76 (28.5)	16 (6.0)	17 (6.4)	67 (25.1)
Elbow	24 (9.0)	10 (3.7)	8 (3.0)	21 (7.9)
Wrist/hand	36 (13.5)	8 (3.0)	6 (2.2)	23 (8.6)
Hip/thigh	45 (16.9)	6 (2.2)	5 (1.9)	34 (12.7)
Knee	34 (12.7)	3 (1.1)	9 (3.4)	26 (9.7)
Ankle/feet	29 (10.9)	9 (3.4)	5 (1.9)	29 (10.9)

Table 4: Gender and classes differences in the Prevalence of Musculoskeletal Pain among teachers Using Mann-Whitney U Test

Variables	Prevalence of Shoulder Pain at 12 months Mean rank	Prevalence of Upper back Pain at 12 months Mean rank	Prevalence of Lower back Pain at 12 months Mean rank
Male (48)	124.47	134.03	123.81
Female (219)	136.09	133.99	136.23
Z value	-1.322	-0.005	1.291
P value	0.186	0.996	0.197
Junior Primary (171)	127.83	130.28	133.61
Senior Primary (95)	143.70	139.30	133.30
Z value	-2.254	-1.354	-0.040
P value	0.024	0.176	0.968

Table 5 present the results of a Kruskal-Wallis Test of significance between prevalence of musculoskeletal pain among teachers with different years of teaching experience and size of classes. The variables assessed include shoulder pain, upper back pain, and lower back pain over a 12-month period. Only shoulder pain ($p = 0.041$) and upper back pain ($p = 0.025$) showed statistically significant differences across years of teaching experience. However, there was no statistically significant association between age groups and musculoskeletal pain prevalence across the shoulder, upper back, and lower back regions ($p > 0.05$).

Table 6 presents the association between musculoskeletal pain (shoulder, upper back, and lower back) and selected work-related factors. A significant association was found between teaching hours and shoulder pain ($\chi^2 = 10.244$, $p = 0.017$), indicating that longer teaching hours increased the likelihood of shoulder discomfort. However, no significant associations were observed between teaching hours and upper or lower back pain ($p > 0.05$).

Teaching posture and frequency of breaks were not significantly associated with musculoskeletal pain in any body region ($p > 0.05$). In contrast, the availability of ergonomic furniture showed a significant association with musculoskeletal pain in the shoulder ($p = 0.025$), upper back ($p = 0.000$), and lower back ($p = 0.010$), suggesting that poor ergonomic conditions contribute substantially to discomfort across these regions.

Table 5: Test of Significant difference in the Prevalence of Musculoskeletal Pain Among teachers with different years of teaching experience and size of classes Using Kruskal-Walli's Test.

Variables	Prevalence of Shoulder Pain at 12 months Mean rank	Prevalence of Upper back Pain at 12 months Mean rank	Prevalence of Lower back Pain at 12 months Mean rank
Years of Teaching:			
0-5	128.15	130.61	129.18
6-10	150.15	150.23	145.08
11-15	140.13	116.03	138.16
16-20	105.00	109.00	149.40
21 above	105.00	109.00	96.00
H value	9.950	11.170	4.603
P value	0.041	0.025	0.330
Class size:			
20-29	130.58	132.98	127.98
30-39	136.62	137.11	139.91
40-49	149.50	123.83	155.33
50-59	149.50	153.50	162.75
H value	2.709	1.854	6.004
P value	0.439	0.603	0.111

Table 6: Test of Association Between Prevalence of Musculoskeletal Pain and Hours of Teaching, Teaching Posture, Break Hours and Availability of Ergonomic Furniture Using Chi Square Test of Association.

Variables	Prevalence of Shoulder Pain at 12 months Mean rank	Prevalence of Upper back Pain at 12 months Mean rank	Prevalence of Lower back Pain at 12 months Mean rank
Hours of Teaching			
<3hours	6(46.2)	2(15.4)	5(38.5)
3-5	20(30.8)	17(26.20	18(27.7)
6-8	30(16.9)	29(16.4)	49(27.7)
>8	2(16.7)	2(16.7)	4(33.3)
X^2	10.244	3.123	0.850
P value	0.017	0.373	0.838
Teaching posture			
Standing	25(18.8)	21(15.8)	36(27.1)
Sitting	5(33.3)	1(6.7)	5(33.3)
Sitting and	28(23.5)	28(23.5)	35(29.4)
Standing	2.087	3.991	0.355
X^2	0.352	0.136	0.838
P value			
Break Hours			
Every hour	15(27.8)	15(27.8)	15(27.8)
Every 2 hours	19(17.4)	16(14.7)	25(22.9)
Once per day	24(24.2)	18(18.2)	34(34.3)
Rarely	0(0.0)	1(20.0)	2(40.0)
X^2	4.102	4.105	3.656
P value	0.251	0.250	0.301
Ergonomic Design Furniture			
Always Available	29(17.90	25(15.40	44(27.2)
Sometimes	12(20.3)	7(11.9)	12(20.30
Rarely Available	6(28.6)	6(28.6)	6928.60
Never Available	11(44.0)	12(48.00	14(56.0)
X^2	9.334	18.394	11.357
P value	0.025	0.000	0.010

DISCUSSION

This study has several limitations that should be acknowledged. Firstly, the cross-sectional design limits the ability to establish a causal relationship between risk factors and musculoskeletal pain, the findings can only suggest associations, not cause-and-effect relationships. Secondly, data collection relied on self-reported questionnaires, which may be subject to recall bias and subjective interpretation of symptoms. Participants might have over- or under-reported their experiences of pain based on personal perception or memory. Thirdly, the study was conducted among teachers in one local government area (Ovia North-East), which may limit the generalizability of the results to all teachers in Edo State or Nigeria. Additionally, ergonomic assessments were based on self-report rather than direct observation, which might not fully capture the actual physical and environmental conditions of the classrooms. Finally, although efforts were made to ensure representative sampling, non-response bias cannot be entirely ruled out since participation was voluntary.

Despite these limitations, the study has notable strengths. It is among the few studies in Nigeria focusing specifically on work-related musculoskeletal pain among primary school teachers, providing valuable local evidence for policymakers and health professionals. The study utilized a standardized and validated instrument (the Nordic Musculoskeletal Questionnaire), ensuring comparability with national and international research. Furthermore, the inclusion of multiple variables such as sociodemographic characteristics, job-related factors, ergonomic conditions, and lifestyle variables provided a comprehensive understanding of the multifactorial nature of musculoskeletal disorders. The relatively large sample size of teachers also enhances the reliability and representativeness of the findings within the study area.

This study assessed the prevalence and pattern of work-related musculoskeletal disorders (WMSDs) among primary school teachers in Ovia North-East, Benin City, Nigeria and explored the association of sociodemographic factors, workplace ergonomics, and physical activity levels with WMSDs. The findings provide valuable insights into the occupational health challenges faced by teachers and have important implications for prevention and physiotherapy interventions.

The results revealed that the overall prevalence of musculoskeletal pain among primary school teachers in Ovia North-East, Benin City was 71.0%. The most affected regions were the lower back (28.5%), shoulder (21.7%), and neck (17.6%). This is consistent with previous research conducted in Nigeria[8-10] and other developing countries[11,12] that reported lower back pain and neck pain as the most reported WMSDs among teachers. The predominance of lower back pain was attributed to prolonged standing, static postures, and the repetitive nature of teaching tasks such as writing on chalkboards. Neck pain was also highly reported, possibly due to awkward head positions when supervising student's work or using poorly positioned desks and boards. The high prevalence indicates that WMSDs are not only common but may also be a neglected occupational health problem among educators in the region[8]. These findings therefore highlight the significant burden of musculoskeletal pain

on teachers, which can impair their quality of life and work productivity[13].

The frequency of pain varied across different body regions, with respondents also reporting shoulder (21.7%), upper back (18.7%), and wrist/hand (13.5%) pain. This aligns with findings by Cardoso *et al.*,[14] and Yue, et al,[15] who observed that teachers often report discomfort in the spine and upper limbs due to the combination of static posture and repetitive upper limb activity.

Interestingly, the prevalence in the lower limbs and wrists was lower, suggesting that teaching primarily imposes strain on the axial skeleton and proximal upper limb musculature rather than the distal joints. This pattern reinforces the role of ergonomic factors and task repetition in WMSDs among primary school teachers.

This study found a statistically significant association between the availability of ergonomically designed furniture and the prevalence of musculoskeletal pain in the neck, shoulders, upper back, and lower back ($p < 0.05$). Teachers with limited or no access to ergonomic furniture reported higher pain prevalence. This is in line with the biomechanical model of occupational injury, which highlights that inadequate workstation design leads to poor posture, increased muscular strain, and eventual musculoskeletal symptoms. Studies from Brazil[12] and South Africa[16] confirm that improving furniture design significantly reduces teacher-reported pain.

Physical activity was significantly associated with upper back pain ($p = 0.048$), no significant associations were found for neck, shoulder, or lower back pain. This suggests that physical activity may have a protective effect on certain muscle groups, particularly the thoracic spine, but is not the sole determinant of WMSD prevalence. This finding is partially supported by the World Health Organization's guidelines, which recommend regular physical activity as part of occupational health programs, but it also highlights that ergonomic interventions must complement exercise to achieve significant impact[17].

Sociodemographic factors such as gender, age, marital status, and years of teaching experience were also explored to understand their impact on musculoskeletal pain. Gender, in particular, was not found to significantly affect the prevalence of musculoskeletal pain. However, the study did find that older age groups (40 years and above) tended to report more frequent musculoskeletal pain, especially in the lower back and neck regions. This aligns with previous studies[18], that suggest musculoskeletal pain increases with age due to accumulated stress on the body.

Job characteristics e.g. posture and lack of ergonomic furniture were shown to significantly influence the prevalence of musculoskeletal pain. Teachers working in junior primary classes experienced higher levels of shoulder pain, likely due to the demands of managing younger students, which may involve repetitive motions and awkward postures. Furthermore, the study revealed that teachers who spent more hours teaching per week, particularly those teaching more than 8 hours, were more likely to report pain, especially in the shoulders. These findings support the hypothesis that prolonged sitting and standing, along with increased physical exertion, contribute to musculoskeletal discomfort[5].

CONCLUSION

This study concluded that WMSDs are highly prevalent among primary school teachers in Ovia North East, Benin City, with the lower back, neck, and shoulder being the most commonly affected regions. The findings are consistent with literature from other geographical regions, confirming that teaching is an occupation with substantial musculoskeletal risk. Significant associations were found between the availability of ergonomic furniture and musculoskeletal pain, as well as between physical activity levels and upper back pain prevalence.

These results reinforce the importance of workplace ergonomics and teacher health promotion strategies in preventing and managing WMSDs. Interventions such as provision of ergonomic classroom furniture, regular workplace assessments, incorporation of physical activity programs, and teacher training on posture and ergonomics could help to reduce the burden of WMSDs.

From a physiotherapy perspective, the study underscores the need for physiotherapists to be actively involved in

workplace ergonomic assessments, preventive education, and rehabilitation of affected teachers.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made to mitigate or decrease the prevalence and impact of musculoskeletal pain among teachers:

Schools should invest in ergonomic furniture, including adjustable chairs, desks, and supportive equipment, to reduce physical strain during teaching.

Teachers should be provided with training on proper posture and ergonomic practices to minimize the risk of musculoskeletal pain

School administrations should consider reducing teaching hours and providing more break intervals to reduce the physical strain of prolonged standing and sitting.

Physical activity should be promoted as part of school wellness programs to improve the overall health and well-being of teachers.

Schools should implement strategies to support older teachers, such as reducing their teaching load and offering guidance on managing musculoskeletal pain.

CONFLICT OF INTREST:

The authors declare no conflict of Interest in this study.

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PREVALENCE AND ASSOCIATED RISK FACTORS OF TRICHOMONIASIS AMONG PREGNANT WOMEN RECEIVING ANTENATAL CARE IN AMAC, FCT ABUJA, NIGERIA

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ABSTRACT

Background: Trichomoniasis is a global public health concern threatening pregnant women and female neonatal health.

Aim: The study was designed to determine the prevalence and associated risk factors of trichomoniasis among pregnant women receiving antenatal care in Abuja Municipal Area Council, FCT, Abuja.

Materials and Method: A cross-sectional descriptive study was employed, and 422 HVS and MSU samples were collected from pregnant women aged 20-50 years and analyzed microscopically using direct wet mount. A self-structured interview questionnaire was administered to collect data on the risk factors associated with trichomoniasis.

Result: The result showed that out of 422 samples tested, 97(23.0%) had the infection. Pregnant women aged 21-25 years had the highest prevalence rates of trichomoniasis with 28.9% and is relatively more (25.6%) among those in their second trimester. Educational status (χ^2 = 71.27, P = 0.0290), marital status (χ^2 = 51.95, P = 0.0140), occupational status (χ^2 = 9.76, P = 0.0180), income (χ^2 = 14.72, P = 0.0020), number of sexual partners (χ^2 = 6.22, P = 0.0130), condom use (χ^2 = 16.55, P = 0.025), and ignorance (χ^2 = 7.15, P = 0.0010) were the risk factors associated with trichomoniasis among the study population.

Conclusion: The study discovered that the overall prevalence of trichomoniasis in the

study population was 23.0% with urine samples having a higher detection rate compared to high vaginal swab samples, though, this may be due to lager urine samples. The pregnant women aged 21-25 years and those in their second trimester of pregnancy had the highest prevalence rates of trichomoniasis. While, marital status, occupation, education, household income, condom use and ignorance were the risk factors associated with trichomoniasis infection. Therefore, there is a need for public health enlightenment to reduce the rate of infection and create more awareness among the study population.

Keywords: Prevalence, risk factors, Trichomoniasis, Pregnant women, AMAC, Nigeria.

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BACKGROUND OF STUDY

Trichomoniasis is a sexually transmitted disease (STD) caused by *Trichomonas vaginalis* (TV), a flagellated, motile, and unicellular parasitic protozoan[1,2]. According to Rasha[3], trichomoniasis affects the urinogenital systems of both men (anterior urethra, epididymis, semen, and prostate) and women (vagina, vulva, cervix, and urethra), and is the most common and widespread sexually transmitted protozoan infection in Nigeria[4&2]. The parasite can transfer from an infected penis to a vagina, or an infected vagina to a penis, or an infected vagina to another vagina[5], a major contributor to pathology in obstetrics and gynecology indeed. It is principally transmitted during sexual interactions through oral, anal, or vaginal intercourse, more so, the non-sexual methods of transmitting the parasite include sharing undergarments or towels with infected individuals[1]. The infection affects between 2.0% and 17.0% of female babies born to infected mothers[6]. Moreover, associated risk factors linked to a high incidence of *T. vaginalis* infection include multiple sexual partners, lack of barrier contraception, co-infection with other Sexually Transmitted Infections, low socio-economic status, poor personal hygiene, intravenous drug use, older age, menstrual cycle, and under-development[2]. Personal hygiene behaviors such as inadequate genital hygiene, frequent or excessive douching, sharing personal items may disrupt natural vaginal flora and introduce pathogens or irritate genital tissue, thus, increasing the risk of trichomoniasis[2]. A healthy vagina of women of childbearing age has a pH of 3.8–5.0, which is moderately acidic[7]. However, disruptive factors like excessive douching can alter this balance, shifting the pH to a more basic level, creating an ideal environment for *T. vaginalis* to thrive, and increasing the risk of trichomoniasis[8]. Sharing personal items like towels, washcloths, or underwear can potentially spread trichomoniasis[9].

Also, people who have previously contracted a sexually transmitted infection (STI), such as syphilis, gonorrhea, or chlamydia, may have had changes in the vaginal microbiota or damage to the tissues of the genital tract. This may have compromised barrier function or disrupted the normal flora of the vagina[10]. Saeed *et al.*,[11] reported that a low level of education indeed influences the prevalence and impact of trichomoniasis in various ways, such as individuals with poor education

may have limited awareness and understanding of sexually transmitted infections (STIs), including trichomoniasis; underestimating their risk of acquiring trichomoniasis and other STIs due to limited knowledge about sexual health and risk factors; holding misconceptions or stigma about STIs, including trichomoniasis, which can hinder open communication about sexual health and discourage seeking medical care which can perpetuate the spread of infection within communities and contribute to the persistence of trichomoniasis. Without access to accurate information and education programs, individuals may be less equipped to protect themselves from infection and may not understand treatment instructions or the importance of completing a full course of medication for trichomoniasis, leading to lower treatment adherence rates and increasing the risk of recurrent or persistent infections, as well as the potential for spreading the infection to sexual partners.

Socioeconomic status significantly influences the prevalence and impact of trichomoniasis in various ways, for instance, individuals living in poverty often face barriers to accessing healthcare services, including STI testing and treatment, resulting in delays in diagnosis and treatment, allowing the infection to persist and spread[12]. Moreover, poverty is associated with lower levels of education and health literacy, leading to limited awareness and knowledge about trichomoniasis and other STIs[13]. Furthermore, economic disadvantage can also contribute to engagement in higher-risk sexual behaviors, such as substance abuse and transactional sex, increasing the likelihood of trichomoniasis transmission[14]. As well, poverty can restrict access to condoms and other forms of contraception, essential for preventing trichomoniasis and other STIs[12].

Moreso, the infection is a gateway to other sexually transmitted infections such as human immunodeficiency virus (HIV), *Chlamydia trachomatis*, and *Neisseria gonorrhoeae*, as well as a predisposing factor to cervical cancers[1 & 2]. Although, women experience symptoms more frequently than men, 10-50% of female cases remain asymptomatic[15] and those infected with *T. vaginalis* may experience symptoms such as foamy-greenish vaginal discharge, dysuria, vaginal erythema (redness), dyspareunia, vulvovaginal itching and swelling, pain during urination, and elevated vaginal pH (>5)[1]. It has also been reported that, this infection is linked to several health issues, such as prostatic cancer, cervical cancer, pelvic inflammatory disease (PID), reversible infertility in men and women, and major pregnancy problems like intra-amniotic or chorio-amnionitis, tubal factor infertility, ectopic pregnancy, premature labor, low birth weight, postabortion infections, preterm delivery, and neonatal mortality as well as morbidity[16 & 17] and can result in reduced sperm motility, prostatitis, urethritis, and epididymitis in males[18 & 19].

Worldwide, *T. vaginalis* infection is common; about 270 million cases are estimated to occur annually[20]. The distribution of *T. vaginalis* infection varies from 2% to more than 50% depending on the geographical location (region, country), gender, age, sex, and environment of the study populations as well as the procedures used for the diagnosis in various studies[21]. According to Samuel *et al.*[22], trichomoniasis is approximately 42.8

million in Africa; the prevalence among pregnant women is between 17% and 20% in Africa, 16% to 53% in the US, and 0.8% in Asia[23]. The pooled prevalence of *T. vaginalis* infection among women of reproductive age in Nigeria was significantly higher among sexually active women and pregnant women. Moreover, the prevalence of trichomoniasis varies widely in Nigeria with significantly higher among sexually active women and pregnant women[24,.25], in 2022, found a prevalence of 10.3% of trichomonas vaginalis infection among pregnant women receiving antenatal care in Abeokuta, Nigeria, and identified risk factors such as age, marital status, and occupational status among the study population[25,.26] found a prevalence of 30.9% of trichomoniasis among pregnant women attending antenatal clinics in Katsina State, Nigeria, and incriminated age, number of sexual partners, method of douching, and type of latrine as risk factors in the study population. Another prevalence study[27, 28] of Trichomoniasis among pregnant women in Kano, Nigeria, highlighted the need for routine screening and treatment of pregnant women found a prevalence of 12.1% of *T. vaginalis* infection among pregnant women attending antenatal care in Nigeria; and that there was a significantly higher prevalence[29] of trichomoniasis among pregnant women (61.4%) compared to non-pregnant women (38.6%). Also, it was revealed associations existed between trichomoniasis and lower socioeconomic status[24, 28], history of vaginal discharge, multiple sexual partners, and lack of condom use. It has been found[30] that associations exist between trichomoniasis and younger age (<25 years), lower education level, multiple sexual partners, history of STIs. The prevalence of *T. vaginalis* infection was higher among pregnant women in Nigeria, with a significant association between the infection and socio-demographic factors[31]. A study on the Prevalence and Correlates of *T. vaginalis* Infection among Women Attending a Primary Healthcare Facility in Nigeria revealed that the prevalence of *T. vaginalis* infection was higher among sexually active women and pregnant women attending a primary healthcare facility in Nigeria[32]; and found that the number of vaginal samples analyzed and the prevalence of Trichomoniasis decreased during the COVID-19 pandemic[33]. A study published in Venereology in 2022 discussed novel treatment approaches to combat Trichomoniasis, including the use of antimicrobial peptides and nanoparticles[34]. Additionally, most *T. vaginalis* infections remain undiagnosed because about half of infected men and women experience no signs or symptoms[15]. *Trichomonas vaginalis* infection is the most common sexually transmitted parasitic disease in Nigeria, however, estimating the incidence of the infection can be challenging due to the asymptomatic presentation in roughly half of the infected persons[2]. Despite all of these studies on Trichomoniasis and associated risk factors, none has been done in AMAC, FCT, Abuja, and there is paucity of information regarding *T. vaginalis* infections among pregnant women receiving antenatal care in Abuja Municipal Area Council (AMAC), FCT, Abuja. Therefore, this study was designed to determine the prevalence and associated risk factors of trichomoniasis among pregnant women receiving antenatal care in AMAC, FCT, Abuja, in order to create

more awareness and provide base-line data for future reference.

MATERIALS AND METHOD

Study design

A cross-sectional descriptive study design was adopted to determine the prevalence and associated risk factors of trichomoniasis among pregnant women attending antenatal care in Abuja Municipal Area Council (AMAC), (FCT), Abuja, Nigeria.

Study area

The Abuja Municipal Area Council (AMAC) in the Federal Capital Territory (FCT), Abuja, Nigeria, is located in the eastern section of the Federal Capital Territory and consists of twelve (12) wards, each represented by an elected Councillor. According to the 2022 projection, AMAC has a population of around 1,693,400 [(35)], 9 tertiary, 45 secondary, and 207 primary health facilities, and housing numerous Federal institutions, Ministries, Departments, and Agencies [(36)].

Study population

The study population comprised all pregnant women that received antenatal care in Federal Medical Centre (FMC), Abuja, Nigeria during the study period.

Inclusion criteria

Pregnant women aged 20-50 years, that received antenatal care in the Federal Medical Centre (FMC), Abuja, Nigeria, during the study period.

Exclusion criteria

Those who were very sick. Pregnant women who had previous vaginal bleeding and genital pathology (such as cervical cancer and premature membrane rupture), or a history of antibiotic treatment (metronidazole) in the past one week, to minimize potential biases in prevalence estimates.

Ethical clearance

The ethical approval with reference number: FMCABJ/HREC/2024/138 for this study was obtained from the Federal Medical Centre Abuja Health Research Ethics Committee (HREC) before the commencement of the study. The committee's institutional norms, rules, and regulations were accordingly complied with. Informed consent was also obtained from all participants, and their confidentiality and privacy were ensured throughout the study.

Sample size determination

Sample size used in this study was determined using an unknown population formula reported by Okoroiwu, (2021):

$n = Z^2 P (1-P)/d^2$

Where;

n = Minimum sample size

Z = Z = 1.96 (Statistical constant)

P = A provisional prevalence of 50% (0.5) was used as a baseline estimate.

d = 5% (0.05) = Desired error of precision (= 0.05)

n = 384 + 10% attrition rate

n = 384+38.4 = 422.

Sampling technique

A simple random sampling technique was employed to select participants from pregnant women receiving antenatal care at the Federal Medical Centre, Abuja, Nigeria, because it allowed for the inclusion of all eligible pregnant women.

Study instruments

This study employed a dual-method approach, a structured questionnaire, and clinical laboratory testing. A structured questionnaire was administered to gather data on the socioeconomic-demographic characteristics, sexual behaviours, personal hygiene practices. Additionally, laboratory testing tools were used to collect and examine high vaginal swabs and mid-stream-urine samples for objective determination of the prevalence of trichomoniasis among the study population.

Method of data collection

This was done through questionnaire for socio-demographic factors and laboratory test to gather original data on the prevalence and associated risk factors of T. vaginalis infection among the pregnant women.

Sample collection

A total of 422 samples (345 mid-stream-urine samples and 77 High Vaginal Swab (HVS) were collected from consented eligible pregnant women receiving antenatal care in the Federal Medical Centre, Abuja, Nigeria. The study participants were instructed to collect the mid-stream-urine samples into pre-labelled and sterile containers [(22)], while, gynaecologists collected High Vaginal Swab (HVS) samples from consented participants by inserting and rotating sterile swab sticks in the vagina for 10-30 seconds, thereafter each swab was labelled with a unique participant identity code. The collected HVS and urine samples were promptly transported to the Medical Microbiology Unit of Federal Medical Centre Abuja, for processing and microscopic examination within one hour to preserve the organism's motility and prevent moisture-related degradation.

Laboratory processing and microscopic examination of samples

The samples were processed using the wet mount preparation method and examined by a microscopic technique. Each mid-stream-urine sample was prepared by centrifuging 10 mL in a sterile test tube at 5,000 rpm for 5 minutes. The supernatant was discarded, and a drop mixture of sediment and normal saline was placed on a clean, grease-free microscope slide, covered with a coverslip, and examined microscopically using x10 and x40 objective lenses. The *T. vaginalis* was easily identified in positive samples by its oval shape and jerky or twitching movement [(38)]. Each high Vaginal Swab (HVS) sample was prepared by immersing it in 0.5 mL of 0.9% normal saline solution in sterile vials and gently twisting. A drop of the resultant suspension was then placed

on a clean, grease-free slide, covered with a coverslip, and examined microscopically using x10 and x40 objective lenses to detect *T. vaginalis*. The *T. vaginalis* was confirmed in a positive sample as explained in Urine samples [39 & 22].

Data analysis

Chi-square testing was used to establish the relationship between the prevalence of trichomoniasis and its associated risk factors in the study population.

RESULTS

The study revealed a 23.0% overall prevalence of *T. vaginalis* infection, with a higher detection rate in urine samples (24.1%) compared to high vaginal swab (HVS) samples (18.2%), this may be due to larger urine sample (345) compared to that of 77 HVS samples tested. The study revealed that pregnant women aged 21-25 years and those in their second trimester of pregnancy had the highest rates of trichomoniasis. Additionally, educational status(p=0.0290), marital status(p=0.0140), occupational status(p=0.0180), number of sexual partners(p=0.0130), condom use(p=0.0025), and ignorance of trichomoniasis(p=0.0010) were identified as risk factors significantly associated with trichomoniasis in the study population.

Table 1: Overall Prevalence of Trichomoniasis in the Study Populations.

Specimen Type	No. Examined (n)	No. Positive (%)	No. Negative (%)
Urine	345	83 (24.1)	262 (75.9)
HVS	77	14 (18.2)	63 (81.8)
Total Number (%)	**422**	**97 (23.0)**	**325 (77.0)**

Table 1 showed that the overall prevalence of Trichomoniasis among the study population is 23.0%, while, the urine samples yielded 24.1% prevalence rate of the infection, HVS samples revealed 18.2% infection rate.

Table 2: Age-related Prevalence of Trichomoniasis in the Study Population.

Age group (yrs)	No. Examined	No. Positive (%)	No. Negative (%)
≤ 20	0	0 (0.0)	0 (0.0)
21 – 25	38	11 (28.9)	27 (71.1)
26 – 30	176	39 (22.2)	137 (77.8)
31 – 35	65	13 (20.0)	52 (80.0)
36 – 40	117	31 (26.5)	86 (73.5)
41 – 45	25	3 (12.0)	22 (88.0)
46 – 50	1	0 (0.0)	1 (100.0)

Table 2: showed that the age-group of 21-25 years old had the highest prevalence (28.9%) of trichomoniasis infection, followed by those in age-group of 36-40 years old who had 26.5% of the infection, while, those in age-groups of <20 years and 46-50 years had the least with 0.0% respectively.

Table 3*:* Prevalence of Trichomoniasis by Pregnancy Stages (Trimesters) of the Study Population

Trimester	No. Examined	No. Positive (%)	No. Negative (%)
1st Trimester	88	21(23.9)	67 (76.1)
2nd Trimester	164	42 (25.6)	122 (74.4)
3rd Trimester	170	34 (20.0)	136 (80.0)

Table 3, showed that Trichomoniasis infection is relatively more (25.6%) among the pregnant women in their second trimester of pregnancy, followed by those in their first trimester (23.9%) of pregnancy.

Table 4: Risk Factors Associated with Trichomoniasis in the Study Population

Variables	No. Examined	No. Positive (%)	No. Negative (%)	χ^2	*P*-Value
Marital status					
Single	6	1 (16.7)	5 (83.3)		
Married monogamous	377	69 (18.3)	308 (81.7)		
Married polyandrous	29	20 (69.0)	9 (31.0)		
Divorced	3	2 (66.7)	1 (33.3)	51.95	0.0140*
Widow	7	5 (71.4)	2 (28.6)		
Religion					
Christianity	269	66 (24.5)	203 (75.5)		
Muslim	153	31 (20.3)	122 (79.7)	0.78	0.3800
Others	0	0 (0.0)	0 (0.0)		
Educational status					
Tertiary	283	35 (12.4)	248 (87.6)		
Secondary	112	42 (37.5)	70 (62.5)		
Primary	24	18 (73.9)	6 (25.0)	71.27	0.0290*
No Formal Education	3	2 (66.7)	1 (33.3)		
Occupational status					
Civil Servant	167	19 (11.4)	148 (88.6)		
Businesswoman	198	57 (28.8)	141 (71.2)		
Force Personnel	5	2 (40.0)	3 (60.0)		
Farmer	3	0 (0.0)	3 (100.0)		
Student	31	9 (29.0)	22 (71.0)	9.76	0.0180*
Housewife	6	1 (16.7)	5 (83.3)		
Unemployed	4	4 (100.0)	0 (0.0)		
Others	8	5 (62.5)	3 (37.5)		
Household income					

≤#50,000	73	29 (39.7)	44 (60.3)		
#51,00 - 100,000	129	23 (17.8)	106 (82.2)		
#101,000-150,000	122	27 (22.1)	95 (77.9)	14.72	0.0020*
≥#151,000	98	18 (18.4)	80 (81.6)		
No. of sexual partners					
Single	419	94 (22.4)	325 (77.6)	6.22	0.0130*
Multiple	3	3 (100.0)	0 (0.0)		
Condom use					
Always	13	3 (23.1)	10 (76.9)		
Sometimes	202	29 (14.3)	173 (85.6)	16.55	0.0025*
Never	208	65 (31.25)	143 (68.8)		
Ignorance of Trichomoniasis					
Yes	189	70(37.0)	119(63.0)	7.15	0.0010*
No	233	58(24.9)			

Table 4 showed that Marital status(p=,0.0140), educational status(p=0.0290), occupational status(p=0.0180), household income(p=0.0020), number sexual partners(p=0.0130), condom use(p=0.0025), and ignorance of Trichomoniasis(p=0.0010) were the risk factors associated with prevalence of trichomoniasis in the study area.

DISCUSSION

Trichomonas vaginalis is a protozoan parasite and is the most prevalent non-viral sexually transmitted infection worldwide causing the curable sexually transmitted disease called trichomoniasis [40]. In this study, an overall prevalent of 23.0% rate of trichomoniasis was discovered among the pregnant women, indicating a significant burden of the infection among the study participants. It is, however, noted that Trichomoniasis was more in urine samples than that of HVS and may be attributed to the number of urine samples (345) examined compared to 77 HVS samples tested. This rate of infection among the pregnant women receiving antenatal care in MAC, FCT, Abuja, may be attributed to among other things, low socio-economic status, educational status, poor personal hygiene, sharing of under-wears [2]. Moreover, personal hygiene behaviours, such as inadequate genital hygiene, frequent or excessive douching, and sharing of personal items may disrupt natural vaginal flora, thereby introducing pathogens or irritate genital tissue, thus increasing the risk of trichomoniasis. A healthy vagina of women of childbearing age has a pH of 3.8-5.0, which is moderately acidic [7]. However, disruptive factors like excessive douching can alter this balance, thus, shifting the pH to a more basic level, creating an ideal environment for Trichomonas vaginalis to thrive, thereby increasing the risk of trichomoniasis [8]. This level of prevalence, is consistent with previous studies on pregnant women. For instance, [23], posited that the prevalence of trichomoniasis among pregnant women is between 17.0% to 20.0% in Africa, 16.0% to 53.0% in the United States and 0.8% in Asia. This prevalence of 23.0% when compared with the results of previous studies such as [41]

in Lagos, [42] in Abeokuta, [28] in Nigeria and [25] in Abeokuta, who revealed prevalent rates of 3.3%, 20.0%, 12.1% and 10.3% , is high, it is, however, low when compared with the works of [26] in Katsina, [29] in Anambra state of Nigeria, who variously got 30.9% and 61.4% respectively in their studies, it is high. The differences in the prevalence rates may be attributed to the area of studies, study population, method of screening and personnels involved in the screening, as well as educational and occupational status of the participants.

On the age-related prevalence of this study population, the age-group of 21-25 years age-cohort had the highest prevalent rate of 28.9%, followed by those in the age-group of 36-40 years, who had infection rate of 26.5% of the infection, while, the least rate of infection went to the age-group of 46-50 years who got a share of 0.0% prevalent rate. This result is in agreement with the works of [42] who recorded highest prevalent of 21.3% of trichomoniasis among the age-group of 20-24 years age cohort, as well as [43] that showed 26.6% among the age-group of 20-24 years. Nevertheless, the result did not align with those of [41] who reported 1.8% among the age-group of 21-30 years cohort and that of [44] and [45], who in their various studies revealed higher prevalent rates within the age-brackets of 40-49 years and 30-39 years populations. The elevated prevalence among individuals aged 21-25 years may be attributed to increased sexual activity and decreased condom use during this life stage. In contrast, the lower prevalence among individuals aged 41-45 years age-group may be due to safer sex practices, fewer sexual partners, and a greater likelihood of seeking medical attention for symptoms, ultimately reducing their risk of infection. In addition, 46-50 years who had 00.0% prevalence may be due to the extremely small sample size or that older adult women do not have much sexual partners as the younger ones. While, the absence of participants aged ≥ 20 years suggests that younger individuals in the study population may not have been married or pregnant.

The study revealed that pregnant women in their second trimester of pregnancy had the highest rates of trichomoniasis, with prevalence rates of 25.6%. While, third trimester had the least prevalent of 20.0%, this corroborates the work of [46], who had 24.5% in their study, also claiming that the third trimester is least infected with Trichomoniasis. The slight disparities between these findings may be as a result of variations in study populations, sampling methods, and diagnostic techniques employed.

On the associated risk factors, the study showed that Marital status(p=0.0140), educational status(p=0.0290), occupational status(p=0.0180), household income(p=0.0020), number sexual of partners(p=0.0130), condom use(p=0.0025), and ignorance of Trichomoniasis(p=0.0010) were the risk factors associated with prevalence of trichomoniasis in the study area. It is worthy to note that a number of authors such as [39], [31], [47], [48], [49], [50], [51] are in agreement with findings of this study. Nevertheless, [52], did not align with the result, positing that condom use is never a risk factor to trichomoniasis infection, also, [53] argued that douching is not a risk factor as [38] disagreed with the fact that ignorance is an associated risk factor of

trichomoniasis infection. The differences in infection rates between Christian and Muslim participants may be attributed to differences in health-seeking behaviours, sexual health knowledge, and cultural and social norms. The discrepancies in these findings may be due to differences in study design, population, and cultural practices.

In conclusion, the study discovered that the overall prevalence of trichomoniasis in the study population is 23.0% with urine samples having a higher detection rate compared to high vaginal swab (HVS) samples, this may be as a result of the number of urine samples (345) to HVS (77). The pregnant women aged 21-25 years and those in their second trimester of pregnancy had the highest prevalence rates of trichomoniasis. While, marital status, occupation, education, household income, condom use and ignorance were the risk factors associated with trichomoniasis infection. These findings highlight the urgent need for a public health awareness campaign to educate the study population and reduce the infection rate of trichomoniasis.

Conflict of interest

The authors declare that they have no competing interests. Funding

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Authors' Contributions

Gideon Okoroiwu and J. Omogu conceived the research idea, Gideon Okoroiwu, Nwanganga I Ubosi and Joseph Omogu analyzed the data, Gideon Okoroiwu wrote the first draft of the manuscript. Joseph Omogu and Nwanganga Ihuoma Ubosi collected the data. The final draft has been read and approved by all the authors.

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SONOGRAPHIC ASSESSMENT OF FOETAL LIVER VOLUME CHANGES IN PREECLAMPSIA

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ABSTRACT

Introduction: The foetal liver serves as a central site for foeto-placental metabolism and vascular connection with the heart, and it is markedly influenced by intrauterine pathologies, rendering liver size assessment by ultrasonography essential for evaluating growth, nutrition, and maturation, and for early detection of microsomia and macrosomia.

Aim: This study aimed to assess foetal liver volume changes in pregnant participants with preeclampsia and to correlate foetal liver volume with the gestational age.

Material and methods: A case-controlled study involving 602 participants was conducted at Borno State Specialist Hospital. Purposive sampling method was adopted to recruit pre-eclamptic pregnant women, while non-pre-eclamptic pregnant women were selected using convenience sampling. The foetal biparietal diameter, femoral length, liver dimensions (antero-posterior, transverse, cephalocaudal), was measured with ultrasonic diagnostic software. Descriptive statistics and normality tests (Shapiro-Wilk) were performed. Mann-Whitney U tested differences in foetal liver volumes between two groups. Spearman's rho assessed correlations between foetal liver volume with gestational age. A p-value of less than 0.05 was considered statistically significant.

Results: Statistically significant reductions ($p < 0.001$) were observed in foetal liver volume of the pre-eclamptic participants compared to non-pre-eclamptic individuals. Strong positive statistically significant correlation existed between the foetal liver volume with gestational age.

Conclusion: Sonography effectively identified a significant reduction of foetal liver volume in pregnancies complicated by pre-eclampsia.

Key words: Foetal, liver, Volume, pre-eclampsia.

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INTRODUCTION

Foetal liver is an important organ involved in foeto-placental metabolism, as well as a vascular connection between the developing placental vessels to the foetal heart[1,2]. The foetal liver is the earliest and most markedly affected organ by intrauterine pathologies[1].The growing liver is extremely sensitive and responsive to maternal physiological changes, such as pre-eclampsia and maternal glucose levels[3]. Therefore, the size of the foetal liver assessed by ultrasonography is crucial in determining the status of foetal growth, nutrition, maturity, and particularly in the early recognition and monitoring both foetal micro and macrosomia[4,5].

Furthermore, a decreased size of the foetal liver is shown to be a typical sonographic marker of intrauterine growth retardation[4,6] whereas enlargement indicates macrosomia, Rh isoimmunization, erythroblastosis, Hb Bart's disease, and intrauterine infections[5]. In clinical practice, direct ultrasonic liver measurement in utero is considerably reliable than indirect measurement of abdominal circumference[7], which is widely used by most sonographers. The assessment of foetal liver volume is indispensable to satisfactory understanding of foetal physiology and status of foetal growth and nutrition.

It has been proposed that three-dimensional ultrasonography yields higher accuracy in organ volume determination in utero than two-dimensional ultrasonography[8], however, three-dimensional ultrasonography has higher tendency of over multiplying the volume of an organ under slight error in intra-observer calliper placement[9]. The two-dimensional ultrasound is mainly used for foetal assessments and measurements in the prenatal period, and in addition, it can be used to calculate volumes using the mathematical model with good correlation[10]. Due to the clinical importance of organs volume determination in utero, the present study undertakes the use of two-dimensional ultrasonography which abounds in the study locality.

MATERIALS AND METHODS

A case–control study design was adopted to perform transabdominal sonography in six hundred and two (602) pregnant women presenting for obstetric sonography in their second and third trimesters between June 2021 and September 2024 at the Borno State Specialist Hospital, Department of

Obstetrics and Gynaecology. Purposive sampling was used to recruit pre-eclamptic pregnant women, while seemingly healthy pregnant women, matched with the pre-eclamptic group, were recruited using convenience sampling. Pregnant women in their 20 weeks and older diagnosed with pre-eclampsia by an obstetrician, with confirmed elevated blood pressure of ≥ 140/90 mmHg and proteinuria level of ≥ 300 mg or 1+ on urine dipstick, were included. Gestational age was confirmed in all cases by sonographic biometric analysis. Other inclusion criteria were singleton gestation, no maternal medical history of diabetes mellitus, and with evidence of foetal viability. An ethical clearance was obtained from the Human Research and Ethics Committee (HREC) of the Borno State Ministry of Health. All participants gave informed consent and joined the study voluntarily.

The patient lay in a supine position on the examination couch with the Sonographer sitting beside the examination couch. Adequate quantity of ultrasound gel was applied on the patient's abdomen. Ultrasound transducer was gently placed on the patient's abdomen, general scanning (in longitudinal, transverse, and oblique budge) of the pregnancy was done to assess the foetal viability and morphology[11]. The foetal biparietal diameter, and femoral length were use to determine the gestational age. The foetal liver was assessed when the foetus was at rest and there was no foetal respiratory movement.The liver was measured at a plane for measuring abdominal circumference in a frozen image of transverse and sagittal planes. The landmarks used to identify the correct section to measure the abdominal circumference, the umbilical portion of the left portal vein in the liver, or the bifurcation of the main portal vein into the right and left branches, with the foetal stomach as secondary landmark[11]. The liver was measured in three major dimensions; the antero-posterior length, transverse length, and cephalocaudal length (fig 1 and 2).

The foetal liver volume in this study was estimated with a formula (0.55 x antero-posterior length x transverse length x cephalo-caudal length)[8]. All the examination was performed using 3.5 MHz tranducer. The acquired data was categorised according to the maternal age, gestational age and apparently healthy and pre-eclamptic participants. Descriptive statistics were used to determine the mean, standard deviation, and the frequency of the distribution and the results were presented in tables and charts. The statistical analysis was carried out using IBM SPSS Statistics for Windows, Version 31.0. (IBM Corp. Released 2024. Armonk, NY.). A p-value of < 0.05 was used as the criterion of statistical significance.

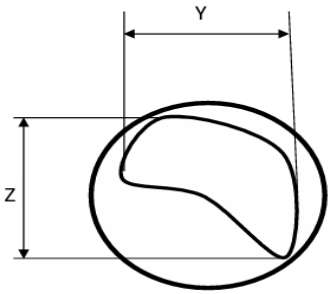

Fig. 1. Schematic presentation of foetal liver in transverse section.

Y= transverse length Z= antero-posterior length.

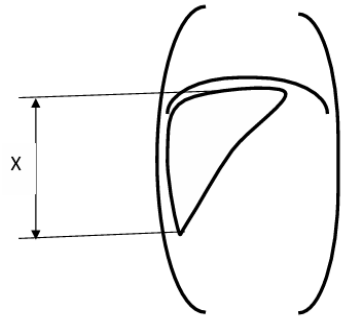

Fig. 2. Schematic presentation of foetal liver in sagittal section.

X= cephalocaudal length.

RESULTS

A total of 602 pregnant women participated in this study, comprising 130 (21.6%) with pre-eclampsia and 472 (78.4%) apparently healthy individuals. The participants' ages ranged from 20 to 46 years, with a mean of 28.67 ± 5.94 years. Shapiro-Wilk tests were conducted to assess the normality of foetal liver volume distributions. The results indicated non-normal distributions ($p < 0.001$), suggesting the use of non-parametric statistical analyses.

Table 1 presents the distribution of pre-eclampsia status across maternal age groups. The results indicate a significant variation in participation rates. Specifically, the 26-28 age group had the highest participation (n = 113, 18.77%), whereas the 44-46 age group had the lowest participation (n = 2, 0.33%). The distribution of gestational age groups among participants with pre-eclampsia is presented in Table 2. The 32-34 gestational age group exhibited the highest frequency (24.92%, n = 149), while the 38-40 gestational age group showed the lowest frequency (5.64%, n = 34). A Mann-Whitney U test was used to compare the mean differences between the foetal liver volumes of the pregnancy complicated by pre-eclampsia with the apparently normal participants ($p < 0.001$).

Table 1: Distribution of maternal pre-eclampsia status with corresponding maternal age group.

Maternal age group	PreE status		
	PreE	Normal	Total
20-22	19 (3.16%)	92 (15.28 %)	111 (18.46%)
23-25	16 (2.66%)	76 (12.62%)	92 (15.27%)
26-28	17 (2.82)	96 (15.95%)	113 (18.77%)
29-31	25 (4.15%)	79 (13.12%)	104 (17.24%)
32-34	7 (1.17%)	42 (6.98%)	49 (8.15%)
35-37	30 (4.98%)	48 (7.97%)	78 (12.95%)
38-40	13 (2.16%)	30 (4.98%)	43 (7.14%)
41-43	3 (.5%)	7 (1.17%)	10 (1.67%)
44-46	0 (0%)	2 (.33%)	2 (.33%)
Total	130 (21.6%)	472 (78.4%)	602 (100)

PreE: pre-eclampsia

Table 2: The distribution of gestational age groups with maternal pre-eclamptic status.

	PreE status		
GA group	**PreE**	**Normal**	**Total**
20.00-22.86	24 (3.99%)	35 (5.81 %)	59 (9.8%)
23.00-25.86	13 (2.16%)	38 (6.28%)	51 (8.44%)
26.00-28.86	9 (1.5%)	79 (13.12%)	88 (14.62%)
29.00-31.68	31 (5.15%)	107 (17.77%)	138 (22.92%)
32.00-34.86	32 (5.31%)	117 (19.43%)	149 (24.74%)
35.00-37.86	19 (3.16 %)	64 (10.63%)	83 (13.79%)
38.00-40.86	2 (.33%)	32 (5.31%)	34 (5.64%)
Total	130 (21.6%)	472 (78.4%)	602 (100%)

PreE: pre-eclampsia

Table 3: Mean distribution of foetal liver volume according to their gestational age group with corresponding maternal pre-eclampsia status.

	PreE status	
	PreE	**Normal**
GA group (W+D)	Mean (cm^3) ± SD	Mean (cm^3) ± SD
20.00-22.86	5.69 ± .63	6.96 ± 1.83
23.00-25.86	9.00 ± 1.72	13.16 ± 2.97
26.00-28.86	17.04 ± .35	27.17 ± 3.77
29.00-31.86	27.74 ± .82	34.10 ± 1.74
32.00-34.86	41.54 ± .81	47.63 ± 2.31
35.00-37.86	52.20 ± 1.77	57.86 ± 1.82
38.00-40.86	60.00 ± 00	61.74 ± .42

PreE: Pre-eclampsia, **SD:** Standard Deviation, **GA:** Gestational Age, **W+D:** Weeks + Days

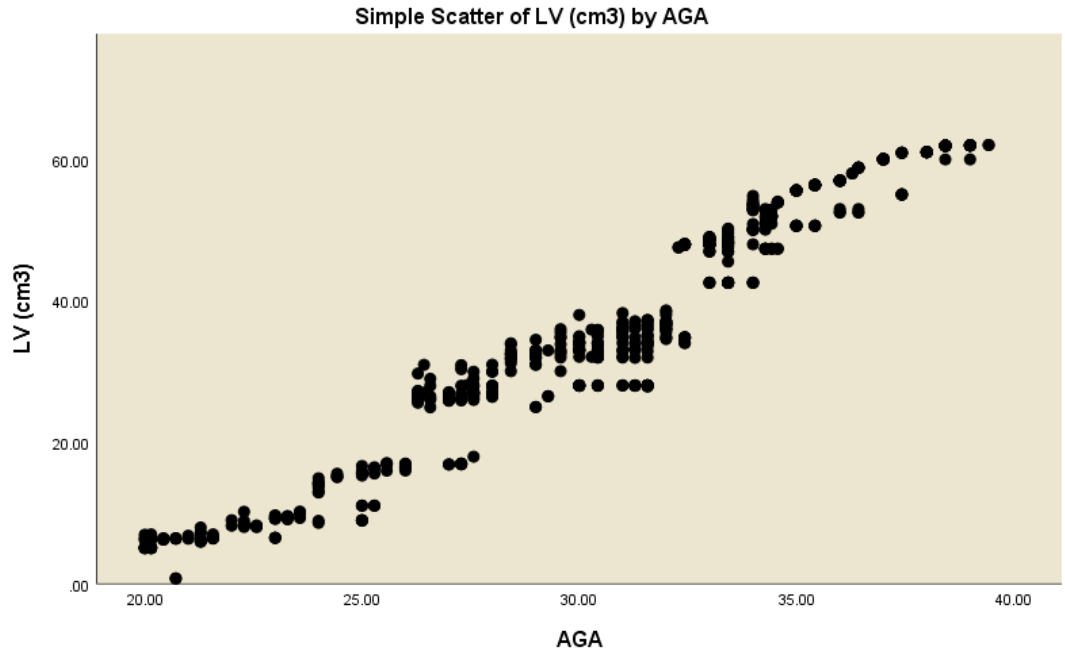

Fig. 1. simple scatter diagram of average gestational age (AGA) against foetal liver volume (LV).

DISCUSSION

Table 2 provides an age-stratified breakdown of pre-eclampsia prevalence, underscoring the importance of age as a factor in disease susceptibility. However, the observed age distribution is characterized by a slight preponderance of younger mothers, contrasted with a marked underrepresentation of older mothers (44-46 years), who comprised a mere 0.33% (n = 2) of the study sample. This finding aligns with established knowledge on age-related declines in fertility and pregnancy rates. The maternal age distribution in this study reveals a peak participation rate among women aged 26-28 years 18.77% (n = 113), with similar proportions observed among those aged 20-22 years 18.46% (n = 111) and 29-31 years 17.24% (n = 104). This finding is consistent with the National Population Commission's (2019) report, which identifies 20-29 years as the peak reproductive age range for Nigerian women.

The findings reveal fascinating patterns in the association between GA and pre-eclampsia. The overall pre-eclampsia prevalence was 21.6% (n = 130), with 78.4% (n = 472) of mothers having normal pregnancy outcomes. Notably, the results of this study diverge from those of previous studies, which was reported a prevalence rate of 4.51%[12], 16.7%[13], and 8.8%[14]. In contrast, the prevalence rate of pre-eclampsia in Northern Nigeria is remarkably high, accounting for approximately 40% of maternal mortality in the region[15]. Unfortunately, no specific percentage or exact prevalence rate for Northern Nigeria was found to compare with the finding of this study. Nonetheless, it is worth noting that PreE is a significant public health concern across Nigeria, affecting approximately 37,000 women annually[15].

A clear trend of increasing foetal liver volume with gestational age was observed in both pre-eclampsia and apparently healthy mothers. This finding is consistent with previous studies[8,16,17,18]. However, in every gestational age group, the mean foetal liver volume is consistently smaller in pregnancies complicated by PreE compared to those without PreE ($p < 0.001$). Furthermore, the data reveal a consistent disparity favouring the normal group in terms of foetal liver volume across all gestational age intervals. In the earliest gestational age group (20.00-22.86 weeks), the mean foetal liver volume for the PreE group was recorded at 5.69 ±0.63 cm^3, while the normal group exhibited a higher mean of 6.96 ±1.83 cm^3. This disparity in foetal liver volume becomes more pronounced in subsequent gestational age groups. For example, in the 23.00-25.86-week age group, the mean foetal liver volume is 9.00 ±1.72 cm^3 for the PreE group, compared to13.16 ±2.97 cm^3 for the normal group. The most significant differences are observed in the later gestational age brackets. At 38.00-40.86 weeks, the mean foetal liver volume for the PreE group was 60.00 ±0.00 cm^3, while the normal group showed a slightly higher mean of 61.74 ±0.42 cm^3. These findings suggest that maternal pre-eclampsia status significantly impacts foetal liver development, potentially influencing foetal growth and well-being. The observed differences in foetal liver volume across gestational age groups emphasize the importance of monitoring foetal growth in PreE pregnancies.

The study shows that maternal PreE has a clear impact on foetal liver development. Foetal liver volumes are consistently smaller at all gestational ages when compared to normal pregnancies. The rate of PreE observed in this study is 21.6%, which is significantly higher than previously reported rates in other areas. This highlights the serious public health issue it poses in the study population. These findings suggest that problems in foetal liver development may lead to negative foetal outcomes linked to PreE.

Integrate foetal liver volume into regular monitoring for PreE. Strengthen public health screening and interventions in areas with high prevalence. Pursue larger multi-centre studies to set standard reference values and evaluate long-term outcomes were recommended.

Conclusion: Sonography effectively identified a significant reduction of foetal liver volume in pregnancies complicated by pre-eclampsia.

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Competing Interest: The authors declare that there are no conflicts of interest related to this work.

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CORRELATION BETWEEN GLYCATED HEMOGLOBIN AND LIPID PROFILE STATUS AMONG NEWLY-DIAGNOSED TYPE 2 DIABETICS OF INDIVIDUALS OF THREE ETHNIC GROUPS IN SOKOTO, NIGERIA

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ABSTRACT

Background: Glycated haemoglobin (HbA1c) has been suggested to be a better predictor for coronary heart disease and strongly associated with atherosclerosis. Changes in lipid profile is linked with severity of diabetes as adjudged by HbA1c. Lipid abnormalities are common in type 2 diabetics, but the pattern may vary between ethnic groups.

Aim: The current study was undertaken to explore the association of HbA1c and serum lipid profile parameters in type 2 diabetics among persons of three ethnic groups in Sokoto.

Methods: The current study was a cross-sectional case-control study. The Cochran formula was used to determine the number of subjects recruited. Demographic and clinical characteristics were obtained from all the participants. HbA1c and lipid profile parameters were determined using standard laboratory tests. Ranges for TC <200mg/dl, TG <150mg/dl, LDL-c <100mg/dl and ranges between 51-60 for females and 41-60 for males for HDL-c were considered dyslipidaemia. All data were presented using mean and standard deviation, while independent samples t-test and one-way analysis of variance (ANOVA) followed by Bonferroni multiple comparison test to evaluate the

mean differences between the groups at statistical significance of <0.05.

Results: The mean values for serum HbA1c were slightly higher in diabetic groups (7.58±0.87 for Hausa/Fulani, 7.23±0.58 for Igbo and 7.34±0.67 for Yoruba) compared to their corresponding control groups (5.21±0.56 for Hausa/Fulani, 5.15±0.55 for Igbo and 5.21±0.55 for Yoruba) with p<0.0001. Serum levels of total cholesterol, triglyceride and LDL-c in diabetic group (207.99±89.82, 183.16±60.76 and 101.27±52.19 respectively) were higher than the control group (161.68±27.64, 137.14±24.18 and 90.16±28.14 respectively) p<0.0001; whereas, HDL-c was decreased in diabetics (37.26±12.90) than the control group (46.64±11.15) p<0.005. The HbA1c correlated with increased TC, TG and LDL-c (r = 0.483269, 0.623952 and 0.390193 respectively) p=0.0001 and decreased HDL-c level (r= -0.247900) p=0.0001.

Conclusion: It was concluded that HbA1c is positively correlated to dyslipidaemia. HbA1c may be considered as an indirect predictor for dyslipidaemia. The current study therefore, recommend adequate glycaemic control via serum evaluation of HbA1c among type 2 diabetics irrespective of ethnic background.

Keywords: Type 2 diabetics, Glycated haemoglobin, Lipid profile, Sokoto Ethnic Groups

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INTRODUCTION

Diabetes mellitus (DM), a heterogeneous group of metabolic disorders is characterized by persistent hyperglycaemia with interruptions in carbohydrates, fats and protein metabolism due to relatively or absolute lack of insulin secretion, insulin action or both.[1] Type 2 diabetes (T2DM) is considered globally to be one of the most pervasive non-communicable diseases. Long-term damage, dysfunction, and failure of various organs, most especially the eyes, kidneys, nerves, heart, and blood vessels are the consequences of uncontrolled hyperglycaemia.[2] Abnormalities in lipid profile parameters among diabetics are often termed as “diabetic dyslipidaemia” typically characterized by increased serum levels of total cholesterol (TC), triglycerides (TG) and low density lipoprotein cholesterol (LDL-c) as well as decreased serum level of high density lipoprotein cholesterol (HDL-c). Diabetes dyslipidaemia may be a risk factor for macrovascular (stroke, peripheral vascular disease, and coronary artery disease [CAD]) and microvascular (nephropathy, neuropathy, and retinopathy) complications in type 2 diabetics.[1,2]

Glycated haemoglobin (HbA1c), a form of haemoglobin chemically connected to a sugar, is considered a gold-standard measure of chronic glycaemia in diabetes. Glycated haemoglobin (HbA1c) has been a better predictor of coronary heart disease (CHD) than the fasting blood sugar (FBG) or 2-hpp glucose; and also strongly associated with atherosclerosis.[2] Measurement of HbA1c in both type 1 and

2 diabetes was recommended, first to determine the degree of glycaemic control and for continuous diabetes management.[1]

Type 2 diabetics often exhibit an atherogenic lipid profile, which greatly increases the risk of cardiovascular disease (CVD) compared to non-diabetics. About 50% of type 2 diabetics die of CVD (primarily heart disease and stroke).[3] Individuals with T2DM have two- to four-fold increased risk of coronary artery disease (CAD), the leading cause of death in diabetes.[4] Changes in lipid profile is also well related with severity of diabetes as adjudged by HbA1c.[5] Lipid abnormalities are common in T2DM, but the pattern of the different lipids may vary between ethnic groups, economic status as well as health care system.[6] Hence, the current study was undertaken to explore the correlation of serum lipid profile parameters with glycated haemoglobin in type 2 diabetics of three ethnic groups (Hausa/Fulani, Igbo and Yoruba) in Sokoto, North West, Nigeria.

MATERIALS AND METHODS

Site of Study

The study participants were males and females with type 2 diabetes attending diabetic clinics at Specialist Hospital Sokoto, Women and Children Hospital Sokoto and Maryam Abacha Hospital Sokoto and recruited using a purposive sampling technique. Apparently healthy individuals (age-, sex, ethnic- matched) served as controls were also similarly recruited within the metropolis.

Study Population

The study was conducted among the three major ethnic groups: the Hausa/Fulani, Yoruba and Igbo situated in the north, west, and east respectively, together comprising over 70% of the total population. The total of 300 participants recruited comprised of 100 participants each for Hausa, Igbo and Yoruba ethnic groups, aged 18-54 years. The total of 174 were Males and 126 were Females. The participants were divided into six groups (3 groups were type 2 diabetics and 3 groups were healthy control). Of the 174 male participants Hausa/Fulani has 56 male, Igbo has 64 males and Yoruba has 54 males. The remaining 44 participants, 36 participants and 46 participants were female for Hausa/Fulani, Igbo and Yoruba respectively. Ethnic backgrounds were identified through clinical records, informed consent form and questionnaire administered.

Study design

The study design was a cross-sectional case-control study. The diabetic participants were consecutively recruited at the diabetic clinics.

Ethical consideration and clearance

Ethical approvals were duly was sought and obtained Sokoto state ministry of health with reference number SMH/1580/V.IV.

Informed consent

Informed consent for inclusion into the study was duly obtained from each participant using standard protocol prior to recruitment.

Instrument for data collection

Self-structured questionnaire was prepared and administered to all the study participants to obtain their socio-demographic characteristics including, gender, age, tribe, occupation, life style, family history of DM, history of DM, etc.

Sample Size Determination

Calculation of sample size of the study, using Cochran formula (1977).[7]

$n=Z^2P(1-P)/d^2$

Where, n= desired sample size

P= Prevalence rate of diabetes in Nigeria = 7.0% = 0.07 (Michael. *et al.*, 2024).[8]

Z= 95% confidence interval=1.96

W= degree of accuracy= 0.05

Therefore,

n =118, approximated to150, thus we have equal sample size (n=50) for each ethnic groups.

Inclusion Criteria

Newly diagnosed type 2 diabetics (with first diagnosis ≤ 2 years), under good glycemic control (HbAIc = 6.5-7.3%) of both sexes (aged between 18 to 55 years old), non-hypertensive and without any apparent disease condition and who reside in the Sokoto metropolis were included for this study. Age-, sex-, tribe- and BMI-matched healthy individuals who had given their informed consent were included in the study

Exclusion criteria

Patients with other disease conditions such as HIV/AIDS, tuberculosis, thyroid disorder, pregnant women and hypertensive were excluded from the study. Other conditions such as retinopathy, nephropathy, and neuropathy were also excluded from the study.

Sample collection and analytical techniques

Blood pressure was measured using the Belsk digital blood pressure monitor (Northfield, IL 60093 USA). The body height and weight were also measured using appropriate instrument (Mechanical Brecknell HS-200M scale, UK). A systolic blood pressure of ≥ 140 mmHg and diastolic blood pressure of ≥ 90 mmHg were considered hypertensive.[9] Body mass index (BMI) was calculated using the equation: Weight in (Kg)/Height (M^2). Values of 20-25, <30 but > 25, >30 and <20 were considered Normal, overweight, obese and underweight respectively. Blood glucose was tested in capillary blood samples by glucose oxidase and peroxidase methods.[10] Four milliliters of venous blood were collected in a red top tube with a clot activator collected from each participant by venipuncture using a 21G needle. It was then subjected to centrifugation at 3000 rpm for five min and the obtained serum was used to test for HbA1C, TG, TC, and HDL. Humastar 80 Auto Analyzer (Human, Wiesbaden. Germany) was utilized to measure the concentration of TC, TG, and HDL in the sera. Glycated hemoglobin was measured as described by Prosenz *et al.*, 2019.[11]

Data analysis

All data were summarized using mean and standard deviation. One-way analysis of variance (ANOVA), followed by Bonferroni multiple comparison test, and independent t-test to evaluate the mean difference of the data between the groups (control and type 2 diabetics). The correlations were measured using Pearson's coefficient of correlation (r) between study variables. Analysis was done at the 95% confidence level and the statistical significance was considered when p-value <0.05.

RESULTS

Table 1 shows the Socio-demographic and clinical characteristics of the study participants. The mean age of the diabetic participants was 50.04±6.64 compared to that of control subjects 45.97±7.58 (p>0.05). The total of 300 participants recruited for this study comprised of 174 (58%) Males and 126 (42%) Females. Of the 174 male participants, Hausa/Fulani has 56 (56%), Igbo has 64 (64%) and Yoruba has 54(54%); while females were 44(44%), 36(36%) and 46(46%) for Hausa/Fulani, Igbo and Yoruba respectively. Table 1 further presents the body mass index (BMI) of the study participants. The mean average BMI of the diabetics was higher compared to control subjects (F=2.741; p <0.05). No statistically significant difference observed in mean systolic and diastolic blood pressure for diabetics of the ethnic groups compared to their corresponding control (F=0.127; p>0.05).

Table 2a showed the mean fasting blood glucose (FBG), HbA1c and lipid profiles of diabetes mellitus and control participants. The mean concentration of FBS, HbA1c, TC, TG and LDL-c (122.20±17.60, 7.39±0.73, 207.99±89.82 and 101.27±52.19 respectively) in the diabetics were significantly higher than those in the control group (93.26±8.68, 5.19±0.55, 161.68±27.64, 137.14±24.18 and 90.16±28.14 respectively) (p<0.05). However, the mean values for HDL-c in diabetics (37.26±12.90) was significantly lower than the control group (46.64±11.15) (p<0.05).

Table 2b showed the mean FBG, HbA1c and lipid profiles of diabetes mellitus and control Hausa, Igbo and Yoruba participants. Higher TC (mg/dl) levels were observed in diabetics of the different ethnic groups (203.74±89.49 for Hausa/Fulani, 216.51±90.35 for Igbo and 203.71±90.29 for Yoruba) compared to their corresponding control groups (159.71±27.70, 162.60±27.15 and 162.74±28.35 respectively) (F= 17.474; p<0.0001), Table 2b. Higher levels of TG were similarly higher in the diabetics of the different ethnic groups (181.21±59.85 for Hausa/Fulani, 189.41±63.40 for Igbo and 178.87±0.67 for Yoruba) with compared to their corresponding control groups (F= 14.083; p<0.0001). Table 2b further showed higher levels of LDL-c (mg/dl) in diabetics compared to control of the different ethnic groups (100.05±51.46 for Hausa/Fulani, 104.82±53.98 for Igbo and 98.94±51.67 for Yoruba) (F= 9.815; p<0.05). Table 2b further showed that HDL-c (mg/dl) was lower in diabetics of the different ethnic groups (34.92±13.72 for Hausa/Fulani, 39.72±12.37 for Igbo and 37.15±12.68 for Yoruba) compared to their corresponding control groups (F=6.015; p<0.05).

Table 3 showed the correlation between HbAIc and serum lipid profile of the study population, HbAIc was found to be associated with increased TC, TG and LDL-c (r=0.432284, 0.569792 and 0.339701 respectively) (p=0.000001). HbAIc was associated with decrease in serum HDL-c (r= -0.247900) p=0.000001.

Table 1: Socio-demographic and clinical characteristics of the study participants

Groups		Mean age (Years)	Gender Male (%)/Female (%) N N	BMI (Kg/m^2)	SBP (mmHg)	DPB (mm/Hg)	Hypertensive: no N(%)/yes N(%)
All Participants	T2DM (n=150)	50.04±6.64	87(58)/63(42)$^{\&}$	30.71±5.15*†	128.95±9.47	80.80±5.01	150(100)/0(0)
(n=300)	Control(n=150)	45.97±7.58	87(58)/63(42)	24.15±4.18	114.06±7.08	79.24±4.57	150(100)/0(0)
Hausa/Fulani	T2DM(n=50)	55.57±7.39	28(56)/22(44)	27.59±4,90	123.74±9.30	78.17±5.00	50(100)/0(0)
(n=100)	Control(n=50)	42.27±8.11	28(56)/22(44)	23.21±4.62	115.18±7.78	69.78±3.80	50(100)/0(0)
Igbo	T2DM(n=50)	55.04±6.34	32(64)/18(36)	32.6±4.60*†	129.37±8.36	72.64±4.19	50(100)/0(0)
(n=100)	Control(n=50)	46.98±7.48	32(64)/18(36)	25.6±3.71	116.71±6.41	74.48±4.89	50(100)/0(0)
Yoruba	T2DM(n=50)	54.51±6.18	27(54)/23(46)	29.81±5.50	131.74±8.42	78.57±4.60	50(100)/0(0)
(n=100)	Control(n=50)	48.65±7.14	27(54)/23(46)	23.6±2.72	110.30±5.94	71.48±4.18	50(100)/0(0)
	F value	6.015	3.474	2.751	0.122	0.127	4.384
	P value	>0.05	>0.05	<0.05	>0.05	>0.05	>0.05

Values are mean ± Standard Deviation of the mean of age, SBP, DBP and BMI ,n= number of participants, T2DM= type 2 diabetics, %= percentage, Kg/m^2, kilogram per meter square; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; BP. Blood pressure, n, sample size; †= comparison between patients and control, &= comparison within the group, and *=p≤0.05 was considered significant in the statistical analysis t-test

Table 2a: Mean (+/- SD) fasting blood glucose, HbA1c and lipid profiles of diabetes mellitus and control participants

Groups		FBS (mg/dL)	HbAIc (%)	TC (mg/dL)	TG (mg/dL)	HDL-c (mg/dL)	LDL-c (mg/dL)
All Participants (n=300)	Diabetes mellitus (n=150)	122.20±17.60***†	7.39±0.73*†	207.99±89.82***†	183.16±60.76***†	37.26±12.90*†	101.27±52.19**†
	Control (n=150)	93.26±8.68	5.19±0.55	161.68±27.64	137.14±24.18	46.64±11.15	90.16±28.14
	p-value	0.000001	0.041232	0.000001	0.000001	0.025210	0.000162

Values are mean ± Standard Deviation of the mean of FBS, LP and HbAIc , glycated hemoglobin; n, number of participants; %, percentage,; †= comparison between patients and control, *=p≤0.05, **=p≤0.01 and ***= p≤0.000001 were considered significant in the statistical analysis t-test.

Table 2b: Mean (+/- SD) fasting blood glucose, HbA1c and lipid profiles of diabetes mellitus and control Hausa, Igbo and Yoruba participants

Ethnicity	Groups	FBS (mg/dL)	HbAIc (%)	TC (mg/dL)	TG (mg/dL)	HDL-c (mg/dL)	LDL-c (mg/dL)
Hausa/Fulani (n=100)	Diabetes mellitus (n=50) (A)	127.70±23.48	7.58±0.87	203.74±89.49	181.21±59.85	34.92±13.72	100.05±51.46
	Control(n=50) (B)	92.80±8.95	5.21±0.56	159.71±27.70	132.91±18.89	46.61±11.23	93.51±30.30
Igbo (n=100)	Diabete mellitus (n=50) (C)	118.12±10.62	7.23±0.58	216.51±90.35	189.41±63.40	39.72±12.37	104.82±53.98
	Control(n=50) (D)	91.68±8.94	5.15±0.55	162.60±27.15	139.38±26.00	46.55±11.19	89.10±26.95
Yoruba	Diabetes mellitus (n=50) (E)	120.80±14.98	7.34±0.67	203.71±90.29	178.87±0.67	37.15±12.68	98.94±51.67
(n=100)	Control(n=50) (F)	95.31±7.82	5.21±0.55	162.74±28.35	139.14±26.66	46.75±11.18	87.88±27.13
	F- value	17.384	5.972	17.474	14.083	6.015	9.815
	P-value	0.000001	0.041232	0.000001	0.000001	0.025210	0.000162
	Post hoc						
	A vs Bs	0.000001 S	0.041232 S	0.000001 S	0.000001 S	0.025210S	0.000162 S
	A vs C	0.132128 NS	0.142503 NS	0.534868 NS	0.092128 NS	0.182503 NS	0.734168 NS
	A vs E	0.634868 NS	0.634868 NS	0.634868 NS	0.634868 NS	0.634868 NS	0.634868 NS
	C vs E	0.142503 NS	0.934868 NS	0.132503 NS	0.212503 NS	0.714868 NS	0.142503 NS
	C vs Ds	0.000001 S	0.041232 S	0.000001 S	0.000001 S	0.025210S	0.000162 S
	B vs D	0.225092 NS	0.301503 NS	0.221092 NS	0.234192 NS	0.181503 NS	0.256092 NS
	B vs F	0.412092 NS	0.456868 NS	0.321154 NS	0.191092 NS	0.452868 NS	0.271154 NS

Values are mean ± Standard Deviation of the mean of FBS, LP and HbAIc , glycated hemoglobin; n, number of participants; %, percentage,; †= comparison between patients and control, *=p≤0.05, **=p≤0.01 and ***= p≤0.000001 were considered significant in the statistical analysis t-test., **Key:** S = Significant, NS = Not Significant

Table 3: Correlation between FBG, HbAIc and BMI with serum lipid profiles of the study population

Parameters		TC (mg/dL)	TG (mg/dL)	HDL-c (mg/dL)	LDL-c (mg/dL)
HbAIc (%)	r value	0.432284**	0.569792**	-0.247900**	0.339701**
	P value	0.000001	0.000001	0.000001	0.000001

**** Correlation is significant at the < 0.01 level (2-tailed).**

DISCUSSION

In this study, the mean values of glycated haemoglobin (%) in diabetics were significantly increased compared to controls. The diabetes complications and control trial (DCCT) considered HbA1c as the gold standard of glycaemic control. Similar findings were also observed in a study conducted by Pasupathi *et al.*, (2018).[14] Mean values of serum Total cholesterol, Triglycerides and LDL-c, in diabetics were higher than the mean values observed in non- diabetic healthy controls ($p<0.05$). However, decreased serum levels of HDL-c were observed in diabetics compared to controls. Similar findings were observed in a study by Samatha *et al.*, (2012)[15] with increased levels of mean total cholesterol, triglyceride and LDL-cholesterol diabetics compared to controls. A significant positive correlation was observed between HbAIc and serum total cholesterol, TG, LDL-c (r=0.339701). In contrast, a significant negative correlation was observed between HbAIc and HDL-c (r=-0.247900).

Similarly, Albrki *et al.*, 2017[16] and Idogun *et al.*, 2017,[17] observed a significant positive correlation between HbA1c and serum total cholesterol, serum triglyceride and serum LDL-cholesterol ($r<0.508$); and a significant negative correlation (r=-0.300) between HbA1c and serum HDL-c. Diabetics with elevated HbA1c and serum lipid values are at very high-risk for cardiovascular disease (CVD). Significant correlations between HbA1c and the lipid parameters and a linear relationship between HbA1c and dyslipidemia point towards the usefulness of HbA1c in screening diabetics at higher risk. It has been estimated that reducing HbA1c levels by 0.2% could lower the cardiovascular risk by 10%.[18]

Patients with diabetes have been evidently recognized with arising complications due to the continuous hyperglycaemic episodes through numerous mechanisms like dyslipidaemia, platelet activation, and altered endothelial metabolism.[19] Both lipid profile and diabetes have been shown to be the vital forecasters for metabolic disorders including cardiovascular complications, dyslipidaemia and hypertension.[20] Blood lipid levels are modifiable risk factors for coronary heart diseases (CHDs). Being hydrophobic in nature, cholesterol, cholesterol esters, triglycerides and phospholipids are

transported to the other tissues in the form of lipoproteins such as chylomicrons, LDL and HDL. Elevated plasma levels of non-HDL lipoproteins are major risk factor for CHD. Dyslipidaemia as a metabolic irregularity is recurrently connected with diabetes mellitus.[21]

In the current work, significantly elevated serum levels of total cholesterol, triglycerides and LDL cholesterol were figured out in patients with diabetes, which are well-identified threat causes for cardiovascular diseases. The prevalence rates for high total cholesterol, very high LDL-C and low HDL-C were seen in the diabetic subjects. HbA1c is done to monitor the control of blood glucose in diabetes mellitus. Several studies have shown the positive correlation of HbA1c with duration of diabetes and as a strong risk factor for cardiovascular diseases in diabetes.[22]

According to a study conducted by Palem SP[23] type 2 diabetes patients with high level of Hb1Ac were at a higher risk of developing cardiovascular diseases in future. The results of the study conducted by Hussain *et al*[24] proved that HbA1c can also be used as a predictor of dyslipidaemia and thus early diagnosis of dyslipidaemia can be used as a preventive measure for the development of CVD in patients with type 2 diabetes. In this present study, we found a statistically significant increase in TC, LDL TG and decrease in HDL among the diabetics compared to control group which is in agreement with the study conducted by Ali *et al*.[25] where diabetic group had high level of TC, TG, LDL, and low level of HDL in comparison to non-diabetic subjects.

HbA1c is considered a key and more accurate criterion in diabetes management than fasting blood glucose levels. HbA1c levels offer an index for long-term glycaemic control related to two to three months of average blood glucose concentration.[21] It has been evident that lowering HbA1c is associated with a reduction in microvascular and macrovascular complications in diabetes.[25] The HbA1c value <7.0% reduced the risk of cardiovascular diseases and value >7.0% leads to dyslipidaemia and thus prone to CVD. It is also reported that lower levels of HbA1c in type 2 diabetics decreases the absolute risk of developing CHD by 5-17%, as well as decreasing all-cause mortality by 6-15%.[20]

A number of studies conducted on type 2 diabetes patients showed that a high levels of HbA1c is positively corelated to higher levels of cholesterol, TGs, and LDL-C.[26, 27] However, investigation on Nepal diabetic population suggested that patients with HbA1c >7.0% did not have different HDL-C compared to the patients with HbA1c≤7.0%,[25] Indeed, a number of studies revealed that inappropriate levels of lipid profile might predict high HbA1c value.[23,26,27]

CONCLUSION

It was concluded that type 2 diabetics were more susceptible to dyslipidaemia. HbA1c, a biomarker for glycemic control, may also be considered as an indirect predictor for dyslipidaemia. The current study therefore, recommend adequate glycaemic control via serum evaluation of HbA1c among type 2 diabetics irrespective of ethnic background.

Competing Interest: There is no conflict of interests.

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THERAPEUTIC POTENTIAL OF LASER THERAPY AND TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION IN CHRONICALLY INFECTED WOUNDS: A NARRATIVE REVIEW

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ABSTRACT

Chronic wounds such as diabetic foot ulcers, pressure ulcers, and venous leg ulcers pose a significant global health burden due to prolonged healing, recurrent infections, and high treatment costs. Traditional wound care often fails to adequately manage these complexities with chronic wounds, particularly when complicated by biofilm-forming, antibiotic-resistant pathogens.

This narrative review evaluates the therapeutic potential of two non-invasive biophysical modalities: Light Amplification by Stimulated Emission of Radiation (LASER) and Transcutaneous Electrical Nerve Stimulation (TENS) for chronically infected wounds. LASER therapy promotes healing through photo-biomodulation by enhancing mitochondrial activity, angiogenesis, collagen synthesis, and photodynamic bacterial destruction.

TENS facilitates healing via pain modulation, improved microcirculation, reduced inflammation, and fibroblast stimulation. Clinical and preclinical evidence highlights the efficacy of both modalities in accelerating wound closure, promoting tissue regeneration, and reducing infection. Furthermore, combining LASER and TENS may offer synergistic benefits by targeting multiple aspects of wound pathophysiology.

Although current evidence is promising, further randomized controlled trials are necessary to establish standardized protocols and evaluate long-term outcomes. Integrating LASER and TENS into multidisciplinary wound care could

significantly enhance healing in patients with chronic wound infections.

Keywords: LASER Therapy, Photo-biomodulation, Transcutaneous Electrical Nerve Stimulation, Wound Infection

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INTRODUCTION

Chronic wounds, including diabetic ulcers, pressure ulcers, and venous leg ulcers, present a major healthcare challenge worldwide[1,2]. The health care cost associated with chronic wounds amounts to Billons in funding in the general population[2,3]. The United States has a record of 1 in 30 Americans with diabetes developing a foot ulcer annually and 1% incidence rate of venous ulcer in the population[2, 4]. These wounds are often painful and slow to heal, leading to significant morbidity and poor quality of life for the affected individuals[1,2,3,4,5]. Specifically, chronic wounds are defined as wounds that fail to progress through the normal phases of healing within an expected time frame of typically 3 months[2,3,6].

Pathophysiology of Chronically Infected Wound

A few etiological risk factors of chronic wounds include wounds in patients with diabetes mellitus, venous insufficiency, and arterial diseases[2,7,8]. Majorly, risk factors of chronic wounds are categorized into local and systemic risk factors. Local risk factors result from lack of oxygen or infection, while systemic risk factors are linked to modifiable and non-modifiable risk factors such as overweight, smoking, malnutrition, impaired mobility, diabetes, and sex[9]. The pathophysiology of chronic wounds is complex and involves persistent inflammatory response, defective cell signalling, and a protracted cycle of tissue destruction and regeneration[5]. Remarkably, chronic infections, delayed tissue regeneration, and chronic inflammation contribute to the poor healing outcomes seen in these wounds[5,10].

Infection is often a complicating factor of chronic wounds with biofilm-forming *Pseudomonas aeruginosa* and *Staphylococcus aureus* contributing to prolonged inflammation and delayed healing[11,12,13]. Also, it is believed that certain species of anaerobic microbes, including *Bacteroides spp., Prevotella spp., Porphyromonas spp, Peptostreptococcusspp, Bacillus anthracis, beta-haemolytic streptococci, Enterococcus spp*, and *Enterobacteriaceae* are associated with chronic wound infections[11-13]. Microbial colonization is the hallmark of chronic wound infection, and it occurs following wound contamination, thereby leading to chronic wound infection[12]. These microbe colonization of chronic wounds manifests characteristic signs and symptoms of poor perfusion, offensive odours, intense pain, cell death with slough formation appearing yellow, green, or white in coloration)[12,13].

Consequently, significant impediments are encountered in the management of chronically infected wounds with traditional

wound care strategies, especially in the event of concomitant factors such as impaired vascular supply, local pressure at the wound site, neuropathy, sustained inflammation, lack of angiogenesis, altered cell proliferation, overuse of antibiotics leading to bacteria resistance (antibiotic crisis), and factors associated with wound dressing, preparation and/or surgical debridement[1,14-16]. While the advancement in the treatment strategies of wound preparation, dressing, and debridement is quite promising[14-16], there appears to be neglect in the use and advancement of non-surgical strategies for chronically infected wounds.

Overview of Biophysical Agents in Wound Care

Over the years, novel therapeutic physical modalities have been advocated to enhance chronic wound healing. There are indications that Transcutaneous Electrical Nerve Stimulation (TENS), Ultraviolet Radiation (UVR), Light Amplification by Stimulated Emission of Radiation (LASER), Ultrasound therapy, and shortwave diathermy are capable of resolving chronically infected wounds[16,17]. These physical modalities, otherwise known as biophysical agents, appear to be effective in addressing both infection and the defective healing mechanisms in chronic wounds[16]. Given that tradition methods of wound management are often insufficient when dealing with persistent inflammation and infections seen in chronic wounds, it is imperative to consider these biophysical agents which, though non-pharmacological in application, have potential for activating endogenous therapeutic substances in the tissues of patients with chronically infected wounds. This narrative review explored the potential of LASER and TENS for the treatment of chronically infected wounds. The review discussed the rationale and mechanisms of action of each modality, present recent clinical and preclinical evidence supporting their use, and the methods of optimizing these therapies for chronically infected wounds.

METHODOLOGY

A search was conducted on Google Scholar, Scopus, Medline, and Web of Science using combined keywords such as LSAER and chronic wounds, TENS and chronic wounds, and Electrical stimulation and chronic wounds for articles and book titles. Relevant articles and book titles relating to the use of LASER therapy and TENS for chronic wounds were selected for this review.

LASER Therapy in Chronically Infected Wounds

LASER remains low-risk, cost-effective physical modality with promising outcomes in the treatment of chronic wound infections[18-20]. Generally, the literature revealed that LASER has a broad range of therapeutic effects in wound healing. LASER has been shown to activate mitochondrial activity by stimulating the mitochondria within cells, which increases adenosine triphosphate production that supports cellular functions necessary for tissue repair, such as protein synthesis, cell migration, and wound contraction[18-20]. There is evidence that LASER modulates inflammatory cytokines, thereby reducing

excessive inflammation in chronic wounds[18-20]. By reducing pro-inflammatory mediators, LASER helps to return the wound healing process to its normal pace, enhancing cell recruitment to the wound site[18-20]. Additionally, LASER enhances the formation of new blood vessels (angiogenesis) and promotes collagen synthesis, essential for wound closure[20,21]. These processes are especially beneficial in chronic wounds where vascularization and tissue regeneration are impaired.

Mechanism of Action

Basically, LASER modalities are classified into two main types, namely, class IIIb or low-level laser therapy (LLLT), which has non-thermal effects and lesser tissue penetration, and class IV or high-intensity laser therapy (HILT), which has thermal effect and deeper tissue penetration[22]. The LLLT has photo-modulatory effects in biological tissues and is used to promote healing in chronic wounds such as diabetic ulcers, pressure sores, and venous leg ulcers[22]. In diabetic foot ulcers, LLLT was found to reduce wound size and improve re-epithelialization[22]. While in pressure ulcers, LLLT was found to aid faster wound closure and pain relief[22]. On the other hand, HILT was reported to have the ability to induce chemical, thermal, and mechanical and bio-stimulating actions capable of reaching the deeper tissues[22-24]. It has been shown to reduce musculoskeletal pain[23]. HILT is reported to deliver LASER energy faster than LLLT and is known to stimulate a larger surface tissue area than LLLT[20-22].

However, and more specifically, LASER finds application in chronically infected wounds as a photodynamic therapy (PDT) tool[25]. As a PDT tool, LASER combines the attributes of delivering light at a particular wavelength, a photosensitizer, and oxygen inducer that is capable of obliterating an infecting organism in chronic wounds[25]. The extent of penetration is dependent on the type of LASER used[21], although PDT tools differ in their means of delivering oxygen to the wound site[26]. The commonly used Type-II PDT generates oxygen through energy transfer within the wound site, which is limited by oxygen concentration in infected sites, unlike the Type-I PDT that is capable of generating oxygen via electron transfer when photons are absorb by the photosensitizer[26]. Overall, the use of LASER in chronically infected wounds is superior to antibiotics, especially in cases of antibiotics-resistant bacteria in chronic wounds[26].

Clinical Evidence

Several studies have demonstrated the effectiveness of LLLT in treating chronic wounds. Previous studies analysed the literature evidence in support of LLLT, including its ability to accelerate healing in chronic diabetic foot ulcer with a shorter time of complete healing compare to a control group[27,28]. A recent study found that LLLT demonstrated superior therapeutic outcomes compared to shockwave therapy[29]. There is consistent evidence that LLLT accelerates wound closure, promotes angiogenesis, and enhances fibroblast migration[18,30]. An animal model of chronic skin wounds demonstrated that LLLT significantly enhanced collagen deposition and re-epithelialization[18].

Optimization Parameters

Optimizing LASER Therapy: Wavelength, power density, and treatment duration are critical factors in optimizing LLLT[18]. For chronic wound healing, red (600–700 nm) and near-infrared (800–900 nm) wavelengths are most commonly used, as they penetrate deeper into tissues and stimulate the desired biological effects[18].

TENS Therapy in Chronically Infected Wound

Electrical stimulation (ES) of chronic wounds is the application of electric currents on the wound surface via electrodes placed directly on the wound. Wound healing by gentle electrical fields is a promising area of research that has shown significant potential in accelerating the healing process[31]. The use of ES was strongly recommended by the 2019 international guidelines for pressure ulcer to facilitate wound healing in recalcitrant Category/Stage II pressure ulcers, as well as any Category/Stage III and IV pressure ulcers[32]. In one study, ES of chronic wounds was shown to enhance cellular migration by inducing the migration of fibroblasts, keratinocytes, and macrophages to the wound site[31]. Also, ES of wounds induces angiogenesis, collagen synthesis, and anti-inflammatory effects by decreasing pro-inflammatory mediators[33,34]. Additionally, ES have bactericidal effects in chronically infected wounds[31,32,34]. Emerging studies revealed promising results in the management of chronic wounds by embedding ES in bandages through advanced technologies[33-36]. The studies demonstrated substantial evidence that ES of wounds accelerated wound closure by 30%, reduced scarring in mice and sped up wound closure[33-35].

There are different forms of ES, including the use of direct current (DC), alternating current (AC), pulsed current (PS), degenerative wave, high-voltage pulsed current (HVPC), microcurrent ES, and the transcutaneous electrical nerve stimulation (TENS)[31,34,37]. The DC is also known as galvanic current and is the use of continuous, unidirectional flow of charged particles from one pole to the other lasting 1 second or longer, while HVPC is the delivery of pulsed DC current via short monophasic pulses at an amplitude from 100 to 500 V [36]. Also, microcurrent ES is the use of pulsed monophasic low-voltage form of electrical stimulation, while TENS is the use of biphasic or modified AC currents[37]. However, the advantage using TENS in the management of chronic wounds over other forms of ES lies in its being inexpensive, portable, readily available, and easy to use for everyone with little precautions.

Mechanism of Action

Therapy involving TENS as a form of ES for chronic wounds uses low-voltage electrical currents applied through the skin around a wound surface or directly on the wound surface to stimulate cellular processes that support tissue repair and regeneration[38]. Originally, TENS was developed for pain relief, and studies have demonstrated that it aids pain relief, especially immediately after its application[39,40]. The only inadequacy in the use of TENS for pain relief is its inability to remove the root cause of the pain. TENS mediates its effect through the pain gate theory by inhibiting the transmission of

nociception at the substantia gelatinosa of the spinal cord[39,41]. Also, low frequency TENS is believed to stimulate the release of certain endogenous chemicals such as mu opioid, 5-HT2, and 5-HT3 receptors, while high frequency TENS mediates delta opioid receptors[39]. There are different forms of TENS in use, including conventional TENS (low intensity and high frequency, 50–100Hz), acupuncture-like TENS (high intensity and low frequency, 2–4Hz), and intense TENS (high intensity and high frequency, 200pps)[39-40].

In recent times, TENS has been found useful in enhancing wound healing. It works by modulating pain signals to the brain, improving blood circulation to the wound, reducing inflammation, enhancing cellular functions necessary for tissue repair and potentially decreasing wound infection rates[38,42]. By stimulating sensory nerves, TENS inhibits pain transmission and induces the release of endorphins, which can significantly reduce pain at the wound site[38]. In the promotion of blood flow, TENS improves microcirculation at the wound site, which is critical for delivering nutrients and oxygen to the tissues and removing waste products. Enhanced blood flow accelerates the healing process by promoting cell proliferation and tissue repair[38]. Also, TENS stimulates fibroblasts and promotes collagen production, which is essential for wound healing[34,38]. Additionally, it can enhance cell migration and proliferation, particularly in diabetic wounds where these processes are often impaired[34,37].

Clinical Evidence

A study demonstrated that biphasic current or TENS therapy significantly improved healing rates by 70% in patients with diabetes by enhancing granulation tissue formation and reducing pain[43]. There are indications that TENS is effective in the treatment of leprous ulcer and chronically infected wounds[41,44-46]. In animal models, TENS has been shown to enhance collagen deposition, improve wound contraction, and reduce the inflammatory response[24]. Overall, the use of TENS in chronic wounds is premised in its ability to re-establish the natural state of the wound even when in a defective state. Preetam and colleagues asserted that the injury's existing state has a significant role in the start of repair and that the human skin that is not injured has a transcutaneous current potential of 20–50 mV and an endogenous electrical potential[41]. Hence, emphasizing the role of TENS in chronic wounds.

Application

To achieve optimal results, parameters such as frequency and intensity of TENS need to be adjusted to low or moderate frequency tolerable by patient. Also, it is essential to apply TENS after a proper wound dressing in which a clean moist gauze with normal saline is placed over the wound. The TENS electrodes of comparable size to the wound surface are placed on the gauge for stimulation. The gauze should remain in place after TENS stimulation until the next stimulation. The duration for application of TENS can be as 30 to 40 minutes or as much as 1 hour. The treatment should be repeated every other day. It is advisable to remove iodine from the wound surface or any other products that may slow the conductivity of electric currents in wounds during the use of TENS[37]. The United States food and drug

administration guidance document for electrical stimulation contradicts the use of ES for patients with demand-type cardiac pacemakers, cancerous lesions, pregnant uterus, and the carotid sinus region[47].

Combination Therapy

Given the potential of LASER and TENS in the management of chronically infected wounds, one underexplored approach to optimize treatment is to combine their treatments in order to effectively manage the wounds. For instance, it is advisable not to commence the use of ES, ultrasound, and pulsed radiofrequency stimulation in the first 48 to 72 hours after an injury[37]. Also, the subtle antimicrobial activity of LASER and TENS can be combined. LASER kills bacteria, while TENS prevents bacteria from entering the wound by maintaining a transcutaneous current around the wound that increases blood flow, thereby supplying oxygen and preventing the growth of bacteria. Hence, initial treatment for chronically infected wounds can begin with the use of LASER in the first week, continued with both LASER and TENS in the weeks ahead, and conclude with the use of TENS when there is substantial contraction of the wound. At all times, a standard wound dressing should precede the application of LASER and TENS.

Limitations and Future Directions

As a narrative review, this article lacks the methodological rigor of a systematic review. The literature selection process was not based on predefined inclusion or exclusion criteria, which may introduce selection bias and limit reproducibility. Although LASER and TENS have minimal adverse effects in comparison to other biophysical agents, the potential adverse effects associated with LASER and TENS discussed in this review are not exhaustive, hence should be checkmated in case of clinical adoption.

Given the increasing prevalence of chronic wounds and the challenges associated with their management, integrating these non-pharmacological strategies into wound care protocols could provide a more comprehensive and effective approach to wound healing. Further research, especially randomized controlled trials in optimizing treatment protocols, especially for combination therapy is needed to establish these therapies as mainstream clinical tools for chronic wound management.

CONCLUSION

The use of LASER and TENS as non-surgical treatments for chronic wound infections is a promising area of research. These modalities offer unique mechanisms of action that can address both the infection and the defective healing mechanisms seen in chronic wounds. Clinical and preclinical studies consistently show the efficacy of these therapies in improving wound healing outcomes, reducing infection, and enhancing tissue regeneration.

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ETHICAL ISSUES IN HUMAN AND ANIMAL RESEARCH: A Review

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ABSTRACT

Research involving human and animal subjects is integral to advancing scientific knowledge, improving healthcare, and informing policy. In human research, ethical issues revolve around safeguarding autonomy, obtaining informed consent, ensuring beneficence, and protecting vulnerable populations such as children, prisoners, and individuals with diminished decision-making capacity. The 4Rs (Replacement, Reduction, Refinement, and Responsibility) in animal research offer a framework for minimizing animal suffering while ensuring the scientific validity of experiments. Ethical issues in human and animal research are not peripheral concerns but central pillars of responsible scientific practice. Addressing them ensures the protection of subjects, upholds human dignity and animal welfare, promotes credible science, and fosters societal benefit. A collaborative effort of researchers, ethicists, policymakers, and the broader community is paramount in handling the ethical challenges in research. Therefore, by maintaining ethical principles and practices, the scientific community can continue to push the boundaries of knowledge while upholding the fundamental rights and wellbeing of both human and animal participants. This study therefore critically examines the ethical issues surrounding both human and animal research, analysing historical contexts by examining case studies and the importance of addressing these ethical issues in research, with the ultimate goal of promoting ethically sound, socially responsible, and scientifically rigorous research practices

Key words: Research, Ethics, Humans, Animals.
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INTRODUCTION

Research is the foundation of scientific advancement. However, these advancements have also brought to the fore various ethical concerns surrounding the treatment of research subjects. As the pursuit of knowledge pushes the boundaries of innovation in health, behavioural, and biological sciences, the protection of human and animal subjects remains a moral and regulatory imperative. In human research, ethical issues revolve around safeguarding autonomy, obtaining informed consent, ensuring beneficence, and protecting vulnerable populations such as children, prisoners, and individuals with diminished decision-making capacity[1]. The codification of ethical standards for human research has evolved historically, particularly after the revelations of egregious human rights violations during World War II[2]. The ethical standards of human research gained prominence following the Nuremberg tribunal, which exposed Nazi war crimes, including vicious human subject experiments without consent or regard for well-being[3]. In response, the Nuremberg Code was established, emphasizing that research involving humans is only permissible if the results are beneficial to society, the participants voluntarily consent and retain the right to withdraw, and no harm, loss of opportunity, or unnecessary discomfort is inflicted[3]. Despite its foundational role, the Nuremberg Code did not adequately address research involving vulnerable populations such as children, cognitively impaired individuals, and those unable to provide informed consent[4]. To bridge this gap, the Declaration of Helsinki, adopted by the World Medical Association in 1964, introduced more comprehensive ethical guidance by allowing the use of legally authorized representatives to consent on behalf of individuals incapable of doing so, while emphasizing the primacy of participant welfare[5,6]. This Declaration is now widely regarded as the cornerstone of international biomedical research ethics. Building upon these frameworks, the Belmont Report was introduced in 1979 by the U.S. Department of Health, Education, and Welfare, articulating three fundamental principles that underpin modern human research ethics: respect for persons, beneficence, and justice[7]. These principles require researchers to uphold the autonomy of all participants, minimize harm while maximizing benefit, and equitably distribute research risks and outcomes[2]. While these developments have strengthened the ethical infrastructure of human research, modern advancements in biotechnology, artificial intelligence, and genomic editing have introduced complex ethical dilemmas around consent, privacy, and equity, especially in cross-cultural and international research settings[8].

In parallel, the use of animals in scientific has played an essential role in the development of medical therapies, vaccine trials, surgical techniques, and toxicity testing[4,9]. However, it presents a profound ethical paradox: the pursuit of human benefit at the expense of animal suffering[10]. Concerns over the moral status of animals, their capacity for pain, and the necessity of their use have prompted the development of

ethical guidelines and the application of the "3Rs" principle: Replacement (using alternatives to animals when possible), Reduction (minimizing the number of animals used), and Refinement (enhancing procedures to reduce suffering)[4,11]. Despite the widespread acceptance of these principles, their practical application varies significantly across research institutions, and critics argue that utilitarian justifications often override animal welfare considerations[12]. Public awareness, bolstered by advocacy from animal rights organizations, has intensified the demand for transparency and the development of non-animal models such as in vitro systems, computer simulations, and organ-on-chip technologies.[13]

Consequently, as research technologies and methodologies continue to evolve, ethical considerations must adapt accordingly, by ensuring that the dignity, rights, and well-being of all research participants (human and animals) remain at the forefront of scientific inquiry. This study therefore critically examines the ethical issues surrounding both human and animal research, analysing historical contexts by examining case studies and the importance of addressing these ethical issues in research, with the ultimate goal of promoting ethically sound, socially responsible, and scientifically rigorous research practices.

MATERIALS AND METHODS

A narrative review of literature from 2015 to 2025 was conducted, focusing on PubMed-indexed, peer-reviewed articles. The review included primary research studies and systematic reviews related to ethical issues in human and animal research. Studies were identified through the PubMed database using keywords such as "Principles of ethics," "human and animal research," "case studies," and "emerging technologies."

Preference was given to the recent papers to ensure the inclusion of the current findings. Highly cited and robust articles on research ethics were selected for their relevance and impact on the key review. Information from CIOMS International Ethical Guidelines for Health-related Research Involving Humans, The Belmont Report on research ethics, The Nuremberg Code and World Medical Association Declaration of Helsinki were included for expert guidelines. Non-English studies, non-peer-reviewed articles, and papers unrelated to ethical issues in human and animal research were excluded.

This review is categorized into sections of the importance of addressing ethical issues in research, major ethical issues in human and animal research in relation to the principles of ethics, illustration of case studies and ethical issues in emerging technologies.

RESULTS AND DISCUSSION

Importance of Addressing Ethical Issues in Research

Research involving human and animal subjects is integral to advancing scientific knowledge, improving healthcare, and informing policy. However, pursuing such knowledge must be grounded in ethical principles to ensure that the rights, dignity, and welfare of participants (human or animal) are safeguarded throughout the research process. Addressing ethical issues

in research is essential for legal compliance and maintaining public trust, ensuring scientific integrity, and protecting the vulnerable.[14]

Ethical practices such as rigorous peer review, transparent methodology, and adherence to established protocols ensure that research findings are reliable and valid[15]. When studies are conducted ethically, they are less likely to be marred by biases, fabrications, or errors that could compromise credibility. For instance, ethical standards demand accurate data reporting and full disclosure of any potential conflicts of interest, which directly contribute to the integrity and trustworthiness of research findings[15,16].

Also, ethical research practices often align with broader societal values and needs, leading to outcomes that are not only scientifically significant but also socially beneficial[14]. By respecting principles like justice and beneficence, researchers ensure that their work with human subjects contributes positively to society[17]. For example, ethical guidelines in medical research emphasize the need to balance scientific advancement with patient welfare, ensuring that new treatments are both effective and safe. This balance is crucial in addressing pressing societal health concerns while safeguarding individual rights and well-being.

Furthermore, the relationship between the public and the scientific community is heavily reliant on trust, which is fostered through consistent ethical conduct in research[14]. When the public perceives that researchers are committed to ethical standards, it reinforces their confidence in the scientific process and its outcomes. Ethical research practices demonstrate a respect for societal norms and values, reinforcing the perception that science serves the public good[16].

Therefore, ethical issues in human and animal research are not peripheral concerns but central pillars of responsible scientific practice. Addressing them ensures the protection of subjects, upholds human dignity and animal welfare, promotes credible science, and fosters societal benefit.

Major Ethical Issues in Human Research

The most salient ethical principles that govern human subject research are: Beneficence (the obligation to do good), non-maleficence (the duty to avoid causing harm), fidelity and trust within the fiduciary investigator-participant relationship, respect for personal dignity, autonomy (encompassing informed, voluntary, and competent decision-making), and privacy, particularly the protection of personal and sensitive data[18].

These principles are enshrined in international codes and guidelines such as the Nuremberg Code (1947)[3,19], the Declaration of Helsinki (1964, and subsequent revisions)[20], and the Belmont Report (1979)[7,21].

Informed Consent

Participants involved in a research study must be adequately informed about the study's nature and associated risks and must voluntarily agree to participate by giving informed consent. It is essential that all participants receive detailed information regarding the study's objectives,

methodology, potential benefits and harms, as well as any existing conflicts of interest.[22,23] They must also be made aware of their right to decline participation or to withdraw at any stage without any consequences.[16] In situations where an individual is not capable of giving informed consent, a legally authorized representative should provide consent on their behalf.[22] However, Avasthi *et al*.[24] argued that if no such representative is available and the research must begin immediately, the study may proceed without prior consent, provided that the justification for this is documented in the research protocol and approved by an ethics review board. They further stated that consent from a legal representative should be sought at the earliest opportunity to allow continued participation in the study.

Privacy and Confidentiality

In the context of clinical research, privacy refers to an individual's ability to control the disclosure of personal details related to their health status, emotions, and social relationships to researchers.[25] Confidentiality involves safeguarding the participant's private data and limiting when and how that information can be accessed or shared with others.[26] Visual data such as X-rays, ultrasound scans, pathology slides, or internal body images do not violate confidentiality, provided that any identifying information is removed and the data is anonymized beforehand.[23]

Beneficence

In the realm of human research, the principle of beneficence refers to the ethical obligation of researchers to prioritize the well-being of research participants by maximising possible benefits and minimizing potential harms.[27] This principle mandates a proactive approach that researchers are not only required to avoid causing harm but are also expected to promote the welfare of participants throughout the study.[26] Beneficence supports moral duties such as defending the rights of individuals, preventing harm, assisting vulnerable populations, and contributing positively to human welfare.[28]

In the research setting, this involves designing studies that have the potential for meaningful scientific advancement while ensuring participants are not exploited or subjected to unnecessary risks. Furthermore, researchers often owe a duty to society due to the public support for education and scientific infrastructure, making the ethical application of beneficence not only an altruistic responsibility but also a form of social reciprocity.[27] This principle becomes particularly relevant when conducting clinical trials where the direct therapeutic benefit to participants may be uncertain but the potential societal gain is high.

Nonmaleficence

The principle of nonmaleficence, which translates to "do no harm," holds a central place in the ethical framework governing research involving human participants.[29] This principle underlies several moral imperatives, including refraining from causing unnecessary pain, injury, or distress; avoiding exploitation; and ensuring that participants are not deprived of fundamental rights or resources.[29]

In practice, non-maleficence obliges researchers to conduct rigorous risk-benefit analyses before initiating a study. For example, invasive procedures, drug trials, or experimental interventions must be justified by the potential scientific or therapeutic benefits and must undergo scrutiny by institutional review boards or ethics committees. Especially in sensitive areas such as end-of-life research, mental health, or vulnerable populations (e.g., children), researchers must ensure that participation does not result in more harm than benefit.[16]
Moreover, in cases where research involves foreseeable but unintended side effects (e.g., distress caused by recalling traumatic events during interviews), protocols must be in place to mitigate harm and offer appropriate support services.[29] The concept of double effect, where an intervention intended for good also has a secondary, unintended negative consequence, must be ethically justified and carefully monitored within the study's ethical framework.[29]

Autonomy

Autonomy is a foundational principle in human research ethics, grounded in the idea that individuals possess inherent worth and the right to make decisions about their own lives and bodies (Florijn, 2022).[30] Respecting autonomy means that participants should be fully informed about the nature of the research, its risks and benefits, and their rights, including the right to withdraw at any time without penalty.[29] This is operationalized through mechanisms like informed consent and confidentiality.
However, Resnik[16] argued that autonomy must be balanced against other ethical principles. For example, if an individual's autonomous choice poses significant harm to others, or if a person lacks decision-making capacity (due to age, cognitive impairment, or mental illness), the principle of autonomy may be limited. In such cases, consent must be obtained from a legally authorized representative, and additional safeguards must be applied to protect participant rights.[16]
Also, critiques of the autonomy principle suggest that it may be overly individualistic and fail to account for relational autonomy, which considers how personal decisions are shaped by social contexts such as culture, family, religion, and gender .[31] In many non-Western societies, collective decision-making processes may be more culturally appropriate than individual consent, particularly in decisions involving serious medical interventions or genetic research.[29]
Additionally, the practice of paternalism, where researchers or medical professionals make decisions on behalf of participants for their perceived benefit continues to raise ethical debates.[32] While rooted in the principle of beneficence, paternalism can undermine autonomy if not carefully justified. Given the evolving landscape of global health, increased literacy, and patient rights movements, it is essential to reassess these dynamics through ethical research and culturally sensitive engagement strategies.[32]
In line with respecting autonomy, researchers are ethically bound to disclose all necessary information to participants in a manner that is understandable and culturally appropriate. This includes providing details about the study’s aims, duration, procedures,

potential risks, benefits, and alternative options.

Case Studies Illustrating Some of these Ethical Issues

The Nazi Medical Crimes and the Nuremberg Trials

The exposure of unethical human experimentation by Nazi physicians during World War II marked a turning point in research ethics.[3] In Nazi concentration camps, German doctors conducted brutal and non-consensual experiments including freezing, high-altitude tests, and deliberate infection with diseases often leading to severe suffering or death. Alongside these, over 350,000 German citizens were forcibly sterilized under Nazi eugenic laws aimed at racial purification.[33,34] This led to the creation of the Nuremberg Code (1947),[7,19] which established key ethical principles for human research, most notably the necessity of voluntary informed consent and the obligation to avoid unnecessary harm. These events laid the foundation for modern research ethics and reinforced the need for strong oversight mechanisms such as institutional review boards.[4]

The Pfizer Trovan Study in Nigeria (1996)

In 1996, during a severe outbreak of cerebrospinal meningitis in Tudun Wada, Kano State, northern Nigeria, an ethically controversial clinical trial was conducted by the multinational pharmaceutical company Pfizer.[35,36] The epidemic, which primarily affected children, prompted a rapid response from both local and international actors. The Kano State Government mobilized resources to contain the outbreak, while humanitarian organizations such as Médecins Sans Frontières (MSF) also provided critical medical assistance.[37]

Amidst the crisis, Pfizer deployed a medical team to conduct a clinical trial of an experimental antibiotic, Trovafloxacin (commercially known as Trovan), a member of the quinolone class.[35,37] The company aimed to test Trovan's efficacy and safety compared to standard treatments already in use. Pfizer recruited 200 children into the study, assigning them to two treatment arms: one group received oral Trovan, while the control group received Ceftriaxone or Chloramphenicol, both known effective therapies for meningitis.[37]

The trial was completed within three weeks, having rapidly reached its participant target. However, it drew intense scrutiny and criticism due to serious ethical lapses. Reports indicated that some children died, while others suffered long-term disabilities potentially linked to the experimental drug or the conditions under which the study was conducted.[37,38]

Several allegations were raised against Pfizer’s conduct: Lack of ethical clearance from relevant Nigerian regulatory bodies before initiating the trial. Failure to obtain informed consent from the parents or guardians of the children enrolled, with no clear disclosure that Trovan was an experimental drug. Exploitation of a vulnerable population, taking advantage of the community's poverty, low literacy, and desperation amidst an epidemic. Finally, abandonment of the community after the

study's conclusion, despite the epidemic still being active.[37]

The controversy culminated in multiple lawsuits against Pfizer in both Nigeria and the United States of America. In 2009, the company reached an out-of-court settlement and paid $75 million to Kano State and $175,000 to four families of dead children.[37] This case has since become one of the most cited examples of ethical misconduct in international biomedical research, highlighting the dangers of conducting clinical trials in resource-limited settings without stringent ethical safeguards.

The ACTG 076 Trial and the Ethical Controversy of Placebo-Controlled HIV Studies in Developing Countries

In 1994, the AIDS Clinical Trials Group (ACTG) reported the groundbreaking results of its Study 076, which demonstrated that the administration of Zidovudine (AZT) to HIV-positive pregnant women significantly reduced the risk of mother-to-child transmission (MTCT) of HIV.[39] Specifically, the regimen consisted of oral AZT during pregnancy, intravenous AZT during labour, and oral AZT administered to the newborn reduced the vertical transmission rate by approximately two-thirds.[39] As a result of these findings, this protocol rapidly became the standard of care for HIV-positive pregnant women in the United States of America and Europe.

However, the widespread implementation of the ACTG 076 regimen was deemed financially and logistically infeasible in many low- and middle-income countries, particularly in sub-Saharan Africa, where the burden of HIV was (and remains) disproportionately high. In response to these challenges, the World Health Organization (WHO) convened a global meeting to explore more affordable and context-appropriate alternatives for the prevention of MTCT in resource-limited settings.[40]

Following this, a number of placebo-controlled clinical trials were initiated across Africa and Asia to assess the effectiveness of short-course AZT regimens or other reduced-cost interventions.[41,42] These studies aimed to find cheaper options that could be more feasibly implemented in low-income countries. However, their ethical legitimacy became the subject of intense international debate.

Bioethicists and public health advocates raised concerns regarding the moral justification of using a placebo-controlled design in these trials. They argued that, given the established efficacy of the ACTG 076 regimen, the ethical research question should not have been whether cheaper interventions were better than nothing, but rather whether these reduced regimens were comparably effective to the existing standard.[42,43] From this perspective, an equivalence or non-inferiority study design, using ACTG 076 as the control arm, would have been more appropriate and ethically sound.

Instead, the use of a placebo arm reframed the question to: "Are these cheaper interventions better than nothing?" effectively denying participants in the control group access to a proven life-saving treatment.[40] Critics argued that such a trial design would have been unacceptable in developed countries, where withholding AZT would be considered unethical, and

therefore its implementation in the Global South reflected a double standard and ethical imperialism.[44]

As a result of these placebo-controlled trials, numerous neonates were denied access to AZT, which could have significantly reduced their risk of contracting HIV.[40] Ethicists contended that this violated the principle of beneficence and justice, as these children were effectively sacrificed in the pursuit of cost-effective research, despite the existence of a known effective treatment.[43]

Ethical Issues in Clinical Trials and Drug Development

Clinical trials are essential in the drug development process, as they ascertain the safety, efficacy and suitability of pharmaceutical product for mass production.[23] Due to an ever-evolving regulatory landscape, pharmaceutical companies are under increasing pressure to ensure that clinical trials are conducted in line with ethical best practices. Those who work in clinical trials are tasked with working out a drug's optimal dosage, efficacy, and safety while adhering to the latest guidelines and regulations, recognising the need for clinical trials which balance ethics and efficiency. A failure to uphold ethical standards can result in inaccurate results, harm to patients, and an undermining of public trust.[23,24] To prevent these damaging outcomes, it is imperative for pharmaceutical companies to adhere to these key ethical considerations in clinical trials and drug development

Informed Consent: Participants in clinical trials must be fully informed about the potential risks and benefits of the study, and their consent must be freely given.[23]

Vulnerable Populations: Special considerations are required when including vulnerable populations, such as children or the terminally ill, in clinical trials

Equitable Subject Selection: Participant selection must be fair and inclusive, ensuring that the burdens and benefits of research are distributed equitably.

Monitoring and Safety: Rigorous monitoring procedures are essential to identify and address any adverse events or safety concerns that arise during clinical trials.

Post-Trial Access: Ethical guidelines address the issue of providing participants with continued access to successful experimental treatments after a trial has ended.

Emerging Technologies and Ethical issues

The rapid advancement of emerging technologies in biomedical and scientific research has brought about transformative possibilities but also introduced significant ethical challenges. For instance, innovations such as gene editing, artificial intelligence (AI), and neurotechnology offer powerful tools for improving health and human capabilities. However, their development and application raise complex questions about human rights, societal values, and the boundaries of ethical research.[45,46] Some of the ethical issues associated with these emerging technologies include:

Gene Editing: The development of gene editing technology raises ethical issues about the potential for misuse, the impact on human genetic diversity, and the creation of

"designer babies" with enhanced or modified traits. [45,47]

Artificial Intelligence: Use of AI in research raises questions about algorithmic bias, privacy, and the potential for AI-driven decision-making that may have unintended consequences on vulnerable populations (Belenguer, 2022).[48]

Neurotechnology: Advances in neuro-technology, such as brain-computer interfaces and neural implants, raise ethical issues about the potential for manipulation of the human mind, privacy violations, and the impact on personal autonomy.[46]

Ethical issues in animal research

Animal model-based research started in the 5th century BC and has increased since the 19th century.[49] Most institutions for medical research around the world use non-human animals as experimental subjects because they play an important part in the chain of research evidence and as such are used to decide which interventions are taken forward in clinical trials.[50] Among the several animal species, rats, mice and purpose-bred birds comprise almost 90% of the animals that are used for research purpose.[50] The World Health Organization estimates that 25% of 57 million deaths per annum that occur globally are caused by microbes.[51] Zoonotic diseases constitute more than 60% of all known infectious diseases, with humans serving as the primary reservoir for only 3% of them.[52] The efficacy of therapeutic interventions in zoonoses is believed to be similar across species and it is prudent to demand scientifically valid evidence of efficacy of an obligation in animal experiments for newer drugs that are applicable to multiple species including humans.[52]

There is an increased tendency with stringent ethical obligations towards limiting the number of animals used in experiments while at the same time ensuring that the replication of previous research is reduced. Around 50 to 100 million vertebrate animals are used worldwide annually for research and experiments to increase the understanding of the functioning of both the human and animal body (Asokan*et al.*, 2012).[52]

The 4Rs (Replacement, Reduction, Refinement and responsibility for the experimental animal) of humane animal experimentation are widely considered to be the guiding principles for the use of animals in research.[53]

Reduction: this refers to methods that enable researchers to obtain comparable levels of information from fewer animals or to obtain more information from the same numbers of animals.[4]

Refinement: involves improvements in procedure that minimize the harmful effects of the proposed experiments on the animals involved, such as reducing pain, distress and suffering in a manner that leads to a general improvement in animal welfare.[53] This can be achieved by improving the living conditions for research animals, proper training of people handling animals, application of anesthesia and analgesia when required and the need for euthanasia of the animals at the end of the experiment to curtail their suffering.

Replacement: refers to approaches that replace or avoid the use of experimental animals altogether.[4] These approaches

involve use of in silico methods/computerized techniques/software and in vitro methods like cell and tissue culture testing, as well as relative replacement methods by use of invertebrates like nematode worms, fruit flies and microorganisms in place of vertebrates and higher animals.[50]

Responsibility: refers to concerns around promoting animal welfare by improvements in experimental animals' social life, development of advanced scientific methods.[53] Thereby objectively determining sentience, consciousness, experience of pain and intelligence in the animal kingdom, as well as effective involvement in the professionalization of the public discussion on animal ethics[50]

Sample Size

Welfare remains a notable issue in animal experiments. Some disciplines use group sizes of 6 or 8 animals regardless of the type of experiment or number of groups. This same number is also conventionally appropriate in pilot or exploratory studies but not in factorial experimental designs or designs with more than 2–3 treatment groups. There is motive to reduce the number of animals that undergo experiment or are sacrificed and yet not compromise scientific validity.

Translation to Human Trials

Another issue is whether the evidence from a reduction in animal experiments be carried forward to human trials.[50] A systematic review of 6 interventions by Perel *et al*.,[54] concluded that agreement between animal studies and clinical studies varied and there are limitations to effective translation of results from animal to human trial. The possible reasons are bias, random error, the failure of animal models to adequately represent human disease, the non-availability of suitable animal models, clinical heterogeneity and inadequate sample sizes.[54]

Inconclusive Result

Another issue is if it is ethical to carry out human trials based on the uncertain or inconclusive results of animal experiments. There are still inconclusive clinical recommendations even with many systematic reviews that have been done on RCT. This has led to exposure of patients to unnecessary risk, wasting of scarce resources and experimental animals, and even suffering the animals unnecessarily.

Equity

It is unethical to subject healthy human volunteers to risk in the absence of precise and scientifically valid results from animal experiments.[52] While designing animal experiments the consideration of ethics should not just be limited to the animals alone but also to multiple species to whom the results are then taken forward to.[50] There should be "shared risks" between humans and animals concerning zoonoses thus promoting better cooperation and collaboration between human and animal health professionals to identify and reduce such risks.[52]

CONCLUSION

Ethical issues in human and animal research represent a cornerstone of responsible scientific practice. As this study has

demonstrated, the pursuit of scientific advancement must never compromise the dignity, autonomy, or welfare of human and animal subjects. Historically, unethical research practices, such as those conducted during the Nazi era or in the Pfizer Trovan trial in Nigeria, underscore the devastating consequences of neglecting ethical safeguards. These events have led to the development of key international ethical codes and principles such as the Nuremberg Code, the Declaration of Helsinki, and the Belmont Report, that now serve as global standards in research ethics.

Therefore, for human research, the study revealed that fundamental principles such as informed consent, beneficence, nonmaleficence, autonomy, and justice are indispensable in guiding researchers toward practices that respect human rights and minimize harm. The study also emphasized that privacy and confidentiality are not only ethical obligations but critical to maintaining public trust in research.

In animal research, the 4Rs (Replacement, Reduction, Refinement, and Responsibility) offer a framework for minimizing animal suffering while ensuring the scientific validity of experiments. However, ethical challenges persist, including concerns about inconclusive results, limited translation to human trials, and equitable risk distribution between humans and animals, especially in the context of zoonotic diseases.

Emerging technologies such as gene editing, artificial intelligence, and neurotechnology further complicate the ethical landscape, raising novel questions about consent, bias, autonomy, and long-term societal impact. These technologies must be navigated with caution and a renewed commitment to ethical principles that safeguard both individual rights and collective welfare.

Ultimately, ethical issues surrounding human and animal research must be an ongoing process as new technologies and research methods emerge. Also, addressing the ethical challenges in research requires a collaborative effort of researchers, ethicists, policymakers, and the broader community.

Therefore, by maintaining ethical principles and practices, the scientific community can continue to push the boundaries of knowledge while upholding the fundamental rights and wellbeing of both human and animal participants.

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ENDING MATERNAL AND NEONATAL TETANUS IN THE GLOBAL SOUTH BY 2030: A ONE HEALTH PERSPECTIVE ON ELIMINATION STRATEGIES

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ABSTRACT

Maternal and Neonatal Tetanus (MNT) remains a preventable yet persistent cause of mortality in the Global South. Despite major progress since the 1989 WHO initiative, the goal of global elimination by 2030 is threatened by health inequities, fragile systems, and environmental exposure. This review examines MNT elimination through a One Health lens, integrating human, animal, and environmental perspectives to expose hidden transmission pathways and new intervention opportunities. It synthesizes current evidence on immunization, clean birth practices, surveillance, and community engagement,

while highlighting cross-sectoral strategies such as veterinary collaboration, sanitation reform, and environmental hygiene. Drawing lessons from successful elimination programs in India, Uganda, and Senegal, the paper argues that sustainable elimination depends on multisectoral coordination, gender equity, and culturally grounded community ownership. The path to ending MNT by 2030 lies not only in vaccines, but in aligning health systems, environmental management, and social structures under a unified One Health strategy.

This review highlights how integrating One Health principles can accelerate the elimination of maternal and neonatal tetanus in the Global South. It emphasizes cross-sectoral collaboration, community engagement, and innovative technologies as essential components of sustainable, equitable strategies.

Keywords: *Maternal and Neonatal Tetanus, One Health; Global South, Tetanus Elimination, Immunization Coverage, Clean Birth Practices, Environmental Health*

INTRODUCTION

Tetanus, caused by *Clostridium tetani*, is an acute and frequently fatal infection marked by severe neuromuscular dysfunction[1-3]. Among its forms, Maternal and Neonatal Tetanus (MNT) stands out as both highly preventable and deeply inequitable[4]. Neonatal tetanus typically follows unsterile cord cutting or application of contaminated substances such as ash or dung[5,6], while maternal tetanus arises from unhygienic obstetric or abortion practices[7-9]. Without prompt care, case-fatality rates remain above 80% in many low-resource settings[10,11].

Women in many regions still give birth outside formal health facilities, often in unsanitary environments, and may rely on unsafe traditional methods for postpartum care[12,13]. The incidence of maternal tetanus is strongly correlated with access to quality obstetric care, family planning services, and safe abortion—all of which are unevenly distributed and often subject to sociopolitical and religious constraints[14]. In patriarchal settings, women's limited mobility, decision-making power, and economic dependence further hinder timely access to preventive and curative care[15-18].

Despite widespread vaccine availability, MNT persists where social vulnerability, gender inequity, and fragile health systems intersect[19]. In 2018, an estimated 25 000 newborns died from neonatal tetanus—a dramatic decline from 787 000 in 1988, yet a reminder that progress is uneven[20,21]. Most deaths occur in low- and middle-income countries (LMICs) of sub-Saharan Africa, South Asia, and parts of Southeast Asia and Latin America. These regions are often characterized by limited health infrastructure, economic instability, and inequities in healthcare access[22-26].
The WHO's Maternal and Neonatal Tetanus Elimination (MNTE) initiative, launched in 1989, set an ambitious 1995 goal that spurred global mobilization[27-29]. By 2023, 52 of 59 priority countries had reached the elimination threshold of < 1 neonatal tetanus case per 1 000 live births per district per year[30]. Yet 12 countries—mainly in Africa

and Asia—remain endemic[31,32]. Persistent insecurity, poor immunization coverage, and weak health infrastructure threaten to stall momentum.

Achieving a proposed global elimination target by 2030 will require more than continued biomedical interventions[33]. MNT transmission occurs at the intersection of human behaviour, environmental contamination, and animal reservoirs—factors inadequately addressed by conventional health approaches[34]. Thus, the path to zero cases requires a One Health perspective—recognizing the ecological and social environment as inseparable from human health. This review critically synthesizes existing literature on MNT control through that framework. It examines disease trends and transmission pathways; assesses the effectiveness of vaccination, surveillance, and cross-sectoral initiatives; and proposes actionable strategies and policy priorities for achieving elimination by 2030.

Global Epidemiology and Burden of MNT

The global burden of non-neonatal tetanus is likely significantly underreported, as evidenced by inconsistent incidence and mortality estimates (Figure 1). While only 21,830 cases were officially reported to WHO in 2023, disease modelling suggests the true annual mortality from tetanus ranges between 30,000 and 50,000 deaths[18,34]. This disparity stems from underreporting in countries where tetanus is not a notifiable disease, as well as surveillance systems that emphasize mortality and overlook survivors requiring intensive care.

Over the past three decades, coordinated immunization and maternal-health initiatives have reduced MNT mortality by over 95%[19-21,35]. From nearly 800 000 neonatal deaths in 1988, the toll declined to approximately 25 000 by 2024[36]. More than 85 countries have validated elimination status, including India (2015), Indonesia (2016), Ethiopia (2017), and the Democratic Republic of Congo (2022)[37,38]. Yet a cluster of high-burden nations—Afghanistan, Angola, Central African Republic, Guinea, Mali, Nigeria, Pakistan, Papua New Guinea, Somalia, South Sudan, Sudan, and Yemen—still report cases[39].

These residual foci share structural fragility: conflict, humanitarian crises, low vaccine coverage, and shortages of skilled birth attendants[40]. Neonatal tetanus continues to drive neonatal mortality in many of these contexts, while maternal tetanus remains under-recognized due to weak surveillance and gender-blind reporting[41].

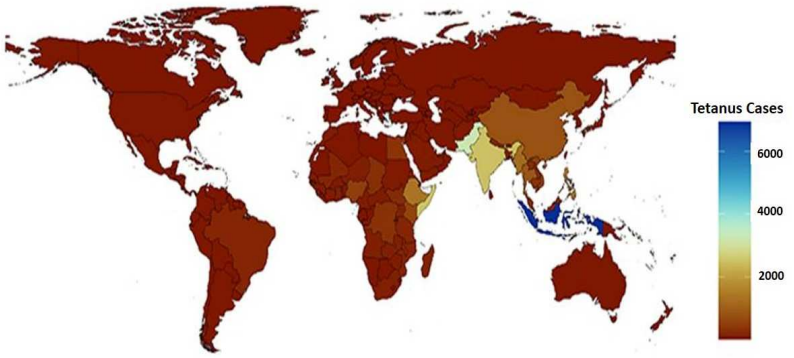

Figure 1: Global Tetanus Cases in patients aged ≥20 in 2021 [18].

New cases of tetanus in adults aged ≥20 in 2021. Differing case burden may reflect unequal reporting and can therefore under-represent certain regions

Table 1: Global and regional Trends in MNT[19-22,42]

Region/ Country Group	MNT Status (2000)	MNT Status (2024)	% Reduction in Neonatal Deaths	Key Drivers of Progress
Global	~170,000 neonatal deaths annually	~25,000 neonatal deaths annually	~85%	Expanded TTCV campaigns, SIAs, improved clean birth practices
Sub-Saharan Africa	High endemicity	8 countries remain non-eliminated (e.g., Nigeria, Mali, Chad)	~70%	Targeted campaigns, TBA training, community outreach
South Asia	Moderate-high burden	Eliminated in India (2015); Pakistan near elimination	~90%	Integration with maternal health, strong political commitment
Southeast Asia	Moderate burden	Most countries eliminated (e.g., Indonesia 2016)	~85%	Facility deliveries, birth kits, improved hygiene
Latin America and Caribbean	Mostly eliminated	All countries eliminated as of 2020	>95%	Strong regional coordination, urban health systems
Middle East/North Africa	Patchy elimination	Some countries still at risk due to instability (e.g., Yemen)	~75%	Vaccination drives, NGO support
High-Income Countries	Eliminated by 1990s	Sustained elimination	~100%	Robust EPI, institutional deliveries

Table 2: Global Status of MNT Elimination (as of 2024)[19.20,22]

Country	WHO Region	MNT Elimination Status	Year of Elimination
Afghanistan	EMRO	Not Eliminated	–
Angola	AFRO	Not Eliminated	–
Benin	AFRO	Eliminated	2011
Burkina Faso	AFRO	Eliminated	2011
Cameroon	AFRO	Eliminated	2013
Central African Republic	AFRO	Not Eliminated	–
Chad	AFRO	Eliminated	2017
Côte d'Ivoire	AFRO	Eliminated	2011
Democratic Republic of Congo	AFRO	Eliminated	2022
Ethiopia	AFRO	Eliminated	2017
Guinea	AFRO	Not Eliminated	–
India	SEARO	Eliminated	2015
Indonesia	SEARO	Eliminated	2016
Kenya	AFRO	Eliminated	2018
Liberia	AFRO	Eliminated	2015
Mali	AFRO	Not Eliminated	–
Mozambique	AFRO	Eliminated	2017
Nepal	SEARO	Eliminated	2005
Nigeria	AFRO	Not Eliminated	–
Pakistan	EMRO	Not Eliminated	–
Papua New Guinea	WPRO	Not Eliminated	–
Senegal	AFRO	Eliminated	2012
Sierra Leone	AFRO	Eliminated	2012
Somalia	EMRO	Not Eliminated	–
South Sudan	AFRO	Not Eliminated	–
Sudan	EMRO	Not Eliminated	–
Tanzania	AFRO	Eliminated	2018
Togo	AFRO	Eliminated	2012
Uganda	AFRO	Eliminated	2011
Yemen	EMRO	Not Eliminated	–
Zambia	AFRO	Eliminated	2007
Zimbabwe	AFRO	Eliminated	2013

Determinants and Pathways of Transmission

Maternal and neonatal tetanus (MNT) arises from infection by *Clostridium tetani*, a Gram-positive, spore-forming anaerobe ubiquitous in soil, dust, and animal faeces[1,2]. The spores can persist for years and germinate in necrotic tissue where oxygen tension is low, releasing the potent neurotoxin tetanospasmin[3,4]. This toxin blocks inhibitory neurotransmitters—gamma-aminobutyric acid (GABA) and glycine—causing the characteristic rigidity and spasms of tetanus[1,5]. Neonatal infection typically follows contamination of the umbilical cord through non-sterile cutting instruments or the application of traditional substances such as dung, ash, or oil[5-7]. Maternal cases occur after unsafe delivery or abortion using contaminated tools or unsterile conditions[2,4,7]. Both conditions are entirely preventable through vaccination and clean delivery practices (Figure 2).

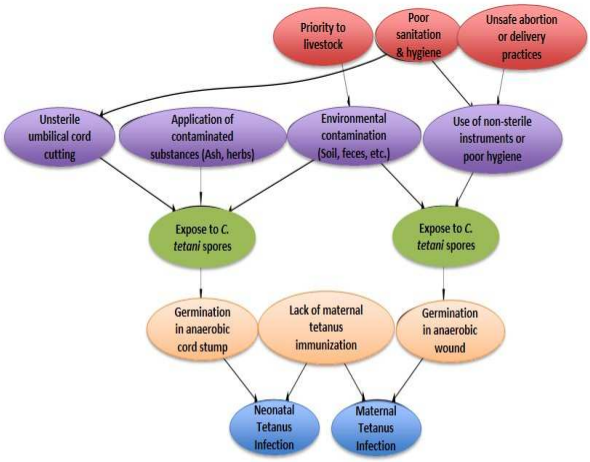

Figure 2: **Flow chart Illustrating MNT Transmission Pathways (*Image Credit:* Enitan, S. S.)**

The Role of Surveillance in combatting MNT

Surveillance for MNT remains a challenge in many countries, particularly for maternal cases, which are frequently underdiagnosed and underreported. Neonatal tetanus is often not recorded unless death occurs in a health facility, leading to substantial underestimation of its true burden. WHO and UNICEF recommend community-based surveillance and verbal autopsies, but implementation varies widely. Improving surveillance is essential not only for tracking progress but also for identifying geographic and demographic pockets of vulnerability. Investment in digital reporting systems, mobile health tools, and community health worker networks can enhance case detection and enable more rapid response to outbreaks[43,44].

The One Health Framework

The One Health approach (Figure 3) recognizes the interdependence of human, animal, and environmental health[45]. Though *C. tetani* is not zoonotic, its ecological persistence is strongly influenced by animal and environmental factors. Livestock excreta enrich soil spore loads; inadequate waste management and poor sanitation magnify exposure risk[46]. In many rural communities, women give birth near animal shelters or on bare ground, where umbilical stumps are exposed to contaminated soil and faeces.

Environmental sanitation plays a critical but underemphasized role in breaking MNT transmission. Poor waste disposal, open defecation, and stagnant water create conditions that sustain tetanus spores. A One Health strategy promotes improvements in livestock management, environmental hygiene, and cross-sector collaboration among ministries of health, agriculture, and environment[47].

In Uganda's Karamoja region, a One Health pilot linked veterinary services with maternal health programs. Joint training for veterinarians and midwives emphasized hygiene, clean birthing spaces, and co-delivery of vaccines for livestock and humans—strengthening community trust and reducing neonatal infections[47]. Similarly, in Nepal, integration of geospatial livestock density data into risk mapping guided distribution of clean birth kits to high-risk villages[48].

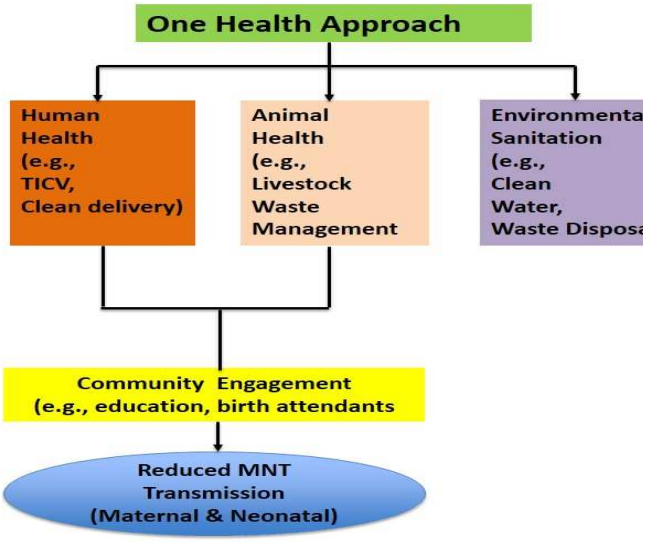

Figure 3: Flow chart illustrating One Health Framework in combatting MNT (*Image Credit:* Enitan, S. S.)

Strategies for Sustainable Elimination

Tetanus toxoid-containing vaccines (TTCVs) remain the cornerstone of prevention[49]. WHO recommends at least two doses for women of reproductive age, supplemented by routine immunization and periodic Supplementary Immunization Activities (SIAs)[50]. Despite proven efficacy, barriers such as inadequate cold chain systems, supply chain disruptions, and vaccine hesitancy persist. Innovative delivery models, including mobile outreach and linking immunization with antenatal care, have shown success in increasing uptake (Table 3)[49,50].

Hygienic delivery practices are equally vital. The WHO Clean Birth Checklist has improved infection control, but adoption remains inconsistent[48]. Training and integrating Traditional Birth Attendants (TBAs) into formal health systems, and incentivizing facility-based deliveries through infrastructure investment, have proven effective. Clean birth kits and supportive supervision are essential in low-resource settings.

Surveillance systems remain a weak point. Passive case detection underreports community cases, whereas mobile health (mHealth) tools enable real-time data reporting and rapid response[51]. Cross-sectoral interventions addressing sanitation, animal waste management, and WASH programs are integral[52]. Community engagement remains central, with behavioural change campaigns and gender-sensitive approaches critical for sustainability[50].

Table 3: Strategic Interventions for MNT Elimination[49,50]

Strategy	Core Components	Key Challenges	Examples of Successful Implementation
Immunization Programs	- TTCV for women of reproductive age	- Cold chain limitations	- Bangladesh: Outreach + mobile teams improved rural TTCV uptake
	- SIAs	- Supply chain disruptions	- Uganda: Use of CHWs to trace unvaccinated women
	- Integration with ANC visits	- Vaccine hesitancy	
Clean Birth Practices	- WHO Clean Birth Checklist	- Limited access to facilities	- India: Clean Birth Kit distribution in Uttar Pradesh
	- Distribution of Clean Birth Kits	- Poor TBA integration	- Nigeria: TBA training programs with referral incentives
	- Skilled Birth Attendance (SBA) promotion	- Inadequate training and supervision	
Surveillance Systems	- Active case detection	- Underreporting in remote areas	- Kenya: SMS-based reporting in rural counties
	- Community reporting networks	- Poor data infrastructure	- Nepal: Community health volunteers using mobile dashboards
	- mHealth tools	- Data privacy and tech access	
Cross-Sectoral Interventions	- Environmental sanitation	- Siloed sectoral planning	- Ethiopia: Health-Agriculture collaboration for safe birthing environments
	- Livestock waste management	- Resource competition	- Nepal: Village WASH + veterinary campaigns
	- Inter-ministerial coordination	- Lack of joint monitoring indicators	
Community Engagement	- BCC campaigns	- Gender norms limiting autonomy	- Senegal: Religious leader inclusion in maternal health advocacy
	- Engagement of male household heads	- Low health literacy	- Pakistan: Radio drama promoting safe cord care practices
	- School and youth education programs	- Resistance to behaviour change	

Challenges and Barriers

Despite decades of global effort, persistent structural and operational barriers continue to undermine elimination in many low- and middle-income countries[18,19]. Weak health systems, workforce shortages, gender inequality, and insecurity remain critical challenges[28,33]. Poor coordination between sectors, logistical constraints, and vaccine hesitancy exacerbate the problem[19,49]. Overreliance on donor funding and inadequate surveillance create fragility that threatens sustainability[52,53].

Opportunities in Elimination of MNT

The evolving global health landscape presents numerous opportunities to accelerate the elimination of maternal and neonatal tetanus (MNT), particularly through the strategic use of technological, financial, and systemic innovations (Figure 4). Emerging technologies offer new hope for MNT elimination. Artificial Intelligence and geospatial analytics help identify tetanus hotspots by integrating data on vaccination coverage, sanitation, and livestock density[54]. Mobile health (mHealth) platforms revolutionize surveillance and maternal follow-up by enabling community health workers to report suspected cases via SMS[33]. Drone-based delivery of vaccines in Rwanda and Ghana bypasses infrastructure gaps, while innovative financing models such as Results-Based Financing (RBF) and public–private partnerships improve program sustainability[55-59].

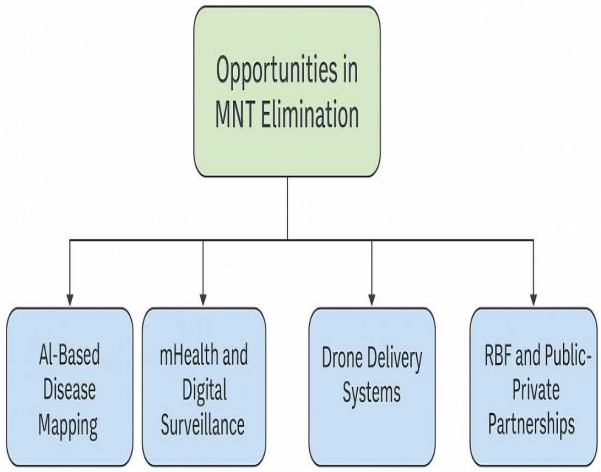

Figure 3: Flow chart illustrating opportunities in MNT elimination (Image Credit: Enitan, S. S.)

Case Studies of MNT Elimination and Lessons Learnt

The global fight against Maternal and Neonatal Tetanus (MNT) has yielded notable success stories, particularly from countries that have implemented integrated, context-specific strategies (Table 4). These examples underscore the importance of strong political commitment, cross-sectoral coordination, and community-based interventions. Conversely, countries still grappling with MNT highlight the persistent structural and operational challenges that hinder elimination efforts[54].

India:

India officially achieved MNT elimination in 2015, marking a major milestone for a country with vast geographic and socio-economic diversity. Key to this success was the integration of tetanus toxoid vaccination

into routine maternal and child health programs and the use of Supplementary Immunization Activities (SIAs) in hard-to-reach areas. The country leveraged Accredited Social Health Activists (ASHAs) to conduct extensive community outreach, promote facility-based deliveries, and distribute clean birth kits. India's experience illustrates the power of decentralized, incentive-driven workforce models and sustained political prioritization[51,52].

Uganda:

Uganda achieved MNT elimination in 2011, building upon a robust community health strategy. The Village Health Team (VHT) model enabled the delivery of health education and vaccination at the household level. In rural areas, TBAs were trained and gradually integrated into formal maternal health systems, ensuring continuity of clean birth practices. Uganda's emphasis on local ownership, coupled with support from international partners, fostered high immunization coverage and culturally appropriate outreach[53,54].

Senegal:

Senegal combined routine immunization with maternal education campaigns and health infrastructure development to reach MNT elimination status in 2012. A distinctive feature of Senegal's approach was the deployment of mobile health clinics to remote regions and the use of public-private partnerships for vaccine distribution. The country also invested in training midwives and TBAs in WHO's Clean Birth Checklist protocols, thereby ensuring safe delivery practices across diverse settings[58].

Despite substantial efforts, countries like Nigeria and Somalia continue to struggle with MNT elimination due to a combination of insecurity, fragile health systems, and limited community trust in government-led programs. In Nigeria, disparities in vaccination coverage between urban and rural populations remain a major hurdle. Conflict in the northeast further complicates service delivery and surveillance. Somalia faces even more profound difficulties, with sustained conflict, political instability, and limited access to maternal health services hindering both immunization and clean birth initiatives. These cases underscore the need for conflict-sensitive health strategies and stronger cross-sectoral collaboration, particularly in fragile states[59].

Table 4: Case Studies of MNT Elimination and Lessons Learnt[52-56]

Country	Elimination Status	Key Interventions	Challenges Overcome	Key Takeaway Lessons
India	Achieved in 2015	- SIAs in underserved areas - Use of ASHAs for outreach - Clean birth kits	- Large, diverse population - Low access in remote rural areas	Decentralized community healthcare workers and political commitment ensure wide coverage.
Uganda	Achieved in 2011	- Village Health Teams (VHTs) - Integration of TBAs - Routine TTCV via ANC	- Limited health infrastructure - Rural cultural practices	Community-based health structures can bridge gaps in rural maternal care.
Senegal	Achieved in 2012	- Mobile clinics in remote areas - Public-private vaccine delivery - Midwife/TBA training	- Geographic isolation - Inconsistent service delivery	Mobile outreach and PPPs improve equity in access.
Nigeria	*Not yet achieved*	- Partial immunization efforts - Targeted campaigns in high-risk states	- Regional conflict - Vaccine hesitancy - Weak surveillance	Conflict-sensitive planning and trust-building are critical in fragile settings.
Somalia	*Not yet achieved*	- Minimal MNT programming - NGO-led services in some regions	- Armed conflict - Political instability - Low health system capacity	State fragility demands humanitarian health solutions with NGO and global support.

Policy and Implementation Recommendations

To sustainably eliminate maternal and neonatal tetanus (MNT), countries must adopt integrated, evidence-based policies that leverage the One Health approach and align with broader global health goals. The following recommendations provide a roadmap for national governments, international partners, and community stakeholders[54,55]:

1. **Develop and Fund National Action Plans with One Health Integration**
   Governments should create or revise national MNT elimination strategies to explicitly incorporate One Health principles—recognizing the intersections between human, animal, and environmental health. These plans must be adequately financed, locally adaptable, and grounded in cross-sectoral collaboration between ministries of health, agriculture, environment, and education[58].
2. **Embed MNT Targets in SDG and UHC Frameworks**
   MNT elimination efforts should be formally integrated into national commitments to the Sustainable Development Goals (SDGs)—especially SDG 3 on good health and well-being—and Universal Health Coverage (UHC). This alignment ensures long-term accountability and leverages existing funding and monitoring infrastructure to advance MNT objectives[59].
3. **Strengthen Health Systems and Maternal Care Platforms**
   Routine immunization, antenatal care, and safe delivery services must be expanded and made accessible, particularly in remote and underserved areas. Investment in health worker training, clean birth kits, cold chain management, and mobile clinics will be essential to address operational gaps[60].
4. **Prioritize Community-Driven and Culturally Appropriate Approaches**
   Community engagement should guide implementation strategies. Empowering local leaders, traditional birth attendants (TBAs), and women's groups can enhance uptake of vaccines and clean delivery practices. Tailored behavior change communication (BCC) strategies should address harmful traditional practices and promote safe maternal health behaviors[60].
5. **Monitor One Health Implementation with Clear Indicators**
   To ensure accountability, countries should establish standardized indicators to monitor and evaluate the integration of One Health in MNT programs. Metrics might include cross-sectoral coordination frequency, environmental contamination levels near birth sites, and vaccination coverage among at-risk populations[61].
6. **Invest in Research and Local Capacity Building**
   Support for operational research, health systems innovation, and local workforce development is vital. Collaborations with academic institutions and civil society can foster

sustainable, context-specific solutions to emerging MNT challenges[56,60,61].

Unanswered questions seeking answers

1. How can we accurately measure MNT incidence in remote and conflict-affected areas? Underreporting due to weak surveillance systems, lack of vital registration, and logistical barriers in hard-to-reach or insecure regions. Expand community-based active surveillance**,** invest in mobile health technologies, and partner with humanitarian organizations to gather real-time data in fragile contexts.
2. What is the optimal model for integrating Traditional Birth Attendants (TBAs) into formal health systems? TBAs are often trusted in communities but lack formal medical training, leading to variable outcomes in clean delivery practices. Develop standardized training and certification programs**,** link TBAs with health facilities, and incorporate them into maternal incentive schemes for referrals and clean birth promotion.
3. How do environmental factors like livestock density and sanitation interact with tetanus transmission? Limited empirical data on the role of animal waste and environmental contamination in sustaining tetanus spores in birth environments. Support One Health field studies to map risk factors and inform cross-sectoral interventions in high-risk rural settings.
4. Why do immunization coverage gaps persist despite vaccine availability? Barriers include vaccine stock-outs, cold chain breakdowns, gender-based restrictions on healthcare access, and misinformation. Strengthen logistics and supply chains**,** empower female healthcare workers, and implement locally tailored behavioural change campaigns**.**
5. What are the long-term effects of combining MNT campaigns with other maternal-child health programs? While integration improves efficiency, it's unclear whether it dilutes focus or increases impact. Conduct longitudinal evaluations of integrated health programs to assess sustainability, coverage, and quality of MNT services over time.
6. How can data privacy be ensured in mobile and AI-based surveillance for MNT? Ethical concerns around patient confidentiality, especially in settings lacking robust digital health governance. Establish clear data protection protocols**,** build capacity among local healthcare workers, and use de-identified data systems in digital MNT platforms.
7. What are the most cost-effective financing mechanisms for sustaining MNT elimination? Donor fatigue and national budget constraints make long-term funding uncertain. Explore Results-Based Financing (RBF)**,** public-private partnerships, and integrate MNT into **national**

health insurance schemes and SDG-aligned investment plans.

CONCLUSION

Ending maternal and neonatal tetanus by 2030 is both achievable and urgent. Despite decades of progress, tens of thousands of preventable deaths persist each year. A One Health approach offers a comprehensive, sustainable framework—bridging human, animal, and environmental health to tackle the roots of transmission. The successes of India, Uganda, and Senegal demonstrate that elimination is possible even in resource-limited settings when political commitment, community engagement, and cross-sectoral collaboration converge. To meet the 2030 target, governments and partners must act decisively: fund One Health–based plans, integrate MNT with maternal and child health initiatives, and leverage technology and gender equity as enablers of change. MNT elimination will not be achieved in laboratories or ministries alone—it will be realized in communities that safeguard every mother and newborn from a preventable tragedy.

Key Research Highlights

1. This review emphasized that maternal and neonatal tetanus is not solely a medical issue—it is also driven by environmental contamination, animal waste exposure, and traditional practices. By framing MNT within the One Health paradigm**,** the paper highlights how cross-sectoral collaboration (human, animal, environmental health) is crucial to sustainable elimination**.**
2. Community engagement and culturally tailored behavior change strategies significantly improve vaccine uptake and clean delivery practices. However, these approaches are often underfunded and sidelined in favor of clinical interventions, despite their proven cost-effectiveness and impact on behavioral norms.
3. Emerging tools like AI-based disease mapping, drone-assisted vaccine delivery, and mHealth platforms offer new pathways to bridge logistical and surveillance gaps. Yet, their deployment remains uneven across socio-economic and geographical lines**,** calling for inclusive implementation frameworks that prioritize accessibility and ethical safeguards.

Abbreviations

MNT - Maternal and Neonatal Tetanus
NT - Neonatal Tetanus
MT - Maternal Tetanus
WHO - World Health Organization
UNICEF - United Nations Children's Fund
TTCV - Tetanus Toxoid-Containing Vaccine
SIA - Supplementary Immunization Activity
TBA - Traditional Birth Attendant
UHC - Universal Health Coverage
SDG - Sustainable Development Goal
LMIC - Low- and Middle-Income Country
mHealth - Mobile Health
RBF - Results-Based Financing
AI - Artificial Intelligence
GIS - Geographic Information System
WASH - Water, Sanitation, and Hygiene

EPI - Expanded Programme on Immunization
CSO - Civil Society Organization
NGO - Non-Governmental Organization
ANC - Antenatal Care
CHW - Community Health Worker
PHC - Primary Health Care
GHSA - Global Health Security Agenda
NHP - National Health Policy
HIS - Health Information System

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Not applicable.

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Conflict of Interest
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