TABLE OF CONTENTS

1. **PERCEPTION OF PHYSIOTHERAPY STUDENTS TOWARDS SPECIALIZATION IN GERIATRIC PHYSIOTHERAPY IN SOUTH-WEST NIGERIA:** *ADELEKE, J. O., TABITI, O.O, ZAKI, D. A, AKINTAYO, D. N, JOHN-CHU, C.G, UZOHUE, B.O……3-21*

2. **KNOWLEDGE OF ARTIFICIAL INTELLIGENCE IN CLINICAL RADIOGRAPHY PRACTICE AMONG RADIOGRAPHERS IN SELECTED CITIES IN NIGERIA:** *OKPALEKE, M. S.……22-40*

3. **MODELS OF DAMAGES CAUSED BY MICROSPORIDIA INFECTION AMONG HIV-POSITIVE PATIENTS IN WHITE ALBINO MICE (*mus musculus domesticus*):** *NYAMNGEE, A., OLATUNDE, K. I. ……41-56*

4. **IMPACT OF VOLUME-ORIENTED INCENTIVE SPIROMETRY ON INSPIRATORY HOLD VARIABLE OF PATIENTS WHO HAD INVASIVE THORACIC PROCEDURE:** *OBASEKI, C.O., BASHIR, O.J., OKUGBO, S., FAWOLE, H.O., OSAHENI, O.……57-65*

5. **ASSESSMENT OF ADIPONECTIN, TRIGLYCERIDE, AND CHOLESTEROL LEVELS AMONG ELDERLY RESIDENTS OF NNEWI, ANAMBRA STATE, NIGERIA:** *IHIM, A.C., UDECHUKWU, J.C., OBI, P.C., IKWELLE, T. A., OBI, C. U., OGALAGU, R.O., OSAKUE, N.……66-76*

6. **ASSOCIATION AMONG HEALTH STATUS, DISABILITY PROFILE AND WORK- RELATED QUALITY OF LIFE OF STAFF OF A UNIVERSITY:** *DADA, O.O., ADEYEMI, A.O., FATUDIMU, M. B.……77-91*

7. **PHYTOCHEMICAL SCREENING AND *in vitro* ANTIOXIDANT PROPERTIES OF *persea americana* SEED GROWN IN NNEWI, SOUTH EASTERN NIGERIA:** *EJIOGU, I.C., MADUKA, H.C., MADUKA, I. C.……92-102*

8. **EVALUATION OF URIC ACID, CREATININE, AND ESTIMATED GLOMERULAR FILTRATION RATE IN ELDERLY AND ADOLESCENT POPULATIONS IN NNEWI METROPOLIS:** *IHIM, A.C., DAVID, F.C., OBI, P. C., OBI, C.U., IKWELLE, T.A., OGALAGU, R.O.*……*103-112*

9. **ASSESSMENT OF ANTIMICROBIAL POTENTIALS AND MINIMUM INHIBITORY CONCENTRATION (MIC) OF EXTRACTS OF DRY *carica papaya* SEEDS ON MULTIDRUG RESISTANT (MDR) CLINICAL MICROBIAL ISOLATES:** *OKEKE-NWOLISA, B.C., BENEDICT, J. C.*……*113-139*

10. **PREVALENCE AND PATTERN OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG LOAD CARRIERS IN IBADAN METROPOLIS:** *TABITI, O.O., AYOMIKUN, O.O., FAPOJUWO, O., ADEYEMI, T*……*140-150*

ORIGINAL RESEARCH

PERCEPTION OF PHYSIOTHERAPY STUDENTS TOWARDS SPECIALIZATION IN GERIATRIC PHYSIOTHERAPY IN SOUTH-WEST NIGERIA

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ABSTRACT

Background: As the global geriatric population increases, so does the demand for specialized physiotherapy services to address the unique health challenges of older individuals. However, there is a growing shortage of geriatric physiotherapist specialists, which may adversely affect the care of elderly individuals at risk of chronic conditions, immobility, and falls.

Aim of the Study: The study aimed to explore the perception of physiotherapy students towards specialization in Geriatric Physiotherapy, in South-West Nigeria

Materials and Methods: This is a cross-sectional survey involving 264 clinical physiotherapy undergraduates in South-West Nigeria. Participants were assessed using a questionnaire, adapted from a previous similar study. Data was analyzed using descriptive statistics and inferential statistics of Chi-square test, at <0.05 level of significance.

Results: The participants' mean age was 21.85±2.174 years, with majority being males (53%). Majority (65.4%) had attended lectures on geriatrics or had clinical experience in the management of geriatric patients. There was a moderate level of interest in geriatrics specialization (17.7%) while job accessibility (29.7%) and potential salary (33.1%) were the top motivators of specialization in geriatrics physiotherapy. Clinical experience (22.9%) was the most significant factors that influenced participants' opinion on geriatric physiotherapy. There was no significant association between the perception of the clinical physiotherapy undergraduates towards specialization in geriatrics physiotherapy and the sociodemographic variables- gender (p=0.473), age (p=0.469), level of study (p=0.776) and school (0.128).

Conclusion: Clinical physiotherapy undergraduates generally value geriatric sessions and show moderate interest in specializing in geriatrics and there was no significant association between their perception and sociodemographic variables.

Keywords: Perception, Physiotherapy, Specialization, Geriatric Physiotherapy.

INTRODUCTION

Physiotherapy plays a critical role in restoring and maintaining functional abilities, as well as enhancing the quality of life of older adults, particularly those with frailty or disabling impairments[1]. As the prevalence of age-related conditions such as musculoskeletal and neuro-degenerative disorders rises, the demand for specialized geriatric physiotherapy services is expected to increase significantly[1,2]. Physiotherapists engage in a variety of treatment approaches aimed at increasing mobility, preventing injuries, and supporting functional independence in older individuals[3,4]. This comprehensive approach is essential, particularly given the physical decline that accompanies ageing, which includes muscle strength loss, reduced stamina, balance, and bone density[5].

As the geriatric population faces an increased risk of falls, functional decline, and chronic diseases, engaging in regular physical exercise has been shown to mitigate these age-related physiological changes, enhance cognitive function, and preserve the capacity for Activities of Daily Living (ADLs)[6]. Physiotherapists are essential in geriatric care, providing fall prevention strategies, pain management, post-operative rehabilitation, and promoting independent living[7,8,9]. The expanding the role of physiotherapy in the care of older adults highlights the need for more specialized training and expertise.

Despite the growing need for geriatric physiotherapy, the profession is experiencing a shortage of physiotherapists specializing in this field[10]. Studies reveal that that while older adults represent a significant portion of patients requiring physiotherapy, physiotherapists that specialize in geriatric care are few[3,11]. Additionally, studies have indicated that positive clinical placements can enhance students' perceptions of geriatric physiotherapy and potentially increase interest in this specialty[12]. However, this area often ranks lower in preference compared to more popular specialties such as sports or musculoskeletal physiotherapy[13].

The global rise in life expectancy and the increasing geriatric population have created a heightened demand for specialized geriatric physiotherapy services to address the complex healthcare needs of older adults[14]. This shortage of physiotherapists specializing in geriatrics, may negatively impact the quality of life and functional independence of elderly individuals, who are at an increased risk of chronic conditions, falls, and immobility[10,15]. In Nigeria, where the ageing population is increasing, understanding the perceptions of physiotherapy students toward geriatric physiotherapy is critical for shaping future healthcare services. Also, research focusing specifically on the perception of physiotherapy students towards specialization in geriatric physiotherapy is sparse. This knowledge gap is crucial for developing educational programmes and strategies that can incentivize students to pursue this specialty. Inadequate study data on physiotherapy students' career preferences hampers effective workforce planning and presents a significant barrier to addressing the healthcare needs of Nigeria's ageing population.

This study, therefore, aimed to explore the perception of physiotherapy students towards specialization in geriatric physiotherapy in South-West Nigeria

MATERIALS AND METHODS

Study Design

This study was a cross-sectional study involving 264 students selected from physiotherapy departments in seven universities in South-West Nigeria. The sample size was calculated using Slovin's formula[16] to give a sample size of 264. Quota sampling method was used to recruit clinical physiotherapy undergraduates for

this study from the various physiotherapy departments in universities in South-West Nigeria.

Study Area: Participants in this study were clinical physiotherapy undergraduates from the various physiotherapy departments in universities in South-West Nigeria (Bowen University, Iwo; Chrisland University. Ogun State; Obafemi Awolowo University, Ife; Redeemers University, Ede; University of Ibadan, Ibadan; University of Lagos, Lagos; University of Medical Sciences, Ondo State).

Study Population: The participants of this study were clinical physiotherapy students, who were aged 15 years and older. The participants excluded from this study were undergraduate students who had suspended studies or taken a gap year. Consent was obtained from each of the participants after the aims of the study had been explained to them. The participants' sociodemographic variables (gender, age, training institution, and level of study) were documented.

Ethical approval: This study was approved by Bowen University Teaching Hospital (BUTH) Health Research and Ethics Committee (HREC) (BUTH/REC-1112).

Research Instruments

A modified version of the questionnaire developed by Marques et al.[17] titled “Perception of Final Year Physiotherapy Students on Specialization in Cardiorespiratory Physiotherapy” was used to obtain data from the students on their perceptions and towards specialization in geriatric physiotherapy. The questionnaire was adapted and validated. In Section A, questions on 'cardiopulmonary' placements were replaced with questions on “geriatric" placements while in Section C, questions on interest in specialization in 'cardiopulmonary' physiotherapy were replaced with questions on interest in specialization in ‘geriatric’ physiotherapy. The questionnaire consisted of 3 sections: clinical placement information, physiotherapy career intentions, interest or not in geriatric physiotherapy specialization, opinions of geriatric physiotherapy, and general questions and suggestions. Most questions were of a closed or categorical nature, using 5-point Likert scales, but offering participants an opportunity to comment openly where appropriate.

Data Analysis

Descriptive statistics of frequency count, percentage, range, mean, standard deviation, and charts were used to summarize participants’ sociodemographic data and their perceptions towards specialization in geriatric physiotherapy. Inferential statistics of the Chi-square test of association were used to determine the association between selected socio-demographic variables (age, gender, institution of training, and level of study) and the perception of the participants' students towards specialization in geriatric physiotherapy. The alpha level was set at 0.05.

RESULTS

Socio-Demographic Profiles

A total of 264 clinical physiotherapy undergraduates (53% males; mean age= 21.85±2.174 years) from seven physiotherapy departments in universities in South-West Nigeria participated in this study. The university with the highest number of participants was Bowen University, Iwo (30.5%) and majority of the participants (51.9%) were in their penultimate year (Table 1).

Geriatric lectures or geriatric physiotherapy clinical experience of participants

Approximately 65.4% of the participants had attended lectures on geriatrics or had clinical experience in the management of geriatric patients. These sessions were most frequently held during the fourth year of study (40.6%) and primarily occurred in institutional settings like teaching hospitals (24.8%) and general hospitals (11.7%). The perceived value of these sessions was mixed, with 25.9% finding them very valuable, while a smaller group (2.3%) found them not valuable at all. Enjoyment levels followed a similar pattern, with 18.8% rating the experience as very enjoyable (Table 2).

Participants' responses regarding career intentions in specializations in Physiotherapy

With respect to career intentions in physiotherapy specializations, the interest was highest in sports physiotherapy (36.5%) and orthopaedics physiotherapy (29.7%) respectively as participants expressed strong interest ("very much"). On the other hand, interest was lowest in specialization in community physiotherapy (10.5%) Geriatrics specializations had a more moderate level of interest, reflecting a diverse range of preferences among the participants for their future careers (very much:17.7%; Somewhat (24.1%). Table 3 shows the participants' career intentions across various physiotherapy specialties.

Participants' knowledge on geriatrics physiotherapy

Prior to entry into the physiotherapy programme, majority (52.6%) of the students were unaware of the role of physiotherapy in the management of geriatric conditions. A significant number (74.8%) did not have a clear idea of the specialty they wanted to pursue upon qualification. However, at their current stage, most of them (45.5%) had identified a specialty of interest, with sports physiotherapy (11.3%) and orthopaedics physiotherapy (10.5%) being the most popular choices. When asked about their interest in specializing in geriatrics physiotherapy, approximately half of them (50.4%) were unsure, indicating a potential for future specialization with proper exposure and guidance. Table 4 provides insights into participants' knowledge and awareness of geriatrics physiotherapy.

Factors influencing decision to consider specializing in geriatrics physiotherapy

Job accessibility (29.7%) and potential salary (33.1%) were the top factors that could strongly motivate specialization in geriatrics physiotherapy. Field experiences and interest in the field were also important, with most of the participants rating these factors highly (23.3% and 21.8% respectively). However, research potential and influence from others were less compelling, with lower percentages of participants (12.8% and 11.3%) considering them as decisive factors (Table 5).

Factors that serve as deterrents to working in geriatrics physiotherapy after graduation

The most common deterrent was a greater interest in another area of physiotherapy (22.6%). Poor job availability in the desired location (12%) and the potential for a better salary in another physiotherapy field (16.5%) were also significant factors. A smaller percentage (7.5%) reported that negative experiences in geriatrics physiotherapy could deter them, while 8.3% were certain they wanted to specialize in this field and would not be deterred (Figure 1).

Factors influencing opinion on geriatrics physiotherapy

Clinical experience (22.9%) and evidence in the literature (18.4%) were the most significant factors that influenced participants' opinion on geriatric physiotherapy as the students expressed that these factors were "very much" impactful. Peers, clinical instructors, and geriatrics lecturers were also influential but to a lesser degree, with these factors receiving mixed responses in terms of their impact on shaping participants' opinions. The data suggests that direct experience and academic resources are key in forming opinions on this specialization (Table 6).

Association between sociodemographic variables of physiotherapy students and their perception towards specialization in geriatrics physiotherapy

There was no significant association between the perception of the clinical physiotherapy undergraduates towards specialization in geriatrics physiotherapy and the sociodemographic variables: gender ($p=0.473$; $X^2= 1.499$), age group ($p=0.469$; $X^2=3.558$), level of study ($p=0.776$; $X^2=0.507$) and school ($p=0.128$; $X^2=17.604$) (Table 7).

Table 1: Sociodemographic variables for participants

Sociodemographic variable		**Mean ± S.D**	**Minimum**	**Maximum**
Age(years)		21.85±2.174	18	30
			Frequency	**%**
Gender	Male		141	53.0
	Female		125	47.0
Age groups (years)	18-21		132	49.6
	22-25		115	43.2
	26-30		19	7.1
School	Bowen University		81	30.5
	Chrisland University		19	7.1
	Obafemi Awolowo University		41	15.4
	Redeemers University		38	14.3
	University of Ibadan		21	7.9
	University of Lagos		29	10.9
	University of Medical Sciences		37	13.9
Level of study	400		138	51.9
	500		128	48.1

Table 2: Geriatric lectures or geriatric physiotherapy clinical experience of participants

Variable		Frequency	%
Have you had physiotherapy lecture or practical sessions in geriatrics	No	92	34.6
	Yes	174	65.4
If Yes,			
How many weeks?	4 weeks	43	16.2
	<4weeks	57	21.4
	> 4 weeks	85	32.0
In what year?	300	42	15.8
	400	108	40.6
	500	30	11.3
In what setting	Federal Medical Centre	23	8.6
	Federal Teaching Hospital	26	9.8
	General Hospital	31	11.7
	In your training institution	66	24.8
	State Teaching Hospital	42	15.8
I found my geriatrics physiotherapy lecture or practical valuable to my geriatrics physiotherapy knowledge	Neutral	54	20.3
	Not at all	6	2.3
	Not really	18	6.8
	Somewhat	43	16.2
	Very much	69	25.9
I found my geriatrics physiotherapy lecture or practical enjoyable	Neutral	65	24.5
	Not at all	15	5.6
	Not really	15	5.3
	Somewhat	47	17.7
	Very much	50	18.8

Table 3: Participants responses regarding career intentions in specialization in Physiotherapy

Specialty	Frequency (%)									
	Neutral		Not at all		Not really		Somewhat		Very much	
	n	%	N	%	n	%	N	%	N	%
Paediatrics	93	35.0	42	15.8	30	11.3	50	18.8	51	19.2
Community	95	35.7	41	15.4	50	18.8	52	19.5	28	10.5
Orthopaedics	87	32.7	17	6.4	22	8.3	61	22.9	79	29.7
Women's health	84	31.6	42	15.8	34	12.8	60	22.6	46	17.3
Neurology	75	28.2	22	8.3	41	15.4	73	27.4	55	20.7
Geriatrics	88	33.1	28	10.5	39	14.7	64	24.1	47	17.7
Cardiopulmonary	76	28.6	35	13.2	44	16.5	61	22.9	50	18.8
Sports	65	24.4	16	6.0	22	8.3	66	24.8	97	36.5
Others	107	40.2	50	18.8	24	9.0	50	18.8	35	13.2

Table 4: Participants knowledge on geriatrics physiotherapy

Variable		Frequency	%
Prior to commencing your Physiotherapy study/practice, were you aware that Physiotherapists have a role in the management of geriatrics problems?	No	140	52.6
	Yes	126	47.4
Prior to beginning your Physiotherapy study/practice, did you know what specialty/area within Physiotherapy you wanted to work in upon qualification?	No	199	74.8
	Yes	67	25.2
If yes, what areas	Community	4	1.5
	Geriatrics	2	0.8
	Neurology	8	3.0
	Orthopaedics	18	6.8
	Paediatrics	6	2.3
	Sports	26	9.8
	Women's health	3	1.2
At this present stage of your study/practice, do you know what specialty/area within Physiotherapy you want to work in upon qualification?	No	145	54.5
	Yes	121	45.5
If yes, what areas	Cardio	12	4.5
	Community	2	0.8
	Geriatrics	7	2.6
	Neurology	21	7.9
	Orthopaedics	28	10.5
	Paediatrics	13	4.9
	Sports	30	11.3
	Women's health	3	1.2
After becoming a registered physiotherapist will you consider specializing in geriatrics s physiotherapy at some stage in your career?	I may be interested in specialising but I am unsure at this time	134	50.4
	No, I am not interested in specialising in geriatrics s physiotherapy at any stage	88	33.1
	Yes, I am definitely interested in specialising at some stage in my career	44	16.5

Table 5: Factors influencing decision to consider specializing in geriatrics physiotherapy

Specialty	Frequency (%)									
	Neutral		Not at all		Not really		Somewhat		Very much	
	n	%	n	%	N	%	n	%	N	%
Job accessibility	40	15.0	12	4.5	9	3.4	41	15.4	79	29.7
Potential salary	32	12.0	4	1.5	15	5.6	43	16.2	88	33.1
Field experiences	47	17.7	8	3.0	11	4.1	53	19.9	62	23.3
Interesting aspect of field	43	16.2	11	4.1	22	8.3	46	17.3	58	21.8
Research potential	46	17.3	20	7.5	33	12.4	48	18.0	34	12.8
Influence from others	44	16.5	29	10.9	36	13.5	42	15.8	30	11.3
Others	44	16.5	38	14.3	30	11.3	40	15.0	28	10.5

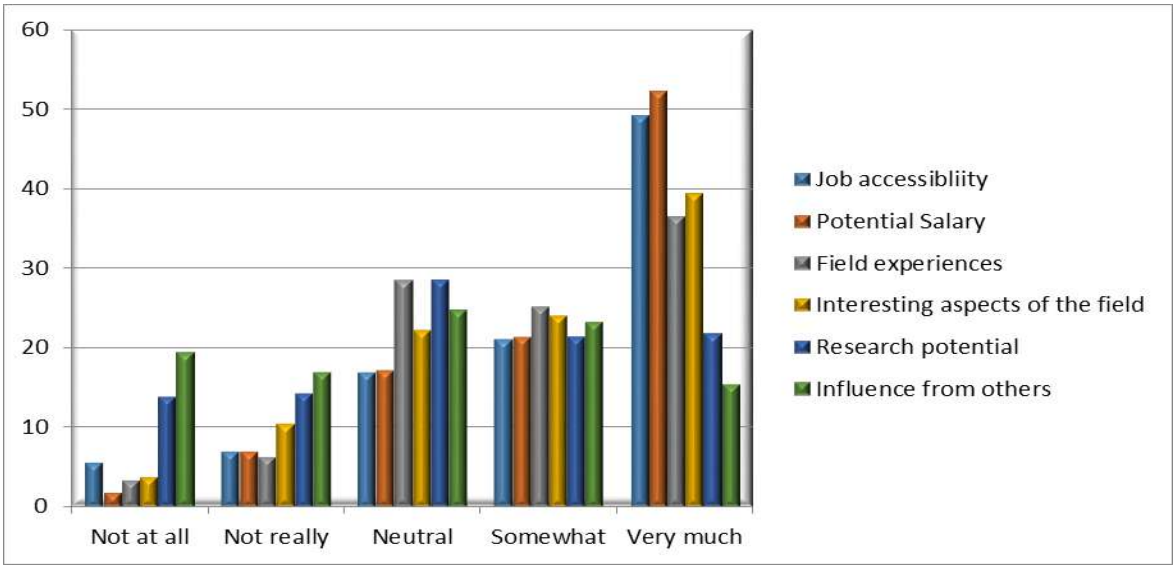

Figure 1: Factors that serve as deterrents to working in geriatrics physiotherapy after graduation

Table 6: Factors influencing opinion on geriatrics physiotherapy among participants

Specialty	**Frequency (%)**									
	Neutral		Not at all		Not really		Somewhat		Very much	
	N	%	N	%	N	%	n	%	N	%
Clinical experience	38	14.3	19	7.1	27	10.2	34	12.8	61	22.9
Evidence in the literature	49	18.4	20	7.5	38	14.3	41	15.4	27	10.2
Peers	50	18.8	26	9.8	41	15.4	37	13.9	23	8.6
Clinical instructor	37	13.9	27	10.2	26	9.8	41	15.4	44	16.5
Geriatrics lecturer	32	12.0	34	12.8	29	10.9	38	14.3	42	15.8

Table 7: Association between sociodemographic variables of clinical physiotherapy undergraduates and their perception towards specialization in geriatrics

Sociodemographic variables	I am not interested at any stage in my career	I am definitely interested at some stage in my career	I may be interested but I'm unsure at this time	X^2	p-value
Gender					
Female	75	42	14	1.499	0.473
Male	59	46	20		
Age group					
18-21	66	46	20	3.558	0.469
22-25	60	37	18		
26-30	8	5	6		
Level of study					
400	72	43	23	0.507	0.776
500	62	45	21		
School of study					
Bowen University	41	29	11	17.604	0.128
Chrisland University	8	8	3		
Obafemi Awolowo University	18	12	11		
Redeemers University	21	15	2		
University of Ibadan	14	2	5		
University of Lagos	14	7	8		
University of Medical Sciences	18	15	4		

***Significant at $p \leq 0.05$**

DISCUSSION

The composition of this study sample revealed a higher proportion of males as participants. This discrepancy may be attributed to male students showing a higher interest to participate in the study. Most of the students were from Bowen University, this can be explained as a quota sampling technique was used and the sample population from each university is representative of the total population.

Findings of this study revealed that the majority of undergraduate physiotherapy participants had attended lectures on geriatric physiotherapy or geriatric placement before completing the survey. The fact that these sessions were often held during the fourth year indicates that they were likely part of advanced coursework, which could allow for deeper learning and hands-on experience in the specialty. Most geriatric-focused sessions occurred in teaching hospitals and general hospitals, aligning with the fact that geriatric physiotherapy is often practiced in institutional settings due to the clinical needs of older populations and the resources present in the institutions. The varied responses regarding perceived value and interest indicate that although students may acknowledge the significance of geriatrics in physiotherapy practice, geriatrics physiotherapy lectures or practical sessions were not so enjoyable. This variation in perceived value and enjoyment may stem from the quality of clinical exposure and the emphasis placed on geriatrics within the curriculum. Also, practical exposure and quality teaching are critical factors in determining the effectiveness of geriatric training[18]. The low percentage of students who found these sessions not valuable could also indicate that geriatrics is still a relatively under-emphasized field in some programs, potentially due to the growing yet still limited integration of geriatric content into physiotherapy curricula worldwide.

Sports physiotherapy and orthopaedic physiotherapy were the most popular specialties among the participants, reflecting the broader trend in physiotherapy where students express a preference for areas that are perceived as more dynamic and widely practiced[19]. In contrast, geriatrics received moderate interest, showing that while not a primary focus, there is a significant awareness and potential interest in this field. The lower interest in community physiotherapy (10.5%) suggests that, compared to other areas, it is less emphasized and perhaps less perceived as a high-demand area, despite its growing importance in addressing global health challenges[20]. Geriatric physiotherapy, however, remains important in light of global ageing trends, and increasing exposure to the specialty could boost its appeal[21].

Prior to entering the physiotherapy programme, a majority of the participants were unaware of the role of physiotherapy in managing geriatric conditions. Furthermore, the majority had no clear idea of the specialty they would pursue upon

graduation. At the time of the study, however, a significant number of them had identified a specialty of interest, with sports and orthopaedic physiotherapy being the most popular. When asked about geriatrics, most of the participants were unsure about specializing in this field. This demonstrates that while students may not initially be aware of the value of geriatrics in physiotherapy, exposure through the curriculum could lead to greater interest and awareness. This finding underscores the importance of early and continuous education on geriatric physiotherapy, especially as the global population ages and the need for geriatric care increases[18].

The top factors influencing participants' decision to specialize in geriatrics physiotherapy were job accessibility and salary potential, reflecting the importance of practical considerations in career choices. Field experience and personal interest were also significant motivators. These results align with studies showing that career decisions in healthcare are often driven by economic factors and the availability of job opportunities[22]. The lower weight given to research potential and influence from others suggests that intrinsic factors, such as personal interest and direct exposure, play a larger role in career choices than external or academic factors. The growing demand for physiotherapists specializing in geriatrics in response to population ageing[20] could make this a more attractive option, particularly if greater job opportunities and competitive salaries become available.

The most common deterrent for not pursuing geriatrics physiotherapy was a perception that the specialty did not offer enough opportunities for growth or development. This finding highlights the need to reshape how geriatric physiotherapy is viewed in the professional landscape, particularly to make it appear more dynamic and forward-looking. Furthermore, low prestige and insufficient pay are recurring challenges in many healthcare disciplines, and more can be done to elevate the value and recognition of geriatric physiotherapy as a specialty.

There was no association between the students' perception towards specialization in geriatric physiotherapy, and their sociodemographic variables (gender, age-group, level of study and school). The lack of a significant association may be from limited exposure in geriatrics training or similar career motivations across groups, regardless of their demographics. Many students prioritize financial prospects and personal interests regardless of their age, gender, institution of training and even level of study. Additionally the dominance of more popular fields like sports or musculoskeletal physiotherapy may contribute to low interest in geriatrics. These factors collectively reduce the likelihood that gender, age, level of study or the institution of training significantly influence specialization choices[17].

CONCLUSION

This study found that clinical physiotherapy undergraduates generally value geriatric

sessions and show moderate interest in specializing in geriatrics. Job accessibility and potential salary were the main motivators for choosing this field, with field experiences and personal interest also playing significant roles. No significant associations were found between students' perceptions of geriatric specialization and their age, gender, institution of training, or level of study.

RECOMMENDATION

We recommend evaluating and enhancing geriatric care training in university physiotherapy curricular, with a particular focus on the clinical aspect, to enhance students' interest. Emphasis should also be made on the increasing ageing population and the importance physiotherapy plays in maintaining and improving health care for the ageing population. Comparative studies on students' perceptions and attitudes towards geriatric physiotherapy across different regions are suggested. Additionally, ongoing research should track trends in specialization among physiotherapy students in South-West Nigeria.

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ORIGINAL RESEARCH

KNOWLEDGE OF ARTIFICIAL INTELLIGENCE IN CLINICAL RADIOGRAPHY PRACTICE AMONG RADIOGRAPHERS IN SELECTED CITIES IN NIGERIA

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ABSTRACT

Introduction: Artificial intelligence (AI) has found wide application in diagnostic radiology but the concepts and applications of AI in radiography practice is yet to be fully understood among Nigerian radiographers.

Aim: The main objective of the study was to access the knowledge of artificial intelligence in clinical radiography practice among radiographers in selected cities in Nigeria.

Methods: This cross-sectional prospective research survey was carried out using a questionnaire. A stratified convenience sample of 118 out of 168 radiographers aged 18-76 years in three Nigerian cities participated in the study between February 2021 and September 2023. This sampling method was used because of the poor attitude of radiographers towards research. The items in the questionnaire were reviewed by experts, tested for reliability and validity before being uploaded to online radiography social media platforms using

Google forms. Descriptive and inferential statistics were used for data analysis at <0.05 level of significance.

RESULTS: 73 (61.9%) of radiographers had basic knowledge of AI while 89 (75.4%) radiographers will support the deployment of AI in health facilities in Nigeria. Regression analysis showed that basic knowledge of AI is associated with support for AI, efforts at personnel development towards AI, professional status and fear of job losses. However, support for AI deployment was the only independent predictor of 'having knowledge of AI' in the population (R^2 = 0.092). There is a positive relationship between having knowledge of AI and support for the deployment of AI.

CONCLUSION: There was a general basic positive knowledge of AI among Nigerian Radiographers but this was limited by fear of job losses. There was a positive relationship between knowledge of AI and support for its deployment, with a need to create more awareness and incorporate AI in the training curriculum of radiography students.

Keywords: Nigerian radiographers, support, artificial intelligence, knowledge.

INTRODUCTION

Artificial intelligence refers to the manifestation of the greatest type of human behaviour in the execution of tasks, especially with the use of machines. The race for AI started long ago in the 1940s further to the development of foremost digital computers. The idea of the scientists then was to develop computer systems that can mimic the thinking and other characteristics of human beings to perform tasks especially difficult ones faster and more efficiently than human beings [1]. To be able to do this, the machines were designed and equipped with various components of human intelligence such as learning, reasoning, solving problems, handling tasks, mastery of languages, perceptions, and thoughts[2]. It also refers to the use of a device or robots usually controlled by a computer. These devices are designed in such a way that they are equipped with programmes that contain the traits and characteristics of human intelligence, thus making them act like superhuman beings. These systems make use of long parallel computers and utilize deep learning platforms, data analytics, and neural networks similar to the neurons of the brain in the collection of data, analysis of data, as well as making decisions[3]. They are applied in industry to optimize operations such as in gas turbines to optimize the emission of toxic substances, and in wind parks to fully optimize changing wind directions effectively to produce energy[4]. They also perform difficult tasks like targeted shootings, analysis of data, and radiographic image interpretation in radiological investigations.

Adoption of new technologies in medicine is known to be slow such that medicine lags behind technological advancements in most countries[5]. Despite this limitation, AI is an

important tool in medicine and radiography being used to make diagnosis (especially by radiologists), make important clinical decisions, and assist radiographers in manipulating radiographic technique, protocol selection as well as in interventional procedures[1] but the knowledge and support of radiographers toward full deployment of AI has not been fully documented in Nigeria.

Artificial intelligence is not a new invention or terminology but an outcome of years of improvements in the use of computers in solving human-related tasks. It has found great applications in the industry based on the understanding that deep learning algorithms of AI computer systems will be able to operate at the same level as human beings[6]. Machine learning systems and algorithms can be applied and adopted in medical imaging to recognize normal from abnormal objects or image details[7,8]. These systems can further be adopted in radiology for disease detection, lesion segmentation, and classification, volumetric assessment functions, bone age assessment, and image-based outcome predictions[9,10,11,12]. However, issues relating to the requirement for large data storage, and the confidentiality of patient data, in AI systems, using DICOM images were of great concerns among other factors. Recent reports indicate that patient identity details can be protected in AI systems with very expensive and labour-intensive curative imaging processing procedures[6]. Despite its limitations, AI systems have been projected to help radiologists prioritize their worklists by carefully identifying suspicious positive cases that require urgent reviews. It has also helped radiologists to extract certain specific information and details from radiographic images which ordinarily will not be discernible by the human eye. This increases diagnostic accuracy and prognostic outcomes[1]. It also reduces variabilities in image interpretations among radiologists, as well as reduces radiologist's workload[13]. AI has also found several applications in digital x-ray imaging, computed tomography imaging, magnetic resonance imaging and ultrasonography and are not likely to displace radiographers or radiologists who use them but will negatively affect those who do not use them[14]. Therefore, radiographers are to initiate high-quality radiographic examinations and produce images of excellent diagnostic quality in the shortest possible time using AI-specific moderated protocols. What is required is for radiographers to acquire requisite knowledge and work hard with industry experts to innovate radiography friendly AI systems. This will help to develop profession-specific algorithms and deep learning platforms to reduce patient waiting times, and improve patient turnaround times without compromising overall image quality. This will invariably come at a cheap cost and less radiation dose to the patient.

Despite the widespread applications of AI in medical imaging, many radiographers do not fully understand AI principles and how it can be applied in practice[15]. Earlier studies indicate that radiographers are willing to accept and support AI in radiography practices but are worried that the clinical roles of radiographers and radiologists will

be taken over by AI[16,17]. The reason for the worries over job stability with AI among many radiographers has been attributed to lack of knowledge and understanding of the applications of AI concepts into radiographic examinations[15]. National and international radiography groups such as the International Society of Radiographers and Radiologic Technologists and the European Federation of Radiographer Societies have advocated on the need for radiographers to have good knowledge of the concept of AI through training and education to maximize its benefits for the welfare of their patients[18]. To achieve these, radiographers especially those in Nigeria must have adequate knowledge of AI which is still lacking among radiographers in Africa[19]. As a result, this study aimed to answer the following research questions;

1. Do radiographers in selected cities in Nigeria have good knowledge of AI?
2. How does support for AI deployment, making personal efforts toward AI development, professional status and fear of job losses due to AI affect radiographer's knowledge of AI?

Limited literature exists on the knowledge of radiographers on AI and the few available pieces of literature were narrowed in scope to African radiographers and medical personnel especially radiologists, and none focused recently on the knowledge base of Nigerian radiographers on the concept of AI which necessitated this study [5,20,21,22]. This study therefore aimed to assess the knowledge of artificial intelligence in clinical radiography practice among radiographers in selected cities in Nigeria. The result of this study will create awareness on the knowledge of radiographers on artificial intelligence in clinical radiography practice. It will also help stakeholders in the radiography profession to design strategic policies that will deepen AI knowledge and its integration into radiography practice in Nigeria.

MATERIALS AND METHODS

The study adopted a cross-sectional prospective research survey using questionnaires. The structured questionnaire was divided into two sections- A and B. The items in section A were used to collect the participants' socio-demographic data while section B of the questionnaire evaluated the perception of radiographers on the deployment of AI in radiography practice. The items in the questionnaire were reviewed by a panel of experts for reproducibility and validity of measurements. Items were included if they met the scale content validity index (S-CVI) score of 0.72[23]. Using the S -CVI of 0.72, a total of 4 and 13 questions were included in sections A and B of the questionnaire, respectively. The questionnaire thereafter returned an average reliability coefficient of 0.70 using the Cronbach alpha and Kuder Richardson (KR) – 20 tests[24]. A pilot study was done with 10 radiographers and intern radiographers to remove ambiguity. Three cities in Nigeria were selected for this study by stratified sampling between February 2021 and September 2023. The cities that

participated in this study were Maiduguri metropolis, Borno State, Lagos Mainland, Lagos State, and Nnewi, Anambra State, Nigeria to represent the Northern, western and eastern Nigeria respectively. The population of radiographers included all practicing radiographers in the selected cities. The population of radiographers in each stratum was obtained from the local branch of the Association of Radiographers of Nigeria in each state. The number of radiographers (sample) in each stratum was determined by the method described by Chaudhuri and Dutta[25] for calculation of the sample size of finite populations. Using this method, a sample of 118 radiographers from all strata was obtained from the total population of 168 radiographers. Radiographers who met the inclusion criteria and who consented to participate in the study were enlisted for the study by convenience sampling. This sampling technique was used because of the poor attitude of radiographers towards research. Therefore, convenience sampling became the most practical and cost-effective method to recruit participants from diverse geographic locations into the study based on their willingness to participate in the study[7]. The researcher diversified the locations of the samples and also combined convenience sampling with stratified sampling to reduce bias[3]. This has also been captured as forming part of the limitations of this study. However, this sampling method is commonly used in online based studies just like the present study where it is usually used to easily pool participants from different locations at the shortest possible time[8]. The questionnaire was designed using Google format and uploaded to various radiographers' platforms using social media and distributed to radiographers social media platforms in the northern, western and eastern regions of Nigeria to introduce diversification and obtain an appropriate cross section of the population. Descriptive and inferential statistics were used for the analysis of the questionnaires at <0.05 level of significance using the statistical package for social sciences (SPSS) version 23.

RESULTS

The majority 47 (39.8%) of the respondents were between the ages of 18-29 years while a few of the respondents were aged more than 65 years of age (Table 1). Table 2 shows that 45 (38.1%) of the participants in this study were clinical radiographers followed by 43 (36.4%) who were intern radiographers.

The participants are aged between 18years and above 65years. Majority of the participants are between the age group of 18-29 years, followed by 54-65years and above 65years age groups. 73 (61.9%), 89(75.4%) of the respondents have basic knowledge of AI and will support the deployment of AI but 80(67.8%) were not pursuing personal development efforts towards AI. 63(61.9%) of the radiographers especially intern and clinical radiographers were afraid that incorporating AI in clinical radiography practice will take away their jobs. This is shown in Table 3.

Clinical radiographers 31(68%) have basic knowledge of AI compared to other categories of radiographers and 34(75.6%) of the clinical radiographers will support the deployment of AI in hospitals but the majority of clinical radiographers 30(66.7%) were not making personal efforts toward personal development in the area of AI. Fear of job losses due to the deployment of AI is common among radiography students 32(74.4%**).** See table 4.

Table 1: AGE DISTRIBUTION OF RESPONDENTS

Age	Frequency (n)	%
18-29	47	39.8
30-41	12	10.2
42-53	16	13.6
54-65	24	20.3
65-76	19	16.1
Total	118	100

Table 2: CATEGORY OF RADIOGRAPHERS

PROFESSIONAL STATUS	Frequency (n)	%
Intern Radiographers	43	36.4
Lecturers	30	25.4
Clinical radiographers	45	+38.1
Total	118	99.9

Table 3: KNOWLEDGE AND ATTITUDE OF RADIOGRAPHERS TOWARDS AI

PARAMETERS	STRONGLY AGREE n(%)	AGREE n(%)	UNDECIDED n(%)	DISAGREE n(%)	STRONGLY DISAGREE- n(%)
knowledge of AI	32(27.1)	41(34.7)	29(24.6)	13(11.0)	3(2.5)
support for deployment of AI	45(38.1)	44(37.3)	17(14.4)	7(5.9)	5(4.2)
No personal efforts towards AI	37(31.4)	43(36.4)	26(22.0)	7(5.9)	5(4.2)
AI will take away my job	34 (28.8)	29(33.1)	22(18.6)	13(11.0)	20(16.9)

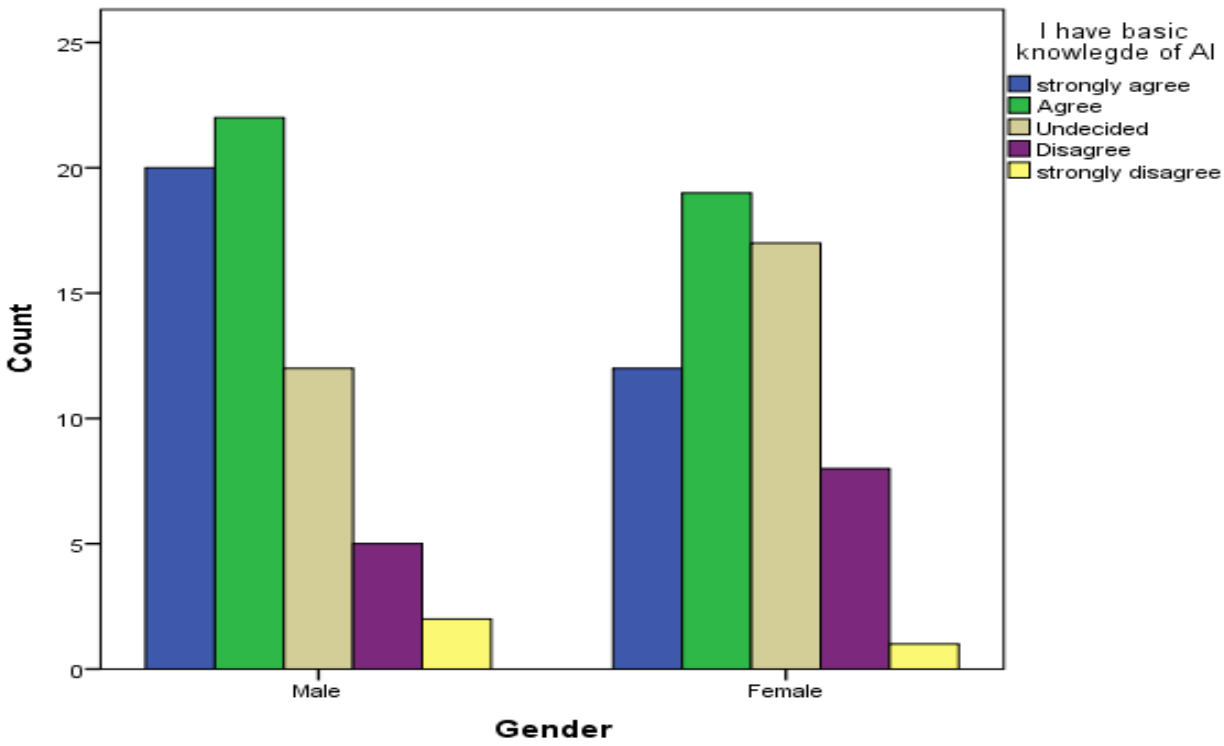

Figure 2: Knowledge of AI by gender

Male radiographers agreed and strongly agreed that they have more knowledge of AI than female respondents.

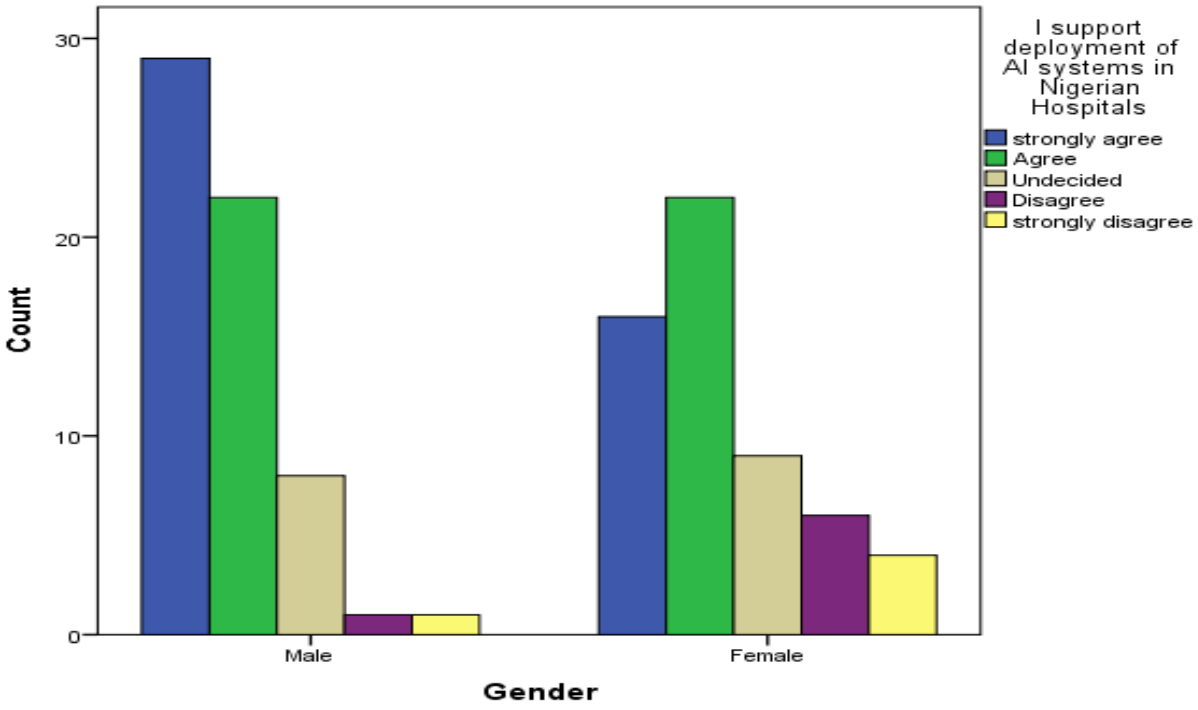

Figure 3: Gender support for AI

Male radiographers will support the deployment of AI in Nigerian Hospitals than female respondents.

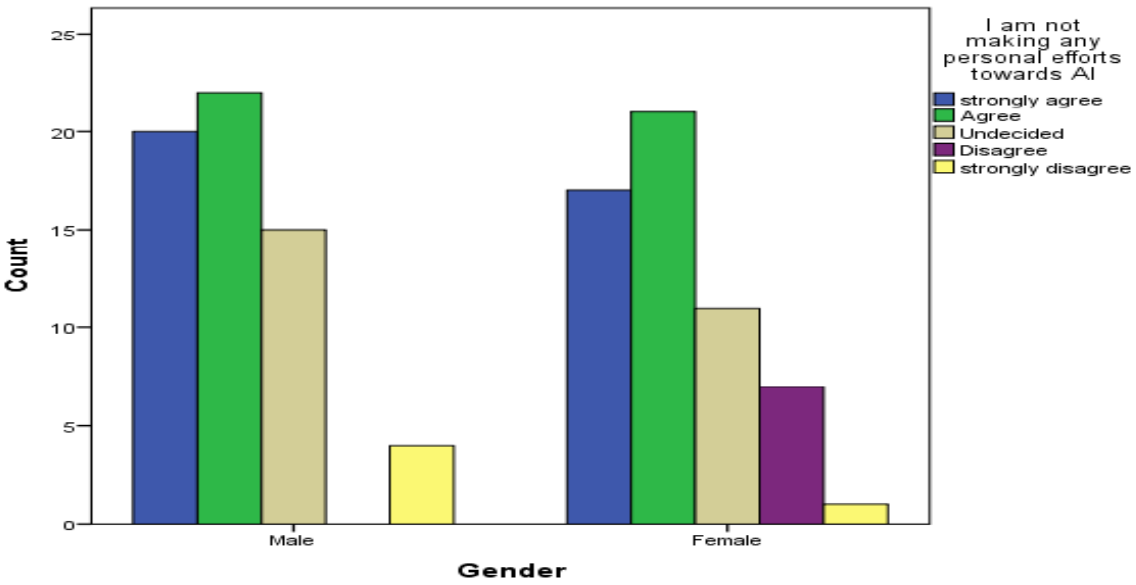

Figure 4: Gender distribution of Personal development efforts toward AI

Male radiographers were making more personal efforts toward developing themselves in the area of AI

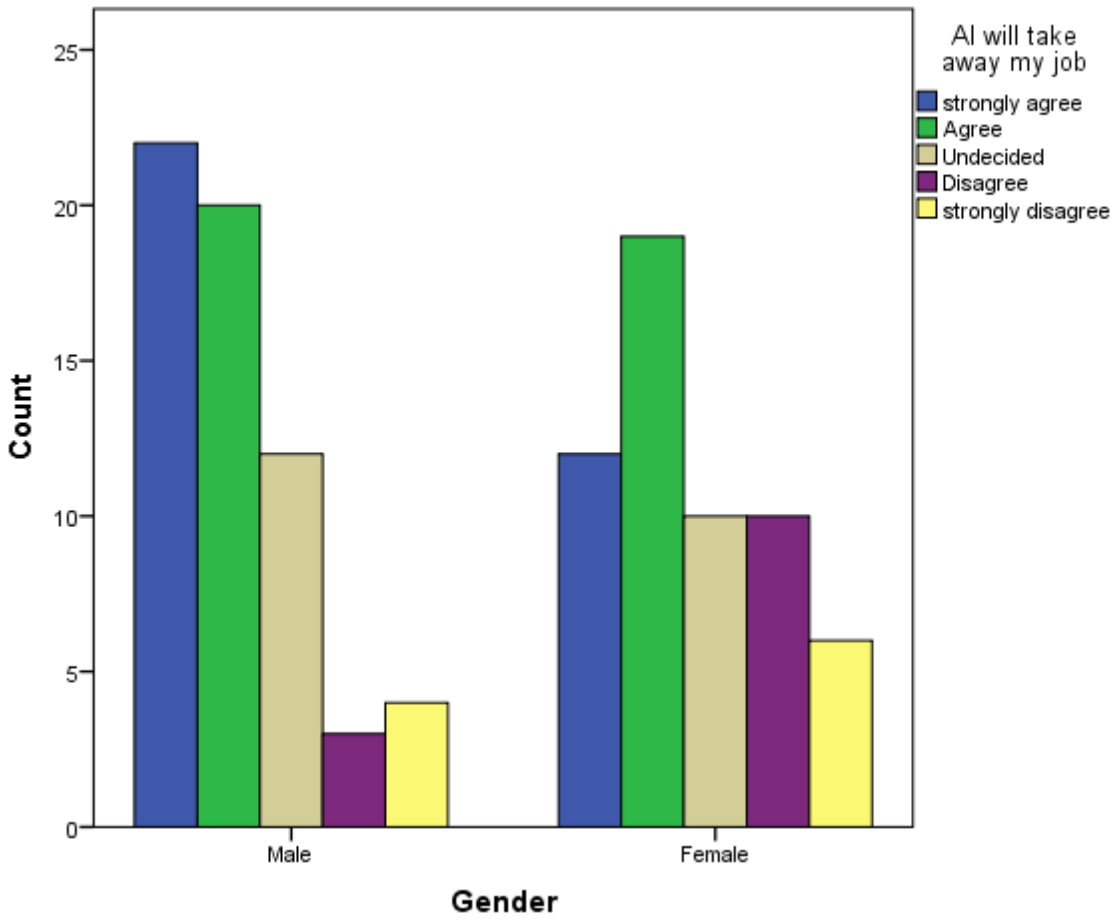

Figure 5: Gender and job security

Male radiographers feared that AI will take away their jobs than female radiographers

Table 4: Perception of AI among different groups of radiographers

Parameters	Category of radiographers	Strongly agree n(%)	Agree n(%)	Undecided n(%)	Disagree n(%)	Strongly disagree n(%)	TOTAL
Basic knowledge of AI	Intern radiographers	11(25.5)	15(34.9)	11(25.6)	4(9.3)	2(4.7)	43(100)
	lecturers	8(26.7)	8(26.7)	9(30.0)	4(13.3)	1(3.3)	30(100)
	Clinical radiographers	13(28.9)	18(40.0)	9(20.0)	5(11.1)	0(0.0)	45(100)
Support for AI	Intern radiographers	13(30.2)	20(46.5)	6(14.0)	2(4.7%)	2(4.7)	43(100)
	lecturers	11(36.7)	11(36.7)	2(6.7)	4(13.3)	2(6.7)	30(100)
	Clinical radiographers	21(46.7)	13(28.9)	9(20.0)	1(2.2)	1(2.2)	45(100)
No personal development in AI	Intern radiographers	12(27.9)	16(37.2)	12(27.9)	2(4.7)	1(2.3)	43(100)
	lecturers	11(36.7)	11(36.7)	3(10.0)	3(10.0)	2(6.7)	30(100)
	Clinical radiographers	14(31.1)	16(35.6)	11(24.4)	2(2.4)	2(2.4)	45(100)
AI will lead to job losses	Intern radiographers	19(44.2)	13(30.2)	5(11.6)	3(7.0)	3(7.0)	43(100)
	Lecturers	6(20.0)	7(23.3)	9(30.0)	4(13.3)	4(13.3)	30(100)
	Clinical radiographers	9(20.0)	19(42.2)	8(17.8)	6(13.3)	3(6.7)	45(100)

Table 5: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	1.474	.360		4.092	.000
	I support deployment of AI systems in Nigerian Hospitals	.314	.093	.319	3.386	.001
	AI will take away my job	.071	.075	.083	.943	.348
	I am not making any personal efforts toward AI	.070	.093	.070	.752	.454
	Professional status	-.076	.109	-.062	-.698	.486

a. Dependent Variable: I have basic knowledge of AI

Support for the deployment of AI is the only independent predictor of knowledge of AI

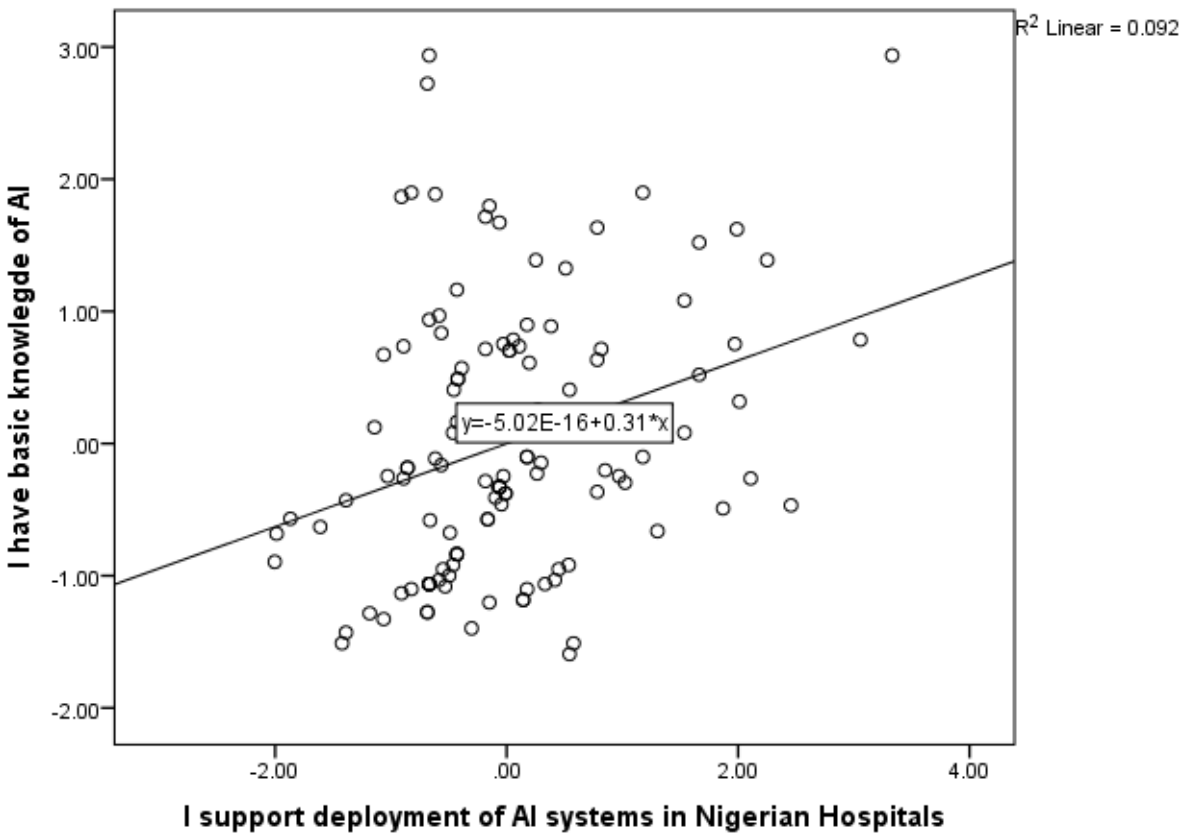

Figure 6: Regression plot of knowledge of AI and support for AI

The relationship between radiographers knowledge of AI and support for AI in selected Nigerian institutions

DISCUSSION

Current advances in healthcare delivery systems and increasing computerization of radiography imaging globally necessitated the concept of AI in radiography practice in Nigeria. Various bodies saddled with imaging practice in the United States of America, Canada, and India have gone far at incorporating AI into their practice [26,27,28].

Majority of the respondents were intern radiographers between the ages of 18-29 years. Radiographers working either as interns or in clinical practice between the ages of 18-29 years constituted the bulk of the respondents in this study. There were more clinical radiographers in the study group compared to other categories of radiographers. This is expected because the clinical radiographers constitute the bulk of radiographers that will be saddled with the use and operation of AI when it is fully deployed into clinical practice. Intern radiographers in training constituted the second-largest (36.4%) of the population studied which is comparable to 31% reported in a related study among radiology residents in training[5]. The earlier study focused mainly on the perception of radiologists and residents in training on the deployment of AI in clinical radiological practice[5] only but we have expanded the scope to accommodate intern radiographers in training, clinical radiographers as well as radiography lecturers who are academics to provide a more robust study.

Clinical radiographers and intern radiographers have more basic knowledge of AI in this study. Males have better knowledge of AI compared to their female counterparts which have been reported in similar studies among radiologists and residents[5]. The clinical radiographers must have developed this basic knowledge over time due to exposure and interaction with biomedical engineers as well as their experiences over many years of practice. To the interns, this may be attributed to their quest for new knowledge and a better way of reducing their workload because most of the radiography examinations in public and private health facilities were mostly performed by intern radiographers under the supervision of their superiors. They would therefore need assistance in the form of AI to help perform their duties, especially in radio-diagnostic centres where there is minimal supervision.

Majority of the radiographers agreed that they have good knowledge of AI and will support its deployments in hospitals while few radiographers were either not making efforts towards AI or felt that AI will take over their jobs. Radiographers involved in clinical practice either as clinical radiographers or internee radiographers provided greater support to the deployment of AI, unlike radiographers who were not fully involved in clinical practice. Fear for loss of job due to the deployment of AI was less among lectures and clinical radiographers above 55years of age compared to interns and clinical radiographers less than 55 years of age. Fifty-four percent of the respondents feared that AI will take over their jobs and this was common in both gender but male radiographers were slightly more apprehensive than the female radiographers. The fear of job insecurity (44%% and 30.2%) was common among intern radiographers probably because their training curriculum is yet to fully incorporate AI. In related studies fear for job security following the deployment of AI were similar to the findings of this study and constituted 42% and 39% respectively [5,22]. This shows that the fear of job losses due to

AI is real among Radiographers irrespective of geographic locations and may the reason behind the slow pace of full deployment of AI in radiology departments in many countries including Nigeria.

This could be attributed to the fact that most of the clinical radiographers were part of the management of their respective health facilities and were aware that the health facility has no immediate plan to deploy AI. Again, the intern radiographers did not pay much attention to vigorously pursuing personnel development in AI because AI has not been fully incorporated into their training curriculum. Also, the intern radiographers may be following the examples of their senior clinical radiographer colleagues. This is contrary to the findings of a related study which opined that radiologists and residents (under training) were more proactive in career development in AI[5.] The differences between the present study and the later study were attributed to environmental factors and differences in the populations studied.

There is a positive relationship between having knowledge of AI and support for AI deployment. The regression plot shows that when radiographers have good knowledge of the role of AI in radiographic practice, they are more likely to support the deployment of AI in clinical practice. Regression analysis showed that basic knowledge of AI is associated with support for the incorporation of AI in clinical radiography practice, fewer efforts at personnel development, professional status and fear of job losses. However, support for AI deployment was on the only independent predictor of 'having knowledge of AI' in the population. 92% of the variations in the observed variations in the knowledge of AI among the radiographers was explained by the support for AI deployment. This means that those who support the deployment of AI will definitely have a good knowledge of AI thereby showing a positive association between having knowledge of AI and support for AI. This shows a more general positive attitude toward the deployment of AI in radiography practice among radiographers in the population studied and is similar to the findings of similar studies in Europe[5,12] and Africa[20]. As a result, more education and awareness on the benefits of AI are needed for all categories of radiographers in Nigeria. Incorporating AI into the training curriculum for radiography students will be a step in the right direction to deepen their knowledge of AI applications in radiography and alleviate the fears of young radiographers about the deployment of AI.

A low response rate (11.17%) was the major limitation of this study which necessitated the use of convenience sampling method in this study which might have introduced a selection bias that is usually associated with questionnaire-based research work[29]. This has been mitigated by combining convenience sampling with other sampling methods such as stratified sampling and the diversification of sample selection[3]. However, there was obtained a better than the response rates of 3.9% compared to response rate of 2.8% reported in related studies respectively[5,22].

CONCLUSION

There is a general basic positive knowledge of AI among Nigerian radiographers in the selected cities, especially among clinical and intern radiographers but this is limited by fear of job losses mostly among male radiographers. There is a need to create more awareness of AI in radiography practice and incorporate AI into the training curriculum of radiography students to stimulate interest in AI.

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Consent for publication: All the respondents provided written informed consent to publish the data contained in this study.

Disclosure of conflict of interests: All the authors declare that they have no competing interests.

Availability of data and materials: The datasets as well as the analysis used for this study are freely available on request.

Abbreviations: AI: Artificial intelligence; S-CVI: Scale content validity index

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ORIGINAL RESEARCH

MODELS OF DAMAGES CAUSED BY MICROSPORIDIA INFECTION AMONG HIV-POSITIVE PATIENTS IN WHITE ALBINO MICE (*mus musculus domesticus*)

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ABSTRACT

Background: Microsporidiasis has been reported mostly in patients with Human-Immuno Deficiency Virus (HIV)/AIDS with diarrhea and in more than 50% of these patients, no enteric pathogen are identifiable.

Aim: This study attempted to establish the natural route of human infection of microsporidiasis and study the pathologically induced manifestations in experimentally infected mice.

Methods: We isolated microsporidia spores from stool specimens of HIV-infected patients aged 2-61years and experimentally infect Albino mice with these isolates in an attempt to establish the natural route of human infection and study the pathologically induced manifestations in these experimentally infected mice. Seven hundred and fifty stool samples were

collected from HIV-infected patients and 375 samples from their non-infected counterparts to determine the prevalence of Microsporidia infection. Chromoptrope 2R and Ficoll-Hipaque techniques were used to isolate Microsporidia spores. Purification of these isolates was conducted using sucrose gradient centrifugation technique. Prednisolone was used to suppress the immune system in the experimental albino mice. Immuno-compromised and immuno-competent albino mice were orally, intranasally and intravenously inoculated with 55 spores/10µl in Phosphate Buffer Saline. At intervals of 2, 5, 10, 17 and 28 days post-infection, the infected mice were sacrificed and their internal organs processed for histopathological studies, using heamatoxylin and eosin stain.

Results: The prevalence of microsporidia isolates in the stool samples of 750 HIV-infected patients (42.4%) was significantly higher than in the HIV-non-infected subjects (19.2%) ($P<0.05$). In the immuno-suppressed Albino Mice, pathological damages were induced in the lungs, small intestines, kidneys and livers, unlike in the non-immuno-suppressed group. Oral ingestion and/or intranasal inhalation are considered to be the natural routes of infection because viable microsporidia spores were recovered only from the stools of treated mice which received microsporidia spores inoculums orally and intranasally.

Conclusion: Microsporidiasis is prevalent among immuno-compromised (HIV/AIDS) patients and the associations of microsporidiasis with overt pathology in vital internal organs have been demonstrated in the immuno-suppressed mice.

Keywords: Models, Damages, Microsporidia, HIV-Positive, White Albino Mice

INTRODUCTION

Microsporidiasis has been found mostly in patients with Human Immuno Deficiency Virus (HIV)/AIDS and chronic diarrhea is common in these patients[1]. However, in more than 50% of these patients, no enteric pathogen are identifiable[2]. Two possible reasons for these cases of unexplained Diarrhoea are; intestinal infection with HIV that has been associated with enteropathy in these patients and infection with yet to be identified enteric organisms[3]. The HIV/AIDS pandemic has revealed the propensity of microsporidia species to infect man, where they have being implicated in causing intestinal, ocular, pulmonary and renal diseases[3]. However, latent cases of the infection in healthy individuals becoming exacerbated when such individuals become immunosuppressed have been reported[4]. The high prevalence of microsporidia infection in immuno-compromised patients has posed serious public health and socio-economic challenges among these patients[5].

At present, microsporidiasis is being recognized as an important medical and public health problem both by the World Health Organisation and the National Institute of Allergy and Infectious Diseases (NIAID), Bethesda, Maryland[6]. A major complication and cause of death among the

HIV-infected patients is Diarrhoea and *E. bieneusi* has been strongly implicated as a major aetiological agent of the chronic Diarrhoea and excessive wasting, high morbidity and high mortality rates among the HIV-infected patients[7]. Elsewhere, these microsporidia have also been reported to have infected even patients with competent immune system[8] and in symptomatic immuno-competent individuals, a self-limited diarrhoea is the most common clinical manifestation too[9].

In spite of its medical, public health and socio-economic implications, there is paucity of information on microsporidia species, particularly in developing countries where no concerted effort has been made to ascertain the prevalence, intensity, mode of transmission and tissue pathology caused by microsporidiasis, especially in the HIV-infected patients. Therefore, it should be a concern that while HIV prevalence, morbidity and mortality rates are rising, the prevalence of microsporidiasis remains unknown and unstudied among HIV/AIDS patients in developing countries. In Nigeria, studies on human microsporidia and microsporidiasis, either among HIV-infected patients or among any other human groups is limited to many. We determined the prevalence of microsporidiasis among HIV-infected patients, isolated the microsporidia spores in human stool specimens of these patients and then study the histopathology of microsporidiasis in experimentally infected laboratory mice.

MATERIALS AND METHODS

The Study Area. This work was carried out at the University of Ilorin Teaching Hospital (U.I.T.H), a tertiary and referral hospital located in Ilorin, Kwara State, Nigeria. UITH is involved in teaching, research and training of medical students, resident doctors and other paramedical studies. Kwara State is the gate way between the south-west and the north and is located south-east of the river Niger. It covers above 75000 km^2 on land mass and shares common boundaries with Benin Republic in the West, Oyo in the Southwest, Niger in the North, Ekiti, and Osun in the South, and Kogi in the East. Ilorin the State capital is located at longitude 8^0 30N and latitude 4^0 30E.

Study Design: A cross sectional study was designed to determine the prevalence of microsporidia species from human stool specimens of immuno-compromised (HIV-infected) patients and immuno-compromised (non-infected) individuals as control.

Preliminary Sampling: All the subjects (HIV-Positive and HIV-negative) in this study were screened for HIV-sero-status as a prerequisite for stool collection. This prerequisite distinguishes the HIV-infected patients from the HIV-non-infected control. Three screening methods, Antec HIV test, Determine test and Uni-Gold test were concurrently used to test and confirm HIV-sero-status.

Copies of the questionnaire were administered on each subject whose stool samples would be collected. They provided information such as; name, sex, age,

address, tribe State local government area, profession/occupation etc. A tag number was given on the questionnaire to correspond with the specimen bottle so as to ensure that each specimen corresponds with the given information.

Determination of Sample Size: This sample size was predicted on the prevalence (39-97%) rate of chronic Diarrhoea among the HIV-infected patients as was determined using Fisher's formula[10]. An overall sample size of one thousand one hundred and twenty five (1125) humans were examined for this study. This composed of seven hundred and fifty (750) HIV-infected patients and three hundred and seventy five (375) HIV-non-infected control, matched for age, sex, and other socio-economic variables.

Ethical Approval: Ethical approval was sought for and obtained from the Ethical Review Committee of the University of Ilorin Teaching Hospital with Reference number: UITH/021/ERC2023. Relevant cooperation and assistance of various heads of clinical departments were mobilized for and granted.

Informed consent sheet: The purpose of what the study is all about was given to all subjects and participation was voluntary, the confidentiality of whatever information given for the purpose of this study was guaranteed.

Data collection procedure

Stool Specimen Collection: Stool specimens were obtained from both the HIV/AIDS patients aged between 2 and 61years and the HIV-non-infected control in the same age group in sterile universal bottles. Sterile universal bottles were used for this study for collection of stool samples for two main reasons; to avoid contamination which would have been acquired environmentally that could affect isolating microsporidia spores in its pure form and to conform with the internationally accepted standard on stool collection in the contemporary world.

The Modified Trichrome Stain (Chromotrope2R) Staining Method: The Trichrome staining method was modified by the CDC Atlanta Georgia, USA, for the identification of microsporidia spores from human stool samples. The main dye, Chromotrope2R, was acquired from Sigma-Aldrich^{Tm} (Sigma-aldrich Co.3050 Sprule St. Louis, mo, C 3143-25G; Cust PO No. ZSA/NGO/ISA/AMASE/001. procedures were done according to manufacturers' instruction.

Ficoll-hypaque technique: This technique was used in this study to isolate pure microsporidia spores from the stool specimen. It is a sterile, ready to use method of density gradient mechanism for purification from human fluids, substances according to their densities using simple centrifugation procedures. Ficoll-hypaque is an aqueous solution of density 1.077±0.0019/ml, containing 5.7g Ficoll 400 and 9g sodium diatrizoate with 0.0231g

calcium disodium ethylenediamintetra-a-cetic acid in every 100ml. It was acquired from Sigma chemicals co. (ca + No SL – 2).

Procedure for isolation of pure microsporidia spore from stool samples: Using Ficoll-hypaque: The refrigerated portion of the microsporidia spore-positive stool-samples was saturated in a 10-fold concentrated phosphate buffer saline (PBS), pH 7.2 to 7.4 and filtered through series of nylon sieves (pore size, 210, 100, 70, 50 and 20µm; small parts, Inc Miami Lakes Florida, USA). The filtrate was then separated, 2ml into a 10ml test-tube (plastic). With the help of a syringe with needle attached, the aqueous Ficoll-hypaque was withdrawn 3ml and put in another 10ml test-tube. The 2ml sieved stool sample was then gently added on top of the 3ml aqueous Ficoll-hypaque. This was then centrifuged, using a cold centrifuge at 400g for 35 minutes at 20^{o}C. The middle band which contained microsporidia spores was carefully collected through a syringe attached with needle. Pure microsporidia spore became heavily concentrated when re-stained with Chromotrope2R. They (the pure microsporidia spores) were stored in a PBS solution and refrigerated under seal for further studies.

Quality Control: As a quality control measure, a control slide of microsporidia spores in a 10% formalin preserved specimen from the CDC Atlanta, USA (No. UN 3373) [25] was viewed alongside with the prepared slides. Spore walls of microsporidia stain a pinkish-red colour and measured about 3 µm were confirmed from both self-prepared and the control slides. All solutions subsequent to chromotrope stain were changed after every 10 slides to obtain proper rinsing and dehydration.

Animal Study design

A total of 43 Albino mice (*Mus musculus domesticus*) were used in this study. These animals were aged between 7-12 weeks, with an average weight of 148g, and their normal CD_4+ cell count ranges between 18-22 cell/mm^3. They (the animals) were divided into three major groups (the immuno-suppressed group– 18, the immuno-competent group– 18, and the Prednisolone administered free line group-6). One of the mice was sacrificed for normal histopathology of the targeted organs (the heart, lungs, livers, kidney, small intestine and the spleen). There were three routes of parasite inoculation (orally/perors, intranasally and intravenously) in both the immuno-compromised and the immuno-competent groups.

Determination of immuno-suppression in the animals

The Determination of immuno-suppression in the animals was done using prednisolone as the immuno-suppressant. The first group of animals whose immune system was suppressed, modeled the HIV-seropositive patients. A 8.6mg/kg body weight of prednisolone serves as the LD50 that reduced the CD_4 cell count of the animals by 50%. Half of this dosage was given to the animals after every 24hours in line with the 1/2 life of the drug. The same process was

applicable for the 6 animals left to move freely within the two groups (immuno-suppressed and immuno-competent groups) serving as control.

Grouping and parasite Inoculation.

In each of the immuno-suppressed and immuno-competent groups (18 each=36) there were three routes of inoculation.

Immuno-suppressed Group -18
- 6 for oral inoculation.
- 6 for intranasal inoculation.
- 6 for intravenous inoculation.

immuno-competent Group– 18
- 6 for oral inoculation.
- 6 for intranasal inoculation.
- 6 for intravenous inoculation.

These animals were marked according to the route of infection in each case and kept in the same feeding and environmental conditions, but in different cages.

Free living/immuno-suppressed Group -6
– 2 mixed with those infected orally
- 2 mixed and with those infected intranasally
- 2 mixed with these infected intravenously

This group of animals (free living) have their immune system suppressed just as the 18 animals in the immuno-suppressed group, but, they were not infected with the parasite and were allowed to move freely with the infected animals in each group, serving as control for the prednisolone administered animals.

Determination of sacrifice days.

The prime number interval selection by Silveira and Canning[10] was used in this section of the study. It is based on the duration of the developmental biology of the parasite in the target organs. Five days of sacrifice were used as shown below:

Day 2 = 1st prime number = 2nd day after inoculation = 1st day of sacrifice

Day 2+ (3, 2nd prime number) = 5th day after inoculation = 2nd day of sacrifice

Day 5 + (5, 3rd prime number) = 10th day after inoculation = 3rd day of sacrifice

Day 10 + (7, 4th prime number) = 17th day after inoculation = 4th day of sacrifice

Day 17 + (11, 5th Prime number) = 28th day after inoculation = 5th day of sacrifice

From the 1st to the 4th day of sacrifice, six animals were sacrifice each day. One for each, in the oral, intranasal and intravenous routes of inoculation.

On the 5th day of sacrifice, 9 animals were sacrificed, including the free living immuno-suppressed mice who were infected with the parasite.

Tissue Staining Procedure: The conventional Hematoxylin and Eosin stains were used in this study for Histopathology as contained in Manual of Histologic and Special Staining Techniques and Atlas of Protozoan Parasites in animal tissues, 2nd ed. and used by Gardiner *et al*.[12].

RESULTS

This study established that the prevalence, of microsporidia species at the University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria, in a total of 1125 patients examined is significantly high (34.7%) P<0.05. Seven hundred and fifty (66.7%) were HIV-infected patients while 375 (33.3%) were HIV-non-infected patients. The prevalence of microsporidia infection among the 750 HIV-infected patients was 42.4%. The corresponding prevalence among the HIV-non-infected patients was 19.2%. This difference in the prevalence of microsporidia infection among HIV-infected patients and their HIV-non-infected counterparts was also statistically significant (p<0.05) (Table 1).

Table 1: Prevalence of Microsporidiasis among HIV-infected and HIV-non-infected Patients (N=1125).

Infection Status	Total No. Examined	No. (%) +ve*
HIV-infected patients	750	318 (42.4)
HIV-non-infected patients	375	72 (19.2)
Total	**1125**	**390 (34.7)**

P<0.05, * = Microsporidiasis.

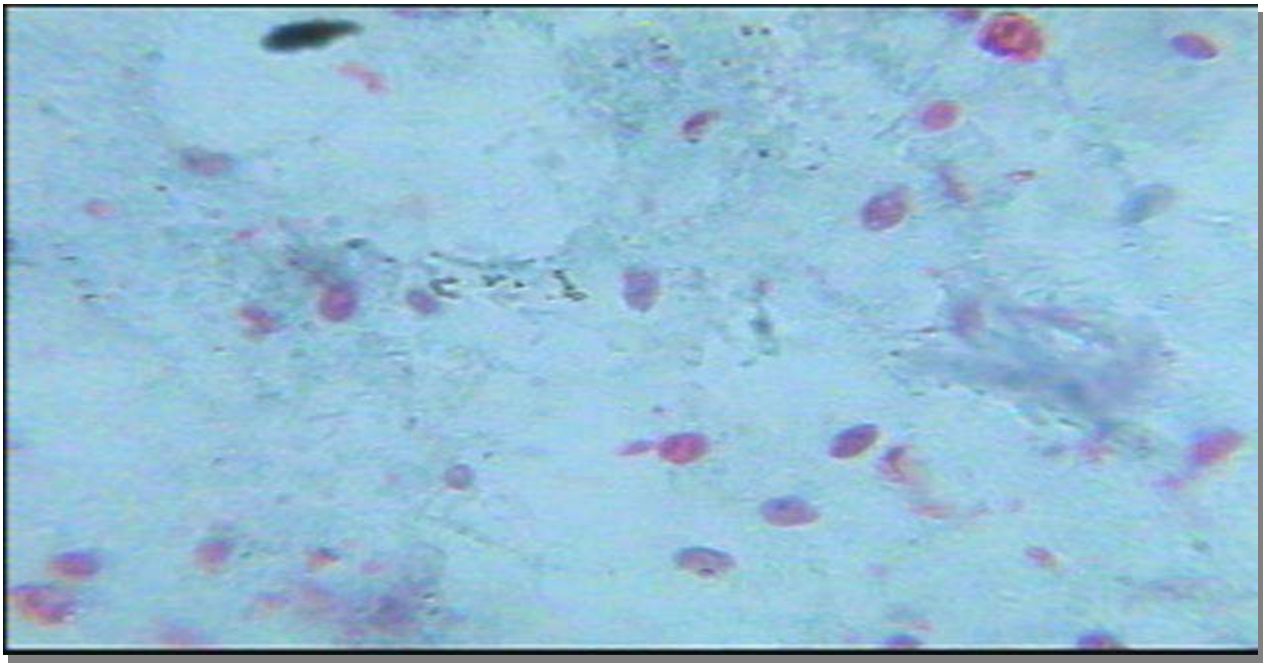
Table 2: Prevalence of Microsporidiasis among HIV-infected and HIV-non-infected Patients by Gender (N = 1125)

Infection status	Male		Female		Total
	No. Examined	No. (%) +ve	No. Examined	No. (%) +ve	No. (%) +ve
HIV-infected patients (N = 750)	356	141 (39.6)	394	177 (44.9)	218 (42.4)
HIV-non-infected patients (N=375)	176	35 (19.9)	199	37 (18.6)	72 (19.2)
Total (N=1125)	**532**	**176 (33.1)**	**593**	**214 (36.1)**	**390 (34.7)**

P>0.05

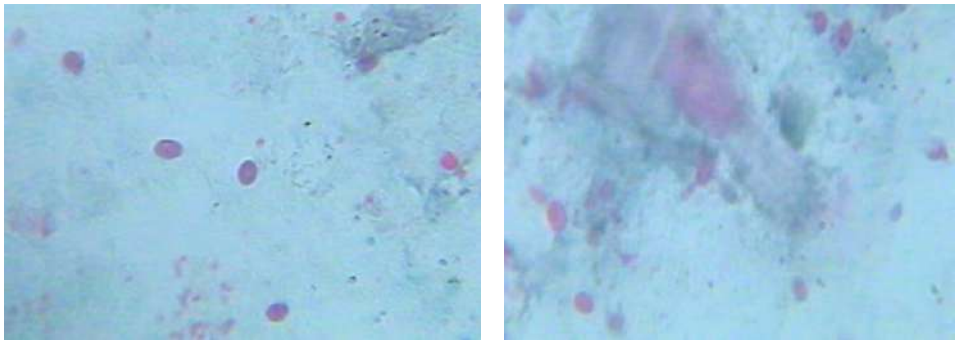
Prevalence of Microsporidiasis by Gender

Table 2 shows that, the prevalence of microsporidiasis among HIV-infected males was 39.6% and was 44.9% among their female counterparts. The difference in the prevalence of microsporidiasis among HIV-infected males and HIV-infected females was not statistically significant P>0.05. Microsporidiasis prevalence among HIV-non-infected males was 19.9% and among HIV-non-infected females was 18.6%. The difference was not statistically significant P>0.05. The total prevalence (both HIV-infected and non-infected patients) among males was 33.1% and among females was 36.1%. The difference however was not statistically significant P>0.05).



The CDC control slide, (No.UN3373)

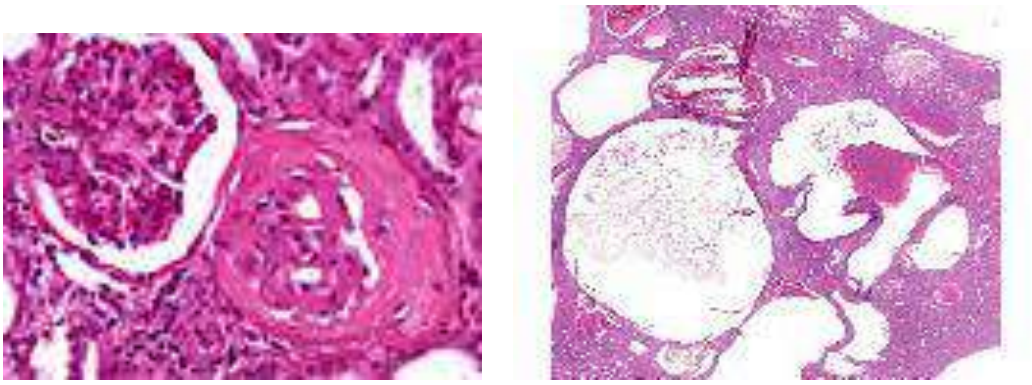
FIG. 1: Images (Photomicrographs) of Microsporidia Stained Samples from Stool Specimens in this Study in Comparison with the Control (the CDC prepared slide 100X)



A B

Figs. 1:A & B (100X); are the Chromotrope 2R stained slides of microsporidia spores from this study, measuring from 1.0-1.8µm x 0.6-1.0µm to 2.0 – 3.5µm x 1-2.0µm using PMIAS 3.0.

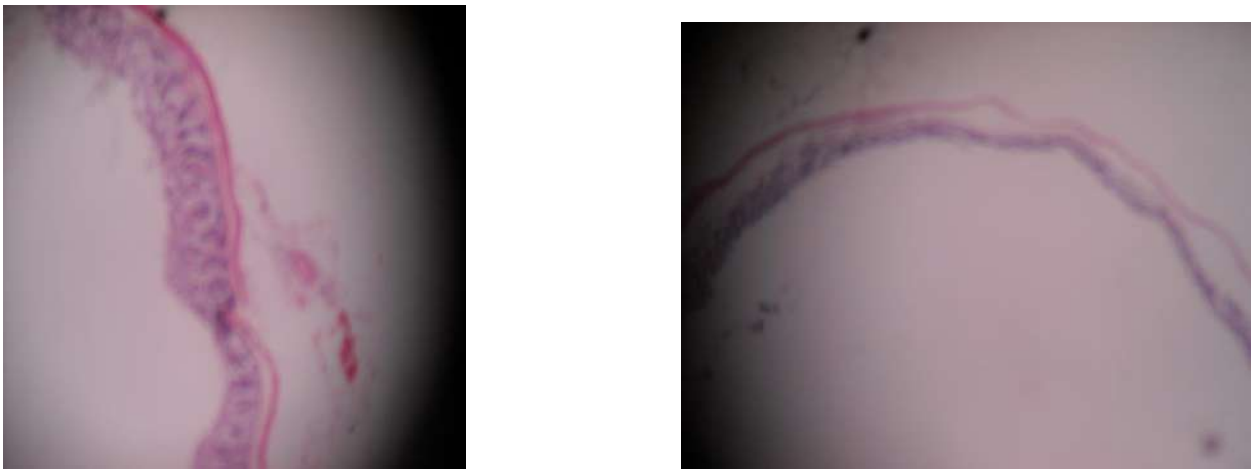
Experimental Study of vital organs of White Albino Mice (*Mus Musculus domesticus*) Infected with Microsporidia Spores.



A= Kidney at day 17 B= Kidney At day 28

Fig. 2: Histopathology of the kidney (x52).

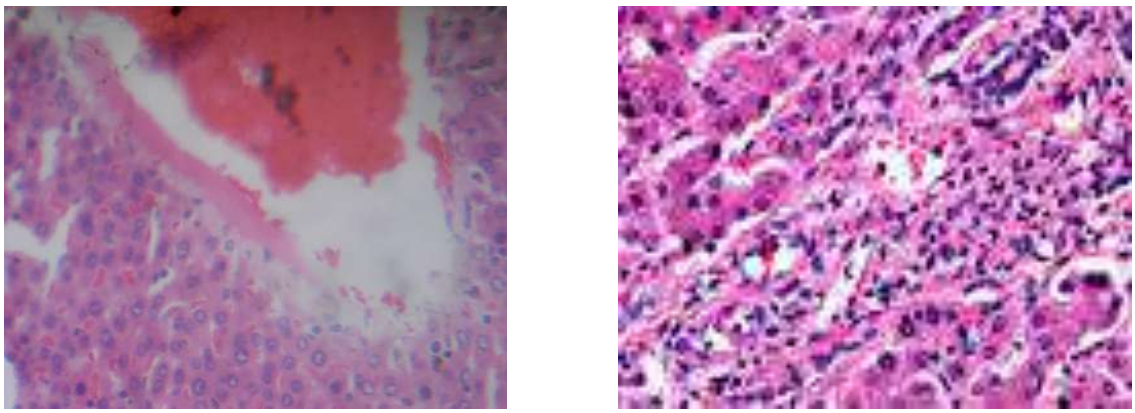
In figs.2A&B above, the glomeruli are obliterated by amorphous amyloid deposits. The vessels are also virtually occulated by the deposition within the walls. Extensive obliteration of the glomerular interstitial tissues as containing heavy infiltrates of white cells, causing widening of the intertubular spaces seen in day 28.



A= Intestine at day 17 B= Intestine at day 28

Fig.3: Histopathology of Small intestines (x52).

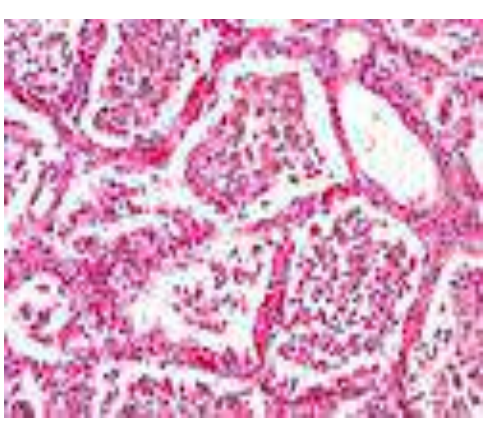
Figs.3 A&B above show partial to complete intestinal mucosa erosion due to the inversion of the microsporidia spores. The superficial mucosa is entirely obscured by the extensive hemorrhage, only the bases of the intestinal glands are visible. Sub-mucosa is also affected in day 28 above.



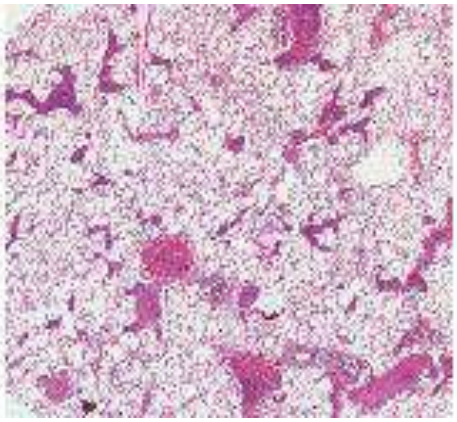
A= Liver at day 17 B= Liver at day 28

Fig.4: Histopathology of the Livers (x52).

In Figures 4 A&B above, an anaplastic carcinoma of the liver was observed. There are great versatility in size and shape of the cells. The nuclei are largely pleomorphic and several hyperchromatic trauma giant cells are readily evident, some with what appears to be multiple nuclei as observed in day 28.



A= Lungs at day 17



B= Lungs at day 28

Fig.5: Histopathology of the Lungs (x52).

In fig.**5** A&B above masses of acute inflammatory cells nearly obliterate lung structure. Panlobular emphysema, the distortion of the characteristically uniform air space was observed. The alveoli and alveolar ducts are dilated with focal areas of paenchymal destruction in day 28.

DISCUSSION

The prevalence of microsporidiasis among the HIV-Positive Patients recorded in this study (42.4%) using Chromotrope 2R is relatively high for an infection which is hardly known or considered significant. The high prevalence of the infection among the HIV-infected patients strongly suggests that microsporidiasis is relatively common among the HIV-infected patients at the University of Ilorin Teaching Hospital, Ilorin. The result also confirms the speculations that, if properly investigated, microsporidiasis prevalence among the immuno-compromised groups could be alarmingly high [12].

The prevalence of microsporidiasis found among the HIV-infected patients poses a concern particularly when it was discovered further from this study that the infection cuts across all ages, sex, educational status, religion and other socio-demographic variables. Presently, this study presents with a high prevalence and intensity of microsporidiasis in both HIV-infected patients and the HIV-non-infected control, creating an epidemiological challenge in both the immuno-compromised and the immuno-competent groups.

In an attempt to further study and morphologically characterize microsporidia species, the isolated spores from this study were measured and found to fall between 2-4µm and a comparison with the CDC control slide, strongly suggest that, the isolated spores are to be those of *Enterocytozoon bieneusi* and *Encephalitozoon cuniculi*.

While there are challenges of probes availability for molecular characterization of

microsporidia to species level, the morphological characterization used in this study and as earlier reported[13] hold promise for further studies on microsporidiasis as supported by their conclusion and that drawn from this study. The measured spores and as compared with the CDC control slide also conform with the report by Coyle *et al.* [(14)] and Yu *et al.*[15]. However, the conclusion they made that only *E. beneusi* was capable and responsible for the Diarrhoea in the HIV-infected patients differs from findings from this study and the conclusion by the CDC. Although this study does not support their conclusions in totality, morphological features presented by their findings agree with those found in the isolated species in this work particularly as concerns *E. beneusi.* The argument put forward by their conclusions and as contained in this study further stresses the need for the rapid development of molecular diagnostic tools that will help characterize microsporidia molecular and to species level.

Animal models which hitherto remain the only veritable tool for the study on microsporidia was experimentally examined in this study, in an attempt to ascertain the route of microsporidial infection and study the pathological damages caused by microsporidiasis. And as revealed in the immuno-suppressed group of albinomice, where pathological damages were observed in the lungs, small intestines, kidneys and livers, Al-Brhami *et al*.[15] and Bojko *et al.* [17] had also observed similar symptom in rabbits and birds respectively. These observations suggest that such damages could possibly be seen in the HIV-infected patients who harbour microsporidia. As Didier *et al.*[18] reported granulomaotus lesions in similar organs in mice and consequent death in those mice, microsporidiasis as discovered from this study strongly suggest to be responsible for the mortality rate of its infected immuno-compromised patients.

In the mice, the onset of overt pathology which occurred on day 17 post-infection and attained the peak severity on day 28 in the affected organs were observed only in the group of mice whose immune systems were suppressed. This shows that microsporidia infection in the immuno-compromised (HIV-infected) patients could result in similar pathological damages capable of causing death in these patients. To affirm this, Ghoshal *et al* in 2021[19] had reported a fatal granulomatous lesion in the liver and lungs as a result of microsporidial infection that were suspected to be responsible for the death of the affected HIV/AIDS patient.

Observations from this study and other findings [20,21] had widened the scope of the morbidity and mortality in the HIV-infected patients as a result of microsporidiasis. Interestingly, these overt pathological damages were observed only from the immune-suppressed mice which received microsporidia inoculums through oral ingestion and intranasal inhalation. This point has confirmed the earlier assumptions by many[22] that oral route is the likely source of microsporidia infection. Furthermore, the result of this study evidenced by the overt pathology in the intranasally inoculated mice suggest that intranasal inhalation is another

route of microsporidia infection whose routes of infection were previously unknown by many [23,24]. By these pathological facts seen, and their absence in other routes of parasite inoculation, it has become established that oral ingestion and intranasal inhalation are the primary routes of microsporidia infection. Also, it is true that, these are the two basic routes where human existence is possible, through feeding and breathing.

Be that as it may, microsporidia can be viewed to be in existence since creation, causing unknown deaths in its host. Encouragingly as revealed from this study and just as the spectrum of microsporidia appears to be getting wider, more understanding about the parasite and the disease will keep unfolding. As reported by Ding *et al.*[25], it will not be out of place if these evidences about microsporidiasis provoke interest for aggressive research about microsporidia worldwide, aiming at making more findings concerning its mode of infection, damages caused, chemotherapy, prevention and control.

The recovery of viable microsporidia spores in the stool samples of the infected immuno-suppressed mice, reaffirms Diarrhoea condition caused by this parasite in the HIV-infected patients, more so with the fact that the immuno-competent mice do not present with Diarrhoea. As Ding *et al* [25] concluded in his remarks, that though parasitic disease have been highly neglected, the little talk about microsporidiasis is as a result of the high level of ignorance about the parasite and the disease, else the danger posed by microsporidiasis in future will not be ignored. As exposure about microsporidia begins to unwind, the danger, by this organism as evidenced by this study will soon remain far and above neglect. Furthermore, this study reveals that, microsporidia will remain a parasite of interest for further studies in the morbidity and mortality rates among the immuno-compromised patients worldwide. While much more is expected to be established about microsporidia, findings from these pioneering initiations are encouraging and enough to substantiate that, epidemiological significance of this parasite and knowledge about the parasite are relevant to man.

CONCLUSION

The prevalence of microsporidiasis (42.4%) (an opportunistic infection) is relatively common among the immuno-compromised (HIV/AIDS) patients, thus posing a serious threat to complicate morbidity and mortality in areas where HIV/AIDS is common. The association of microsporidiasis with overt pathology in vital internal organs of immuno-compromised (HIV/AIDS) patients has been demonstrated. We recommend that Routine laboratory search, screening in hospitals and identification of microsporidia spores should be made mandatory and/or reportable. More studies on the etiology of microsporidiasis should be undertaken including histopathology study of different organs at autopsy.

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ORIGINAL RESEARCH

IMPACT OF VOLUME-ORIENTED INCENTIVE SPIROMETRY ON INSPIRATORY HOLD VARIABLE OF PATIENTS WHO HAD INVASIVE THORACIC PROCEDURE

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ABSTRACT

Background: Patients who have had invasive thoracic procedures often experience a decrease in respiratory components which includes inspiratory hold capacity (IHC). This can lead to postoperative respiratory complications. Volume-oriented incentive spirometry (VOIS) is a breathing exercise that can improve respiratory function. However, there is limited research on the impact of VOIS on the inspiratory hold capacity of spontaneously breathing patients who have had invasive thoracic procedures.

Aim: To investigate the short-term impact of VOIS on inspiratory hold capacity (IHC) of patients who have had invasive thoracic procedures.

Materials and Methods: 12 patients who had undergone invasive thoracic surgery were purposively recruited for this study. The patients performed VOIS exercises as prescribed by the researchers (3 sets of 5

breaths with 1-minute rest between each set) for every 2 hours of awake period. Rest periods were given to prevent the participants from hyperventilating.

Results: Participants were of mean age 38.83 ± 18.11years, with 9 (75%) of them being male. There was a significant increase in IHC as well as incentive-inspired volume (IIV) following the administration of VOIS for two weeks. There was a significant positive correlation between IHC and IIV.

Conclusion: VOIS is effective in increasing IHC as well as IIV in patients following thoracic surgery. By promoting sustained maximum inspiration, incentive spirometry aids in the recruitment of alveoli, improving lung volumes and overall pulmonary function, and can be effective in reducing postoperative pulmonary complications.

Keywords: Volume-oriented incentive spirometry, Inspiratory hold capacity, Invasive thoracic surgery, Cardiopulmonary, Spirometer.

INTRODUCTION

Physiotherapy plays a critical role in the recovery of patients who have undergone thoracic surgery, particularly in managing airway clearance and the implementation of breathing exercise protocols. These interventions are essential for reducing the incidence of postoperative pulmonary complications (PPCs) such as atelectasis, and in cases where PPCs have already developed, physiotherapy contributes to their resolution[1]. In the physiotherapy management for postoperative patients, deep breathing is a vital practice, emphasizing the use of the diaphragm rather than the accessory muscles for respiration. Patients who actively engage in deep breathing protocols benefit from several physiological improvements. These include the reversal of atelectasis, enhanced oxygenation, increased alveolar ventilation, increased functional residual capacity, and increased diaphragmatic mobility[2,3,4]. Additionally, deep breathing contributes to a higher tidal volume and facilitates the clearance of pulmonary secretions[5,6].

Inspiratory hold is a surrogate measure of plateau pressure or alveolar compliance in patients on ventilators, it permits the pressure to equalize through the respiratory system[7]. During the process of inhalation, an inspiratory hold takes place on the ventilator, in which the flow is deliberately halted. Conversely, in a patient who is spontaneously breathing, the patient voluntarily suspends their breath after the inspiration phase, this action serves to eliminate the pressure impact caused by airway resistance and unveils the pressure within the alveoli[8]. Inspiratory hold capacity (IHC) is a measure of the maximum amount of air a person can hold in their lungs after taking a deep breath[9]. It is an important indicator of respiratory function and can be used to assess the severity of lung disease. Patients who have had invasive thoracic procedures, such as a lobectomy or pneumonectomy, often experience a decrease in IHC[10]. This is due to several factors, including the removal of lung tissue, damage to the nerves and muscles that control breathing, and also due to pain**.** To estimate IHC when using an incentive spirometer, inspiratory hold time (IHT) is utilized, as it is a significant factor of IHC and has been demonstrated to strongly correlate with IHC[11].

Incentive spirometry is frequently used after thoracic surgery to help patients more effectively adhere to deep breathing protocols. This device facilitates sustained, slow deep breaths by replicating the natural

act of sighing[12]. Incentive spirometry is centred on the principle of sustained maximum inspiration (SMI), which is believed to recruit collapsed alveoli and restore preoperative pulmonary function in thoracic surgery patients[13]. The device facilitates SMI by providing visual feedback on inspiratory effort, enabling physiotherapists to coach patients effectively while allowing patients to monitor their performance and progress[13,14]. Volume Oriented Incentive Spirometry (VOIS) is one of the two common types of incentive spirometers. The VOIS enables patients to inhale air through a mouthpiece connected to corrugated tubing, and the volume of inhaled air is indicated on a scale located on the device[15]. While previous studies have demonstrated the efficacy of VOIS in improving post-operative pulmonary function[15,16,17], to the best of the researchers' knowledge, there is a dearth of literature on the effect of VOIS on inspiratory hold capacity post-surgery.

MATERIALS AND METHODS

Participants

The participants of this study were adult patients aged 18 years and above, who have undergone any kind of invasive thoracic procedures (such as thoracotomy, lobectomy or pneumonectomy, mediastinoscopy, thoracocentesis, sternotomy, etc) at the University of Benin Teaching Hospital (UBTH) Benin-city, Edo State, Nigeria. Patients who required mechanical ventilation postoperatively, were sedated, or had a reduced Glasgow Coma Scale (GCS) score and were unable to follow instructions were excluded from the study.

Sample Size & Sampling Technique

A total of 12 participants were recruited via the purposive sampling technique.

Research design

This study was a brief longitudinal study. Participants were monitored over two weeks with inspiratory hold time (IHT) repeated measurements taken at specific intervals (baseline and at 2 weeks).

Research instrument.

Participants used a volume-oriented incentive spirometer (produced by Hudson RCI and Respironics, 2014) as an intervention for deep breathing exercises. A stopwatch was used to measure the time for the inspiratory hold.

Research Procedure

Ethical approval for this study was sought and obtained from the Ethical and Research Committee of the University of Benin Teaching Hospital (ADM/E/22/A/VOL.VII/148301171).
Participants were recruited from the cardiothoracic surgery wards at the University of Benin Teaching Hospital. Before the study commenced, prospective participants were informed about its purpose, and written informed consent was sought and obtained from each participant. The researchers provided participants with instructions on performing volume-oriented incentive spirometer (VOIS) exercises and the inspiratory hold manoeuvre technique. Participants were instructed to perform VOIS exercise with prescription (3 sets of 5 breaths with 1 min rest in between each set) for every 2 hours of awake period, for two weeks. Rest periods were given to prevent the participants from hyperventilating. IHT and incentive-inspired volume were

measured before and after the VOIS intervention.

To measure the dependent variable (IHT) an inspiratory hold manoeuvre technique was carried out at baseline and after two weeks as follows; Patients were positioned in a comfortable and tolerable position. They were then instructed to take a deep breath through their nose hold it for as long as possible, and exhale slowly afterward. A stopwatch was used to measure the time for the inspiratory hold. The procedure was repeated three times and the longest IHT was recorded. Demographic information (age, gender, and type of surgery undergone) was also collected.

Method of Data Analysis

Descriptive statistics was used to summarize the data. Paired t-tests were used to compare the changes in the variables (incentive-inspired volume and IHC) and Pearson's correlation was used to determine the relationships between incentive-inspired volume and inspiratory hold capacity. A p-value of <0.05 was considered statistically significant. Data was analyzed using SPSS software version 27.

RESULTS

A total of 12 patients who had undergone invasive thoracic surgery at UBTH participated in this study. The participants had a mean age of 38.83 ± 18.11 years and 9 (75%) were male. 8 (66.7%) of the participants had closed tube thoracostomy drainage. Other procedures included sternotomy and mediastinal mass excision (8.3% each), thoracocentesis (8.3%), percutaneous drainage (8.3%), and needle decompression (8.3%). This is presented in Table 1.

The mean incentive-inspired volume at baseline score was 983.33 ± 815.57ml and at week two 1704.17 ± 871.90ml. VOIS had a significant effect on the IIV of the participants (p <0.001), with a mean increase of 720.83ml. The mean score for inspiratory hold capacity at baseline was 15.67 ± 7.74 seconds and at week two 20.83 ± 8.45 seconds. VOIS had a significant effect on the IHC of the participants (p = 0.001) with a mean increase of 5.16 seconds. This is shown in Table 2.

There was a significant positive correlation between IIV and IHC both at baseline (p = 0.013) and after two weeks of VOIS intervention (p = 0.008).

Table 1: Sociodemographic characteristics of the participants

	Frequency	**Percentage (%)**
Gender		
Male	9	75
Female	3	25
Type of Surgery		
Closed tube thoracostomy drainage	8	66.7
Sternotomy and mediastinal mass excision	1	8.3
Thoracocentesis	1	8.3
Percutaneous drainage	1	8.3
Needle decompression	1	8.3
	Mean ± SD	
Age (years)	38.83 ± 18.11	

Table 2: Effect of VOIS on incentive-inspired volume and inspiratory hold capacity

	Mean ± SD	**Mean Diff.**	**CI**		**t**	**p**
			Upper	**Lower**		
IIV Baseline	983.33 ± 815.57	720.83	-1002.86	-438.81	-5.63	<0.001
IIV Wk. 2	1704.17 ± 871.90					
IHC Baseline	15.67 ± 7.74	5.17	-7.83	-2.50	-4.27	0.001
IHC Wk. 2	20.83 ± 8.45					

IIV = Incentive inspired volume (ml)

IHC = Inspiratory hold capacity (s)

Table 3: Relationship between incentive-inspired volume and inspiratory hold capacity at baseline and two weeks of VOIS intervention

	R	P
IIV * IHC (Baseline)	0.690	0.013
IIV * IHC (Wk. 2)	0.725	0.008

IIV = Incentive inspired volume (ml)

IHC = Inspiratory hold capacity (s)

DISCUSSION

The study investigated the short-term effect of volume-oriented incentive spirometry (VOIS) on incentive-inspired volume (IIV) and inspiratory hold capacity (IHC) in patients who have undergone an invasive thoracic procedure. From the findings of the present study, VOIS had a significant effect on IIV, with a significant increase observed after 2 weeks of intervention. This finding is in tandem with that reported by Toor *et al*., [13], whose study observed a significant increase in maximum inspiratory volume among patients who used an incentive spirometer daily for 4 weeks. Similar findings were also observed by Ganesh *et al*.,[18] who reported that administration of VOIS for 7 days significantly improved lung volume and peak expiratory flow rate among patients with a tracheostomy tube. Lunardi *et al*.,[19] also reported that VOIS had a greater effect on chest wall volume among healthy adults while requiring lower muscle activity compared to flow incentive spirometer.

This study also observed that VOIS had a significant impact on the IHC of the participants, with a marked increase in inspiratory hold time after two weeks of intervention. To the researchers' knowledge, there is a paucity of studies that have investigated the effect of VOIS on IHC, hence there is a limitation of studies with which the findings of the present study can be directly compared or contrasted. However, similar studies on incentive spirometry have reported positive effects on pulmonary functions like breath-holding time. Vediappan *et al*.,[20] reported that incentive spirometry had a significant effect on breath-holding time among patients with coronary artery bypass graft, albeit the effect is less pronounced compared to when incentive spirometry is combined with the Buteyko breathing technique. The observed significant impact of VOIS on inspiratory hold capacity (IHC) aligns with broader findings on the benefits of incentive spirometry in enhancing pulmonary functions. The increase in inspiratory hold time after two weeks suggests that VOIS effectively promotes deeper, more sustained breaths, which likely strengthens the respiratory muscles and improves lung compliance.

This present study also observed a significant positive correlation between IIV and IHT both at baseline and after two weeks of VOIS administration. This is supported by Aggarwal *et al*.,[21] who reported a significant correlation between breath-holding time and pulmonary functions such as Forced Expiratory Volume in one second,

Forced vital capacity, and Peak expiratory flow rate. The relationship between incentive spirometry and inspiratory hold time may be explained by the way incentive spirometry promotes lung expansion and deep breathing. Incentive spirometers are designed to encourage slow, deep inhalations, which naturally extend the inspiratory phase. By holding the breath after inhalation (inspiratory hold), patients keep the alveoli open longer, allowing for better gas exchange and lung recruitment. This process helps improve lung volumes, increases inspiratory hold time, and enhances overall respiratory function, especially in patients recovering from surgery or with compromised lung function.

CONCLUSION

VOIS is effective in increasing IHC as well as IIV in patients following thoracic surgery. By promoting sustained maximum inspiration, incentive spirometry aids in the recruitment of alveoli, improving lung volumes and overall pulmonary function, and can be effective in reducing postoperative pulmonary complications.

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ORIGINAL RESEARCH

ASSESSMENT OF ADIPONECTIN, TRIGLYCERIDE, AND CHOLESTEROL LEVELS AMONG ELDERLY RESIDENTS OF NNEWI, ANAMBRA STATE, NIGERIA

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ABSTRACT

Background: The WHO defines aging as beginning at 65 years or older, highlighting the need to understand the interplay between adiponectin, triglycerides, and cholesterol in promoting elderly health. Critical to metabolic and cardiovascular well-being, these biomarkers interact complexly, serving as indicators and potential targets for improving overall health in aging populations.

Aim: This research aims to evaluate the levels of adiponectin, triglycerides, and cholesterol among elderly residents of Nnewi, Anambra State, Nigeria, to better understand their metabolic and cardiovascular health status.

Methods: This study evaluated serum levels of adiponectin, triglycerides, cholesterol, and BMI in 90 participants, including 45 elderly subjects (65 years and above) and 45 younger controls. Spectrophotometric methods were used for biomarker analysis, with statistical assessments conducted using t-tests and correlation analysis.

Results: There were no significant differences in the mean serum levels of adiponectin, triglycerides, and cholesterol between the test and control groups ($p = 0.38$, 0.88, and 0.25, respectively; $p > 0.05$). However, the test group exhibited significantly higher mean values for BMI, SBP, and DBP (25.87 ± 5.03, 140.22 ± 22.41, and 87.78 ± 17.31, respectively; $p < 0.05$) compared to the control group. Correlation analysis revealed a weak positive correlation between triglycerides (TG) and waist circumference (WC) ($r = 0.298$, $p = 0.047$), as well as between cholesterol (CHOL) and diastolic blood pressure (DBP) ($r = 0.326$, $p = 0.029$) in the test group.

Conclusion: These findings highlight the interplay between metabolic and cardiovascular factors, suggesting that elevated BMI and blood pressure may be linked to subtle changes in lipid metabolism and its relationship with anthropometric measures in the test group.

Keywords: Aging, Metabolic health, Adiponectin, Triglycerides, Cholesterol

INTRODUCTION

Aging, an inevitable process, is often measured by chronological age, with individuals aged 65 years or older typically classified as "elderly"[1]. As the global population continues to age, understanding the complex interactions among adiponectin, triglycerides, and cholesterol becomes vital for enhancing the health and well-being of older adults. These biomarkers play critical roles in metabolic and cardiovascular health, serving as both indicators and potential targets for interventions to improve aging outcomes. Adiponectin, an adipocyte-derived hormone with anti-inflammatory and insulin-sensitizing properties, is central to metabolic regulation[2]. Maintaining adequate adiponectin levels is crucial in the elderly, as reduced levels have been associated with insulin resistance, inflammation, and increased risk of cardiovascular diseases[3]. Moreover, adiponectin levels have been linked to longevity, with higher levels correlating to a reduced risk of cardiovascular diseases, type 2 diabetes, and metabolic syndrome[4,5]. Triglycerides, a key marker of dyslipidaemia, often increase with age and pose significant cardiovascular risks[6]. Elevated triglyceride levels in older adults are associated with metabolic syndrome, insulin resistance, and even cognitive decline[7]. As a known risk factor for cardiovascular events, triglyceride monitoring in the elderly is crucial for early detection and intervention[8]. Cholesterol, an essential lipid for cell membrane integrity and hormone synthesis, has a nuanced relationship with aging. While high cholesterol levels are linked to cardiovascular risks, excessively low levels have been associated with cognitive decline, necessitating careful management[9]. Cholesterol management strategies in the elderly must balance cardiovascular protection and cognitive preservation[10]. These biomarkers do not function independently but interact complexly, influencing overall health. For instance, adiponectin is inversely correlated with triglycerides and positively correlated with high-density lipoprotein cholesterol (HDL-C)[11]. Investigating these interconnections in aging populations could reveal targeted intervention strategies to mitigate age-related health challenges effectively.

MATERIALS AND METHOD

The study was a longitudinal study design which evaluated the levels of total cholesterol, triglyceride, adiponectin, and BMI in elderly individuals residing in the Nnewi metropolis. A total of 90 subjects were recruited for the study, comprising 45 male and/or female participants aged 65 years and above as test subjects and 45 younger individuals as the control group. Their heights in meters and weights in kilograms were measured, recorded and used to calculate their BMI (kg/m^2) by dividing their weight with the value of the square of their heights in meters as described by [12] . Overweight and obesity were defined as Body Mass Index (BMI) ≥ 25 and 30 kg/m2, respectively.

Written consent was sought and obtained from the participants, and structured questionnaires were administered to obtain demographic information from the participants. Five millilitre(5 ml) venous blood sample was collected aseptically from each student and dispensed into plain tubes. The samples were allowed to clot, followed by centrifugation at 5,000 rpm for 5 minutes to separate serum for the evaluation of total cholesterol, adiponectin, and triglyceride. Statistical analysis was performed using an independent Student's t-test, with significance determined at $p < 0.05$. Additionally, the correlation between the parameters was assessed using Pearson's correlation coefficient.

Ethical approval: The study sought and obtained ethical approval from the Ethics Committee of the Faculty of Health Sciences and Technology College of Health Sciences Nnamdi Azikiwe University with reference no. FHST/REC/023/566

RESULTS

The Mean Values of Adiponectin, Triglycerides and Cholesterol in the Elderly living in Nnewi Metropolis and the Control(Mean ± S.D)

There was no significant difference in the mean level of serum Adiponectin of the test group (428.87± 69.55 pg/ml) compared with the control group (659.00±14.00 pg/ml) ($p>0.05$).

There was no significant difference in the mean level of serum Triglyceride of the test group (1.23±0.31 mmol/l) compared with the control group (1.03± 0.31 mmol/l) ($p>0.05$).

There was no significant difference in the mean level of serum Cholesterol of the test group (3.76 ± 0.54 mmol/l) compared with the control group (3.79 ± 0.52 mmol/l) ($p>0.05$).

Table 1: Mean Values of Adiponectin, Triglycerides and Cholesterol in the Elderly living in Nnewi Metropolis and the Control (Mean ± S.D)

Parameter	Test Group (N = 45) Mean ± S.D	Control Group (N= 45) Mean ± S.D	T-value	P-value
Adiponectin (pg/ml)	428.87 ± 69.55	659.00 ± 14.00	-1.101	0.38
Triglyceride (mmol/L)	1.23 ± 0.31	1.03 ± 0.31	3.076	0.88
Cholesterol (mmol/L)	3.76 ± 0.54	3.79 ± 0.52	0.318	0.25

** Statistical significance at P<0.05*

Body Mass Index, Waist circumference, Systolic and Diastolic Blood pressure in the Test group (Elderly) and Control group (Young)(Mean ± S.D).

There existed significant higher mean values of BMI, SBP and DBP (25.87 ± 5.03, 140.22± 22.41, 87.78 ± 17.31) of the test group compared with the control (23.37 ± 4.24, 36.77± 45.01, 114.27±8.24) (P<0.05).However , no significiant difference existed in the mean values of waist circumference (31.54± 4.23) of the test group compared to the control group (36.77± 45.01) (p>0.05)

Table 2: Body Mass Index, Waist circumference, Systolic and Diastolic Blood pressure in the Test group (Elderly) and Control group (Young)(Mean ± S.D).

Parameter	Test group (n=45) Mean ± SD	Control group (n=45) Mean ± SD	T-value	P-value
BMI (kg/m^2)	25.87 ± 5.03	23.37 ± 4.24	2.549	0.013
WC (cm)	31.54 ± 4.23	36.77 ± 45.01	-0.775	0.441
SBP (mmHg)	140.22 ± 22.41	114.27 ± 8.24	7.293	0.001
DBP (mmHg)	87.78 ± 17.31	79.40 ± 9.71	2.832	0.016

** Statistical significance at P<0.05*

Key:
BMI=Body Mass Index
SBP= systolic blood pressure
DBP= diastolic blood pressure
WC= Waist Circumference

Association between Adiponectin vs Triglyceride, Cholesterol studied in the Test group(Elderly)

No association existed between AD vs TG (r= -0.190, p=0.212) and AD vs CHOL (r=0.092, p=0.546) in the elderly (test group). In the control group, no significant association was observed between AD and TG (r = 0.251, p = 0.096) or between AD and CHOL (r = -0.051, p = 0.740) ($p < 0.05$).

Table 3: Association Between Adiponectin Vs Triglyceride, Cholesterol Studied In The Test Group(Elderly)

PARAMETERS	r	p-value
Ad Vs TG	-0.190	0.212
Ad Vs Chol	0.092	0.546

** Statistical significance at P<0.05*

Table 4: Correlation Of The Parameters Measured In The Control Group

PARAMETERS	**r**	**p-value**
Ad Vs TG	0.251	0.096
Ad Vs Chol	0.051	0.740

** Statistical significance at P<0.05*

Key:
AD=Adiponectin
TG=Triglyceride
Chol= Cholesterol

Association between Adiponectin, Triglyceride & Cholestreol with Body Mass Index,Waist Circumference,Systolic&Diastolic Blood pressure in the Elderly.

In elderly participants, a weak positive correlation was observed between triglycerides (TG) and waist circumference (WC) (r = 0.298, p = 0.047). No significant associations were found between TG and diastolic blood pressure (DBP) (r = 0.258, p = 0.088), body mass index (BMI) (r = -0.252, p = 0.095), or systolic blood pressure (SBP) (r = 0.133, p = 0.385). Similarly, adiponectin (AD) showed no significant associations with BMI (r = 0.062, p = 0.685), WC (r = -0.139, p = 0.361), SBP (r = -0.005, p = 0.973), or DBP (r = 0.145, p = 0.341). Cholesterol (CHOL) was not significantly associated with BMI (r = -0.257, p = 0.880), WC (r = 0.130, p = 0.395), or SBP (r = 0.216, p = 0.154), but a weak positive correlation was found between CHOL and DBP (r = 0.326, p = 0.029).

Table 5: Association between Adiponectin, Triglyceride and Cholestreol with Body Mass Index,Waist Circumference,Systolic&Diastolic Blood pressure in the Elderly

Parameters		BMI (kg/m^2)	WC (cm)	SBP (mmHg)	DBP (mmHg)
Adiponectin (pg/ml)	r-value	0.062	-0.139	-0.005	0.145
	P-value	0.685	0.361	0.973	0.341
Triglyceride (mmol/L)	r-value	-0.252	0.298	0.133	0.258
	P-value	0.095	0.047	0.385	0.088
Cholesterol (mmol/L)	r-value	-0.257	0.130	0.216	0.326
	P-value	0.088	0.395	0.514	0.029

** Significant at P<0.05*

Association Between Adiponectin, Triglyceride And Cholesterol With Body Mass Index, Waist Circumference, Systolic And Diastolic Blood Pressure In The Control Group

In the control group, adiponectin showed no significant associations with BMI (r = 0.036, p = 0.814), WC (r = 0.037, p = 0.809), SBP (r = -0.609, p = 0.650), or DBP (r = 0.016, p = 0.917). Triglycerides (TG) exhibited a weak positive correlation with BMI (r = 0.344, p = 0.021), but no significant associations were found with WC (r = 0.088, p = 0.960), SBP (r = 0.201, p = 0.185), or DBP (r = 0.237, p = 0.117). Similarly, cholesterol (CHOL) showed no significant correlations with BMI (r = 0.114, p = 0.455), WC (r = -0.160, p = 0.294), SBP (r = 0.056, p = 0.714), or DBP (r = 0.163, p = 0.283) in the control participants.

Table 6: Association Between Adiponectin, Triglyceride And Cholesterol With Body Mass Index, Waist Circumference, Systolic And Diastolic Blood Pressure In The Control Group

Parameters		BMI (kg/m^2)	WC (cm)	SBP (mmHg)	DBP (mmHg)
Adiponectin (pg/ml)	r-value	-0.036	-0.037	-0.069	0.016
	P-value	0.814	0.809	0.650	0.917
Triglyceride(mmol/L)	r-value	0.344	0.008	0.201	0.237
	P-value	0.021	0.960	0.185	0.117
Cholesterol(mmol/L)	r-value	0.114	-0.160	0.056	0.163
	P-value	0.455	0.294	0.714	0.283

** Significant at P<0.05*

DISCUSSION

Understanding the interplay between adiponectin, triglycerides, and cholesterol is vital for supporting the health and well-being of the elderly, especially as the global population ages. Adiponectin, a hormone involved in regulating glucose metabolism and fat oxidation, plays a protective role against conditions like obesity, type 2 diabetes, and cardiovascular diseases[13]. However, its levels tend to decline with age, contributing to increased risks of metabolic dysfunction[14]. This decline is often accompanied by elevated triglycerides, which are linked to insulin resistance and cardiovascular complications, and imbalances in cholesterol, such as higher LDL levels and lower HDL levels, which exacerbate these risks. The findings of this study revealed no significant differences in the mean serum levels of Adiponectin, Triglycerides, and Cholesterol between the test group and the control subjects. Previous studies have demonstrated that higher serum levels are linked to an increased risk of total and cardiovascular mortality and increased risk of coronary heart disease (CHD) in a large population of older adults[15,16]. The test group of elderly subjects exhibited significantly higher mean values for body mass index (BMI), systolic blood pressure (SBP), and diastolic blood pressure (DBP) compared to the control group. Body mass index (BMI) is positively and independently linked to increased morbidity and mortality from hypertension, cardiovascular disease, type II diabetes mellitus, and other chronic conditions[17]. Overweight and obesity heighten the risk of high blood pressure (BP), cardiovascular diseases, type II diabetes, and certain cancers. A BMI above 21 kg/m^2 contributes to 58% of diabetes cases and 21% of global ischemic heart disease[18]. In developing countries, high BP, influenced by aging and modernization, is a leading cause of cardiovascular deaths, accounting for 7.1 million fatalities annually[18,19]. A cross-sectional study conducted by Mungreiphy et al. among Tangkhul Naga tribal males in Northeast India revealed that body

weight, BMI, and blood pressure increase with age. The study also identified a strong positive correlation between age, BMI, and blood pressure, aligning with the findings of the present study[20]. Kapoor et al [20] and Tandon reported this increase in BMI and blood pressure with age in their respective studies[21]. A positive correlation was observed between the triglycerides (TG) and waist circumference (WC) in the elderly group. Waist circumference (WC) is a key predictor of chronic diseases and mortality, even after accounting for BMI[22]. Its measurement and BMI are important in primary care, and the triglyceride glucose-WC index serves as a novel diabetes predictor[23]. A study by Raj et al. examined the relationship between triglyceride levels and waist circumference in men and women, revealing that individuals with larger waist circumferences had higher triglyceride levels, highlighting a significant association between waist circumference and hypertriglyceridemia[24]. A study by Zhang et al. on factors influencing triglyceride (TG) levels among adults in Northeast China found a positive association between body mass index (BMI), waist circumference (WC), and TG levels across all quantiles[25]. Additionally, the impact of WC on TG levels was shown to be more pronounced as TG levels increased[25]. Cholesterol and DBP showed a weak positive correlation in the elderly group. A longitudinal study by Wong et al. demonstrated a relationship between LDL-C and CVD events only when blood pressure (BP) was <140/90 mmHg[26]. Additionally, an association between HDL-C and CVD events was observed up to a BP of 160/100 mmHg, indicating that elevated BP increases the risk of CVD in elderly individuals across all lipid levels. These findings align with the results of the current study. An analysis of pooled data from six large prospective U.S. cohort studies revealed that elevated diastolic blood pressure (DBP) and low-density lipoprotein (LDL) levels during young adulthood were linked to an increased risk of coronary heart disease (CHD)[27]. Additionally, elevated systolic blood pressure (SBP) and DBP in young adults were associated with a higher risk of heart failure (HF), independent of exposures later in life. These findings indicate that elevated SBP, DBP, and LDL during early adulthood independently contribute to the risk of developing CHD and HF in later life.

CONCLUSION

The results from this study underscore a complex interplay between adiponectin, triglycerides, cholesterol, and metabolic health in elderly subjects, highlighting significant association between triglycerides, waist circumference, cholesterol, and blood pressure. This emphasizes the importance of early interventions targeting these factors to mitigate the risk of cardiovascular diseases and metabolic dysfunction in aging populations.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Contributors: ACI, PCO, and NO conceived and designed the research proposal. CUO, JCU, OAI, and ACI performed sample collection, experiments, and data analysis. CUO, ACI, ROO, and OAI contributed to the final version of the manuscript. All authors have read and approved the final manuscript.

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Data availability: The data used to support the findings of this study are available from the corresponding author upon reasonable request.

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ORIGINAL RESEARCH

ASSOCIATION AMONG HEALTH STATUS, DISABILITY PROFILE AND WORK- RELATED QUALITY OF LIFE OF STAFF OF A UNIVERSITY

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ABSTRACT

Background: Health status could be impacted by disability, and might affect workplace productivity and quality of life. There appears to be a dearth of studies on the association among health status (HS), disability profile (DP) and work-related quality of life (WRQoL) among workers.

Aim: This study investigated the association among HS, DP and WRQoL of staff of a university.

Methods: Participants in this cross-sectional study were recruited using a stratified sampling technique. The HS, DP and WRQoL were assessed using Short Form Health Survey (SF-12) Questionnaire, Washington Group Questionnaire and Work-Related Quality of Life Scale respectively. Data were summarized using mean, frequency, percentage and standard deviation. Chi-square test was used to evaluate the association among HS, DP and WRQOL. Mann-Whitney U test was used to evaluate the difference in HS, DP and WRQOL between the academic and non-academic staff. Level of significance was set at $p<0.05$.

Results: Three hundred and seventy (370) workers participated in the study (46.2±10.15 years; male, 56%) with 52.7% reporting a better HS and 87.8% reporting no disability. About 95.4% had a high level of WRQoL. There was a significant association between HS and DP (p=0.001); HS and WRQOL (p=0.002) as well as DP and WRQoL (p=0.001). There was a significant association between academic

qualification and HS (p=0.003). There was a significant difference in health status between the academic and non-academic staff (p=0.02). However, there was no significant difference in disability profile between the academic and non-academic staff (p=0.48) as well as WRQOL (p=0.66).

Conclusion: This study concluded that most of the staff of the University of Ibadan had good health status, were without disability and had high level of WRQOL. Efforts should be made to sustain these health parameters among staff members.

Keywords: Health status, disability profile, work, related quality of life, staff

INTRODUCTION

Health status is a measure of how people perceive their health which they may rate as excellent, very good, good, fair, or poor[1]. According to the World Health Organization, the main determinants of health include the social and economic environment, the physical environment and the person's individual characteristics and behaviours[2]. Reported health status is a predictor of important health outcomes including mortality, morbidity, and functional status[3]. An individual's ability to have a high quality of life, maintain independence and participate fully in the society can be influenced by health status[4]. An individual's health status can affect their performance at work, as poor health may lead to decreased productivity, increased absenteeism and difficulty in maintaining a work-life balance. Studies have shown that poor health can negatively impact various dimensions of work-related quality of life, such as job satisfaction, work engagement and overall productivity[5,6]. Conversely, good health can enhance job satisfaction, performance and overall well-being contributing positively to work-related quality of life. Factors that may impact self-reported health status include severity of disability or health condition, duration of the disability and type of activity limitation of the person with the disability[7].

Research has shown that disability has significant negative impact on health status of individuals and their capacity to work, which could cause work limitation[8]. Disability is any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions). According to the World Health Organization[9], disability results from the interaction between individuals with a health condition with personal and environmental factors including negative attitudes, inaccessible transportation and public buildings and limited support[2]. About one billion people have one or another form of disability, whereas close to 110-190 million adults have major limitations in performing their routine activities[9]. Adults with disabilities are 4 times more likely to report their health to be fair or poor than people with no disabilities (40.3% vs 9.9%)[10]. The WHO estimates that over 15% of the world's population lives with some form of disability, with about 12% of the US population having disabilities[9]. People with disabilities may have difficulties performing job-related tasks, leading to decreased productivity in their workplace[10].

In the workplace context, there is a possibility that individuals may lack awareness of their disabilities. This lack of awareness could add to the potential consequences on both physical and mental well-being. Factors contributing to this lack of awareness include the gradual onset of

conditions, a general lack of knowledge about specific health issues and the persisting stigma that surrounds disability disclosure[11]. This combination of factors shapes an environment where individuals may not fully grasp the complexities of their own situations. Disability can significantly impact the health status of individuals, particularly in the workplace, as undetected disabilities can lead to stress, which could affect mental health and overall well-being. The severity and nature of the disability can influence an individual's health status and subsequent quality of life outcomes. Having a disability, irrespective of type, increases the risk of developing mental health problems and disorders because of associated adverse individual and environmental factors[2]. Research has shown that approximately 20% of employees reported having an unrecognized disability and these could impact their health and well-being[12].

Work- related quality of life (WRQoL) is a broad concept used to define the quality of life of individuals at their workplace, be it of any type or size[13]. Quality of work life can affect staff performance and job engagement and these also predict the quality of organizational service. The quality of work life is important because it is associated with employee commitment, organizational effectiveness and productivity[14]. Having some form of disability can affect work-related quality of life in various ways, these could be difficulties assessing the workplace, limitations in performing job tasks and potential discrimination. Individuals with disabilities may also face specific health challenges that can impact their work-related quality of life[15].

Overall, understanding the association among health status, disability profile and work-related quality of life is crucial for improving the well-being of individuals with disabilities. Considering various disabilities and health conditions, as well as their impact on work-related quality of life, interventions can be developed to address the specific needs of these individuals and enhance their overall well-being. This study was aimed at determining the association among the health status, disability profile and work - related quality of life of staff of University of Ibadan.

MATERIALS AND METHODS

Study design and population

The study was a cross-sectional study in which stratified sampling technique used to select participants from the two classes of staff in University of Ibadan (academic staff and non-academic staff). The sample size for this study was calculated using the Slovin's formula n= $N/(1+N(e^2)$. n=required sample size; N=Total population of staff. The calculated sample size was 370 and based on the ratio of academic staff to non-academic staff (1:2.3) obtained from the registry department of the University, the academic staff sample size was 113 while the non-academic staff sample size was 257. Participants were recruited from randomly selected faculties which have both categories of staff (Faculty of Science, Faculty of Arts, Faculty of Social Science, Faculty of Technology, Faculty of Public Health and Faculty of Education). Some non-academic members of staff were further recruited from other administrative offices which have only non-academic staff, such as the registry, the bursary and the works offices. Ethical approval was sought and obtained from University of Ibadan/University College Hospital Health Research Ethics Committee (UI/EC/23/0807) before the commencement of the study. An informed consent form was

administered to seek and obtain consent from the participants who met the inclusion criterion, before the administration of the questionnaires. The inclusion criterion was that they must have been working in the University for at least 2 years. The nature, purpose and rationale of the study were explained to each participant and they were also informed of their freedom to refuse to take part in the study.

The set of questionnaires was distributed to each participant - the Health Status (HS), Disability Profile (DP) and Work-related Quality of Life Scale (WRQoL) were assessed using Short Form Health Survey (SF-12) Questionnaire, Washington Group Questionnaire and Work-Related Quality of Life Scale respectively. The duration of completion the questionnaires was between 7 and 15 minutes. The completed questionnaires were retrieved by the researcher immediately or later depending on the participants' preference. A sociodemographic data form (Appendix VI) was included to elicit responses about age, gender, marital status, highest level of education.

Data analysis

Data were summarized using descriptive statistics of mean, frequency, percentages, standard deviation while inferential statistics of Chi- square test was used to test the association among the following:

- Health status, disability profile and work- related quality of life of members of staff of the University of Ibadan.
- Health status and each of age group, gender, and academic qualification of members of staff of the University of Ibadan.
- Disability profile and each of age group, gender and academic qualification of members of staff of the University of Ibadan.
- Work-related quality of life and each of age group, gender and academic qualification of members of staff of the University of Ibadan.

Similarly, Mann-Whitney U test was used to test for the difference in health status, disability profile and work-related quality of life between academic and non-academic staff of University of Ibadan. The level of significance was set at 0.05.

RESULTS

Socio-demographic characteristics of participants

Three hundred and seventy questionnaires were self-administered to participants from University of Ibadan. All (100%) the questionnaires were retrieved and deemed fit for analysis.

Two hundred and seven (55.9%) participants were males and 163 (44.1%) were females. The participants' age were ranged from 24 to 67 years (mean=46.2±10.2 years). Participants' sex distribution, marital status, level of education and religion are summarized in table 1. One hundred and thirteen (113) academic staff and 257 (257) non-academic staff were involved in the study.

Health status, disability profile and work-related quality of life of the participants

One hundred and seventy-five participants (47.3%) had poor health status while 195 participants (52.7%) had a better health status. Seventy-one participants (55.5%) aged between 41 and 50 years had better health status. Ninety-nine male participants

(47.8%) had poor health status while seventy-six female participants (46.6%) had poor health status. One hundred and seventy-one participants (55.3%) that were married had better health status. Sixty-nine participants (43.4%) with BSc had better health status. Seventy-three participants (64.4%) among the academic staff had better health status while 122 participants (47.5%) of the non-academic staff had better health status (Table 2).Three hundred and twenty-five (87.8%) participants were without disability while forty-five (12.2%) participants had disability. Fourteen participants (3.8%) had low level of work-related quality of life; three participants (0.8%) had average level of work-related quality of life while 353 participants (95.4%) had high level of work-related quality of life. There was significant association between the health status and work-related quality of life of participants (p=0.002); disability profile and work-related quality of life of participants (p=0.001) and health status and disability profile of participants (p=0.001).

Association between among socio-demographic variables (age, gender, academic qualification) and each of health status, disability profile and work-related quality of life

There was no significant association between participants' health status and any of age (p=0.21) and gender (p=0.82). The participants below the age of 30 years had the least proportion of people with better health status while participants within the age groups 41-50 and 51-60 years had the highest proportion of people with better health status. The higher percentage of male participants had better health status. However, there was a significant association between their academic qualification and health status (p=0.003). The participants with bachelor and doctoral degrees had higher proportion of people with better health status (Table 2).

There was no significant association between disability profile and any of participants' age (p=0.61), gender (p=0.49) and academic qualification (p=0.12). Participants within the age group, 41-50 years had the highest proportion of people with disability. Also, higher proportion of male participants had disability while participants with Bachelor degree had higher proportion of disability compared with other academic qualification (Table 3).There was no significant association between each of participants' age (p=0.41), gender (p=0.28), academic qualification (p=0.25) and their work-related quality of life. Participants within the age group 41-50 years and those with Bachelor degree had the highest proportion of people with high level of WRQoL. More male participants had high level of work-related quality of life (Table 4).

Differences in health status, disability profile and work-related quality of life between academic and non-academic staff of University of Ibadan

There was significant difference in the health status between academic and non-academic staff (p=0.02). However, there was no significant difference in the disability profile between academic staff and non-academic staff (p=0.48). Also, there was no significant difference in the work-related quality of life between academic staff and non-academic staff of University of Ibadan (p=0.66).

Table 1 Socio-demographic characteristics of the participants (N=370)

Variables	Frequency (n)	Percentage (%)
Age (years)		
Below 30	24	6.5
30-40	83	22.4
41-50	128	34.6
51-60	106	28.6
Above 60	29	7.8
Gender		
Male	207	55.9
Female	163	44.1
Marital status		
Single	47	12.7
Married	309	83.5
Widowed	9	2.4
Divorced	1	0.3
Separated	1	0.3
Others	3	0.8
Academic qualification		
Primary	2	0.5
SSCE	11	3.0
Bachelors	159	43.0
Masters	88	23.8
PhD	99	26.8
Others	11	3.0
Religion		
Christianity	322	87.0
Islam	46	12.4
Others	2	0.5
Category of staff		
Academic staff	113	30.5
Non-academic staff	257	69.5

Key:

SSCE – Senior Secondary Certificate
PhD – Doctor of Philosophy

Table 2 Association between health status of staff of University of Ibadan and each of selected socio-demographic variables (age, gender, academic qualification)

Variables	Health status		χ^2	p
	Poor health status	Better health status		
	n (%)	n (%)		
Age (years)			5.88	0.21
Below 30	16 (66.7%)	8 (33.3%)		
30-40	43 (51.8%)	40 (48.2%)		
41-50	57 (44.5%)	71 (55.5%)		
51-60	48 (45.3%)	58 (54.7%)		
Above 60	11 (37.9%)	18 (62.1%)		
Gender			0.53	0.82
Male	99 (47.8%)	108 (52.2%)		
Female	76 (46.6%)	87 (53.4%)		
Academic qualification			17.69	0.003*
Primary	1 (50.0%)	1 (50.0%)		
SSCE	8 (72.7%)	3 (27.3%)		
Bachelors	90 (56.6%)	69 (43.4%)		
Masters	32 (36.4%)	56 (63.6%)		
PhD	37 (37.4%)	62 (62.6%)		
Others	7 (63.6%)	4 (36.4%)		

Key:

SSCE – Senior Secondary Certificate
PhD – Doctor of Philosophy
χ^2 - Chi-square
*significant at p value < 0.05

Table 3. Association between disability profile of staff of University of Ibadan and each of selected socio-demographic variables (age, gender, academic qualification)

Variables	Disability Profile		χ^2	p-value
	People without disability n(%)	People with disability n(%)		
Age (years)			2.69	0.61
Below 30	23 (95.8%)	1 (4.2%)		
30-40	73 (88.0%)	10 (12.0%)		
41-50	109 (85.2%)	19 (14.8%)		
51-60	95 (89.6%)	11 (10.4%)		
Above 60	25 (86.2%)	4 (13.8%)		
Gender			0.49	0.49
Male	184 (88.9%)	23 (11.1%)		
Female	141 (86.5%)	22 (13.5%)		
Academic qualification			8.85	0.12
Primary	2 (100.0%)	0 (0%)		
SSCE	7 (63.6%)	4 (36.4%)		
Bachelors	136 (85.5%)	23 (14.5%)		
Masters	80 (90.9%)	8 (9.1%)		
PhD	90 (90.9%)	9 (9.1%)		
Others	10 (90.9%)	1 (9.1%)		

Key:
SSCE – Senior Secondary Certificate
PhD – Doctor of Philosophy
χ^2 - Chi-square

Table 4. Association between work-related quality of life of staff of University of Ibadan and each of selected socio-demographic variables (age, gender, academic qualification)

Variables	Work-related quality of life			χ^2	p-value
	Low	Average	High		
	n (%)	n (%)	n (%)		
Age (years)				8.28	0.41
Below 30	1 (4.2)	0 (0%)	23 (95.8)		
30-40	6 (7.2)	1 (1.2)	76 (91.6)		
41-50	3 (2.3)	1 (0.8)	124 (96.9)		
51-60	4 (3.8)	0 (0%)	102 (96.2)		
Above 60	0 (0%)	1 (3.4)	28 (96.6)		
Gender				2.57	0.28
Male	7 (3.4)	3 (1.4)	197 (95.2)		
Female	7 (4.3)	0 (0%)	156 (95.7)		
Academic qualification				12.62	0.25
Primary	0 (0%)	0 (0%)	2 (100)		
SSCE	1 (9.1)	0 (0%)	10 (90.9)		
Bachelors	6 (3.8)	1 (0.6)	152 (95.6)		
Masters	2 (2.3)	0 (0%)	86 (97.7)		
PhD	5 (5.1)	1 (1.0)	93 (93.9)		
Others	0 (0%)	1 (9.1)	10 (90.9)		

Key:
SSCE – Senior Secondary Certificate
PhD – Doctor of Philosophy
χ^2 - Chi-square

Table 5. Difference in health status, disability profile and work-related quality of life (WRQoL) between academic (n=113) and non-academic staff (n=257)

	Academic Mean rank	Non-academic Mean rank	Mann-Whitney U	p-value
Health status	207.51	175.82	12033.0	0.02*
Disability profile	176.10	189.63	13458.0	0.48
WRQoL	184.17	186.08	14370.5	0.66

*significant at p value < 0.05

DISCUSSION

The study was conducted to investigate the association between health status, disability profile and work-related quality of life among staff of a University in Nigeria and further associations between these parameters and socio-demographic characteristics of the participants were investigated. A higher proportion of the 370 participants were males which was a reflection of the overall distribution of member of staff working in the University. The mean age was within what is expected for individuals who work in a University setting in Nigeria, most were between 35 and 55 years. A high proportion of participants had Bachelors and higher degrees, as these are minimum requirements for securing employment in the University, especially for the academic and senior non-academic staff.

The observation that a higher proportion of the participants had better health status which might mean that the participants were not limited in moderate activities or had no pain interfering with their life. This is contrary to the findings of a similar study among university staff[16]. The profile of disability showed that a higher proportion of participants without disability. This is similar to the result of the study conducted by Shigaki et al.[17] which showed that 15% of the staff had disability. A study conducted, among health workers by Picakciefeet al.[18], reported that only 19.5% of workers had disability, similar to the results of a study conducted by Sulaiman et al.[19] which reported that there was low rate of disability among the staff who participated in their study. A greater proportion of the participants in our study had a high level of work-related quality of life (95.4%). This differed from the findings of the studies by Opollo et al.[20] and Moradi, et al.[21] which indicated that most participants had low level of work-related quality of life, although this could be due to differences in the population, as their study was carried out among healthcare workers.

The significant association between participants' health status and work-related

quality of life could mean that staff, with better health status, are likely to experience fewer physical and mental health issues, resulting in higher levels of energy, productivity and job satisfaction. Poor health often leads to increased absenteeism (missing work) and presenteeism (being at work and not fully productive). This could affect work-related quality of life leading to increased workloads for other staff, reducing team morale, and impacting overall organizational performance[22]. However, consideration must be given to the possibility of the existence of other factors, unrelated to work, which could directly influence participants' ratings of their health status. Diener & Chan[23] had a contrary finding to our result as their study showed there was no significant association between health status and work-related quality of life.

Participants' disability profile was significantly associated with work-related quality of life, similar to the result of a study conducted by Schur et al.[24]. A low level of disability would translate to a high level of work-related quality of life and health status among university staff. A previous study reported a significant association between health status and disability among staff[25]. Individuals with no disability are more likely to have better health status, which in turn impacts on their quality of life.

There was no significant association between the participants' sociodemographic data (age, gender) and each of health status, disability profile and work-related quality of life. This implies that the age and gender of staff had no influence on their health status, disability profile and work-related quality of life. Jetha et al.[26] reported that there was no significant association between age and disability among employed Canadians, although they found out that there was significant association between type of disability and gender; however, their study had more female participants.

Our study revealed a significant association between participants' academic qualification and their health status. Education often correlates with socio-economic status, and higher socio-economic status is associated with better health outcomes. Individuals with higher academic qualifications may have access to better-paying jobs, healthier living conditions, and greater resources to maintain their health[27]. It was observed that higher academic qualification did not determine their disability profile nor work-related quality of life. This result is in contrast to a study carried out by Abbasi et al.[28], where there was significant association between work-related quality of life and age, academic qualification among nurses working in educational hospitals.

The result of this study showed that there was significant difference in health status between the academic and non-academic staff. This could be due to several factors such as, job demands, stress levels, work environment and lifestyle habits. These results are consistent with the findings of a study carried out by Winefield & Jarrett[29], in which academic staff reported higher levels of occupational stress compared to administrative staff, primarily due to the pressures of academic performance. Another study carried out by Kinman & Jones[30] showed that there was significant difference in health status between academic and non-academic staff, it was highlighted that academic staff often lack sufficient administrative support and face higher job strain, which could negatively impact their health. Also, findings from a study[31] indicated that academic staff tend to work longer hours, often taking work home, which can lead to poorer health outcomes compared to non-academic staff who might

have more defined work hours. Conversely, a study in New Zealand conducted by Boyd & Wylie[32] had reported no significant difference in health status among the staff, with them indicating that stress levels could be similar across different job types within the same organization, pointing to organizational culture and policies as critical factors influencing health.

No significant difference was obtained in the disability profile between academic and non-academic staff. A possible explanation for this finding may be attributed to several factors such as, similar workplace accommodations, overall job safety standards and possibly similar lifestyle or healthy behaviours. This result is consistent with the findings of a study carried out by Schur et al.[33], who found no significant difference in the disability profile between academic and non-academic staff. However, this contradicts a study carried out by Carayon & Smith[34], this could be because different job roles can lead to varying levels of exposure to physical and psychosocial factors risk factors, which can influence disability rates.

Results further showed no significant difference in work-related quality of life between academic and non-academic staff. This could be due to a variety of factors, such as comparable access to institutional resources, similar levels of job support, and uniform policies affecting all staff members. This result is comparable to findings from a study carried out Houston et al.[35], which indicated that both staff can experience similar levels of job satisfaction and support, contributing to comparable WRQoL. However, this result contradicts the findings from a previous study that had reported significant difference in the work-related quality of life between academic and non-academic staff[29]. A possible explanation to this could be that academic staff often struggle more with work-life balance due to flexible and often unpredictable work hours, which can affect their WRQoL differently from non-academic staff.

CONCLUSION

There was significant association between work-related quality of life and each of health status and disability profile of staff of University of Ibadan, Nigeria. There was significant difference in health status between the academic and non-academic staff of University of Ibadan but there was no significant difference in their disability profile and work-related quality of life.

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Authorship

Dada: concept, design, the definition of intellectual content, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing and manuscript review.

Adeyemi: concept, design, the definition of intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation.

Fatudimu: design, literature search, data analysis, statistical analysis, manuscript editing and manuscript review.

The manuscript has been read and approved by all the authors. Final approval of the version to be published was given by the three authors and it represents honest work.

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ORIGINAL RESEARCH

PHYTOCHEMICAL SCREENING AND *in vitro* ANTIOXIDANT PROPERTIES OF *persea americana* SEED GROWN IN NNEWI, SOUTH EASTERN NIGERIA

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ABSTRACT

Background: *Persea americana* (avocado) is a popular plant that has been used traditionally for its nutritional and medicinal values. The efficacy of a medicinal plant is contingent upon the bioactive compounds it possesses.

Aim: The study investigated the phytochemical and *in vitro* antioxidant properties of the ethanolic seed extract of *P. americana* obtained from rural part of Nnewi, Anambra State, Nigeria.

Methodology: The dried pulverized seeds of *P. americana* were extracted with ethanol by the maceration method. The extract obtained was subjected to phytochemical screening. In vitro antioxidant assays, (2,2'-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay and ferric reducing antioxidant properties (FRAP) were also carried out on the extract.

Results: The phytochemical screening of the extract revealed the presence of flavonoids, saponins, alkaloids, tannins, glycosides, steroids and oxalate. Kaempferol, a flavonoid was found to be the predominant phytochemical compound (50.890.002 µg/ml). The extract showed a higher DPPH scavenging activity than the ascorbic acid standard at lower concentrations. The DPPH

activity was highest (91.61±0.10 %) at concentration of 31.5 mg/ml. The extract also showed a concentration-dependent increase in FRAP activity, and was found to have a higher activity than the reference antioxidant, ascorbic acid.

Conclusion: This study revealed that the plant seed contains substantial amount of hydroxyl radical scavenging, and ferric reducing power activity, and could be a source of naturally occurring antioxidants that is beneficial to health.

Keywords: *Persea americana*, Flavonoids, Free radicals, Antioxidants, Medicinal plants

INTRODUCTION

Numerous bioactive secondary metabolites found in nature are utilized to treat and prevent a wide range of human illnesses. Additionally, these secondary metabolites serve as vital sources of inspiration for the creation of new medicinal agents[1]. Many of these natural remedies had long been available from the plant world, and it is believed that over 25% of our present medication arsenal comes from higher plants[2]. For the great majority of people worldwide, the traditional medical system, which mostly relies on herbal remedies, is crucial to their bodily and mental health[3]. Herbal medication is generally recognized due to its ease of accessibility, comparatively cheaper cost and relative safety profiles when compared to the synthetic alternatives. For example, almost 80% of the African population rely on herbal treatment[4], either independently or in conjunction with conventional medications[1], and the use of herbs is progressively receiving acknowledgment in western nations.

Free radicals are unavoidable components of everyday human existence. Free radicals are beneficial to health in moderation, but too many of them can lead to oxidative stress[5]. This condition speeds up the aging process and the onset of illness by causing oxidative damages at the level of cells, tissues, and organs[6]. Antioxidants are required to counteract and neutralize the effects of those free radicals. Medicinal plants include a diverse range of natural antioxidants, including flavonoids, coumarins, tocopherols, carotenoids, and phenolic acids[7]. Plant antioxidants can interact with pro-oxidant metals and behave as reducing agents, even though their primary role is to scavenge free radicals. Fruits and vegetables that we frequently eat, like avocados, can provide antioxidant compounds.

Persea americana, the avocado, as it is usually called, is a Central American edible fruit that may be readily adapted to tropical climates[8]. An underutilized resource, avocado seeds make up 16% of the weight of an avocado fruit[9]. Phytochemical studies on avocado seeds have identified various classes of natural compounds such as phytosterols, triterpenes, fatty acids, furanoic acids, abscisic acid, proanthocyanidins, flavonoids and polyphenols[10,11]. Given that the quantity of phenolic compounds and their phytochemical makeup in plants may be influenced by environmental conditions[12], the current study examined the phytochemical and *in vitro* antioxidant properties of *P. americana* seed obtained from rural part of Nnewi, Anambra State, Nigeria.

METHODS

Plant sample procurement and identification

Mature avocado fruits were obtained from Eke Amobi rural market in Otolo Nnewi

Anambra state, Eastern Nigeria. The seed was separated from the pulp, and was authenticated by a taxonomist from Botany Department of Nnamdi Azikiwe University, with Habarium number, NAUH-183[A].

Preparation of plant material

The avocado seed was prepared according to the method postulated by Egbuonu *et al*.[13]. The avocado seed was sun-dried and milled, and the powder extracted with cold maceration using 90% ethanol in ratio 1:2 solid to solvent. Afterwards, the extract was filtered using a linen. The filtrate was concentrated at 60℃ using a water bath and dried at 50℃ with an oven.

Phytochemical screening

This was done using standard method as described by Sharma *et al*.[14]. One gram of the extract was weighed and transferred into a test tube. This was followed by the addition of 15 ml ethanol and 10 ml of potassium hydroxide to the test tube. The test tube was warmed in a water bath for 60 min at 100 ^{0}C. After this, the solution was transferred to a separating funnel. The test tube was washed with 20 ml of ethanol, 10 ml of cool water, 10 ml of hot water and 3 ml of hexane respectively. The extract was washed three times with 10 ml of 10 %w/v ethanol:aqueous solution, and dried with anhydrous sodium sulphate and the solvent evaporated. The sample obtained was solubilized in 1000ul of pyridine of which 200 ul was transferred to a vial for analysis. The analysis of each of the phytochemicals in the extract was performed using gas chromatography equipped with flame ionization detector.

***In vitro* antioxidant assay**

The *in vitro* antioxidant assays, 2,2'-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging and ferric reducing antioxidant properties (FRAP*)* assays were determined according to the method described by Shwetha and Sudha[15].

2,2'-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay

Serial dilution of the sample (31.25, 62.50, 125, 250, 500 mg/ml) was filtered using Whatman 125 mm filter paper and 4 ml of each was mixed with 1 ml of DPPH radical reagent. Exact serial concentrations of ascorbic acid were used as standard. The mixtures were shaken and incubated for 30 mins at room temperature. The absorbance was measured at 517 nm using UV-VIS spectrophotometer (Model 752, China)

Calculations:

$$\text{Percentage inhibition} = \frac{Ao - A1}{Ao} \times 100$$

Where A_0 = Absorbance of Blank

A1 = Absorbance of test sample. Ascorbic acid was used as standard.

Ferric reducing antioxidant properties (FRAP) assay

Nine hundred microlitre (900µL) of FRAP reagent was mixed with 90 ml of distilled water and 30 ml of various concentrations of the extract (0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 mg/ml). The reaction mixture was incubated at 37^{o}C for 30 mins using incubator (model DNP-9052A, China) and the absorbance was measured at 593 nm using UV-VIS spectrometer (model 752, China).

Calculation:

The percentage inhibition of ferrous-TPTZ complex formed was calculated using:

$$\frac{Ao - A1}{Ao} \times 100\ (\%)$$

Where A_0 = Absorbance of blank

A_1 = Absorbance of test sample

Data analysis

Descriptive statistics was carried out on the data generated by analysis of variance (ANOVA). Results were expressed as mean±SEM of triplicate determinations.

RESULTS

The results of quantitative phytochemical analysis of ethanolic seed extract of *Persea americana* revealed that kaempferol, a type of flavonoid was the predominant phytochemical compound (50.89±0.002 µg/ml) present in the seed's extract. Aphyllidine and dihydrocysisine, are alkaloid compounds found in moderately high quantity, 10.68±0.002µg and 12.87±0.001µg respectively. Tannin, oxalate, cardiac glycoside, steroid, sapogenin (saponin) were also detected in moderate quantities (Table 1). Table 2 showed the *in vitro* DPPH scavenging activity of 31.25 mg/ml, 62.5 mg/ml, 125 mg/ml, 250 mg/ml and 500 mg/ml of the *P. americana* seed extract using ascorbic acid of corresponding concentrations as a reference standard. There was a concentration dependent decline in the scavenging activity of the extract. The activity was lowest for 500 mg/ml (61.21±0.37%) and highest for 31.25 mg/ml (91.61±0.10%). The extract showed a higher DPPH scavenging activity than ascorbic acid. Table 3 showed the *in vitro* ferric reducing antioxidant power of 0.2 mg/ml, 0.4 mg/ml, 0.6 mg/ml, 0.8 mg/ml, 1.0 mg/ml and 1.2 mg/ml of the *P. americana* seed extract using corresponding concentrations of ascorbic acid as reference standard. There was a concentration-dependent increase in the FRAP of the extract from 0.2 to 1.2 mg/ml in relation to the standard. The activity was highest for 1.2 mg/ml (67.65±0.04%) and lowest for 0.2 mg/ml (18.63±0.01%). The extract showed a higher FRAP reducing power than the standard.

Table 1: Quantitative phytochemical analysis of ethanolic seed extract of *Persea americana*

Compound	Concentration (µg/ml)
Flavonoids	
Kaempferol	50.89±0.002
Proanthocyanidin	25.24±0.001
Anthocyanin	27.70±0.001
Catechin	0.02±0.000
Flavonones	8.75±0.001
Narigenin	0.02±0.00
Flavone	0.01±0.00
Alkaloids	
Aphyllidine	10.68±0.002
Dihydrocysisine	12.87±0.001
Ribalinidine	7.27±0.001
Ammodendrine	2.91±0.001
Epihedrine	9.37±0.002
Tannin	8.16±0.002
Cardiac glycoside	9.16±0.001
Oxalate	1.84±0.001
Steroid	17.89±0.001
Sapogenin	2.78±0.001

Each value represents Mean±SEM of triplicate determinations.

Table 2: DPPH free radical scavenging activity of the *P. americana* extract

	DPPH inhibition (%)	
Conc. (mg/ml)	**Ascorbic acid**	**Extract**
31.25	10.77±0.09	91.61±0.10
62.5	17.62±0.05	84.87±0.22
125	21.04±0.04	82.26±0.17
250	25.02±0.03	76.49±0.26
500	28.42±0.02	61.21±0.37

Each value represents Mean±SEM of triplicate determinations.

Table 3: FRAP activity of the *P. americana* extract

	FRAP activity (%)	
Conc. (mg/ml)	**Ascorbic acid**	**Extract**
0.2	10.51±0.00	18.63±0.01
0.4	15.30±0.01	48.17±0.06
0.6	17.29±0.01	49.26±0.02
0.8	23.72±0.01	57.59±0.02
1.0	59.15±0.01	62.84±0.22
1.2	65.45±0.11	67.65±0.04

Each value represents Mean±SEM of triplicate determinations

DISCUSSION

Nigeria has wide variety of medicinal herbs with therapeutic benefits. Alkaloids, polyphenols, terpenes, glycosides, and other compounds with potential medicinal uses have been found in Nigerian plants, according to studies on them[16]. The phytochemical screening of the extract revealed the presence of flavonoids, saponins, alkaloids, tannins, glycosides, steroids, oxalate in the ethanolic seed extracts of *P. americana.* Flavonoids were the predominant class of compounds detected, with kaempferol having the highest value (50.89±0.002 µg/ml). This result is in agreement with the previous analysis of *P. americana* seed extracts obtained by Okoye *et al*.[17], except for the absence of steroids in their extract. Egbuonu *et al*.[13] reported similar finding, except for the absence of oxalate. Phenols detected in *P. americana* seeds examined in this study may suggest that these seeds have anti-inflammatory, anticoagulant, antioxidant, immune-boosting, anticarcinogenic, and antiaging properties. Flavonoids are powerful water-soluble super antioxidants that scavenge free radicals[18]. They protect against all phases of carcinogenesis, have potent anticancer properties, and mitigate oxidative cell damage. They are the most prevalent and extensively distributed class of plant phenolic chemicals, and they reduce the risk of inflammation and heart disease[19]. Alkaloids are important secondary metabolites found in plants that have medicinal use. Because of their bactericidal and analgesic properties, alkaloids in their isolated, pure form as well as their synthesized derivatives are employed as fundamental therapeutic agents. The seed extract's application in ethnomedicine may be justified by the presence of alkaloids. The free astringency and bitter taste of *P. americana* seeds may be due to the tannin content[20]. Saponins are a broad collection of chemicals that are stable in aqueous solutions and create soap-like foams. According to Henry *et al*. [21], saponins have the ability to lower blood pressure and heart rate because they bind to cholesterol and create insoluble complexes. The amount of

saponin in the seed sample was moderate and thus, would not have a negative impact on the animals' growth. The quantity of oxalate in the seed sample was less than the (3-5 g) lethal dosage of soluble oxalate intake [22]. The phytochemical findings of this study are in line with the report of Omorovbiye *et al*.[18]. These phytochemical substances may be the reason why the plant's seed extract used in this investigation is applied in folklore medicine, and could be explored more for pharmaceutical applications.

One commonly used method for assessing the antioxidant properties of plant extracts is the scavenging of DPPH free radicals[23]. "DPPH is a stable free radical that can be used to test the ability of the sample's polyphenols to scavenge free radicals" [24]. The result of the DPPH activity revealed that the *P. americana* extract has DPPH radical scavenging property. The extract showed a higher scavenging activity than the ascorbic acid standard which may indicate increased ability of the components of the extracts to donate hydrogen ions, reducing the radical to corresponding hydrazine. This further suggest that the extract could be an effective therapeutic agent for the treatment of pathological damages caused by free radicals. However, there was a dose-dependent decline in radical scavenging activity of the extract, Olasunkanmi and Ogunyemi[25] reported similar pattern of result. The decline in activity with dose could be as a result of high concentrations of antioxidants and the presence of colour compounds in the extract. Antioxidants lose their beneficial effects when present in excess[19,26]. Phenolic compounds in excess can transit from antioxidants to prooxidants[27]. Colour pigments present in plant-food samples can interfere with the elaborate absorbance readings of the DPPH radicals because the absorb in the same wavelength range[28]. Previous studies have reported DPPH radical scavenging activity of *Persea americana* seeds extract[29,23,24,30]. Also, Onyedikachi *et al*[30], reported DPPH radical scavenging property of *P. americana* seed oil. The radical scavenging activity of the *P. americana* extract could be attributed to polyphenols such as flavonoids present in the extract. Flavonoids are powerful hydrophilic antioxidants and scavengers of free radicals, that mitigate oxidative cell damage and prevent growth of cancers[31]. The plant's seed high antioxidant activity is indicative of its significance in natural product development.

"The principle of FRAP assay was to reduce the colourless Fe^{3+}–TPTZ complex to produce blue-coloured Fe^{2+}–TPTZ complex under low pH condition by antioxidants present in the sample extract"[23]. The findings of this study revealed that *P. americana* seed extract demonstrated ferric reducing antioxidant property. The FRAP activity of the extract showed a dose-dependent increase, and was found to have a higher activity than the standard ascorbic acid. In general, substances that break the chain of free radicals by donating a hydrogen atom are associated with reducing characteristics[32]. Due to the development of the Fe^{2+}-TPTZ complex with increasing concentration, which was also observed in the reference antioxidant, the extract's ferric reducing property increased noticeably. This could indicate that the plant seeds can provide electrons to free radicals that are stable in the food and biological systems, thus, preventing radical-related damages and deteriorations Previous studies have reported FRAP activity of *Persea americana* seed extract [33,29,24]. Also, Onyedikachi *et al*.[30], demonstrated FRAP activity of *P. americana* seed oil. The FRAP activity of the extract could be attributed to phenolic compounds present in the extract. Due to their strong

redox reactivity, phenolic compounds have effective antioxidant potential, reducing free radicals and averting harmful cascade events[24]. The *in vitro* antioxidant properties of the ethanolic seed extract of *P. americana* could be an indication of its *in vivo* antioxidant potentials.

CONCLUSION

The findings of this study have shown that the ethanolic seed extract of *P. americana* contains good amounts of bioactive compounds, with alkaloids, flavonoids, and tannins abundantly present, which possess high antioxidant and free radicals scavenging activities. The *in vitro* antioxidant activities of the extract indicated that the plant seed possesses a substantial amount of hydroxyl radicals scavenging and ferric reducing power activity in comparison to the reference antioxidant ascorbic acid, and could serve as a source of naturally occurring antioxidants for health benefits.

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Authors contributions: Ejiogu Ikedichukwu Chibueze: Methodology, Investigation, Formal analyses, Data curation, Writing – original draft. Maduka Hugh Clifford Chima: Conceptualization, Supervision, Writing – review and editing. Maduka Ignatius Chukwudi: Validation, Supervision, Writing – review and editing.

Conflict of interest: The authors declare that they have no known competing interest

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ORIGINAL RESEARCH

EVALUATION OF URIC ACID, CREATININE, AND ESTIMATED GLOMERULAR FILTRATION RATE IN ELDERLY AND ADOLESCENT POPULATIONS IN NNEWI METROPOLIS

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ABSTRACT

Background: Kidney efficiency declines with age due to cumulative cellular damage, while adolescence involves rapid physiological and hormonal changes that impact uric acid levels. Elevated uric acid is associated with gout, metabolic syndrome, and kidney diseases. Creatinine, a key marker of glomerular filtration, is influenced by muscle mass, while eGFR, a commonly used indicator of kidney function, naturally declines with age

Aim: This study compared the levels of uric acid, creatinine, and estimated glomerular filtration rate (eGFR) among elderly and adolescent populations in Nnewi, Anambra State, Nigeria

Materials and Methods: The study recruited 90 participants, comprising 45 adolescents (15–25 years) and 45 elderly individuals (60 years and above). Serum uric acid and creatinine levels were measured spectrophotometrically, and eGFR was calculated using the Modification of Diet in Renal Disease (MDRD) equation. Data were analyzed using independent t-tests and Pearson correlation coefficients at <0.05 level of significance.

Results: The results showed significant differences in uric acid, creatinine, and eGFR levels between adolescents and the elderly. The elderly had lower uric acid levels (264.19 ± 97.56 mg/dL) Vs adolescent(272.78±61.99mg/dL) higher creatinine levels (92.72 ± 18.37 µmol/L)Vs adolescent(73.57±15.19 µmol/L), and lower eGFR (68.99 ± 14.83 mL/min/1.73m²) compared to adolescents(111.00±17.00mL/min/1.73m²)(P <0.05). Blood pressure and anthropometric measurements also differed, with the elderly showing higher blood pressure values. Correlation analysis highlighted significant links between uric acid levels and anthropometric indices, particularly in the elderly group.

Conclusion: These results emphasize age-related differences in renal function markers, with elderly individuals showing elevated creatinine levels and decreased eGFR, suggesting a decline in kidney function compared to adolescents.

Keywords: Kidney Function, Uric acid, Creatinine, Adolescent, eGFR

INTRODUCTION

Elderly individuals are typically classified as those aged 65 years and older, with subcategories including youngest-old (65–74 years), middle-old (75–84 years), and oldest-old (85 years and above)[1]. Biologically, aging is characterized by cumulative cellular and molecular damage over time, leading to reduced physical and mental capacity, increased disease risk, and eventual mortality. These changes are nonlinear and vary among individuals[2]. Adolescence, the transition from childhood to adulthood, involves significant physical, behavioral, cognitive, emotional, and social changes. It is divided into three stages: early (10–13 years), middle (14–17 years), and late adolescence/young adulthood (18–21 years and beyond)[3].Serum creatinine (SCr), serum uric acid (SUA), and estimated glomerular filtration rate (eGFR) are vital markers for assessing kidney function, used to monitor disease progression and guide prognosis[4]. The kidneys are crucial in filtering blood and excreting waste as urine; impaired function can result in serious health issues[5]. Renal function tests measure various blood and urine components to evaluate kidney efficiency, focusing on GFR[6]. Advancements in estimating kidney function contribute to identifying therapeutic targets and novel biomarkers for early kidney injury detection[4].

Purine metabolism produces uric acid, which is mainly eliminated by the proximal tubules. Changes in excretion or production lead to abnormal levels[7,8].

Elevated uric acid, or hyperuricemia, is linked to gout, metabolic syndrome, and various diseases. Normal adult levels are >416 µmol/L (7.0 mg/dL) for males and >357 µmol/L (6.0 mg/dL) for females[9]. Children's uric acid levels rise with age, peaking during puberty due to hormonal shifts[10].

Creatinine, derived from muscle metabolism, reflects GFR and varies with muscle mass, complicating its interpretation in individuals with abnormal muscle composition[11]. Its concentration increases linearly with age, showing gender differences in patterns of change over time. Reference ranges differ between men (0.63–1.16 mg/dL) and women (0.48–0.93 mg/dL)[11]. eGFR estimates kidney filtration efficiency using equations like MDRD and Cockroft-Gault, though none are perfect. Normal eGFR exceeds 90 in adults but declines naturally with age[12].

The level of uric acid increases with age. Gender differences in uric acid levels occur after the onset of puberty. Additionally,

linear regression reveals a positive correlation between the uric acid level and Body Mass Index (BMI)[13]. Serum creatinine concentration increased steadily with age; in females from the age of 40 years and 60 years for males while the estimated glomerular filtration rate lowered in the elderly[14].

Materials and Methods

This study was a cross-sectional design aimed at assessing the levels of serum uric acid, creatinine, and estimated glomerular filtration rate (eGFR) in elderly individuals (aged 60-80 years) and adolescents (aged 15-25 years) in Nnewi Metropolis, Anambra State, Nigeria. A total of 90 participants were enrolled, consisting of 45 elderly and 45 adolescents. Participants were selected using simple random sampling, where all elderly and adolescent individuals in Nnewi Metropolis were assigned numbers. Odd-numbered individuals were excluded, while those with even numbers were included in the study. A 5 ml blood sample was collected from each participant, transferred into plain tubes, and allowed to clot. The samples were then centrifuged at 3000 rpm for 10 minutes to isolate the serum, which was stored at 2°C until analysis. Uric acid and creatinine levels in the serum were subsequently measured. Creatinine was determined spectrophotmetrically as described by[15,16]. The body mass index (BMI) was calculated using the anthropometric method. Blood pressure was measured using the oscillometric method[17], and eGFR was calculated using the MDRD equation as described by[16]. Statistical analysis was conducted using an independent Student's t-test, with results considered significant if $p < 0.05$. The correlation between the parameters was assessed using Pearson's correlation coefficient.

RESULTS

The Mean Values of Uric Acid, Creatinine and Estimated Glomerular Filtration Rate in Elderly and Adolescents' Groups (MEAN ± SD)

The results revealed a statistically significant difference in uric acid levels, with the test group showing lower mean values (264.19 ± 97.56 mg/dL) compared to the control group (272.78 ± 61.99 mg/dL) ($p<0.05$). The test group also had significantly higher mean creatinine levels (92.72 ± 18.37 µmol/L) than the control group (73.57 ± 15.19 µmol/L) ($p<0.05$). Additionally, the mean estimated glomerular filtration rate (eGFR) was significantly lower in the test group (68.99 ± 14.83 mL/min/1.73m²) compared to the control group (111.00 ± 17.00 mL/min/1.73m²) ($p<0.05$).

Table 1 The Mean Values of Uric Acid, Creatinine and Estimated Glomerular Filtration Rate in Elderly and Adolescents' Groups (MEAN ± SD)

Parameters	Test group (elderly) (N=45) Mean ± SD	Control group (adolescent) (N=45) Mean ± SD	T- test	P- value
Uric acid (mg/dl)	264.19±97.56	272.78±61.99	-0.499	0.001
Creatinine (umol/l)	92.72±18.37	73.57±15.19	5.387	0.269
eGFR (ml/min/1.73m^2)	68.99±14.83	111.00±17.00	-12.614	0.079

Key:
eGFR=estimated glomerular filtration rate

Anthropometric Measurements and Blood Pressure In Elderly and Adolescent Groups (MEAN ± SD)

The test group exhibited a significantly lower mean BMI (25.46±5.78 kg/m²) compared to the control group's mean BMI (28.07±6.81 kg/m²) (P<0.05), and showed significantly higher mean values for HC (36.40±4.21 cm), WC (31.65±4.09 cm), SBP (137.56±22.17 mmHg), and DBP (88.22±15.85 mmHg) than the control group, with mean values of HC (34.60±3.70 cm), WC (28.58±3.16 cm), SBP (122.44±9.6 mmHg), and DBP (83.11±11.64 mmHg) (P<0.05).

Table 2: The Anthropometric Measurements and Blood Pressure In Elderly and Adolescent Groups (MEAN ± SD)

Parameters	Test Group (N=45) Mean ± SD	Control Group (N=45) Mean ± SD	T-test	P- value
BMI (kg/m^2)	25.46±5.78	28.07± 6.81	-1.97	0.950
WC (cm)	31.65± 4.09	28.58± 3.16	3.99	0.185
HC (cm)	36.40± 4.21	34.60± 3.70	2.15	0.271
SBP (mmHg)	137.56± 22.17	122.44± 9.63	4.19	0.001
DBP (mmHg)	88.22± 15.85	83.11± 11.64	1.74	0.167

Statistical significance at p<0.05
Key:
BMI=Body Mass Index
SBP= systolic blood pressure
DBP= diastolic blood pressure

HC= hip Circumference
WC= Waist Circumference

The correlation of parameters measured in the test group (elderly)
A weak positive correlation was observed between the parameters UA and Cr ($r = 0.427$, $p = 0.003$) and a strong negative correlation-between eGFR and Cr ($r = -0.756$, $p = 0.001$) in the test group ($p < 0.05$). However, no significant correlation was found between the parameters UA and eGFR ($r = -0.139$, $p = 0.361$).

TABLE 3: Correlation of parameters measured in the test group (elderly)

PARAMETERS	R	p-value
UA vs Cr	0.427	0.003
UA vs eGFR	-0.139	0.361
eGFR vs Cr	-0.756	0.001

Statistical significance of $p<0.05$
Keys
eGFR=estimated glomerular filtration rate
Cr = creatinine
UA = uric acid

Correlation of the parameters measured in the control group (adolescents group)
There was no significant correlation observed between the parameters UA and Cr ($r = -0.035$, $p = 0.821$) and between UA and eGFR ($r = 0.079$, $p = 0.605$) in the control group. However, a strong negative correlation existed between eGFR and Cr ($r = -0.748$, $p = 0.001$) in the control group.

Table 4. Correlation of the parameters measured in the control group (adolescents group)

PARAMETERS	R	p-value
UA vs Cr	-0.035	0.821
UA vs eGFR	0.079	0.605
eGFR vs Cr	-0.748	0.001

Statistical significance of $p<0.05$

Correlation of the biochemical analytes with the anthropometric indices and blood pressure in the test

A significant negative weak association existed between UA (mg/dl) and BMI(kg/m2)(r=-0.356, P=0.016), UA (mg/dl) Vs SBP (mmHg) **(r =-**0.304, P= 0.043), UA (mg/dl) Vs H**C (cm) (r=-**0.045, P=0.002**),** while a moderate negative association was seen in UA (mg/dl) Vs **WC (cm) (r=-**0.537, P=0.001**),** but no relationship was seen in UA (mg/dl) Vs DBP (mmHg) (r = -0.259, P= 0.086**)**

Table 5: correlation of the biochemical analytes with the anthropometric indices and blood pressure in the test

PARAMETERS	BMI(kg/m2)	SBP(mmHg)	DBP(mmHg)	WC(cm)	HC(cm)
UA(mg/dl) r value	-0.356	-0.304	-0.259	-0.537	-0.0450
p value	0.016	0.043	0.086	0.001	0.002
Cr(umol/l) r value	-0.180	-0.231	0.004	-0.182	-0.187
p value	0.236	0.127	0.980	0.231	0.219
eGFR(ml/min/1.73m2)					
p value	-0.074	0.076	-0.034	-0.062	-0.034
	0.627	0.622	0.827	0.687	-0.824

Statistical significance of $p<0.05$

Keys

eGFR=estimated glomerular filtration rate

Cr = creatinine

UA = uric acid

Correlation of the biochemical analytes with the anthropometric indices and blood pressure in the control (adolescence group)

The association was observed between UA(mg/dl) and BMI (kg/m^2) (r= -0.261, P= 0.083), UA (mg/dl) Vs SBP (mmHg) (r=-0.075, p=0.622), UA (mg/dl) Vs DBP (mmHg) (r=0.082, p=0.592),UA (mg/dl) Vs WC (cm) (r=-0.023, p=0.883), UA (mg/dl) Vs HC (cm) (r= -0.054, p=0.724), Cr (umol/l) vs BMI (kg/m^2) (r= -0.053, P= 0.729), Cr (umol/l) vs SBP (mmHg) (r=-0.078, p=0.611), Cr (umol/l) vs DBP (mmHg) (r=0.011, p=0.942),Cr (umol/l) vs WC (cm)(r=-0.145, p=0.343), Cr(umol/l) vs HC(cm)(r=-0.147, p=0.335), eGFR(ml/min/1.73m2) vs BMI(kg/m^2)(r= -0.306, p=0.041),eGFR(ml/min/1.73m2) vs SBP(mmHg)(r=0.209, p=0.169), eGFR(ml/min/1.73m2) vs DBP(mmHg)(r=0.213, p=0.160),eGFR(ml/min/1.73m2) vs WC(cm)(r=-0.204, p=0.179), eGFR(ml/min/1.73m2) vs HC(cm)(r=0.030, p=-0.847)

Table 6: Correlation of the biochemical analytes with the anthropometric indices and blood pressure in the control (adolescent group)

PARAMETERS	BMI(kg/m2)	SBP(mmHg)	DBP(mmHg)	WC(cm)	HC(cm)
UA(mg/dl) r value	-0.261	-0.075	0.082	-0.023	-0.054
p value	0.083	0.622	0.592	0.883	0.724
Cr(umol/l) r value	-0.053	-0.078	0.011	-0.145	-0.147
p value	0.729	0.611	0.942	0.343	0.335
eGFR(ml/min/1.73m2)	-0.306	0.209	0.213	-0.204	0.030
p value	0.041	0.169	0.160	0.179	-0.847

Statistical significance of $p<0.05$

DISCUSSION

The evaluation of serum uric acid (SUA), creatinine, and estimated glomerular filtration rate (eGFR) was conducted in both elderly and adolescent populations. The results revealed a statistically significant difference in the mean uric acid levels between the two groups, with the elderly group exhibiting lower levels compared to the adolescent group. This finding aligns with Kurahashi et al.'s research, which suggested that during adolescence, an increase in androgens, particularly testosterone, promotes muscle anabolism, and muscle mass is a significant source of purines[19]. Serum uric acid rises as a result of high testosterone levels. Additionally, higher muscle mass boosts adenosine triphosphate metabolism, releasing more purine intermediates, which further affects uric acid levels, contributing to higher levels in adolescents compared to older individuals[19]. This observation is also supported by Dai et al., whose study on age- and gender-specific reference intervals for uric acid levels concluded that uric acid levels rise rapidly in children and adolescents, coinciding with puberty development[13].

The mean creatinine levels were significantly higher in the elderly group compared to adolescents, reflecting reduced renal function in older adults. This aligns with established knowledge of age-related declines in kidney function, as creatinine serves as a key marker of glomerular filtration rate (GFR)[20]. The elevated creatinine levels in the elderly suggest decreased GFR and are associated with functional limitation, consistent with prior literature that has demonstrated reduced physical performance in persons with kidney disease[20], which is further supported by the significantly lower estimated GFR (eGFR) observed in this group relative to adolescents. Previous studies also showed a consistent increase in serum creatinine with physiological advancements in age[21,22.]

A significantly higher difference was observed in the mean values of hip circumference, waist circumference, systolic blood pressure, and diastolic blood pressure in the test group compared to the control

group ($P<0.05$), which may help explain the observed differences in kidney function markers between the groups.

The correlation analysis revealed significant relationships between biochemical analytes and anthropometric indices in the elderly, with BMI, systolic blood pressure (SBP), and waist circumference (WC) showing a positive correlation with uric acid levels. This finding is consistent with previous studies[22], which highlighted a positive correlation between uric acid levels and BMI. Overweight or obese individuals are more likely to have elevated uric acid levels due to increased production and reduced renal excretion. In contrast, no significant correlations were observed between these parameters in adolescents, except for a positive correlation between BMI and eGFR.

CONCLUSION

This study concludes that elderly individuals exhibit higher creatinine levels and lower eGFR, indicating diminished kidney function compared to adolescents. Also, the findings suggest that age-related changes in kidney function significantly influence serum uric acid, creatinine levels, and eGFR.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Contributors: IAC, DFC, and OPC conceived and designed the research proposal. OCU, ORO, IOA, and IAC performed sample collection, experiments, and data analysis. OCU, IAC, ORO, and IOA contributed to the final version of the manuscript. All authors have read and approved the final manuscript.

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Data availability: The data used to support the findings of this study are available from the corresponding author upon reasonable request.

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Conflict of interest: None declared.

Ethical approval: The study sought and obtained ethical approval from the Ethics Committee of the Faculty of Health Sciences and Technology College of Health Sciences Nnamdi Azikiwe University with reference no. FHST/REC/024/590

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ORIGINAL RESEARCH

ASSESSMENT OF ANTIMICROBIAL POTENTIALS AND MINIMUM INHIBITORY CONCENTRATION (MIC) OF EXTRACTS OF DRY *carica papaya* SEEDS ON MULTIDRUG RESISTANT (MDR) CLINICAL MICROBIAL ISOLATES

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ABSTRACT

Background: Infections caused by drug-resistant microorganisms are usually more difficult to treat, require longer hospital stays, and are associated with higher mortality rates. Researchers and scientists have begun using medicinal plants as alternatives to synthetic drugs. Various parts of medicinal plants including *carica papaya* are being examined.

Aim: This study aimed to investigate the antimicrobial activities of aqueous and 40% ethanolic extracts of dry c*arica papaya* seeds against some clinical isolates, the Minimum Inhibitory Concentration (MIC) and the median lethal dose (LD_{50}) of the extracts.

Methods: Both extracts were tested at 10mg/ml (5%), 50mg/ml (25%), 100mg/ml (50%) and 200mg/ml (100%) on the bacterial and fungal isolates. The in-vitro antibacterial and antifungal activities of the aqueous and 40% ethanolic extracts were determined using Disc diffusion technique. Test organisms were obtained from the laboratory, resuscitated in peptone water,

sub-cultured into nutrient agar for the bacteria test organisms and Sabouraud dextrose agar (SDA) for the fungi test organisms and incubated at 37^0C for 24hours. The test organisms were standardized by matching with the appropriate McFarland's standard. LD_{50} was ascertained using modified Lorke's method (Lorke 1983) using 26 Wistar rats (*Rattus norvegicus*).

Results: Both extracts had antimicrobial activities of varying degrees based on Clinical Laboratory Standards Institute (CLSI) interpretive criteria (CLSI, 2012). The 40% ethanolic extract gave a higher antibacterial activity on the test organisms than the aqueous extract. MIC of 12.5mg/ml was observed from the 40% ethanolic extract. LD_{50} for both extracts was found to be greater than 5000mg/kg.

Conclusion: It can be inferred that extracts of dry Carica papaya seeds have antibacterial and antifungal potential.

Keywords: *Antimicrobial, Carica papaya, seeds, aqueous extract, ethanolic extract, Wistar rats.*

INTRODUCTION:

Multidrug resistance (MDR) is indeed a serious problem caused by the abuse and misuse of antibiotics and other antimicrobials. Infections caused by drug-resistant microorganisms are usually more difficult to treat, require longer hospital stays, and are associated with higher mortality rates[1].Antibiotic resistance has been on a steady rise because of the abuse of antimicrobial agents and the development of resistant strains of microbes, researchers and scientists have begun using medicinal plants as alternatives to synthetic drugs[2] . Various parts of medicinal plants including Carica papaya are being examined[2,3]. *Carica papaya*, commonly known as papaya or pawpaw belongs to the family *caricaceae* in the order *brassicales*. It is a tropical fruit tree native to Central America and Mexico. It is widely cultivated for its edible fruit and medicinal properties[4]. Papaya fruit is highly regarded for its nutritional and economic benefits. Notably, various parts of the plant, including the roots, bark, leaves, peels, seeds and pulp have medicinal properties[5,6] .

Of these, the seeds hold the greatest therapeutic value despite being discarded and accounting for just 7% of the fruit's weight.

Multidrug resistance (MDR) is a critical problem arising from the abuse and misuse of antibiotics and other antimicrobials. Infections caused by drug-resistant microorganisms are often more difficult to treat, require longer hospital stays, and are associated with higher mortality rates[1] .This problem has caused scientists and researchers to explore other medicinal sources such as plants, as alternatives to the commercially available antibiotics.

Though *carica papaya* has been used in traditional medicine for its medicinal properties, there is paucity of data on the antimicrobial activity of seeds of *carica papaya* on multidrug resistant microbes. Hence, this study is intended to investigate the antimicrobial properties of the aqueous and 40% ethanolic extracts of c*arica papaya* seeds and how they can be used as a better alternative to chemotherapeutic drugs in treating antibiotic resistant microbes.

Figure 1: Diagram of *Carica papaya* tree with fruits (A) and longitudinally cut sections of the ripe fruits, exposing the seeds (B).

MATERIALS AND METHODS

Study design:

The *Carica papaya* seeds were sourced from randomly collected ripe *Carica papaya* fruit samples from fruit sellers within Nnewi metropolis. The seeds from the fruits were air-dried, ground and extracted using two extraction solvents (40% ethanol and water). Eight microorganisms were used for the antimicrobial assays, three Multidrug Resistant (MDR) bacteria isolates and three non-MDR bacteria isolates, one MDR fungal isolate and one non-MDR fungal isolate. The results obtained were compared with the results from similar study work and that of the control.

Study area:

The study area that was used for this study is within Nnewi North metropolis. It is a commercial city in Anambra State, South Eastern Nigeria. Nnewi as a metropolitan city has two Local Government Areas, which are Nnewi North and Nnewi South. Nnewi North comprises four autonomous Communities: Otolo, Uruagu, Umudim and Nnewichi[7]. The 2016 population estimation showed that Nnewi had a population of over 900,000. The city spans over 200 square miles (520 km^2) in Anambra State. Nnewi Metroprolitan Area and its Statellite towns are home to nearly 2.5 million residents as of 2005[8].

Sample extraction of the pawpaw seeds and determination of the median lethal dose was carried out in Department of Physiology Laboratory, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, Nnewi; while the antimicrobial activity testing of the extracts analysis was done in Microbiology Laboratory at Nnamdi Azikiwe University Teaching Hospital (NAUTH), Nnewi.

Materials: This research used seeds of ripe fruits of *carica papaya*, 40% ethanol, sterile water, Dimethylsulfoxide (DMSO), Wistar rats (*rattus norvegicus*), Whatman filter paper, rotary evaporator, refrigerator, autoclave, electronic weighing balance,

incubator, measuring cylinder, beaker, conical flask, Petri dishes, forceps, paper puncher, laboratory hot air oven, electronic blender, bunsen burner, wire loop, micro-titer plate, 2,3,5-triphenyltetrazolium chloride (TTC), swab sticks, Nutrient agar (ACCUMEDIA/Swemed Diagnostics LTD. Bangalore, India), Sabouraud dextrose agar (SDA) (ACCUMEDIA/Swemed Diagnostics LTD. Bangalore, India), clinical isolates of bacteria and fungi, personal protective equipment (PPE).

Identification of the fruits:
Before sample preparation, the ripe pawpaw fruits were identified by a Taxonomist at the Department of Botany Sciences, Faculty of Natural Sciences, Nnamdi Azikiwe University Awka. The herbaruim number of the plant is **NAUTH-190^{A}**.

Sample preparation
The ripe fruits were washed in running tap water and air-dried under room temperature. The seeds were aseptically removed from the fruit samples, and weighed on a weighing balance. Approximately 1kg was obtained. The seeds were washed under running tap water, air dried at room temperature on the clean table for a week and weighed. The dried seeds were grounded to fine powder using a sterile electronic blender and stored in a sterile bottle at 4^0C for analysis.
This preparation method was done with modifications according to the method by Dagne *et al*., (2021)[9].

Preparation of aqueous extracts of dry *carica papaya* seeds:
The *Carica papaya* aqueous seed extract was prepared by dissolving 20g of the fine seed powder in 200ml of distilled water in a 250ml capacity conical flask. The extract was obtained by macerating 20g of the fine seed powder in 200ml of distilled water for 48 hours until the soluble materials dissolves. The extract was then filtered using a clean handkerchief and further filtration was done using Whatman no.1 filter paper into a clean glass jar.
The residue of the extract was weighed and the volume of the filtrate was measured.
The filtrate was concentrated by evaporation to dryness in a hot air oven at 40^0C until the solvent from extract evaporates. The resulting extract was put in a vial and stored at 20^0C. This extraction method was adopted and done with modifications according to the method by Dagne *et al*., (2021)[9].

Preparation of 40% ethanolic extracts of dry *carica papaya* seeds:
The *Carica papaya* 40% ethanolic seed extract was prepared by dissolving 20g of the fine seed powder in 200ml of 40% ethanol in a 250ml capacity conical flask. The extract was obtained by macerating 20g of the fine seed powder in 200ml of 40% ethanol for 48 hours until the soluble materials dissolves. The extract was then filtered using a clean handkerchief and further filtration was done using Whatman no.1 filter paper into a clean glass jar. The residue of the extract was weighed and the volume of the filtrate was measured. The filtrate was concentrated by evaporation to dryness in a hot air oven at 40^0C until the solvent from extract evaporates.
The resulting extract was put in a vial and stored at 20^oC. This extraction method was adopted and done with modifications according to the method by Dagne *et al*., (2021)[9].

Preparation of stock solution of the extracts:
0.5gram each of the aqueous and 40% ethanolic extract was taken and dissolved in 2.5ml of DMSO respectively. Thus

200mg/ml of stock was obtained as a standard concentration of the extracts (Was prepared using standard procedures). Different concentrations of 5% (10mg/ml) [0.2 in 10ml]; 25% (50mg/ml) [0.5g in 10ml]; 50% (100mg/ml) [0.5g in 5ml], and 100% (200mg/ml) aqueous and ethanolic extracts were prepared by diluting the appropriate grams of the extract in the required volume of DMSO.

Laboratory tests: isolation, purification and identification of bacterial and fungal microorganisms

The test microorganisms used were Gram positive bacterium (*Staphylococcus aureus*), Gram negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) and fungus (*Candida albicans*) both MDR strains and non MDR strains. Pure cultures of the test organisms were gotten to avoid mixed growth by sub-culturing an already isolated and identified test microorganism in the laboratory's incubator into freshly prepared nutrient agar for bacteria isolates and into Sabouraud Dextrose Agar (SDA) for the fungal isolate. At the end of incubation period, pure bacterial and fungal isolates were selected based on morphological and biochemical characteristics [10]. The antimicrobial activity of the aqueous and ethanolic seeds extracts of *Carica papaya* was done by agar disc diffusion method for the MDR isolates and agar dilution method for the non MDR isolates while the MIC was done by broth micro-dilution method.

Sensitivity testing:

preparation of Macfarland standards:

0.5 and 1.5 McFarland standards were prepared by mixing 0.05ml of 1.175% barium chloride hydrate ($BaCl_2.2H_2O$) with 9.95ml of 1% sulfuric acid (H_2SO_4) with constant stirring for the 0.5 McFarland while 0.15ml of 1.175% barium chloride hydrate ($BaCl_2.2H_2O$) with 9.85ml of 1% sulfuric acid (H_2SO_4) were mixed to prepare 1.5 McFarland standard.

The 0.5 McFarland standard is expected to give an approximate cell density (1.5×10^8 CFU/ml) giving optical density (absorbance) of 0.1 at 600nm wavelength while the 1.5 McFarland standard was expected to give an approximate cell density (4.5×10^8 CFU/ml) giving optical density (absorbance) of 0.357 at 600nm wavelength.

The prepared McFarland standards were put into tightly screwed tubes and stored at room temperature away from sunlight[11].

Preparation of test organisms:

Two colonies of the already isolated bacterial test microorganisms were emulsified in 4-5ml of sterile nutrient broth and matched with 0.5 McFarland's standard. Same was done for the fungal test organism but it was matched with 1.5 McFarland's standard. The broths containing the microorganisms were allowed to stand for 2 -3 hours before it was used[12].

Antimicrobial susceptibility testing:

This was done by filter paper disc diffusion technique as described in[13] with modifications for the MDR isolates and agar dilution method as described in[14] Kenneth *et al*., (1973) with modifications.

Preparation of discs

Diffusion discs of 6mm diameter prepared from Whatman filter paper by using a sterile paper puncher and sterilized at 120^0C for 1hour in hot air oven. Subsequently, the sterilized discs were impregnated aseptically by applying 0.02ml (20µl) of the aqueous and ethanolic extracts of the plant at

concentrations of 10mg/ml (5%), 50mg/ml (25%), 100mg/ml (50%) and 200mg/ml (100%) using a sterile micropipette and then allowed to dry in an hot air oven at 40^0C.
The discs were then placed in sterile container and stored at 4^0C.

Disc diffusion technique:
Sterile nutrient agar medium (14g nutrient agar in 500ml distilled water, autoclaved at 115^0C and 15psi for 30 minutes) was prepared, cooled to 50^0C, poured into the sterile Petri dishes and allowed to solidify. Pure isolates were collected from the broth culture of the test organisms and streaked on the agar with a sterile swab. The discs were placed on the surface of the medium using a flame sterilized forceps. The discs were also placed on fungal isolate inoculated in SDA.
The culture plates were then incubated at 37^0C for 24 hours to obtain zones of inhibition.
The diameter of these zones of inhibition was measured using a meter rule, vertically, horizontally and diagonally.
The mean was calculated and presented in millimeter[15,16] and read as resistant, intermittent or sensitive based on the length of the inhibition zone. The zones of inhibition were compared with that of the conventional antibiotic discs.

Agar dilution technique:
Using a sterile micro pipette, 1ml of the different concentrations of the 40% ethanolic and aqueous extracts were put in about 20ml each of already prepared molten nutrient agar in a sterile universal container for the bacteria isolates and SDA for the fungi isolate when the agar media were still in molten form (50^0C). The mixture was mixed properly by gently turning the corked tube it was in up and down three times. The mixture was then poured into sterile Petri dishes and allowed to cool and solidify. Each Petri dish/culture plate contained a specific concentration of the extracts.
The Petri dishes containing the mixture were then swab inoculated aseptically with the different test organisms from the standardized broth culture of the organisms and allowed to incubate at 37^0C for 24 hours to check for the presence or absence of growth which was read as resistant[-] or sensitive[+][14].

Determination of minimum inhibitory concentration (mic):
Minimum inhibitory concentration is the lowest concentration of antimicrobial agent that will completely inhibit visible growth of the test-organism.
The most preferred method for determination of MIC using extracts is the broth micro-dilution method. This method as described by [17], was performed using a new sterile 96-well micro-titer plates. The 96-well plates made up of 8 rows (A - H) and 12 columns (1 -12) were prepared by dispensing 50µl of Nutrient broth into the specific row to be used. Each row is made up of 12 wells labelled 1-12. 50µl from the specific concentration of the test extract to be used was added into well 1(positive control) and 3 of the specific row of the plate to be used.
Then two fold serial dilutions were performed by using a sterile micro pipette from the 3rd well to the 12th well and the last dilution discarded.
Determination of mic cont.:
The resulting dilutions were as follows: 1 in 2(1/2) for well 3, 1 in 4(1/4) for well 4, 1 in 8(1/8) for well 5, 1 in 16(1/16) for well 6, 1 in 32(1/32) for well 7, 1 in 64(1/64) for well 8, 1 in 128(1/128) for well 9, 1 in 256(1/256) for well 10, 1 in 512(1/152) for well 11 and 1 in 1024(1/1024) for well 12. 10µl of the test inocula was added to the 2nd well (negative control) till the 12th well

except the 1st well. The specific concentration of extract to be used with broth (1st well) was used as a positive control and inoculum with broth (2nd well) was used as a negative control. The test plates were then incubated at 37ºC for 18hours.

After 18hours, 50µl of 0.01% solution of 2, 3, 5- triphenyltetrazolium chloride (TTC) was added to the wells with a sterile micropipette and the plate incubated for another hour. Since the colorless tetrazolium salt will be reduced to red/pink colored product by biological active bacteria, thus the inhibition of growth can be detected when the solution in the well doesn't change to pink/red after incubation with TTC.

The **MIC** is the lowest sample concentration showing no colour change (clear) and exhibited complete inhibition of growth.

Determination of 50% lethal dose ld_{50} (acute toxicity):

The acute toxicity or the median lethal dose (LD_{50}) of the aqueous and 40% ethanolic extracts of dry seeds of *Carica papaya* were evaluated in 26 rats of the Wistar strain(13 rats for each extract) using a modified Lorke's method[18]. Prior to the test, the rats were acclimatized to standard animal cage conditions for a week and fasted overnight. 2.04g of the ethanolic extract was dissolved in 20mls of distilled water and administered using an oral cannula. The process was done in two phases for both the aqueous and 40% ethanolic extract.

In the first phase, a total of three groups were formed, and within each group, three rats were randomly placed. The rats were given the 40% ethanolic extracts, orally at doses of 10, 100, and 1000 mg/kg body weight (b.w). The rats were observed for 24 hours for signs of toxicity (morbidity and mortality).

During the second phase, four groups with one rat in each group were given the 40% ethanolic extracts orally. The doses administered were 1200, 1600, 2900, and 5000 mg/kg b.w in a similar manner as above. The rats again were observed for 24 hours for any signs of toxicity.

After the last phase, the LD_{50} was calculated as the geometric mean of the highest non-lethal dose (a) and the least toxic dose (b).

$LD_{50} = \sqrt{a \times b}$

Ethical approval: The study was approved by Nnamdi Azikiwe University Animal Research Ethics Committee (NAU-AREC), Awka (NAU/AREC/2024/0076).

Data analysis: The data obtained in this study was presented in tables and figures.

RESULTS

Antimicrobial Susceptibility Testing (AST)

In the results according to this study it was observed that the aqueous and 40% ethanolic extracts showed no signs of antimicrobial activity against the MDR isolates in which disc diffusion method was used as seen in Table 1, Figures 1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d but showed varying degrees of activity against non-MDR isolates in which agar dilution was used as seen in Table 2, Figure 4c-7d

Table 1: Zone of inhibition of MDR-microorganisms in 40% ethanolic and aqueous extracts of *Carica papaya* seeds using disc diffusion method.

MDR Microorganisms	Zone of Inhibition diameter (mm) for *Carica papaya* seed extracts							
	Aqueous extract (AE)				Ethanolic extract (EE)			
	5%	25%	50%	100%	5%	25%	50%	100%
Escherichia coli	0	0	0	0	0	0	0	0
Pseudomonas aeruginosa	0	0	0	0	0	0	0	
Staphylococcus aureus	0	0	0	0	0	0	0	0
Candida albicans	0	0	0	0 0	0 0	0		

KEY: MDR-Multidrug Resistant.
0-Resistant (Okeke-Nwolisa *et al*., 2023a)

Figure 1a: Culture plate showing MDR *Escherichia coli*
Figure 1b: Aqueous and ethanolic *Carica papaya* seed extract on MDR *E.coli* showing no zone of inhibition after incubation at 37^0C for 24 hours

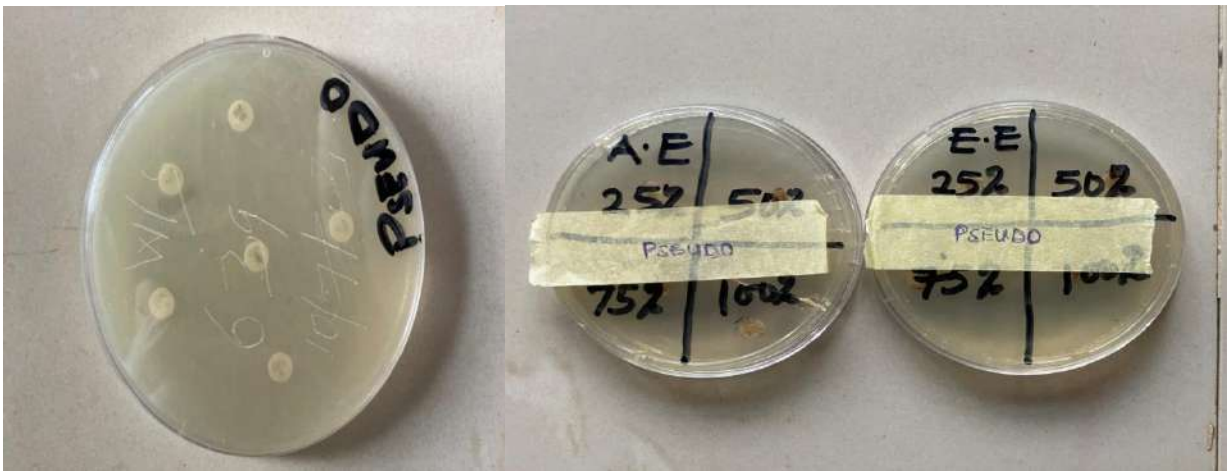

Figure 1c: Culture plate showing MDR *Pseudomonas aeruginosa*
Figure 1d: Aqueous and ethanolic *Carica papaya* seed extract on MDR *P.aeruginosa* showing no zone of inhibition after incubation at 37^0C for 24 hours

Figure 2a:Culture plate showing MDR *Staphylococcus aureus*
Figure 2b: Aqueous and ethanolic *Carica papaya* seed extract on MDR *S. aureus* showing no zone of inhibition after incubation at 37^0C for 24 hours

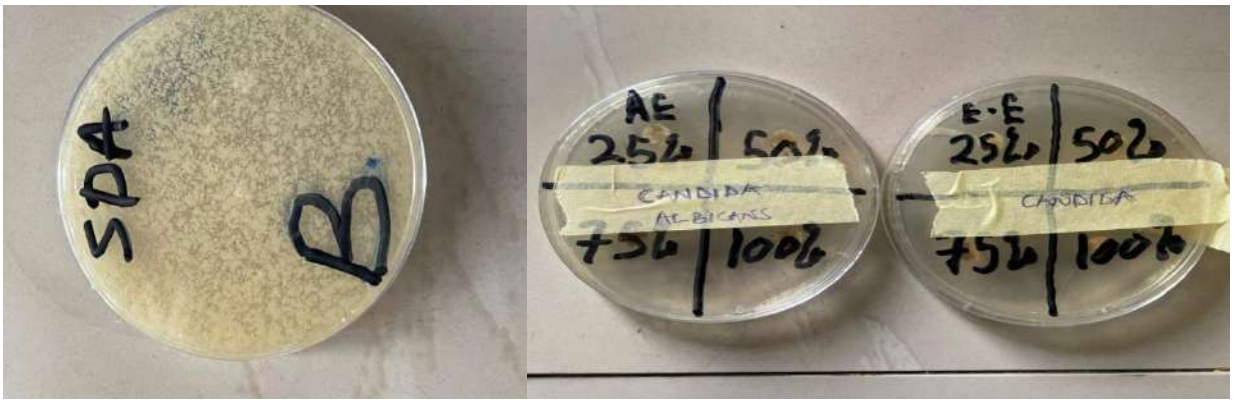

Figure 2c: SDA Culture plate showing MDR *Candida albicans*
Figure 2d: Aqueous and ethanolic *Carica papaya* seed extract on MDR *C.albicans* showing no zone of inhibition after incubation at 37^{0}C for 24 hours
KEY: MDR (Multidrug Resistant).
AE- Aqueous extract
EE- Ethanolic extract

Table 2: Presence or absence of inhibition in 40% ethanolic and aqueous extracts of *Carica papaya* seeds on Non-MDR microorganisms.

Non-MDR Microorganisms	Aqueous extract				Ethanolic extract			
	5%	25%	50%	100%	5%	25%	50%	100%
Escherichia coli	-	-	-	-	-	+	+	+
Pseudomonas aeruginosa	-	-	+	+	-	-	-	-
Staphylococcus aureus	-	-	-	-	-	-	-	-
Candida albicans	-	-	-	+	-	+	+	+

KEY: SENSITIVE (+)
RESISTANT (-) (Kenneth *et al*., 1973).
MDR (Multidrug Resistant).

It was also observed that the 40% ethanolic extract showed higher antimicrobial activity than the aqueous extract. The lowest concentration of the 40% ethanolic extract that showed inhibition was the 25% concentration (50mg/ml), having inhibitory effect against *Escherichia coli* and *Candida albicans* as seen in Table 2, Figure 6c and 6d while that of the aqueous extract was the 50% concentration (100mg/ml) having slight inhibitory effect against *Pseudomonas aeruginosa* as seen in Table 2, Figure 5a. Both extracts showed increased inhibitory effect on increased concentration against the susceptible microorganisms as seen in Table 4.2 and Figure 4c-7d

The 5% and 25% concentrations of the aqueous extract and 5% concentration of the 40% ethanolic extracts showed little to no activity against the non-MDR test organisms as seen in Table 2 and Figure 4c, 4d, 4e, 4f, 6a and 6b. The 50% and 100% concentrations of the aqueous extract, 25%, 50% and 100% concentrations of the ethanolic extract inhibited the growth of some the non-MDR test organisms as seen in Table 2 and Figure 5a, 5b, 5c, 5d, 6c, 6d, 7a, 7b, 7c and 7d.

Candida albicans showed the highest susceptibility as it was inhibited by both the

aqueous extract (100% concentration) and the 40% ethanolic extract (25%, 50% and 100% concentrations) as seen in Table 2 and Figure 5c, 6c, 7a and 7c. It is followed by *Escherichia coli* which was inhibited by 25%, 50% and 100% concentrations of the ethanolic extract as seen in Table 2 and Figure 6d, 7b, 7d. *Staphylococcus aureus* showed the least susceptibility as it was resistant to all concentrations of both aqueous and 40% ethanolic extracts as seen in Table 2 and Figure 4d, 4f, 5b, 5d, 6b, 6d, 7b and 7d. It was followed by *Pseudomonas aeruginosa* which was only susceptible to 50% and 100% concentrations of the aqueous extract as seen in Table 2 and Figure 5a and 5c.

Antimicrobial susceptibility testing revealed that the Non-MDR test organisms were resistant to some of the control antibiotics used as seen in Table 3 and Figures 3a, 3b and 3c below.

Table 3: Antibiotic Susceptibility Test results of Non-MDR test organisms on control drugs.

Non-MDR Microorganisms	Zone of Inhibition diameter (mm) ANTIBIOTICS							
	GEN	**CRX**	**CXM**	**OFL**	**AUG**	**NIT**	**CPR**	**CAZ**
Escherichia coli	20	-	16	23	-	18	25	-
Pseudomonas aeruginosa	13	-	-	20	-	-	26	-
Staphylococcus aureus	6	-	-	-	-	26	-	-

KEY: MDR- Multidrug Resistant
GEN - Gentamicin
CRX – Cefuroxime
CXM – Cefixime
OFL – Ofloxacine
NIT - Nitrofurantoin
CPR - Ciprofloxacine
CAZ - Ceftazidine
(**-**) - Resistance.

Figure 3a: Antibiotic sensitivity discs on *Staphylococcus aureus* showing zones of inhibition after incubation at 37^0C for 24 hours

Figure 3b: Antibiotic sensitivity discs on *Escherichia coli* showing zones of inhibition after incubation at 37^0C for 24 hours

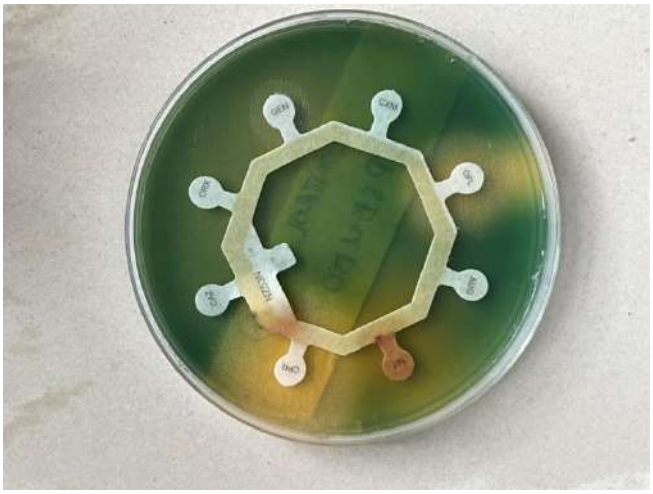

Figure 3c: Antibiotic sensitivity discs on *Pseudomonas aeruginosa* showing zones of inhibition after incubation at 37^0C for 24 hours

Figure 4a: Media control culture plate plate

Figure 4b: 40% Extract control culture

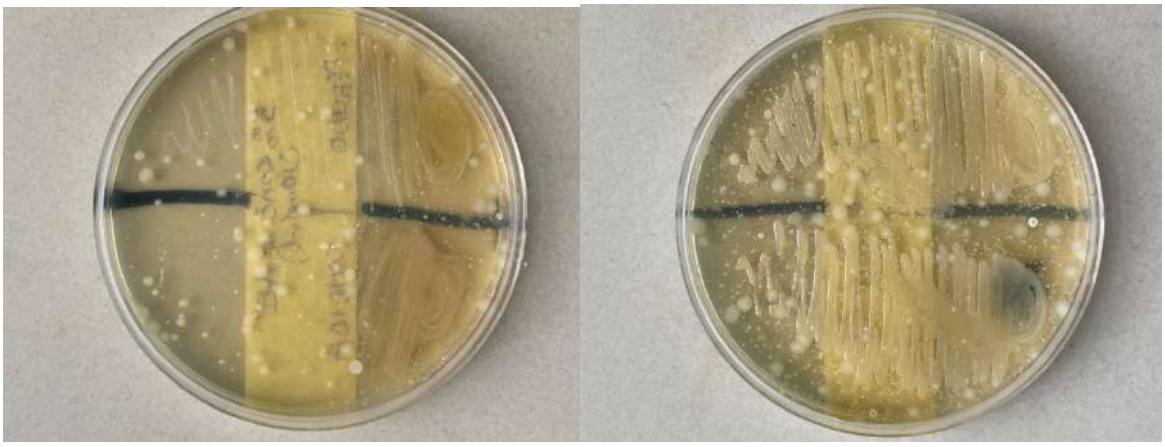

Figure 4c: 5% AE on *Pseudomonas aeruginosa* and *Candida albicans* after incubation at 37^{0}C for 24 hours

Figure 4d: 5% AE on *Escherichia coli* and *Staphylococcus aureus* after incubation at 37^{0}C for 24 hours

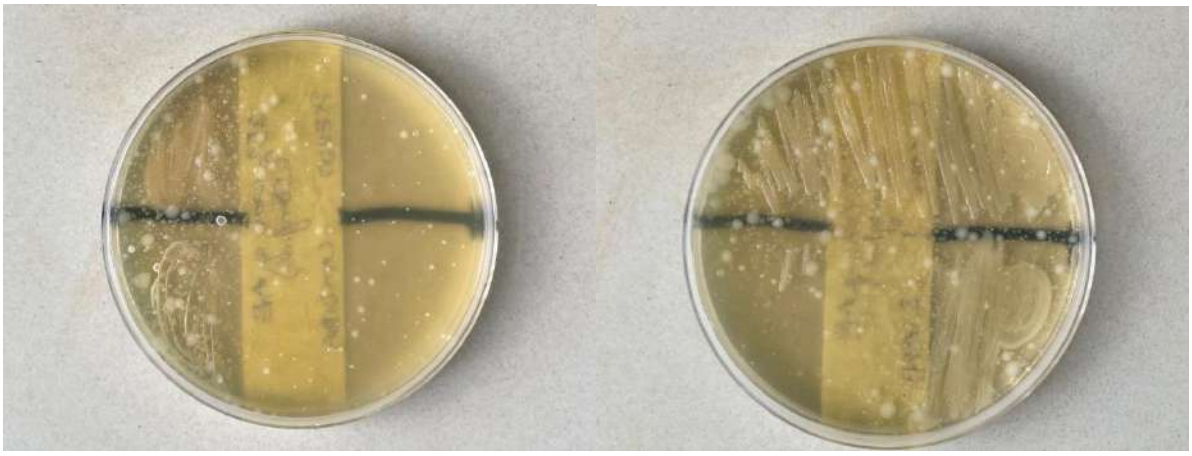

Figure 4e: 25% AE on *Pseudomonas aeruginosa* and *Candida albicans* after incubation at 37^{0}C for 24 hours

Figure 4f: 25% AE on *Escherichia coli* and *Staphylococcus aureus* after incubation at 37^{0}C for 24 hours

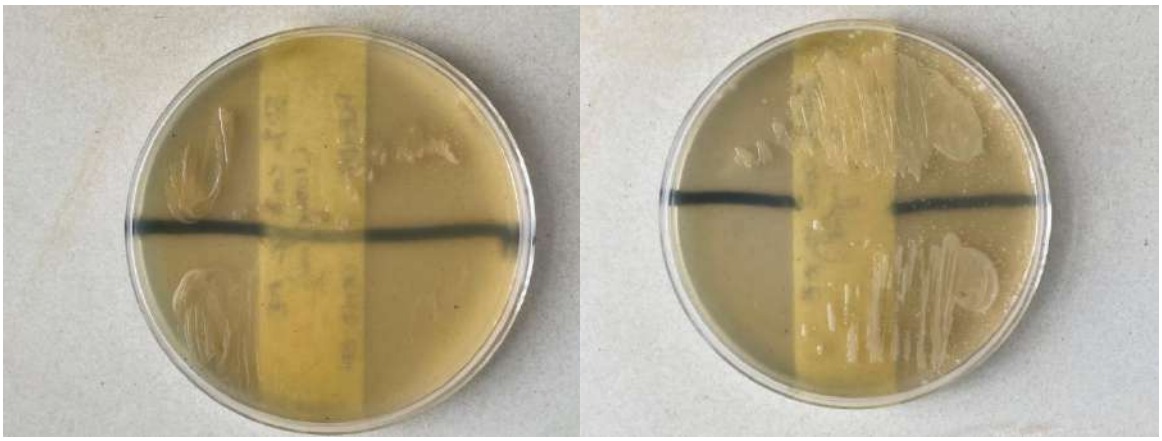

Figure 5a: 50% AE on *Pseudomonas aeruginosa* and *Candida albicans* after incubation at 37^0C for 24 hours

Figure 5b: 50% AE on *Escherichia coli* and *Staphylococcus aureus* after incubation at 37^0C for 24 hours

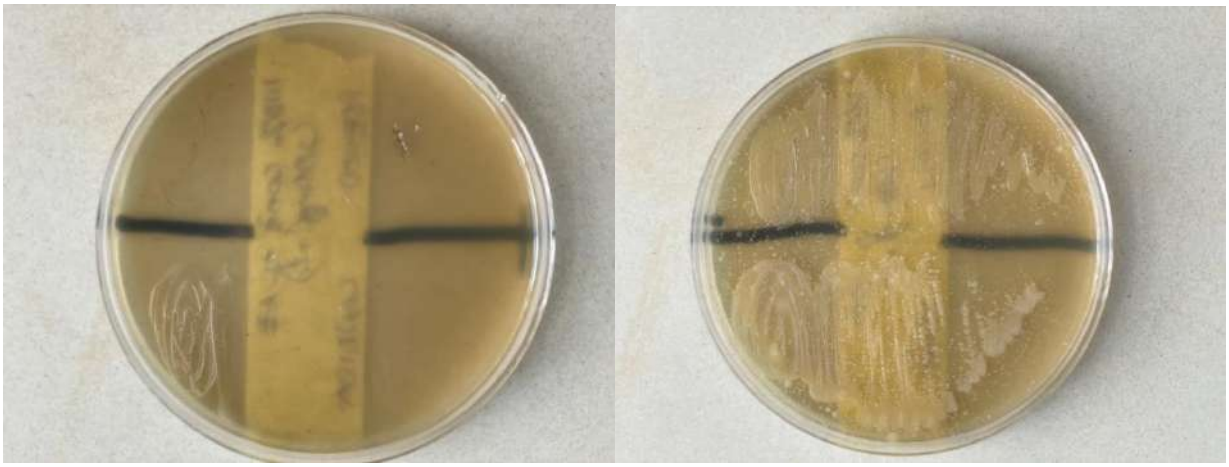

Figure 5c: 100% AE on *Pseudomonas. aeruginosa* and *Candida albicans* after incubation at 37^0C for 24 hours

Figure 5d: 100% AE on *Escherichia. coli* and *Staphylococcus. aureus* after incubation at 37^0C for 24 hours

KEY: AE-Aqueous Extract

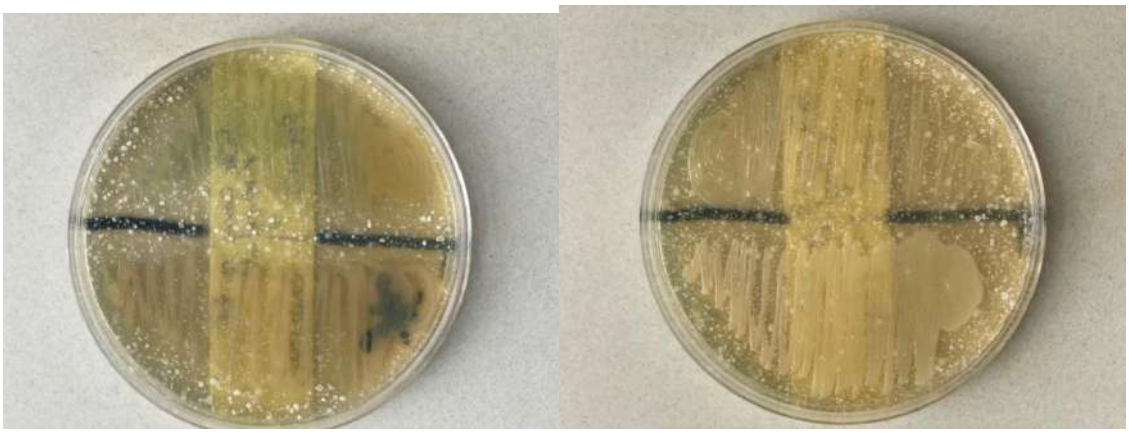

Figure 6a: 5% EE on *Pseudomonas. aeruginosa* and *Candida. albicans* after incubation at 37ºC for 24 hours

Figure 6b: 5% EE on *Escherichia. coli* and *Staphylococcus. aureus* after incubation at 37^0C for 24 hours

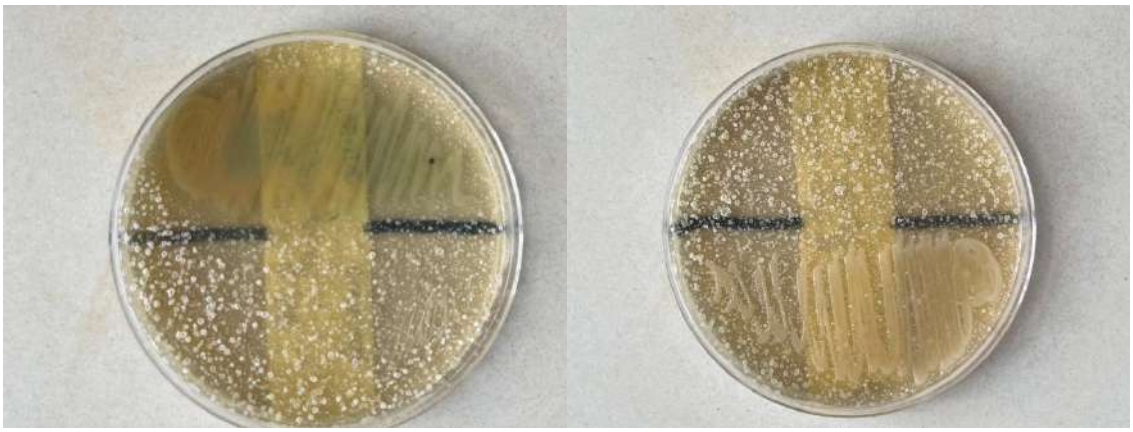

Figure 6c: 25% EE on *Pseudomonas. aeruginosa* and *Candida. albicans* after incubation at 37^0C for 24 hours

Figure 6d: 25% EE on *Escherichia. coli* and *Staphylococcus. aureus* after incubation at 37^0C for 24hours

KEY: EE-Ethanolic Extract.

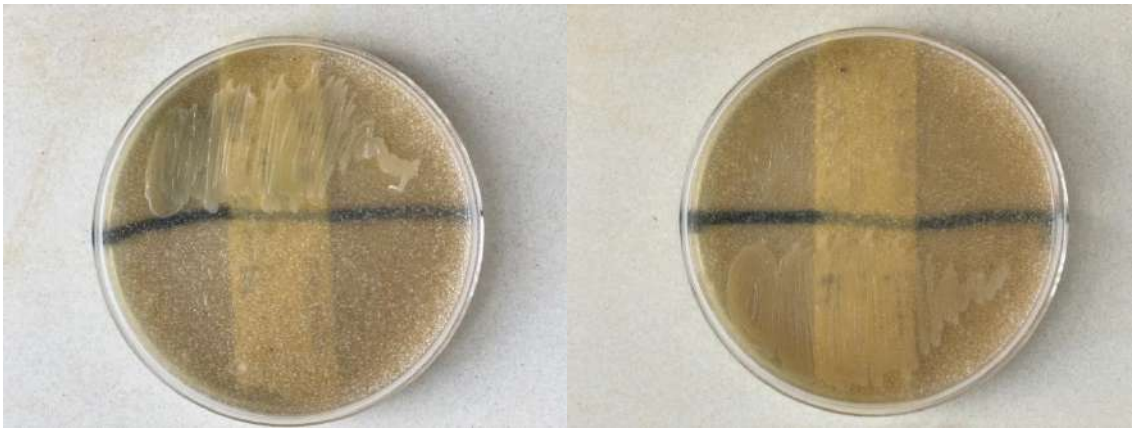

Figure 7a: 50% EE on *Pseudomonas. aeruginosa* and *Candida. albicans* after incubation at 37^0C for 24 hours

Figure 7b: 50% EE on *E. coli* and *S. aureus* after incubation at 37^0C for 24hours

Figure 7c: 100% EE on *Pseudomonas. aeruginosa* and *Candida. albicans* after incubation at 37^0C for 24 hours

Figure 7d: 100% EE on *Escherichia. coli* and *Staphylococcus. aureus* after incubation at 37^0C for 24hours

KEY: EE-Ethanolic Extract.

Minimum Inhibitory Concentration (MIC)

This was carried out to determine the effectiveness of the various extract concentrations that were able to inhibit the growth of the test organism in the agar dilution method.

Table 4 and Figure 8a, 8b and 8c below shows decreasing antimicrobial activity with decreasing concentration of papaya seeds extracts

Table 4: Determination of MIC using Broth micro-dilution method

	MIC for *Carica papaya* seed extracts in mg/ml						
Non-MDR	**Aqueous extract**				**Ethanolic extract**		
Microorganisms	**50%**	**100%**			**25%**	**50%**	**100%**
Escherichia coli	-	-			6.25	12.5	12.5
Pseudomonas aeruginosa	25	25	-	-	-		
Candida albicans	-	50	6.25	12.5	12.5		

KEY: MDR- Multidrug Resistant

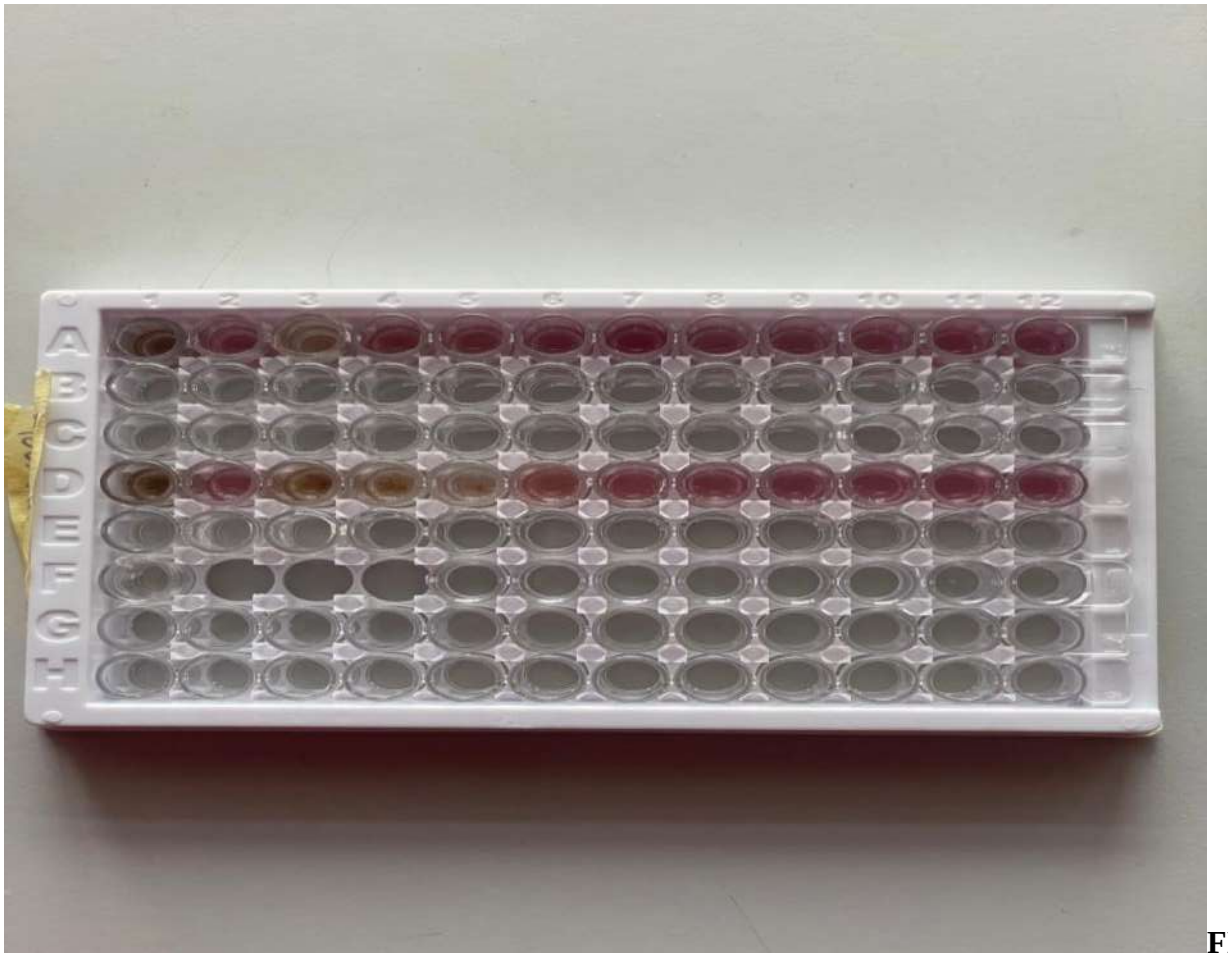

FIGURE 8a: MIC of 50% and 100% AE on *Pseudomonas aeruginosa*
KEY: AE- Aqueous Extract
Row A: 50% Aqueous extract, **Row D**: 100% Aqueous extract.
Column 1: Positive control, **Column 2**: Negative control, **Column 3**:1/2 diltuion, **Column 4**: 1/4 diltuion, **Column 5**: 1/8 diltuion, **Column 6**: 1/16 diltuion, **Column 7**: 1/32 diltuion, **Column 8**: 1/64 diltuion, **Column 9**: 1/128 diltuion, **Column 10**: 1/256 diltuion, **Column 11**: 1/512 diltuion, **Column 12**: 1/1024 diltuion.

Table 5: Showing the different dilutions in each column of the microtitre plate

Column	1	2	3	4	5	6	7	8	9	10	11	12
Dilutions	**+ve**	**-ve**	½	¼	1/8	1/16	1/32	1/64	1/128	1/256	1/512	1/1024

KEY: +ve -Positive control (Nutrient broth plus extract)
-ve -Negative control (Nutrient broth plus organism)

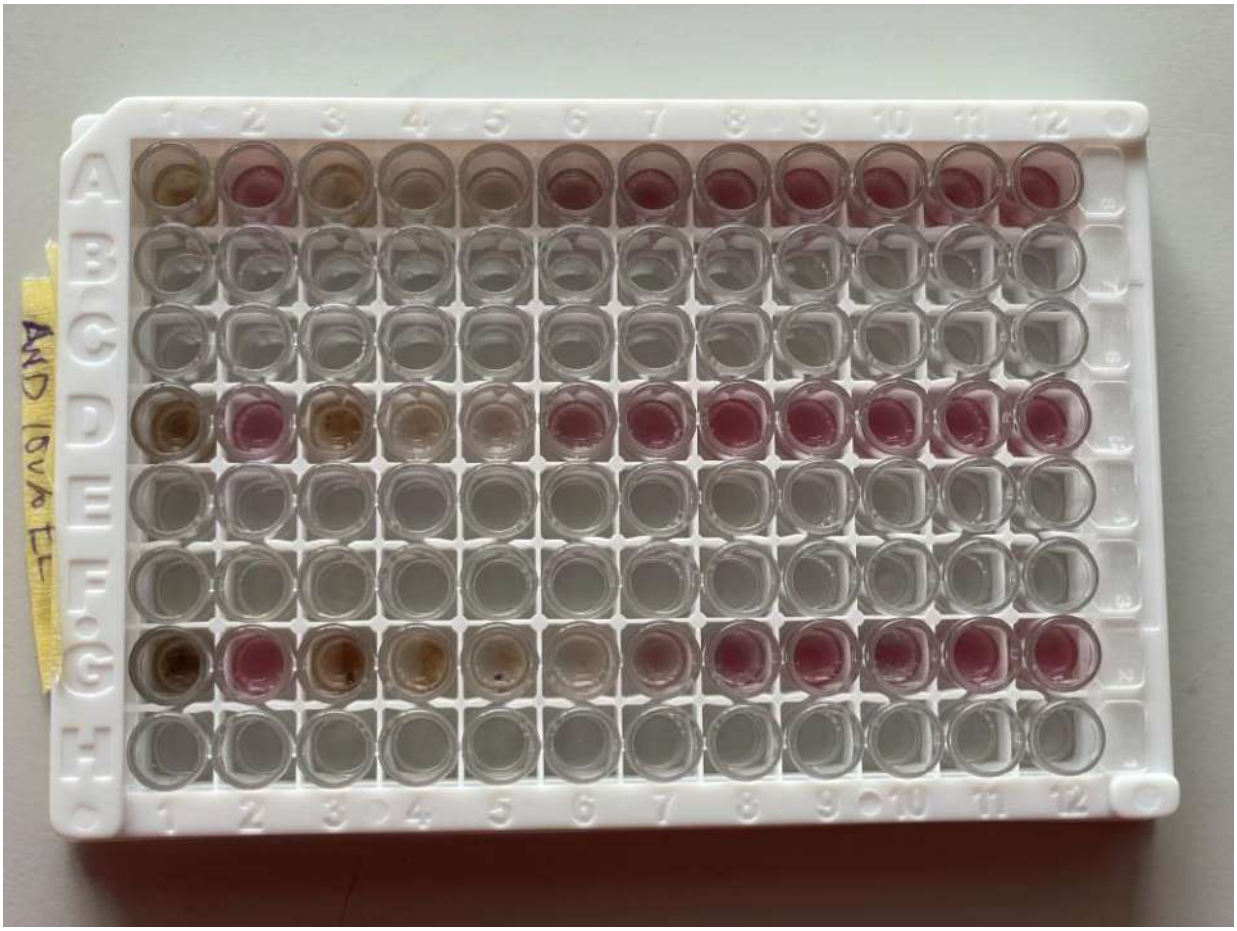

Figure 8b: MIC of 25%, 50% and 100% EE on *Escherichia coli*
KEY: EE- Ethanolic Extract
Row A: 25% Ethanolic extract, **Row D**: 50% Ethanolic extract, **Row G**: 100% Ethanolic extract.

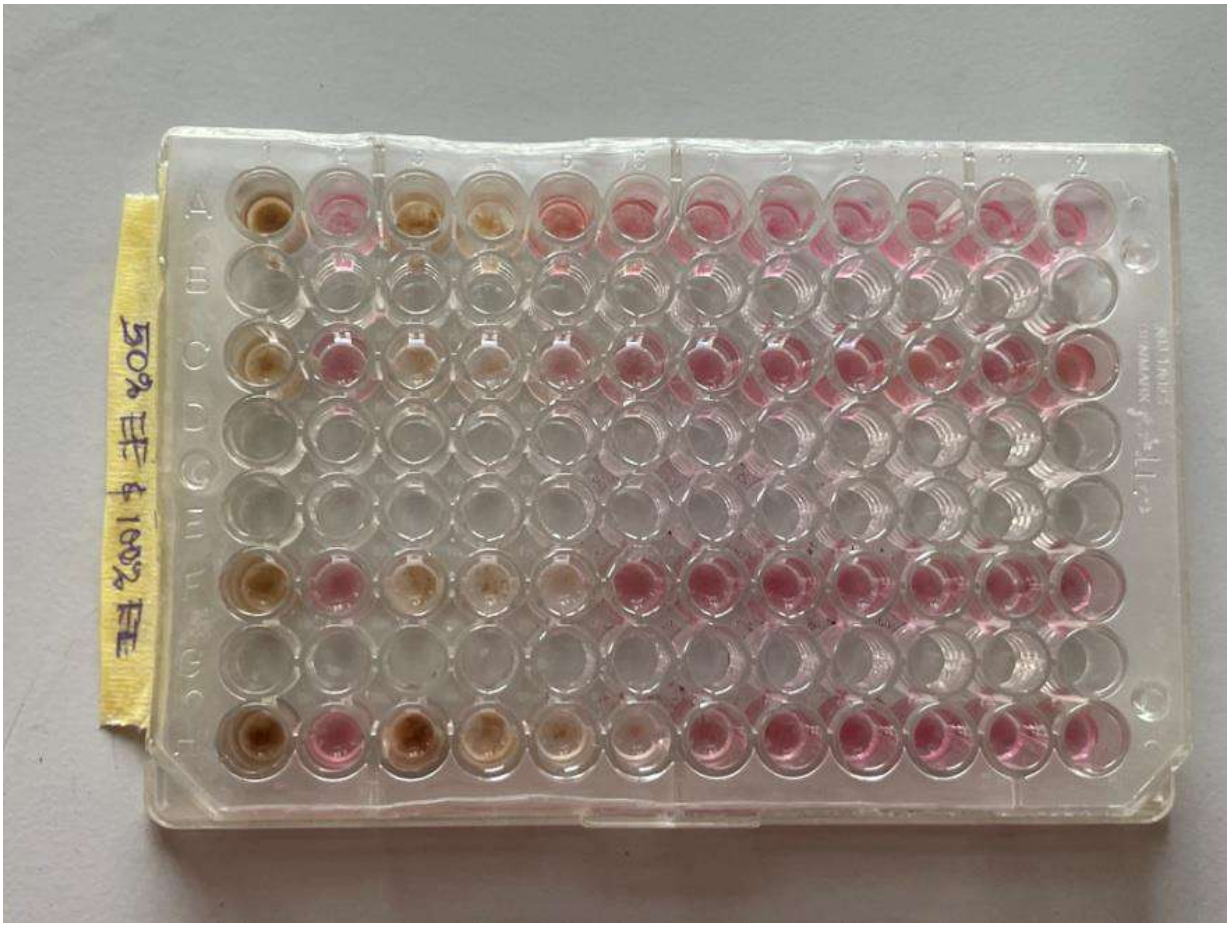

Figure 8c: MIC of 100% AE, 25%, 50% and 100% EE on C*andida albicans*
KEY: AE- Aqueous Extract
EE- Ethanolic Extract
Row A: 100% Aqueous extract, **Row C**: 25% Ethanolic extract, **Row F**: 50% Ethanolic extract, **Row H**: 100% Ethanolic extract.

For *Pseudomonas aeruginosa*, 50% (Row A in Figure 8a) and 100% (Row D in Figure 8a) concentrations aqueous extract were used as seen in Figure 8a. For *Escherichia coli*, 25% (Row A in Figure 8b), 50% (Row D in Figure 8b) and 100% (Row G in Figure 8b) concentrations of 40% ethanolic extract were used as seen in Figure 8b. For *Candida albicans*, 100% concentration of the aqueous extract (Row A in Figure 8c), 25% (Row C in Figure 8c), 50% (Row F in Figure 8c) and 100% (Row H in Figure 8c) concentrations of the 40% ethanolic extract were used as seen in Figure 8c.

Among the 100% concentration (200mg/ml) of the aqueous seed extract, the MIC was 25mg/ml (1/8 dilution as seen in Row D, column 5 of Figure 8a) for *Pseudomonas aeruginosa* and 50mg/ml (1/4 dilution as seen in Row A, column 4 of Figure 8c) for

Candida albicans. Among the 100% concentration (200mg/ml) of the 40% ethanolic seed extract, the MIC was 12.5mg/ml (1/16 dilution as seen in Row G, column 6 of Figure 8b) for *Escherichia coli* and 12.5mg/ml (1/16 dilution as seen in Row H, column 6 of Figure 8c) for *Candida albicans.*

Acute Toxicity Testing

In Table 5, which is an acute toxicity study of the 40% ethanolic seed extract of *Carica papaya*, no animal death was recorded both in phase 1 and phase 2 with a maximum dose of 1000mg/kg and 5000mg/kg per phase. A total of 13 Wistar rats were used to carry out this study.

Table5: Acute Toxicity study of ethanolic seed extract of *Carica papaya* for phase 1 and 2

	Phase	Dose(mg/kg/bw)	Death (13)	Observation
40% ethanolic seed extract of *Carica papaya*	1	10	0/3	The rats remained normal
		100	0/3	The rats remained normal
		1000	0/3	The rats remained normal
	2	1200	0/1	The rats remained normal
		1600	0/1	The rats remained normal
		2900	0/1	The rats remained normal
		5000	0/1	No death occurred

KEY: **mg** - milligram; **kg** - kilogram **bw** - body weight

In Table 6, which is an acute toxicity study of aqueous seed extract of *Carica papaya*, no animal death was recorded both in phase 1 and phase 2 with a maximum dose of 1000mg/kg and 5000mg/kg. A total of 13 Wistar rats were used to carry out this study.

Table 6: Acute Toxicity study of aqueous seed extract of *Carica papaya* for phase 1 and 2

	Phase	Dose(mg/kg/bw)	Death (13)	Observation
Aqueous seed extract of *Carica papaya*	1	10	0/3	The rats remained normal
		100	0/3	The rats remained normal
		1000	0/3	The rats remained normal
	2	1200	0/1	The rats remained normal
		1600	0/1	The rats remained normal
		2900	0/1	The rats remained normal
		5000	0/1	No death occurred

KEY: **mg** - milligram; **kg** - kilogram; **bw** - body weight

DISCUSSION

This study showed differences in antimicrobial activities between the two extracts used which is dependent on the extraction solvent used. This implied that the release of bioactive compounds of plant parts depend on the extraction solvent[9]. The result of this study showed that the aqueous extract was less effective than the ethanolic extract and this is in agreement with the works of Wemambu *et al*., (2018)[19], and Dagne *et al*., (2021)[9], all recorded higher antimicrobial activity of ethanolic extract of *Carica papaya* seeds. This may be due to the better solubility of the active components of the seeds in organic solvents [20].

It was also observed that the extracts showed higher antibacterial activity against Gram negative bacteria organisms than the Gram positive bacteria organism tested. This coincides with the findings of previous works of Mangalanayaki and Nirosha (2013)[21] and Peter *et al*., (2014)[22]. This result however contradicts the results of Jigna and Sumitra, (2006)[23], that recorded higher antibacterial activity against Gram positive bacteria than Gram negative bacteria. This might be due to slight differences in the method used for antimicrobial testing.

The MIC was carried out to determine the effectiveness of the various dry *Carica papaya* seeds extract concentrations that were able to inhibit the growth of the test microorganisms in the agar dilution method. The dry *Carica papaya* seeds which were extracted with different solvents showed different MIC. The 100% concentration of the 40% ethanolic extract of dry *Carica papaya* seeds inhibited *Escherichia coli* and *Candida albicans* at 12.5mg/ml. So, it has a potential to treat infections caused by *Candida albicans* and *Escherichia coli*.

In this study, the fact that the extracts showed activity against fungi, Gram negative bacteria and in other works stated above, against Gram positive bacteria may indicate broad spectrum of activity. Several other reports have shown that *Carica papaya* have significant antibacterial activity in various extracts from different tree parts [24;25 and 26]. Zakira *et al*., 2006 analyzed the antimicrobial activity of *Carica papaya* flowers against bacterial pathogens[27]. Romasi *et al*., 2011 reported that the extracts of papaya leaves could inhibit the growth of *Rhizopus stolonifer*[28].

The antimicrobial effectiveness of plant extracts have been attributed to the presence of secondary metabolites in the investigated plant part which probably plays a vital role in its usefulness as a medicinal plant [29]. Sukadana *et al*., (2008)[30] in Martiasih (2014)[31] had reported that papaya seeds contained a potential antibacterial, triterpenoid aldehyde compound [32]. Triterpenoid has ability to disrupt cell pores so the membrane permeability was disrupted as well.

Another reported antibacterial compound in papaya seeds was carpaine alkaloid. Carpaine digests proteins from microorganisms and changes it into peptone. According to Sabir (2005)[33], flavonoid contents in *Trigona sp. propolis* inhibited the growth of *Streptococcus mutans* in vitro.

Flavonoid denatures proteins and disrupts the cell membrane leading to the death of bacterial cell. Mustikasari and Ariyani (2010)[34] stated that alkaloids had antimicrobial activity by disrupting the microbial cell wall [32]. All these active components play a role in the antimicrobial activities of *Carica papaya.*

The investigation also revealed that the median lethal dose (LD_{50}) of *Carica papaya* seeds extract were found to be over 5000mg/kg for both the 40% ethanolic and the aqueous seeds extracts as seen in Table 4.5 and 4.6. This outcome is due to the absence of any instances of subject mortality at this dosage level administered to the wistar rats. This discovery aligns with the work of Kanadi

et al., 2019[35] and Chinoy *et al*., 1994[36], which indicated that the aqueous extract exhibited an LD_{50} greater than 5000mg/kg. This finding also agrees with the guideline of OECD which states that any substance having LD_{50} above 5000mg/kg ingested orally is safe or essentially non-toxic[37].

CONLUSION

According to this study, dry *Carica papaya* seeds extracts possess antimicrobial activities and therefore is a potential source of therapeutic agent against certain bacteria and fungi. MIC of 12.5mg/ml was observed from the 40% ethanolic extract of dry *Carica papaya* seeds extracts. The aqueous and 40% ethanolic decoction prepared from the dry seeds of *Carica papaya* is tolerable at a dose of up to 5000mg/kg/bw.

RECOMMENDATIONS

Further pharmacological studies are necessary in order to give better insight on the therapeutic potential of the plant so as to properly extract and utilize the appropriate bioactive components which can be used in the treatment of diseases and to ascertain its effectiveness against multidrug resistant organisms so as to reduce the increasing rise of antimicrobial resistance. In addition, further studies are required to eliminate the possibility of toxicity in conditions of more chronic exposure or use of the extract.Researchers should explore other medicinal indigenous African plants for antimicrobial activities to help tackle the problem of multidrug resistance among pathogenic microbes.

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ORIGINAL RESEARCH

PREVALENCE AND PATTERN OF WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG LOAD CARRIERS IN IBADAN METROPOLIS

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ABSTRACT

Background: Load porterage is a blue-collar job that is more manually driven in low-and-middle income countries where individuals are prone to sustain musculoskeletal complications due to exposure to risks such as carrying heavy loads for shoppers.

Aim: This study aimed to investigate the prevalence and pattern of work-related musculoskeletal disorders (WMSDs) among load porters in Bodija and Akande markets in Ibadan, Oyo State.

Materials and Methods: This cross sectional study was conducted using consecutive sampling technique in selecting 113 load porters with the market conveniently selected. The Nordic Musculoskeletal Questionnaire (NMQ) was used to assess the prevalence and pattern of WMSDs. Descriptive statistics of mean, frequency and percentage were used to summarize the data.

Results: One hundred and two (90.27%) participants reported musculoskeletal pain in one or more body parts in the last 12 months with low back (68.14%) and neck (66.37%) as the most affected body regions. There was significant association between prevalence and tribe and BMI (p=0.04 and p=0.05 respectively). Fifty two (46.02%) participants reported pain in the last 7 days with low back (36.28%) and neck (33.63%) as the most affected regions.

Conclusion: There was high prevalence of WMSDs among respondents.. The most affected body regions were low back and neck.

Recommendation: It was therefore, recommended that healthcare providers should embark on awareness campaign to educate and enlighten load carriers on proper lifting technique which will enhance good work hygiene and ergonomic practice among load carriers .

Keywords: Prevalence, Pattern, Work-related musculoskeletal disorders, load porters, markets

INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are impairments of the musculoskeletal system, primarily caused by the performance of work tasks and the direct environment in which work is carried out[1]. WMSDs are the most notorious common cause of severe long term pain and physical disability affecting millions of people across the world, with substantial costs and impact on quality of life[2]. It could be the result of regular exposure to work activities that contribute significantly to the development or exacerbation of painful symptoms or conditions that are worsened or that persist due to work conditions[3]. Work-related Musculoskeletal Disorders (WMSDs) are the major cause of pain, disability, absenteeism, reduced productivity, and heavy financial costs among workers worldwide[4]. MSDs exert deleterious effects on the life of the workers in all fields, especially those requiring manual labour [5].

Risk factors often cited for musculoskeletal disorders in the workplace include high hand exertions, repetitive impact on the hand and wrist, awkward postures, prolonged standing and sitting, poor lifting or carrying techniques. Repetitive movements are especially hazardous when they involve the same joints and muscle groups over and over and when the same motion is done too often, too quickly and for too long[6]. Studies have also shown that MSDs make up 39% of all work-related health burdens on the employees, leading to loss of body parts and time, low productivity, change of career, handicap and total or partial dependence on the society[(5,6)]. Several studies have been conducted on prevalence of WMSDs among manual labourers of different occupational group all over the world such as brick carriers in India (90%), water carriers in South Africa, Ghana and Vietnam (98%), butchers (74.5%) , drivers (21.2%)[(7,8,9,10)] but little among load carriers

Numerous conducted studies have shown that carrying heavy loads on a daily basis on the head can cause MSDs, which is detrimental to the spinal health of the carrier. This is because it exerts pressure on the axial skeleton[11]. The findings recorded from a study[11] reveal an exacerbated degenerative change in the cervical spine following axial loading on the head. Poor work posture was one of the major causes of work-related pain and it is important to point out that repeated actions that come with the execution of a task lead to a cumulative workload that could be considered the cause of muscle pain and weakness[11]. These complaints affect the workers' ability, making them less willing to stay in their jobs for a long time, thereby leading to early retirement.

Over the years, there has been an emergence of the physically demanding occupation of commercial load carrying popularly called "alaaru" or "alabaru" among the Yorubas in the South-West of Nigeria who are commonly seen in the markets where they assist shoppers to carry their groceries of varying weights over varying distances for paltry economic reward[12]. This professional load carriers in many developing countries use their heads to carry loads that could be as heavy as 100 kg on a regular basis for many years and this is a very common practice in many African countries carried out by both male and female of varying age groups as a way of surviving downturns in the

economy[12]. The load carriers are thus needed to transport market goods and wares particularly since the African urban market spaces are mostly unmotorable and heavily congested and also, against the backdrop of huge unemployment in Nigeria, load porterage has become and remained an important leeway for people to earn a living[13]. Protecting this category of workers from undue WMSDs can only be achieved where there are proper and adequate empirical studies on WMSDs among them. Thus, there is need for an empirical update of WMSDs among this occupational group in which the burden of WMSDs among this high-risk group seems to have received less attention in research, despite its implications in policy and practice. This study aimed to assess the prevalence of self-reported musculoskeletal disorders among load potters, the pattern of distribution of WMSDs among the body parts and to investigate the relations between work-related musculoskeletal disorders (WMSDs) and work profile of load carriers in Bodija and Akande markets, Ibadan.

MATERIALS AND METHODS

Research design and participants selection

This was a cross sectional study in which the studied sample of 113 respondents (99 females, 14 males) was selected using consecutive sampling technique and it was carried out in Bodija and Akande markets, Ibadan, the capital and the most populous city of Oyo state, in Nigeria. It is the third largest city by population in Nigeria with a total population of 2,649,000 as of 2021, and over 3 million people within its metropolitan area. It is one of the country's largest city by geographical area[18].

Research instrument

The Nordic Musculoskeletal Questionnaire was used to gather information on WMSDs from participants and it comprises an anatomical diagram featuring nine major areas of the body (neck, shoulders, upper-back, elbows, wrists/hands, low back, hips/thighs, knees and ankles/feet). Participants were instructed to note body parts where they have felt any ache, discomfort or pain in the last 12 months and 7days. Thereafter, using the knowledge of the body areas, respondents were asked to answer 11 questions that followed. Two of the questions inquired whether respondents ever had any ache, discomfort or pain on any of the highlighted body regions in the last 12 months and 7 days. Nine questions specifically inquired whether respondents had troubles on each of the body parts in the last 12 months. Respondents were also asked whether or not such ache, discomfort or pain in the last 12 months prevented them from doing their normal work. Further, socio-demographic information including (age, sex, marital status, educational level and years of practice) and work profile (working hours per day, working hours per week, months of experience) were obtained from respondents using a proforma.

Inclusion criterion

The participants included in this study were consenting male and female load carriers who have been involved in this job for at least one year. Eligible respondents were those who were 18 years and more, and who were mainly involved in load carriers as a full-time occupation.

Exclusion criteria

Those excluded from this study were load carriers with musculoskeletal disorders other than work-related and pregnant load carriers in their second and third trimesters.

Ethical approval and consent to participate

All guidelines as per declaration of Helsinki and good clinical practice guidelines were followed. Ethical approval was sought and obtained from Bowen University Teaching Hospital Health and Research Committee (BUTH-HREC) with the number BUTH/REC-827 and the Oyo State Research Council. Administrative approval to conduct this study was obtained from the chairperson of the Association of load potters in both Bodija and Akande markets. A written informed consents were obtained from the load potters after the purpose of the study was explained to them prior to their participation in the study. The Yoruba translated version of the informed consent was made available for those who had preference for or were literate in Yoruba language only, since Yoruba is the local language spoken in the setting where this study was conducted.

Sample size calculation

Sample size for this study was determined using the Cochran's sample formula (Cochran, 1965) as shown below: Where n_0 signifies the sample size; z-value is found in a Z table (1.96 for a confidence level of 95%); p is the (estimated) proportion of the population which has the attribute in question (0.92); q is 1-p (1–0.92 = 0.08) and d is the desired level of precision (i.e., the margin of error = 0.05)

$$n = \frac{(1.96)^2 \times 0.92 \times (1-0.92)}{(0.05)^2}$$

=113 Load potters

Data analysis

Descriptive statistics of means, standard deviation, frequency and percentage was used to summarize the obtained data (demographic variables and work profile of the occupational load carriers).

RESULTS

Demographics and work profile of the respondents

A greater proportion of the participants 99 (87.61%) were females. The mean age of the participants was 39.85±12.30 years. Out of 113 participants, 49 (43.36%) were married. Participants from the Yoruba tribe had a higher representation of 111 (98.23%) participants and then the Hausa tribe with a representation of 2 (1.77%). The educational level was largely distributed across primary and secondary levels with 54 (47.79%) and 51 (45.13%) participants respectively and followed by participants with no education, 7 (6.19%) and participants with tertiary education, 1 (0.88%). The mean Body Mass Index (BMI) of participants is 21.81±3.76 with the minimum as 16.02kg/m^2 and the maximum as 45.20kg/m^2. The mean months of working experience of the participants was 43.86±49.88 with the minimum and maximum as 12 and 240 months respectively. The number of days per week worked by the load porters had a mean of 5.21±1.39 with minimum number of days per week as 2 and the maximum as 7 with most of these load porters working 5 to 6 days a week. The mean daily work hours was 8.39±2.24 with minimum and maximum working hours of 3 and 13 respectively (Table 1).

Table 1: Demographic variables and work profile of the respondents

Variables	Mean ±S. D	Minimum	Maximum
Age (Years)	39.85±12.30	14	70
BMI (Kg/m^2)	21.81±3.76	16.02	45.2
Duration of work(hours)	8.39±2.24	3	13
Duration of work(days)	5.21±1.39	2	7
Working experience (Months)	43.86±49.88	12	240
		Frequency	**Percentage**
Gender	Female	99	87.61
	Male	12	12.39
Highest education	No formal education	7	6.19
	Primary	54	47.79
	Secondary	51	45.13
	Tertiary	1	0.88
Age (Years)	<20	12	10.62
	21 – 30	11	9.73
	31 – 40	42	37.17
	> 40	48	42.4
BMI (kg/m^2)	Normal weight	90	80.36
	Obesity	2	1.79
	Overweight	8	7.14
	Underweight	12	10.71
Marital Status	Divorced	10	8.85
	Married	49	43.36
	Single	41	36.28

12-months and 7-days Prevalence and Pattern of distribution of musculoskeletal disorders across body parts of respondents

In the last 12 months, the overall prevalence of WMSDs among this participants is 90.27%. Out of 113 participants, 75(66.37%) participants reported pain in the neck, 52(46.02%) participants reported pain at the shoulders, 39(34.51%) reported pain at the elbows, 49(43.36%) reported pain at the wrist, 57(50.44%) reported pain at the upper back, 77(68.14%) reported pain at the low back, 60(53.09%) reported pain at the hip, 65(57.52%) reported pain at the knees and 72(63.72%) reported pain at the ankle (Table 2). In the last 7 days, the overall prevalence of WMSDs is 46.02%. 38(33.63%) participants complained of pain in the neck, 21(18.58%) participants complained of pain at the shoulders, 18(15.93%) participants complained of pain at the elbow, 23(20.35%) participants complained of pain at the wrist, 28(24.78%) complained of pain at the upper back, 41(36.28%) participants complained of pain at the low back, 28(24.78%) participants complained of pain at the hip, 37(32.74%) participants complained of pain at the knees, 30(26.55%) participants complained of pain at the ankles (Table 2)

Table 2: 12-months and 7-days prevalence and pattern of MSD across body parts of respondents

Associated body region	Category	12-months prevalence	Associated body region	Category	7-days prevalence
Neck	**No**	**38(33.63%)**	**Neck**	**No**	75(66.37%)
	Yes	75(66.37%)		Yes	38(33.63%)
Shoulder	No	61(66.98%)	Shoulder	No	10(94.41%)
	Yes	52(46.02%)		Yes	21(18.58%)
Elbow	No	74(78.49%)	Elbow	**No**	95 (84.07%)
	Yes	39(34.51%)		Yes	18(15.93%)
Wrist/hand	No	64(56.64%)	Wrist/hand	No	90(79.65%)
	Yes	49(48.36%)		Yes	23(20.35%)
Upper back	No	56(49.56%)	Upper back	No	85(75.22%)
	Yes	57(50.44%)		Yes	28(24.78%)
Lower back	No	36(31.86%)	Lower back	No	72(76.71%)
	Yes	77(60.00%)		Yes	41(36.28%)
Hip /thighs	No	53(46.90%)	Hip	No	85(75.22%)
	Yes	60(53.09%)		Yes	28(24.78%)
Knee	No	48(42.48%)	Knee	No	76(67.26%)
	Yes	65(57.52%)		Yes	37(32.74%)
Ankle	No	41(36.28%)	Ankle	No	83(73.45%)
	Yes	72(63.72%)		Yes	30(26.55%)

DISCUSSION

The purpose of this study was to investigate the prevalence and pattern of WMSDs among occupational load porters in Ibadan, Oyo state. As at the time this research was carried out, there seemed to be paucity of studies that have been carried out on WMSDS among load porters in Nigeria. The findings of this study revealed that females were predominant with a percentage frequency of 87.61% and mean age of 39.85±12.30 years. This is similar to the finding by[13]. The unintentional gender bias during recruitment seen in this study was because most of the male load porters did not give consent to participate in this study. Also, in terms of geographical location and religion, women in the south west are permitted to engage in outdoor activities in order to support the family financially. Netting[13] linked increasing women's involvement to an increasingly high rate of migration of young women to leading urban market centres, with load porterage being the most accessible job for the poorly trained women. However, when load porterage began in Nigeria, it was introduced by male migrants from the northern part and this was because this area was a male domain[13]. However, with an increasing level of male unemployment, changes in the structure of the economy and excruciating poverty in the developing world, women were introduced into employment and many have been forced into the informal sector as they lack the requisite capacities and skills to compete in the formal sector of the competitive economy[13]. The mean body mass index (BMI) of the respondents was 21.81±3.76 kg/m2. The distribution of BMI categories shows that the majority of respondents 80.36% have a normal weight. These metrics suggest that while most respondents maintain a healthy weight

which is necessary to ensure their effective discharge of their load carriage job. A previous study among prevalence and risk factors of work-related musculoskeletal disorders among shopkeepers in Ethiopia by[16] shows similar reports where 70.9% of shopkeepers though that of this present study is higher. Based on the current study, it is suggested that most load carriers have a healthy weight that will enhance their better performance on the job. The high percentage of individuals with normal weight indicates effective management of lifestyle factors, such as diet and physical activity, which may contribute to their overall health and well-being.

The ages of the participants ranged from 14 to 70 years with the mean age as 39.85±12.30 years and with over 70% in middle aged category working as load porters and this was because a vast majority of the people involved in this occupation in that market were older individuals who had to financially fend for their home which to an extent was expected due to poverty and economic downturn. However, it was expected that younger individuals would be seen in this occupation due to the physically tasking nature of the occupation. However, not many young people want low paying jobs and may want to further their education. The marital status of the participants revealed a larger percentage of them to be married. It was reported that the reason for doing this work was due to the unemployment rate in Nigeria and they had to earn a living by doing this work in order to fend for their dependents. Some of them are widowed (11.50%) and so they become the sole breadwinner of the family. Most of the participants in this study were of the Yoruba tribe (98.23%). This being that the area is vastly populated by the Yoruba tribe. Also, most consenting participants were from the Yoruba tribe. However, when the load porterage business began, it was primarily common amongst the Hausas but with time, the Yorubas began gaining more grounds[13]. Most of the participants in this study had only undergone primary education and this may be because of lack of financial means to further their education to higher levels. The reason most of them do this work is due to poverty and this may be the restricting factor to furthering their education beyond the primary level. The participants had working experiences that varied between a year and 15 years. The mean of the years of experience was 43.86±49.88 months (3.66±4.16 years). This present finding differs from that from a previous similar study[17] which reported their average experience was 4.55±1.66 years, ranging from 1 to 6 years. The wide range of experience in this present study could be due to quick personal daily money they earn and easy entrance into occupational load carriers without educational or skills and flexible work arrangements. The participants had working hours ranging from 3-13 hours daily which there is no rigid time frame of working unlike the white collar jobs that require standard 8 hours workdays. This differs from a study on prevalence of musculoskeletal pain among computer users working from home during the COVID-19 pandemic which reported the daily working hour from 6-8 hours[18]. The longer working hours may be linked to their willingness to work as long as the markets are still open and there are shoppers that need their service and the financial incentive they get as a reward as their labour.

The 12-month prevalence of WMSDs among the load porters was 90.27% The high prevalence of reported pain indicates a significant burden of musculoskeletal disorders among load carriers and this was similar to a study[5] on prevalence of WMSDs among Nigerian quarry workers with 12-month prevalence value of 89.8%. The physically demanding nature of load carriers must have contributed to the high prevalence of pain and also the

monotonous nature of load carriers work has been shown to increase repetitive strain and predispose them to a higher risk of WMSDs. The 12-month self-reported distribution of WMSDs across various anatomical body parts was the lower back pain (68.14%) was highest among occupational load porters in Bodija and Akande markets and this was similar with a study carried on prevalence of WMSDs among brick field workers in India[8] and this may be as a result of frequent stooping, heavy lifting and poor lifting techniques. This claim was also similar in a study conducted on prevalence and exposure to ergonomic risk factors among crop farmers in Nigeria[19]. Also, a study conducted on prevalence of WMSDs among butchers by, reported highest prevalence in low back (66.7%)[9]. However, a study carried out in Kano on prevalence of WMSDs among load carriers reported highest prevalence in the upper back (71%)[20]. The self-reported WMSDs symptom being highest at the lower back is in line with what obtained among manual labourers involved in manual handling and carrying activities[11], and were more likely to suffer from lower back pain. The neck was the second most affected body region with a prevalence of 66.37% and this is similar to the findings of a similar study on WMSDs among peasant farmers with prevalence of (66.7%)[21] and this could have occurred due to the fact that when heavy loads are persistently carried on the head, it produces a resultant deformation of the intervertebral discs and drying up of the intervertebral disc fluid thereby causing pain. Also, a study on spinal deformities among load porters conducted showed cervical spondylosis to be common among load carriers and this was believed to be because load porters stiffen their necks while carrying loads in order to bear the weight of the loads[12]. The results of this study showed that the prevalence of WMSDs varied significantly among the body parts of workers. Reports from the developed world showed that WMSDs may account for as high as 60% of occupational health conditions[11]. It can therefore be deduced that the statistics from developing countries may be higher due to poor working conditions, lack of up to date ergonomically suitable equipment, and health and safety-related policies[22]

The overall 7-day prevalence of WMSDs was 46.02% and this similar to what was reported (41.1%) in a previous study among heavy load carriers in Yaounde, Cameroon[16] and this also similar to a study conducted on prevalence and risk factors of WMSDs among low resourced urban dwellers (37.4%)[23] although prevalence from this study is higher than that of the urban dwellers but they are both below average. However, this finding is contradicted by a study on prevalence of WMSDs carried out on sugarcane farmers in northern Thailand which had a prevalence of 88%.

In the past 7-days, lower back pain had the highest prevalence (36.28%) and this could be as a result of repetitive straining of the lower back due to heavy lifting and prolonged standing or walking with the load on their heads. and this is similar to a study conducted on prevalence and risk factors of WMSDs among low resourced urban dwellers (45.6%)[23]. However, this is below what was reported among heavy load carriers[16]; the difference in the reports might be due to peculiarities of the location where the study were carried, the nature of the size of loads the carriers had to carry and the specific body part they used most for such endeavors. This pattern of distribution of WMSDs is a reflection that the most vulnerable part of our body to be affected due to heavy and poor lifting technique is the spine.

Limitations

There are some limitations that should be considered when interpreting the outcomes of this study. Firstly, because the

convenience sampling technique was used to exclusively select the two markets from which the respondents were recruited, this might have resulted in selection bias, hence the participants may not be true representatives of the occupational load carriers in Ibadan. Also, our study only inquired whether the respondents had WMSDs or not did not use measures such as visual analogue pain score to assess the severity of symptoms. Furthermore, some of the respondents might not have given precise answers or might have amplified their WMSDs owing to recall bias and regardless of whether they were caused by work or not.

CONCLUSION

The outcome of this study revealed that there was high prevalence of musculoskeletal disorders among load carriers in Ibadan metropolis with the low back and neck as the most affected body parts during the last 12 months and last 7 days which may be due to not being aware and not implementing proper manual handling of unorganized loads and poor ergonomically working positions adopted. It was therefore, recommended that healthcare providers should embark on awareness campaign to educate and enlighten load carriers on proper lifting technique which will enhance good work hygiene and ergonomic practice among load carriers and also in order to minimize the overload of the load carriers body an assistive equipment can be used to carry out their load carrying job. Policy makers should ensure that protective measures are put in place and ergonomically fitting working equipment are utilized.

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