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NEUROMATRIX-INFORMED PHYSIOTHERAPY FOR CHRONIC PAIN MANAGEMENT: A SCOPING REVIEW OF EVIDENCE AND CLINICAL APPLICATIONS

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ABSTRACT

Background: Pain is a complex, multifaceted experience that extends beyond mere nociception. The neuromatrix theory, introduced by Melzack, reframes our understanding of pain by conceptualizing it as an output of a widely distributed neural network influenced by sensory input, cognitive evaluation, and emotional state.
Aim: This scoping review examined the application of the neuromatrix model within physiotherapy, evaluating its relevance as a comprehensive, non-pharmacological framework for managing diverse pain conditions.
Methods: A systematic search was conducted between January 15 to january 30 2025, across PubMed, Science Direct, and Google Scholar using predefined keywords. After screening 1,273 articles and assessing 127 full-text papers, 36 studies met the inclusion criteria, including randomized controlled trials, observational studies, qualitative research, and mixed-methods designs. The review mapped how physiotherapists apply neuromatrix-informed strategies-such as movement therapy, pain neuroscience education, manual techniques, and psychosocial interventions-to address the multidimensional nature of pain.
Results: Findings underscore a shift from biomedical to biopsychosocial approaches, highlighting the importance of therapeutic alliance, patient beliefs, and neuroplasticity in modulating pain perception and promoting recovery. Interventions targeting chronic pain conditions such as low back pain, fibromyalgia, and phantom limb pain showed evidence of altered brain activity and pain modulation consistent with neuromatrix principles.
Results: However, study heterogeneity and limited high-quality trials suggest that further research is needed to confirm these outcomes and support broad implementation.

Keywords; Neuromatrix theory, chronic pain, physiotherapy, biopsychosocial model, non-pharmacological interventions.

ABBREVIATIONS

Al	Artificial Intelligence
AR	Augmented Reality
CBT	Cognitive Behavioral Therapy
CLBP	Chronic Low Back Pain
FMRI	Functional Magnetic Resonance Imaging
GMI	Graded Motor Imagery
RCT	Randomized Controlled Trial
VR	Virtual Reality

INTRODUCTION

Pain as a pandemic refers to the global prevalence of chronic and severe pain conditions that significantly impact individual health, societal function, and healthcare systems[1]. This concept underscores the notion that pain is not an isolated symptom, but a multidimensional disease affecting physical, psychological, and social well-being[2]. It is a leading cause of disability worldwide, particularly among working-age adults and older populations, contributing to increased morbidity, healthcare utilization, and economic burden[3]. Chronic pain affects over 1.5 billion people globally[4], with conditions such as back pain, osteoarthritis, neuropathy, and fibromyalgia documented in virtually every country[5].

Beyond physical suffering, chronic pain disrupts employment, education, mental health, and social participation[6]. A significant disparity exists in access to pain management, particularly in low- and middle-income countries, where the availability of effective therapies and pain medications is limited. Unlike acute pain, chronic pain may persist for months or even years, becoming a lifelong condition for many[7]. Despite its widespread impact, chronic pain is often underdiagnosed and undertreated—reflecting systemic gaps in medical education, healthcare delivery, and research priorities.

The Neuromatrix Theory of Pain was developed to address limitations of earlier models, such as the biomedical and gate control theories[8], which could not adequately explain persistent or complex pain phenomena. Ronald Melzack proposed the neuromatrix theory based on clinical observations that pain could continue in the absence of active tissue damage, vary greatly between individuals, or even be felt in body parts that no longer exist—such as in phantom limb pain. These insights emphasized the need for a more inclusive framework that considers the brain, emotions, memory, cognition, and genetics in the pain experience.

According to the neuromatrix theory, pain is not simply a direct response to sensory signals but an output generated by a neural network in the brain—the neuromatrix—that integrates multiple sources of input, including sensory, emotional, and cognitive signals[9]. This theory helps explain why individuals with similar injuries report vastly different pain experiences and why chronic pain may persist long after healing has occurred. A key example supporting this theory is phantom limb pain, in which individuals experience pain in an amputated limb[10], reinforcing the concept that pain is brain-derived and not solely tissue-based.

In clinical practice, the neuromatrix model aligns closely with the biopsychosocial approach to pain, promoting a holistic framework for assessment and intervention. This model legitimizes the subjective pain experiences of patients and supports treatment strategies that engage both the body and mind[11]. Interventions such as cognitive-behavioral therapy, mindfulness-based practices, and neuroplasticity-driven rehabilitation target the brain's processing of pain and offer promise in reducing pain-related disability[12].

THE ROLE OF PHYSIOTHERAPY IN PAIN MANAGEMENT

Physiotherapy plays a pivotal role in the management of pain, particularly in the context of chronic pain conditions. It offers a holistic approach that integrates physical, emotional, and psychological elements, in alignment with the neuromatrix theory[13]. Physiotherapists utilize a range of techniques, including manual therapy, exercise therapy, and education, to address the underlying causes of pain, improve function, and reduce disability. Furthermore, physiotherapy aims to empower individuals to manage their pain through self-care strategies, improving their quality of life. As chronic pain continues to rise globally, physiotherapy has emerged as a cornerstone in the treatment and rehabilitation of individuals affected by this condition[14].

Objectives Of The Review

This scoping review aims to explore the intersection between the pain pandemic, the neuromatrix theory of pain, and the role of physiotherapy in addressing chronic pain. The objectives of this review are to:

- Examine the global prevalence and impact of chronic pain, contributing to the pain pandemic.
- Analyze the neuromatrix theory of pain as a comprehensive framework for understanding chronic pain conditions.
- Explore the evidence for physiotherapy interventions in the management of chronic pain and their alignment with the neuromatrix theory.
- Identify the challenges and future directions of neuromatrix-based physiotherapy in pain management

MATERIALS AND METHODS

Search Strategy

Databases: PubMed, Science Direct, Google Scholar

Search period: January 15–30, 2025

Date Range: January 2000–December 2024

Search Terms: “neuromatrix” OR “pain matrix” AND “physiotherapy” OR “physical therapy” AND “chronic pain” OR “persistent pain” AND “biopsychosocial” OR “holistic”

Time Frame: The search covered articles published from January 2000 to December 2024, aligning with the exclusion criterion that omitted studies older than the year 2000.

Eligibility Criteria

Inclusion Criteria: Studies were eligible for inclusion if they met the following criteria:

i. Addressed the application of the Neuromatrix Theory within physiotherapy practices.

ii. Focused on chronic pain and rehabilitation in a physiotherapy context.

iii. Included human participants (with musculoskeletal, neurological, or chronic pain conditions).

iv. Published as peer-reviewed journal articles, including both qualitative and quantitative designs between 2000 – 2024.

Exclusion Criteria:

The following were excluded:

i. Non-peer-reviewed publications.
ii. Studies involving solely theoretical frameworks or animal models.
iii. Articles not focused on physiotherapy or clinical applications of the Neuromatrix Theory.
iv. Publications prior to the year 2000.

Study Selection Process

The selection followed the PRISMA-ScR framework:

1. Identification: A total of 1,273 articles were identified across the selected databases.

2. Screening: After removing 218 duplicates, 1,055 articles were screened by title and abstract.

3. Eligibility: 127 full-text articles were retrieved and assessed for relevance.

4. Inclusion: 36 studies met all inclusion criteria and were included in the final review.

Data Extraction and Synthesis

Data from the included studies were charted into categories including study type, population, intervention type, and key findings. No formal risk of bias assessment or quality grading was performed, as is consistent with scoping review methodology. Instead, a descriptive synthesis was conducted to map current evidence and identify gaps related to neuromatrix-informed physiotherapy for chronic pain.

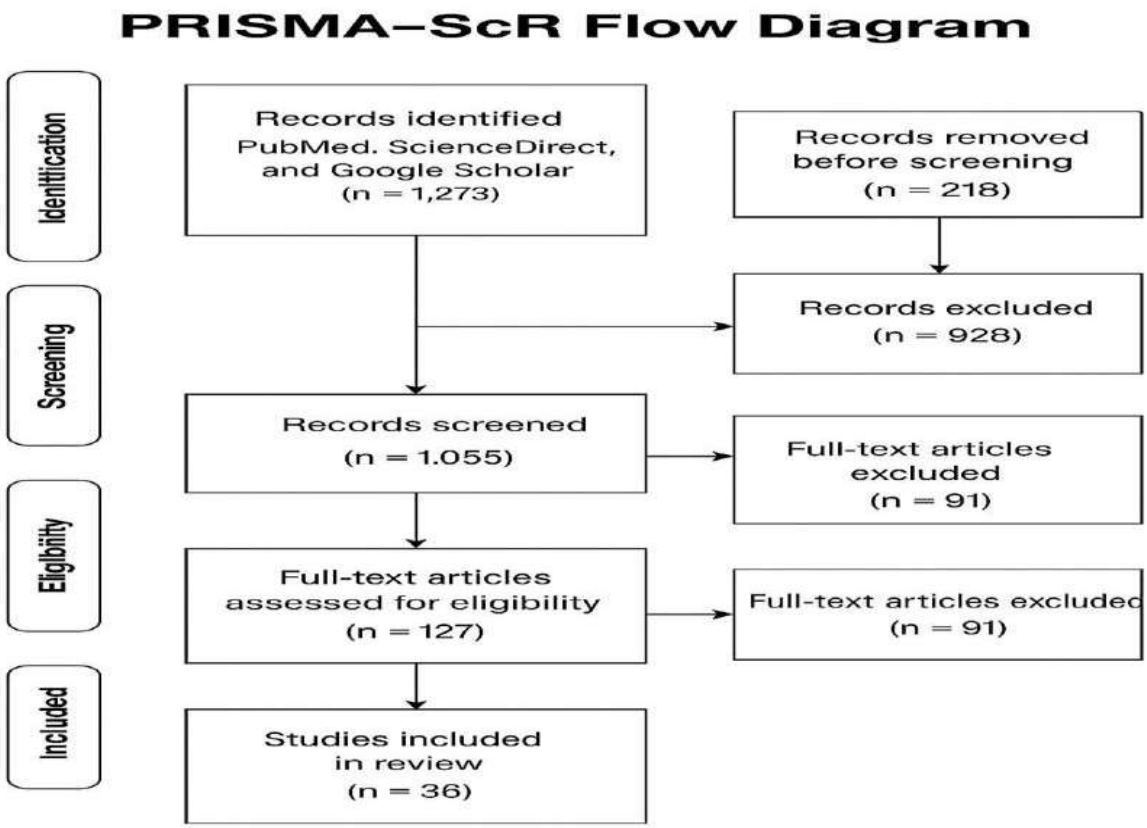

FIGURE 1: PRISMA Flow Diagram

RESULT

Study Selection

The initial database search yielded 1,273 articles. Following the removal of 218 duplicates, 1,055 records were screened by title and abstract. Of these, 127 full-text articles were assessed for eligibility, and 36 studies met the final inclusion criteria. The study selection process is detailed in the PRISMA-ScR flow diagram (Figure 1).

Characteristics of Included Studies:

Among the 36 included studies:

i. 15 were randomized controlled trials (RCTs)
ii. 10 were observational studies
iii. 6 were qualitative studies
iv. 5 employed mixed-methods designs

Populations Studied

The studies addressed various chronic pain populations:

i. Chronic low back pain (n = 18)
ii. Fibromyalgia (n = 9)
iii. Chronic neck pain (n = 5)
iv. Other chronic pain conditions (n = 4), including neuropathic pain and generalized musculoskeletal pain

Intervention Types

The interventions evaluated across the studies included:

i. Pain neuroscience education (n = 20).
ii. Graded motor imagery (n = 12)
iii. Biopsychosocial-based exercise programs (n = 18)
iv. Mindfulness-based physiotherapy (n = 6)

Key Findings

Most of the studies reported positive outcomes in areas such as:

i. Pain reduction
ii. Improved physical function
iii. Enhanced patient engagement and self-efficacy

Interventions informed by the Neuromatrix Theory often emphasized cognitive-emotional factors, neuroplasticity, and the importance of therapeutic alliance. However, there was variation in intervention protocols, duration, and outcome measures, which limited the ability to generalize across populations and settings.

ANALYZING NEUROMATRIX THEORY IN PAIN MANAGEMENT

The Neuromatrix Theory of pain, proposed by Ronald Melzack in the late 20th century, revolutionized the understanding of chronic pain[15]. Unlike previous models, which focused solely on the idea of pain being a direct result of tissue damage, the neuromatrix theory introduces a more complex and multidimensional view. It suggests that pain is not merely a response to sensory input, but rather a result of the brain's processing of multiple factors such as sensory, emotional, and cognitive inputs. This integrated process occurs within a neural network known as the "neuromatrix" in the brain, which is responsible for the perception of pain, as well as other phenomena such as body image and emotion[16].

The theory emphasizes that pain perception is constructed by the brain based on both incoming stimuli and pre-existing neural patterns[17]. It highlights the role of the brain's

plasticity, suggesting that the brain's pain networks can be shaped by experiences, emotions, and prior pain experiences, thus offering a more comprehensive explanation for chronic pain conditions.

Cognitive, Emotional, and Sensory Factors in Chronic Pain

Melzack's neuromatrix theory integrates several factors in the experience of chronic pain:

Cognitive Factors: Thoughts, beliefs, expectations, and past experiences can profoundly influence how a person experiences pain[18]. For example, fear-avoidance models show that individuals who catastrophize about pain or expect worse outcomes are likely to experience heightened pain intensity and disability. Cognitive-Behavioral therapy (CBT) is often used to address these factors in the treatment of chronic pain.

Emotional Factors: Emotions such as stress, anxiety, depression, and fear are known to amplify the perception of pain. Emotional distress can enhance pain sensitivity by altering neural processing in the brain[18]. Chronic pain can also lead to emotional dysregulation, creating a vicious cycle that worsens the pain experience[19].

Sensory Factors: These are the traditional, physiological aspects of pain, such as tissue injury or inflammation[20]. However, sensory input alone is insufficient to explain the full experience of pain, which is where the cognitive and emotional factors come in. For instance, people with chronic pain often report heightened sensitivity to stimuli that would not normally be painful[21].

STUDIES SUPPORTING THE NEUROMATRIX MODEL

Fibromyalgia: A condition marked by widespread musculoskeletal pain, fibromyalgia has been associated with heightened central sensitization and abnormal sensory processing in the brain. Studies using functional magnetic resonance imaging (fMRI) have shown that individuals with fibromyalgia exhibit altered brain activity in regions linked to pain processing, such as the insula, anterior cingulate cortex, and thalamus, aligning with the neuromatrix model[22].

Phantom Limb Pain: Research on phantom limb pain, where individuals experience sensations in a limb that no longer exists, provides strong evidence for the neuromatrix theory. The pain is not caused by any tissue injury but rather the brain's processing of the missing limb's sensory input. Studies suggest that reorganization of the sensory cortex in the brain leads to the experience of pain, even in the absence of sensory input from the limb[23].

Chronic Back Pain: Chronic low back pain (CLBP) is another example where the neuromatrix model has been supported. Studies have shown that emotional and cognitive factors significantly influence the intensity and persistence of back pain[24]. Furthermore, fMRI studies demonstrate altered brain activity in people with chronic back pain, including changes in the primary somatosensory cortex, which suggests a shift in how sensory input is processed[25].

PHYSIOTHERAPY INTERVENTIONS FOR CHRONIC PAIN: ALIGNING WITH THE NEUROMATRIX THEORY

Physiotherapy encompasses a wide range of treatment approaches designed to alleviate pain, restore function, and improve quality of life for individuals experiencing chronic

pain. These approaches are not one-size-fits-all but are tailored to meet the unique needs of each patient. The key physiotherapy methods that have gained attention in the context of chronic pain include:

Manual Therapy:
Manual therapy techniques, such as joint mobilization and soft tissue manipulation, are commonly used to reduce pain and improve mobility[26]. The hands-on approach aims to restore normal joint function, alleviate muscular tension, and reduce mechanical nociceptive (pain-producing) signals[27]. These methods are particularly useful in musculoskeletal pain syndromes like lower back pain, neck pain, and joint arthritis.

Movement-Based Interventions:
Movement therapies, including exercise-based rehabilitation, focus on restoring proper movement patterns and improving physical conditioning[28]. These may include therapeutic exercises, postural training, and functional movement retraining. Movement-based interventions help improve strength, flexibility, and endurance, which not only reduce pain but also promote long-term recovery and prevent future injuries. Exercise has been found to have both physical and psychological benefits, helping individuals with chronic pain improve their mood, self-efficacy, and overall well-being[29].

Neuroplasticity Techniques:
Neuromuscular re-education and techniques aimed at stimulating the brain's neuroplasticity play an important role in pain management[30]. These techniques are designed to retrain the brain and nervous system to re-establish normal pain processing patterns, ultimately reducing pain perception. Approaches like graded motor imagery (GMI) or sensory discrimination training target the brain's cortical representation of the affected body part[31]. These techniques can effectively address central sensitization, a phenomenon in which the brain's pain processing becomes amplified and distorted, leading to chronic pain[32]. Physiotherapy approaches are inherently aligned with the Neuromatrix Theory, as they focus on the multifactorial aspects of pain, integrating both the physical and cognitive-emotional dimensions. The neuromatrix framework suggests that pain is not just a sensory experience but is also influenced by psychological and social factors. Physiotherapy incorporates this holistic view by targeting both the physical manifestations of pain and addressing the psychological barriers to recovery[33].
Manual therapy and movement-based interventions help modulate sensory inputs to the brain, potentially reshaping how pain is perceived and processed. By improving joint function and movement, these interventions directly influence the sensory components of pain, while also contributing to the brain's neuroplastic changes, thus supporting the brain's ability to recalibrate its pain response. Neuroplasticity techniques are directly aligned with the neuromatrix model. By engaging the brain's ability to adapt and reorganize itself, physiotherapists leverage neuroplasticity to alter pain processing patterns[34]. This approach helps break the cycle of chronic pain by retraining the brain's response to stimuli, ultimately reducing pain perception and improving motor function.

Moreover, physiotherapists often educate patients about pain neuroscience, helping them understand the role of the brain in pain perception. This education empowers patients to actively engage in their recovery and reduces fear-avoidant behaviors, which are common in chronic pain conditions and further perpetuate the pain cycle.

PATIENT-CENTERED APPROACHES AND BIOPSYCHOSOCIAL APPLICATIONS

A patient-centered approach is fundamental in contemporary physiotherapy practice, particularly when treating chronic pain. This approach recognizes that pain is a complex experience influenced by physical, emotional, and social factors[35].

Biopsychosocial Model: The biopsychosocial model of pain integrates biological, psychological, and social elements into the treatment plan[36]. In physiotherapy, this means recognizing the importance of not only the physical symptoms of pain (such as musculoskeletal dysfunction) but also the emotional and social contexts that influence pain perception and coping[37]. By addressing the psychological impact of pain, such as anxiety, depression, or fear of movement, physiotherapists can help break the vicious cycle that exacerbates chronic pain.

Psychosocial Support: Many physiotherapists incorporate techniques like cognitive-behavioral therapy (CBT) or mindfulness-based approaches to help patients manage the emotional and cognitive aspects of pain[38]. These techniques teach patients to recognize and challenge unhelpful thoughts and beliefs about pain, thus improving their emotional well-being and reducing pain intensity. For example, by promoting a positive outlook, reducing catastrophizing thoughts, and encouraging graded exposure to movement, physiotherapists can help patients re-engage with life despite chronic pain.

Tailored Rehabilitation: Patient-centered care in physiotherapy involves developing individualized treatment plans that are shaped by the patient's specific needs, preferences, and goals[39]. This personalized approach ensures that patients feel heard and involved in their own care. It also acknowledges the variability in how pain is experienced across different individuals, further aligning with the neuromatrix's understanding of the pain experience as highly individualistic and dynamic. Physiotherapists also work with patients to address the social factors contributing to chronic pain. This includes considering workplace environments, family dynamics, and community support, which can all impact a patient's recovery. By incorporating these elements into treatment plans, physiotherapy can help mitigate external stressors that may worsen pain perception.

CHALLENGES AND FUTURE DIRECTIONS

Lack of Standardized Protocols: While the neuromatrix theory provides a broad conceptual framework for understanding chronic pain, there are no universally accepted, standardized protocols for its application in physiotherapy. The field lacks clear guidelines on how to systematically incorporate neuromatrix principles into treatment plans. For instance, while neuroplasticity techniques such as graded motor imagery are effective for certain conditions, their use is not widespread across physiotherapy settings due to a lack of consensus on how best to implement them[40].

Limited Training for Clinicians: Many physiotherapists are not fully trained in the application of the neuromatrix model in clinical practice. This limits their ability to address the cognitive, emotional, and sensory components of pain in an integrated manner[41]. While cognitive-behavioral techniques, manual therapy, and movement interventions are common, the holistic approach of addressing the brain's pain

networks may not be emphasized enough in physiotherapy education and practice.

Patient Adherence to Multidimensional Approaches: A significant challenge is encouraging patient adherence to the multifaceted treatments required in neuromatrix-based physiotherapy. Treatment plans often involve a combination of manual therapy, exercise, education, and cognitive techniques, but patients may struggle to engage consistently in such comprehensive programs. Addressing the emotional and psychological aspects of chronic pain requires patience, motivation, and the active participation of the patient, which can be a barrier in many cases[42].

POTENTIAL INNOVATIONS IN PAIN THERAPY

The future of neuromatrix-based physiotherapy in pain management holds significant promise, particularly with the advent of technological innovations that can enhance treatment delivery:

Artificial Intelligence (AI) in Pain Therapy: AI technologies hold great potential in personalizing pain management[43]. AI algorithms could analyze vast amounts of patient data (e.g., pain history, sensorimotor data, psychological profiles) to tailor treatment plans more precisely to the individual's unique pain experience. Machine learning could help predict how a patient's pain will respond to different interventions, creating highly personalized care plans that adjust dynamically over time. For example, AI could optimize the delivery of graded motor imagery or help identify the most effective combination of manual therapy and exercise programs based on a patient's progress.

Virtual Rehabilitation: Virtual reality (VR) and augmented reality (AR) are emerging tools in the rehabilitation of chronic pain[44]. These technologies can be used to create immersive environments that engage patients in movement exercises, neuroplasticity training, and pain education. VR has been shown to reduce pain perception and improve mobility in patients with conditions such as phantom limb pain and fibromyalgia by providing controlled, safe, and engaging environments for pain management[45]. Virtual rehabilitation could become an essential tool for physiotherapists, allowing them to remotely monitor patients, provide real-time feedback, and adjust interventions to enhance engagement and effectiveness.

Personalized Treatments: Advances in wearable technology, such as smart devices and biofeedback tools, could provide real-time data on a patient's physical activity, movement patterns, and pain responses[46]. Physiotherapists could use this data to adjust treatments in real-time, allowing for a truly personalized approach to pain management. These technologies could also help track and enhance neuroplastic changes in the brain, further improving the application of neuromatrix-based physiotherapy.

DISCUSSION

This scoping review examined how physiotherapy interventions align with the Neuromatrix Theory of Pain in the management of chronic pain. The findings demonstrate a shift from traditional biomedical approaches toward integrative, neuromatrix-informed strategies that address cognitive, emotional, and sensory factors[15, 16]. These approaches reflect the increasing adoption of the biopsychosocial model[11], supporting a more individualized and patient-centered framework for chronic pain rehabilitation.

Physiotherapy interventions such as pain neuroscience education[43], graded motor imagery[31], neuroplasticity-based exercises[30], and biopsychosocial-focused rehabilitation programs[29, 33] have been shown to target central pain mechanisms. These techniques aim to modulate the neuromatrix by addressing maladaptive patterns such as catastrophizing, fear avoidance, and altered sensorimotor processing[24, 35]. For instance, studies on phantom limb pain[23] and fibromyalgia[22] provide evidence of brain-based pain generation and support interventions that retrain cortical representations.

The therapeutic alliance, patient beliefs, and pain literacy are also key components in neuromatrix-aligned physiotherapy. Educating patients about the brain's role in pain and encouraging active participation fosters improved coping and reduced reliance on passive treatments[43]. This aligns with cognitive-behavioral and mindfulness-based approaches increasingly incorporated into physiotherapy practice[37, 38].

However, challenges to implementation remain. There is no standardized protocol for delivering neuromatrix-based interventions[40], and many physiotherapists lack formal training in integrating psychological and neuroeducational components[41]. Patient adherence can also be a barrier, as multimodal care requires sustained engagement and self-management[42]. These gaps highlight the need for expanded clinical education and clearer practice guidelines.

Emerging innovations offer potential to address these limitations. Virtual reality and augmented reality tools have shown early success in pain modulation and functional improvement[44, 45]. Wearable technologies and AI-driven feedback systems may further personalize rehabilitation and support neuroplasticity-driven recovery[43, 46].

In summary, the integration of the Neuromatrix Theory into physiotherapy represents a promising evolution in the management of chronic pain. By targeting the dynamic interactions within the brain's pain matrix and addressing biopsychosocial factors, physiotherapy can deliver more holistic, adaptive, and evidence-based care. Nonetheless, further high-quality research and implementation frameworks are required to validate these approaches and improve accessibility across diverse healthcare contexts.

CONCLUSION

This scoping review emphasizes the importance of integrating the Neuromatrix Theory into physiotherapy for effective chronic pain management. The key takeaways highlight that pain is not just a sensory experience but a complex interaction of sensory, cognitive, and emotional factors processed by the brain. Physiotherapy, through manual therapy, movement-based interventions, and neuroplasticity techniques, aligns well with this model by addressing all these dimensions. Emerging technologies like AI, virtual rehabilitation, and wearable devices offer exciting opportunities for more personalized and adaptive pain management.

The integration of the Neuromatrix Theory into physiotherapy helps shift the focus from simply treating physical symptoms to addressing the multifactorial nature of pain, leading to more holistic, patient-centered care.

From a public health perspective, embracing the neuromatrix-informed physiotherapy paradigm offers a scalable and sustainable strategy to address the chronic pain crisis. It

supports health system resilience by promoting preventive care, reducing healthcare costs, and improving quality of life across diverse populations. As such, advancing public awareness, access to skilled physiotherapy services, and interdisciplinary collaboration is imperative in transforming the pain care landscape and mitigating its widespread impact on global health.

Ethical Consideration:

As this study is a scoping review of published literature, it did not involve any direct human or animal participants, and thus did not require formal ethical approval. All data were obtained from peer-reviewed and publicly accessible sources. The review was conducted in accordance with the principles of transparency, integrity, and proper citation of original work

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EVALUATION AND CHARACTERIZATION OF MULTIDRUG-RESISTANT BACTERIA ISOLATED FROM RAW BEEF AND CHICKEN LOCALLY SOLD AT NNEWI MARKETS IN ANAMBRA STATE, SOUTH-EASTERN, NIGERIA

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ABSTRACT

Background: The emergence and rapid spread of microbes resistant to affordable and effective first-line antibiotics have become a widespread challenge accounting for a significant portion of the global infectious disease burden. In Nigeria, surveillance and documentation of antimicrobial resistance patterns remain inadequate, with only a limited number of studies available on bacterial prevalence and resistance trends. This lack of oversight exacerbates the challenge of combating antimicrobial resistance in the country.

Aim: This study aimed to evaluate and characterize multidrug-resistant bacteria isolated from raw beef and chicken locally sold at Nnewi markets.

Methods: This descriptive, cross-sectional study was conducted between April and September 2024 across four major markets in Nnewi Metropolis. Forty raw meat samples (28 beef and 12 chicken) were aseptically collected and transported to a research laboratory for microbial analysis. Bacterial isolates were cultured, identified, and tested for antibiotic susceptibility using the Kirby-Bauer method. Highly resistant isolates were further characterized using 16S rRNA sequencing.

Results: A total of 65 bacterial isolates were obtained—61.5% from beef and 38.5% from chicken—mainly Gram-negative bacilli. High resistance was recorded for metronidazole (100%), Ceftazidime (87.7%), and Amoxicillin-Clavulanic (84.6%), while none showed resistance to ciprofloxacin and levofloxacin. No significant difference in resistance patterns between beef and chicken was observed ($p = 0.11–0.95$). Twenty-four isolates (36.9%) were multidrug-resistant (MARI > 0.5).

Conclusion: The presence of MDR bacteria in these meat products poses a serious threat to consumers.

Recommendation: Strengthening routine antimicrobial surveillance and enforcing hygienic meat processing standards are urgently needed.

Keywords: Antibiotic resistance, Beef, meat, Nnewi market

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INTRODUCTION

Despite decades of revolutionizing healthcare and saving countless lives with the introduction of antibiotics, bacterial pathogens have developed resistance to almost all available antibiotics on a global scale[1]. This growing resistance poses a serious threat to the advancements made in modern medicine, including life-saving procedures such as surgeries, cancer treatment, and organ transplants[2]. Antimicrobial resistance remains a significant global concern, accounting for numerous fatalities daily. In Nigeria, the prevalence of multidrug-resistant (MDR) bacteria exacerbates this issue, complicating treatment efforts and posing substantial public health challenges.

The emergence and rapid spread of microbes resistant to affordable and effective first-line antibiotics have become a widespread challenge. This issue is particularly pronounced in bacterial infections, which account for a significant portion of the global infectious disease burden including diarrheal diseases, respiratory infections, meningitis, sexually transmitted infections, and tuberculosis[2]. The resistance of

Staphylococcus aureus to penicillin was first observed in 1942, shortly after its clinical introduction. By the late 1960s, more than 80% of both community-acquired and hospital-acquired *S. aureus* isolates had developed resistance to penicillin[3].

Common MDR pathogens in Nigeria include *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*. Studies have documented high rates of resistance among these bacteria, particularly in healthcare settings. For instance, research from Sokoto, northwest Nigeria, identified a high prevalence of MDR Gram-negative bacterial infections, predominantly caused by *E. coli* and *K. pneumoniae*[4].

Studies have shown that common antimicrobial-resistant bacteria such as *Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, Streptococcus pneumoniae,* and *Salmonella* species, which are part of the normal human microbiota as well as significant human pathogens, are among the predominant bacteria in foodborne diseases[5, 6]. Poultry and livestock serve as reservoirs for these drug-resistant microorganisms, facilitating the spread of pathogens and antimicrobial resistance[7]. Animal-derived food products, which contain a mix of both pathogenic and non-pathogenic bacteria, have become a breeding ground for bacterial interactions that can lead to the development of new drug-resistant and multidrug-resistant (MDR) bacteria through horizontal gene transfer[8, 9].The widespread use of antibiotics in the poultry industry, both for disease prevention and as growth enhancers, has further accelerated the emergence of resistant bacterial strains.

Globally, the poultry farming sector continues to undergo industrialization to meet rising consumer demand. Nigeria ranks 33rd in global meat production, with the sector contributing approximately 17% to the agricultural Gross Domestic Product (GDP) and 5% to the national GDP. Meat production in Nigeria has seen significant growth over the years, with poultry and livestock farming expanding to fulfill increasing consumer needs. To meet this demand, many farmers resort to the excessive use of antimicrobials as an easy and quick solution for disease prevention and productivity enhancement[10]. However, the overuse and misuse of these medications have profound effects on microbial ecosystems, leading to the emergence and evolution of antimicrobial-resistant bacteria[11]. These newly resistant bacteria pose a heightened threat to individuals working in farms, the animal health sector, meat processing units and consumers, as they can spread through direct or indirect contact with contaminated food, infected animals, manure, and other environmental sources.

In Nigeria, a significant portion of the population purchases meat from small-scale vendors, where storage conditions are often inadequate, and handling practices are suboptimal, leading to increased microbial contamination. Studies have indicated that the hygienic conditions of meat shops in major Nigerian cities are unsatisfactory, with a high prevalence of coliform bacteria contamination. Similarly, slaughterhouses in key urban areas do not adhere to proper sanitation standards, further exacerbating the risk of bacterial transmission [12]. Additionally, the sale of veterinary drugs without professional consultation or prescription contributes to the rising problem of antimicrobial resistance. It has been observed that 50% of antibiotics used as feed supplements are inappropriately prescribed, and approximately 71% of veterinary medicines are dispensed without the guidance of a licensed veterinarian[13].

In Nigeria as well as other developing countries like Nepal, surveillance and documentation of antimicrobial resistance patterns remain inadequate, with only a limited number of studies available on bacterial prevalence and resistance trends[13, 14]. Furthermore, there is currently no government-regulated veterinary antimicrobial resistance monitoring system, nor are there comprehensive guidelines for veterinary drug usage and regulation. This lack of oversight exacerbates the challenge of combating antimicrobial resistance in the country. Therefore, this study aimed at evaluating and characterizing multidrug-resistant bacteria isolated from raw beef and chicken locally sold in selected markets in Nnewi.

MATERIALS AND METHOD

Study Design, Study Location, and Sampling

This descriptive, cross-sectional, and prospective study was conducted in Nnewi Metropolis between April and September 2024. A total of 40 fresh raw meat samples were collected from four major markets, each representing one of the autonomous quarters in Nnewi metropolis. The selected markets included Orie Agbo (Nnewichi), Nkwo Nnewi (Uruagu), Okpunegbu (Umudim), and Eke Amobi (Otolo). The samples were categorized into 28 beef samples and 12 chicken samples. Seven beef samples were obtained from butchers from each market, and 3 chicken samples each were collected from poultry breeders. A simple random sampling technique was employed to collect fresh beef from different butcher stalls in the four markets. All samples were immediately placed in sterile, leak-proof containers and transported in a cold chain box to Perfect Glory Research Laboratory, Nnewi, for microbial analysis.

Bacterial Isolation and Identification

A 25-gram portion of each meat sample was thoroughly homogenized for two minutes in 250 ml of 1% buffered peptone water. A 0.1 ml aliquot of the sample was then inoculated onto different culture media, including Nutrient Agar, MacConkey Agar, Salmonella-Shigella Agar, and Mannitol Salt Agar (all from TM-Media, India). The culture plates were incubated at 37°C for 24 hours to facilitate bacterial growth. The resulting colonies were then observed based on their morphological features, staining reactions, and biochemical characteristics, following the standard procedures outlined by U.S. Department of Agriculture, Food Safety and Inspection Service[15].

Pathogenicity (Virulence) Test on Blood Agar Plate

The virulence of bacterial isolates was assessed using Blood Agar Plates (BAP), a nutrient-rich medium containing 5% sheep red blood cells. The plates were prepared by sterilizing nutrient agar at 121°C for 15 minutes, cooling it to 50°C, and aseptically adding 5% sheep blood before gently mixing.

The bacterial isolates were inoculated onto the BAP to evaluate hemolysis. Beta hemolysis (β) was identified by a clear zone around the colonies, indicating complete lysis of red blood cells. Alpha hemolysis (α) showed a greenish, opaque zone, indicating partial hemolysis, while gamma hemolysis (γ) exhibited no noticeable changes, signifying the absence of hemolysis[16].

Antimicrobial Susceptibility Test

The antimicrobial susceptibility of the bacterial isolates was evaluated using the Kirby-Bauer disk diffusion method on Mueller-Hinton Agar (Hi-Media, India), following the guidelines established by the Clinical and Laboratory Standards Institute (CLSI, 2017). To determine the antibiotic

susceptibility pattern, commercially available antibiotic discs were employed. The antibiotics tested included Ceftazidime (CTZ - 30µg), Streptomycin (S - 30µg), Azithromycin (AZM - 10µg), Amoxil (AMX - 20µg), Ciprofloxacin (CPX - 10µg), Erythromycin (E - 30µg), Levofloxacin (LEV - 20µg), Gentamycin (CN - 10µg), Cefuroxime (CEF - 30µg), Rifampicin (RD - 20µg), Ofloxacin (OFX - 10µg), Augmentin (AU - 30µg), Peflacine (PEF - 10µg), Ceporex (CEP - 10µg), Ceftriaxone (TRX - 30µg), and Metronidazole (MTZ - 50µg). These antibiotics were selected based on their clinical relevance and effectiveness against a broad spectrum of bacterial pathogens. The plates were incubated at 37°C for 24 hours. Zones of inhibition were measured using a meter rule and interpreted using standard recommendations of the Clinical and Laboratory Standard Institute[17].

RESULTS

The microbial load (**Table 1**) of beef and chicken samples was assessed at different dilution levels, with Total Viable Count (TVC), Total Enteric Count (TEC), and Total Staphylococcal Count (TSC) recorded in Colony Forming Units per milliliter (CFU/ml). At lower dilutions (10^{-1} and 10^{-2}), microbial growth in both beef and chicken samples were too numerous to count (TNTC), indicating a high microbial load. As the dilution factor increased, countable microbial colonies were observed. For beef, TVC ranged from 2.2×10^6 CFU/ml at 10^{-3} to 8.5×10^8 CFU/ml at 10^{-6}, while TEC and TSC followed a similar trend, with values reaching 7.6×10^8 CFU/ml and 5.1×10^8 CFU/ml, respectively, at 10^{-6} dilution.

Chicken samples exhibited a slightly different trend, with TNTC counts persisting up to 10^{-3} dilution for TVC, whereas TEC and TSC became countable at 10^{-3} dilution. The highest recorded counts at 10^{-6} dilution for chicken were 5.7×10^8 CFU/ml (TVC), 6.9×10^6 CFU/ml (TEC), and 4.8×10^6 CFU/ml (TSC). Overall, the microbial load in both meat types was significantly high, especially at lower dilutions, with bacterial counts reducing as the dilution factor increased.

Tables 2A and 2B present the identification and biochemical characteristics of bacterial isolates obtained from the meat samples. Table 2A provides details on the Gram staining reactions, morphological characteristics, and biochemical test results, including catalase, oxidase, indole, urease, citrate utilization, motility, and Kligler iron agar tests. These tests were used to classify the isolates into their respective bacterial species. Table 2B illustrates the sugar fermentation profiles of the isolates, indicating their ability to utilize different carbohydrates such as glucose, lactose, xylose, fructose, and sucrose. The combination of these biochemical tests was essential for confirming the identity of the bacterial species present in the samples. Out of the 65 bacterial isolates, twenty-one (21) were Gram-positive (32.3%), while forty-four (67.7%) were Gram-negative, indicating a higher prevalence of Gram-negative bacteria in the analyzed meat samples.

Table 3 presents the virulence test results of the bacterial isolates based on their hemolysis patterns on a blood agar plate. Hemolysis was categorized into gamma (γ), alpha (α), and beta (β) hemolysis, indicating different levels of virulence. Out of the 65 isolates analyzed, 47 isolates (72.3%) exhibited gamma (γ) hemolysis, 14 isolates (21.5%) showed alpha (α) hemolysis, and 4 isolates (6.2%) demonstrated beta (β) hemolysis. The predominance of

gamma hemolysis suggests that most of the isolates had low virulence, while a smaller proportion exhibited medium and high virulence.

Table 1: Total Microbial Count of the Meat Samples (CFU/ml)

Sample	Location	TVC (cfu/ml)	TEC (cfu/ml)	TSC (cfu/ml)
Beef	Orie Agbor	2.1×10^8	2.09×10^6	7.1×10^6
	Okpuno Egbu	8.7×10^7	2.1×10^5	1.5×10^4
	Eke Amobi	2.2×10^6	7.6×10^8	1.2×10^6
	Nkwo Nnewi	1.4×10^7	1.1×10^7	5.8×10^8
Chicken	Ogbo Okuko A	2.08×10^7	2.07×10^6	1.02×10^7
	Ogbo Okuko B	5.7×10^8	1.3×10^7	5.1×10^7
	Ogbo OKuko C	1.4×10^8	6.9×10^6	1.2×10^6

TVC = Total Viable Count; TEC = Total Enteric Count; TSC = Total Staphylococcal Count; TNTC = Too Numerous Too Count; TFTC = Too Few To Count; CFU = Colony Forming Unit.

Table 2A: Gram Staining and Biochemical Test Identification of Isolates

Isolates	Gram Strain	CAT	OX	IND	UR	CIT	MO	KIA	Suspected Organism
BOA1	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BOA2	-ve bacilli	+	-	-	+	+	+	+	*Citrobacter murliniae*
BOA3	+ve cluster-cocci	+	-	-	+	-	-	-	*S. aureus*
BOA4	+ve cluster-cocci	+	-	-	-	-	-	+	*S. aureus*
BOA5	-ve bacilli	+	-	-	+	+	-	+	*Salmonella spp.*
BOA6	+ve bacilli	+	-	-	+	-	+	+	*Listeria*
BOA7	-ve bacilli	+	-	-	+	+	-	-	*Salmonella spp.*
BOA8	+ve bacilli	+	-	-	-	-	+	+	*Lysinibacillus boronitolerans*
BOE1	+ve cluster-cocci	+	-	-	-	+	-	-	*S. aureus*
BOE2	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BOE3	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BOE4	-ve bacilli	+	+	+	+	+	-	+	*Vibrio spp.*
BOE5	-ve bacilli	+	-	-	+	+	+	-	*Salmonella spp.*
BOE6	-ve bacilli	+	+	+	+	+	-	+	*Vibrio spp.*
BOE7	+ve cluster-cocci	+	-	-	-	-	-	+	*S. aureus*
BOE8	-ve bacilli	+	-	+	-	+	+	-	*Morganella spp.*
BOE9	-ve bacilli	-	-	+	-	-	+	-	*Morganella spp.*
BOE10	+ve bacilli	+	-	-	-	+	+	+	*Citrobacter spp.*
BEA1	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BEA2	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BEA3	-ve bacilli	+	-	+	-	-	-	-	*Shigella spp.*
BEA4	-ve bacilli	+	-	+	-	+	-	-	*Salmonella spp.*
BEA5	-ve bacilli	+	+	+	+	+	+	-	*Vibrio spp.*
BEA6	+ve cluster-cocci	+	-	-	-	-	-	-	*S. aureus*
BEA7	+ve cluster-cocci	+	-	-	-	-	-	+	*S. aureus*
BEA8	-ve bacilli	+	+	+	+	+	-	+	*Vibrio spp.*
BNN1	-ve bacilli	+	+	+	+	-	+	-	*Vibrio spp.*
BNN2	-ve bacilli	+	-	-	+	+	+	-	*Salmonella spp.*
BNN3	-ve bacilli	+	-	-	+	+	+	+	*Citrobacter murliniae*
BNN4	-ve bacilli	+	-	-	-	+	+	+	*Citrobacter spp.*
BNN5	-ve bacilli	+	-	-	-	+	+	-	*Providencia sneebia*
BNN6	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
BNN7	-ve bacilli	+	-	-	-	+	+	+	*Salmonella spp.*
BNN8	-ve bacilli	+	-	-	-	+	+	-	*Morganella morganii*
BNN9	+ve bacilli	+	+	+	+	+	-	+	*Vibrio*

BNN10	-ve bacilli	+	+	+	+	+	+	-	*Vibrio*
BNN11	-ve bacilli	+	-	+	-	+	+	-	*Pseudocitrobacter vendiensis*
CHA1	+ve cluster-cocci	+	+	-	-	-	-	-	*S. aureus*
CHA2	+ve bacilli	+	-	-	+	+	+	+	*Listeria*
CHA3	+ve cluster-cocci	+	+	-	-	-	-	-	*S. aureus*
CHA4	+ve bacilli	+	-	-	+	+	+	+	*Lysinibacillus boronitolerans*
CHA5	-ve bacilli	+	-	+	-	+	+	-	*Morganella spp.*
CHA6	-ve bacilli	-	-	+	+	-	-	-	*E. coli*
CHA7	-ve bacilli	+	-	-	-	+	+	+	*Salmonella spp.*
CHA8	-ve bacilli	+	-	+	-	-	+	-	*E. coli*
CHA9	-ve bacilli	-	-	-	-	-	+	+	*Salmonella*
CHA10	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
CHA11	+ve cluster-cocci	+	-	+	-	+	+	+	*Lysinibacillus boronitolerans*
CHB1	-ve bacilli	+	-	+	-	-	+	+	*Salmonella spp.*
CHB2	+ve cluster-cocci	+	+	-	-	-	-	-	*S. aureus*
CHB3	-ve bacilli	+	-	+	-	+	+	-	*Morganella spp.*
CHB4	-ve bacilli	+	-	-	-	+	+	+	*Salmonella spp.*
CHB5	-ve bacilli	+	+	+	-	-	-	+	*Shigella spp.*
CHB6	+ve bacilli	+	-	-	+	+	+	-	*Lysinibacillus boronitolerans*
CHB7	-ve bacilli	+	-	-	+	+	+	-	*Salmonella*
CHB8	+ve bacilli	+	-	-	+	-	+	+	*Listeria*
CHC1	+ve cluster-cocci	+	-	-	+	-	-	-	*S. aureus*
CHC2	-ve bacilli	+	-	-	+	-	-	+	*Shigella spp.*
CHC3	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
CHC4	-ve bacilli	+	-	+	-	-	+	+	*E. coli*
CHC5	-ve bacilli	+	-	-	-	-	-	+	*Shigella spp.*
CHC6	-ve bacilli	+	-	-	-	+	+	-	*Providencia sneebia*
CHC7	+ve cluster-cocci	+	-	-	-	-	-	+	*S. aureus*
CHC8	+ve cluster-cocci	+	-	-	-	-	-	+	*S. aureus*
CHC9	-ve bacilli	+	-	+	-	-	+	-	*E. coli*

CAT = Catalase Test; OX = Oxidase Test; IN = Indole Test; UR = Urease Test; CIT = Citrate Utilization Test; MO = Motility Test; KIA = Kliger Iron Agar Test; +ve = positive while –ve = negative results.

Table 2B: Sugar Fermentation Test of Isolates

Isolates	GLU	LAC	XYL	FRU	MAN	GAL	SUC	DEX	MAL	MANN
Citrobacter murliniae	+	-	+	+	+	-	-	+	+	+
S. aureus	+	+	-	+	+	-	+	-	+	+
E. coli	+	+	+	-	-	+	+	-	-	+
Salmonella spp.	+	-	+	+	+	+	-	-	+	+
Shigella spp.	+	-	+	+	-	+	+	-	+	+
Vibrio spp.	+	-	-	+	-	-	-	+	-	-
Citrobacter spp.	+	-	+	+	+	-	-	-	+	-
Providencia sneebia	+	-	-	-	+	-	+	+	-	-
Morganella morganii	+	+	-	-	+	-	+	+	-	-
Listeria spp.	+	-	-	+	+	+	+	-	-	-
Pseudocitrobacter vendiensis	+	-	+	+	+	-	-	+	-	+
Lysinibacillus boronitolerans	+	-	+	+	-	+	+	-	+	-
Morganella spp.	+	-	-	-	+	-	-	+	+	-

GLU = Glucose; LAC = Lactose; XYL = Xylose; FRU = Fructose; MAN = Mannitol; GAL = Galactose; SUC = Sucrose; DEX = Dextrose; MAL = Maltose; MANN = Mannose.

Table 3: Virulence Test on Blood Agar Plate

Isolates	Hemolysis	Virulence
BOA1	**Γ**	Low
BOA2	**Γ**	Low
BOA3	**Γ**	Low
BOA4	**Γ**	Low
BOA5	**Γ**	Low
BOA6	**Γ**	Low
BOA7	**A**	Medium
BOA8	**Γ**	Low
BOE1	**Γ**	Low
BOE2	**A**	Medium
BOE3	**Γ**	Low
BOE4	**Γ**	Low
BOE5	**A**	Medium
BOE6	**Γ**	Low
BOE7	**Γ**	Low
BOE8	**Γ**	Low
BOE9	**A**	Medium
BOE10	**Γ**	Low
BEA1	**α**	Medium
BEA2	**γ**	Low
BEA3	**α**	Medium
BEA4	**α**	Medium
BEA5	**γ**	Low
BEA6	**γ**	Low
BEA7	**γ**	Low
BEA8	**γ**	Low
BNN1	**γ**	Low
BNN2	**γ**	Low
BNN3	**γ**	Low
BNN4	**γ**	Low
BNN5	**γ**	Low
BNN6	**γ**	Low
BNN7	**γ**	Low
BNN8	**γ**	Low
BNN9	**α**	Medium

BNN10	**α**	Medium
BNN11	**α**	Medium
CHA1	**γ**	Low
CHA2	**β**	High
CHA3	**β**	High
CHA4	**β**	High
CHA5	**α**	Medium
CHA6	**γ**	Low
CHA7	**α**	Medium
CHA8	**α**	Medium
CHA9	**γ**	Low
CHA10	**α**	Medium
CHA11	**α**	Medium
CHB1	**γ**	Low
CHB2	**γ**	Low
CHB3	**γ**	Low
CHB4	**γ**	Low
CHB5	**γ**	Low
CHB6	**γ**	Low
CHB7	**γ**	Low
CHB8	**β**	High
CHC1	**γ**	Low
CHC2	**γ**	Low
CHC3	**α**	Medium
CHC4	**γ**	Low
CHC5	**γ**	Low
CHC6	**γ**	Low
CHC7	**γ**	Low
CHC8	**α**	Medium
CHC9	**γ**	Low

γ = Gamma; α = Alpha; β = Beta.

Table 4 presents the antibiotic susceptibility patterns of the bacterial isolates against 16 different antibiotics. The susceptibility of each isolate was determined based on whether it was resistant (R) or susceptible (S) to the tested antibiotics. The table provides insight into the resistant profiles of the isolates, highlighting variations in their response to different antimicrobial agents.

The prevalence of antimicrobial resistance in isolates from beef and chicken samples is represented in table 5. Overall, our results showed that the bacterial isolates exhibited high resistance to metronidazole (100%), Ceftazidime (87.7%), Amoxicillin-Clavulanic (84.6%), Cefuroxime (78.5%), Amoxicillin (69.2%), and Cefalexin (66.2%). However, no resistance was observed against ciprofloxacin and levofloxacin (0%).

The difference in the distribution of resistant isolates between beef and chicken isolates across the antibiotics tested was not statistically significant with p-values ranging from 0.11 to 0.95 (which were much greater than the typical significance level: $p>0.05$) and $X^2 < 3.84$ indicating no strong evidence that the resistance to the antibiotics differs significantly between beef and chicken isolates; thus the observed variations in resistance were likely due to chance rather than a systematic difference between the two sources.

Antibiotic susceptibility of bacterial isolates based on the CLSI interpretative criteria breakpoints, 2020 is presented in Figure 4.1. High resistance was observed for Metronidazole, Ceftazidime, Amoxicillin, and Amoxi-Clav, indicating they are ineffective. In contrast, Ciprofloxacin, Levofloxacin, and Ofloxacin showed high sensitivity, making them the most effective. Some antibiotics like Streptomycin, Gentamicin, Erythromycin had mixed responses, showing intermediate susceptibility, suggesting that combination therapy or alternative dosing strategies might be needed.

Figure 2 shows the Multiple Antibiotic Resistance Index (MARI) of the isolates, a numerical value that assesses bacterial resistance to antibiotics. It serves as an indicator of the extent to which an organism is resistant to multiple antibiotics.

The MARI was calculated and interpreted[18] using the formula: MARI = $\frac{x}{y}$ where 'x' represents the number of antibiotics to which an isolate was resistant, and 'y' represents the total number of antibiotics tested. The tables show isolates with MARI ranging from 0.50 to 0.88 showing BNN5 with the highest MARI of 0.88.

Figure 3 shows agarose gel electrophoresis of the extracted and amplified genes of the 5 most resistant isolates and Table 4.6 shows their molecular identities.

Table 4A: Antibiogram of Gram-Positive Isolates

Isolates	CTZ	S	AZM	AMX	CPX	E	LEV	CN	CEF	RD	OFX	AMC	PEF	CEP	TRX	MTZ
BOA3	R	R	I	R	S	S	S	R	I	S	S	R	S	R	R	R
BOA4	R	S	S	I	S	S	S	S	R	R	S	I	S	I	I	R
BOA6	R	I	I	R	S	S	S	R	S	S	S	R	S	R	R	R
BOA8	R	S	S	I	S	I	S	R	R	S	R	R	I	R	I	R
BOE1	R	R	S	I	S	I	S	R	R	S	R	R	I	R	R	R
BOE7	R	I	I	S	S	S	S	I	R	I	S	R	S	R	S	R
BOE10	R	S	R	S	S	R	S	R	R	S	S	R	I	I	S	R
BEA6	R	I	R	R	S	R	S	I	R	I	S	R	S	R	I	R
BEA7	R	S	I	R	S	S	S	I	I	S	S	R	S	R	I	R
BNN9	R	I	I	R	S	R	S	S	I	S	S	R	S	I	S	R
CHA1	R	S	I	R	S	S	S	S	R	S	S	R	I	R	R	R
CHA2	I	S	I	R	S	S	S	S	I	S	S	I	S	I	R	R
CHA3	R	S	I	R	S	S	S	I	R	S	S	I	S	I	R	R
CHA4	R	I	R	R	S	I	S	S	R	S	I	R	S	R	R	R
CHA11	R	S	I	I	S	I	S	I	R	S	S	R	S	R	R	R
CHB2	R	I	R	R	S	R	S	I	R	R	S	I	I	I	S	R
CHB6	R	R	R	R	S	R	S	I	R	I	S	R	S	R	R	R
CHB8	I	S	R	R	S	I	S	S	I	I	S	R	S	R	S	R
CHC1	R	R	R	R	S	R	S	I	R	I	S	S	S	R	R	R
CHC7	R	S	R	S	S	R	S	R	R	S	I	I	S	R	S	R
CHC8	R	I	R	R	S	I	S	S	I	S	S	S	S	I	R	R

Table 4B: Antibiogram of Gram-Negative Isolates

Isolates	CTZ	S	AZM	AMX	CPX	E	LEV	CN	CEF	RD	OFX	AMC	PEF	CEP	TRX	MTZ
BOA1	R	S	R	R	S	S	S	S	R	S	S	R	S	S	I	R
BOA2	R	I	R	R	S	R	S	I	R	R	S	R	R	R	R	R
BOA5	R	S	R	R	S	I	S	I	R	S	S	I	S	I	I	R
BOA7	R	I	S	I	S	I	S	R	R	S	R	R	I	R	I	R
BOE2	R	S	S	I	S	I	S	I	R	S	S	R	S	R	I	R
BOE3	R	I	R	R	S	R	S	R	R	S	I	R	S	R	R	R
BOE4	R	I	I	R	S	I	S	I	R	S	I	R	S	R	S	R
BOE5	R	R	R	R	S	R	S	I	R	I	S	R	S	R	S	R
BOE6	R	I	I	R	S	R	S	S	R	S	S	R	S	I	S	R
BOE8	R	S	I	I	S	I	S	S	R	I	S	R	S	S	S	R
BOE9	I	I	R	S	S	R	S	I	I	S	S	R	S	R	S	R
BEA1	R	S	I	I	S	R	S	I	R	I	S	R	S	R	S	R
BEA2	R	I	R	R	S	R	S	S	R	I	S	R	S	R	S	R
BEA3	R	R	R	R	S	R	S	R	R	I	S	R	I	I	S	R
BEA4	R	S	S	R	S	S	S	I	R	S	S	R	S	R	R	R
BEA5	I	R	R	R	S	R	S	I	R	I	S	R	S	R	R	R
BEA8	R	I	I	R	S	R	S	S	R	S	S	R	S	R	I	R
BNN1	R	I	R	R	S	R	S	I	R	R	S	I	S	S	S	R
BNN2	R	S	I	R	S	S	S	I	R	R	S	R	S	S	S	R
BNN3	R	S	R	I	S	R	S	R	R	S	I	R	S	S	I	R
BNN4	R	I	R	R	S	S	S	R	R	R	I	R	S	R	R	R
BNN5	R	R	R	R	S	R	I	R	R	R	R	R	R	R	R	R
BNN6	I	S	I	R	S	R	S	S	R	I	S	R	S	R	S	R
BNN7	R	I	R	R	S	S	S	I	R	S	S	R	S	I	S	R
BNN8	R	I	R	R	S	I	S	R	R	S	R	R	R	R	R	R
BNN10	R	I	R	R	S	R	S	R	R	S	S	R	S	R	R	R
BNN11	R	R	R	R	S	R	S	I	R	S	S	R	S	R	R	R
CHA5	I	I	S	I	S	R	S	I	R	R	S	R	S	R	I	R
CHA6	R	S	I	R	S	I	S	I	S	S	I	R	S	R	R	R
CHA7	R	R	R	R	S	R	S	R	R	I	S	R	S	R	I	R
CHA8	R	I	I	R	S	R	S	I	R	I	I	R	S	R	R	R
CHA9	R	S	S	I	S	I	S	I	R	R	I	R	S	I	I	R
CHA10	R	R	R	R	S	I	S	R	R	I	S	R	S	R	I	R
CHB1	R	I	I	R	S	S	S	I	R	I	S	R	S	I	S	R
CHB3	R	R	R	R	S	R	S	I	I	I	S	R	S	R	S	R
CHB4	R	I	S	R	S	R	S	I	R	I	S	R	S	R	R	R
CHB5	R	S	I	R	S	R	S	S	I	I	S	R	S	R	R	R

CHB7	R	I	R	I	S	R	S	R	R	R	I	R	S	R	R	R
CHC2	R	I	R	S	S	S	S	I	I	I	S	R	S	S	R	R
CHC3	R	I	R	R	S	R	S	I	R	I	I	R	S	R	S	R
CHC4	I	S	I	I	S	S	S	I	R	I	S	R	S	R	S	R
CHC5	R	I	R	R	S	S	S	R	I	I	S	R	S	S	S	R
CHC6	I	R	I	I	S	S	S	I	R	S	I	I	I	S	I	R
CHC9	R	S	S	I	S	I	S	S	I	I	I	R	S	I	R	R

CTZ = Ceftazidime; S = Streptomycin; AZM = Azithromycin; AMX = Amoxicillin; CPX = Ciprofloxacin; E = Erythromycin; LEV = Levofloxacin; CN = Gentamycin; CEF = Cefuroxime; RD = Rifampicin; OFX = Ofloxacin; AMC = Amoxicillin-Clavulanic; PEF = Pefloxacin; CEP = Cefalexin; TRX = Ceftriaxone; MTZ = Metronidazole.

S means the isolate is susceptible to the given antibiotic while I shows intermediate resistance and R shows resistance.

Table 5: Prevalence of Antimicrobial Resistance in Isolates from Beef and Chicken

Antibiotics	Concentration (µg)	Beef (n=40) N (%)	Chicken (n=25) N (%)	Total (n=65) N (%)	P-value	X^2
Ceftazidime	30	36 (63.2%)	21 (36.8%)	57 (87.7%)	0.27	1.211
Streptomycin	30	5 (38.5%)	8 (61.5%)	13 (20.0%)	0.20	1.608
Azithromycin	10	18 (54.5%)	15 (45.5%)	33 (50.8%)	0.87	0.025
Amoxicillin	20	26 (57.8%)	19 (42.2%)	45 (69.2%)	0.80	0.063
Ciprofloxacin	10	0 (0.0%)	0 (0.0%)	0 (0.0%)	0	0
Erythromycin	30	17 (54.8%)	14 (45.2%)	31 (47.7%)	0.90	0.015
Levofloxacin	20	0 (0.0%)	0 (0.0%)	0 (0.0%)	0	0
Gentamicin	10	8 (44.4%)	10 (55.6%)	18 (27.7%)	0.33	0.962
Cefuroxime	30	29 (56.9%)	22 (43.1%)	51 (78.5%)	0.89	0.018
Rifampicin	20	4 (40.0%)	6 (60.0%)	10 (15.4%)	0.31	1.028
Ofloxacin	10	3 (60.0%)	2 (40.0%)	5 (7.7%)	0.85	0.034
Amoxi-Clav	30	31 (56.4%)	24 (43.6%)	55 (84.6%)	0.95	0.004
Pefloxacin	10	2 (66.7%)	1 (33.3%)	3 (4.6%)	0.71	0.141
Cephalexin	10	25 (58.1%)	18 (41.9%)	43 (66.2%)	0.77	0.086
Ceftriaxone	30	11 (40.7%)	16 (59.3%)	27 (41.5%)	0.11	2.524
Metronidazole	50	40 (61.5%)	25 (38.5%)	65 (100.0%)	0.36	0.832

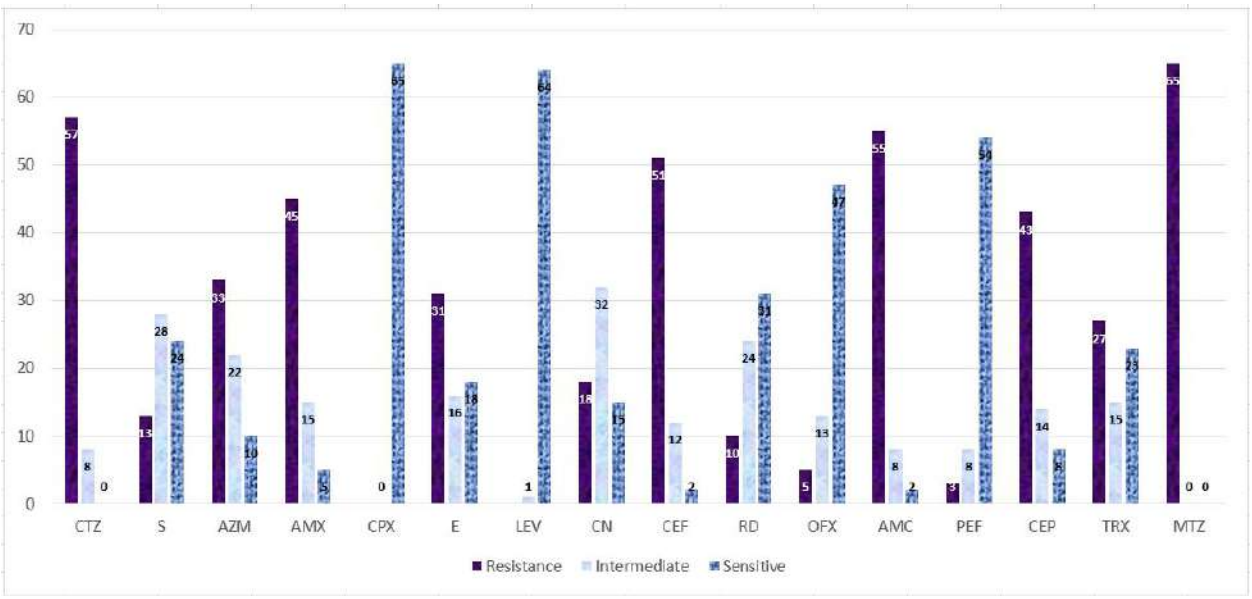

Figure 1: Chart showing the distribution of Antibiotic Susceptibility Test of Isolates

Key:
CTZ = Ceftazidime; S = Streptomycin; AZM = Azithromycin; AMX = Amoxicillin; CPX = Ciprofloxacin; E = Erythromycin; LEV = Levofloxacin; CN = Gentamycin; CEF = Cefuroxime; RD = Rifampicin; OFX = Ofloxacin; AMC = Amoxicillin-Clavulanic; PEF = Pefloxacin; CEP = Cefalexin; TRX = Ceftriaxone; MTZ = Metronidazole.

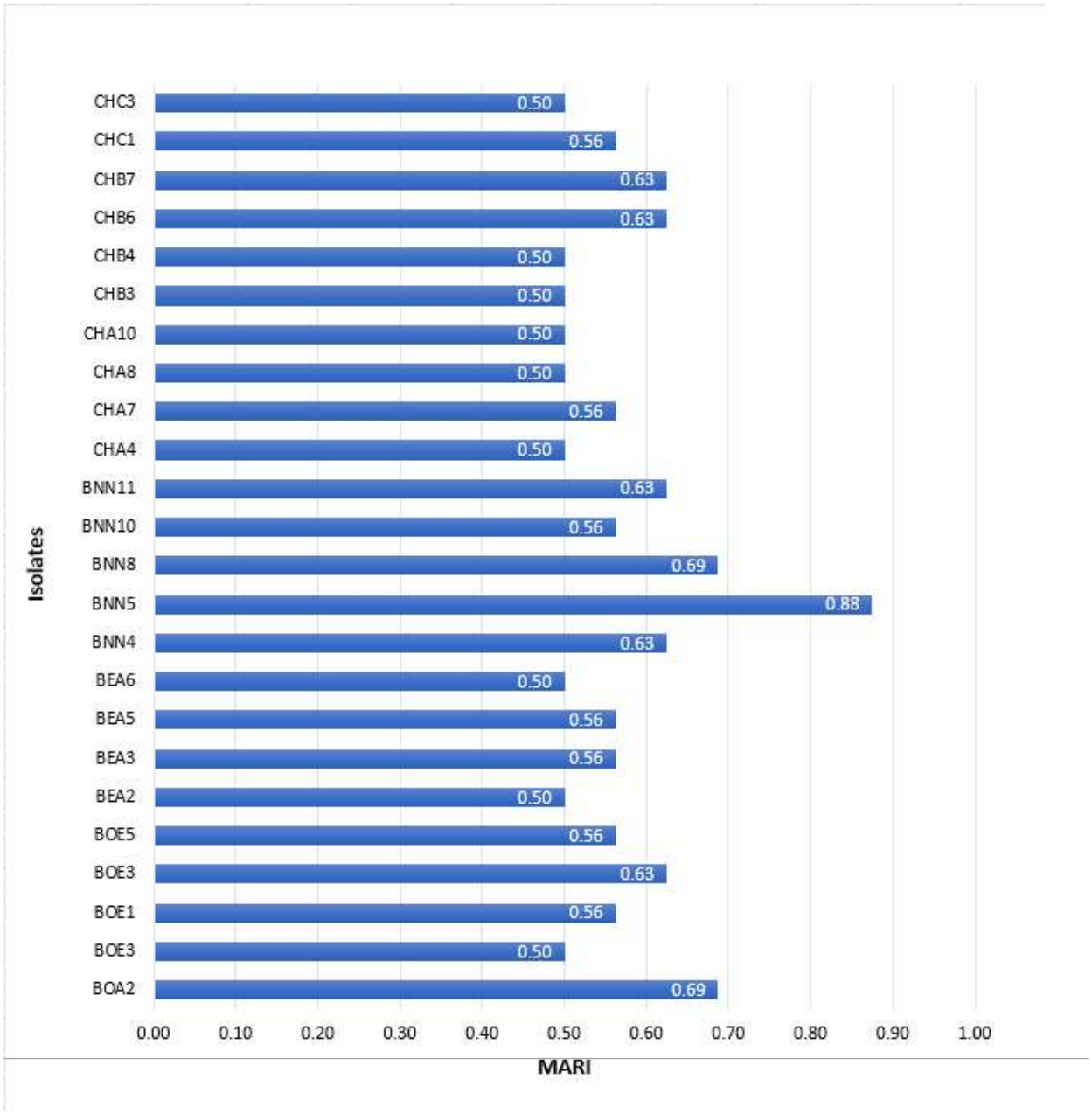

Figure 2: Multiple Antibiotic Resistance Indices of MDR Bacterial Isolates

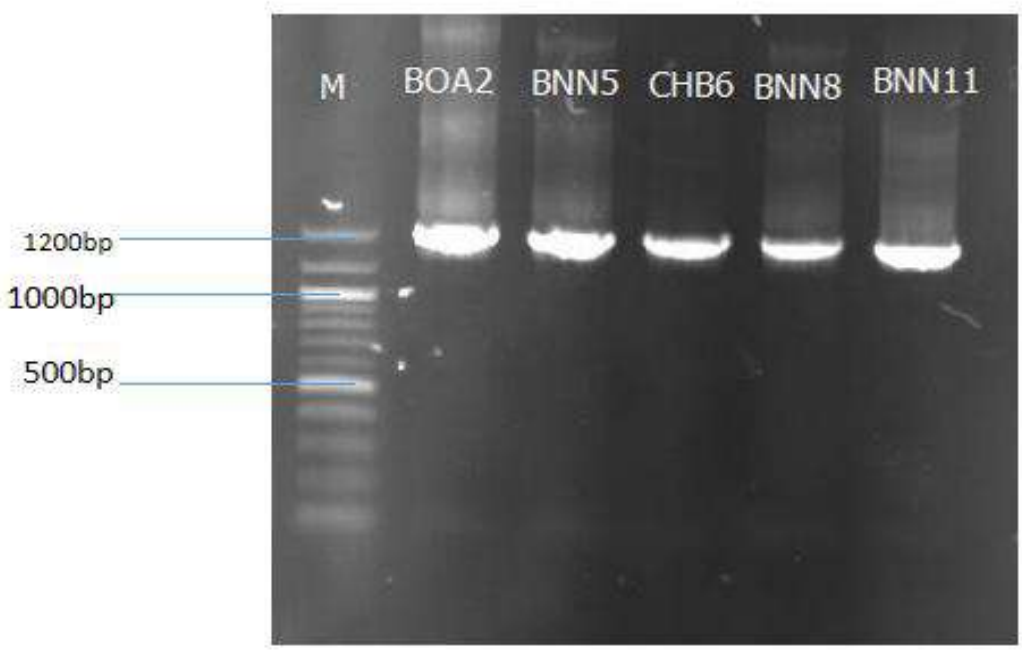

Figure 3: Agarose Gel Electrophoresis Showing Amplicons of Isolates

Table 6: Molecular Identities of Selected Bacterial Isolates

Isolates	Score	Length (bp)	Identity (%)	Sequence ID	Description
BOA2	1095 bits (1214)	1530	99	NR_028688.1	*Citrobacter murliniae* strain CDC 2970-59 16S ribosomal RNA, complete sequence
BNN5	1173 bits (635)	1465	99	NR_104913.1	*Providencia sneebia* DSM 19967 strain A 16S ribosomal RNA, complete sequence
CHB6	891 bits (482)	1478	99	NR_114207.1	*Lysinibacillus boronitolerans* strain NBRC 103108 16S ribosomal RNA, complete sequence
BNN8	1144 bits (619)	1356	99	NR_043751.1	*Morganella morganii* subsp. *sibonii* strain DSM 14850 16S ribosomal RNA, complete sequence
BNN11	1147 bits (621)	1542	99	NR_180316.1	*Pseudocitrobacter vendiensis* strain CPO20170097 16S ribosomal RNA, complete sequence

Figure 4 is a phylogenetic tree used to represent evolutionary relationships among microorganisms based on their genetic data.

The tree shows the genetic distances between the samples labeled BNN11, BOA2, BNN8, BNN5, and CHB6, identified as *Pseudocitrobacter vendiensis, Citrobacter murliniae, Morganella morganii, Providencia sneebia* and *Lysinibacillus boronitolerans* respectively. Branch lengths represent the amount of genetic change. Shorter branches indicate closer genetic relationships, while longer branches suggest greater divergence.

BNN11 and BOA2 share a very close relationship, with a small branch length of 0.01. BNN8 and BNN5 also form a closely related pair, with a similar branch length of 0.02. These two pairs (BNN11/BOA2 and BNN8/BNN5) are part of a larger cluster, sharing a common ancestor with a branch length of 0.02. CHB6 is the most genetically distinct sample in the tree, with a longer branch length of 0.14 separating it from the others.

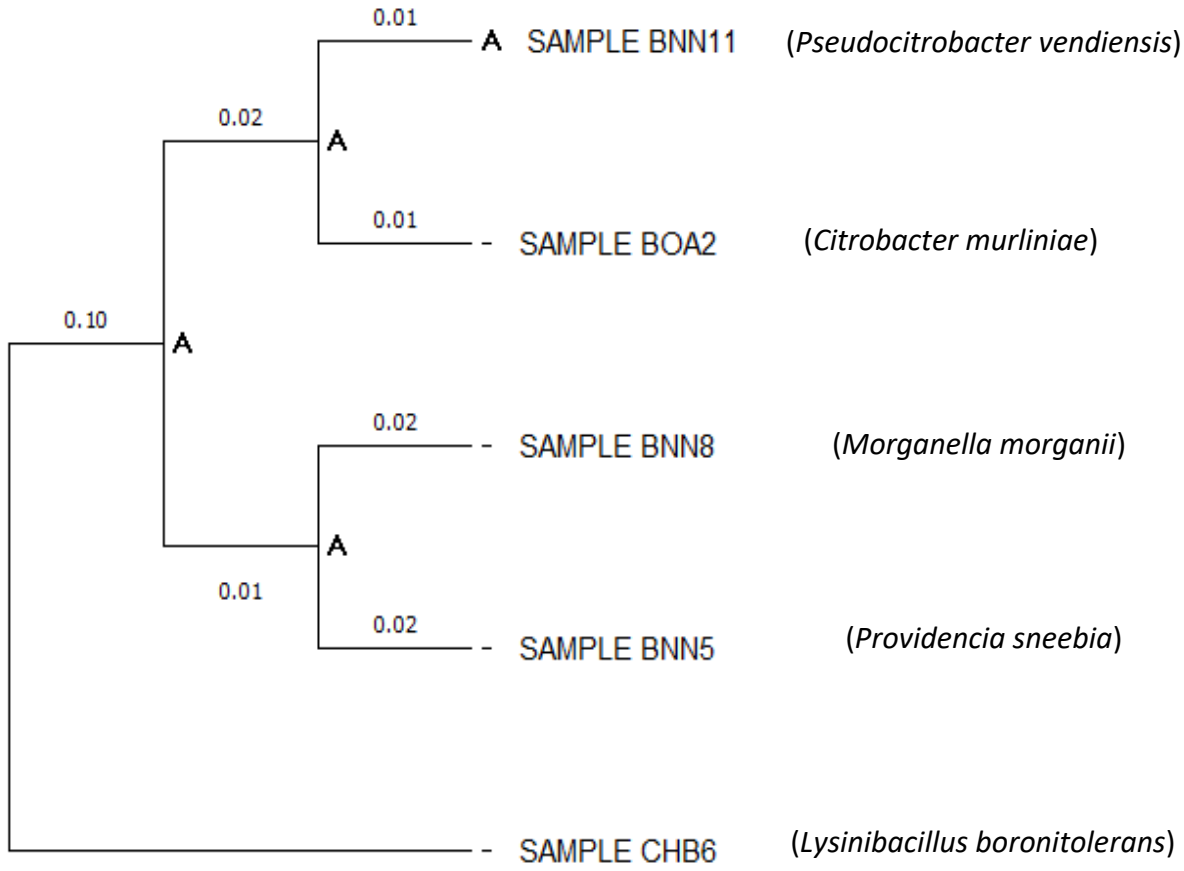

Figure 4.4: Phylogenetic Tree Showing Relationship of Identified Isolates

DISCUSSION

A total of 65 bacterial isolates were obtained, 61.5% from beef and 38.5% from chicken. The microbial isolates identified in this study include; *E. coli, Citrobacter murliniae, Salmonella spp, Providencia sneebia, Staphylococcus aureus, Shigella spp, Lysinibacillus boronitolerans, Morganella morganii* and *Pseudocitrobacter vendiensis,* with a predominance of Gram-negative *bacilli*, particularly members of Enterobacteriaceae and *S. aureus* which is easily carried by human vectors through skin and mucous membranes. The predominance of the Enterobacteriaceae family in this study is similar to a study carried out by Anene *et al.* [11]. and Mir *et al.*[19]. where the predominant organisms were *E. coli* and *Salmonella* amongst a host of other Gram-negative *bacilli* isolated from chicken, beef and mutton. Although the isolates identified

are part of the enteric flora of livestock and poultry birds, they are of public health importance since they are implicated in multi-antibiotic resistance.

The degree of microbial distribution was high with beef (61.5%) showing slightly higher loads than chicken (38.5%). The result of the total microbial count in table 1 highlights the microbial contamination levels in beef and chicken samples, with counts categorized as Total Viable Count (TVC), Total Enteric Count (TEC), and Total Staphylococcal Count (TSC) across the different market locations. TEC ranged from 1.1×10^7 CFU/ml to 7.6×10^8 CFU/ml in beef and 1.3×10^7 CFU/ml to 6.9×10^6 CFU/ml in chicken, while TSC ranged from 1.2×10^6 CFU/ml to 7.1×10^6 CFU/ml in beef and 1.02×10^7 CFU/ml to 5.1×10^7 CFU/ml in chicken. This agrees with the study of Isolates from raw meat samples sold in Ibadan as reported by Afolabi *et al.*[20] where the microbial load ranged from 1.5×10^6 to 9.4×10^8. The high level of total viable count, enteric and staphylococcal load is more than the acceptable level of 10^4 CFU/g count recommended by the Centre for Food Safety, Food and Environmental Hygiene Department[21], a government body in Hong Kong. The acceptable level of *S. aureus* in ready-to-eat food should be below 10^3 colony-forming units per gram (cfu/g) of food. If the number of bacteria is greater than 10^4 cfu/g, the food is unsatisfactory and potentially hazardous for health and/or unfit for human consumption. Thus, it has reached the marginal level where control and critical action are required[22].

The virulence test results (Table 3) showed 47 isolates (72.3%) exhibited gamma (γ) hemolysis, 14 isolates (21.5%) showed alpha (α) hemolysis, and 4 isolates (6.2%) demonstrated beta (β) hemolysis, indicating varying degrees of pathogenic potential among the bacterial isolates. The hemolytic profiles observed in this study predominantly gamma hemolysis (72.3%), followed by alpha (21.5%) and beta (6.2%) suggest a predominance of non-hemolytic bacterial isolates, with a smaller subset exhibiting varying degrees of pathogenic potential. These findings align partially with the study from Nnamdi Azikiwe University Teaching Hospital, where alpha and beta hemolysins were detected in 5.11% and 6.5% of blood donors, respectively[23]. Although their study focused on hemolysin production in human donors, and ours evaluated bacterial hemolytic activity on agar, both point to the clinical relevance of hemolysins in health and disease contexts.

The Multiple Antibiotic Resistance Index (MARI) is an important analysis to check antibiotic resistance and health risk factors. According to Afunwa *et al.*[18], organisms with MARI indices of greater than > 0.2 confirm the presence of multidrug-resistant genes originating from the environment where these drugs are abused. In this study, a high prevalence of multidrug resistance was indicated by an antibiotic susceptibility test that determined the MARI of the different isolates. The analysis of the MARI of isolates (figure 2) showed values ranging from 0.50 to 0.88, indicating moderate to high resistance levels. The isolates BNN5 - *Providencia sneebia* (0.88), BOA2 - *Citrobacter murliniae* (0.69) and BNN8 - *Morganella morganii* (0.69) exhibited the highest MARI, reflecting extreme multidrug resistance. Isolates with 0.50 showed relatively lower resistance but still exceeded the safe threshold of 0.2, indicating significant resistance.

Out of the 65 bacterial isolates analyzed in this study, Twenty-four (36.9%) isolates that demonstrated resistance to at least 8 out of 16 antibiotics tested, with MARI greater

than 0.5 were termed multi drug resistant. This study is similar to Anene *et al.*[11] which showed the MARI of isolates from chicken droppings, *Providencia stuartii*, gave a MARI of <0.20 as it had a MARI of 0.13. The highest MARI index was 0.875 and those above 0.5 were termed multi-drug resistant. Both gram-positive and gram-negative bacteria tested were highly resistant to more than 50% of the used antibiotics. The resistant percentage (%) of some isolates include; BNN5 - Providencia *sneebia* (87.5%), BOA2 - *Citrobacter murliniae* and BNN8 - *Morganella morganii* (69.0%). These findings are in agreement with previous studies done by Kilonzo-Nthenge *et al.*[24] in Tennessee, where members of the *Enterobacteriaceae* including *Citrobacter spp.* and *Morganella morganii* were isolated from beef and chicken meat.

This study revealed that bacterial isolates recovered from meat samples exhibited multidrug resistance, posing a potential risk of transmission to humans through contaminated food. Notably, all poultry and beef isolates were completely resistant to Metronidazole (100%), while Ceftazidime (87.7%), Amoxicillin-Clavulanic Acid (84.6%), and Cefuroxime (78.5%), as well as Amoxicillin (69.2%), also showed widespread resistance, as seen in table 4.5. In contrast, moderate resistance was observed for Ofloxacin (7.7%), and Pefloxacin (4.6%) though still noteworthy. On the other hand, high susceptibility was recorded for Ciprofloxacin and Levofloxacin (100%), while Pefloxacin (95.4%), Ofloxacin (92.3%), and Rifampicin (84.6%) also demonstrated strong effectiveness against the isolates. Out of the 65 isolates analyzed, 65 (100%) were resistant to at least one of the Cephalosporin antibiotics used in the study. 87.7% were resistant to Ceftazidime (3rd gen.), 78.5% were resistant to Cefuroxime (2nd gen.), 66.2% were resistant to Cephalexin (1st gen.), and 41.5% were resistant to Ceftriaxone (3rd gen.). These findings align with the 56.5% Ceftriaxone resistance reported by Gashe *et al.*[25] in clinically isolated *Enterobacteriaceae.* The resistance rates observed in this study are slightly higher than those reported by Akujobi and Ewuru[26] who detected 34.4% Ceftriaxone and 20.8% Ceftazidime resistance. The comparatively lower resistance in their study may be attributed to the inclusion of *Proteeae species,* which may exhibit different resistance mechanisms compared to the isolates in the present study.

Among the Aminoglycosides, 27.7% resistance to Gentamicin and 20.0% in Streptomycin was observed. This is closely related to the 19.6% resistance to Gentamicin reported by Kilonzo-Nthenge *et al.*[24] in the study of the prevalence of drug-resistant *Enterobacteriaceae* from beef and poultry meats but higher than the 43.8% resistance to Streptomycin from the same study. This higher rate might be a result of differences in geographic areas. A slightly close rate of 52.8% and 34.4% for Gentamicin and Streptomycin respectively was observed in Akujobi and Ewuru's[26] study on ESBL gram-negative *bacilli.*

The Macrolides antibiotics detected a 50.8% bacteria resistance to Azithromycin, 47.7% to Erythromycin and a fairly low 15.4% for Rifampicin. Other researchers have also detected resistance to Erythromycin, like Maripandi and Al-Salamah[27] who recorded a 91.3% resistance by *Salmonella* and *Shigella spp.* Similarly, a 100% resistance to Erythromycin was detected in a study by Kilonzo-Nthenge *et al.*[24] and a 69.0% resistance to Azithromycin was detected in porcine and bovine-isolated bacteria by Ivanova *et al.*[28]. Penicillin drugs also

showed high resistance, with 69.2% of isolates showing resistance to Amoxicillin and 84.6% resistance to Amoxicillin-Clavulanic acid (Augmentin). These findings are higher than the 32.6% detected in 2010 by Maripandi and Al-Salamah[27] to Augmentin. The high rate detected in this study means an increase in resistant spread and antibiotic use this day compared to 2010 and 2019, which was a long time.

Metronidazole, a nitroimidazole was observed as the antibiotic with the highest resistance in the study (table 5), with all 65 isolates showing resistance to the drug (100%). This shows how misused this antibiotic has been for human and animal use. It is one of the most commonly available antibiotics used as growth promoter and routine chemoprophylaxis among livestock in Nigeria. They are readily available in different dosage forms and in combination with other antibiotics and vitamins, probably the reason why most organisms have developed resistance to them[20].

Quinolones have been used by clinicians as a "lifesaver" in the treatment of multi-drug resistant bacteria pathogens[29]. In this study, Ciprofloxacin and Levofloxacin showed no resistance, giving us a 100% susceptibility and 0% resistance rate; Pefloxacin and Ofloxacin both showed 4.6% and 7.7% resistance respectively, making them a better choice of antibiotic. These antibiotics may therefore be used as an effective single broad-spectrum antibiotic in treating the infections caused by this type of microorganisms. The higher degree of sensitivity to the quinolones, observed in this study, agrees with the observation done by[30, 20].

CONCLUSION

The challenge posed by multidrug-resistant (MDR) bacteria is becoming increasingly alarming, as these resistant pathogens continue to be isolated from locally sourced raw beef and chicken. This finding underscores the escalating public health crisis driven by the misuse and overuse of antibiotics among local breeders who strive for profit making rather than consumer's overall wellbeing. The widespread presence of MDR bacteria in these commonly consumed meat products signifies a dangerous shift, where antibiotic-resistant pathogens are no longer rare occurrences but are becoming a persistent and pervasive problem.

This research highlights the urgent need for intervention, as the continued emergence of MDR bacteria in raw meat poses a direct threat to food safety, public health, and the effectiveness of current antibiotic stewardship campaign. If left unchecked, this growing resistance could lead to increased treatment failures from hetero resistance, prolonged illnesses, and a surge in untreatable infections, placing immense pressure on healthcare systems. The presence of MDR bacteria in food sources suggests that resistant strains are not only thriving but are also readily transmitted to humans through food consumption, increasing the risk of outbreaks and potentially leading to global health crises.

RECOMMENDATION

Immediate action is essential to halt the alarming rise of antimicrobial resistance. Key strategies include enforcing strict regulations, enhancing surveillance and documentation, improving hygiene during meat processing, regulating antibiotic use in

animal husbandry, and increasing public awareness. Without these measures, antimicrobial resistance will likely intensify, posing a serious threat to global public health and community well-being

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SELF- EFFICACY AS A PREDICTOR OF PHYSICAL ACTIVITY PATTERNS AMONG OLDER ADULTS IN SOUTH-EASTERN NIGERIA

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ABSTRACT

Background: Physical activity plays a vital role in promoting healthy aging. Exercise self-efficacy, the belief in one's ability to engage in physical activity despite challenges, is a key determinant of exercise behaviours among older adults. Understanding the interaction between these variables is essential for designing effective interventions.

Aim: To examine the relationship between self-efficacy and physical activity levels among older adults and explore the influence of sociodemographic factors such as age, gender, marital status, and educational attainment on these constructs.

Methods: A cross-sectional study was conducted among 400 community-dwelling older adults (≥65 years) selected using disproportionate stratified sampling across four quarters of Nnewi, Anambra State. Data was collected using the Exercise Self-Efficacy Scale, the Physical Activity Scale for the Elderly, and a structured sociodemographic questionnaire. Descriptive statistics of maen and standard deviation, as well as Spearman's rank order correlation, Mann–Whitney U test, and Kruskal–Wallis test were used for data analysis with level of significance set at <0.05.

Results: Most of the participants exhibited low physical activity levels and moderate exercise self-efficacy. A weak but significant positive correlation was found between exercise self-efficacy and physical activity ($r = 0.292$, $p < 0.001$). Age was negatively correlated with both physical activity ($r = -0.351$, $p < 0.001$) and self-efficacy ($r = -0.240$, $p < 0.001$). Educational level and marital status significantly influenced both outcomes, while gender differences were not statistically significant.

Conclusion: The findings highlight a significant association between self-efficacy and physical activity in older adults, emphasizing the need for interventions that enhance self-efficacy and reduce barriers to physical activity. Tailored programs that consider age, education, and marital status may improve physical activity participation among older adults in this setting.

Keywords: Self-efficacy, Physical activity, Older adults, Exercise behaviours, Sociodemographic factors

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INTRODUCTION

Individuals aged 65 and older (Older adults)[1] are characterized by the natural aging process, leading to various physical, psychological, and social challenges[2]. Aging involves loss of bone mass and a general decline in physical strength, which increases their vulnerability to illnesses and injuries[3]. The number of older adults in the United States will grow significantly, from 46.2 million today to over 98 million by 2060[3]. In contrast, Africa has the lowest number of

individuals aged 60 and older. However, the population of older adults in Africa is projected to triple between 2020 and 2050[4]. Nigeria, Africa's leading economy and most populated country, has the highest number of older people, ranking 19th globally. By 2050, the population is expected to nearly triple. Unfortunately, this increase occurs amid extreme poverty, unresolved development challenges, socioeconomic inequality, the HIV/AIDS epidemic, and a decline in traditional support for older adults. The lack of an operational national aging policy and safety net services and programmes poses a unique challenge to older Nigerians and their families.

This demographic shift highlights the need to effectively manage the hazards and costs associated with chronic illness and disability linked to aging. Fortunately, physical activity is associated with improved physical function and quality of life[3]. Despite this, current statistics reveal that the pooled crude prevalence of physical inactivity in Nigeria is 52.0%[5]. This rate was higher among women at 55.8% than among men at 49.3%. Additionally, urban dwellers have a significantly higher prevalence of physical inactivity at 56.8% than rural dwellers at 18.9%. The number of physically inactive individuals aged 20–79 years increased from 14.4 million in 1995 to 48.6 million in 2020, a 240% rise[5]. A study conducted among stroke survivors in Nnewi, Nigeria, showed that physical inactivity was one of the most prevalent risk factors[6]. According to the United States' Center for Disease Control and Prevention's Healthy Ageing Research Network Guidelines, which highlight the importance of exercise and physical activity[7], addressing age-related declines in physical function that can affect motivation to stay active is important. Consequently, understanding and enhancing self-efficacy for exercise among older adults is increasingly crucial[3]. Maintaining an active lifestyle is crucial for the overall health and well-being of older adults.

Self-efficacy, or belief in one's ability to perform specific tasks, significantly influences exercise behavior and adherence to physical activity routines[8]. Therefore, understanding how self-efficacy affects exercise participation, sedentary behavior, and overall physical activity levels in older adults is essential. Self-efficacy could play a role in breaking up sedentary periods by standing up every 30 min, even when fatigued. Higher levels of self-efficacy, both general and specific to reducing sedentary behavior, are associated with lower levels of sedentary behavior[9].

The World Health Organization recommends that older adults engage in at least 2.5 h per week of moderate-intensity activities and 1.5 h per week of vigorous-intensity activities[10]. However, many older adults struggle to meet these recommendations, highlighting the need to understand how to enhance self-efficacy to promote sustained physical activity participation in this demographic. Therefore, this study aimed to explore the relationship between self-efficacy and exercise behaviors among older adults.

MATERIALS AND METHODS

Research design

This was a cross-sectional study in which a disproportionate stratified sampling technique was adopted to recruit 400 older adults aged 65 years and above, with 100 participants selected from four quarters (Otolo, Uruagu, Umudim, and Nnewichi) of Nnewi, Anambra state.

Inclusion criteria

The inclusion criteria included: older adults ≥65 years; older adults who gave informed consent; and older adults who were oriented in time, place, and who did not present with physical impairments and were not institutionalized or bedridden.

Research instruments

The Exercise Self Efficacy Scale (ESES): was used to assess the participant's confidence in their ability to engage in and maintain regular physical exercise, especially in the face of common barriers such as fatigue, lack of time, or bad weather. It typically includes 6 to 18 items rated on a 0–100 scale, with higher scores indicating greater self-efficacy. The scale has strong psychometric properties, with high internal consistency (Cronbach's alpha = 0.76–0.94) and good validity, making it useful for predicting exercise adherence and evaluating physical activity interventions, especially among older adults and those with chronic conditions.

The Physical Activity Scale for the Elderly (PASE): was used to assess the level of physical activity in older adults, measuring occupational, household, and leisure-time physical activities over one week. It includes items on leisure, household, and occupational activities, with each activity weighted based on its intensity. Scores are calculated by multiplying activity frequency by intensity weights, producing a total score where higher values indicate greater physical activity. The PASE has demonstrated good reliability (test-retest $r \approx 0.75$) and validity in older populations, making it suitable for both clinical and research use in assessing functional status and activity patterns.

Data collection

Recruitment took place in commonly frequented community locations such as homes, churches, and local markets. Ethical approval was sought and obtained from the Research Ethics Committee of the Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi Campus (Approval No: FHST/REC/024/684). Informed consent was obtained from all participants before enrolment. The purpose, procedures, and benefits of the study were clearly explained to the participants, and their participation was entirely voluntary. Assurances of anonymity, confidentiality, and the right to withdraw at any time without any consequences were provided. Additional permission was also sought from community leaders and clergy, where appropriate. Data collection was facilitated with the assistance of trained research assistants. Each eligible participant completed a structured questionnaire, which comprised sociodemographic information, the ESES, and the PASE. For participants with literacy, the questionnaires were read

aloud and responses recorded by the research assistants to ensure accurate and inclusive data capture.

Data analysis

Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize participants' sociodemographic characteristics and responses to the ESES and PASE. Inferential statistics were employed to examine the relationships and group differences among key variables. The Mann–Whitney U test was used to determine gender- and marital status-based differences in physical activity and exercise self-efficacy levels. The Kruskal–Wallis test was used to assess the influence of educational attainment on these same outcomes. Spearman's rank-order correlation was used to evaluate the relationships between age, exercise self-efficacy, and physical activity levels. Statistical significance was set at $p < 0.05$.

RESULTS

Socio-demographic Profiles of the Participants

Four hundred older adults in Nnewi participated in this study. Among them, 249 (62.3%) were females and 151 (37.8%) were males. Marital status distribution of the respondents showed that 235 (58.8%) of the participants were married, whereas 165 (41.3%) were widowed. One hundred and ninety-three (48.3%) participants had primary school education as their highest level of education, making this the predominant level among the participants. Meanwhile, 42 (10.5%) had secondary education, and 6 (1.5%) attained tertiary education. However, 159 (39.8%) reported no formal education (Table 1).

Table 1. Socio-demographic Profile of Participants

Variable	Class	Frequency	Percentage
Gender	Male	151	37.8
	Female	249	62.3
Marital status	Married	235	58.8
	Widowed	165	41.3
Educational level	No education	159	39.8
	Primary level	193	48.3
	Secondary level	42	10.5
	Tertiary level	6	1.5

Physical activity level of the participants

Results obtained with the PASE analyzed showed that most participants (75.40%) had low physical activity levels, with 20.30% having moderate physical activity levels. Conversely, 3.50% reported high physical activity levels, and only 0.80% attained very high physical activity levels, demonstrating a trend of low physical activity levels among the participants (Figure 1).

Exercise self-efficacy of the participants

The ESES revealed varying levels of confidence among older adults regarding their ability to maintain physical activity in the face of common barriers. Approximately 52.5% of the participants reported moderate confidence in their ability to overcome obstacles to physical activity when they tried hard enough, while 40.5% indicated that this was rarely true for them. Only 3% expressed high confidence, stating that it was always true that they could overcome such barriers (Table 2).

When asked whether they could find ways to be physically active, 48.3% reported moderate confidence, and 41.0% said it was rarely true. Likewise, 48.5% indicated moderate confidence in accomplishing set physical activity goals, and 50.5% rarely believed they could find multiple solutions when facing exercise-related barriers.

Regarding exercising while fatigued, 50% of the participants reported low confidence, and only 1.5% believed they could always stay active despite being fatigued. A similar pattern was observed for exercising while feeling depressed, with 46.8% indicating low confidence and only 1.3% expressing high confidence.

Confidence in exercising without external support was mixed. About 46.3% of participants had moderate confidence in being active without help from family or friends, and 48.3% felt the same about exercising without a therapist or trainer. However, when it came to exercising without access to a gym or facility, 58.5% reported low confidence, highlighting perceived environmental barriers.

Additionally, 43% of the participants moderately agreed they could resume physical activity after a break, suggesting moderate resilience in reinitiating exercise habits. In general, 90.3% of the participants exhibited fair to moderate overall exercise self-efficacy, while 8.5% had low self-efficacy and only 1.3% demonstrated high self-efficacy (Figure 2).

Self-efficacy and physical activity level among the participants

The mean score of the total individual scores for the PASE was 70.175 ± 61.1613, with the maximum and minimum scores being 451.56 and 2.2, respectively. The high standard deviation highlights the high variability of respondents' performance. Likewise, the mean score reported for the total scores of the exercise self-efficacy scale was 24.22 ± 2.850, with the maximum and minimum scores being 33 and 13, respectively (Table 3).

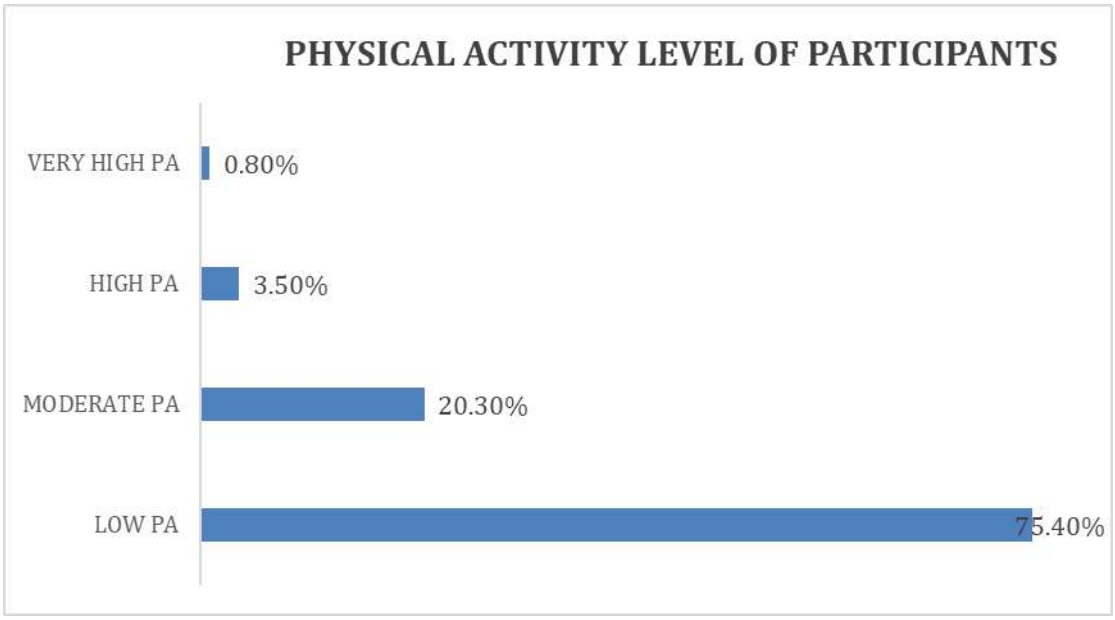

Figure 1. Physical Activity Level of Participants

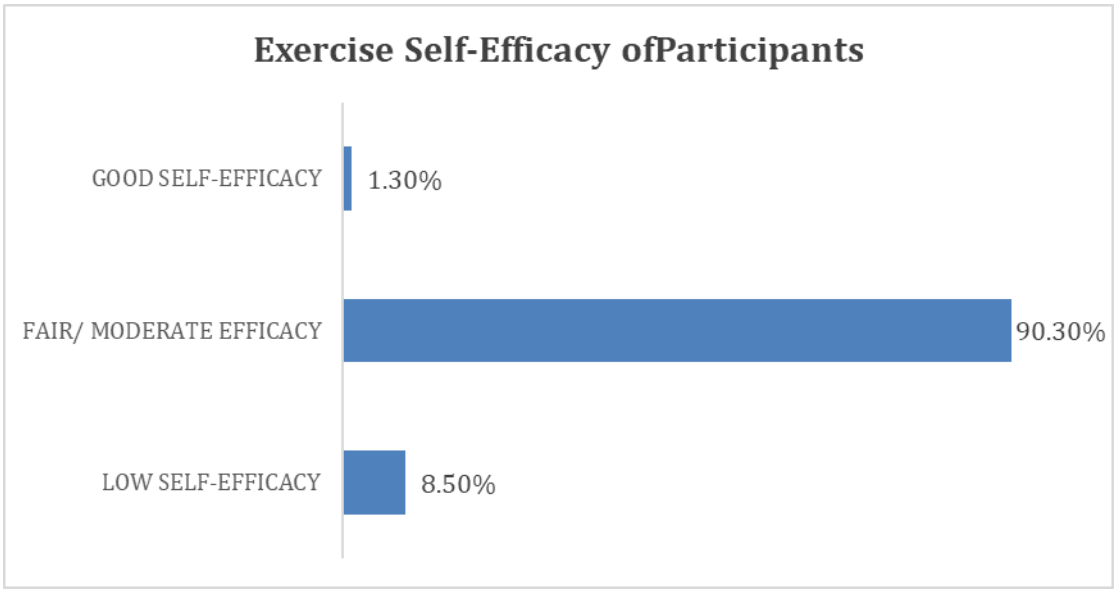

Figure 2. Exercise Self Efficacy of participants

Table 2. Participants' Response to the Exercise Self-Efficacy Scale (ESES) Instrument

Items	not always true (n)	%	rarely true (n)	%	moderately true (n)	%	Always true (n)	%
I am confident that I can overcome barriers and challenges regarding physical activity and exercise if I try hard enough	16	4.0	162	40.5	210	52.5	12	3.0
I am confident that I can find means and ways to be physically active and exercise	6	1.5	164	41.0	193	48.3	37	9.3
I am confident that I can accomplish my physical activity and exercise goals that l set	20	5.0	147	36.8	194	48.5	39	9.8
I am confident that when I am confronted with a barrier to physical activity or exercise, I can find several solutions to overcome this barrier	31	7.8	202	50.5	150	37.5	17	4.3
I am confident that I can be physically active or exercise even when I am tired	65	16.3	200	50.0	129	32.3	6	1.5
I am confident that I can be physically active or exercise even when I am feeling depressed	95	23.8	187	46.8	113	28.2	5	1.3
I am confident that I can be physically active or exercise even without the support of my family or friends	32	8.0	176	44.0	185	46.3	7	1.8
I am confident that I can be physically active or exercise without the help of a therapist or trainer	22	5.5	174	43.5	193	48.3	11	2.8
I am confident that I can motivate myself to start being physically active or exercising again after I've stopped for a while	20	5.0	185	46.3	172	43.0	23	5.8
I am confident that I can be physically active or exercise even if I have no access to a gym, exercise, training or rehabilitation facility	18	4.5	234	58.5	135	33.8	13	3.3

Table 3. Mean self-efficacy and physical activity levels among the participants

Variables	Minimum	Maximum	Mean	Standard deviation
Total Physical Activity Scale for the Elderly	2.2	451.6	70.175	61.1613
Total Exercise Self-Efficacy Scale	13	33	24.22	2.85

Correlation among age, self-efficacy, and physical activity among the participants using the Spearman's rank order test

Spearman's rank order test of correlation was conducted to examine the relationships among age, exercise self-efficacy, and physical activity level. The analysis revealed a weak but significant negative correlation between age and exercise self-efficacy ($r = -0.240$, $p < 0.001$, $n = 400$), indicating that exercise self-efficacy decreases as age increases. Similarly, a weak negative correlation was found between age and physical activity level ($r = -0.351$, $p < 0.001$, $n = 400$), suggesting that physical activity level also declines with increasing age. Conversely, a weak positive correlation was observed between exercise self-efficacy and physical activity level ($r = 0.292$, $p < 0.001$, $n = 400$), indicating that higher exercise self-efficacy is associated with increased physical activity levels (Table 4).

Table 4. Spearman Rank Order Test of Correlation Among Age, Self-Efficacy and Physical Activity Among Older Adults in Nnewi, Anambra State

	ESES Total	PASE Total
Age (years)	r = -0.240	r = -0.351
	p<0.001	P<0.001
ESES Total		r=0.292
		P<0.001

ESES, Exercise Self Efficacy Scale; PASE, Physical Activity Scale for the Elderly

Influence of gender on level of exercise self-efficacy and physical activity among the participants using the Mann–Whitney U test

The influence of gender on exercise self-efficacy and physical activity levels was analyzed using the Mann–Whitney Test. No significant difference was observed in physical activity levels between male and female participants ($p = 0.135$), although males had a higher mean rank (211.59) than females (190.07). Similarly, no significant difference was found in exercise self-efficacy between genders ($p = 0.085$), with males again showing a higher mean rank (213.20) than females (192.80) (Table 5).

Influence of the highest educational qualification on level of self-efficacy and physical activity among the participants using Kruskal–Wallis

A significant difference was observed in physical activity levels among those with no education, primary education, secondary education, and tertiary education ($p < 0.001$, $k = 80.202$). The tertiary education group had the highest mean rank (347.33), then the secondary level (289.77), primary level (223.10), and no education group (143.94). Similarly, significant differences were observed in exercise self-efficacy across the various educational levels ($p < 0.001$, $k = 70.758$). The tertiary education group had the highest mean rank (323.08), then the secondary level (272.85), primary level (226.61), and no education group (145.07) (Table 6).

Influence of marital status on level of self-efficacy and physical activity among the participants using Mann–Whitney U test

A significant difference was observed in the level of physical activity between those married and those widowed ($p = 0.001$), with those married having a higher mean rank (215.93) than those widowed (178.52). Similarly, Mann–Whitney test of the influence of marital status on level of exercise self-efficacy showed a significant difference in the level of exercise self-efficacy between those married and those widowed ($p<0.001$), with those married having a higher mean rank (222.07) than those widowed (169.78) (Table 7).

Table 5. Influence of gender on level of exercise self-efficacy and physical activity among the participants using the Mann–Whitney U test

Variable	Class	Mean Rank	U	p
PASE Total	Male	211.59	17125.500	0.135
	Female	190.07		
ESES Total	Male	213.20	16882.000	0.085
	Female	192.80		

ESES, Exercise Self Efficacy Scale; PASE, Physical Activity Scale for the Elderly

Table 6. Influence of the highest educational qualification on level of self-efficacy and physical activity among the participants using Kruskal–Wallis test

Variable	Class	Mean Rank	k	P
Total PASE	No Education	143.94	80.202	<0.001
	Primary Level	223.10		
	Secondary Level	289.77		
	Tertiary Level	347.33		
Total ESES	No Education	145.07	70.758	<0.001
	Primary Level	226.61		
	Secondary Level	272.85		
	Tertiary Level	323.08		

ESES, Exercise Self Efficacy Scale; PASE, Physical Activity Scale for the Elderly

Table 7. Influence of marital status on level of self-efficacy and physical activity among the participants using Mann–Whitney U test

Variable	Class	Mean Rank	u	P
PASE Total	Married	215.93	15761.500	0.001
	Widowed	178.52		
ESES Total	Married	222.07	14319.500	<0.001
	Widowed	169.78		

ESES, Exercise Self Efficacy Scale; PASE, Physical Activity Scale for the Elderly

DISCUSSION

Engaging in regular physical activity is a cornerstone of healthy aging, offering protective effects against several chronic diseases and functional decline. This study examined the relationship between self-efficacy and exercise habits among older adults in Nnewi, Anambra State, with a focus on how age, gender, marital status, and educational level influence these variables. The findings provide insight into the complex interactions between psychosocial factors and behavioural health among the elderly in Nigeria.

The results revealed that most participants reported low levels of physical activity, with only a small proportion engaging in high or very high levels. This trend aligns with national statistics that place Nigeria's overall physical inactivity rate at 52%, with higher prevalence in urban areas and among women[5]. The observed inactivity among the elderly may be attributed to several interrelated factors, including age-related functional decline, limited access to safe recreational spaces, socioeconomic limitations, and traditional gender roles that may restrict outdoor engagement, particularly for women[2,11].

Moreover, physical inactivity is a major risk factor for non-communicable diseases such as cardiovascular disease, diabetes, and certain cancers[12]. The World Health Organization estimates that insufficient physical activity contributes to approximately 6% of global deaths[10,13]. Therefore, the low physical activity levels observed in this study population suggest an urgent need for public health strategies that promote active aging.

Participants generally reported moderate levels of exercise self-efficacy, with only a small percentage indicating high confidence in their ability to maintain physical activity in the face of barriers such as fatigue, depression, or lack of external support. This suggests that many older adults are aware of the benefits of physical activity but lack the confidence or resources to sustain such behaviours consistently.

Several studies support the finding that self-efficacy is a critical determinant of exercise behaviours. Individuals with higher self-efficacy are more likely to initiate and maintain health-promoting behaviours, including physical activity[14]. A study similarly reported that self-efficacy not only predicts physical activity participation but is also enhanced through successful exercise experiences[15]. In this study, low self-efficacy in scenarios involving fatigue or lack of access to exercise facilities suggests that perceived internal and external barriers are major limiting factors. These findings are similar to that of a study that identified fatigue and fear of injury as prominent internal barriers[16], and another that emphasized environmental constraints such as lack of nearby facilities in rural and low-density areas[17]. Implying that interventions must be multifaceted, addressing not only motivation and beliefs but also environmental and infrastructural barriers.

A significant proportion of the participants expressed moderate confidence in exercising

independently— without therapists or family support— but confidence dropped significantly when access to gyms or facilities was removed. This points to the importance of accessible infrastructure and social support systems in fostering physical activity among older adults. A study emphasized the value of social connections in motivating older adults to remain physically active[18]. Group exercises, walking clubs, and community-based physical activity programs can not only improve adherence but also provide emotional and psychological support, reinforcing self-efficacy. Additionally, disturbances in routine or lack of suitable programs can negatively affect older adults' willingness to resume exercise, reinforcing the importance of consistency and accessibility[19]. The statistical analysis showed a weak but significant positive correlation between exercise self-efficacy and physical activity level, suggesting that greater confidence in one's ability to exercise is associated with increased activity levels. This supports findings from a study that reported that self-efficacy is positively related to physical activity, life satisfaction, and self-esteem in older men[20].

Conversely, negative correlations were observed between age and both physical activity and self-efficacy, implying that as people age, their physical activity levels and confidence in their ability to stay active decrease. This pattern is consistent with findings of studies that reported that increasing age often brings physical decline, health concerns, and reduced motivation, all of which can diminish self-efficacy and limit engagement in physical activity[18,21].

This study found no significant gender-based differences in physical activity or exercise self-efficacy levels. Although males had slightly higher mean ranks for both variables, the differences were not statistically significant. This contradicts some previous findings, which reported gender-based disparities in activity levels and confidence[8,22]. Socio-cultural contexts likely play a role in these variations. For instance, traditional roles in Nigerian communities may limit women's engagement in structured physical activity, but not necessarily their engagement in physically demanding domestic chores, possibly balancing out perceived activity levels.

Educational attainment emerged as a significant factor influencing both physical activity and self-efficacy. Participants with tertiary education had the highest mean ranks, while those with no formal education had the lowest. These results mirror findings from studies that linked higher educational levels to increased self-efficacy[23] and that academic achievement during adolescence and adulthood predicts physical activity engagement[24]. Education likely enhances awareness of health benefits and improves access to resources and environments conducive to physical activity.

Marital status also showed a significant influence. Married individuals had higher self-efficacy and physical activity levels than their widowed counterparts. This aligns with studies that reported that spouses often

serve as sources of motivation, accountability, and companionship in maintaining active lifestyles[25,26]. The absence of a partner may reduce emotional support and opportunities for shared activities, contributing to decreased exercise engagement among widowed individuals.

This study had some limitations. First, the cross-sectional design limited the ability to establish causality between variables. Second, the reliance on self-reported data from questionnaires such as the ESES and PASE may have introduced recall bias or social desirability bias, potentially affecting the accuracy of responses. Additionally, the study was conducted in a semi-urban area in Anambra State, which may limit the generalizability of findings to other regions in Nigeria, especially rural or more urbanized settings.

CONCLUSION

The results revealed that while most participants exhibited moderate levels of self-efficacy, their physical activity levels remained low. A weak but significant positive correlation between self-efficacy and physical activity was identified, indicating that individuals who are more confident in their ability to exercise are more likely to engage in physical activity. Age was negatively associated with both self-efficacy and physical activity, suggesting that advancing age may contribute to declining motivation and activity levels. Additionally, educational level and marital status significantly influenced both constructs, with higher education and being married linked to better outcomes. Although gender differences were not statistically significant, the observed trends merit further exploration.

Competing interests

The authors declare no competing interests.

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INTER-LIMBS EFFECT, DIFFUSION AND STRENGTH PREDICTORS IN ARM FLEXORS

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ABSTRACT

Background: Strength training is a methodical exercise regimen that enhances muscle action, and is the act of repeated voluntary muscle contractions against a resistance greater than usually accomplished during activities of daily living. However, there are controversial reports on the effects of cross education and strength diffusion in untrained muscles.

Aims: The aim of this study was to establish the inter-limb phenomenon between trained and untrained contralateral homologous muscle and other adjacent muscle groups of the trained extremity.

Materials and Methods: Forty undergraduate students participated in this study. They were randomly assigned to 2 groups. For progression, One-Repetition Maximum (1-RM) was determined four times within six weeks isometric training of the arm flexors for participants in the experimental group (group 1) while participants in group 2 served as control. Using standard procedures, spring balance was used to measure the strength of the arm flexors and other selected muscles in both limbs, at onset and at the 6th week. The Body Mass Index (BMI) was computed while height, weight, and girth were measured. Descriptive statistics, Paired and Independent t-tests; and ANOVA were used to analyze the data. Level of significance was set at 0.05.

Results: There were significant differences between the right and left right arm flexor strength following 6 weeks isometric strength training in both the experimental and control groups ($t = 6.57$, $p = 0.001$; $t = 5.10$, $p = 0.001$). There were significant differences between the initial and final for both right and left right arm flexor muscle strength following 6 weeks isometric strength training ($t = -7.95$, $p = 0.001$; $t = -8.97$, $p = 0.001$ respectively) but none in the control group. There was only significant increase in the selected adjacent muscles in the experimental group despite that they were not trained ($p = 0.001$). Height was the most significant predictor of arm flexors strength, contributing 29% ($p = 0.005$).

Conclusion: There was cross education effect at the untrained contralateral homologous muscle (arm flexors) following 6 weeks training of the other opposite extremity. Similarly, there were strength gains in the untrained shoulder flexor, extensor, abductor, adductor; and extensor, muscle groups, implying strength diffusion. Also, height of the participants was the most significant predictor of arm flexors strength.

Keywords: Muscle Strength, Inter-limb effects, Diffusion, Isometric training, Arm flexors

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INTRODUCTION

Strength is the amount of force produced in a muscle during a single maximal effort and it can only be achieved through effective training that largely depends on time tested principles, experimentation, exercise and sequence variations, and appropriate selection of procedures[1, 2]. Resistance training is any form of exercise that causes muscles to contract against an external resistance to build strength and hypertrophy[3]. Strength training is a methodical exercise regimen used to improve the capacity to apply or resist force[4]. Strength training is an engagement that enhances muscle strength and it is the act of repeated voluntary muscle contractions against a resistance greater than those usually accomplished during daily living activities[5, 6].

Most old literature are still very relevant in the principles of using 1-RM and progressive overloading with external resistance. The external resistance has to be progressed and the training stimulus must gradually and constantly be increased in order to achieve the goal. However, it is noteworthy that if overload increases too rapidly, injury may occur and if overload progresses too slowly, improvements will be minimal or non-existent[1, 7].

The term "cross-education" had been postulated for several decades and it was a phenomenon of strength gains in an untrained contralateral limb after unilateral resistance training[8,9,10,11]. There are so many reports on the inter-limb effects but it is generally accepted that the transfer effect is muscle-specific, primarily affecting the homologous contralateral muscles alone. However, some reports speculated that there may be a minimal effect to some synergist group of muscles[12]. The clinical significance of the radiating effects is considered to be small by some researchers[13,14]. The analysis conducted in the reviews of were restricted to studies that used training intensities higher than 50% of maximum strength for at least 2 weeks[15,9,11].

The prime movers for flexion activities at the elbow joint are the biceps brachii, the brachialis, and the brachioradialis, however, the biceps is a major flexor whose strength cannot be neglected for full hand functions after impairment[16,17]. Onigbinde *et al* established the existence of cross training effect in patients with unilateral orthopaedic and neurological disorders[18,19,20]. However, the findings could not be generalized because of the small sample size and weak self-control design adopted in the studies. There is need to have a true experimental design with control in order to be able to generalize the findings. Asides this, most previous studies were not explicit in the values of 1-RM and progression adopted in the isometric training. Furthermore, while there are some studies on cross education effect, there are limited empirical data on the establishment of strength gains (diffusion) to untrained synergist and adjacent muscles in the same trained ipsilateral extremity. This study therefore aimed at determining the effects of cross education to contralateral homologous muscle and strength diffusion from trained arm flexors to other untrained heterologus muscles of the same upper extremity.

MATERIALS AND METHODS

Participants

Participants in this study were 40 undergraduate students at the University of Medical Sciences, Ondo State, Nigeria.

Inclusion and Exclusion criteria

Included in this study were apparently healthy and right hand dominant undergraduate students within the ages of 18 to 30 years. Excluded were students with musculoskeletal abnormalities, who engaged in active sports or were taking stimulants or steroid drugs.

Site of Study

The investigation took place at the gymnasium of the Physiotherapy Department, Faculty of Medical Rehabilitation, University of Medical Sciences, Ondo State.

Study Design

The design was a randomized control trial (RCT). There were two groups; the experimental and the control group. The participants were randomly assigned to the group using fish-bowl technique.

Sampling technique

A convenience sampling technique was utilized to recruit the participants. The sample size was determined using the sample size equation of Araoye *et al*[21]. The size was computed to be 35 for both groups, however, 40 participants were recruited for the study in order to give room for attrition.

Instruments

Bathroom weighing scale was used to measure the weight while Stadiometer was used to measure the height of the participants. The spring balance was used to quantify the strength of the selected muscle groups. The spring balance is graded from 0 to 100kgf but the values were converted to Standard Unit, Newton(N) to have a grade of 0 to 980.67N, (1kgf=9.8067N)[22]. The Multigym Exercises was used to strengthen the bicep brachii muscles while the BMI (Body Mass Index) was computed by dividing the body weight in kilograms by the square of the height (kg/m^2).

Procedures

Ethical approval was obtained from the Ethics and Research Committee of University of Medical Sciences, Ondo. Individual undergraduate students were approached to participate and those who met the inclusion criteria were recruited. The procedures were explained to each participant. A quick interview was used to determine the participants' dominant hand, using the procedure of Balogun and Onigbinde[22]. One-Repetition Maximum (RM) was determined for the dominant right hand by measuring the heaviest weight the subject could only carry once to execute the final elbow flexion[23]. This was determined for all the subjects prior to commencement, at 3rd, 5th and 6th week. The value of RM determined the amount of weight used to strengthen the biceps brachii muscles for each patient at each week. The dosage of training was 3sets and 10 repetitions with a passive recovery time of 3 minutes[24].

Procedures for training and quantification of the arm flexors muscles

The biceps curl exercises were done to train the muscles of the upper limb with one end of the pulley connected to the multigym. Each exercise was performed in a standing position. The arm was maintained parallel to the trunk. Each

participant was instructed to flex the elbow joint and pulled the loaded weight at the other side of the multigym and sustained the contraction, isometrically, sustaining it for 10 seconds, 10 repetitions and 3 sets[25]. Each exercise phase was separated by at least 3 minutes of passive recovery[24]. Prior to the main exercise phase, 25% of the determined1-RM was used as warm-up, consisting of 3 sets x 10 repetitions of biceps curl exercise. The strength of the arm flexors, arm extensors, shoulder flexors, extensors, adductors and abductors muscles were quantified and recorded at onset, (2) after 2 weeks, after 4 weeks and after 6weeks (Fig 1 - 6).

Procedures for measurements of arm flexors muscle strength

Each participant was in a seated position with elbow in 90° flexion. The wrist attachment of the spring balance was fixed proximal to the wrist joint while the other side of the spring balance was anchored to the bottom of the plinth. The forearm was abducted against the thorax ensuring that the anchor points are in line with the movement trajectory. Each participant was instructed to maintain the neutral spine position, avoiding lateral trunk flexion to the opposite side, as well as the elevation of the scapula of the same side. The participant was instructed to pull the spring balance upward, maximally, the applied force was then quantified on the balance and the measurement was recorded[26].

Procedures for measurements of arm extensors muscle strength

The participants were in supine position, with 90 degrees flexion in both shoulder and elbow. The attachment of the spring balance was placed on the wrist with patient thumb facing downward. The distal end of the spring balance was anchored to the plinth in line with the wrist ensuring that the anchor points are in line with the movement. Each participant was instructed to pull the spring balance backward, maximally, the measurement on the spring balance was recorded[26].

Procedures for measurements of shoulder flexors strength

The participants were positioned in a sitting position, with their shoulder at 90° flexion and arm pronation. The wrist attachment of the spring balance was firmly placed proximal to the elbow joint, while the distal end was anchored to the bottom of the plinth on the opposite side ensuring that the spring balance anchor points are in line with the movement trajectory. The participant was instructed to maintain the neutral spine position and to avoid the lateral flexion. To additionally eliminate compensations, a manual pressure was applied to the opposite shoulder while the movement is performed. The participant was instructed to pull the spring balance upward, when complete, the participant released the applied force and the measurement was recorded[26].

Procedures for measurements of shoulder extensors

The participants lied in a prone position with arm in pronation. The wrist attachment of the spring balance was firmly placed proximal to the elbow joint while the distal end of the spring balance was anchored to the bottom of the plinth on the opposite side ensuring that the spring balance anchor points are in line of the movement trajectory. The participant

was instructed to pull the spring balance upward, when complete, the participant released the applied force and the measurement was recorded[26].

Procedures for measurements of shoulder abductors

The participants in sitting position, kept the shoulder joint in 90° abduction with the arm pronation. The wrist attachment of the spring balance was firmly placed proximal to the elbow joint while the distal end of the spring balance was anchored to the bottom of the plinth at the opposite end ensuring that the spring balance anchor points are in line with the movement trajectory. The participant was instructed to maintain the neutral spinal position throughout the measurement, avoiding lateral flexion. To additionally eliminate compensation, a manual pressure was applied to the opposite shoulder while the movement is performed. The participant was instructed to pull the spring balance upward, when completed, the participant released the applied force and the measurement was recorded[26].

Procedures for measurements of shoulder adductor and abductor muscles

Standard procedures were used to quantify the shoulder adductor and abductor muscles using the spring balance (Figures 5 & 6). The protocols adopted for this study with regards to training and testing positions, and verbal motivation are standard procedures where maximum peak isometric forces could be generated[27].

The assessments were done at onset, after 2 weeks, after 4 weeks, and after 6 weeks.

Fig 1: Procedure for measurements of arm flexors

Fig 2: Procedure for measurements of arm extensors

Fig 3: Procedure for measurements of shoulder flexors

Fig 4: Procedure for measurements of shoulder extensors

Fig 5: Procedure for measurements of arm abductors

Fig 6: Procedures for measurements of shoulder adductors

Procedures for warm up for each training

The participant stood in an erect position with elbow extension and held the sandbag in front of the body with forearm in supine position. The weight of the sandbag is the 25% of the 1-RM that was determined for the participant, the participant was instructed to execute full elbow flexion and extension, and perform the exercise for 10 reps.

Data Analysis

The data were summarized using descriptive statistics of (range) mean and standard deviation. Paired t-test was used to compare the right and left upper limb, the initial and final strength within the groups. Student t-test was to compare variables of the groups, ANOVA was used to compare the 1-RM at initial, 3rd, 5th and 6th week. Post hoc (LSD) was used to reveal the trend of the differences. Level of significance was set at <0.05.

RESULTS

Gender, Age and Anthropometric Parameters of Participants in the Experimental and Control Groups

There were 7 female (35.0%) and 13 male (65.0%) in the experimental group while there are 11 female (55.0%) and 9 male (45.0%) in the control group. The average age of the participants in the experimental and control groups were 22.05 ± 2.24 and 21.05± 2.52 years respectively. The height, weight and BMI are presented in the table 1. The results showed that there were no significant differences in the age, height, weight and BMI of the participants of the experimental and control groups (Table 1).

Comparison of Selected Muscle Strength and Arm Flexor Girth of the Experimental group

The mean values of one-RM, muscle strength and girths are presented in table 2. The result of the paired t-test (dependent t-test) showed that there was significant difference between the right and left right arm flexor muscle strength following 4 weeks isometric strength training ($t = 6.57$, $p = 0.001$). There were significant differences between the initial and final for both right and left right arm flexor muscle strength following 4 weeks isometric strength training ($t = -7.95$, $p = 0.001$; $t = -8.97$, $p = 0.001$ respectively). The results of comparison of other group of muscles in the upper extremity are presented in Table 2.

At baseline the result showed that the average arm girth of the right and left arm girth was 27.38 ± 2.08cm and 26.85 ± 2.24cm for the participants in the experimental group. There was significant difference between the right and left right arm girth following 6weeks isometric strength training ($t = 4.10$, $p = 0.001$). There were significant differences between the initial and final for both right and left right arm girth following 6 weeks of isometric strength training ($t = -1.55$, $p = 0.137$; $t = -2.93$, $p = 0.009$ respectively).

Table 1: Comparison of Age, and Anthropometric Parameters of both experimental and control group

	Experimental	SD	Control	SD	t	p
Age	22.05	2.24	21.05	2.52	1.33	0.19
Height	1.74	0.09	1.70	0.07	1.79	0.08
Weight	65.88	9.70	71.34	19.44	-1.13	0.27
BMI	21.82	3.39	25.00	7.63	-1.71	0.10

Table 2: Within-group Comparison of Muscle strengths and Girth for the Experimental group

	Mean (N)	S.D (N)	T	p
Arm flexors:				
Right	219.52	65.04		
Left	195.02	57.75	6.57	0.001
Right arm flexors:				
Initial	219.52	65.04		
Final	280.28	71.41	-7.95	0.001
Left arm flexors:				
Initial	195.02	57.75		
Final	248.92	56.91	-8.97	0.001
Right shoulder abductors:				
Initial	237.16	59.96		
Final	303.80	70.67	-6.96	0.001
Right shoulder adductors:				
Initial	196.98	56.69		
Final	270.48	68.07	-7.80	0.001
Right shoulder extensors:				
Initial	195.02	51.46		
Final	283.22	66.84	-8.04	0.001
Right shoulder flexors:				
Initial	252.84	66.97		
Final	340.06	83.71	-7.21	0.001
Right arm extensors:				
Initial	291.05	90.90		
Final	380.73	101.21	-4.83	0.001
Arm girth:				
Right	27.38	2.08		
Left	26.85	2.24	4.10	0.001
Right arm girth:				
Initial	27.38	2.08		
Final	27.82	1.74	-1.55	0.137
Left arm girth:				
Initial	26.85	2.24		
Final	27.75	1.89	-2.93	0.009

Comparison of Selected Muscle Strength and Arm Flexor Girth of the Control group

The mean values of muscle strength and girths for the participants in the control group are presented in table 3. The result of the paired t-test (dependent t-test) was significant difference between the right and left right arm flexor muscle strength after 6 weeks of not training ($t = 5.10$, $p = 0.001$). There were no significant differences between the initial and final for both right and left right arm flexor muscle strength after 6 weeks of not training ($t = -1.14$, $p = 0.27$; $t = -0.37$, $p = 0.72$ respectively). The results of comparison of other group of muscles in the upper extremity are presented in Table 3.

Comparison of Selected Muscle Strength and Arm Flexor Girth of the Experimental and Control groups

At baseline, the result showed that the average muscle strength of the right arm flexors of the experimental and control group 219.52 ± 65.04 and 204.82 ± 62.78N respectively. The result of the student t-test showed that there was no significant difference in the initial right arm flexors of the experimental and control groups. However, there was significant difference in the final right arm flexors of the experimental and control groups ($t = 3.58$, $p = 0.001$). The left arm flexors of the experimental and control group were 195.02 ± 57.75N and 188.16 ± 58.77N. Similarly, there was no significant difference in the initial left arm flexors of the experimental and control groups but there was significant difference in the final left arm flexors of the experimental and control groups ($t = 3.44$, $p = 0.001$). The results of other comparisons are presented in Table 4.

Correlation between age, selected Anthropometric variable, Girths, Repetition Maximum and Right arm elbow flexors

The results of the Pearson's Correlation Co-efficiency showed that there were significant correlations between age and right ($r = 0.43$, $p = 0.005$) and left arm elbow flexors ($r = 0.46$, $p = 0.003$). There was also significant correlation between age and the baseline Rep Max ($r = 0.47$, $p = 0.04$). Similarly, height had significant correlations with right elbow flexors ($r = 0.54$, $p = 0.001$), left elbow flexor ($r = 0.50$, $p = 0.001$), baseline RM ($r = 0.61$, $p = 0.004$) and Final RM ($r = 0.66$, $p = 0.002$). However, there was no significant correlation between right elbow extensors and height ($r=0.01$, $p=0.97$). There was also no significant correlation between right shoulder adduction and weight. ($r=0.54$, $p=0.74$). The results of other correlations are presented in Table 5.

Results of the Multiple Regression Analyses

The results of multiple regression analyses showed that age, height, weight, BMI, right and left arms girth were significant predictors of right arm flexors strength ($F=3.85$, $P=0.005$) in Table 6. The results showed that age contributed 18.8% to the prediction of right arm flexors strength while height had 29.0%. The results of other contributions are presented in table 7. The coefficient of determination was found to be 0.41. The predictive equation obtained for the right arm flexor strength:

Right arm flexor strength= *-607.614+ Age (8.55) + height (328.41) + weight (0.686) + BMI (-1.137) + Right girth (0.75) + Lt girth (1.066) .*

Table 3: Within-group Comparison of Muscle strengths and Girth for the Control roup

	Mean	S.D	t	P
Arm flexors:				
Right	204.82	62.78		
Left	188.16	58.77	5.10	0.001
Right arm flexors:				
Initial	204.82	67.78		
Final	207.76	55.95	-1.14	0.27
Left arm flexors:				
Initial	188.16	58.77		
Final	187.18	56.69	0.37	0.72
Right shoulder abductors:				
Initial	239.12	43.87		
Final	243.04	43.32	-1.71	0.10
Right shoulder adductors:				
Initial	203.83	47.34		
Final	204.81	36.80	-0.17	0.87
Right shoulder extensors:				
Initial	185.22	63.10		
Final	182.28	62.01	1.00	0.33
Right shoulder flexors:				
Initial	253.82	49.45		
Final	253.82	49.86	0.001	1.00
Right arm extensors:				
Initial	282.24	85.65		
Final	281.26	82.25	0.15	0.88
Arm girth:				
Right	28.95	6.01		
Left	29.02	6.18	-0.72	0.48
Right arm girth:				
Initial	28.95	6.01		
Final	29.32	6.18	-0.72	0.48
Left arm girth:				
Initial	29.02	6.18		
Final	29.17	6.01	2.03	0.06

Table 4: Comparison of the Arm Flexor Muscle strength and Girth of the Experimental and Control groups

	Experimental		Control group			
	Mean	**S.D**	**Mean**	**S.D**	**t**	**p**
Right arm flexors:						
Initial	219.52	65.04	204.82	62.78	0.73	0.47
Final	280.28	71.41	207.76	55.95	3.58	0.001
Left arm flexors:						
Initial	195.02	57.75	188.16	58.77	0.37	0.71
Final	248.92	56.9s1	187.18	56.69	3.44	0.001
Rt shld abd Initial	237.16	59.96	239.12	43.87	-0.12	0.91
Final	303.80	70.67	243.04	43.32	3.28	0.002
Right shoulder add						
Initial	196.98	56.69	203.83	47.34	-0.42	0.68
Final	270.48	68.07	204.81	36.80	3.80	0.001
Right shoulder ext						
Initial	195.02	51.46	185.22	63.10	0.54	0.39
Final	283.22	66.84	182.28	62.01	4.95	0.001
Right shoulder flex						
Initial	252.84	66.97	253.82	49.45	-0.05	0.96
Final	340.06	83.71	253.82	49.86	3.96	0.001
Right arm ext						
Initial	291.05	90.90	282.24	85.65	0.32	0.75
Final	380.73	101.21	281.26	82.25	3.41	0.002
Right girth: Initial	27.38	2.08	28.95	6.01	-1.10	0.28
Final	27.83	1.74	29.17	6.01	-0.96	0.35
Left girth: Initial	26.85	2.24	29.02	6.18	-1.48	0.15
Final	27.75	1.89	29.33	6.18	-1.10	0.28

Key: *Shld: shoulder, Abd: abductors, Add: adductors, Ext: extensors, Flex; flexors*

Table 5: **Correlation between age, selected Anthropometric variable, Girths, Repetition Maximum and Right arm elbow flexors**

Variable		Age	Height	Weight	BMI	RTELFL	LTELFL	InitialRM	FinalRM	RTSHAB	RTSHAD	RTSHFL	RTSHEX	RTELEX
Age	R	1												
	P													
Height	R	0.29	1											
	P	0.07												
Weight	R	-0.20	-0.04	1										
	P	-0.21	0.80											
BMI	R	-0.20	-0.40*	-0.93**	1									
	P	0.08	0.011	0.001										
RTELFL	R	0.43**	0.54**	0.10	-0.10	1								
	P	0.005	0.001	0.55	0.53									
LTELFL	R	0.46**	0.50**	0.110	-0.08	0.97**	1							
	P	0.003	0.001	0.51	0.62	0.001								
InitialRM	R	0.47*	0.61**	-0.03	-0.41	0.89**	0.91**	1						
	P	0.04	0.004	0.91	0.073	0.001	0.001							
FinalRM	R	0.32	0.66**	-0.07	0.48*	0.86**	0.86**	0.94**	1					
	P	0.17	0.002	0.77	0.033	0.001	0.001	0.001						
RTSHAB	R	0.37*	0.57**	0.15	-0.06	0.85**	0.85**	0.89**	0.86**	1				
	P	0.002	0.001	0.36	0.71	0.001	0.001	0.001	0.001					
RTSHAD	R	0.45**	0.38*	0.05	-0.08	0.76**	0.77**	0.81**	0.77**	0.76**	1			
	P	0.004	0.02	0.74	0.62	0.001	0.001	0.001	0.001	0.001				
RTSHEX	R	0.41**	0.51**	-0.06	-0.23	0.80**	0.77**	0.76**	0.77**	0.72**	0.66**	1		
	P	0.009	0.001	0.70	0.16	0.001	0.001	0.001	0.001	0.001	0.001			
RTSHFL	R	0.40*	0.36*	0.03	-0.09	0.80**	0.82**	0.84**	0.86**	0.86**	0.80**	0.69**	1	
	P	0.01	0.02	0.86	0.59	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
RTELEX	R	0.40*	0.28	0.01	-0.1	0.76**	0.73**	0.69**	0.70**	0.76**	0.74**	0.73**	0.78**	1
	P	0.01	0.08	0.97	0.54	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	

* Correlation is significant at the 0.05 level (2- tailed) ** Correlation is significant at the 0.01 level (2- tailed)

Key: *BMI: Body Mass Index, RT: Right, LT: Left, RM: Repetitive Maximum, AD: Adductors, AB: Abductors, FL: Flexors, EL: Extensors, SH: Shoulder*.

Table 6: Results of multiple Regression Analysis for the right arm elbow flexors

	Sum of Squares	df	Mean Square	F	p
Regression	64790.411	6	10798.402	3.847	0.005
Residual	92628.753	33	2806.932		
Total	157419.164	39			

Table 7: Percentage Contribution of the independent Variables

Variable	Percentage Contribution
Age	18.8
Height	29.0
Weight	0.9
BMI	1.1
Left girth	1.9
Right girth	2.5

DISCUSSION

The age, height, weight and BMI of both groups are comparable as there were no significant differences in the values, hence, any difference observed in strength cannot be attributed to difference in these variables. The main purpose of this study was to investigate if there was cross education effects on the untrained left elbow flexors after isometric training to the right arm elbow flexors for 6 weeks and if there was (diffusion of strength) at the adjacent muscles after training the right elbow flexors for 6 weeks, with a view to establishing cross training and diffusion effects.

This study found that the arm elbow flexors muscle strength of the untrained left arm elbow flexors increased significantly after 6 weeks isometric training of the right arm elbow flexor muscles, this implies cross education effects. There were significant increases in the final muscle strength of adjacent muscles namely; shoulder

extensors, shoulder flexors, shoulder abductors, shoulder adductors and elbow extensors. This implies that there was diffusion of strength in selected muscles of the right arm following 6 weeks isometric training of only the right arm elbow flexor muscle. There was significant increase in the right and left arm girth following 6 weeks isometric strength training, this, established a significant cross training effect. For the control group, the participants didn't train for 6 weeks, unlike the participants in the experimental group, there was no significant difference between the strength when the initial and final strength were compared for the right and left arm flexors, and adjacent muscles. This implies that there was no diffusion and cross education effects without isometric training.

There are previous reports which had established cross training effects after volitional exercise training[28]. This current finding corroborated the finding of Zhou *et al.,* but contradicted that of Sariyildiz *et al.,* who found no increment in the contralateral strength, although, it was the wrist flexor groups of muscles that were strengthened in their studies[8,29]. This current finding also corroborated the reports of Onigbinde *et al*., who established cross training effect in the quadriceps muscles of apparently healthy individual[19]. They had earlier speculated that the inter-limb phenomenon might be useful for patients with unilateral pathologies such as osteoarthritis and cast immobilization[18]. We observed that our findings were comparable to the effect of high resistance exercise training utilized to improve muscle strength as reported by Abe *et al*., and Onigbinde *et al*., who concluded that it would be clinically useful to train one limb to generate a strength increase in the untrained limb of patients as the un-trained contralateral muscle strength also increased significantly after 6 weeks[19,30]. Physiological changes such as increased hypertrophy and hyperplasia of muscle fibers; neural activation (firing and synchronization of more motor units); increased tensile strength of tendon, ligaments and connective tissues had been reported for exercise strengthening programmes[31]. The implication of this was that it would be non-beneficial if the workload was not progressively increased to keep pace with newly won strength at the third week of training. Since discovery in 1894, subsequent studies have confirmed the existence of cross education in contexts involving voluntary, imagined and electrically stimulated contractions[18]. There are two hypothetical explanations described by Lee and Carroll for cross training effects[5]. The first hypothesis suggested that unilateral resistance training may activate neural circuits that chronically modify the efficacy of motor pathways that project to the contra-lateral untrained limb. The second hypothesized that the opposite untrained limb may access the modified neural circuits by induction from motor areas that are primarily involved in the control of movements of the trained limb. These were not different from the theories of bilateral co-activation of cortico-spinal tract explained by Carr *et al*.; bilateral co-activation suggested activation of afferent modulation at contra-lateral limb by Horgtobagyi *et al.,* and diffusion of impulses between cerebral hemisphere opined by Yue and Cole[32,33,34]. Our finding had lent

credence to previous theories and explanations on cross training.

We found out that age and anthropometric parameters were significant predictors of the right arm elbow flexors strength. For the prediction of arm flexors, we found that age contributed 18.8%, height 29.0%, weight 0.9, BMI 1.1%, right and left elbow girth 2.5% and 1.9% respectively. The findings of this study were similar to that of Onigbinde *et al* [18]. However, Onigbinde *et al* observed that the strongest predictor of strength was weight but this present contribution found height as the highest[18]. The coefficient of determination was found out to be 0.41 and this can be considered to be moderately good. The moderate 0.41 could be attributed to the narrow age range (18-28years) of the participants. Therapists using our present equation should realize that despite the statistically significant predictive potential of age and anthropometric indices, considerable variability remains when they are used to predict the right arm elbow flexors.

Our current findings have clinical implications because it established that the strengthening of right arm elbow flexors produced meaningful and significant increase in strength of the untrained left arm elbow flexors contralateral homologous group of muscles. The increment in both arm flexors may translate to an improvement in functional activities and decreased loading rate at the elbow joint[35]. The inter-limb phenomenon may potentially contribute to more effective use of resistance training protocols that exploit these cross-limb effects to improve the recovery of patients with movement disorders where one side of the body are predominantly affected[5]. The measured effects vary from adaptations of muscle performance to alterations in gene expression, inflammation and tissue remodeling[36].

There are morphological and architectural changes in muscle structure using exercises[37]. It is noteworthy that the clinical significance of this study is high because it has ascertained that training the good limb can generate strength increase in the contralateral extremity with pathology or immobilized in a cast, especially, in patients requiring orthopaedic and neurological rehabilitation. One of the main goals of stroke rehabilitation is training ambulation and this depends to a large extent on the muscle strength of the affected lower limb, asides impairment in balance, and presence of moderate extensor pattern[38].

CONCLUSION

It was concluded that there was cross education effect on the untrained left arm flexor muscles after 6 weeks of isometric training of the right arm flexors. Also, this study established strength gain or diffusion into adjacent muscles (shoulder flexors, extensors, abductors, adductors and triceps) of the right upper extremity following 6 weeks isometric training of only the right arm flexors. It was also concluded that age, weight, height, Body Mass Index, left and right girth are significant predictors of right arm flexor muscles strength.

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AWARENESS, KNOWLEDGE, AND ATTITUDE TOWARDS VIRTUAL AND AUGMENTED REALITY TECHNOLOGIES IN PHYSIOTHERAPY PRACTICE AMONG FINAL YEAR PHYSIOTHERAPY STUDENT AT A SUBSAHARAN AFRICAN UNIVERSITY

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ABSTRACT

Background: Technological innovations such as virtual reality (VR) and augmented reality (AR) are transforming healthcare education and clinical practice. These immersive technologies offer opportunities for interactive, experiential learning and can enhance rehabilitation outcomes. However, the extent to which physiotherapy students are aware of, knowledgeable about, and have a positive attitude toward VR/AR remains underexplored, especially in resource-limited settings like Nigeria.

Aim: To assess the awareness, knowledge, and attitudes of final-year physiotherapy students toward the application of VR and AR in physiotherapy practice across selected Nigerian institutions.

Materials and methods: A descriptive cross-sectional study was conducted among 400 final-year physiotherapy students from five Nigerian universities using a self-structured, validated online questionnaire. The tool assessed participants' demographic details, familiarity with VR/AR, practical knowledge, and attitudes. Data was summarized using descriptive statistics and visual representations.

Results: While 74.2% of students were aware of VR/AR applications in physiotherapy, only 1.8% had good knowledge, and just 1.0% had practical experience using VR/AR. However, 62.4% strongly agreed that VR/AR should be integrated into physiotherapy practice, and 58.8% expressed high interest in learning more. Major barriers identified included lack of exposure in the curriculum, insufficient equipment, and inadequate instructor training.

Conclusion: Although final-year physiotherapy students in Nigeria showed high awareness and interest in VR/AR, practical knowledge and experience remain low. The findings support the urgent need to integrate VR/AR into physiotherapy curricula through hands-on training, workshops, and institutional investment to prepare future practitioners for technology-enhanced rehabilitation.

Keywords: Virtual reality, Augmented reality, Physiotherapy students, Rehabilitation, Nigeria, Health Technology Education

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INTRODUCTION

Virtual reality (VR) is a simulated 3D environment that enables users to explore and interact with virtual surroundings that approximate reality, as it is perceived through the users' senses.[1,2] Augmented reality (AR) is an enhanced version of the real world, achieved through computer-generated digital information.[3] AR integrates digital information with the user's environment in real time.[4] While VR and AR are designed to simulate an environment, each concept is unique and involves different use cases.[5] VR provides a fully immersive digital experience for the viewer, while AR allows more freedom as it enhances the real world rather than replacing

it. Virtual reality originated in 1838 with Charles Wheatstone's stereoscope, which used an image for each eye to create a 3D image, and this technology has grown and become more incorporated into our everyday lives.[6] In 1968, Ivan Sutherland introduced the world to the first head-mounted AR display, *The Sword of Damocles*, which laid the foundation for VR.[7] Over the decades, technological advancements have accelerated the development of VR. In the 1980s and 1990s, companies like Sega and Nintendo developed VR gaming systems, with limited success; however, it was not until the 2010s that companies like Oculus and HTC Vive introduced high-quality VR headsets that leveraged powerful graphics and motion-tracking technology.[7]Virtual reality (VR) and AR have been used in gaming, entertainment, fashion, and health. In healthcare, the rise of AR and VR is forever changing the way health professionals treat and care for their patients.[8] VR and AR aid in accurate diagnoses, personalized treatment planning, patient education, and demystifying complex medical information.[9]

In physiotherapy, recent advancements in VR have opened life-changing possibilities in rehabilitation.[10] VR and AR technologies provide new experiences to users during rehabilitation, increasing engagement for improved physical outcomes. VR can be used for different purposes in exercise therapy, including pain management, improved functional ability, increased range of motion, increased muscular strength, and increased motivation. For stroke survivors, VR incorporates several theories of neuroscience and motor learning,[11] while AR provides real-time feedback and guidance with visual cues, instructions, or corrections.

Integrating AR and VR into treadmill training is an emerging rehabilitation tool, used to improve gait and balance in stroke survivors.[11] Moreover, it can help increase adherence and retention by enabling patients to track their progress, set goals, and receive reminders or notifications. VR systems optimize motor learning in a safe environment and can help improve activities of daily living by replicating real-life scenarios. Within VR, augmented feedback about a person with Parkinson's performance enables repetitive practice of motor tasks, thus stimulating both motor and cognitive processes simultaneously.

Despite the burgeoning interest in VR and AR, there is a lack of comprehensive studies focusing on final-year students' perspectives on these technologies. Therefore, this study aimed to assess awareness, knowledge, and attitude about VR and AR among final-year physiotherapy students.

MATERIALS AND METHODS

Research Design and population

This was a cross-sectional descriptive study involving four hundred final-year physiotherapy students from Nnamdi Azikiwe University, University of Nigeria Nsukka, University of Benin, University of Maiduguri, and University of Ilorin who were recruited via purposive sampling. The participants included male and female

physiotherapy students in their final year of the selected institutions only.

Research instrument

Data were collected using a self-structured questionnaire designed to assess awareness, knowledge, and attitude about VR and AR among final-year physiotherapy students. The questionnaire was developed based on existing literature and validated through a pilot study.

Data collection

Ethical approval was sought and obtained from the Ethical Review Committee of Faculty of Health Sciences and Technology Nnamdi Azikiwe University, Nnewi. Data were collected through a structured, self-administered questionnaire designed to evaluate the awareness, knowledge, and attitude of final-year physiotherapy students towards VR and AR technologies in physiotherapy practice. The questionnaire was created based on existing literature and validated through a pilot study to ensure clarity and relevance. The questionnaire consisted of four sections: demographic information, awareness of VR/AR, knowledge of VR/AR applications, and attitude towards using these technologies clinically. The questionnaire was distributed online using google forms. The link to the questionnaire was sent to participants through different social media platforms. The purpose of the study was explained to the participants, and informed consent was obtained before administering the questionnaire. Participation was voluntary, and confidentiality and anonymity of responses were assured.

Data Analysis

Descriptive statistics were used to summarize participants' demographic characteristics, level of awareness, level of knowledge, and attitude towards VR and AR. Pie chart and bar chart will be used for visual representations of data. Frequencies and percentages were used to present categorical variables such as gender, age group, institution, awareness of VR/AR, and responses to knowledge and attitude questions, Mean and standard deviation were used for continuous variables.

RESULTS

Socio-demographic characteristics of the participants

A total of 400 final-year physiotherapy students participated in the study. The gender distribution was nearly equal, with 201 (50.2%) males and 199 (49.8%) females. Regarding age, most respondents, 313 students (78.3%), were between 18 and 25 years, followed by 83 students (20.8%) aged 26–35 years, and only 4 students (1.0%) aged 36–45 years.

Awareness of VR/AR

Figure 1 illustrates the participants' familiarity with VR/AR. A moderate proportion of students (50.40%) reported being familiar with the concepts of VR and

AR, while a smaller percentage were either unfamiliar (34.80%) or very familiar (14.80%). Regarding curricular exposure, 91% of the students indicated they had not been previously exposed to VR/AR through their coursework (Figure 2).

Knowledge of VR/AR in physiotherapy practice

Table 2 presents participants' responses to knowledge-based questions on VR/AR. While 74.2% of students knew that VR and AR have applications in physiotherapy practice, only 1.0% had previously used any VR/AR device or software. Figure 3 shows what participants most commonly associate VR/AR with, with education (63%) and gaming (25.80%) being the highest. Despite high awareness of potential applications, 64% of students had poor knowledge of VR/AR in practice, 28.7% had fair knowledge, 5.5% had no knowledge, and only 1.8% demonstrated good knowledge (Figure 4). Students reported needing access to training workshops, equipment, and practical demonstrations to feel competent in using VR/AR technology (Figure 5).

Attitude towards VR/AR in physiotherapy

Attitude-based responses, summarized in Table 3 and Figures 6 and 7, revealed that 58.8% of participants were very interested in learning about VR/AR, 37.5% were somewhat interested, and only 3.8% were not. Regarding opinions on integrating VR/AR into physiotherapy, 62.4% strongly agreed it should be integrated into education and practice, 53.8% agreed that VR/AR would improve patient outcomes, and 58.8% believed it would make treatment more engaging for patients.

Participants also identified cost, lack of equipment, and insufficient training opportunities as major challenges to implementing VR/AR in clinical settings (Figure 6). Nevertheless, many expressed a willingness to participate in future training or workshops to enhance their skills (Figure 7).

Table 1. Sociodemographic characteristics of the participants

Variable	Class	Frequency	Percentage (%)
Gender	Male	201	50.2
	Female	199	49.8
Age	18–25 years	313	78.3
	26–35 years	83	20.8
	36–45 years	4	1.0
Institution	University of Benin	11	9.9
	University of Ilorin	3	2.7
	University of Maiduguri	12	10.8
	University of Nigeria Nsukka	21	18.9
	Nnamdi Azikiwe University	64	57.7

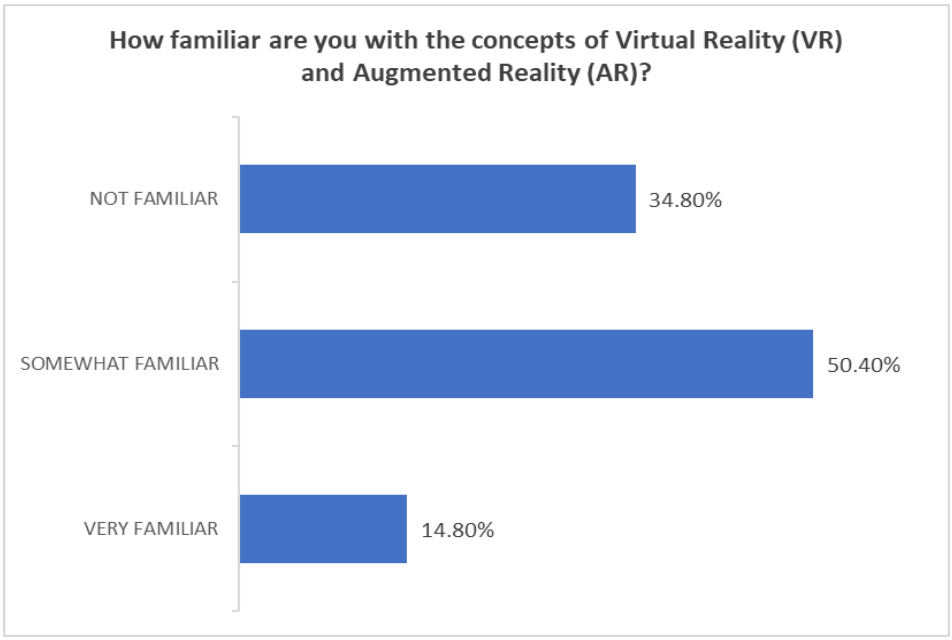

Figure 1. Familiarity of participants with the concepts of virtual and augmented realities

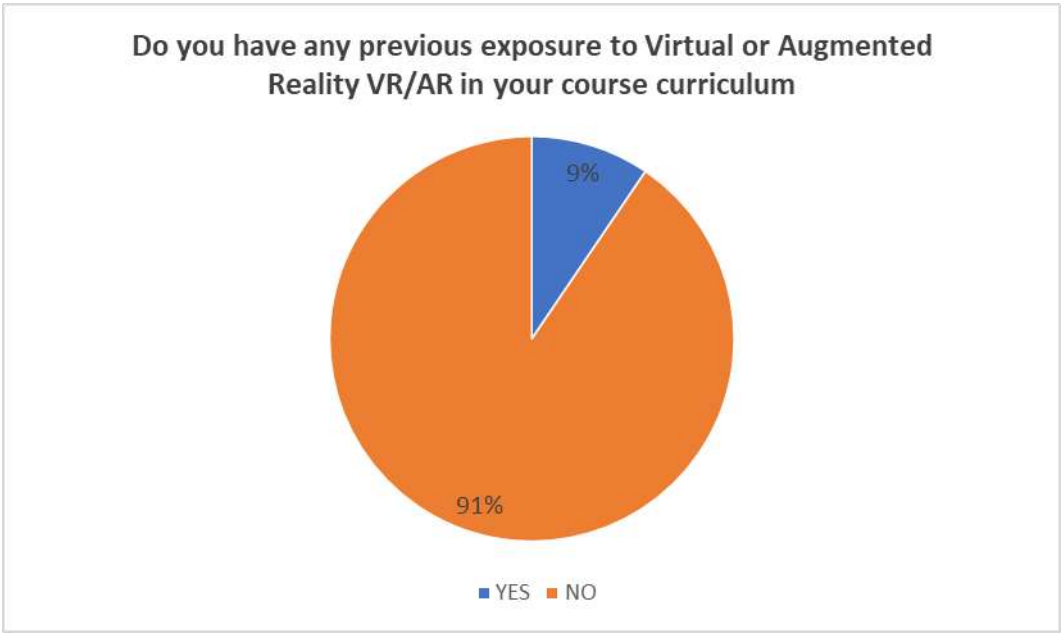

Figure 2. Previous exposure to virtual/augmented reality in the physiotherapy curriculum

Table 2. Knowledge of VR and AR in physiotherapy practice

Items	Yes (n)	%	No (n)	%
Have you used any VR and AR device or software in the past?	4	1.0	395	99.0
Are you aware of the use of VR/AR technology in physiotherapy treatment?	296	74.2	103	25.8
What areas of physiotherapy do you think can benefit from VR/AR technology? - Musculoskeletal Rehabilitation	331	82.8	69	17.3
What areas of physiotherapy do you think can benefit from VR/AR technology? - Neurological Rehabilitation	334	83.5	66	16.5
What areas of physiotherapy do you think can benefit from VR/AR technology? Cardiorespiratory rehabilitation	329	82.3	71	17.8
What areas of physiotherapy do you think can benefit from VR/AR technology? Pediatrics	287	71.9	112	28.1
What areas of physiotherapy do you think can benefit from VR/AR technology? Orthopedics	373	82.2	81	17.8
What areas of physiotherapy do you think can benefit from VR/AR technology? Others	266	66.7	133	33.3

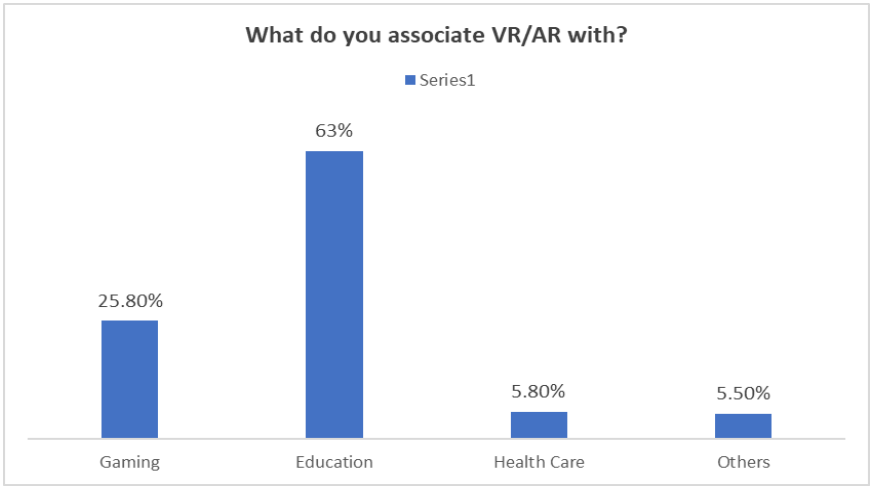

Figure 3. Participants' level of knowledge regarding VR/AR applications in physiotherapy practice

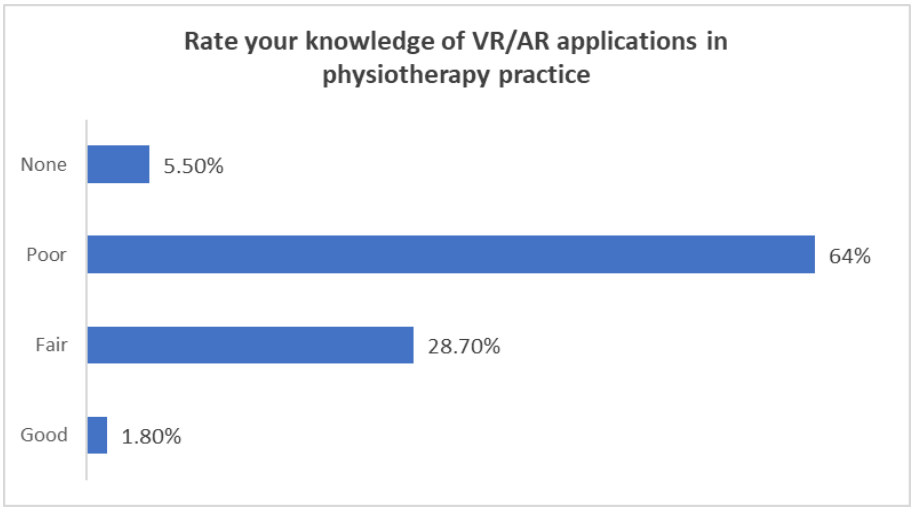

Figure 4. Self-Rated Knowledge of VR/AR Applications in Physiotherapy

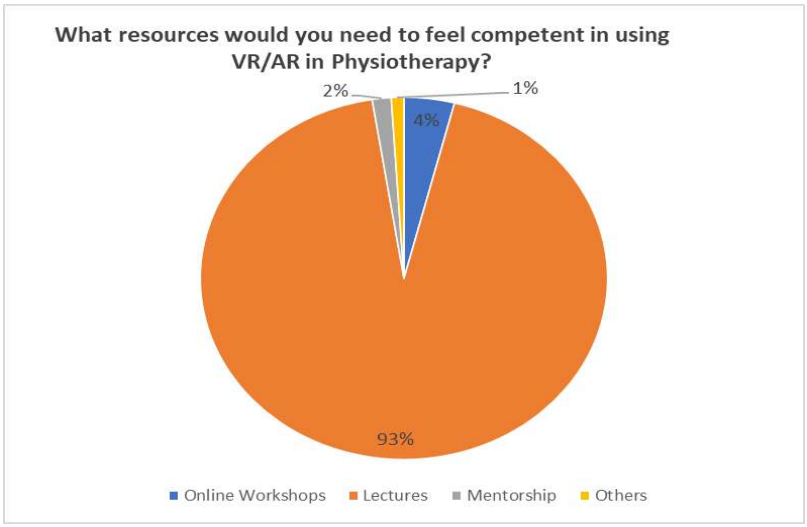

Figure 5. Resources needed by participants to feel competent in using VR/AR in physiotherapy

Table 3. Attitude towards VR and AR in physiotherapy practice

Items	Very Interested (n)	%	Somewhat interested (n)	%	Not Interested (n)	%
How interested are you in learning about VR/AR for physiotherapy?	235	58.8	150	37.5	15	3.8
	Strongly Agree (n)	%	Agree (n)	%	Neutral (n)	%
Do you think the inclusion of VR/AR in physiotherapy practice will improve patient outcomes?	97	24.9	215	53.8	88	22.0
Do you think the use of VR/AR in physiotherapy will make treatment more engaging for patients?	101	25.3	235	58.8	64	16.0
Do you believe VR/AR should be integrated into physiotherapy education and practice?	105	26.3	249	62.4	45	11.3

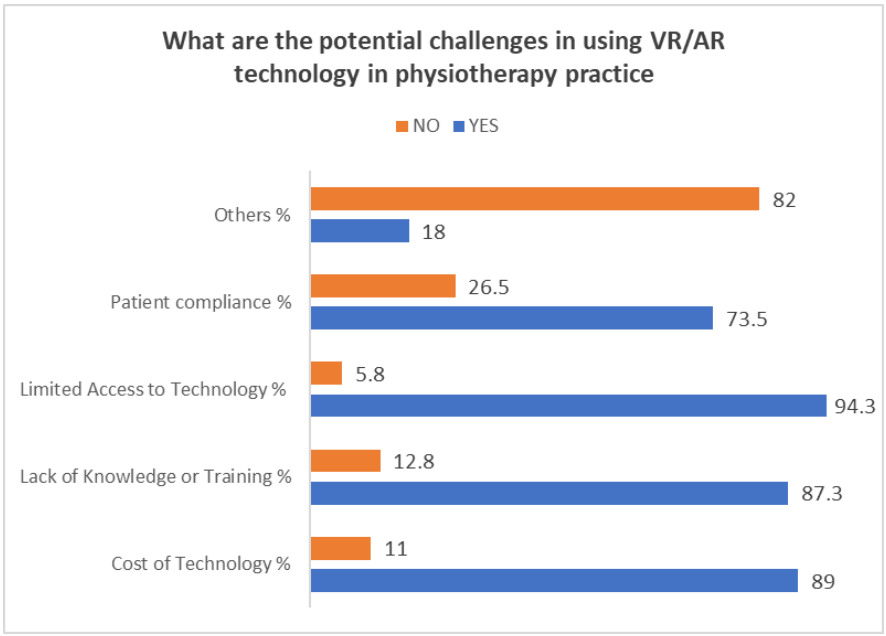

Figure 6. Perceived Challenges in Using VR/AR Technology in Physiotherapy Practice

Figure 7. Willingness of participants to participate in vr/ar training or workshops

DISCUSSION

This study aimed to assess the awareness, knowledge, and attitudes of final-year physiotherapy students towards VR and AR technologies in physiotherapy practice. With a healthcare industry striving to incorporate technology to improve clinical outcomes and education, it is important that physiotherapy students, future healthcare professionals, are well equipped to comprehend, assess, and utilize such tools in practice. The results of this study will provide useful information on the ability of students in institutions in Nigeria to adopt these innovations.

The results revealed that many participants were aware that they can use VR and AR in physiotherapy practice. This implies that students are not totally unknown to immersive technologies as there is an increasing world presence through media, gaming, or informal teaching. The high level of awareness corresponds with the report of a study that VR/AR has been recognized more among medical students and trainees owing to their massive discussions in healthcare innovations.[12]

However, this study also showed that a few of the participants had ever used VR or AR tools, and most of them had poor knowledge of their use in physiotherapy. This disparity has been emphasized in studies as a general challenge to incorporating emerging technologies into health education.[13,14] Many institutions, particularly in low-resource contexts, do not have the infrastructure or expertise to expose students to such advanced technological systems.

The participants illustrated the broad utility of VR/AR into multiple specialties in physiotherapy, which include musculoskeletal, neurological, cardiorespiratory, pediatrics, and orthopedics. These responses reflect a conceptual awareness of the clinical potential of VR/AR, which is reinforced by research highlighting that VR/AR are used in post-stroke rehabilitation, for chronic pain management, balance training, gait retraining, pediatric motor therapy.[15,16] VR-based therapy can significantly improve range of motion and pain in patients after total knee arthroplasty, confirming student perceptions in this study.[17]

However, the participants' reported lack of practical knowledge may restrict their utilization of such tools effectively, highlighting the importance of structured exposure and simulation-based learning in undergraduate training.[18,19]

Positive attitudes towards VR/AR integration into physiotherapy were demonstrated in the study. Most participants reported a high level of interest in learning about VR/AR, and VR/AR should be incorporated into physiotherapy education and as part of physiotherapy practice. Additionally, most agreed that VR/AR would help to better patient outcome and make treatment more engaging for patients. This indicates student willingness to accept innovation if there is enough support and training given. Analogous attitudes were found in a study where physiotherapists considered VR to be a promising addition to rehabilitation in increasing motivation and compliance of the patients.[20] Most

participants indicated a willingness to participate in VR/AR-related training and workshops, suggesting that while current knowledge levels are low, students are motivated to learn if given the opportunity. Two studies highlighted the importance of learner-centered approaches and interactive environments in improving VR/AR adoption in rehabilitation education.[21,22]

The participants also identified several barriers to the effective use of VR and AR in physiotherapy practice, including lack of access to VR/AR hardware and software, limited inclusion of technology in current curriculum, inadequate instructor training, and financial constraints. These challenges reflect similar dominant issues experienced globally, in developing nations, where lack of resources has been responsible for limited progress in adopting technological solutions in education.[23,24] In addition, cost implications related to the acquisition and maintenance of VR/AR infrastructure are high and a great challenge to institutions that are already faced with teaching resource challenge.

Apart from financial challenges, another great challenge is the shortage of trained faculty and standardized set of teaching modules. Faculty development programs are essential to developing institutional capacity and an instructor's readiness to teach the theoretical and practical aspects of VR/AR use.[14] It is imperative to modify Nigerians physiotherapy programs by incorporating curriculum to learn about digital rehabilitation tools, which include VR and AR. This inclusion instead of theoretical foundations should contain also practical exposure, by means of cooperation with providers of technology, simulation labs, or inter-university cooperation.

Furthermore, integrating VR/AR into physiotherapy education aligns with a broader trend in healthcare education towards experiential learning methodologies, where students conduct interactive scenario-based activities that mimic real-life situations.[25] These technologies have shown promise in surgical training, pain management, cognitive rehabilitation, and neurorehabilitation.[26,27]

This study had some limitations. This study's reliance on self-reported data may be subject to response bias, as participants might have overestimated or underestimated their awareness, knowledge, or attitudes towards VR and AR technologies. Additionally, the study utilized an online questionnaire distributed via social media, which may have excluded students with limited internet access, potentially affecting the representativeness of the sample. The study was also limited to final-year physiotherapy students in five selected Nigerian universities, restricting the generalizability of the findings to students in other institutions or disciplines. Furthermore, the cross-sectional design provides a snapshot of perceptions at a single point in time, without accounting for changes in knowledge or attitudes that may occur with increased exposure or curriculum updates. Finally, the study did not explore potential differences in responses based on demographic variables such as gender or prior exposure to technology, which could have offered more nuanced insights.

CONCLUSION

This study examined the awareness, knowledge, and attitudes of final-year physiotherapy students in selected Nigerian universities toward using VR and AR in physiotherapy practice. The findings revealed that while most students were aware of the existence and potential applications of VR and AR in rehabilitation, only a small proportion possessed adequate knowledge or had practical experience with these tools. Despite these knowledge gaps, students demonstrated a strong interest in learning about VR/AR and a positive attitude toward integrating these technologies into physiotherapy education and clinical practice.

The results highlight a clear need to incorporate modern digital tools like VR and AR into physiotherapy curricula through structured training, simulations, and workshops. Doing so will not only improve students' competence but also prepare them to meet the evolving demands of technology-driven healthcare. Bridging the gap between awareness and practical application is essential to equipping future physiotherapists with the skills required to deliver innovative and effective patient care in an increasingly digital world.

Competing interests

The authors declare no competing interests.

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KNOWLEDGE, ATTITUDE, PRACTICE AND ACCEPTABILITY OF CERVICAL CANCER SCREENING AMONG WOMEN IN IN SELECTED HEALTH FACILITIES IN ABUJA, NIGERIA

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ABSTRACT

Background: Cervical cancer is the second most common cause of death from cancer among women in Nigeria. Most studies indicate that the level of knowledge of cervical cancer and its preventive measures are low among the women population.

Aim: To assess the level of Knowledge, Attitude, Practice and Acceptability of cervical cancer screening among women in FCT, Abuja.

Materials and methods: A cross-sectional descriptive study design was used and data were collected from respondents using self-administered structured questionnaire. Data were collected from three hundred and fifty-seven (357) respondents whose ages ranged from 20 to 60^{+} years. Data was presented using descriptive statistics of frequency distribution tables and charts, while chi-square was used to determine associations at the <0.05 level of significance **Results:** The result showed that the women had a good knowledge (90.0%) and a positive attitude (90.0%) with a poor practice (44.0%) of cervical cancer screening. The acceptability among the women was reasonably good (60.0%) and the most preventive measure against cervical cancer infection was Human Papilloma Virus vaccination before sexual debut (98.0%, p=0.001), followed by regular PAP smear test (92.0, p=0.003). Fear of diagnosis (p=0.032), embarrassment (p=0.021), financial constraints (p=0.001), stigma (p=0.001) and staff attitude (p=0.036) were the barriers to cervical cancer screening among the study population.

Conclusion: The study revealed that the women had a good knowledge of cervical cancer screening, and positive attitude towards cervical cancer screening. However, a poor practice of cervical cancer screening was observed among the women, therefore, there is need for enlightenment campaign towards increasing the involvement of more women in participating in the cervical cancer screening programmes that will enable and encourage them to participate more in the screening exercises.

Keywords: Cervical cancer, HPV, Attitude, Knowledge, Screening, Women.

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INTRODUCTION

Cancer is a disease characterized by the uncontrolled growth of abnormal cells in the body and these can invade and destroy surrounding healthy tissues, including organs. Moreso, some of the cancers cause visible growths called tumors, while others do not[1]. They can as well spread throughout the body, a process known as metastasis[1]. Genital (gynecologic) cancer is formed when malignant (cancerous) cells develop in the tissue of the reproductive organ. Examples of genital (gynecologic) cancers are cervical, ovarian, uterine, vaginal and vulva. Of all these, only cervical cancer, which is as a result of Human Papilloma Virus (HPV) infection in

99.8% cases, has screening tests that can detect it early when treatment can be effective[9]. It is, however, worthy to note that cancers rarely begin in the vagina. Most often, cancers that begin in other parts of the body spread to the vagina, those that spread to the vagina most commonly begin in the cervix (cervical cancer) or the lining of the uterus (uterine cancer) and this usually develops slowly over time[2] and occurs, when normal cells in the cervix change into cancer cells[3].

Human Papilloma Virus (HPV) infection, which is the most causative agent of cervical cancer is a necessary factor in the development of nearly all cases of cervical cancer and the infection leads to the development of cervical intraepithelial neoplasia and cervical cancer, this spreads through sexual contact. Although most women's bodies can fight the infection, most times the virus leads to the development of cervical cancer[4]. The major risk factor for the development of pre-invasive or invasive cervical carcinoma is infection with the HPV, which is sexually transmitted[5], and can be detected in 99.7% of cervical cancers[6]. Moreover, over 50.0% of sexually active women acquires the virus from 50 years of age[6]. It is the most common malignancies among females worldwide, especially in women of 20–39 years of age. Globally there are over 500,000 new cases of cervical cancer annually and in excess of 270,000 deaths, accounting for 9% of female cancer deaths and 85% of the cases occur in developing countries and in Africa[7] and remained the second leading cause of cancer deaths after breast cancer and the fifth deadliest cancer in women, accounting for approximately 10% of cancer deaths[8]. During persistent HPV infection, precancerous changes may be detected in the cervix. Therefore, early detection and treatment of these changes is an effective strategy for the prevention of cervical cancer and forms the basis of cervical cancer screening programmes[9]. The World Health Organization in 2019 reported that women with many sexual partners, and those whose partners have had many sexual consorts, or have been previously exposed to the virus, are mostly at the risk of developing the disease[10].

In developed countries like Europe and America that have organized national cervical screening programs, early detection and treatment of precancerous cervical lesions have resulted in a dramatic reduction in the incidence of, and mortality from cervical cancer[10]. Pap smear screening can identify potentially precancerous changes. This is a major risk in women today especially those within the age of 20years and above. Awareness of screening programme, vaccination and diet are preventive measures that reduce the incidence of cervical cancer[11].

The prevalence and mortality rates resulting from cervical have declined substantially in Western countries following the introduction of screening programmes. The ideal age of women for screening is 30– 40 years, owing to high risk of precancerous lesions due to high sexual activity[1]. Lack of knowledge concerning cervical cancer screening may be one of the reasons why the incidence has not decreased in developing countries,

despite the fact that the disease, is one of the most preventable of all cancers through primary and secondary prevention using prophylactic Human Papilloma virus (HPV) vaccination and cervical screening [12]. Possible reasons for a low participation in cervical cancer screening include; ignorance of the existence of such test, ignorance of importance of screening, absence of symptoms and lack of awareness of centers where such services are obtainable[13].

According to Rositch et al.[14], health literacy is the ability to read, comprehend medical terminology, understand and act on health information such as medication instructions, appointment slips, and complete health-related forms. Thus, to a large extent, knowledge is correlated with health literacy. The more literate a person is, the more knowledgeable the person will be and the more likely he or she is to gain access to socially privileged positions and thereby gain the capacity and the information to influence thoughts, plans and behaviours[14], although lack of knowledge about cervical cancer is one of the barriers to cervical cancer screening[15]. A study conducted in Indian urban women showed that 16.4% of women were aware of cervical cancer screening[16]. Similar study done in the southern part of the same country revealed that majority of the women (81.9%) have poor knowledge about cervical cancer[17]. Another study in Nigeria on HIV-positive women showed that 56.2% and 34.5% respondents were aware of cervical cancer disease and screening/test[14]. In the southeastern part of the same country, less than 37.5% of the women were aware of cervical cancer; as 30% of them knew that it was preventable; 25% were aware of cervical cancer screening, nevertheless, 20% knew the screening center[18]. While among Gabonese women, only 27.9% had heard about cervical cancer screening[19].

Furthermore, regarding knowledge about cervical cancer screening and perception of risks among women attending outpatient clinic in rural Kenya, out of 419 participants, 327 (78.0%) had heard of cervical cancer screening, 288 (68.7%) women felt at risk for cervical cancer, and 333 (79.5%) stated that they would undergo screening if offered[20], and facility-based study in Ethiopia, Addis Ababa, among women living with HIV indicated that 97 (88.2%) participants believed that the disease is preventable, and 31.4% knew the availability of the screening procedures for the disease[20]. In the same Addis Ababa, a study among reproductive health service clients, said that 478 (91.9%) and 222 (42.7%) women heard about cervical cancer and cervical cancer screening, respectively[19]. In a similar study conducted in Ethiopia, about 71% of participants had ever heard of cervical cancer. Among women who had ever heard of cervical cancer, 49% did not know the cause, while 74% were able to identify at least one risk factor for cervical cancer[21]. In another hospital-based study in Nigeria, report showed that 62.5% of respondents have the willingness to be screened for cervical cancer[18]. Moreso, in Nigeria, among HIV-positive women, 79.8% respondents accepted to take cervical cancer screening[14]. While a study in

Uganda indicated that 63.0% of women reported intention to screen for cervical cancer[21]. A study in Burkina Faso, showed that 96.67% of the women would accept to be screened, and 11.07% were screened for cervical cancer[21] and a study in Addis Ababa from reproductive clients reported that 132 (37.9%) of participants strongly agreed that cervical cancer screening prevents cervical cancer, while 158 (45.4%) were willing to undergo cervical cancer screening[19]; a facility-based study in the same city of Addis Ababa among women living with HIV showed that 62.7% of the study population were willing to screen for cervical cancer, while a quarter (24.8%) of them decided to be screened in the near future[22]. In addition, a study among HIV-positive Nigerian women showed that cost of the test and religious denial were the most common reasons given for refusal to take the test[14]. A number of factors may affect a woman's ability and desire to participate in cervical cancer prevention programmes, and the impact of a woman's decision-making process cannot be ignored [23].

MATERIALS AND METHODS

Research Design

The study adopted a cross-sectional descriptive design; it was adopted for effective data collection and descriptive approach to examine the level of knowledge, attitude, practice and acceptability of cervical cancer screening among women of the Federal Capital Territory, Abuja.

Study Area and Population

Gwagwalada is a Local Government Area in the Federal Capital Territory in Nigeria. It has an area of 1,043km2 and a population of 153,770 at the 2006 census. It is projected to have a 6.26% growth between 2020 and 2025, which is the largest increase on the African continent.

The study population included all women from ages 20 to 60 years and above, because they are at risk of developing cervical cancer since the risk of invasive cervical cancer increases with age. A study of women attending Gynecological Clinic in University of Abuja Teaching Hospital, Primary Health Center Dobi and Town Clinic Gwagwalada, FCT-Abuja.

Inclusion Criteria

The following individuals were included in the study;

- Women aged 20 to 60years and above.
- Female individuals, receiving follow-up medical care for uncomplicated cervical cancer screening at the University of Abuja Teaching hospital's outpatient medical clinics and others
- Individuals who had consented to study participation.

Ethical Clearance

Ethical approval for this study was obtained from the University of Abuja Teaching Hospital Research Ethics Committee via the hospital clinic patron **(UATH/HERC/PR/380).** Permission for Data Collection was sought and granted

from hospital via the Matron and Medical Officer in-charge. Participation in the study was voluntary. Eligible participants were provided with a Participant Information Sheet describing the research, its nature, purpose, and objectives before giving informed consent. Confidentiality was assured throughout the study.

Informed Consent

The purpose of the study was described to the respondents. Both verbal and written consents were obtained from the respondents prior to the interview. The respondents were ensured of the confi-dentiality of information provided.

Sample Size Determination

A suitable sample size of 384 women (from age 20 to 60 years and above) attending the Gynecological clinics in Gwagwalada Area Council was calculated and chosen using $n=Z^2P(1-P)/d^2$ according to [24].

Where: n = the minimum sample size;

Z= statistical standard (1.96);
p = 50% (estimated previous population (0.5) was chosen since no study of this nature has been conducted in that area).;
d= the degree of accuracy or margin of error of 5%(0.05).

Therefore: $n = 1.96^2 \times 0.5 \times 0.5 / 0.05^2$;
n = 384.2 = 384.

Sampling Technique

Simple random sampling technique was used in selection of the participants. The number selected served as a representative of the entire population because each respondent was selected randomly. This enabled us to collect data which was a true representation of the study population in order to generalize the result.

Research Instrument And Administration

The questionnaire was used as the instrument for data collection. The questionnaire consisted of 31 questions with few open-ended questions and a majority of close-ended questions. The questions were constructed in simple English to ensure clarity, unambiguity, neutrality and unimpeded responses as Research assistants helped in interpreting it in Gbagyi, Yoruba, Igbo and Hausa to some persons who could not understand English Language.

Method of Data Collection

The survey was carried out during the day on women attending the Gynecological Clinic in University Teaching Hospital, Gwagwalada, FCT-Abuja, Primary Health Care Dobi and Town Clinic Gwagwalada. The questionnaire was divided into five (5) sections: socio-demographics characteristics, level of awareness, attitude towards cervical cancer screening, practices of cervical cancer screening, and prevention/ barriers to cervical cancer screening.

Data Analysis

Data was presented using descriptive statistics of frequency distribution tables and charts, while chi-square was used to determine associations at the <0.05 level of significance.

Results

Rsesults showed that those within 40-44 years were 144 (40%) and 40 (11%) were between the age-group of 35-39 years. Among the marital status, married women took the highest the highest share of participants of 180 representing 50.0%, while, the least was those in separate group with 4.0%. In the educational status, secondary school participants were the highest with 32.0%, while, those without any educational qualification participated least (Table1). Table 2 showed that 323(90.5%) have the knowledge of cervical cancer, 328(92.0%) have heard about it. 191(53.5%) of the study do not know the predisposing factors of cervical cancer, while, 190(53.2%) do not know the signs and symptoms.

Table 3 showed that there was a positive attitude towards cervical cancer screening among female groups by majority of the respondents, as most of the participants(90.0%) indicated that women should go for screening. Also, Table 4 showed that out of 357 participants, 157 representing 44.0% have practiced or done the screening, while, 200 of them representing 56.0% have not. Table 5 revealed that HPV vaccination before sexual debut (98.0%; p=0.001) is the most effective preventive measure against Cervical cancer.

From Figure 1, it can be deduced that more than half of the respondents 214 (60%) accepted but had never been screened for cervical cancer, while, 143 (40%) never accepted and has never been screened, whereas Figure 2 showed that cervical cancer screening is mostly at child bearing age group

From Table 6 it can be seen that fear of diagnosis (p=0.032); Embarrassment (p=0.021); Financial constraints (p=0.011); Limited availability (p=0.042); Stigma (p=0.001); Staff attitude (p=0.036); and Location (p=0.042) were found to be the significant barriers to cancer screening among the study population.

Table 1: Socio-demographic characteristics of respondents in Gwagwalada Area Council.

Variables	Frequency	Percentage %
Age in Years		
20−24	20	6
25−30	36	10
31−34	53	15
35−39	40	11
40−44	144	40
45−50	18	5
51−54	15	4
55− 59	20	6
60 and above	9	3
Marital Status		
Single	46	13
Co-habiting	18	5
Married	180	50
Divorced	61	17
Separated	15	4
Widowed	37	11
Highest Level of Education		
None	30	8
Primary	57	16
Secondary	115	32
Tertiary	155	44
Employment Status		
Employed	196	55
Unemployed	82	23
Pensioner	61	17
Employee	18	5
Occupation		
Civil/Public Servant	143	40
Business	47	13
Artisan	78	22
Students	28	8
Others	61	17
Working Experience		
None	52	15
≤ 2 years	30	8
3 – 5 years	60	17
6 – 10 years	110	31
11 – 15 years	90	25
16 years and above	15	4
Religion		
Christianity	196	55
Islam	104	29

Others	57	16

Table 2: level of knowledge among women in FCT, Abuja attending Gynecological Clinic in Gwagwalada Area Council **about cervical cancer screening**.

Questions	Yes (%)	No(%)
Knowledge of Cervical cancer?	323(90.5)	34(9.5)
Heard of cervical cancer?	328(92.0)	29(8.0)
Know of the Predisposing factors like?	166(46.5)	191(53.5)
Knowledge of Cervical Cancer signs and symptoms?	167(46.8)	190(53.2)

Table 3: **Level of Attitude of the Women**

Questions	Yes(%)	No(%)
Do you think women should be screened for cervical cancer?	321(90.0)	36(10.0)
Do you think all women across the ages should be screened?	154(43.0)	203(57.0)

Table 4 **Level of Practice of cervical cancer screening among women in FCT, Abuja, attending Gynecological Clinic in UATH, PHC Dobi and Town clinic in Gwagwalada Area Council**

Questions	Yes(%)	No(%)
Have you done the screening before?	157(44.0)	200(56.0)

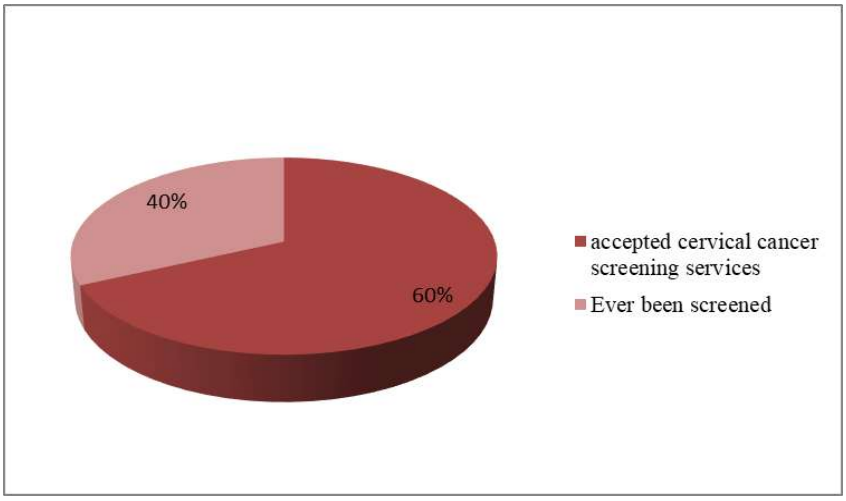

Figure 1 level of acceptability of cervical cancer screening among the study population

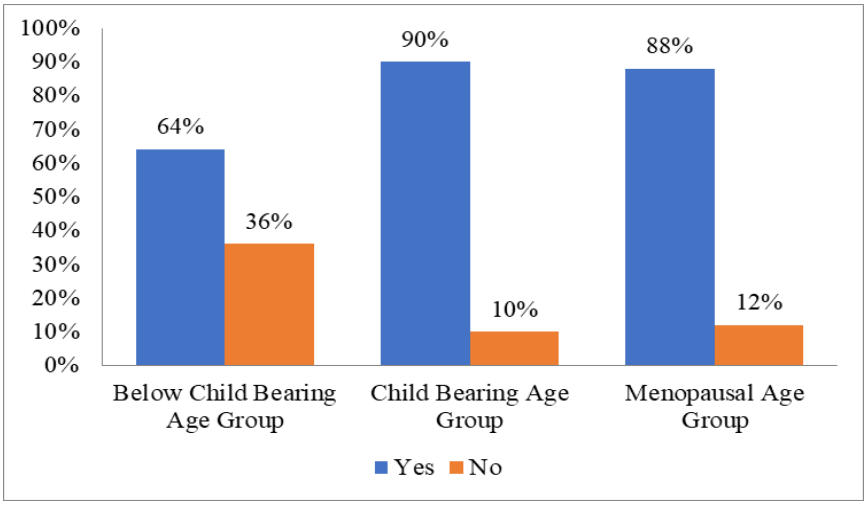

Figure 2. The age at which screening of cervical cancer is most among women attending Gynecological Clinic in Gwagwalada Area Council

Table 5: Preventive Measures Of Cervical Cancer

Questions	Yes(%)	No(%)	X^2	P=value
Is abstinence a preventive measure?	**278(78.0)**	**79(22.0)**	**68.2**	**0.002**
Is condom use a preventive measure?	**271(76.0)**	**86(24.0)**	**71.8**	**0.004**
Is single sexual partner a preventive measure?	**314(88.0)**	**43(12.0)**	**70.5**	**0.018**
Is regular PAP smear test a preventive measure?	**328(92.0)**	**28(8.0)**	**69.3**	**0.003**
Is HPV vaccination before sexual debut a preventive measure?	**350(98.0)**	**7(2.0)**	**66.7**	**0.001**

Table 6: Barriers to Cervical Cancer Screening

Barriers to Cervical Cancer Screening	Yes(%)	No(%)	X^2	P_value
Fear of the Diagnosis	189(53.0)	168(47.0)	43.2	0.032*
Lack of awareness	157(44.0)	200(56.0)	39.0	0.854
Embarrassment	198(55.5)	159(44.5)	52.9	0.021*
Financial constraints	230(64.4)	127(35.6)	44.2	0.011*
Limited availability	185(51.8)	172(48.2)	51.7	0.042*
Stigma	298(83.5)	59(16.5)	64.0	0.001*
Time constraints	148(41.5)	209(58.5)	55.8	0.682
Staff attitude	200(56.0)	157(44.0)	56.7	0.036*
Location	195(54.6)	162(45.4)	51.9	0.042*

DISCUSSION

Cancer of the cervix is a serious burden on the reproductive health of women worldwide, despite the fact that it is preventable. It is the most second common cause of cancer-related deaths among adult women globally. In this survey, the findings revealed that the women under study had good knowledge (90.0%) about cervical cancer[14]. From the study assessment, it was revealed that health literacy enhanced their ability to read and comprehend medical terminology, understand and act on health information such as medication instructions, appointment slips, and complete health-related forms. They noted that higher education is associated with health literacy. Thus, to a large extent, knowledge is correlated with health literacy. The more literate a person is, the more knowledgeable the person will be and the more likely he or she is to gain access to socially privileged positions and thereby gain the capacity and the information to influence thoughts, plans and behaviours. Moreso, some authors have reported that low health literacy correlated with less knowledge about cervical cancer screening[15]. Thus that lack of knowledge about cervical cancer is one of barriers to cervical cancer screening. The participants in this study, when compared with results from other studies on knowledge and awareness, appear to have better knowledge and awareness. For instance, a study in India showed that 16.4% of women were aware of Cervical cancer[16], while a similar study in southern part of the same country revealed that majority of the women (81.9%) had poor knowledge of Cervical cancer[17]. Among Gabonese women, only 27.9% had heard about screening[19]. Several pilot projects in India found that 99.0% of respondents have never been screened despite the massive efforts to implement cytological screening[25]. Many women in Nigeria, remain unaware of cervical cancer screening and have no access to cervical cancer screening services[15] and this is alarming and requires urgent attention.

On the attitude of the women towards cervical cancer screening, the study found out that participants have a positive attitude (90.0%), however, there was poor practice (44.0%) of cervical cancer screening among the women. The acceptability of cervical cancer screening among the women was good (60.0%), though, compared with previous works on knowledge, attitude and practice of cervical cancer screening, it is low. For instance, a hospital-based study in Nigeria showed that 62.5% of respondents had the willingness to be screened for cervical cancer[18] and a similar study conducted in different parts of southern Nigeria, among HIV-positive, 79.8% of the participants accepted to take cervical cancer screening[14], while a study in Uganda indicated that 63.0% of women had the intention to be screened for cervical cancer screening [21]. In Burkina Faso, 96.6% of the women would accept to be screened and 11.07% were screened for cervical cancer [21].

Furthermore, on the age at which acceptability of cervical cancer screening is

most, the result of the study, most of the participants in this study agreed that cervical cancer screening should be mostly at child-bearing age group (90.0%), while some accept that is should be in menopausal age group (88.0%) and below child-bearing age-group (64.0). This finding agrees with the age range of 20-45 years according postulated by earlier authors[11], [1], who posited that the ideal ages of women for screening are 30-40 years owing to high risk of precancerous lesions due to being sexually active. At this stage, a precancerous lesion is detectable for 10 years or more before cancer develops. Most likely, cervical cancer develops when the women are 60 years of age[9]. This buttressed the statement that cervical cancer is not a disease of old age, the majority of its victims are women who are at the peak of their biological and economically productive stages of life[26]. It is well known that Human Papilloma Virus (HPV) infection is a necessary factor in development of nearly all cases of Cervical cancer. A sexually transmitted HPV infection leads to the development of cervical intraepithelial neoplasia and cervical cancer, and HPV is spread through sexual contact, although, most women's bodies can fight the infection, sometimes the virus leads to the development of cervical cancer [4].

On the barriers to effective cervical cancer screening, the study revealed fear of diagnosis, Embarrassment, Financial constraints, Limited availability, Stigma, Staff attitude and Location as the barriers to cancer screening among the study population. This is in accordance with the results of similar previous study[27] which reported that the barriers, for example, high cost, anxiety borne by women, fear, as well as, the work of Malagon et al.,[28] who posited that disadvantaged ethnic minorities and women living in poverty in affluent countries and the poorest women in poor countries are also challenges to cervical cancer screening. Other possible reasons for a low participation in cervical cancer screening according to[13] are ignorance of the existence of such test, ignorance of the importance of screening or lack of risk awareness and the risk factors to the development of cervical cancer, absence of symptoms and lack of awareness of centers where such services are obtained, in addition to lack of motivations. Moreover, other challenges to the cervical cancer screening and treatment are similar to those for other health interventions and competing health needs, lack of political will, access to services, under developed healthcare structures, equipment and human resources, long ques and waiting times[15]. These barriers could be lifted if health service delivery will be improved, for instance, through quality improvement of techniques that are available at low cost. Women's anxiety over test results still needs to be further assessed to work out risk communication strategies that take into account broader educational frameworks[29]. It is also to be noted that such strategies should infuse the way health services are provided for cervical cancer prevention regardless of the specific test used. Bingham and colleagues concluded that a key step to achieving optimal coverage is to gain broad community support. Developing Communication strategies for raising

knowledge about services and encouraging participation can have a positive influence on acceptability[29].

The study established that the most preventive measure to cervical cancer infection was Human Papilloma Virus vaccination before sexual debut, followed by regular PAP smear test. This revelation supports the suggestion that during persistent HPV infection, precancerous changes may be detected in the cervix, that those changes are readily detectable and occur in the cells lining the surface of the cervix, therefore, early detection and treatment of these changes is an effective strategy for the prevention of cervical cancer, and form the bases of cervical cancer screening programmes[9]. PAP smear screening can identify potentially precancerous changes[11]. Also, women with many sexual partners and those whose partners have had many sexual consorts, or have previously been exposed to the virus were most at risk of developing the disease[10].

Limitations

The study targeted only women of 20 years and above which was difficult to capture as some women who were going to the clinic were younger than 20 years.The study targeted only women attending Gynecological Clinic in UATH, Gwagwalada, the PHC Dobi and Town Clinic Gwagwalada, all in Gwagwalada Area Council, FCT, Abuja but the health workers point of view was not considered. Moreover, the study sample was small, therefore findings may not be generalizeable to the larger population of Nigeria.

CONCLUSION

In conclusion, the study has revealed that the study population has good knowledge of cervical cancer screening, and positive attitude towards cervical cancer screening. The study, however, observed a poor practice of cervical cancer screening among the women. There was a reasonable acceptability of cervical cancer screening services. Also, the most accepted preventive measure against cervical cancer was HPV vaccination before sexual debut. Fear of diagnosis, embarrassment, financial constraints, stigma, and staff attitude were the barriers to effective cervical cancer screening.

Declaration of conflict of interest

No conflict of interest among the authors

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ARTIFICIAL INTELLIGENCE IN NIGERIAN PHYSIOTHERAPY: EXPLORING IMPLEMENTATION CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Background: Artificial intelligence (AI) has emerged as a transformative tool in healthcare, with growing relevance in physiotherapy for improving assessment, diagnosis, and treatment planning. However, the integration of AI into clinical practice, particularly in low-resource settings such as Anambra State, Nigeria, faces numerous challenges.

Aim: To identify the facilitators and barriers of AI applications in physiotherapy practices in Anambra state.

Materials and methods: This study was a cross-sectional which used a convenience sampling technique to recruit 60 physiotherapists residing and/or working in Anambra State's health facilities. Data were collected using a self-structured questionnaire and analysed using descriptive statistics.

Results: Most participants (53.3%) were female, within the age group of 30–39 years. Most participants (88.0%) indicated that they had never used AI during treatment. Approximately 53.3% identified social media as the platform where they sourced information about the application of AI in physiotherapy, and 98.3% indicated that the application of AI cannot replace physiotherapists. Wearable devices were identified as the most impactful AI tool. The inability of AI to manage all patients' health conditions or impairments, cost of AI equipment and treatment, and acceptance and adoption of AI technologies were identified as the major barriers.

Conclusions: The findings indicated limited application of AI among physiotherapists, despite the potential for improvement through various supportive measures. Factors such as funding availability, training programs, and access to AI-powered platforms can significantly enhance the integration of AI in healthcare practices.

Keywords: Facilitators, Barriers, Artificial Intelligence, Physiotherapy, Healthcare Technology

INTRODUCTION

Recent advances in health technology have positively impacted various economic sectors, especially the healthcare industry. These advancements provide solutions that ensure the expansion and interchange of medical knowledge and information, and ensure long-term health results.[1,2] Digital health technologies, such as wearable devices, computerized decision support systems, and telemedicine, improve the technical performance and satisfaction of healthcare employees, decrease direct and indirect costs of medical services, and enhance the quality of care.[3]

Artificial intelligence (AI), a major field in computer science, can enhance the healthcare system via novel delivery strategies, informed decision-making, and facilitation of patient engagement. AI can forecast outcomes and automate decision-making. The features of this technological breakthrough impact all facets of society,

potentially disrupting socioeconomic, health, legal, and moral institutions, ultimately contributing to the advancement of humanity.[4] AI technologies, including machine learning, neural networks, and deep learning, are increasingly playing a role in many health-related practices.[5] Many healthcare professionals use these technologies in clinical decision-making, diagnosis, and patient management.[6–8]

Restoring physical strength and function is the main goal of physical therapy; however, physiotherapy interventions can take many different forms, including multi- or single-component programs, hospital- or community-based, clinician-led or self-directed. Physical therapy is readily available; however, its use is often underutilized, and compliance rates are low globally.[9] One of the physical therapists' responsibilities is to conduct physical rehabilitation assessment and design appropriate clinical plans of care for patients with physical disorders.[10] This initial process depends on the experience of the physiotherapists, and the time constraints or limited availability of the human workforce can make it challenging. Hence, there is a need for advanced technologies such as AI-based applications.

The primary applications of AI in physiotherapy and rehabilitation include risk analysis, virtual assistants, dexterous robotics, video analysis, and predictive algorithms.[8] These approaches can improve data analysis and implementation, classification of functions, and disability predictions.

Furthermore, in physiotherapy practices, AI systems can be used to train patients and monitor their progress, using either virtual (informatics) or physical (robotics) AI concepts.[10] Moreover, a study showed the effectiveness of a virtual physiotherapy system in improving the balance and mobility of patients with Parkinson's disease remotely.[11] AI technology has a high accuracy level in remote training and patient management processes. Moreover, AI can monitor and enhance patient adherence to therapeutic exercises for musculoskeletal issues, such as neck or back pain. Similarly, a study found that using AI-enabled mobile applications with patients who had neck and back pain was beneficial in increasing therapeutic exercise adherence.[12]

Additionally, research into supervised machine learning has also examined whether AI-enabled devices can monitor patients' compliance with home exercises. However, there are still challenges in using AI in medicine, including ethical considerations, issues with technology trust, a lack of knowledge and expertise among medical practitioners, and maintenance costs.[13] Therefore, this study aimed to ascertain the facilitators and barriers of artificial intelligence applications in physiotherapy practices in Anambra State.

MATERIAL AND METHODS

Research design and Population

This was a cross-sectional study, involving a population of 90 physiotherapists residing and/or working in selected healthcare facilities in Anambra State who have at least one year of experience. A consecutive sampling technique was used to recruit

participants. The physiotherapists were recruited from the following health facilities: Nnamdi Azikiwe University Teaching Hospital; Landmark Physiotherapy Services, Nnewi; General Hospital Ekwulobia; Chukwuemeka Odumegwu University Teaching Hospital, Amaku; General Hospital Enugwu-Ukwu; and Federal Medical Centre, Onitsha.

Inclusion criteria

1. Licensed physiotherapists with at least one year of experience.
2. Physiotherapists who reside and/or work in Anambra state.
3. Physiotherapists who were willing to participate in the study.
4. Physiotherapists with slight knowledge of artificial intelligence applications in physiotherapy practices.

Research instrument

A structured self-administered questionnaire was designed to assess the facilitators of and barriers to AI applications in physiotherapy practices. It was a 21-item questionnaire categorized into four sections. Section A assessed the socio-demographic profile of the participants. Section B determined the application of AI in physiotherapy practice. Section C assessed the facilitators of AI in physiotherapy practice. Section D ascertained AI in physiotherapy practice.

Data collection

Ethical approval was sought and obtained from the Ethical Review Committee of the Nnamdi Azikiwe University Teaching Hospital, Nnewi, before the commencement of the study (Ethical approval number: FHST/REC/024/890). Six research assistants were recruited and trained to administer the questionnaire, and the completed questionnaires were collected afterward.

Data analysis

Descriptive statistics were used to summarize participants' demographic characteristics and responses. Frequencies and percentages were computed for categorical variables such as gender, work setting, awareness and use of AI, and perceptions of facilitators and barriers to AI adoption in physiotherapy. Cross-tabulations were performed to observe trends and potential associations between demographic characteristics (years of experience and gender) and AI usage or perceptions. Statistical significance was set at $p < 0.05$.

RESULTS

Socio-demographic characteristics of the participants

Sixty physiotherapists participated in this study. Approximately 53.3% were female. Most participants were within the age group of 30–39 years, accounting for 46.7%. Additionally, 35% had less than 3 years of experience. Most participants (80.0%) held a bachelor's degree as their highest educational qualification, and 55% were classified as junior physiotherapists (Table 1).

Application of AI in Physiotherapy

This study revealed that most participants (88.0%) had never used AI during treatment (Fig. 1). Approximately 53.3% identified social media as the platform where they sourced information about the application of AI in physiotherapy (Fig. 2). More than half of the participants (58.3%) indicated that the most important essence of AI in physiotherapy practice was providing a thorough assessment (Fig. 3). Most participants (65.0%) revealed that the area of physiotherapy that AI would be more useful was neurology (Fig. 4). Furthermore, 98.3% of the participants indicated that AI cannot replace physiotherapists (Fig. 5). Additionally, most participants (63.3%) indicated that wearable devices, an artificial intelligence tool, would have the best impact on patients (Fig. 6).

Facilitators of AI applications in physiotherapy practices

This study revealed that approximately 83.3% of the participants affirmed that workshops, seminars, and training programs are needed to educate physiotherapists on AI technologies to enhance their integration. Additionally, 76.7% affirmed that reliable internet access and an AI-powered software platform are essential for AI-based physiotherapy. Similarly, most participants (68.3%) concurred that AI-based tools that provide treatment plans and patient monitoring would encourage physiotherapists to adopt them. Additionally, most participants (70.0%) concurred that creating awareness about the benefits of AI for improving patient outcomes can facilitate broader acceptance among practitioners and patients. Additionally, the study showed that most participants (86.6%) stated that the availability of funding from private and public sources could enhance the use of AI in physiotherapy practice (Table 2).

Barriers of AI applications in physiotherapy practices

Most participants indicated that the inability of AI to manage all patients' health conditions or impairments (93.3%) and the cost of AI equipment and treatment (86.7%) were barriers to AI applications in physiotherapy practice. Also, the acceptance and adoption of AI technologies by patients and physiotherapists (83.3%) and insufficient knowledge and skills (98.4%) were identified as barriers to AI applications in physiotherapy practice. Also, approximately 51.7% of the participants neither agreed nor disagreed that limited therapist-patient interaction was a barrier to AI applications in physiotherapy practice (Table 3).

Table 1. Socio-demographics characteristics of the participants

Variable	Class	Frequency	Percentage
Gender	Male	28	46.7
	Female	32	53.3
Age group	<29 years	19	31.7
	30–39 years	28	46.7
	40–49 years	11	18.3
	>50 years	2	3.3
Years of experience	< 3 years	21	35.0
	3–6 years	20	33.3
	7–10 years	8	13.3
	>10 years	11	18.3
Highest level in physiotherapy practice	Junior physiotherapist	33	55.0
	Senior physiotherapist	11	18.3
	Principal physiotherapist	7	11.7
	Chief physiotherapist	8	13.3
	Physiotherapists	1	1.7
Highest level of education	B.Sc	48	80.0
	M.Sc	10	16.7
	PhD	2	3.3

Table 2. Facilitators of AI applications in physiotherapy practices

Items	Strongly Disagree (n)	%	Disagree (n)	%	Neutral (n)	%	Agree (n)	%	Strongly Agree (n)	%
Workshop, seminars and training programs to educate physiotherapists on AI technologies to enhance its integration.	1	1.7	1	1.7	8	13.3	23	38.3	27	45.0
Reliable internet access and AI powered software platforms are essential for AI based physiotherapy.	1	1.7	1	1.7	12	20.0	27	45.0	19	31.7
AI based tools that provide treatment plans and patient monitoring will encourage physiotherapists to adopt them.	1	1.7	18	30.0	0	0	26	43.3	15	25.0
Creating awareness about the benefits of AI for improving patient outcomes can facilitate broader acceptance among practitioners and patients alike.	1	1.7	0	0	17	28.3	27	45.0	15	25.0
Availability of funding from private and public sources can enhance the use of AI in physiotherapy practice	1	1.7	0	0	7	11.7	26	43.3	26	43.3

AI, Artificial Intelligence

Table 3. Barriers of AI applications in physiotherapy practices

Items	Strongly Disagree (n)	%	Disagree (n)	%	Neutral (n)	%	Agree (n)	%	Strongly Agree (n)	%
Inability of AI to manage all patients' health conditions or impairments.	1	1.7	0	0	3	5.0	21	35.0	35	58.3
Cost of the AI equipment and treatment	1	1.7	2	3.3	5	8.3	28	46.7	24	40.0
Acceptance and adoption of AI technologies by both patients and physiotherapist	0	0	0	0	10	16.7	33	55.0	17	28.3
Insufficient knowledge and skills	0	0	0	0	1	1.7	19	31.7	40	66.7
Limited therapist-patient interaction	1	1.7	13	21.7	31	51.7	15	25.0	15	25.0

AI, Artificial Intelligence

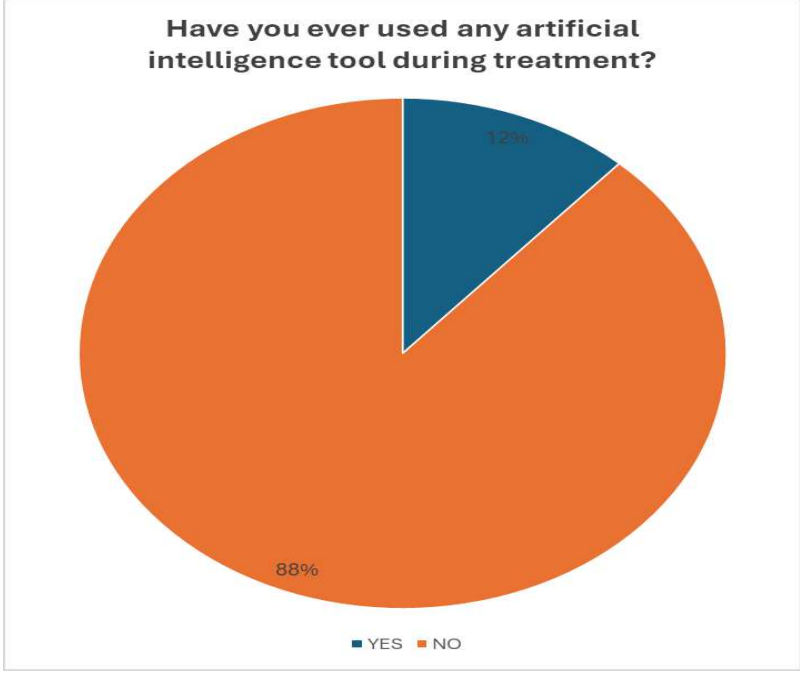

Figure 1. Have you ever used any artificial intelligence tools during treatment?

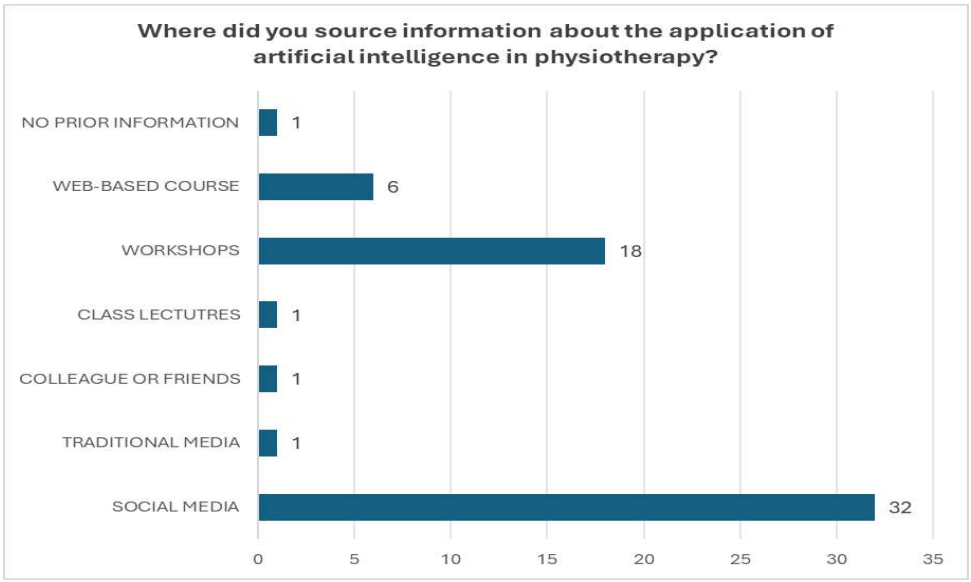

Figure 2. Where did you source information about applying artificial intelligence in physiotherapy?

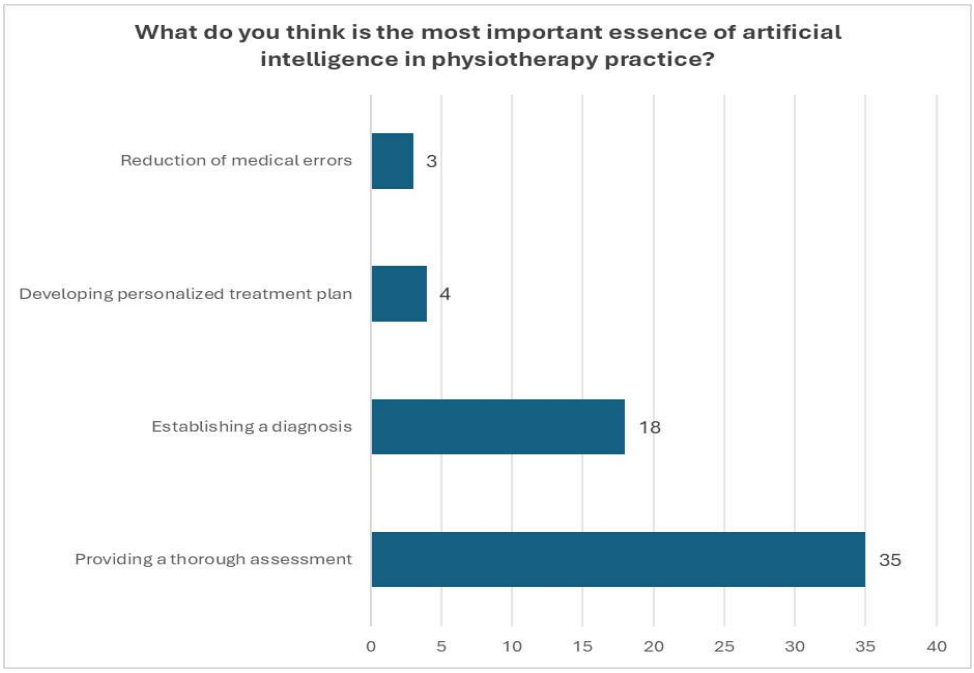

Figure 3. What do you think is the most important essence of artificial intelligence in physiotherapy practice.

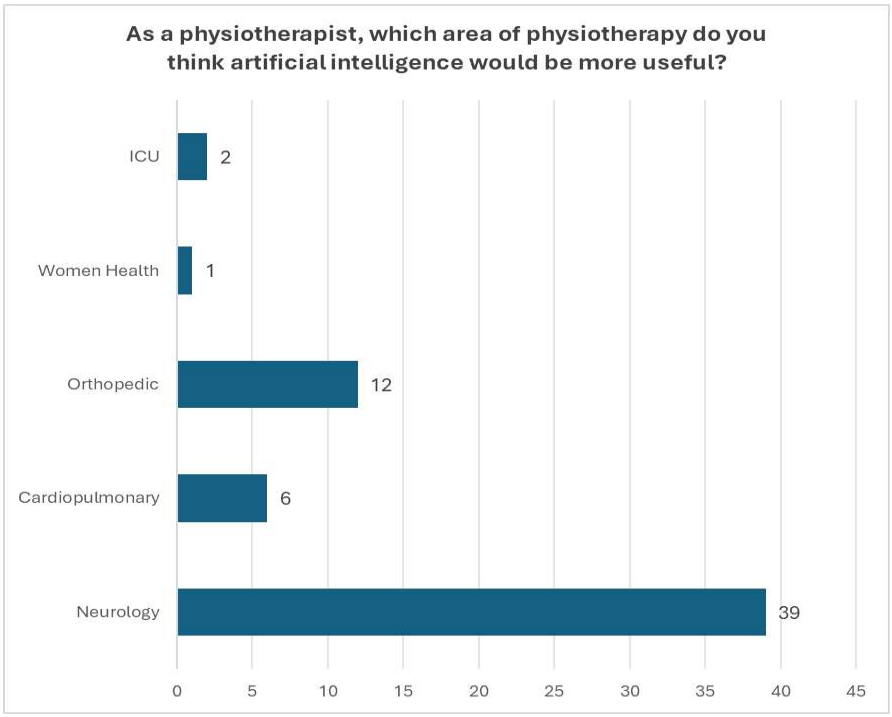

Figure 4. Opinions on Usefulness of artificial intelligence in physiotherapy practice

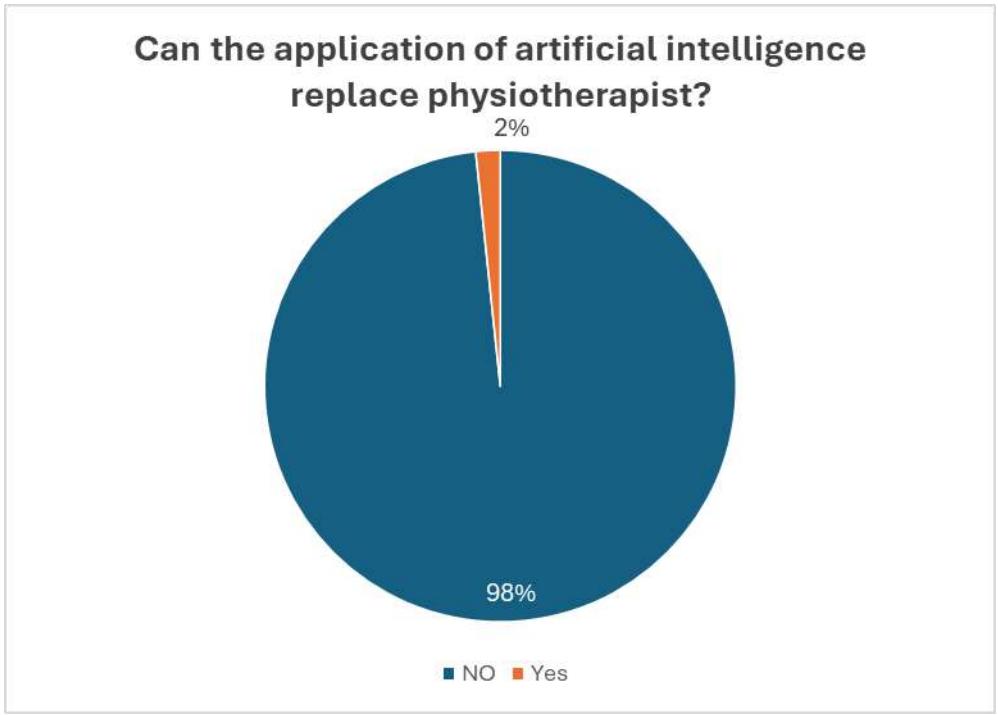

Figure 5. Can the application of artificial intelligence replace physiotherapist?

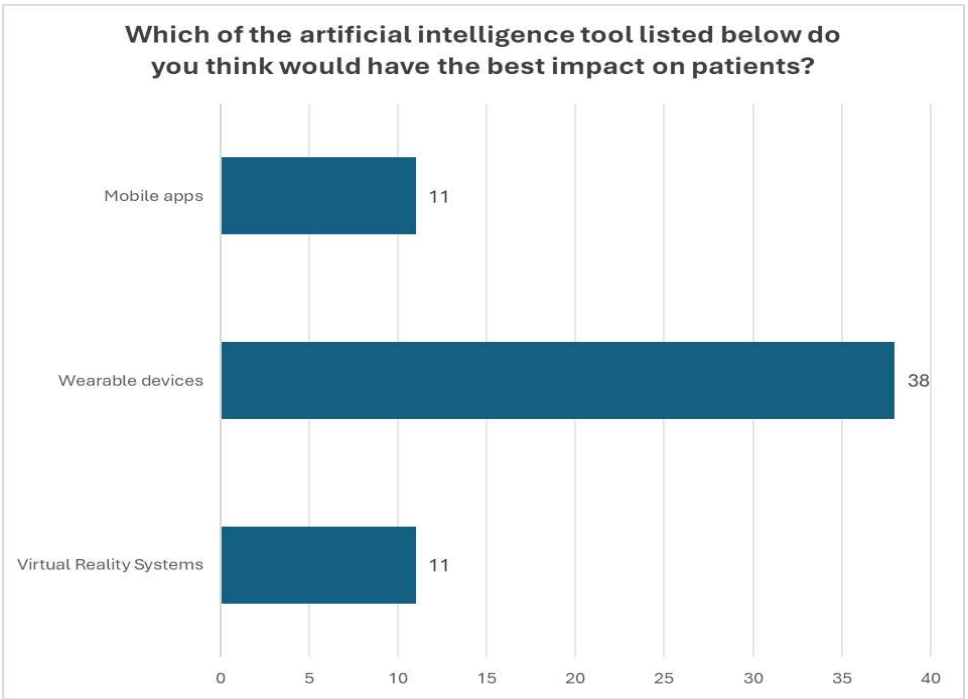

Figure 6. Which of the artificial intelligence tools listed do you think would have the best impact on patients?

DISCUSSION

The use of AI in healthcare, including physiotherapy, has rapidly increased recently owing to advancements in machine learning, wearable devices, and data analytics. AI can revolutionize physiotherapy by improving diagnostic accuracy, optimizing treatment plans, and enhancing patient outcomes. However, integrating AI into clinical practice is not without challenges. This study aimed to assess AI application in physiotherapy practices in Anambra State, Nigeria, specifically identifying the facilitators and barriers. By analyzing the perceptions and experiences of 60 physiotherapists, this study aims to provide valuable insights into the factors that influence the integration of AI in physiotherapy and its potential to improve clinical practices.

This study comprised 60 participants, with more than half of the participants being females and a modal age group of 30–39 years. The demographic profile of the participants is crucial for understanding their potential openness and exposure to AI. Most participants held a bachelor's degree, and more than half of the participants were junior physiotherapists with less than 3 years of experience. These findings align with the

growing trend of young, educated professionals entering the healthcare workforce, which is often associated with higher adaptability to new technologies.[14] However, the relatively low years of experience may also limit the depth of their exposure to AI technologies, as their practices are still in the early stages of professional development. The younger age group (30–39 years) suggests that these physiotherapists may be more technologically savvy and open to AI adoption, as they are generally more accustomed to digital tools and technologies in their personal and professional lives.[3] However, their limited experience in the field could also hinder their ability to fully appreciate the potential benefits of AI if they have not encountered advanced AI-based tools in their practices. This demographic context is consistent with findings from studies in other countries, where younger physiotherapists exhibit a greater willingness to embrace AI, though they still face barriers such as a lack of training and resources.[15–16]

This study found that most participants had never used AI tools during treatment. This suggests that despite the growing awareness of AI technologies globally, their adoption in physiotherapy practices in Anambra State remains limited. Several factors may contribute to this lack of application. One possibility is the relative novelty of AI in physiotherapy. While AI has been used in areas like diagnostic imaging and rehabilitation in other parts of the world,[16] it has not become a mainstream tool in physiotherapy, particularly in regions with limited access to cutting-edge technology.

Similarly, a study conducted in Turkey found that AI in physiotherapy was underutilized,[17] primarily owing to limited awareness and the cost of AI-based equipment. This is likely the case in Anambra State, where the infrastructure for AI adoption is still developing. Furthermore, the limited availability of specialized AI training for physiotherapists could explain why few participants have used AI tools. This highlights a gap in education and professional development, which could be addressed through workshops, seminars, and other forms of continuous education.

Regarding information sources, more than half of the participants indicated that social media was the primary platform for learning about AI in physiotherapy. This finding underscores the role of social media as a key knowledge dissemination tool, especially in regions where access to formal educational resources may be limited.[15] While social media is a valuable resource for initial awareness, it also carries risks of misinformation or incomplete knowledge. Therefore, the need for structured, reliable, and accredited training programs for physiotherapists is crucial to bridge this gap.

This study found that more than half of the participants viewed the primary benefit of AI in physiotherapy as its ability to provide thorough assessments. This finding is consistent with previous research that highlights AI's capacity to analyze large volumes of data quickly and accurately, facilitating better-informed clinical decisions.[18,19] AI tools, such as those used in neurology and rehabilitation, can help physiotherapists identify subtle changes in patient progress that may be overlooked in

traditional assessments. Most participants who identified neurology as the most promising area for AI use reflect the growing trend of AI applications in complex fields like neurological rehabilitation, where detailed monitoring and analysis are crucial for effective treatment planning.[20]

Furthermore, majority of the participants agreed that AI cannot replace physiotherapists, a sentiment that aligns with broader global perceptions of AI in healthcare. AI is a complementary tool that enhances the physiotherapist's capabilities rather than replacing human expertise. Some studies have similarly reported that AI in physiotherapy is expected to support, rather than supplant, human practitioners, emphasizing the importance of maintaining the human element in patient care.[3,20]

Several facilitators were identified as essential for integrating AI into physiotherapy. This study found that most participants affirmed that workshops, seminars, and training programs were critical for AI integration. This finding is supported by a study that reported that training and education are central to overcoming resistance to new technologies in healthcare.[14] In Switzerland, educational initiatives aimed at teaching healthcare professionals about AI have successful increased adoption rates.[19] Therefore, investing in educational programs for physiotherapists in Anambra State could significantly boost AI integration.

Additionally, most participants agreed that reliable internet access and AI-powered software platforms are crucial for implementing AI-based physiotherapy. This is consistent with findings from a study in the Netherlands, where the adoption of AI was contingent on the availability of robust digital infrastructure.[16] Limited internet access and inadequate technological infrastructure can pose significant barriers to AI adoption in low-resource settings, which is likely a challenge in Anambra State. AI tools that offer treatment plans and patient monitoring were also seen as facilitators by majority of the participants. This is consistent with the increasing use of AI-driven rehabilitation tools in countries like Singapore and Switzerland, where such tools help monitor patient progress and adjust treatment protocols accordingly.[19,20] Integrating AI into patient care workflows can improve efficiency and patient outcomes, and this potential is recognized by physiotherapists in Anambra State.

Moreover, in this study, most participants believed that creating awareness about AI's benefits would facilitate broader acceptance. This finding echoes the sentiment in other countries, where awareness campaigns have been crucial in increasing understanding of AI's potential in healthcare.[18] Awareness-raising efforts that highlight AI's positive impact on patient outcomes and treatment efficacy could be key to overcoming resistance to its adoption in physiotherapy.

Several barriers to AI adoption were identified, including the inability of AI to manage all health conditions, the high cost of AI equipment and treatments, and the insufficient knowledge and skills among physiotherapists. These barriers are consistent with those found in other regions. A study conducted in Saudi Arabia identified high costs and a lack of training as significant barriers to AI adoption in

physiotherapy.[15] The inability of AI to fully replace human expertise in complex cases also reflects a global concern regarding its limitations in meeting the diverse needs of patients.[16]

The cost of AI tools was highlighted by most participants in this study. This is a significant concern, particularly in low-income regions where the financial resources for acquiring advanced technologies may be limited. A study conducted in Turkey similarly highlighted the financial barriers to AI integration, suggesting that without sufficient funding, AI adoption may be constrained.[17]

Moreover, most participants in this study identified the lack of acceptance and adoption of AI among patients and physiotherapists as a barrier. This is a common challenge globally, as healthcare providers and patients often show resistance to new technologies, particularly those perceived as complex or intimidating. This finding mirrors studies conducted in Norway and Saudi Arabia, where attitudes toward AI were initially skeptical but gradually improved with increased exposure and training.[15,21]

Notably, limited therapist–patient interaction was not seen as a significant barrier, suggesting that participants in Anambra State may view AI as a tool that can enhance, rather than replace, interpersonal interactions. This contrasts with some international studies that have raised concerns about the potential loss of human touch in healthcare when AI is overly relied upon.[18]

The findings in Anambra State may indicate a more balanced view, where AI is seen as a supportive adjunct to traditional physiotherapy practices rather than a replacement for the essential human touch in patient care. This perspective aligns with global trends emphasizing the complementary role of AI in enhancing the capabilities of healthcare professionals while preserving the critical interpersonal aspects of treatment. Studies conducted in Australia and Denmark highlight that AI can streamline clinical processes, such as diagnostics and monitoring, without diminishing the value of direct therapist–patient interactions.[3,18] Such a balanced perspective may stem from the participants' acknowledgment of the limitations of AI, including its inability to address the full spectrum of human health conditions or replicate the empathy and adaptability of human physiotherapists. This underscores the importance of positioning AI to augment clinical decision-making and treatment efficacy while reinforcing, rather than substituting, the human element in care.

This study had some limitations. First, the sample size of 60 physiotherapists limits the generalizability of the findings to the broader population of physiotherapists. Additionally, using a convenience sampling technique may have introduced selection bias, as only those who were readily available and willing to participate were included. The reliance on self-reported data through questionnaires poses the risk of response bias, which may affect the accuracy of the responses. Furthermore, the study focused primarily on general perceptions of AI without evaluating

specific AI tools or their practical application in clinical settings, thereby limiting the depth of insight into implementation challenges. The cross-sectional design of the study also restricts the ability to establish causal relationships between the identified factors.

CONCLUSION

This study explored the facilitators and barriers to the application of AI in physiotherapy practices in Anambra State. The findings revealed limited utilization of AI tools among physiotherapists, despite a general awareness of their potential benefits in enhancing clinical assessment, treatment planning, and patient monitoring. Key facilitators identified include the need for training programs, reliable internet access, availability of AI-powered platforms, increased awareness, and adequate funding. However, significant barriers such as insufficient knowledge and skills, high costs, limited infrastructure, and concerns about AI's ability to handle complex health conditions hinder widespread adoption. While physiotherapists generally do not view AI as a replacement for human practitioners, they acknowledge its potential to complement and enhance physiotherapy services. Addressing these barriers through strategic investment in education, infrastructure, and policy support is essential for the successful integration of AI in physiotherapy practice.

Competing interests

The authors declare no competing interests.

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QUALITY OF LIFE AND PHYSICAL ACTIVITY AMONG LOWER LIMB AMPUTEES VISITING PHYSICAL REHABILITATION CENTRE, UNIVERSITY OF MAIDUGURI TEACHING HOSPITAL, NIGERIA

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ABSTRACT

Background: Lower limb amputees usually have reduced mobility which affects their capacity to carry out daily tasks and physical activity which greatly affects their quality of life (QoL).

Aim: This study determined the QoL, physical activity and their associations with demographic and clinical factors of lower limb amputees at University of Maiduguri Teaching Hospital.

Methods: This was a **c**ross-sectional survey involving fifty amputees recruited through a convenience sampling technique. Quality of life was assessed using the WHOQOL-Bref (Hausa version) while physical activity (PA) was assessed using the International Physical Activity Questionnaire (IPAQ)-short form (Hausa version). Socio-demographic information of age, gender, level of education, and clinical factors such as cause of amputation, level of amputation and time since amputation were also obtained. Data were analysed by descriptive statistics and inferential statistics of Chi-square (χ^2) test. Statistical significance was set at $p<0.05$.

Results: Quality of life was higher in the "psychological" domain (67.88±13.52), relatively lower in the "social" domain of QoL (59.00±17.30). It shows (30%) low physical activity (570.24±555.69 MET-min/week), a high percentage (56%) of moderate physical activity level (649.60±884.61 MET-min/week) and (14%) vigorous physical activity (685.60±1868.24 MET-min/week) among the amputees. Significant associations between physical domain and age ($p<0.05$), psychological domain and level of education ($p<0.05$), environmental domain and cause of amputation ($p<0.05$) were observed. No significant associations ($p>0.05$) were found between the QoL domains with either gender, level of amputation and time since amputation. There was a significant association between physical activity levels with age and time including amputation ($p<0.05$) respectively.

Conclusion: There was a moderate physical activity level among lower limb amputees, with quality of life higher in the psychological domain which significantly associated with age, level of education and cause of amputation. Benefits of physical activity to the amputees at both the preoperative and postoperative phases of rehabilitation should be disseminated by healthcare professionals to enhance overall quality of lining.

Keywords: Quality of Life, Physical activity, Lower limb, Amputation, Physical Rehabilitation Centre, Northeastern Nigeria.

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INTRODUCTION

Amputation is among the leading causes of irreversible disability often associated with anxiety, isolation, and depression, with changes in societal and leisure time activities of an individual with lower limb amputation[1]. Amputation is the total or partial loss of a part or whole limb either surgically or traumatically[2]. It can be as the result of various conditions which are either congenital or acquired, due to diseases such as, tumours, circulatory disorders, trauma,

accidents, metabolic disease and infection[3]. Amputation of a limb is the last-resort decision for the surgeon and the patient when the limb is injured beyond salvage, or severely diseased and painful, functionless, and constitutes a nuisance to the patient[4]. Lower limb amputees usually have decrease mobility which affects their capacity to carry out daily tasks and to efficiently integrate into community life[5]. Lower limb amputation may be unilateral (involving a single limb) or bilateral (involving both of the limbs) and can be performed at a minor or major level[6]. In developed countries, peripheral vascular disorder is the most common cause for lower limb amputations, while in developing countries diabetic foot and trauma are the leading causes[7]. Although, trauma and crush injuries as a result of road traffic accidents predominate in Nigeria and account for about 50% of all amputations, complications of diabetes mellitus accounts for about 38% of the cases[3]. Overall, the estimated prevalence of lower limb amputation in Nigeria is 1.6 per 100,000 populations[6].

Quality of life (QoL) of amputees may be reduced due to limitations posed by body function and structure as a result of the amputation which hinders the activity and participation level. It has been recognized as an important outcome of rehabilitation programs and also as an indicator to assess adjustment to prosthesis[8]. According to Migaou *et al.*[9], time since amputation and family income status are some factors that affect the quality of life of an individual with lower limb amputation. Moreover, amputees' QoL tends to decline regardless of the cause of their amputation due to the physical changes immediately after amputation as well as the long-term implications in varied aspect of life[10].

An important aspect of rehabilitation following limb loss is assisting individuals to engage in regular physical activity for physical, psychological, and social health benefits[11]. Individuals with lower limb amputation generally have decreased mobility which influences their capacity to carry out daily responsibilities and to efficiently integrate into community life[5]. Carvalho *et al.*[12] and Lessa *et al.*[13] revealed that the prevalent outcomes of amputation in Brazil consist of functional impairment, psychiatric disturbances and occupational absence, with reduction in QoL. Some studies have found that many individuals with lower limb amputation undertake low levels of physical activity[14,15] and that individuals with lower limb amputation are less active than individuals without lower limb amputation[16].

Melo *et al.*,[17] found that the QoL and physical activity among adults and elderly individuals with lower limb amputation were lower. A study in Nigeria by Adegoke et al.,[3] found the QoL of Nigerians with lower limb amputation was moderate[3]. Another study on quality of life among lower limb amputees in Sweden reported that lower limb amputees had lower QoL compared to a group without amputation, and also indicated that higher perception of community inclusion and higher self-associated gait ability improved quality of life[18].

There appears to be a paucity of studies which investigated QoL and physical activity among lower limb amputees

undergoing physical rehabilitation in Maiduguri, Northeastern Nigeria. Consequently, this study will provide insights into the physical activity levels and QoL among amputees in Maiduguri. It will also inform the development of tailored rehabilitation programs that address the specific needs of amputees in Maiduguri, enhancing their physical activity levels and overall QoL. Therefore, the present study explored the QoL and physical activity among lower limb amputees attending physical rehabilitation centre, University of Maiduguri Teaching Hospital, Northeastern Nigeria.

METHODS

Study design and sampling technique

The study was a cross-sectional survey in which a convenience sampling technique was used to recruit participants for the study.

Study procedures

Ethical approval for this study was sought and obtained from the Research and Ethical committee of the University of Maiduguri Teaching Hospital (UMTH) number UMTH/REC/22/957. A written informed consent was sought and obtained before the commencement of the study. World Health Organisation Quality of Life Brief Version (WHOQOL-BREF) and International Physical Activity Questionnaire (IPAQ) questionnaires were administered on the participants who met the inclusion criteria, and explanations was given to participants where necessary in filling the questionnaires. Socio-demographic form was used to elicit information of their age, gender, level of education, cause of amputation, level of amputation and time since amputation. Period of study was between February to April 2022.

Study Participants

The participants of this study were lower limb amputees visiting the physical rehabilitation centre in UMTH.

Inclusion criteria: Male and female lower limb amputees visiting the physical rehabilitation centre in UMTH, age range of 15-65 years, unilateral or bilateral lower limb amputees.

Exclusion criteria: Individuals with both upper and lower limb amputation, amputees with hearing or vision impairment, amputees who are already fitted with prosthesis.

Outcome measures

The primary outcome measures for the study were QoL assessed using the WHOQOL-BREF questionnaire and level of physical activity assessed using the IPAQ.

Data collection instruments

Consent for was read and signed by each participant before the commencement of the research. Socio-demographic form was used to collect demographic and clinical information from the participants which include age, gender, level of education, cause of amputation, level of amputation and time since amputation. WHO Quality of life (WHOQOL-BREF) questionnaire Hausa version was used to assess quality of life among the lower limb amputees, the WHOQOL-BREF is a shorter version of the WHOQOL-100; both were developed by the World Health Organization (WHO). The WHOQOL-BREF is 26 items self-

administered questionnaire, responses to questions are on a 1-5 scale where 1 represents "disagree" or "not at all" and 5 represents "completely agree" or "extremely". The questionnaire contains four domains namely: Physical Health (7 items), Psychological Health (6 items), Social Associations (3 items) and Environment (8 items). The remaining two items, at the beginning of the questionnaire (coded Q1 and Q2), ask specifically about the participant's rating of their quality of life and satisfaction with their health. The Hausa version of WHOQOL-Bref is a valid, reliable and acceptable instrument for assessing quality of life; and is recommended for use in Hausa speaking populations[19]. The International Physical Activity Questionnaire (IPAQ) Short form Hausa version was used to assess the level of physical activity among the lower limb amputees. It measures the types of intensity of physical activity that people do as part of their daily lives and estimate the total physical activity in MET-min/week. It's a 7 items self-report questionnaire with a 7-day recall of physical activity. Results can be reported in categories (low activity levels, moderate activity levels or high activity levels) or as a continuous variable (MET minutes a week). MET minutes represent the amount of energy expended carrying out physical activity. A MET is a multiple of estimated resting energy expenditure. One MET is what is expended when at rest. Therefore 2 METS is twice what is expended at rest. To get a continuous variable score from the IPAQ (MET minutes a week) we consider walking to be 3.3 METS, moderate physical activity to be 4 METS and vigorous physical activity to be 8 METS. Those who score HIGH on the IPAQ engage in vigorous intensity activity on at least 3 days achieving a minimum total physical activity of at least 1500 MET minutes a week OR 7 or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 3000 MET minutes a week. Those who scored MODERATAE on the IPAQ engages in 3 or more days of vigorous intensity activity and/or walking of at least 30 minutes per day OR 5 or more days of moderate intensity activity and/or walking of at least 30 minutes per day. OR 5 or more days of any combination of walking, moderate intensity or vigorous intensity activities achieving a minimum total physical activity of at least 600 MET minutes a week. LOW level of physical activity on the IPAQ means that you are not meeting any of the criteria for either MODERATE or HIGH levels of physical activity. IPAQ is a generic scale and has a reliability of 0.80 and criterion validity of 0.30, which means that it is reliable, valid and of wide utility[20]. The Hausa IPAQ-SF has good concurrent validity with Spearman correlation coefficients (ρ) ranging from 0.78 for vigorous activity (Min Week^{-1}) to 0.92 for total physical activity (Metabolic Equivalent of Task [MET]-Min Week^{-1}), but poor construct validity, with cardio respiratory fitness ($\rho = 0.21$, $p = 0.01$) and body mass index ($\rho = 0.22$, $p = 0.04$) significantly associated with only moderate activity and sitting time (Min Week^{-1}), respectively. Reliability was good for vigorous (ICC = 0.73, 95% C.I = 0.55-0.84)

and total physical activity (ICC = 0.61, 95% C.I = 0.47-0.72), but fair for moderate activity (ICC = 0.33, 95% C.I = 0.12-0.51), and few meaningful differences were found in the gender and socioeconomic status specific analyses[21].

Sample size and sampling technique

The sample size for this research was calculated by using Taro Yamane[22] formula with 95% confidence level. The formula for Taro Yamane is presented as follows.

$$n=\frac{N}{1+N(e)^2}$$

Where:
n= sample size required
N = number of people in the population
e = allowable error (%)
1= unit constant
Total number of amputees visiting physical rehabilitation centre =50

$$n=\frac{57}{1+57(0.05)^2}=49.89$$

Therefore, the minimum sample size n= 50

Data analysis

Descriptive statistics of mean, standard deviation and percentages was used to summarize the socio-demographic and clinical variables, the WHOQoL-BREF and IPAQ questionnaires scores. Inferential statistics of chi-squared test was used to determine the association between quality of life and physical activity with socio-demographic variables (age, gender and level of education) and clinical characteristics (cause, level of amputation and time since amputation). The level of significance for this study was set at $p<0.05$.

RESULTS

Socio-demographic characteristics of the participants

Fifty (50) lower limb amputees completed and returned their questionnaires for analysis. They comprised 38 (76%) males and 12 (24%) females with a mean age of 37.26±15.03 years (age range: 15-65 years). Road Traffic Accident (RTA) 13(26%) and bomb blast/ gunshot 13(26%) account for the major cause of the lower limb amputation and the major level of amputation was below knee 34(68%). The details of the socio-demographic characteristics and clinical characteristics of the participants are shown in table 1.

Level of quality of life of the participants

The level of quality of life among the participants was reported according to the domains of WHOQOL-Bref. It was reported to be higher in the "psychological" domain (67.88±13.52) and relatively lower in the "social" domain (59.00±17.30) (Table 2).

Level of Physical activity of the participants

Majority of the participants 28(56%) are moderately physically active (649.60±884.61 MET/min/week) meeting the recommended guideline while 15 (30%) accumulated a low physical activity level (570.24±555.69 MET/min/week) (Table 3).

Association between quality of life and characteristics of the participants

Table 4 shows the association between quality of life and characteristics of the participants. There was a statistically significant association between quality of life and age group in the "physical health" domain ($p=0.036$) of quality of life. No

significant association was observed between quality of life and gender in all the quality-of-life domains ($p>0.05$). a significant association was found between level of education and "Overall QoL" ($p=0.026$), "physical health" ($p=0.037$) and "psychological health" ($p=0.010$) respectively. A significant association between quality of life and cause of amputation was recorded in "overall QoL" ($p=0.040$) and "environmental" ($p=0.014$) domain. There was no significant association ($p>0.05$) between all domains of quality of life and level of amputation. Also, there was no significant association ($p>0.05$) between quality-of-life domains and time since amputation.

Association between physical activity and characteristics of the participants

Table 5 shows the association between physical activity and characteristics of the participants. There was a significant association ($p=0.004$) between physical activity and age group. No significant association was found between physical activity and gender ($p=0.274$), level of education ($p=0.255$), cause of amputation ($p=0.200$) and level of amputation ($p=0.341$). A significant association was observed ($p=0.007$) between physical activity and time since amputation.

Table 1: Socio-demographic and clinical characteristics of the participants (n= 50)

Characteristics	frequency (n)	percentage (%)	Mean ± SD
Age group			37.26±15.03
15-24	15	30	
25-34	5	10	
35-44	15	30	
45-54	7	14	
55 above	8	16	
Gender			
Male	38	76	
Female	12	24	
Level of education			
Non formal	21	42	
Primary	5	10	
Secondary	16	32	
Tertiary	8	16	
Cause of amputation			
RTA	13	26	
Diabetes	8	16	
Bomb blast/Gunshot	13	26	
Infection/PVD	5	10	
Cancer	5	10	
TBS gangrene	6	12	
Level of amputation			
Below knee	34	68	
Above knee	16	32	
Time since amputation (years)			2.14±0.990
<1	14	28	
1-5	21	42	
6-10	10	20	
11-20	4	8	
>20	1	2	

Key: n=Frequency, SD=Standard Deviation, RTA=Road Traffic Accident, PVD=Peripheral vascular disease, TBS=Traditional Bone Setters

Table 2: Level of quality of life of the participants (n=50)

	Quality of life (WHOQOL-Bref) Mean ± SD
WHOQOL-Bref domains	
Physical	62.86 ± 15.72
Psychological	67.88 ± 3.52
Social	59.00 ± 17.30
Environmental	61.94 ± 14.27

Key: n=Frequency, SD=Standard Deviation, PA=Physical Activity, WHOQOL-Bref=World Health Organization Quality of Life Brief Scale

Table 3: Level of Physical activity of the participants n=50

	Physical activity		
	n	**%**	**Mean ± SD (MET)**
Low	15	30	570.24±555.69
Moderate	28	56	649.60±884.61
High	7	14	685.60±1868.24
Total PA			1905.44±2303.76

Key: n=Frequency, SD=Standard Deviation, PA=physical activity level; MET=Metabolic Equivalent of Task (MET/min/week).

Table 4: Association between quality of life and characteristics of the participants

Characteristics	n (%)	WHOQOL-Bref domains Q1 χ^2- value, p-value	Q2 χ^2-value, p-value	D1 χ^2 -value, p-value	D2 $\chi,^2$-value, p-value	D3 χ^2-value, p-value	D4 $\chi,^2$ -value, p-value
Age group							
15-24							
25-34		10.108,	17.918,	62.227,	39.824,	47.785,	59.536,
35-44	15(30%)	0.861	0.118	0.036	0.161	0.090	0.059
45-54	5(10%)						
55 above	15(30%)						
	7(14%)						
	8(16%)						
Gender							
Male		8.159,	5.806,	15.689,	5.435,	8.838,	6.368,
Female	38(76%)	0.086	0.121	0.153	0.710	0.452	0.848
	12(%)						
Level of education							
Non formal							
Primary		23.195,	17.859,	26.056,	42.902,	22.892,	31.301,
Secondary	21(42%)	0.026*	0.037*	0.799	0.010*	0.691	0.552
Tertiary	5(10%)						
	16(32%)						
	8(16%)						
Cause of amputation							
RTA							
Diabetes	13)26%)						
Bomb blast/Gunshot	8(16%)	32.317,	21.871,	58.615,	34.516,	34.796,	80.619,
Infection/PVD		0.040*	0.111	0.344	0.715	0.864	0.014*
Cancer	13(26%)						
TBS gangrene							
	5(10%)						
	5(10%)						
	6(12%)						
Level of amputation							
Below knee	34(68%)	3.898,	2.540,	6.725,	11.572,	10.719,	14.952,
Above knee	16(32%)	0.420	0.468	0.821	0.171	0.295	0.185
Time since amputation							
<1		11.981,	11.505,	42.510,	42.899,	37.252,	48.865,
1-5	14(28%)	0.745	0.486	0.536	0.094	0.411	0.284
6-10	21(42%)						
11-20	10(20%)						
>20	4(8%)						
	1(2%)						

Key: *=significant at p<0.05; $\chi,2$=Chi-value; Q1= Overall quality of life; Q2=Overall health; D1=physical; D2= psychological; D3=social; D4=environmental; RTA=Road Traffic Accident, PVD=Peripheral vascular disease, TBS=Traditional Bone Setters

Table 5: Association between physical activity and characteristics of the participants

Characteristics	Physical activity			χ^2- value	p-value
	Low n (%)	Moderate n (%)	High n (%)		
Age group				22.51	0.004*
15-24	2(4%)	12(24%)	1(2%)		
25-34	0(0%)	2(4%)	3(6%)		
35-44	4(8%)	8(16%)	3(6%)		
45-54	3(6%)	4(8%)	0(0%)		
55 above	6(12%)	2(4%)	0(0%)		
Gender				2.59	0.274
Male	11(22%)	20(40%)	7(14%)		
Female	4(8%)	8(16%)	0(0%)		
Level of education				7.78	0.255
Non formal	10(20%)	9(18%)	2(4%)		
Primary	1(2%)	4(8%)	0(0%)		
Secondary	2(4%)	10(20%)	4(8%)		
Tertiary	2(4%)	5(10%)	1(2%)		
Cause of amputation				13.44	0.200
RTA	2(4%)	9(18%)	2(4%)		
Diabetes	4(8%)	3(6%)	1(2%)		
Bomb blast/Gunshot	3(6%)	7(14%)	3(6%)		
Infection/PVD	2(4%)	3(6%)	0(0%)		
Cancer	4(8%)	1(2%)	0(0%)		
TBS gangrene	0(0%)	5(10%)	1(2%)		
Level of amputation				2.15	0.341
Below knee	8(16%)	21(42%)	5(10%)		
Above knee	7(14%)	7(14%)	2(4%)		
Time since amputation				20.89	0.007*
<1	2(4%)	10(20%)	2(4%)		
1-5	11(22%)	10(20%)	0(0%)		
6-10	0(0%)	7(14%)	3(6%)		
11-20	2(4%)	0(0%)	2(4%)		
>20	0(0%)	1(2%)	0(0%)		

Key: χ^2- value =chi-square value, *=significant at $p<0.05$; RTA=Road Traffic Accident, PVD=Peripheral vascular disease, TBS=Traditional Bone Setters

DISCUSSION

These cohort sample of amputees revealed moderate quality of life in all the domains after lower limb amputation. This finding may not be unrelated to the fact they are majorly (56%) also moderately physically active, which may have influenced their quality of life. Most Nigerians especially those coming from the not so urban regions do not participate in leisurely activities like camping, outdoor recreation, hiking, etc therefore the loss of a lower limb though detrimental and worrisome may not harbour mental affectations which may hinder their normal day to day activities and impair their quality of life to such detoriating level.

There was a significant association in the "physical health" domain of quality of life with age of the participants. Physical health domain was significantly lower among the older amputees compared with the younger amputees. The study by Shankar et al.[23] did not report the significant association of the four domains of quality of life with age, though the participants scored second highest on the physical health domain with the highest score in the environmental domain of the quality of life respectively. In line with the present study findings Banskota et al.[24] found significant association between age and both components of quality of life among lower limb amputees in Nepal. This means as age increases physical activity levels decline with decreasing physical health due to the natural aging process.

No significant association between gender and all the domains of quality of life. This was consistent with the study done by Razak et al,[10]. The higher occurrence of males than females with lower limb amputation in the present study are similar to other previous studies[25,23]. This higher occurrence of amputations in male may be associated with them partaking in professions that involve higher occupational risk because most often it is the male member of a household who venture out for purpose of work or undertake travel for the same; they are henceforth, more at risk of road traffic and industrial accidents leading to amputations. One additional reason might be due to the adventurous nature of the male gender, therefore exposing them to more dangers and injuries in their lifetime compared to the female gender who are more reserved and mostly live their life indoors due to cultural practices observed in the northern Nigeria. *Stutts et al*.,[26] reported women to generally experience high levels of posttraumatic emotional growth following amputation and

they have unique perspectives regarding coping, social support, perceived societal and workplace discrimination, acceptance, support groups, and other concerns related to gender identity in women.

Level of education presented in this study revealed significant association with "overall QOL", "overall health" and "psychological health" domain of quality of life with the number of individuals in non-formal education being higher. This is consistent with the study by Melo et al.[17] which indicates that education level is an important social factor for avoiding amputation and enhancing quality of life. Most of the participants were internally displaced persons form hard to access areas lacking knowledge regarding their health status and

attitude toward accessing existing healthcare services. Those with higher educational level might feel more socially equipped and find it easier to deal with psychological and social aspects of amputation that affect their quality of life.

The cause of amputation was significantly associated with "overall QOL" and "environmental" domains of quality of life with road traffic accidents (RTA) and bomb blast/gunshot the highest cause of lower limb amputations among the study population. Previous studies in Nigeria[3] and Pakistan[23] reported trauma, especially from road traffic accidents, as the most leading cause of amputation. Bomb blast caused lower limb amputation at the study centre was higher, this could be that majorly of the participants were victims of boko haram insurgency in Borno state, northeastern Nigeria during the year 2010 that marked the climax of the attacks. These attacks increased the rate of both bomb blast and traumatic amputations seen in the centre overtime. The causes of amputation have been reported to be influence by the level of development of the individual's region, assess to good transportation system and access to prompt quality medical care[17].

The level of amputation has no significant association in all the domains of quality of life, this finding buttressed previous findings [3, 27] that reported no significant association between scores of quality-of-life domains with below or above amputations among their participants. This finding indicates that amputations performed either below or above knee levels of the lower limbs does not influence the quality of life among these participants. However, this finding contrast with the study of Davies[28] that found below knee amputees had better physical function, better mental health and better social functioning than above knee amputations. It is also in contrast with the study by Bennett et al.,[29] which found out that worse physical functioning was associated with more proximal levels of amputations.

Time since amputation among the lower limb amputees in this study did not significantly influence participants' quality of life in all the domains studied, which is consistent with previous studies [3, 8] they did not find pattern of increased quality of life with time since amputation. However, this is in contrast with the study finding of Matos et al.,[30] which reported that, as time since amputation increased, adjustments to limitations improved. The Potential reason for not detecting change in quality of life considering time since amputation in the present study might be explained by the difference in perceived quality of life among the amputees which might have occurred earlier in rehabilitation and readjustment periods.

The study revealed a moderate level of physical activity among the amputees. This means that a majority of the amputees engages in daily life hustle and other social activities which might have enhances their physical activity participation. However, this finding is inconsistent with the study of Luza et al.,[31] that reported low physical activity among people with lower limb amputation in Brazil. The reason for this difference might be most of the amputees are of younger age with lots of energy levels making them to remain independent in performing their activities of daily living

thus more physically active. Physical activity is very central for rehabilitation, it improves on the physical function, and mental health of the amputees and with regular exercises improve on cardiorespiratory health, muscle strength, proprioception, balance and pave way for independent living[24].

There was a significant association between physical activity and age, with those in the age group of >55 years significantly presenting with lower physical activity when compared to their younger counter parts. This finding is similar to the study of Melo et al.,[17] that compares physical activity among the younger adults and the elderly lower limb amputees. It is also consistent with the study of Langford et al.,[32] that also reported a significant correlation between levels of physical activity with age of lower limb amputees. The study by Pepin et al.,[33] additionally buttressed the present study finding which reports that age was associated with levels of physical activity even though weak. The reason for this finding might be most times physical activity tends to decrease with age due to decline in overall strength, mobility and endurance that comes as one aged. Existence of health comorbidities like diabetes mellitus, arthritis can also limit their ability to engage in physical activity.

Gender was not significantly associated with physical activity. This finding is in line with the study by Langford et al.,[32]. Previous findings have shown women with lower limb amputation that carried out more domestic activities to reported higher practices of physical activity[31]. However, domestic activities were not assessed in the current study. The non-significant association revealed in this study may be difficult to explain in the literature as both genders might share same intrinsic and extrinsic factors that affect their physical activity levels. Both men and women amputees may face similar barriers when it comes to physical activity, such as pain, fatigue, limited access to healthcare or rehabilitation services. These factors may equally affect both genders, leading to similar levels of activity despite gender differences.

Level of education revealed no significant association with physical activity, with the number of lower limb amputees in non-formal education higher than the other educational levels among this cohort of amputees. therefore, not having any formal education did not have any significant influence on their level of physical activity. This is in line with the study by Melo et al.,[17] that reported schooling among amputees to have no association among its adults and elderly amputees. Educated amputees might probably portray more health-promoting behaviours and a higher level of physical activity as they are likely to recognise the benefits of physical activity.

Cause of amputation showed no significant association with physical activity which is in line with the study by Littmann et al.,[15] who reports, lower limb amputees with dysvascular cause of amputation participate less in physical activity than those with non-dysvascular aetiology due the underlying disease or have been leaving a less active lifestyle before the amputation. RTA and bomb blast reported the highest and equal proportion of indications of

amputation in the present study. This finding is somewhat similar with findings of previous studies [3, 34]. The finding is in contrast with previous studies of Shankar et al.,[23] that reported the major cause as trauma followed by RTAs, Melo et al. and Enweluzo et al., reported diabetes mellitus followed by trauma to be the indications for lower limb amputation in their studies[17, 35]. The study of Banskota et al.,[24] additionally reported burns to be the highest cause of amputation followed by trauma. The cause of amputation among lower limb amputees have impacts on mental health, with traumatic amputations leading to more psychological stress like anxiety and posttraumatic stress disorders while chronic diseases cause of amputations adds to ongoing emotional burdens and stress[36].

Physical activity levels revealed no significant association with level of amputation among the amputees. This is inconsistent with the previous study of Langford et al.,[32] that reported significant association between levels of physical activity and level of amputation among lower limb amputees. It has been documented that those with transtibial and trans-femoral amputations show varied levels of physical activity[1]. This suggests that the adoption and restoration of a substantial amount of physical activity among amputees may be contingent with the level of amputation present.

Time since amputation shows a significant association with physical activity, which is in line with the study by Littmann et al.,[15]. The study finding is also buttressed by the study of Langford et al.,[32] that also reported a significant correlation between physical activity levels among lower limb amputees with time since amputation. This is based on the fact that as time goes on, amputees accept and comes to term with their disability in addition to any rehabilitation process they are undergoing, therefore, tend to adapt and engage in physical activity participation regardless of their condition (disability).

Limitations of the study

The study is not without some limitations; even though the study used standardized tools making findings comparable with previous studies, the cross-sectional design used in the study makes it difficult for causal inferences. The low sample size in the study also limits the generalisation of findings and may increase the likelihood of type II error. Likewise, the self -report measures used in the study may be bias due to social desirability phenomenon.

CONCLUSIONS

Findings on this study show a high percentage 28(56%) of moderate physical activity level among lower limb amputees. The level of quality of life among the participants was reported to be higher in the "psychological" domain and relatively lower in the "social" domain of quality of life. Quality of life was significantly associated with age, level of education and cause of amputation and not significantly association with gender, level of amputation and time since amputation. While, Physical activity was significantly associated with age and time since amputation; but was not significantly associated with gender, level of education, cause of amputation and level of amputation among the lower limb amputees.

Recommendations

The study recommended that preoperative and postoperative training of patients is of vital importance for a successful rehabilitation after amputation. As it will help in enhancing their self-esteem in postoperative rehabilitation making preoperative rehabilitation process a bedrock to rehabilitation process. This will ease physical activity participation and prepares them psychosocially after the amputation. Benefits of participating in physical activity should be disseminated by health professionals to the amputees at both the preoperative and postoperative phases of rehabilitation. Studies with more larger sample size are also recommended. Additional studies on physical activity participation and quality of living are recommended due to scarcity of baseline studies in Nigeria.

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RELATIONSHIP BETWEEN MINDFULNESS PRACTICES, STRESS LEVELS, AND WELL-BEING AMONG LECTURERS AT A NIGERIAN UNIVERSITY

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ABSTRACT

Background: University teachers (lecturers) face significant stress from their teaching, research, and service duties which negatively impact their health and well-being. Mindfulness, characterized by present-moment awareness and non-judgmental acceptance, can reduce stress, alleviate anxiety and depression, and improve job satisfaction, performance, and work-life balance.

Aim: To examine how mindfulness influences work stress and overall well-being of lecturers at the Nnamdi Azikiwe University, Nnewi Campus, Nigeria.

Materials And Methods: This was a cross-sectional study that involved 73 lecturers, with a mean age of 45.7±9.945.7 years. The Five Facets of Mindfulness, work stress, Work-Related Quality Of Life Scale, and WHO-5 Well-Being Questionnaires were used to assess mindfulness, stress level, and well-being respectively. Data was analyzed with descriptive statistics and Spearman's rank correlation with level of significance set at <0.05.

Results: No significant differences were found in mindfulness (K = 4.213, p = 0.837) or work stress (K = 10.128, p = 0.256) among lecturers of different departments. Male lecturers reported significantly higher work-related quality of life and general well-being than females (WRQoL: U = 429.5, p = 0.023; WHO-5: U = 362.5, p = 0.002). However, no significant correlations were observed among mindfulness, work stress, well-being, age, or years of lecturing experience.

Conclusion: The findings suggest that mindfulness, stress levels, and well-being are not significantly correlated. While gender differences in well-being were evident, other demographic factors such as age and professional experience showed no significant influences.

Keywords: Mindfulness, Stress level, Well-being, Lecturers, Work-related quality of life

INTRODUCTION

Today's educational system hinges heavily on the dynamic performance of the academic staff, otherwise known as lecturers[1]. A university lecturer is a teacher, and an expert employed in a university to teach on a part-time, full-time, contract, adjunct, or voluntary basis[2]. Lecturers in higher educational institutions are primarily responsible for teaching undergraduates and postgraduates in areas designated by the Head of Department, conducting research and producing related outputs regarding their personal objectives, securing research funding, and participating in scholarly and professional communities[3]. They also supervise or assist with supervising students at various levels, contribute to curriculum development and implementation, and help create learning materials, plan coursework, and track student progress and attendance[3]. Lecturers put in much energy to get the most out of students, which may result in stress[2]. In addition, stress at work is a growing problem[4]. However, evidence suggests that mindfulness may reduce stress[5].

Mindfulness refers to observing the happenings in the present moment without passing judgment on it[6]. Mindfulness can be applied in different contexts, including technology, therapy, or way of life[7]. Mindfulness is used in settings such as parliaments, schools, and universities. Mindfulness involves a mental state where individuals are aware of events as they occur and are adaptable in interpreting them, enabling them make the most of their circumstances[8]. This practice centers on awareness and emphasizes the importance of focusing on immediate experiences, such as bodily sensations, emotional responses, mental imagery, mental dialogue, and perceptual experiences[9].

Modern conceptualizations of mindfulness emphasize the importance of accepting one's experiences and approaching them with an open mindset. Attending to experiences with a questioning, dispassionate, and nonreactive perception forms the basis of a receptive attitude. Accepting reality is not a passive attitude[9]. Those who practice mindfulness are less sensitive to emotional cues and can better control their emotions and reactions to stressful situations[10].

Work stress occurs when employees take on tasks that surpass their capabilities or when the resources needed to complete these tasks are inadequate. This situation often arises when there is a significant gap between compensation and the expectations placed on employees[11]. Stress negatively impacts employees in several ways, including their reaction, stimulus, and transaction. When lecturers are assigned too many classes in a semester, they may respond differently based on their coping skills and personal characteristics, which may be positive or negative.

A study highlighted that how lecturers communicate with management and students is crucial to their experience of stress[2]. The body responds to stress by releasing hormones such as cortisol, adrenaline, and noradrenaline, which activate the autonomic and central nervous systems to preserve homeostasis, enabling us to react and adjust to daily activities, some of which may be stressful[12]. To achieve happiness, health, and success, one must react correctly to anticipated and unforeseen stressors, which is known as well-being[13].

In philosophy, "well-being" refers to what is inherently or ultimately beneficial to an individual. In everyday usage, "well-being" typically pertains to health[14]. In the past decade, the higher education sector has undergone substantial and diverse changes, which have affected the well-being of academic staff[15]. Furthermore, there has been growing concern about the well-being of academic staff, with many being reported as at risk of experiencing burnout[16]. Stress and well-being are inversely associated.[17]

Mindfulness training can lower the prevalence of mental disorders that result in anxiety and/or depression[18]. Furthermore, mindfulness boosts a person's performance, job satisfaction, and work-related well-being[19]. It also helps lower stress levels, which are connected to health problems and increased rates of attrition in educational settings.[19] Practicing mindful behavioral responses to stressful situations enhances our emotional regulation and reduces cortisol, the stress hormone, which activates the prefrontal cortex, helping individuals

gain a clearer perspective and stay calm during challenging situations.[10] The benefits of mindfulness have been reported in lecturing, law, and medicine.[19] Although being unmindful can have adverse effects, practicing and cultivating mindfulness can improve one's well-being and foster greater awareness of oneself and the outside world.[20] Mindfulness can enhance well-being by helping individuals cultivate flexible attention and embrace a perspective focused on experiences.[21] This approach reduces their dependence on automatic thought patterns and ineffective emotion regulation strategies.[21] Mindfulness practice offers numerous benefits, such as enhanced problem-solving, better decision-making, greater creativity, improved interpersonal relationships, and more effective communication. It is essential in the workplace.[22]

Therefore, this study aimed to examine how mindfulness practices influence work stress level and overall well-being among lecturers at the College of Health Science, Nnamdi Azikiwe University, Nnewi Campus.

MATERIALS AND METHODS

Research design

This study was a cross-sectional analytical survey, which utilized a stratified sampling technique to recruit 73 lecturers at the College of Health Sciences, Nnamdi Azikiwe University, Okofia, Nnewi, Anambra State.

Inclusion criteria

Male snd female Lecturers in the College of Health Sciences, Okofia, Nnewi in Anambra State who have been in the occupation on full time basis for at least 2 years.

Study instruments

The Five Facets Of Mindfulness Questionnaire (FFMQ) (short form) was used to determine the effect of mindfulness on psychological health of individuals. The Work Stress Questionnaire (WSQ) revised version was used to identify those at risk of being placed on the sick list unexpectedly because of work-related stress. The Work-Related Quality Of Life (WRQoL) scale was used to assess employees' perceived QoL. The World Health Organization (WHO)-5 well-being scale was used to assess subjective well-being in a broad and general manner.

Data collection

Ethical approval was sought and obtained from the ethical review committee of Faculty of Health Science and Technology, Nnamdi Azikiwe University, Nnewi campus before commencing the study. The purpose and aim of the study were explained to the participants, and informed consent was sought thereafter, and only those who gave consent participated in the study. The questionnaires were administered to the participants, and the questionnaires that were completed were retrieved.

Data analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the sociodemographic characteristics of the participants and their responses to the

mindfulness, work stress, and well-being questionnaires. Inferential statistics were used to examine differences and relationships among variables. The Kruskal–Wallis test was used to compare mindfulness (FFMQ15), work stress (WSQ), and well-being scores (WRQoL and WHO-5) across departments and age categories, while the Mann–Whitney U test assessed gender-based differences in these variables. Additionally, Spearman's rank-order correlation test was used to determine the associations between mindfulness, work stress, well-being, and years of lecturing experience. Statistical significance was set at $p < 0.05$.

RESULTS

Sociodemographic characteristics of the participants

Seventy-three lecturers, 41 (61.6%) males and 28 (38.4%) females, at the College of Health Sciences, Okofia, Nnewi participated in this study, with a mean age of 45.7±9.945.7 years. Table 1 shows the sociodemographic characteristics of the participants.

Table 2 presents a comparison of the levels of mindfulness across the various departments in the College of Health Sciences using Kruskal–Wallis test. The results showed no significant differences in mindfulness scores (P=0.837, K= 4.213). WSQ scores across departments were also evaluated using Kruskal–Wallis test, which showed no significant difference in work stress levels across the departments (P= 0.256, K= 10.128).

A Mann–Whitney U test was utilized to compare gender work well-being (WRQoL) and general well-being (WHO5) scores. The analysis revealed significant differences between male and female lecturers (WRQoL: U = 429.5, p = 0.023; WHO5: U = 362.5, p = 0.002) (Table 3). Additionally, to evaluate potential gender differences in mindfulness and work stress, a Mann–Whitney U test was also conducted, which revealed no significant gender differences in mindfulness or work stress scores (Mindfulness [FFMQ15]: U = 598, p = 0.716; Work Stress [WSQ]: U = 580.5, p = 0.574).

Spearman's rank order correlation analysis was performed to evaluate the relationship between mindfulness and work stress, revealing no significant correlation (rho = 0.228, P = 0.052) (Table 4). Spearman's rank order correlation was also used to examine the correlation between mindfulness and overall well-being (WHO5 and WRQoL), which indicated no significant correlation (For WHO5: rho = -0.009, P = 0.942; For WRQoL: rho= -0.020, P = 0.868). Furthermore, Spearman's rank order correlation was also used to examine the correlation between years of lecturing experience and well-being (WHO5 and WQRoL) scores, which showed no significant correlation (rho = -0.019, P = 0.875; and rho = 0.082, P = 0.489, respectively). The relationship between years of lecturing experience and mindfulness (FFMQ15) was analyzed using Spearman's rank order correlation, which revealed no significant correlation (rho = 0.151, P = 0.202). Finally, the correlation between years of lecturing experience and

work stress was analyzed, which showed no significant correlation (rho = 0.062, P > 0.05).

The Kruskal–Wallis test was performed to assess potential age-based differences in mindfulness (FFMQ15), work stress (WSQ), and well-being (WHO5 and WRQoL). The results were: Mindfulness (FFMQ15): χ^2 = 5.507, p = 0.239; Work stress (WSQ): χ^2 = 5.831, p = 0.212; Well-being (WHO5): χ^2 = 3.152, p = 0.533, Well-being (WRQoL): χ^2= 1.766, p = 0.779 (Table 5).

Table 1. Sociodemographic characteristics of the participants

Variable	Frequency (%)	Total (%)	Mean ± SD
Age (years)		73 (100%)	3.29 ± 1.13
20–29	1 (1.4%)		
30–39	23 (31.5%)		
40–49	26 (35.6%)		
50–59	16 (21.9%)		
60–69	7 (9.6%)		
Gender		73 (100%)	1.38 ± 0.49
Male	45 (61.6%)		
Female	28 (38.4%)		
Department		73 (100%)	4.74 ± 2.32
Anatomy	14 (19.2%)		
Biochemistry	7 (9.6%)		
Environmental Health Science	8 (11.0%)		
Human Nutrition and Dietetics	3 (4.1%)		
Medical Laboratory Science	13 (17.8%)		
Medical Rehabilitation	9 (12.3%)		
Nursing	5 (6.8%)		
Human Physiology	7 (9.6%)		
Radiography	7 (9.6%)		

Table 2. Comparison of the five facets of mindfulness and work stress scores across departments

Variable	Department categories									K value	p-value
	1	2	3	4	5	6	7	8	9		
FFMQ15	32.93	43.71	40.00	50.33	30.73	34.78	38.70	37.71	41.86	4.213	0.837
WSQ	34.50	39.43	36.25	15.83	48.00	35.94	38.40	23.64	42.79	10.128	0.256

Key:
1, Anatomy; 2, Biochemistry; 3, Environmental Health Science; 4, Human Nutrition and Dietetics; 5, Medical Laboratory Science; 6, Medical Rehabilitation; 7, Nursing; 8, Human Physiology; 9, Radiography; FFMQ15; Five facets of mindfulness questionnaire; WSQ, Work stress questionnaire

Table 3. Correlation between gender and well-being, mindfulness, and work stress

Variable	Gender categories		U value	p-value
	1	2		
WRQoL	41.46	29.84	429.5	0.023
WHO-5	42.94	27.45	362.5	0.002
Mindfulness	38.29	38.14	598	0.716
Work Stress	35.90	38.77	580.5	0.574

Key:
WRQoL, Work-related quality of life; WHO-5=World Health Organization well-being index; 1, Male; 2, Female

Table 4. Correlation between mindfulness with work stress and well-being and years of lecturing with mindfulness, stress level, and well-being

Variables	rho-value	p-value
Mindfulness and Work Stress	0.228	0.052
Mindfulness and WHO-5	-0.009	0.942
Mindfulness and WRQoL	-0.020	0.868
Years of Lecturing and Mindfulness	0.151	0.202
Years of Lecturing and Work Stress	0.062	0.601
Years of Lecturing and Well-Being (WHO-5)	-0.019	0.875

Variables	rho-value	p-value
Years of Lecturing and Well-Being (WRQoL)	-0.082	0.489

WRQoL, Work-related quality of life; WHO-5, World Health Organization well-being index

Table 5. Comparison of mindfulness, work stress and well-being among the different age categories

Variables	Age category					K value	p-value
	1	2	3	4	5		
Mindfulness	10.00	42.37	31.58	36.84	43.71	5.507	0.239
Work Stress	43.00	33.22	38.77	44.88	24.00	5.831	0.212
Well-Being (WHO5)	32.00	43.20	32.75	35.69	36.14	3.152	0.533
Well-Being (WRQoL)	27.00	38.65	39.56	34.06	30.21	1.766	0.779

Key:
1, 20–29; 2, 30–39; 3, 40–49; 4, 50–59; 5, 60–69; WRQoL, Work-related quality of life; WHO-5, World Health Organization well-being index

DISCUSSION

This study investigated the relationship between mindfulness, work stress, and well-being among lecturers in the College of Health Sciences, Okofia, Nnewi. A major finding was the absence of significant differences in mindfulness levels across various academic departments via the Kruskal–Wallis test, which suggests that departmental affiliation does not substantially influence the development or expression of mindfulness among lecturers. This aligns with existing literature, which posits that mindfulness is not inherently tied to occupational roles but can be cultivated through individual practice and training across varied environments.[23,24] The uniformity in mindfulness scores across departments also implies that the pressures or demands specific to different academic disciplines do not differentially affect lecturers' capacity for present-moment awareness and non-judgmental observation—core tenets of mindfulness.

Similarly, no significant difference was observed in work stress levels across departments, indicating that stressors may be systemic rather than role-specific. This finding supports that of a study that stress among academic staff is often related to institution-wide issues such as workload, administrative burdens, research expectations, and limited support structures, rather than challenges unique to disciplines.[25] These systemic stressors can create a pervasive atmosphere of pressure, affecting staff across the board regardless of departmental alignment.

Gender-based analysis revealed that male lecturers reported significantly higher levels

of general well-being (WHO-5) and work-related quality of life (WRQoL) than female lecturers, suggesting a potential gender disparity in the experience or perception of well-being within the academic environment. Previous studies have identified similar patterns, attributing them to societal roles, work-life balance challenges, and gender-based occupational stress.[26,27] Women in academia often face additional expectations, such as caretaking responsibilities, which may exacerbate stress and reduce perceived well-being. These gendered dynamics could also reflect unequal access to institutional resources or differences in coping strategies between male and female lecturers.

However, no significant gender differences were found in mindfulness or work stress scores, indicating that while male and female lecturers may experience different levels of well-being, their mindfulness capacities and perceived work stress levels are comparable. This finding is consistent with a study that suggested that although gender can influence emotional health outcomes, it does not necessarily affect dispositional mindfulness.[28] It may also suggest that mindfulness, as measured by the FFMQ, operates similarly across genders in this academic context.

The correlation analysis revealed no significant relationships between mindfulness and work stress, nor between mindfulness and the two well-being indicators (WHO-5 and WRQoL). Although a weak positive trend was observed between mindfulness and work stress, it was not significant. This finding contrasts with numerous studies that have reported mindfulness to be a protective factor against stress and a contributor to enhanced well-being.[9,29,30] However, a study reported similar non-significant results, suggesting that the benefits of mindfulness may not be universal and could depend on the frequency, depth, or authenticity of its practice.[31] It is also possible that external stressors, such as institutional challenges or economic constraints, may be more dominant influences on stress and well-being than internal resources like mindfulness.

Furthermore, no significant correlations were observed between years of lecturing experience and any of the measured variables—mindfulness, work stress, or well-being, suggesting that tenure or time in the profession does not necessarily translate into increased coping ability, reduced stress, or higher well-being. While it may be assumed that more experienced lecturers develop better coping strategies over time, the findings indicate that this is not always the case. This aligns with a study that found that experience alone may not mitigate stress unless supported by targeted interventions and supportive workplace environments.[32]

The study also found that age was not significantly associated with differences in mindfulness, stress, or well-being. This further supports the idea that these psychological constructs are not heavily influenced by chronological age. Consistent with a study whose findings imply that individuals across age groups can cultivate mindfulness and experience similar levels of well-being and stress.[33] Therefore, interventions aimed at improving mindfulness and well-being should include

all age brackets within the academic workforce.

Altogether, these findings paint a nuanced picture. While mindfulness has been widely promoted for its benefits in reducing stress and improving well-being, its impact in this academic setting appears limited, at least when considered in isolation. The lack of significant relationships may point to other intervening variables, such as institutional support, personal life challenges, or environmental stressors that were not captured in this study. Moreover, the significant gender differences in well-being but not in mindfulness or stress highlight the need for gender-sensitive approaches to promoting mental health and work satisfaction in academia.

Limitations

The cross-sectional design limits the ability to establish causal relationships between mindfulness, work stress, and well-being. The data represent a snapshot in time and may not capture fluctuations in stress or mindfulness over longer periods. Second, the relatively small sample size, limited to lecturers within an institution, may restrict the generalizability of the findings to other academic environments or geographical regions. Additionally, the reliance on self-reported questionnaires introduces the potential for response bias. Lastly, the study did not control for external variables such as workload intensity, personal life stressors, or access to mental health resources, which may have influenced participants' levels of stress or well-being independently of mindfulness.

CONCLUSION

The findings revealed no significant associations between mindfulness and stress levels or well-being, and no notable differences in these variables across departments, age groups, or years of lecturing experience. However, significant gender differences were observed in general and work-related well-being, with male lecturers reporting higher scores than their female counterparts. These results suggest that while mindfulness may offer personal benefits, its influence on occupational stress and well-being in academic settings may be limited or shaped by broader systemic and individual factors. The uniformity of experiences across demographic and professional variables also points to shared institutional stressors rather than isolated or role-specific issues.

Competing interests

The authors declare no competing interests.

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RELEVANCE OF URINE RAPID TEST IN THE DIAGNOSIS OF MALARIA AMONG FEBRILE CHILDREN AGED 1-10 YEARS IN SOUTH EASTERN NIGERIA

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ABSTRACT

Background: Early diagnosis, prompt and effective treatments are the basis for the management of malaria and key to reducing the associated morbidity and mortality. Laboratory diagnostic challenges exist because clinical diagnosis is imprecise and leads to excessive use of antimalarial drugs. Thus there is need to introduce other non-invasive rapid diagnostic tools in order to achieve the goal of universal access to malaria diagnosis.

Aim: The aim of this study was to determine the reliability and usefulness of urine malaria test in the diagnosis of malaria among febrile children aged 1-10 years.

Materials and Methods: A cross-sectional descriptive study in which 212 febrile children aged 1-10years were consecutively recruited. Socio-demographic and clinical data of the subjects were obtained using interviewer-administered questionnaires. Each of the subjects were screened for malaria using blood and urine based malaria test kits respectively. Blood samples from each subjects were also sent to the laboratory for malaria microscopy.

Results: Out of 212 subjects studied, 38 subjects (17.9%) had malaria parasitaemia based on microscopy. The prevalence of malaria based on blood-based malaria rapid diagnostic test and urine malaria test were 21.7% and 9% respectively. Microscopy as the gold standard for malaria diagnosis compared to other diagnostic modalities.

Conclusion: In view of the low sensitivity of urine malaria test in this study, there is need for further improvement in the sensitivity of urine malaria test before it can be used alone as screening/diagnostic test for malaria in our locality.

Key Words: Diagnosis, Laboratory, Urine, Anti-malaria, Parasitaemia

INTRODUCTION

Malaria is a major cause of morbidity and mortality among children in developing countries.[1] Despite the global effort in prevention and control of the disease, progress in reducing the burden of malaria has stalled since 2017.[2] The World Health Organization has issued a directive that there is need for urgent targeted action especially in Nigeria where the number of cases are increasing rather than reducing annually.[2]

Early diagnosis, prompt and effective treatment are the basis for the management of malaria and key to reducing the morbidity and mortality associated with the disease.[3] Parasite-based diagnosis of malaria prior to treatment with antimalarial is fundamental to this goal because clinical diagnosis is imprecise and leads to over diagnosis of malaria with resultant wastage of antimalarial medicine and development of drug resistance.[4,5] Accurate and rapid diagnosis of malaria in endemic areas is particularly important in children and non-immune populations in whom falciparum malaria can be rapidly fatal.[1,3]

Blood film microscopy is the gold standard for the diagnosis of malaria, which depends mainly on the experience of the Microscopist, quality of the slides, stain, microscope, time spent in examination of the slides and the fact that it is not available in resource-limited settings.[6] The World Health

Organization have recommended the use of blood-based rapid diagnostic test as an acceptable, accurate and rapid method for the parasitological diagnosis of malaria.[7] However its use requires collection of blood by lancet/needle prick which carries some risk of injury and disease transmission.[8] Furthermore, in Africa, cultural and religious beliefs can also be an obstacle to the use of blood based malaria rapid diagnostic test (BMRDT).[9] Therefore, there is need to continue the search for an alternative or complementary malaria rapid diagnostic test that will employ other non/less invasive specimen apart from blood.

Histidine rich protein 2 (HRP-2) is a water soluble protein and could potentially be detected in urine since urine is an Ultra-filtrate of plasma.[10] Thus urine could be used as an alternative body fluid for the detection of plasmodium falciparum malaria. Histidine rich protein 2 (HRP-2), a protein produced by P.falciparium and has been proven from previous studies that it can be detected in urine of individuals infected with P.falciparium malaria[11]. The protein is believed to be excreted ito the blood stream and then removed via ultra filtrtion in the kidney into the urine[12]. It (HRP-2) has been explored as a biomarker for malaria diagnosis due to its high sensitivity and specificity in detecting P.falciparium presence and infection[13] Therefore, its presence in urine marks it as a promising target for non-invsive diagnostic tool. It is important to note that the detection of HRP-2 in urine has significant implications for malaria diagnosis, particularly in resource-poor settings like Nigeria. Non-invasive urine based test could favour a non-invasive and rapid diagnostic tool, improving access to malaria diagnosis and treatment[14]. The aim of this study was to determine the reliability and usefulness of urine malaria rapid diagnostic test (UMT) in the diagnosis of malaria among febrile children aged 1-10 years.

MATERIALS AND METHOD

Study Area and Design

This was a cross-sectional study carried out between 3rd of May to 5th of August 2019 at Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi, South-East Nigeria. The hospital is one of the two tertiary health institutions in Anambra State. Nnewi is a commercial city located in Nnewi North local Government Area. It has a population of 391,227 based on 2006 census estimate[15]. The inhabitants are predominantly Igbo-speaking and are mainly traders and civil servants. Nnewi is located on latitude 6^0 01' N of the equator and longitude 6^0 55' E of the Greenwich Meridian.[16] It has a mean daily temperature of 30.4^0C and mean annual rainfall of about 2000cm[16]. Nnewi falls within the tropical rainforest region of Nigeria with 2 main seasons; the rainy season spanning from April to October, and the dry season spanning from November to March[16]. The hospital, NAUTH, amongst other services maintains a Children Out-Patient Clinic (CHOP) that is open from Monday to Friday every week and a Children Emergency Room (CHER) that is open 24 hours daily. Even though NAUTH is supposed to be a referral center, the hospital functions as primary, secondary and tertiary health-care facility as many patients from the community present here for the first time without any referral.

Study Population

The study population consisted of febrile children aged 1-10 years who presented to the CHOP and CHER of the hospital. Inclusion criteria were axilliary temperature ≥ 37.5^0c and history of fever in the preceding 48hours. Children who had received full course of Artemisinin Combination Therapy (ACT) in the index illness or on malaria prophylaxis prior to the onset of the current illness were excluded.

Subjects Recruitment

Written informed consent was obtained from the subjects' caregivers/parents while assent was obtained from subjects aged 7 years and above. The subjects who met the inclusion criteria were consecutively recruited into the study until the sample size was reached. The information obtained from the subjects included bio-data, such as age, sex, parental occupation and highest educational level of the parents. Socioeconomic class of the subjects were grouped into low, middle and high class.[17]

Laboratory Procedures

The preparation and reading of the thick and thin blood film for malaria microscopy was done with the assistance of two Laboratory Scientists trained and certified in malaria microscopy by the World Health Organization. The Laboratory Scientists that assisted in the study were blinded to the history and examination findings of the subjects. While maintaining aseptic and universal safety precautions, two millilitre of blood were collected from each child into an ethylene diamine tetra acetic acid (EDTA) bottle. Each EDTA bottle was assigned a code number and the blood were subjected to test within 24 hours of collection. Thick and thin blood films were prepared on a single slide for each of the sample: 6µl of blood for the thick film and 2µl for the thin film. Three percent working Giemsa stain was prepared with stock of Giemsa staining solution and working Giemsa buffer. The thick and thin blood films were stained for 45 minutes with working Giemsa stain after fixing the thin film with absolute methanol.[18] Once the staining was over, the slides were air dried on a rack. Each slide was examined microscopically using 100x objectives (oil immersion). At least 100 oil immersion fields were examined before reporting the slide as negative.[18] Thick films were used to determine the parasite density while the thin films were used to identify the parasite species. The blood film was said to be positive when a concordant result was produced by the two Microscopists. The parasite density per micro-liters of blood was estimated from the thick film by counting the number of asexual parasites per 200 white blood cells expressed as parasites /µl (micro-litre) assuming a total WBC count of 8000/µl.[19]

$$\frac{\text{number of parasites x total leukocyte count}}{200}$$

Blood and urine samples from each of the subjects were screened for malaria using BMRDT and UMT kits. It is very vital to note here that the urine samples were collected as the patients present in Clinic, that is, anytime the patients presents. The procedure was carried out by the researchers according to the manufacturer's guideline. The rapid diagnostic tests and microscopy were performed independent of each other. The rapid diagnostic test kits (BMRDT and UMT, kits) were supplied by the manufacturers. BMRDT kits were produced by standard diagnostic INC based in Korea LOT NO: 05CDDO26A while the UMT kits were produced by Fyodor company based in Maryland USA LOT NO: F8001.

Ethical Clearance

Ethical clearance was obtained from the health research and ethics Committee of NAUTH Nnewi. Informed consent was

obtained from each caregiver and assent from children who were 7 years and above after educating them on the need for the study.

Determination Of Sensitivity And Specificity:

The sensitivity and specificity was calculated using the formula:

$$\text{Sensitivity}(\%) = \frac{TP}{TP + FN} \quad X\ 100,$$

where TP =True positive, FN= False Negative

$$\text{Specificity}\ \% = \frac{TN}{TN + FP} \quad X\ 100$$

Where TN= True Negative, FP= False Positive

Determination of positive and Negative Predictive Value:

$$\text{PPV} = \frac{TP}{TP + FP} \quad X\ 100$$

$$\text{NPV} = \frac{TN}{TN + FN} \quad X\ 100$$

TP= True Positive
FP= False Positive
TN= True Negative
FN = False Negative
PPV = Positive predictive value
NPV = Negative predictive value

Data Analysis

The independent and dependent variables were categorized accordingly and association was compared using contingency tables such as Chi-square (x^2) or Fischer's exact analysis where appropriate. The *p-value* was considered statistically significant at ≤ 0.05. The dependent variables: the parasite densities, UMT and BMRDT results were expressed in proportions (percentages), categorized for determination of sensitivity, specificity and predictive values (positive and negative).

RESULTS

A total of 212 subjects were recruited and successfully studied. There were 134 (63.2%) males and 78 (36.8%) females, giving a male: female ratio of 1.7:1. Their age ranged from 1 to 10 years, with a median age of 4 years. Children less than five years were the highest in the study population consisting 58% of enrolled subjects while children from the age of 5 to 10 years were the least (42%) (see Table 1). Axillary temperature ranged from 35.3^{0}C to 40.3^{0}C with a mean of 37.5±1.1^{0}C. The mean number of days the subjects had fever before presentation was 3.5 ±2.4days with a range of 6 hours to 14 days. Thirty-eight subjects (17.9%) were positive by microscopy, 46 (21.7%) were positive by BMRD while 19(9%) were positive by UMT (Figure 1).

Seventeen subjects had corresponding positive microscopy and UMT results (true positive tests) whereas 172 subject were negative by both diagnostic method (true negative tests) (see Table 2). Also, thirty-seven subjects had a corresponding positive microscopy and BMRDT results (true positive tests) and 165 subjects were negative by both diagnostic test methods (true negative tests) (see Table 3).

Using microscopy as the gold standard, the sensitivity and specificity of UMT was 44.7% and 98.9% respectively while the positive and negative predictive values were 89.5% and 89.1% respectively. Also, the sensitivity and specificity of BMRD was

97.4% and 94.8% respectively. The positive and negative predictive values of BMRD was 80.4% and 99.4% respectively (Table 4). The sensitivity of BMRDT increased as parasite density increases while that of UMT increase and decrease as parasite density increases (Table 5).

Table 1: Background characteristics of the subjects

Variable	Frequency	Percentage(%)
Age (years)		
< 5	122	58%
≥ 5	90	42%
Gender		
Male	134	63.2
Female	78	36.8
Socioeconomic class		
Upper	34	16.0
Middle	114	53.8
Lower	64	30.2
Temperature at presentation		
≥ 37.5ºC	104	49.1
< 37.5ºC	108	50.9

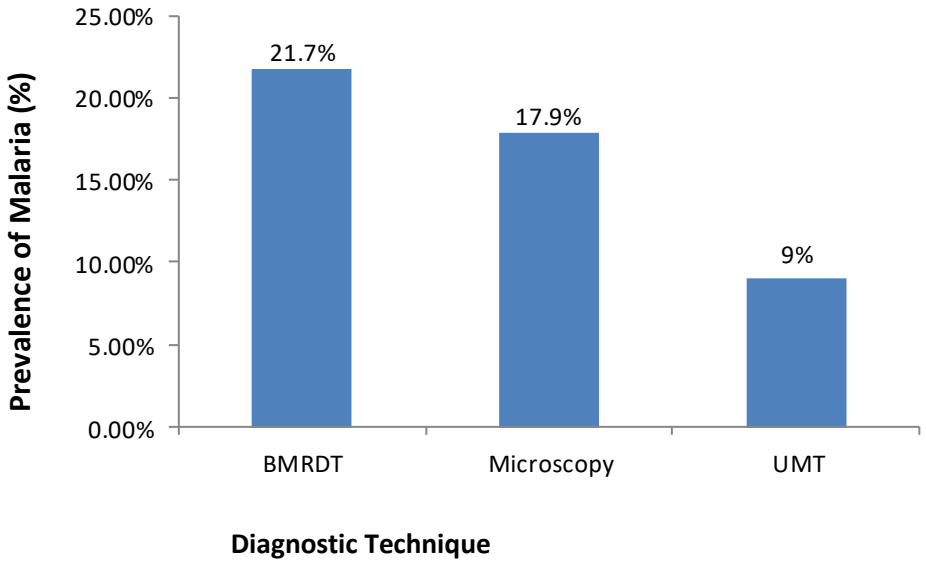

Figure 1:Bar chart showing the prevalence of malaria parasitaemia based on the different diagnostic techniques.

Table 2: Comparison of result of UMT and microscopy

	Microscopy.		
UMT	**Positive**	**Negative**	**Total**
Positive	TP = 17	FP = 2	19
Negative	FN = 21	TN = 172	193
Total	38	174	212

TP = True Positives, TN = True Negatives, FN = False Negatives, FP = False Positives.

Table 3: Comparison of result of BMRDT and microscopy

BMRDT	**Microscopy**		
RDT	**Positive**	**Negative**	**Total**
Positive	TP = 37	FP = 9	46
Negative	FN = 1	TN = 165	166
Total	38	174	212

TP = True Positives, TN = True Negatives, FN = False Negatives, FP = False Positives.

Table 4: Performance evaluation of BMRDT and UMT using microscopy as gold standard

Performance characteristics	UMT	BMRDT
Sensitivity	44.7%	97.4%
Specificity	98.9%	94.8%
PPV	89.5%	80.4%
NPV	89.1%	99.4%
False positive rate	1.1%	5.2%
False negative rate	55.3%	2.6%

PPV= Positive predictive value, NPV= Negative predictive value.

Table 5: Variation of sensitivity of the rapid diagnostic test by parasite density

Parasite density/µl	No. positive by microscopy(%)	No. positive by BMRDT(%)	No. positive by UMT(%)	Sensitivity(%) UMT	BMRDT
(<50/µl)	0	0	0	0	0
(50 -< 500/µl)	3(7.9%)	2(4.3%)	1(2.6%)	33.3%	66.7%
(500 -<5,000/µl)	12(31.6%)	12(31.6%)	7(18.4%)	58.3%	100%
(5000-<50,000/µl)	12(31.6%)	12(31.6%)	1(2.6%)	8.3%	100%
(≥ 50,000/µl)	11(28.9%)	11(28.9%)	8(21.0%)	72.7%	100%

DISCUSSION

The sensitivity of UMT established in this study was quite low (44.7%) while the specificity was very high (98.9%). The sensitivity of UMT observed in this study was below the WHO recommendation for an appropriate malaria rapid diagnostic test while the specificity was consistent with the WHO recommendation[20]. The implication is that at a sensitivity of 44.7% the kit is capable of detecting 44 out of 100 children with malaria. This implies that it will miss more than 55% of the children who have malaria. The sensitivity of UMT observed in this study was comparable to what has been reported in other studies elsewhere[21-23]. However, it was lower than what has been reported in other studies conducted in Nigeria[10,24,25]. Egbuche et al.[26] observed a higher sensitivity of 76.9% in a study conducted in Awka North Local Government Area of Anambra State. Although both children and adults were included in the study. The variations in the sensitivity of UMT in different settings may be due to differences in the methodology or parasite density in the area. The positive and negative predictive value of UMT observed in this study was high and is comparable to what has been reported in other studies[25, 27, 28].

A high sensitivity (97.4%) and specificity (94.8%) of BMRDT was observed in this study. The performance of BMRDT in this study is in line with the WHO recommendation for an appropriate malaria rapid diagnostic test. The sensitivity of 97.4% implies that the test is capable of detecting 97 out of 100 children that have malaria. This means that it will miss less than 3% of children who have malaria. The sensitivity and specificity of BMRDT in this study was comparable to what was reported in other studies, done in Enugu and Sokoto[29,30]. However, the sensitivity was higher than what has been reported in Zamfara State and Delta State[31,32]. The high sensitivity of BMRDT documented in our study may be due to the high parasite density observed.

CONCLUSION AND RECOMMENDATION

The sensitivity of urine malaria test observed in this study was below the standard set by the WHO while the performance of blood based malaria rapid diagnostic test was consistent with the WHO standard. A screening test for a devastating disease like malaria is expected to have high sensitivity. Therefore urine malaria test kits should not be used alone as a screening test for malaria in our locality.

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Conflict Of Interest Disclosure

All the Authors declared that there was no conflict of interest

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MOLECULAR EVALUATION OF *CHLAMYDIA TRACHOMATIS* AND *NEISSERIA GONORRHOEAE* INFECTIONS AND THEIR CO-INFECTION AMONG WOMEN WITH INFERTILITY ISSUES AT GYNEACOLOGICAL CLINICS IN ADO – EKITI, NIGERIA

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ABSTRACT

Background: *Chlamydia trachomatis* and *Neisseria gonorrhoeae* are obligate intracellular bacteria that cause urethritis, cervicitis, salpingitis, pelvic inflammatory disease, ectopic pregnancy, painful urination, abnormal and unusual increase discharge from the vagina and penis. Due to the similarities in these microorganisms' clinical presentations, one can be taken for the other.

Aim: This study evaluated the level of chlamydia and gonorrhoeae infections and their co-infection among women attending fertility clinics in Ado–Ekiti, Ekiti State.

Methods: 115 urine and 115 high vagina swab samples (230 samples) were collected from women attending selected fertility clinics. Rapid kits specific for *C. trachomatis* and *N. gonorrhoeae* were used and quantitative polymerase chain reaction (qPCR) was carried out to further test for these microorganisms in both urine and high vagina swabs samples.

Results: A total of 36 (31.3%) and 39 (33.9%) were positive to *C. trachomatis* and *N. gonorrhoeae* respectively when tested with rapid test kit using urine sample; 37 (32.2%) and 49 (42.6%) were positive to *C. trachomatis* and *N. gonorrhoeae* respectively when urine samples were tested with qPCR; 13 (11.3%) were positive *C. trachomatis* when HVS samples were tested with qPCR, 51 (44.3%) were positive to *N. gonorrhoeae* with HVS samples when tested with qPCR. A total of 19 (16.5%) showed co–infection of *C. trachomatis* and *N. gonorrhoeae* with rapid kit using urine; 23 (20%) showed co–infection of these microorganisms when tested with qPCR and 9 (7.8%) showed co–infection from HVS samples tested with qPCR. Co–infection of *C. trachomatis* and *N. gonorrhoeae* were statistically significant ($P< 0.05$).

Conclusion: This study has indicated the need for inclusion of the screening of these organisms routinely especially in fertility centers and gynecological clinics. This will further help in combating the havoc that can be caused by these silent microorganisms.

Keywords: Infertility, *C. trachomatis*, *N. gonorrhoeae*, co–infection, women.

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INTRODUCTION

Chlamydia trachomatis is the most common sexually transmitted bacterial infections worldwide, and women carry the major burden of the disease, as well as the potential source of infection to their partners. The incidence of Chlamydial infections in women has increased dramatically from 79 to 467 per 100,000 between 1987 and 2003[1]. According to the World Health Organization report (WHO) [2], 101 million Chlamydial infections are detected annually worldwide. The clinical presentation, course, complications and late sequelae of *C. trachomatis* closely resemble *Neisseria gonorrhoeae* infection. There are four recognized species of Chlamydia: *C. trachomatis*, *C. psittaci*, *C.*

pneumoniae and *C. pecorum*. *Chlamydia trachomatis* includes the agents of trachoma, lymphogranuloma venereum (LGV), urogenital tract disease, and inclusion conjunctivitis[3]. No attempt has been made to comprehensively review the biology, pathogenesis, or epidemiology of *C. trachomatis* infections, although several excellent reviews have been published on these subjects[4]. The prevalence of *C. trachomatis* infection in sexually active adolescent women, the population considered most at risk, generally exceeds 10%, and in populations of women, the prevalence can reach 40%. The prevalence of *C. trachomatis* infection ranges from 4 to 10% in asymptomatic men and from 15 to 20% in men attending STD clinics[5]. Chlamydial infections in newborns occur as a result of perinatal exposure with approximately 65% of babies born from infected mothers becoming infected during vaginal delivery[6]. The biggest challenge to the control of Chlamydial disease is that as many as 70 to 80% of women and up to 50% of men who are infected do not experience any symptoms[7]. This results in a large reservoir of unrecognized, infected individuals who are capable of transmitting the infection to sexual partners. Contributing to this challenge is the fact that immunity following infection is thought to be type specific and only partially protective. Therefore, recurrent infections are common. Evidence suggests that the risk of developing sequelae such as ectopic pregnancy or infertility increases with each successive episode of infection[7, 2]. Although most infections caused by *C. trachomatis* in women are asymptomatic, clinical manifestations include cervicitis, urethritis, endometritis, PID, or abscess of the Bartholin glands[7, 5]. Although the initial site of infection is usually the cervix, the urethra and rectum may also be infected. Culture studies have shown that among women infected with *C. trachomatis*, 50 to 60% are infected at both the cervix and urethra, 30% have only cervical infections, and 5 to 30% have only urethral infections[8]. Pelvic Inflammatory Disease, which results from ascending infection, is responsible for most of the morbidity and cost resulting from chlamydial infection[9]. Chlamydial infections can apparently cause more severe tubal immunopathology than other agents in spite of the absence of overt symptoms. This is most probably due to the greater chronicity and fulminating character of Chlamydial infections compared with more acute infections such as gonorrhea[10]. Silent and untreated salpingitis is now recognized as a major cause of infertility as more than 50% of women with documented tubal occlusion report no history of PID but show serologic evidence of previous *C. trachomatis* infection. Similarly, multiple studies have shown associations between previous Chlamydial infection, both symptomatic and asymptomatic, and ectopic pregnancy. The prevalence of *C. trachomatis* infection in pregnant women ranges from 2% to 35%[11]. Pregnant women with Chlamydial infections are at increased risk for adverse outcomes of pregnancy, and postpartum PID. In one study by Martin *et al*.,[12] pregnant women with *C. trachomatis* infection were 10-fold more likely to have outcomes of stillbirth and neonatal death. Gestation periods were also significantly shorter in infected women.

There are 70 different strains of *N. gonorrhoeae*. Gonorrhea, or infection with the gram-negative coccus *Neisseria gonorrhoeae*, is a major cause of morbidity among sexually-active individuals worldwide. Extragenital infections of the pharynx and rectum are prevalent in certain groups, such as men who have sex with men (MSM). Invasive infections with *N. gonorrhoeae*, including disseminated gonococcal infection, endocarditis, and meningitis, are uncommon but can result in serious morbidity[13,14]. Gonococcal resistance to several classes of antimicrobial agents is widespread. The growing threat of antimicrobial resistance in *N. gonorrhoeae* highlights the importance of ensuring the availability of appropriate diagnostic modalities for surveillance[15]. *Neisseria gonorrhoeae* is a common cause of urethritis, particularly in urban areas. Disproportionately higher rates of infection are reported from sexually transmitted infection (STI) clinics compared with private sector settings, in part due to diagnostic and reporting characteristics in public settings. Sexually Transmitted Infection clinic-based studies suggest that the majority of infected men are symptomatic[16]. In contrast, population-based studies, suggest that up to 60 percent of men may be asymptomatic or have very mild symptoms. Two methods for detecting *N. gonorrhoeae* are culture and non-culture tests. Culture techniques are considered the tests of choice; but non culture techniques, which are less labor-intensive and are similar in accuracy to cultures, have replaced culture techniques in some instances. The newest non culture technique is the nucleic acid amplification test[17]. This test has good sensitivity (92 to 96 percent) and specificity (94 to 99 percent) compared with cultures.

As aforementioned, gonorrhea is frequently asymptomatic, and if symptoms are present, they are commonly nonspecific. Accordingly, appropriate laboratory diagnostics are crucial for confirmed diagnosis, case finding, and test of cure. This study aimed at evaluating *C. trachomatis* and *N. gonorrhoeae* infections and their co-infection among women with infertility issues at gyneacological clinics in Ado–Ekiti, establish the level of co-infection of *C. trachomatis* and *N. gonorrheae* among patients attending gyneacological clinics in Ado Ekiti L.G.A., Ekiti State, investigate the correlation between *N. gonorrhoeae* and *C. trachomatis* and infertility, compare the diagnostic methods, using the results obtained from both the rapid test kit results and PCR results and confounding factors in the diagnosis of the two infections. *N. gonorrhoeae* PID is often mistaken as *C. trachomatis* and both have been established to be responsible for high rate of infertility in both male and female. These organisms caused both preventable and treatable infertility and adverse pregnancy outcome, even though they can be asymptomatic and silent in some patients[18,19].

MATERIALS AND METHODS

Study Area

The study area is Ado–Ekiti, headquarter of Ado Local government area of Ekiti State. It is situated in southwest Nigeria and it is the State capital of Ekiti State. The latitude of Ado–Ekiti 7.612426 and the longitude is

5.237109. Ado–Ekiti is a city with GPS coordinates of 7^0 36'44.7336'N and 5^0 14'13.5924'E. The elevation of Ado–Ekiti is 430.582, with its time zone as Africa/Lagos. The population in 2006 was 308,621. The people of Ado–Ekiti are mainly of Ekiti sub–ethnic group of the Yoruba.

Study Location

This study of *Chlamydia trachomatis* and *Neisseria gonorrhea* co-infection was carried out among patients attending selected infertility clinics within Ado–Ekiti, Ekiti State. The selected hospitals are:

i. Ekiti State Teaching hospital, Ado-Ekiti.
ii. Olive Hospital, along housing road, Ado–Ekiti
iii. Maternal and Child hospital, along Federal Polytechnic/immigration road, Ado–Ekiti.
iv. ABUAD Multi-System Hospital, Ado–Ekiti.

These clinics were selected for their renowned facility, capability and efficiency in handling infertility or gyneacological cases, these clinics has an average of twenty patients or more per clinic days and have consultation days more than once a week.

Study Population

All the women attending infertility clinics within Ado –Ekiti Local Government Area were recruited and evaluated in this study.

Study Design

The study is a cross sectional investigation of infertile women for presence of *C. trachomatis* and *N. gonorrhoeae*. Random sampling of the study population was done using informed consent form.

Sample size

The sample size was obtained using the formula:

$$N = \frac{[(Z_1 - \alpha/2)^2 P(1-P)]}{d^2}$$ [37]

Where N=Minimum sample size

$Z_1 - \alpha/2$ = standard normal variant at 5% type 1 error, $P < 0.05$ =1.96 on the Z table

P = Expected prevalence in population based on previous studies or pilot studies (18.3%) [20].

d = Absolute error or precision, placed at absolute error of 5% = 0.05.

Substituting into the above stated formula:

The number of samples screened for both *C. trachomatis* and *N. gonorrhoeae* infections were 230 (115 urine samples and 115 HVS samples).

Ethical Clearance

Ethical approvals were obtained from the Ethical and Research Committees of both ABUAD Multi-System Hospital, Ado-Ekiti and College of Medicine and Health Sciences, ABUAD after consideration and review of the protocol for this study. The approval identification numbers were AMSH/ REC/EAH/44 and ABUDHREC/10/01/2021/001 from the multisystem hospital and the University respectively.

Sample collection and transportation

Informed consent forms were filled by the participants to ascertain their willingness and voluntary participation. Those who were not comfortable with the exercise were excluded from the study. Questionnaires

were administered to volunteers who filled and were willing to give samples. A total number of 230 samples (urine and HVS samples) were collected from volunteers. It was collected within a period of one year. About 15 mls urine samples in sterile universal bottle with laboratory number, date and time of collection, were packed in a clean leak proof ziplock and transported in ice packs to Medical Laboratory Science (MLS) Department, ABUAD. The HVS tips were cut with a sterile scissors in a viral transport medium (VTM) and transported to MLS Department, ABUAD.

Specimen Processing

Ten (10) mls of urine samples were centrifuged at 1000 rpm for 10 minutes and the supernatants was discarded and the precipitate was used for the detection. 5 mls of the urine samples in a sterile plain sample bottles were frozen at -20^0C in the laboratory refrigerator. The urine samples were processed at the laboratory of each selected clinics before transporting it to Medical Laboratory Science department, ABUAD. The HVS tip was also frozen at -20^0C in the VTM vials. The frozen samples were transported while maintaining its cold chain to Biorepository and Clinical Virology Laboratory, University College Hospital, Ibadan, Oyo State for PCR test.

Detection of *Chlamydia trachomatis* Antigen in Urine Samples

The rapid test for detecting *Chlamydia trachomatis* antigen was used (Wandfo Biotech Co. Limited catalog No: N 35-C (4.0) mm, South China University of Technology, Guuagyzhon, P.R. China)[39,21]. The Wandfo Biotech one step Chlamydia swab/urine test is a rapid immune chromatographic test for the visual detection of *Chlamydia trachomatis* antigen in urine specimens or endocervical swab specimens. This test adopts double antibodies sandwich method. When exactly four drops of the specimen is added to the sample well, the specimen is absorbed into the device by capillary action, mixes with the antibody-dye conjugate, and flow across the pre coated membrane. When the *Chlamydia trachomatis* antigen levels are at or above the target cut off, the antigen in the specimen binds to the antibody- dye conjugate are captured by monoclonal antibody immobilized in the region (T) of the device. This produces a coloured test and indicates a positive result. When the cut off antigen levels are zero or below the target cut off (the detection sensitivity of the test), there is not a visible colored band in the test region (T) of the dense, which indicates a negative result. To serve as a procedure control, a coloured line will appear at the control region (C), if the test has been performed properly[21].

Test procedure I

Samples were brought to the laboratory, the same day it was collected in a cold chain and were tested immediately without delay. About 15 mls of urine specimen each was collected from volunteers into a clean sterile universal bottle. 10 mls of the urine specimen each was transferred into a clean, dry, sterile centrifuged tubes and was centrifuged at 1000 rpm for 10 minutes. After centrifuging, the supernatant was discarded and the precipitate was used for detection. In the tubes with the precipitated, 300 µl extraction of buffer A was added to

each and mixed well. After five minutes, 300 µl extraction of buffer B was also added to each tube and was mixed. The test cassette was removed from its sealed foil pouch by tearing along the notch. 4 drops (100 µl of the Liquid from the extraction tube) was dispense into sample well of test cassette using a separator dropper for each tubes. The reactions were observed and the results were read and recorded after 5 minutes respectively.

Interpretation of Results

Positive result

Appearance of visible two rose pink bands in both the control region and test region indicates that there is presence of *Chlamydia trachomatis*.

Negative result

One rose-pink band in the control region with no apparent band in the control region with no apparent band in the test region indicates that *Chlamydia__trachomatis* antigen is absent

Detection of *Neisseria gonorrhoeae* Antigen in Urine Samples

The rapid test kit for *N. gonorrhoeae* manufactured by Maternova Biotech Co. Catalog No: MA 2033, North America, USA. The test works by defecting the *N. gonorrhoeae* antigen in the urine/urethral sample as it flows through the assay by first; *N. gonorrhoeae* antibodies conjugated with colloidal gold that attach to *N. gonorrhoeae* antigen and provide a "visual tag" for antigen – antibody colloidal gold complex and second; by a last zone with immobilized antibodies that capture the complex, the visual tags producing a visible pink-coloured band that is confirmation of the presence of *N. gonorrhoeae* and a positive result for gonorrhea. If there is no pink line, *N. gonorrhoeae* is not present, indicating result for absence of gonorrhea. Results are ready in few minutes[22].

Test procedure II

The cassette was removed from the seal pouch and was used immediately. The extraction buffer was added to the urine deposit, mixed properly and left for about 2 minutes. The test cassette was placed on a clean and leveled surface, 3 drops of the extraction solution (approximately 100 ml) was dropped into the specimen into the specimen well of the test cassette, then the start timer was set. It was observed for coloured line(s). It was read after 10 minutes.

Interpretation of Results

Positive result

Appearance of visible two pinks bands in both the control and test regions indicates that there is presence of *N. gonorrhea*

Negative result

One pink hand in the control region with no visible band at the test region indicates that no *N. gonorrhea* antigen in present.

Invalid result

Either one pink band or two pink band in control region only or both control and test region are considered invalid if cassette are left unread after 30 minutes and still showed visible bands

Polymerase Chain Reaction (PCR)

DNA was extracted from 200 µl urine samples under sterile conditions using DaAnGene extraction kit (decode genetics)

following the manufacturers manual. The extracted DNA (s) was stored at –20ºC until amplification.

qPCR primer design

The 23S rRNA genomics DNA specie specific region was used to design specific primers for the diagnosis of *C. trachomatis* and *N. gonorrhoeae*. 23S rRNA sequences for *C. trachomatis* were obtained from the genebank database on National Center for Biotechnology Information (NCBI) website. This was done by accessing NCBI website (*http://www.ncbi.nlm.nih.gov/*), then selecting nucleotide from the drop down and key in *C. trachomatis* 23S rRNA gene in the search box and send, sequence related were made accessible and a total of 50 accessions were selected for cluster multiple alignment. These sequences were uploaded in a bioedit software and cluster ran to reveal converse regions unique to all strains of *C. trachomatis* 23S rRNA and this was used in primer designing. *https://www.idtdna.com/PrimerQuest/Home/Index* site was then accessed and sequenced pasted in the sequence entry box and multiple qpcr primers were generated. It is very necessary to ensure that the primers anneal to region where *C. trachomatis* 23S rRNA sequences are conserved. Each primer pair was then checked for specificity to be sensitive to only *C. trachomatis* 23S rRNA and also ability to cut across all strains then the best primer was selected and synthesized in Inqaba Biotech in South Africa. The 23S rRNA genomic DNA for *N. gonorrhoeae* gene was also designed following the same procedure.

qPCR

qPCR was carried out using the Luna universal qpcr master mix (New Biolab) following the manufacturers protocol. 20 µl total reaction volume consisting of 10 µl Luna universal qPCR master was mix, 0.25 µl forward and reverse primer were made from 15µl with sterile distilled water to which 5 µl DNA template was added. qPCR reaction was carried out in a CFX96 real time system C1000 thermal cycler system (BioRad., USA) with a cyclic conditions including initial denaturation at 95ºC for 1 minute, followed by 40 cycles of each cycle comprised of 30 seconds denaturation at 95ºC, 30 seconds annealing at 60ºC, plus plate reading, termination at 72ºC for 10 minutes. Results were read on the screen based on the threshold cycle (CT Value) of each cycle using each primer.

Data Analysis

Results obtained from Laboratory tests kit, questionnaires and qPCR test results were summarized on tables with frequency and percentage.

Table 1: Showing the forward and reverse primer sequence

Specimen	Primer name	Primer sequence
C. trachomatis	ChTF	TGATAGCGTCACACCAAGTG
	ChTR	CCTGCTGAACCAAGCCTTAT
N. gonorrhoeae	NeGF	CGTAGACACTCGTCATCACTTC
	NeGR	TAGCTTGTTTAAGCCGGTAGG

RESULTS

Demographic Characteristics of the Subjects

The age of participants ranges between 25–50 years, the highest percentage (34.7%) of the participants in this study fell within the age range of 36–40 years while the lowest percentage (9.6%) of participant were in the age range of 20–25 years (Table 2). A total of 98.2% of the participant were currently married while the rest were either divorced (0.9%) or have re–married (0.9%), (Table 2). The highest percentages (34.8%) of the participants have been married for 7–10 years while 1.7% of them were in marriage of less than one year (Table 2). A total of 69.6% of the participant have had previous history of sexually transmitted disease while 30.4 had no such record (Table 2). In the present study, about 56% of the participants have combination of signs and symptoms of sexually transmitted infections. About 23% reported no such symptoms while 10.4% reported itching as most obvious sign of STI (Table 2). A percentage of 47 of the participants reported improper diagnosis of their condition at their hospitals while 61% admitted that they were properly diagnosed (Table 2). There were various responses as to the spouse of the participant agreeing to be treated for the symptoms noticed (Table 2). About ninety percent (91.3%) of the participant admitted that they have been not been pregnant before (primary infertility) while 8.7% were cases of secondary infertility (Table 2). About 4.3% of the participant recorded miscarriage at 1–2 months, 3.55 had miscarriage at 3–4 months of pregnancy, 0.9% confirmed miscarriage at 5–6 months while about 91% had no experience of miscarriage (Table 2). Some of the participants (8.7%) have had previous cases of fibroid while about 90% never had a case of fibroid. History of stillbirth was reported by 7.0% of the participant and over ninety (93%) had no such experience (Table 2).About 5 % were not aware if they had had any form of hormonal imbalance as they were never tested nor diagnosed for it, some (7%) agreed of being diagnosed, while 89.6% were never tested or diagnosed of any form of hormonal imbalance (Table 2). About 55.6% of the participant admitted to have had some STI/STD's symptoms at different time but never treated and felt these symptoms has cleared without any treatment, 2% are indifferent as they do not treat nor felt any symptoms, 42.6% agreed to have treated in different ways (Table 2). Among the participants, 4.3% admitted that there was a delay in childbearing in their family and that of their spouses, about 8% had no idea of any delay in either their family or that of their spouses', over 80% reported there was no such history in both their family and the spouses' family (Table 2). About 3.5% admitted that for a period of 4–6 years there was delay in child bearing in their family lineage, 4.3% reported 7–9 years, 11.3% agreed it was over 10 years, 80.9% reported no such waiting period in their family lineage (Table 2).

Analysis of the Samples by the Diagnostic Methods Employed

When urine samples were tested with rapid kit, 31.3% tested positive to *C. trachomatis* and 33.9% tested positive to *N. gonorrhoeae* (Table 3). With qPCR, 32.3% tested positive to *C. trachomatis* when urine samples were tested and 42.6% tested positive to *N.*

gonorrhoeae with urine samples as well (Table 4). In the current study, HVS samples tested for *C. trachomatis* and *N. gonorrhoeae* infections with qPCR, 11.3% tested positive to *C. trachomatis* and 44.35 tested positive to *N. gonorrhoeae* (Table 5). In the study, a co–infection of these microorganisms was evaluated with rapid test kit and qPCR, in urine samples from these subjects, 16.5% and 20.0% tested positive with rapid kit and qPCR respectively from urine (Table 6). HVS tested with qPCR recorded co–infection rate of 7.8% (Table 6). The co–infection in urine samples tested with rapid test and co–infection in urine sample tested with qPCR, were not significantly different ($P>0.05$) (Table 7). The level of co–infection in urine sample tested with rapid kit and co–infection from HVS tested with qPCR is significantly different ($P<0.05$) (Table 7). The number of positive cases for *C. trachomatis* in HVS tested with qPCR was significantly different from that of urine tested with rapid kit ($P < 0.000$) (Table 8). Table 9 showed significance differences in the number of participant who tested positive *N. gonorrhoeae* when HVS was tested with qPCR and urine rapid test ($P<0.05$). HVS samples tested with qPCR for *N. gonorrhoeae* infection and urine samples tested with qPCR for *N. gonorrhoeae* as well were not significantly different ($P>0.05$) (Table 10) while urine samples tested with qPCR for *C. trachomatis* and HVS tested with qPCR for this same organism were significant ($P<0.05$) (Table 11). The level of co–infections of HVS tested with qPCR and that of urine tested with qPCR were also significant ($P<0.05$) (Table 12). The confounding factors such as; previous history of fibroid, properly treated infections either with antibiotics or injections, those that have experienced still birth or ectopic pregnancy, subjects with previous history of delay or bareness in either their family or husband's. This study showed that these factors were insignificant to the outcome of the test results.

Table 2: Demographic characteristics of subjects from the selected hospitals with frequency and percentage

Age distribution of participants	N	%
20 – 25	11	9.6
26 – 30	18	15.7
31 – 35	30	26.1
36 – 40	40	34.7
41 – 50	16	13.9
Total	**115**	**100.0**
Marital status	N	%
Currently married	113	98.2
Divorced	1	0.9
Re – married	1	0.9
Total	**115**	**100.0**
Duration the participants have been married		
Number of year(s) married	**N**	**%**
>1	2	1.7
1 – 3	25	21.7
4 – 7	27	23.5
7 – 10	40	34.8
> 10	21	18.3
Total	**115**	**100.0**
Previous history of sexually transmitted infection or diseases		
Responses	**N**	**%**
Yes	80	69.6
No	35	30.4
Total	**115**	**100.0**
Visible signs and symptoms noticed by participants for STI/STDs		
	N	%
None	27	23.5
Itching	12	10.4
Smelling discharge	5	10.4
Painful urination	1	0.9
Delayed menstrual cycle	2	1.7
Smelly menstrual cycle	3	2.6
Combination of symptoms	65	56.5
Total	**115**	**100.0**
Improper diagnosis of subjects' at their various hospitals		
Response	**N**	**%**
Yes	54	47.0
No	61	53.0
Total	**115**	**100.0**
Response to the treatment of previous infection by the subjects' spouses		
Response	**N**	**%**
Not applicable	12	10.4
Strongly agree	23	20.0
Agree	19	16.5
Neutral	2	1.7
Strongly disagree	21	18.3
Disagree	38	33.0

Total	**115**	**100.0**
Number of subjects that have been pregnant before		
Response	**N**	**%**
Yes	10	8.7
No	105	91.3
Total	**115**	**100.0**
Duration of the pregnancy had by the subjects before miscarriage		
	N	**%**
Not applicable	105	91.3
1 – 2 months	5	4.3
3 – 4 months	4	3.5
5 – 6 months	1	0.9
	115	**100.0**
Previous history of fibroid		
Response	**N**	**%**
Yes	10	8.7
No	105	91.3
Total	**115**	**100.0**
Previous history of still birth or ectopic pregnancy among subjects' tested		
Response	**N**	**%**
Yes	8	7.0
No	107	93.0
Total	**115**	**100.0**
Number that were diagnosed with hormonal imbalance		
Response	**N**	**%**
Yes	7	6.1
No	103	89.6
Not aware	5	4.3
Total	**115**	**100.0**
Number of subject that had signs / symptoms of STI/STDs and never treated with spouses but felt it has cleared after a while.		
Response	**N**	**%**
Not treated	64	55.6
Indifferent	2	1.7
Treated	49	42.6
Total	**115**	**100.0**
History of delay in childbearing in the subjects' family or spouses'		
Response	**N**	**%**
Yes	5	4.3
No	100	87.0
Not aware	10	8.6
Total	**115**	**100.0**
History of delay and duration of waiting before childbirth in the subjects' or spouses' family		
Number of years	**N**	**%**
Not applicable	93	80.9
4 – 6 years	4	3.5
7 – 9 years	5	4.3
>10 years	13	11.3
Total	**115**	**100.0**

Table 3: Numbers of positive cases of the microorganisms tested with rapid test kits using urine samples (n = 115).

Parameters	Positive	Negative	Percentage positive (%)
Number of *C. trachomatis* that were positive in urine samples tested with rapid kit.	36	79	31.3
Number of *N. gonorrhoeae* that were positive in urine samples tested with rapid kit.	39	76	33.9

Table 4: Numbers of positive cases of the microorganisms tested with qPCR using urine samples (n = 115).

Parameters	Positive	Negative	Percentage positive (%)
Number of *C. trachomatis* that were positive in urine samples tested with rapid kit.	37	78	32.2
Number of *N. gonorrhoeae* that were positive in urine samples tested with rapid kit.	49	66	42.6

Table 5: Numbers of positive cases with qPCR using high vaginal swab (HVS) samples (n = 115).

Parameters	Positive	Negative	Percentage positive (%)
Number of *C. trachomatis* positive cases when HVS samples were tested with qPCR.	13	102	11.3
Number of *N. gonorrhoeae* positive cases when HVS samples were tested with qPCR.	51	64	44.3

Table 6: Level of co – infection by the microorganisms (n = 115).

Parameters	Positive	Negative	Percentage positive (%)
Level of co – infection using urine when tested with rapid kit.	19	96	16.5
Level of co – infection using urine when tested with qPCR.	23	92	20.0
Level of co – infection using HVS when tested with qPCR.	9	106	7.8

Table 7: Rate of co–infection of both microorganisms tested with rapid kit and qPCR.

Parameters	Number positive	T – value (t ≥ 1.98)	P – value (< 0.05)
Co – infection in urine samples tested with rapid kit.	19 (11.5)	- 1.138	0. 259
Co – infection in Urine sample tested with qPCR.	23(20)		
Co- infection in urine sample tested with rapid kit.	19 (11.5)	2.095	0.038
Co – infection from HVS tested with qPCR.	9 (7.8)		

Table 8: Number of *C. trachomatis* positive in urine tested with rapid test and HVS tested with qPCR.

Parameters	Number positive	T – value (t ≥ 1.98)	P- value (<0.05)
HVS using qPCR.	13 (11.3)	-4.599	0.000
Urine using rapid test.	36 (31.3)		

Table 9: Number of *N. gonorrhoeae* positive in HVS tested with qPCR and urine tested with rapid test.

Parameters	Number positive	T – value (t ≥ 1.98)	P – value (<0.05)
HVS tested with qPCR.	51 (44.3)	-0.470	0.000
Urine tested with rapid test.	39 (33.9)		

Table 10: Number of *C. trachomatis* positive when both urine and HVS were tested with qPCR.

Parameters	Number positive	T – value (t ≥ 1.98)	P – value (<0.05)
Urine tested with qPCR.	37 (32.2)	0.428	0.000
HVS tested with qPCR.	13(11.3)		

Table 11: Number of *N. gonorrhoeae* positive when both urine and HVS were tested with qPCR.

Parameters	Number positive	T – value (t ≥ 1.98)	P – value (<0.05)
Urine tested with qPCR.	49 (42.6)	7.368	0.639
HVS tested with qPCR.	51 (44.3)		

Table 12: Number of co – infection positive when both urine and HVS were tested with qPCR.

Parameters	Number positive	T – value (t ≥ 1.98)	P – value (<0.05)
Co – infection urine tested with qPCR.	23 (20)	0.577	0.000
Co – infection HVS tested with qPCR.	9(7.8)		

DISCUSSION

C. trachomatis and *N. gonorrhoeae* have long been known to cause mild to chronic infection in humans such as urethritis, endemic trachoma, cervical pains, pelvic inflammatory disease, painful urination, ectopic pregnancy amongst others. This study was aimed at evaluating the level of *C. trachomatis* and *N. gonorrhoeae* infections as well as determining the level of co–infection of these microorganisms among women attending infertility clinics within Ado–Ekiti. Statistical data obtained from Nigeria (Southern, South East, Northern parts), Ghana, and other developing countries such as Philippines, Asia and India revealed that the screening for either or both organisms is not included in the routine/regular test in either antenatal or any gyneacological/fertility clinics probably because of their silent nature or due to lack of possible publicity, lack of information on proper screening methods of these microorganisms, and their mis-diagnosis. These organisms have been implicated as cause of health problems in both males and females, pregnant women, newborns as well as the foetus. In this study, emphasis was on each of the organisms as causes of severe reproductive damage individually and in combination because of the way both organisms are mistaken for each other considering the similarity in their clinical presentations, although differing in the treatment approach due to the hierarchy of drug usage. In the studied population, a total of 230 specimens were tested: 115 urine samples were tested for both *C. trachomatis* and *N. gonorrhoeae*, 115 HVS specimen were tested for these same organisms. Both samples were collected from same subjects. *C. trachomatis* infection is most commonly reported natural noticeable disease in the United States, with more than 900,000 cases reported to state and local health departments in 2015, among obstetrics and gyneacology cases. So also in Philippines, between the year 2012–2016, with about 53% positive among sex female workers and 62% among already confirmed cases of infertility[23] and in countries like United State, Philippines, indiscriminate use of antibiotics is not common hence the validity of the reports recorded. This report from Philippines is higher than the results from Chlamydia screening from the present study. This is likely to be due to the category of subjects screened but still confirming the existence of this organism in females. The prevalence of genital chlamydia and gonococcal infections in women at risk in the Kumasi Metropolis, Ghana, and between women aged between 18–35 years with a history of having at least 3 sexual acts per week and having at least 2 sex partners in the previous 3 months reported 4.8% positive to chlamydia and 0.9% participants positive to gonococcal infection[24]. A study done on women who attended the gyneacology clinic of Korle Bu Teaching Hospital, Accra, Ghana for various reasons reported a prevalence of 4.9% and 3.1% respectively for *C. trachomatis* and *N. gonorrhoeae* In the same study, postpartum women tested for these organisms showed 7.7% and 3.4% positive to *C. trachomatis* and *N. gonorrhoeae*[25]. Dela *et al*.[26] found gonorrhoeae and chlamydia transmission in selected health facilities in Ghana as 28% who had gonorrhoeae and 11% who had

chlamydia. The reported positive results were low to that obtained from this study. Understanding the incidence rate and the multinational epidemiology of *N. gonorrhoeae* has helped developed countries with prevention and control policies. The World Health Organisation estimated that approximately 87 million new Gonococcal infections occurred among 15–49 years old in 2016[27]. The estimated global prevalence in 2012 was 13 million cases of *C. trachomatis* and 78 million cases of *N. gonorrhoeae* in adults between the ages of 15-49 years[28]. The annual estimation indicates different rates from 1.9%-30.6% in pregnant women and 1.6–18% in neonates[29]. It was also reported that *C. trachomatis* is the most frequent infectious agent accounting for 18% to 50% of all neonatal conjunctivitis and 3% to 20% of infantile pneumoniae[29]. Likewise, about half of the neonates born from infected mothers with *N. gonorrhoeae* will develop neonatal conjunctivitis[30]. Untreated gonococcal conjunctivitis may lead to corneal scarring and blindness whereas the risk of severe ocular damage is high with a co–infection with *C. trachomatis*. A prevalence of 38.18% was reported by Costumbrado *et al*[31]. This prevalence of *C. trachomatis* infections in patients attending gyneacological clinics was reported in Zaria, Northern Nigeria. High vaginal swab samples were used and enzymes linked immunosorbent assay (ELISA) was used for the detection. This prevalence was higher than the result obtained from this research (11.3%), probably due to the different method used in screening. In 2016, Okunola *et al*[32] carried out this study on antenatal patients in Ile–Ife, to find out the prevalence of *Chlamydia trachomatis* only. It was recorded that 10%-15% of untreated Chlamydia cases led to pre–term delivery and neonatal conjunctivitis after a follow up with the antenatal patients for a period of time. Adachi *et al*[33] reported a research on *C. trachomatis* on sexually active asymptomatic females in Okada, South–South, Nigeria using different types of kits to screen 170 females using their urine samples a total of 7.85% were found positive despite their asymptomatic state. The result (32.2%) from this research is higher which may be due to the category of subjects tested. However, this previous research has shown even if a patient is asymptomatic, the 'silent' Chlamydia is present. Keshinro, *et al*[20], studied the prevalence of HIV, Chlamydia and Gonorrhoeae co–infections among men having sex with men, and transgender women in Abuja and Lagos State, Nigeria. A prevalence of 18.3% co-infection of *N. gonorrhoeae* and *C. trachomatis* was reported among women in Lagos State. This is lower to the result (20%) recorded in this research, but this has also confirmed the possibility of co–infection of these microorganisms among women. These are major health concerns in which this research has helped to shed more light. Consequently, if the mothers are checked for these organisms, proper treatment and monitoring will be given to both waiting and pregnant women, so as to avert any complications that can arise. This study has also showed that the prevalence of *N. gonorrhoeae* is higher when urine samples were tested with both rapid kit and qPCR as well as when HVS

samples were tested with qPCR, hence the organism is of medical importance. Also, based on this study, *C. trachomatis* urine sample is better for its diagnosis compared to high vagina swab.

CONCLUSION

Comparative methods used in screening for *C. trachomatis* and *N. gonorrhoeae* in the research work have clearly shown that polymerase chain reaction test procedure is significant. It revealed the presence of these microorganisms in samples analyzed. Despite this, rapid test kit for preliminary screening is also significant. Most previous studies were basically done using complement fixation test, rapid test kit and ELISA. The most recommended is the use of PCR, despite its drawback in cost of running this test, is still worth screening patients especially those attending infertility clinics and the best sample to use when testing for *C. trachomatis* is urine while for *N. gonorrhoeae*, high vagina swab (HVS).

RECOMMENDATION

Proper screening of patients: women attending infertility clinics, pregnant women, and their husbands for *C. trachomatis* and *N. gonorrhoeae* as a routine test before undergoing IVF and /or delivery. Proper and consistent monitoring and a repeat test should be carried out after a month from the first time of being tested and treated. Patients, health providers should be educated at all level of health care.

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