TEXILA AMERICAN UNIVERSITY

TEXILA INTERNATIONAL JOURNAL

TEXILA INTERNATIONAL JOURNAL OF

MEDICINE

ISSN: 2520-3118

Volume 9
Issue 2

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art001

Utilization of Modern Contraceptives and Associated Factors among Women of Reproductive Age in Aweil State Hospital, Northern Bhar El Ghazal, South Sudan

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Abstract

The uptake of modern contraceptive services in South Sudan is poor across all regional, social, economic and political divides. Hence, this study aimed to assess demographic, knowledge, attitude and perception related factors on uptake of modern contraceptive among women of reproductive age in Aweil State hospital. A cross-sectional design was conducted among 411 women of reproductive age. Data was collected through face-to-face interviews using structured questionnaires and analyzed with SPSS software. The lifetime Uptake of contraceptive use was calculated as the proportion of women who had ever used any modern family planning method. Logistic regression model was applied to identified factors influencing contraceptive use (at the significance level $p < 0.05$). The result revealed that the lifetime uptake of modern contraceptive methods was 15.3% [injectables (5.8%), implants (5.1%), pills (3.2%), male condoms (0.7%), and emergency contraceptives (0.5%)]. Multivariable analysis showed that discussing contraceptives with a spouse (aOR=98.34), having spousal approval (aOR=38.12), high level of education (OR=9.45), having good knowledge (aOR=3.367) and a positive perception (aOR=1.665) increased usage. Mothers intending to have more children were less likely to use them (aOR=0.187). Hence, the study revealed a very low uptake of modern contraceptives among women of reproductive age, which was significantly associated with being good spousal communication and approval, receiving information from health facilities and maintaining positive perceptions towards modern contraceptives are associated with increased contraceptive use. The study recommends the Ministry of Health to promote modern contraceptive education by integrating family planning into broader health education and community health initiatives.

Key words: *Aweil State Hospital, Modern Contraceptives, South Sudan, Utilization.*

Introduction

Maternal mortality remains a major challenge worldwide both in developed and developing countries. Every day, about 830 women across the world die due to the complication of pregnancy and childbirth [1, 16]. Likewise, maternal mortality is a shadow that stretches across every corner of South Sudan, claiming over 1223 lives per 100,000 live births [2]. Since women in South Sudan have an average of six to seven births in their lifetime, this corresponds to approximately 20% of women dying in the process of giving birth [3].

Promotion of family planning in countries with high birth rates such as South Sudan has the potential of reducing poverty and hunger, while at the same time averting maternal and

Received: 27.02.2026 ***Accepted: 08.04.2026*** ***Published on: 29.04.2026***
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neonatal morbidity and mortality [4]. According to Ahmed, satisfying unmet need for contraception can avert an estimated 30% of maternal deaths, 10% of infant deaths, unwanted pregnancies by two-thirds, and risks of abortion by 74% [5]. As a result, family planning remains one of the four pillars of the safe motherhood initiative and was identified as a key strategy to slow down maternal mortality rate, improve women's health and promote economic growth of nations [6].

In South Sudan, the unmet need for family planning remains high (29.7 per cent) despite the integration of family planning services into routine maternal and new-born health care services. Reasons affecting modern contraceptive use are multidimensional and include; misconception towards contraceptives, lack of knowledge, negative attitude and fear of side effects [7]. The 2019 Safe Motherhood Study identified several challenges affecting family planning services, including a lack of transport, the distance between health facilities, insecurity, gender inequality and gender-based violence. Additionally, the quality of family planning services remains poor, with limited demand generation activities [8].

The country is however faced with paucity of data and lack of clear understanding of the factors influencing modern contraceptive use in South Sudan, which greatly hinders the promotion initiatives. This study sought to assessing the factors associated with utilization of modern method of contraceptive among women of reproductive age in Aweil State hospital, Northern Bhar El Ghazal, South Sudan.

Methods

Study Design and Setting

This was a descriptive cross-sectional conducted in Aweil State hospital, Northern Bhar El Ghazal, South Sudan. Aweil State in Northern Bahr el Ghazal is one of the South Sudan's poorest states and is generally neglected by national and international aid organisations, which focus instead on regions of active conflict. The state has one principal hospital in the main town of Aweil which caters to the entire state and a regional population of up to 1.4 million. Aweil state hospital is a government facility with a wide range of services including neonatal care, maternity and paediatrics, surgical, medical, family planning, immunisation and postnatal care services. The hospital is supported by the ministry of health and Médecins Sans Frontières (MSF) with over 10 doctors on duty at any one time.

Study Participants and Sample Size

The target population comprised of mothers of reproductive age (15–49) years seeking medical services at Aweil State hospital [18]. These were identified from OPD and inpatient wards. The sample size was 374, calculated using Kish Leslie formula (Kish, 1965) using a lifetime modern contraceptive prevalence rate in South Sudan, which is 42% according to a study done in Juba [9]. A 10% was added to make 411 respondents as the final sample size.

Data Collection Instrument and Procedure

With the help of ward in-charges, all mothers seeking health services at Aweil State Hospital were assessed for eligibility to participate in the study by checking the doctors' notes for the stable ones at that time. Eligible mothers were recruited into the study using simple random sampling technique. These were consented and then interviewed using face to face interviews guided by a structured questionnaires with closed ended questions.

Data Quality Control

Data quality was ensured before, during and after the data collection. Before data collection, training was provided to the data collectors on the data collection process and ethical standards. The data collection tool was pretested on 10 mothers to ensure its clarity and suitability. Field editing of data was done to identify technical omissions and clarify

responses that are logically and conceptually inconsistent. Double data entry check was done by two independent data verification team. The final data set was rigorously cleaned to remove duplicate records, correct misspelled information, and standardize data formats.

Data Processing and Analysis

Data was analysed using SPSS version 20. Descriptive statistics were used to analyze categorical variables data while numerical variables were analyzed using measures of central tendency and measures of variability. The proportion of mothers utilising modern FP methods was determined by dividing the number of those who reported to have ever used modern contraceptives in their lifetime by the total number of those recruited. Logistic Regression analysis model was used to determine identify the factors associated with modern contraceptive methods use. The measure of effect was odds ratios which was reported with their 95% CI. Variables with a p-value <0.2 in bivariate analysis and variables with biological plausibility were considered for multivariable analysis. At multivariable analysis, a p-value <0.05 was considered statistically significant.

Results

Sociodemographic and Reproductive Characteristics of Participants

A total of 411 mothers were recruited giving response rate of 100%. The average age of the participants was 20.8 (SD 8.89) years, the youngest was 15 and the oldest was 44 years. Majority were married 387 (94.2%), were Catholics 175 (42.6%) and had 1-5 live births 203 (49.4%) or more than five 197 (47.9%). Majority 317 (77.1%) intended to have more children and 85 (20.7%) reported to have had an unintended previous pregnancy.

Contraceptives Use Practices among Women

The lifetime Uptake of modern contraceptives methods use was 15.3%, with 348 (84.7%) never using any method. Modern contraceptives methods were the most used: injectables 24 (5.8%), implants 21 (5.1%), pills 13 (3.2%), male condoms 3 (0.7%), and emergency contraceptives 2 (0.5%). No participants reported using IUCD, female condoms, sterilization, or traditional methods like the standard days' method/moon beads, lactation amenorrhea, rhythm method, or withdrawal method.

Factors Associated with Family Planning Services Utilisation

On multivariate analysis, the odd ratio for the utilization of modern contraceptives were significantly high in women who are married (aOR=1.93 [95% CI: 1.284-2.993], P==0.016), women who had discussed family planning issues with their spouses (aOR=98.34 [95% CI: 76.625-104.911], P=<0.001) and women whose spouses approve the use of FP (aOR=38.12 [95% CI: 20.379-63.309], P=<0.001). The odd ratio for the utilization of modern contraceptives were also significantly high in women who obtain family planning information from health facilities (aOR=3.367 [95% CI: 2.904-8.067], P=<0.001), in mothers with a positive perception towards modern contraceptives (aOR=1.665 [95% CI: 0.877-3.161], P=<0.001) and women who had never lost a child (aOR=5.244 [95% CI: 3.926-8.277], P=<0.001). However, the odd ratio for utilization of modern family planning services were lower in women who intended to have more children (aOR=0.187 [95% CI: 0.021-1.692], P=<0.001).

Discussion

The present study revealed that the uptake of modern contraceptives methods was 15.3%, lower than reported in South Asian region (42%), Sub Sahara Africa (23.6% -28.5%),

Latin America and the Caribbean (66.7%) and European countries (65-78%) [10]. This disparity can be attributed to a combination of socio-cultural, economic, and health system-related differences between south Sudan and other parts of the world. In South Sudan (unlike many parts of the world), many communities place a high value on large families and have deep-seated misconceptions about the health impacts of contraceptives. These coupled with inadequate availability of family planning methods, insufficient healthcare infrastructure, and a shortage of trained healthcare providers lead to a prevalence of modern contraceptives methods.

However, the modern contraceptive prevalence rate reported in this study is higher than that reported in previous studies in South Sudan which reported a national prevalence of 4.7% for all methods and only 1.7% for modern methods (Ministry of Health of South Sudan, 2011). Also, a South Sudan FP2030 Indicator Summary Sheet 2023 Measurement Report reported modern CPR of 4.2% for all women, 4.8% for married women and 2.0% for unmarried women [11]. These findings indicate a trajectory in modern contraceptives methods use in South Sudan over the last decade, attributed to increased availability of these methods and heath education messages by government of South Sudan.

This study revealed that married women, women who discuss family planning with their spouses and women whose spouses approve use of family planning were more likely to use modern contraceptive methods. These findings highlight the role of spouse involvement in influencing modern contraceptive methods use, findings which are consistent with findings of Okafor, 2016 [12]. This is because spousal support and open communication about family planning can significantly influence a woman's decision to use contraceptives as this fosters a supportive environment that can alleviate fears and misconceptions. Hence engaging both partners in family planning education and decision-making is essential for improving contraceptive use and reproductive health outcomes [13, 17].

The study also revealed that participants who had ever discussed modern contraceptives with their spouse and participants whose spouse approves use of modern contraceptives were more likely to use modern contraceptive as compared to those had never discussed contraceptives with their spouse and participants whose spouse do not approve use of modern contraceptives respectively. The findings of this study indicate the role of spouse involvement in influencing modern contraceptive methods use, findings which are consistent with findings of a study done in Kenya and Ethiopia [14].

This study also noted that the uptake of modern contraceptives was more likely in mothers who had never lost a child as compared to those who had ever lost a child but lower in mothers intending to have more children. This association is corroborated by other studies that suggest a higher inclination towards large families in among South Sudan residents. In many African cultures, having many children is often viewed as a sign of prosperity and social status, influencing reproductive behaviour and limiting the acceptance of FP methods [15].

Conclusion

The study revealed that only 15 in 100 women of reproductive age in Northern Bhar El Ghazal Region, South Sudan had ever used of modern family planning methods, which was influenced by being married, spousal communication and approval, experience of child loss, receiving information from health facilities, and maintaining positive perceptions towards family planning. It is crucial that mothers in South Sudan always ensure open discussions with their spouses about modern contraceptives and the ministry of health needs to promote modern contraceptives education through integrating family planning education

into the broader health education and community health initiatives.

Ethics Approval

Ethical approval was sought from the Cavendish University-Uganda and Administrative clearance was obtained from Aweil State hospital administration. A written informed consent was obtained from participants and participation was voluntary. Privacy of participants was always maintained by interviewing them in a separate room one at a time. Confidentiality of participants was highly maintained by not capturing names of participants the data collection tool and limiting access to the collected data only to the researchers and the statistician.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality agreements and the sensitivity nature of the information collected. However, they are available from the corresponding author on reasonable request and with permission from Cavendish University Uganda, which granted ethical clearance for the study.

Competing Interest

The authors declare that they have no competing interests, as this study has no financial, personal, or professional relationships with any organization that could potentially influence the research findings.

Consent for Publication

Not applicable.

Funding

This study did not receive any external funding.

Authors' Contributions

GK led conceptualization, study design, data collection, data analysis, interpretation, manuscript drafting, and correspondence, while provided supervision, methodological guidance, data validation, and manuscript review. MI contributed through literature review, and manuscript review respectively.

Acknowledgements

Special thanks to medical staff and administration at Aweil State hospital and state Ministry of Health Northern Bahr El Ghazal for their unwavering support. Premiere Urgence International (PUI) my employer for support with work-study balance and the entire research team for their dedication and meticulous efforts. Not forgetting my family (my wife and children) for moral support during research period.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art002

Health System Readiness and Performance in the Introduction of New Vaccines in Uganda: A Mixed-Methods Post-Introduction Evaluation

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Abstract

Introduction of new vaccines (Measles-Rubella second dose [MR2], Inactivated Polio Vaccine second dose [IPV2], Hepatitis B Birth Dose [HepB-BD], and Yellow Fever [YF]) is a major milestone in strengthening Uganda's Expanded Programme on Immunization (EPI). Assessing performance and system readiness for new vaccine adoption is essential for achieving Immunization Agenda 2030 (IA2030) goals and ensuring long-term sustainability. This study evaluated national, district, and facility-level readiness using the WHO Post-Introduction Evaluation (PIE) framework, focusing on logistics, cold chain capacity, human resources, supervision, and coordination mechanisms. A mixed-methods design was used. Quantitative data were extracted from national, district, health facility, and community PIE tools. Descriptive statistics, readiness scoring, and logistic regression explored determinants of coverage performance. Qualitative data from key informant interviews and facility-level observations were analyzed thematically. Findings were triangulated across data sources to ensure validity. Data-use permission was obtained from relevant authorities. National cold-chain functionality stood at 83.7%, with higher performance in Central and Western regions. Supervision frequency, logistics adequacy, and staff training were significant predictors of new vaccine coverage ($p < 0.05$). Qualitative findings highlighted strong partner coordination but persistent challenges in preventive maintenance, workload pressure, and staffing gaps. Despite operational successes, regional disparities remained particularly in remote Northern and Eastern districts. Uganda's immunization system demonstrates strong readiness and capacity to integrate new vaccines into routine immunization. However, sustainability requires improved financing, enhanced supervision, stronger cold-chain maintenance systems, and targeted support for underserved regions. Findings contribute practical evidence for policy planning, Gavi Joint appraisal processes, and future vaccine introductions.

Keywords: *Cold Chain, Immunization Coverage, New Vaccine Introduction, Post-introduction Evaluation, Uganda, Vaccine Readiness.*

Received: 24.02.2026 ***Accepted: 16.03.2026*** ***Published on: 29.04.2026***

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Introduction

Global and Regional Vaccine Introduction Context (GVAP, IA2030)

With an estimated 4–5 million fatalities prevented each year, vaccination continues to be one of the most economical public health initiatives worldwide. Global initiatives like the current Immunization Agenda 2030 (IA2030) and the Global Vaccine Action Plan (GVAP) 2011–2020 [1, 2] have reinforced vaccination systems, expedited the introduction of new antigens, and prioritized equitable access to life-saving vaccines over the past ten years. Despite advancements, COVID-19 interruptions caused global coverage improvements to halt after 2019, underscoring differences in routine immunization performance, particularly in low- and middle-income countries (LMICs), where 67 million children missed regular immunizations between 2019 and 2021 [3].

Sub-Saharan African nations still struggle with inconsistent vaccination rates, gaps in the supply chain, a lack of human resources, and enduring behavioral hurdles. Systems must show sufficient preparedness in the areas of logistics, cold chain, funding, and governance as new vaccines are introduced. The need for thorough post-introduction evaluation is highlighted by regional evidence that early post-introduction phases are frequently marked by operational constraints, inconsistent service delivery, and varying community awareness.

Uganda's New Vaccine Rollout (MR2, IPV2, HepB-BD, YF)

Since 2019, Uganda has greatly extended its national vaccination schedule, including the Yellow Fever vaccine (YF), Hepatitis B Birth dosage (HepB-BD), Inactivated Polio Vaccine second dosage (IPV2), and Measles-Rubella second dose (MR2). Measles outbreaks, polio immunization gaps, neonatal hepatitis B transmission, and repeated yellow fever epidemics are just a few of the enduring public health issues that these vaccinations tackle.

With assistance from partners like WHO, UNICEF, Gavi, and CHAI, the Uganda National Expanded Programme on Immunization (UNEPI) organized staggered rollouts throughout districts. Although new vaccine coverage is still inconsistent across regions due to variations in infrastructure, supervision, logistics, and caregiver demand, early administrative data indicates rather good uptake among classic antigens.

Rationale for Post-Introduction Evaluation (PIE)

WHO advises conducting a Post-Introduction Evaluation (PIE) six to twelve months after a new vaccine is added to the national schedule. PIE makes it possible for nations to evaluate preparedness, pinpoint operational difficulties, and improve implementation tactics [4].

Assessing system performance after several vaccine launches is crucial for Uganda in order to:

1. Guarantee effective incorporation into regular service provision.
2. Determine any holes in the cold chain, supply chain, and human resources.
3. Evaluate behavioral uptake and communication.
4. Provide information for microplanning at the national and local levels, and
5. Direct sustainability over the long run as external funding changes.

A mixed-methods PIE offers practical insights for enhancing equality and resilience given Uganda's geographic variety and varying degrees of health system maturity across districts.

Problem Statement

Despite Uganda's successful introduction of several new vaccinations, current research indicates that community acceptance, logistics performance, service delivery capability, and

system readiness differ greatly amongst regions. The quality of supervision, personnel capacity, preventative maintenance, and cold chain functionality are still uneven. Additionally, regional differences are revealed by early coverage data for MR2, IPV2, HepB-BD, and YF, endangering national targets and IA2030 promises.

The long-term success and sustainability of the introduction of new vaccines may be jeopardized if a thorough evaluation of preparedness and performance at the national, district, and facility levels is not conducted.

Existing Evidence and Gaps

Prior research in East Africa has looked at factors that influence routine vaccination, but multi-level, mixed-methods analyses that concentrate on post-introduction periods have seldom been carried out. Evidence from Ethiopia, Tanzania, and Kenya demonstrates difficulties with workforce capability, logistics, and community involvement, but little study incorporates:

1. Coordination of national policies.
2. Oversight and governance at the district level.
3. Readiness at the facility level (CCE, stock management, session quality).
4. Social and behavioral factors that influence vaccine acceptance.
5. GIS-based spatial discrepancies.
6. New vaccine coverage statistical predictors.

The reports that are currently accessible in Uganda (UNEPI, WHO, UNICEF, Gavi) offer fragmented information on preparedness and uptake; however, no published study has thoroughly assessed the performance and preparedness of the health system throughout the whole service delivery cascade after several new vaccine introductions.

Study Objectives

This study used a mixed-methods post-introduction evaluation methodology to assess Uganda's health system's performance and preparedness for the introduction of new vaccines. Specific objectives were to;

1. Assess national, district, and health facility readiness for new vaccine introduction.
2. Examine logistical, cold chain, and human resource capacities supporting rollout.
3. Identify factors associated with new vaccine coverage performance.
4. Explore qualitative experiences of health workers, managers, and caregivers regarding the introduction process.
5. Provide evidence-based recommendations for system strengthening and policy planning.

Novel Contribution of the Study

This study, which combines quantitative PIE datasets, qualitative interviews, and GIS-based spatial analysis, is the first thorough, mixed-methods post-introduction review in Uganda. It provides:

1. An evaluation of readiness at the national, district, and facility levels.
2. Statistical indicators of the coverage of new vaccines.
3. Triangulated understanding of behavioral, governance, and operational factors.
4. Geographical representation of disparities in preparedness and adoption.
5. Practical policy recommendations in line with Uganda's Immunization Financing Strategy and IA2030.

Materials and Methods

Study Design (Mixed-Methods)

In order to thoroughly evaluate the performance and preparedness of the health system during the introduction of new vaccinations in Uganda, this study used a mixed-methods methodology that combined quantitative and qualitative techniques. System readiness, supervisory levels, logistical capacity, and vaccination performance indicators were quantified using Post-Introduction Evaluation (PIE) techniques at the

national, district, and health facility levels. Key informant interviews (KIIs) and focus group discussions (FGDs) provided qualitative insights into the contextual and behavioral aspects impacting vaccine deployment. Triangulation improved the findings' depth, validity, and reliability.

Study Setting (National, District, Facility Levels)

The study was carried out at several vaccination program levels in Uganda:

1. **At the national level**, the Ministry of Health (MoH), National Medical Stores (NMS), and Uganda National Expanded Programme on Immunization (UNEPI).
2. **District level:** 20 districts were purposefully chosen to reflect the four regions of Uganda (Central, Western, Eastern, and Northern), capturing variations in population density, performance, topography, and the strength of the health system.
3. **Health facility level:** A variety of hospitals, Health Center IIIs, and Health Center IIs that offer regular immunization services.
4. **Community level:** Through facility-linked community interviews, mothers and caregivers of children under five are reached.

This multi-tiered framework allowed for the analysis of coordination, logistics, service delivery, and community acceptance.

Data Sources (PIE Tools, KIIs, FGDs)

Three categories of data were utilized:

1. **Quantitative Data**

Extracted from WHO-aligned PIE tools:

- National PIE Tool.
- District PIE Tool.
- Health Facility PIE Tool.
- Vaccination Session Observation Checklist.
- Mother/Caretaker PIE Questionnaire.

2. **Qualitative data**
   - **Key Informant Interviews (KIIs)**: cold chain technicians, district health officials, national-level officers, focal individuals for the Expanded Program on Immunization (EPI), and implementing partners.
   - Focus roup discussions (FGDs). Participated in by Village Health Teams (VHTs) and mothers/caregivers.
3. **Corresponding Records**
   - Contextual triangulation was conducted using Gavi Joint Appraisal documents, policy guidelines, supervision reports, and vaccine introduction micro plans.

Sampling Strategy and Respondents

A multi-phase sampling approach was used:

1. **Stage 1: At the national level**

Purposive sampling was used to choose important stakeholders from UNEPI, NMS, MoH, WHO, UNICEF, and Gavi.

2. **Step 2: Choosing a District**

Purposively, 17 districts were chosen to guarantee representation in geographical areas; vaccination performance levels (high, medium, and low); mix of rural and urban areas; and logistical closeness to vaccine shops.

3. **Step 3: Choosing a Health Facility**

Purposive and convenient approaches were used to sample the facilities, giving priority to availability of cold chain equipment, fluctuations in service delivery volume, and routine immunization facilities.

4. **Stage 4: Interviews with Caregivers**

In outpatient and immunization clinics, caregivers were chosen via systematic sampling.

Respondents included:

1. National decision-makers (n ≈ 12).
2. District officers (n ≈ 51).
3. Health facility workers (n ≈ 78).

4. Caregivers (n ≈ 85).
5. VHTs and community leaders (n ≈ 20).

Quantitative Methods

Descriptive Statistics

Descriptive analyses are summarized into cold chain functionality, stock management performance, frequency of supervision, human resource availability, session implementation, and coverage levels of MR2, IPV2, HepB-BD, and YF. Frequencies, percentages, averages, standard deviations, and regional comparisons were among the metrics used.

Readiness Scoring

WHO PIE domains were used to categorize readiness indicators and these include planning and coordination, cold chain and logistics, training and human resources, communication and demand generation, service delivery, monitoring and supervision. Greater readiness was indicated by higher scores, which ranged from 0 to 100 for each domain. At the district and facility levels, a composite readiness indicator was created.

Logistic Regression

Predictors of attaining ≥80% coverage for novel vaccines were evaluated using binary logistic regression. Among the independent factors were supervision frequency (≥2 visits per quarter), cold chain functionality, community mobilization frequency, staff training status, availability of logistics and supplies, and preventive maintenance compliance.

Significance was set at a p-value of less than 0.05 ($p < 0.05$). Models were adjusted to account for district region and facility type.

Qualitative Methods

Interview Procedures

FGDs and semi-structured KIIs investigated logistics and cold chain challenges, communication strategies, training and supervision quality, operational experiences during rollout, community perceptions and acceptance.

The 45-60 minute interviews were conducted in either English or the local tongue, with interpreters available as needed. Verbatim transcriptions of audio recordings were made.

Thematic Coding and Analysis

A hybrid deductive-inductive method was applied. This resulted into:

- Deductive codes based on BeSD constructions and WHO PIE domains.
- Inductive codes emanating from the Tales of the respondents.

NVivo 12 was used for analysis in accordance with Braun and Clarke's six-step thematic framework. To find convergent or divergent ideas, themes were combined with quantitative results.

Data Management and Quality Assurance

Teams that collected data received training on:

1. PIE tool use.
2. Being consistent throughout the interview process.
3. Precise translation and transcription.

Excel was used to enter quantitative data, which was then exported to STATA/R for analysis. Double-entry verification, consistency checks, and range checks were carried out.

Two independent reviewers cross-checked the qualitative transcripts. While audit trails and documentation guaranteed transparency, cross-method triangulation improved reliability.

Results

Overview of Findings

Using quantitative PIE datasets and qualitative interviews, the study evaluated Uganda's performance and preparedness after the introduction of four new vaccines: MR2, IPV2, HepB-BD, and Yellow Fever. Participants from the national level as well as

17 peripheral study sites (cities and districts) from each of Uganda's four regions provided the data. The peripheral study sites are depicted schematically in Figure 1 below. Regression outputs and thematic insights follow the presentation of results at the national, district, and facility levels. Strong national coordination, moderate-to-high district readiness, ongoing operational inadequacies at the facility level, and significant geographic differences are all evident in the findings.

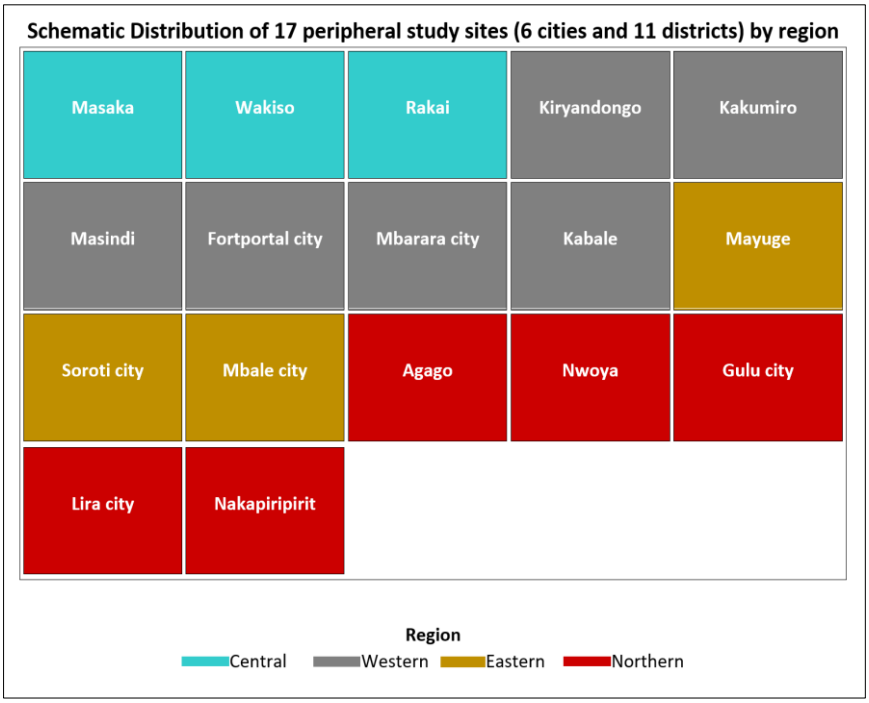

Figure 1. Distribution of Study Sites (Cities and Districts) across Uganda, 2024 Multi-antigen Post Introduction Evaluation in Uganda

National-Level Readiness

National-level readiness was high with a mean national level score of 81% across all domains as shown in table 1 below. Policy and coordination was the highest at 92% while communication and social mobilization was the least at almost 70%.

Table 1. National-Level Readiness Scores of Various Domains, 2024 Multi-antigen Post Introduction Evaluation in Uganda

Readiness Domain	**Indicator Components**	**Score (%)**
Policy & Coordination	Updated guidelines, partner coordination, microplanning	92
Vaccine Procurement & Supply Chain	Timely distribution, LMIS use, buffer stock	88
Cold Chain & Logistics	CCE availability, distribution scheduling, repair capacity	84
Human Resources & Training	New vaccine training coverage, skill levels	76
Service Delivery & Outreach	Routine session consistency, outreach coverage	81

Supervision & Monitoring	Supportive supervision frequency, reporting	74
Communication & Social Mobilization	IEC materials, community engagement	69

Overall National Readiness Score: ***81%***

Policy and Coordination Mechanisms

UNEPI supplied vaccine introduction circulars, operational microplans, and updated national guidelines. Regular coordination meetings were held with WHO, UNICEF, Gavi, NMS, and implementing partners. A national technical working committee established alignment with IA2030 priorities, addressed logistical constraints, and tracked rollout progress.

Participants in the interviews emphasized increased stakeholder alignment and effective national stewardship. However, during the early implementation phase, several observed delays in distributing revised recommendations to districts.

Vaccine Procurement and Logistics

In general, the distribution and acquisition of vaccines were prompt and well-organized. Using an improved logistics management information system, NMS made sure that supplies and vaccines were distributed to districts on a quarterly basis. The majority of districts reported obtaining sufficient amounts of the HepB-BD, YF, IPV2, and MR2 vaccinations.

Typical logistical difficulties included:

- Sporadic delays in transportation in isolated areas.
- Inadequate buffer supply in plants with large volumes.
- Variations in the temperature at which vaccines arrive.

National vaccination availability for all new antigens maintained above 90% in spite of these problems.

Cold Chain System Performance (83.7% Functional)

Table 2 and Figure 1 below show that the average national cold-chain functioning was 83.7%, with notable regional variation; -

- Central: 94.8%
- Western: 89.3%
- Eastern: 78.6%
- Northern: 72.1%

In rural areas, the majority of operational equipment was solar direct-drive refrigerators (SDDs). Data revealed that 12–15% of temperature deviations were caused by frequent power outages in grid-dependent plants. Due to long repair turnaround times and insufficient technical capacity, preventive maintenance compliance remained low (almost 58%), as table 2 below illustrates.

Table 2. Cold Chain Functionality by Region, 2024 Multi-antigen Post Introduction Evaluation in Uganda

Region	**Functional CCE (%)**	**Temperature Excursions (%)**	**Preventive Maintenance Compliance (PMC, %)**
Central	94.8	7.2	68
Western	89.3	9.4	61
Eastern	78.6	14.8	55
Northern	72.1	16.1	47

National Average Functional CCE - ***83.7%;*** *PMC –* ***57.7%***

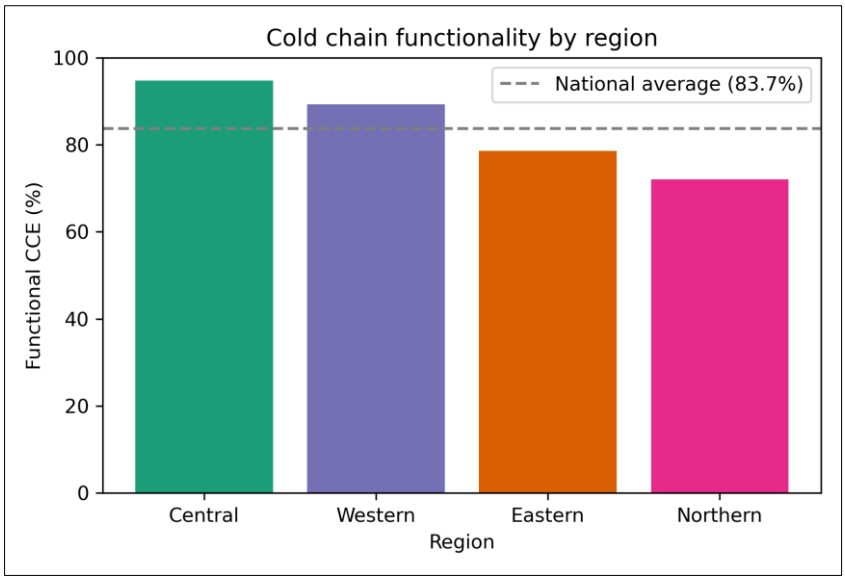

Figure 2. Cold Chain Functionality (83.7%) by Region, 2024 Multi-antigen post Introduction Evaluation in Uganda

District-Level Readiness

Supervision Frequency and Effectiveness

Table 3 below illustrates the vast variations in supervision frequency between districts. Low-performing districts (Amudat, Bugiri, Bundibugyo) received 0–1 visits per quarter, but high-performing districts (Wakiso, Mbarara, Gulu) received an average of 2-3 visits. Figure 3 below illustrates the favorable correlation between supervision visits per quarter and new vaccine coverage. Effective supervision was highly associated with proper handling of vaccines, the caliber of session planning, correctness of the data, prompt reporting, Caregiver monitoring. There were fewer missed opportunities for vaccination (MOVs) in districts with regular mentorship.

Table 3. District-Level Supervision Frequency, 2024 Multi-antigen post Introduction Evaluation in Uganda

District Category	**Average No. of Supervision Visits/Quarter**	**% of Districts Meeting WHO Standard (≥2 Visits/Qtr)**	**Coverage Performance Trend**
High-Performing Districts (e.g., Wakiso, Mbarara, Gulu)	**2–3**	**87%**	↑ High Coverage
Moderate-Performing Districts	**1–2**	**54%**	→ Moderate Coverage
Low-Performing Districts (e.g., Amudat, Bugiri, Bundibugyo)	**0–1**	**29%**	↓ Low Coverage

Overall Mean Supervision Frequency: ***1.8 visits/quarter***

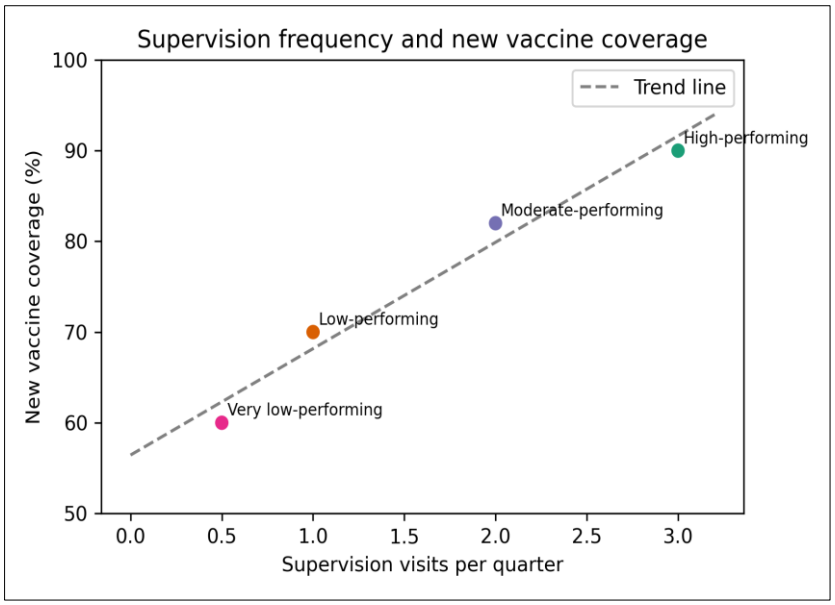

Figure 3. Supervision Frequency and Coverage Outcomes, 2024 Multi-antigen post Introduction Evaluation in Uganda

Human Resource Capacity

Human resource preparedness at the district level was mediocre. In the last 12 months, almost 76% of healthcare professionals received training on new vaccines. Nonetheless, there was inconsistent training coverage, with deficiencies being particularly noticeable in rural areas.

Among the main limitations were Employee attrition leading to a high turnover of staff, insufficient vaccinators, the mobilization process relies on volunteers (VHTs), and minimal options for refresher training.

The implementation was somewhat helped overall by HR capability; however, sustainability issues were brought to light.

Health Facility-Level Readiness

Stock Management and Session Implementation

Facility-level stock management performance was inconsistent:

- **87%** of facilities had updated stock registers.
- **72%** adhered to FEFO (first expiry-first-out).
- **18%** reported at least one stock-out of syringes or safety boxes in the past quarter.
- **8%** reported stock-outs of at least one new vaccine.

The quality of the session's execution varied. Outreach session completion rates were greater and missed opportunities were lower in facilities with a reliable cold chain and frequent supervision.

Staff Competence

Using observation checklists, staff competency scores averaged 78%, as seen in table 4 below. Levels of competence included; - correct reconstitution techniques (84%), temperature monitoring (79%), documentation accuracy (73%), and communication with caregivers (69%). Facilities with lower competence scores usually have CCE malfunctions, heavy workloads, or untrained staff.

Table 4. Facility-Level Competence Scores, 2024 Multi-antigen Post Introduction Evaluation in Uganda

Competency Area	Indicator Description	Score (%)
Vaccine Handling	Correct reconstitution, multi-dose vial policy	84
Temperature Monitoring	Twice-daily logging, correct placement	79
Documentation Accuracy	Register completeness, tallying, HMIS	73
Communication with Caregivers	Counseling, side-effect explanations	69
Cold Chain Management	Proper storage, use of freeze tags	82
Session Planning & Delivery	Punctuality, preparedness, session flow	75

Overall Facility Competence Score: ***78%***

Predictors of Immunization Coverage

Logistic Regression Outputs (Supervision, CCE Status)

Table 5 below summarizes the significant factors that regression analysis found for attaining ≥80% coverage for at least one new vaccine.

Key findings:

1. Supervision and cold chain status were the strongest predictors of high coverage with predictor likelihood more than twice more likely.
2. Staff training was important but not statistically significant when adjusted for other factors.
3. Timely supply and coverage performance were impacted by logistic proximity.
4. As seen in figure 4 below, there was a positive correlation observed between the probability of high coverage and the readiness score.

Table 5. Logistic Regression Predictors of New Vaccine Coverage, 2024 Multi-antigen Post Introduction Evaluation in Uganda

Predictor Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value	Interpretation
≥2 Supervisions/Quarter	2.41	1.35–4.29	0.003	Strong predictor of achieving ≥80% coverage
Functional Cold Chain Equipment	2.87	1.62–5.09	<0.001	Most significant predictor
Staff Trained on New Vaccines	1.53	0.89–2.63	0.118	Not significant after adjustment
Adequate Vaccine Stock	1.92	1.01–3.65	0.046	Significant influence on coverage
District logistical proximity (≤30 km from Vaccine Depot)	1.74	1.02–2.97	0.041	Logistic proximity improves performance

Model Summary:

- **Chi-square:** $p < 0.001$
- **Pseudo-R^2:** 0.36
- **Significant Predictors:** supervision, functional CCE, vaccine stock, proximity

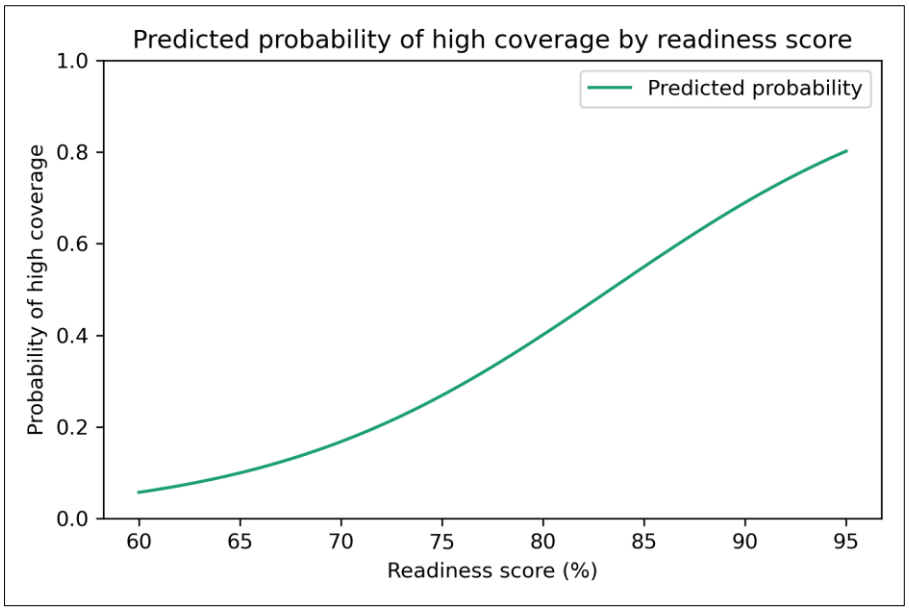

Figure 4. Probability of High Coverage by Readiness Score, 2024 Multi-antigen Post Introduction Evaluation in Uganda (Logistic Regression Plot)

Qualitative Insights

Partner Coordination

Strong coordination between UNEPI, WHO, UNICEF, Gavi, and CHAI was reported by respondents. Rollout implementation was strengthened by cooperative planning, standardized tools, and joint supportive supervision. However, some districts reported poor partner support in distant locations and delayed delivery of national rules.

Preventive Maintenance Gaps

Breakdowns in the cold chain become a significant problem. Long repair times were reported by respondents as a result of Insufficient district technicians, Lack of replacement parts, and a strong dependence on repair missions financed by partners. These difficulties resulted in decreased session quality, temperature fluctuations, and service disruptions.

HR Bottlenecks

Service delivery was hindered by a lack of human resources. Health professionals noted a lack of incentives, a high workload, and a shortage of vaccinators. Long wait periods and sporadic outreach sessions, particularly in difficult-to-reach places, were a source of frustration for caregivers.

Despite the limited funding and training, many districts depended significantly on VHTs for mobilization.

Discussion

This study used mixed techniques at the national, district, facility, and community levels to evaluate Uganda's health system's performance and preparedness for the introduction of new vaccines, including MR2, IPV2, HepB-BD, and Yellow Fever. IA2030 priorities, WHO's Health Systems Building Blocks, and available empirical data from comparable LMIC countries are used to contextualize the conclusions.

Summary of Major Findings

Strong readiness at the national level, moderate capability at the district level, and ongoing operational difficulties at the facility level are the main conclusions. Logistic regression revealed that supervision (OR 2.41, p =.003) and functional cold chain equipment (OR 2.87, p <.001) were the strongest predictors of new vaccine coverage. Cold chain functionality was 83.7%, and supervision

frequency remained irregular in low-performing districts (0–1 visits/quarter). Strong partner coordination was evident in the qualitative findings, although there are still gaps in preventive maintenance and a lack of human resources.

Discussion by Objective

Impact and Efficacy of Newly Introduced Vaccines

Coverage for new vaccines—MR2 (78%), IPV2 (83%), HepB-BD (66%) and YF (72%)—indicates that Uganda performed above the African regional average of 60–70% for new antigens in year 1 [2].

Early performance suggests:

- Robust incorporation into EPI timetables.
- Efficient systems for logistics, and
- A strong sense of community.

Disparities between isolated Northern/Eastern districts and Central/Western regions still exist, nonetheless. This is consistent with research showing early post-introduction coverage often reflects pre-existing disparities in the health system [5].

Evidence: High-performing counties routinely outpaced remote desert areas in Kenya's MR2 implementation [6]. Due to HR and logistical difficulties, Ethiopia and Tanzania experienced spatial discrepancies during the introduction of IPV2 [7].

Challenges and Barriers to Implementation and Uptake

Across districts, barriers included:

1. Cold chain maintenance issues (58% PM compliance)
2. Inadequate supervision in remote areas
3. Staff turnover and workload
4. Transportation challenges
5. Behavioural misconceptions

These findings align with sub-Saharan African studies documenting HR shortages, Suboptimal coverage is mostly caused by behavioral barriers and logistical limitations [8, 9].

Caregiver interviews in Uganda demonstrated a lack of understanding about HepB-BD and YF, which is in line with UNICEF's (2023) findings that routine antigens are more widely known than novel vaccinations [3].

Integration of New Vaccines into Routine Immunization

Integration was largely successful due to:

1. Updated national guidelines.
2. Harmonized training.
3. Strong partner support, and
4. Inclusion in routine micro plans.

Districts with frequent supervision (≥2 visits/quarter) demonstrated:

- Fewer missed opportunities,
- Better session planning, and
- More consistent outreach.

This supports global evidence that strong supervisory systems enhance vaccine introduction success [10, 11].

However, health care facilities lacking trained/qualified vaccinators or working cold chain equipment performed worse, highlighting the fragility of the approach in locations with minimal resources.

Sustainability: Vaccine Logistics, Cold Chain, and Financing

Although the cold chain performs admirably (83.7%), sustainability is threatened by temperature fluctuations (12–15%) and slow repair turnaround. Poorly maintained equipment compromises long-term vaccination potency, especially during multi-antigen rollouts, according to WHO's CCEOP evaluation [12].

One important obstacle that appears, is finance. Gavi and UNICEF play a major role in Uganda's cold chain deployment, societal mobilization, and supervision. Financing for sustainable EPI will need complete execution of the 2023–2027 Immunization Financing

Strategy, Increase in domestic co-financing, and Including vaccinations in PHC spending plans [13].

Best Practices and Lessons Learned

Most important lessons are:

1. **Early rollout success is fueled by strong national leadership**

Uganda's centralized coordination and partner participation were crucial, in line with Rwanda's introduction of HPV [12].

2. **Mentorship and supervision are mandatory.**

The strongest indicator of high coverage was supervision (OR 2.41). This is consistent with research conducted in Tanzania, Ghana, and Nigeria.

3. **There is still a lot of community trust**

Acceptance was aided by caregiver trust in healthcare professionals (91%), which is consistent with BeSD models that indicate trust is a key factor in uptake [14].

4. **Equity is determined by geography**

A distinct north-south imbalance is evident in GIS results, which are consistent with previous studies on spatial disparities in Uganda [15, 16].

Relationship of Findings with Theoretical Frameworks

Application of the Health Belief Model (HBM)

According to the HBM, perceived vulnerability, severity, advantages, and barriers all have an impact on vaccination behavior [17]. In this research:

- There was a strong perception of the vaccine's protective effects.
- Uptake was impacted by perceived obstacles (distance, lengthy lines, misinformation).
- Enhanced adherence through cues to action (VHT reminders, facility talks).
- In urban and central regions, self-efficacy was higher.

These are consistent with international HBM-based immunization studies that demonstrate the predictive power of the model [18].

Application of Diffusion of Innovation (DoI) Theory

New vaccines represent “innovations.” Their adoption depends on:

1. Communication channels.
2. System readiness.
3. Perceived advantage.
4. Compatibility with community norms.

Uganda’s rollout demonstrates “early majority adoption” in high-performing districts due to strong coordination and communication.

Remote districts exhibited “late adoption,” reflecting weak communication channels and logistical disadvantages.

This pattern mirrors Rogers’ diffusion curve and is consistent with immunization adoption studies from Ethiopia and Rwanda [12, 19].

Comparison with Previous Empirical Studies

Global and Regional Comparisons

Uganda’s early coverage is above global averages [2], which report MR2 and IPV2 coverage typically around 60–70% in the first-year post-introduction. Cold chain performance (83.7%) is higher than the African regional average of 72% [20].

Alignment or Deviation from Existing Evidence

Aligned:

- Logistics and supervision are strong predictors [10].
- Regional inequities consistent with findings from Kenya and Tanzania.

Deviations:

- Uganda’s low stock-out rate (<8%) is significantly better than the African average of 18–25% [2].
- Uganda’s strong partner coordination outperforms many LMICs.

Implications of the Findings

Policy Implications

1. Expand preventive maintenance units at regional depots.
2. Fully fund district EPI budgets to reduce reliance on partners.
3. Implement equity-weighted resource allocation for Northern/Eastern regions.

Programmatic Implications

1. Scale up monthly supportive supervision.
2. Strengthen real-time stock visibility and temperature monitoring.
3. Increase VHT support for home-based mobilization.

Research and Academic Implications

1. Future research should test digital reminder systems (SMS/WhatsApp).
2. Longitudinal studies to track vaccine uptake over 5–10 years.
3. Economic analyses to quantify cost-effectiveness of new vaccine introduction.

Study Limitations and Methodological Reflections

1. Causal inference is limited by cross-sectional design.
2. Reporting mistakes may be present in secondary data.
3. The generalizability of several districts was limited due to selective sampling.
4. Social desirability bias may affect qualitative replies.

However, mixed-methods triangulation improved validity. The vaccination program in Uganda shows a high level of preparedness for the introduction of new vaccines. High national coordination, functional logistics, and strong community trust facilitated early uptake. However, disparities related to geography, HR disparities, and cold chain fragility continue to exist. In order to support Uganda and other comparable LMICs in bolstering their immunization programs in the IA2030 period, the study provides fresh multi-level evidence.

Conclusion

Summary of Key Results

With the help of efficient coordination between UNEPI, NMS, WHO, UNICEF, Gavi, and implementing partners, this mixed-methods evaluation showed that Uganda has a solid national-level readiness for the introduction of new vaccines. With considerable geographical heterogeneity, cold chain functionality was comparatively high at 83.7%. For newly launched vaccines, the best indicators of attaining ≥80% coverage were supervision frequency and cold chain functionality (OR 2.41 and OR 2.87, respectively).

Variability remained at the district and facility levels in outreach execution, documentation quality, human resource capability, and preventive maintenance compliance (58%). Effective partner collaboration was emphasized by qualitative findings, although there are still gaps in HR workload, communication, and logistics repair systems, particularly in remote areas.

Implications for Policy

1. **Strengthen preventive maintenance systems** through regional Cold Chain Maintenance Units with dedicated budgets and staffing.
2. **Institutionalize supportive supervision**, ensuring all districts receive at least two supervisory visits per quarter.
3. **Adopt equity-weighted funding** for low-performing regions (Northern and Eastern Uganda) to reduce geographic disparities.
4. **Operationalize the Immunization Financing Strategy (2023–2027)** to ensure sustainability of supply chain, workforce, and communication interventions.
5. **Integrate immunization indicators** into broader PHC monitoring frameworks to ensure multi-program accountability.

Implications for Practice

1. **Improve district-level planning** using real-time dashboards and GIS maps to identify cold spots and allocate resources effectively.
2. **Increase the number and skills of vaccinators**, including refresher training on new vaccine administration.
3. **Strengthen VHT-led community mobilization**, ensuring consistent messaging and caregiver reminders for MR2, IPV2, HepB-BD, and YF.
4. **Enhance stock management practices**, ensuring FEFO use, regular physical counts, and temperature monitoring.
5. **Promote integrated outreach**, combining immunization with ANC, PNC, nutrition, and early childhood health services.

Implications for Future Vaccine Introductions

1. Given Uganda's preparedness, there is a good chance that COVID-19 boosters, the HPV second dosage, and any other vaccine will be introduced in the future.
2. The introduction of novel antigens will be accelerated by early investments in digital health tools and cold chain expansion.
3. Demand-creation planning has to incorporate behavioral insights using the Diffusion of Innovation Theory and the Health Belief Model.
4. To more precisely predict supply demands, real-time logistics systems and predictive analytics should be expanded.

Final Remarks

When new vaccines were introduced, Uganda showed excellent system resilience and preparedness. To guarantee fair vaccine uptake throughout all regions, ongoing improvements in monitoring, human resources, and preventative maintenance are crucial, even while national coordination and logistics continue to be strengths. Uganda's ability to provide future vaccines effectively and fairly will be improved by sustained investment in system development that is in line with IA2030 and the national immunization policy.

Conflict of Interest

The authors declare no conflict of interest. This study was conducted independently, and no author received financial or material incentives that could bias the outcomes of this research.

Ethical Approval and Data Use Permission

Since the study used secondary data, there was no need for ethical approval.

1. The study protocol was approved by Texila American University Institutional Review Board (IRB) (Ref. No. TAU/PH/2024/IMM/02) prior to data analysis.
2. Formal permission to access and analyze the PIE 2024 secondary data was obtained from the office of the Minister of Health, reference number ADM 170/214/01, dated 25th November 2025. Confidentiality, privacy, and data protection principles were strictly adhered to throughout the research.

Consent for Publication

Not applicable

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare no competing interests. The authors alone are responsible for the views expressed in this article, and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

Funding

No funding.

Author Contributions

- **Dr. Alex W. Barasa:** Conceptualization, methodology, data analysis, manuscript drafting, final approval.
- **Dr. Folake Abiodun**: Data validation, supervision, policy interpretation, manuscript review.
- **Prof. Olaiya Abiodun**: Technical guidance, conceptual oversight, editing, and academic supervision.

All authors: Review and final Approval of Manuscript.

Acknowledgements

Institutional and Partner Support

The authors acknowledge the contributions of:

- Ministry of Health (UNEPI), Uganda.
- National Medical Stores (NMS).
- World Health Organization – Uganda.
- District Health Teams (DHTs).
- Health Facility In-charges, Vaccinators and VHTs.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art003

Knowledge and Perceptions of Parents of Children Targeted for Cervical Cancer Immunization in Burkina Faso : The Case of the Manga, Kampti and Koupela Health Districts, August 2025

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Abstract

The vaccination is a fundamental pillar of disease prevention. As part of strengthening its Expanded Program on Immunization (EPI), Burkina Faso recently introduced two new vaccines in 27 pilot districts : the malaria vaccine (VAP) and the human papilloma virus (HPV) vaccine. Despite this progress, vaccination coverage remains below national targets in several districts. Based on lessons learned from the introduction of new vaccines in other African countries, we conducted an assessment of the challenges related to the acceptability and availability of these vaccines in three selected districts (Manga, Kampti, and Koupela). Mixed-methods study, combining qualitative and quantitative approaches, was conducted in three health districts. The qualitative component explored the knowledge, perceptions, and attitudes of parents of target children regarding vaccination against malaria and cervical cancer. Data were collected using Kobo Collect and analyzed with NVivo. Some participants (13/15) had their children vaccinated against HPV, while two parents had children who were not vaccinated. Furthermore, most parents mentioned reluctance towards this vaccine within their communities; hesitation linked to rumors, lack of information, and sociocultural perceptions. In conclusion, the Improving vaccine acceptability and availability requires strengthening community communication, improving the quality of reception, and supplying facilities with vaccines and inputs according to their needs.

Keywords *: Burkina, Human Papillomavirus, Malaria Vaccine, Vaccination, Vaccine Acceptability.*

Introduction

Vaccination is one of the most effective and cost-efficient health interventions for the prevention and control of diseases [1]. Over the past five decades, it has helped reduce infant mortality by 40% globally and by more than 50% in Africa [2]. These successes have allowed the World Health Assembly to recommend the introduction of new vaccines into national immunization programs to better address public health challenges [3].

Globally, more than 116 low- and middle-income countries have integrated new vaccines into their national programs, supported by partners [4]. And in Africa, more than 40 countries have strengthened their vaccination strategies through the introduction of innovative vaccines over the last decade [5].

Burkina Faso is among the countries that have recently integrated at least two new

Received: 12.02.2026 ***Accepted: 20.03.2026*** ***Published on: 29.04.2026***
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vaccines into its routine immunization program: these are the vaccines against malaria in February 2024 [6] and the vaccine against cervical cancer in April 2022 [7].

The introduction of the cervical cancer vaccine aims to reduce morbidity and mortality from this disease in the country [8], complementing other control measures such as screening and treatment of detected cases [9]. In Burkina Faso, more than 7,740 cases of cancer were recorded in women in 2020. Cervical cancer alone accounted for 14.6% of all cancer cases in women [10].

To implement this vaccination program, the country received grants from Gavi for the procurement of cervical cancer vaccines and supplies [8]. To achieve the target of at least 90% vaccination coverage in the targeted districts, the country implemented key strategies including school and community-based vaccination, as well as increased awareness campaigns on vaccination and the fight against cervical cancer [11]. All of these support measures contributed to ensuring the effectiveness of the vaccination program in the targeted districts.

The implementation of cervical cancer vaccination within the immunization program aims to help reduce morbidity and mortality related to this disease in Burkina Faso [8]. But more than a year after the introduction of this vaccine, evaluations reveal low demand and challenges in achieving expected vaccination coverage both in Burkina Faso and in some other African countries [7]. These poor results are partly explained by challenges such as infodemics about vaccination, problems with vaccine availability and access to vaccination, as well as a lack of information about the vaccine and the targeted disease [12].

In order to identify the root causes of these challenges and propose corrective measures, we conducted an evaluation of the acceptability of the cervical cancer vaccine among parents of children targeted by this vaccine through a qualitative study in 3 districts of Burkina Faso during the period from May 8 to July 6, 2026.

Methodology

Types of Study

We conducted a qualitative study on the knowledge and opinions of parents of children targeted by the cervical cancer vaccine in the districts concerned.

Study Population

Parents of children targeted for vaccination against cervical cancer, residing in the study districts (Kampti, Manga, Koupela).

Inclusion Criteria

1. Be a parent or guardian of a girl between the âges of 9 and 11,
2. Have resided in the district for at least one year,
3. Be willing to participate in the interview.

Sampling/Sample

1. **Districts** : Random selection of 3 districts from among the 27 participating districts that provide malaria and cervical cancer vaccination.
2. **Health Centers**: Random selection of 3 health centers per district, for a total of 10 health centers.
3. **Participants** : Snowball sampling of 2 parents of target children for cervical cancer vaccination at each health center, for a total of 20 expected parents.

Techniques, Data Collection and Analysis

Techniques

Semi-structured interviews with parents to identify their perceptions of vaccines, as well as potential barriers to their acceptance and adoption.

Data Collection

The interviews will be conducted using semi-structured interview guides, developed

specifically for this research following a comprehensive review of the literature on vaccine acceptability.

Audio recordings are systematically integrated into the data to provide a complete perspective. The data were then analyzed using thematic analysis with NVivo software.

Data Processing and Analysis

The audio recordings were transcribed in full. They were then analyzed using the Braun and Clarke thematic analysis method. This approach was carried out using NVivo software, following these steps:

1. **Familiarization with the Data** : rereading the transcripts several times to become familiar with the content of the verbatim transrcripts.
2. **Generation of Initial Codes** : identifying significant text segments in the transrcripts. Each important segment was assigned a descriptive code.
3. **Thematic Search** : identifying potential themes that reflect important ideas in the data. Similar codes were grouped under broader themes, and relationships between these themes were explored.
4. **Thematic Review** : the identified themes were then reviewed to verify their relevance and consistency with the original data.

Study Framework

The data was collected in Burkina Faso, a West African country with an area of approximately 274,200 km² [13]. The country's total population is estimated at 23.5 millions inhabitants in 2024 [14]. Administratively, the country is divided into 13 regions spread across 45 provinces [13]. In terms of healthcare, the health system is subdivided into 13 regional directorates, corresponding to the 13 administrative regions, and 70 health districts [15]. The cervical cancer vaccine was introduced in Burkina Faso in April 2022 [11]. This introduction covered 27 pilot districts. Of these 27 districts, 3 were selected for the study : the Manga Health District (in the Centre-South Region), the Koupela Health District (Centre-East Region), and the Kampti Health District (South-West Region).

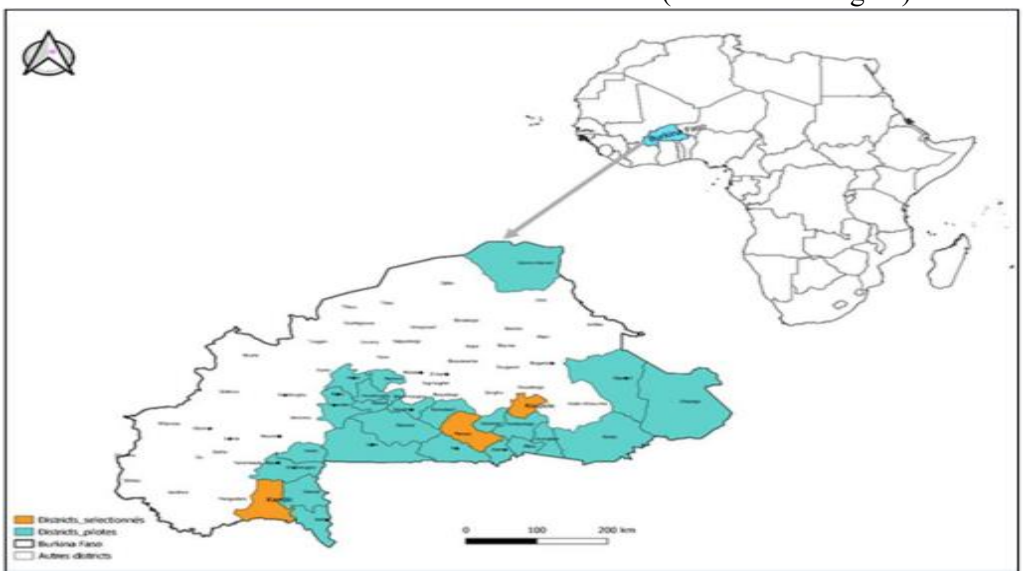

Figure 1. Map of Pilot Districts Targeted for the Introduction of New Vaccines

Comments

The map shows the districts implementing malaria and cervical cancer vaccination programs in Burkina Faso. Three districts from different regions were selected to assess the perceptions of parents of targeted children regarding cervical cancer vaccination (Figure 1).

Results

Socio-demographic Characteristics of HPV Target Participants

Table 1. Socio-demographic Characteristics of HPV Target Participants

Code	Age range	Gender	Education level	Profession
Part_HPV1	30-39 year	Female	Secondary	Household
Part_HPV2	30-39 year	Female	Secondary	Household
Part_HPV3	30-39 year	Female	Other	Household
Part_HPV4	30-39 year	Female	Primary	Household
Part_HPV5	30-39 year	Female	Secondary	Household
Part_HPV6	40-49 year	Female	Primary	Household
Part_HPV7	40-49 year	Female	Other	Household
Part_HPV8	30-39 year	Male	University	Teacher
Part_HPV9	30-39 year	Female	Other	Household
Part_HPV10	30-39 year	Female	Secondary	Teacher
Part_HPV11	40-49 year	Male	Secondary	Other
Part_HPV12	40-49 year	Female	Primary	Household
Part_HPV13	20-29 year	Female	Other	Trader
Part_HPV14	30-39 year	Female	Secondary	Other
Part_HPV15	30-39 year	Male	Other	Other

Comments

The majority are aged 30-39 (10) and female (11). Ten participants have at least a primary school education, and the majority (8/15) are employed in household services (table 1).

Perceptions of the Impact of Cervical Cancer in the Community

1. All participants in the HPV target group (15/15) reported never having known a case in their community. One participant from DS Kampti stated : “No, I have never come across a case of cervical cancer. Neither in my family nor among my acquaintances.” [Part_HPV1].
2. Another participant from Koupela stated : “No, there has been no cervical cancer in my family. I also don’t know anyone who has had this disease.” [Part_HPV12].

Knowledge of Target Groups and Vaccination Schedule

1. Nearly half (8/14) of respondents are familiar with the target groups and vaccination schedule for cervical cancer. Participant Part_HPV10 explains : “It’s the 9-year-old girls who are vaccinated against this disease.”
2. Another participant says : “It’s HPV… the target group is girls, girls aged 9 to 14.” [Part_HPV3]
3. A portion of the respondents (6/14) are unaware of the target groups and vaccination schedule. One DS Manga resident said : “I’ve never heard of these vaccines,” [Part_HPV13].
4. Others, however, were aware of the vaccine but did not know the target group. This was the case for “I think it’s the vaccine called HPV, right ? I think all children are eligible from 59 months onwards,” [Part_HPV15].

Immunization Status and Opinions on the Cervical Cancer Vaccine

1. The majority of respondents (13/15) had their children vaccinated. Their explanations were linked to the effect of awareness campaigns : “I had her vaccinated because through awareness campaigns and the images we see on television, we understand that cervical cancer is not a good disease.” [Part_HPV4].
2. The school's involvement in the vaccination strategy encouraged some parents to vaccinate their children : “It was the teacher himself who called me and explained the disease to me, what it can do, and now I've given permission to have my daughter vaccinated.” [Part_HPV5]
3. Some did not vaccinate their children due to a lack of information : "My child didn't get the vaccine because we hadn't learned about the vaccination campaign against this disease" [Part_HPV13]

Reasons for Acceptability and Reluctance Regarding Cervical Cancer Vaccination

The main reasons for acceptability cited by parents include :

1. The effect of health worker awareness campaigns encourages some parents to get their children vaccinated, according to 4 out of 7 respondents. One stated : "With the health worker awareness campaigns, they understood the need to let their children get vaccinated" [Part_HPV3].
2. Trust in the vaccine as a means of cancer prevention : "Those who accept this vaccine want to protect themselves and their children against diseases. That's the right reason" [Part_HPV10].

However, many parents of children at high risk for HPV revealed significant reluctance for the following reasons :

1. **Fear of family planning through the HPV vaccine**, based on rumors, was highlighted by many parents (7/15) as the main reason for reluctance towards the HPV vaccine. Participant Part_HPV6 explained : “Others are hesitant. They wonder why girls and not boys ? That’s their concern because they suspect contraception.” Participant Part_HPV5 added, “And they really think about contraception since only girls are vaccinated.”
2. **Lack of trust and consent from the parents of the target population**. Participant Part_HPV2 explained : “It’s the family that decides which women and girls should be vaccinated. If the family doesn’t agree, the girl cannot be vaccinated.”
3. **Lack of knowledge about cancer** also explains the irrelevance of this vaccine for some parents ; one stated : “It’s difficult now to bring their children to be vaccinated against a disease they don’t know about” [Part_HPV1].

Discussion

The aim of this study was to assess the knowledge and opinions of parents of children targeted for the cervical cancer vaccine and to identify the main challenges to vaccine acceptance and propose corrective measures. Our analysis reveals mixed results, ranging from some support to some reluctance.

Some parents are in favor of the HPV vaccine and have had their children vaccinated. They justify their support by citing increased awareness and knowledge of the disease. Guenon and colleagues obtained similar results in Cameroon [16]. The school's involvement in the vaccination strategy also encourages some parents to get their children vaccinated. A study on Réunion Island reached the same conclusions [17].

Hesitancy towards HPV vaccines in the community was mentioned by most of the parents interviewed. The main reasons for this hesitancy were fears about family planning through the HPV vaccine. These results are

consistent with those obtained in Tanzania, which indicated rumors about the risks of infertility associated with the vaccine as a cause of hesitancy [18]. Fear of infertility is also one of the main reasons for reluctance towards this vaccine in The Gambia [19].

A lack of knowledge about cervical cancer also contributes to reluctance towards vaccination against this disease: "It's difficult now to bring their children to be vaccinated against a disease they don't know about" [Part_HPV1]. But these conclusions differ from those put forward by Fisher in England, who reveals that reluctance towards this vaccine is partly linked to some parents not perceiving the necessity of vaccination, even though they are aware of the disease [20].

Conclusion

The introduction of a cervical cancer vaccine in Burkina Faso presents an opportunity to significantly reduce the morbidity and mortality associated with this disease.

Despite the efforts made by the Ministry of Health and its partners to support vaccination programs through community awareness campaigns and improvements in the quality of vaccination services, including training and supervision of providers, hesitancy towards vaccination persists.

The main reasons for this hesitancy are fears related to family planning and a lack of knowledge about cervical cancer among some community members. To address this, we recommend that the Ministry of Health and its partners strengthen awareness campaigns about cervical cancer through the effective involvement of local authorities and the media, as well as improve the quality of vaccination services.

Limitations

We used a qualitative method, and the sample is not representative of the population, but it does highlight some perceptions. Therefore, comparing our results regarding the acceptability of and reluctance towards the HPV vaccine with other studies should be done with caution.

Author contributions

S. F. developed the research strategy, coordinated data collection, and wrote the manuscript. KS and all authors reviewed the manuscript. All authors read and approved the final version of the manuscript.

Funding

This research received no external funding.

Ethical Approval

for the collection and analysis of data, we obtained approval from the Health Research Ethics Committee (CERS) of Burkina Faso under number 2025-04-134. We also obtained authorization from the relevant regional directorates as well as informed consent from the participants.

Data Availability

Further inquiries about this article can be directed to the corresponding author.

Acknowledgments

We thank all those who provided help and technical support during data collection and manuscript writing.

Conflicts of Interest

The authors declare no conflicts of interest.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art004

A Mixed-Method Study on the Factors Associated with Emigration of Nurses and Impact on Nursing Profession and Health Sectors

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Abstract

The migration of registered nurses from Saint Vincent and the Grenadines to wealthy countries such as the United Kingdom and the United States of America raises concerns. This is a multidimensional subject that can only be completely investigated with a hybrid approach. This study aimed to identify the factors associated with nurse emigration from SVG and to examine its implications for the nursing profession and health sector. A sequential explanatory mixed-method design was employed between October 2024 and April 2025. Quantitative data were collected using structured paper-based and online questionnaires from 103 registered nurses. Qualitative data were obtained through in-depth interviews with 20 purposively selected participants. Quantitative data were analyzed using SPSS version 26, while thematic analysis was applied to qualitative data. Quantitative findings revealed a statistically significant association between religion and migration ($\chi^2(12) = 21.753$, $p = 0.040$), and regression analysis identified economic incentives as a significant predictor of outward migration ($p = 0.008$). Qualitative analysis identified inadequate salaries, unfavorable working conditions, limited career advancement, political interference, influence of family abroad, and dissatisfaction with governance as key drivers of migration. Nurse migration from SVG is primarily driven by economic and systemic health system factors rather than sociodemographic characteristics alone. Improving remuneration, working conditions, merit-based promotion, and nurse involvement in policy development is essential to strengthening retention and sustaining the national healthcare workforce.

Keywords*: Factors, Health System, Implication**,** Migration, Registered Nurses, Saint Vincent and the Grenadines.*

Introduction

A well-distributed, adequately trained, and motivated nursing workforce is fundamental to achieving universal health coverage and delivering high-quality healthcare. Nurses constitute the largest segment of the global health workforce; however, persistent shortages continue to affect many low- and middle-income countries (LMICs), largely due to large-scale international migration to high-income countries (HICs) [1]. The Caribbean region has experienced sustained emigration over the past five decades, with Saint Vincent and the Grenadines (SVG) recording among the highest migration rates relative to population size. Nurses represent a substantial proportion of this migrant population, contributing to workforce instability, increased workloads, and compromised healthcare delivery. Post–COVID-19 international recruitment efforts have further intensified this trend. Evidence indicates that more than five million individuals have emigrated from the Caribbean over the

Received: 14.01.2026 ***Accepted: 29.01.2026*** ***Published on: 29.04.2026***
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past 50 years, with SVG and Guyana experiencing some of the highest relative population losses [2]. Migration within the region is highly feminized, reflecting the gender composition of the nursing profession. A significant proportion of these migrants are healthcare workers, particularly nurses, resulting in critical workforce shortages and exacerbating health system strain.

In SVG, nurse attrition has reached unprecedented levels. Reports indicate that 58 nurses resigned from hospital services in 2021 alone, followed by continued resignations in subsequent years [3–7]. In response, government officials have acknowledged the growing nursing shortage and proposed policy measures, including bonding arrangements for newly trained nurses [4]. Despite these efforts, international recruitment opportunities and persistent dissatisfaction with local working conditions continue to fuel outward migration. Migration decisions among nurses are shaped by a complex interaction of economic, professional, organizational, social, and political factors. While income disparities remain a dominant driver, emerging evidence highlights the importance of working conditions, career development opportunities, governance, and social networks. However, limited empirical research has examined these dynamics within the context of SVG. This study therefore aims to identify the key factors influencing nurse migration from Saint Vincent and the Grenadines and to assess the implications for the nursing profession and healthcare system. The findings are intended to inform evidence-based policy interventions to improve nurse retention and workforce sustainability.

Material and Method

Study Design

A sequential explanatory mixed-methods design was used to examine factors associated with the emigration of registered nurses from Saint Vincent and the Grenadines (SVG). Quantitative data were collected first and subsequently complemented with qualitative data to explain and contextualize the statistical findings. The study was conducted within public healthcare facilities in Saint Vincent and the Grenadines, with emphasis on the Milton Cato Memorial Hospital, the country's primary referral hospital with 215 beds serving approximately 100,616 residents. The study population consisted of registered nurses trained in SVG who were either currently employed by the Ministry of Health, Wellness, and the Environment or had migrated within the past ten years. A purposive sampling technique was employed. A total of 103 nurses participated in the quantitative phase, and 20 nurses participated in the qualitative phase.

Data Collection

Quantitative data were collected using a structured questionnaire administered in both paper-based and online formats. The questionnaire captured sociodemographic characteristics, job satisfaction, migration intentions, and perceived push and pull factors. Qualitative data were collected through in-depth semi-structured interviews conducted between April 17 and April 26, 2025. Interviews were conducted in private offices or via telephone, audio-recorded with consent, and supported by field notes. Interviews lasted 11–35 minutes and continued until data saturation was achieved.

Data Analysis

Quantitative data were analyzed using SPSS version 26. Descriptive statistics summarized participant characteristics, while inferential statistics—including chi-square tests, regression analysis, cross-tabulation, and ANOVA—were used to examine associations. Statistical significance was set at $p < 0.05$. Qualitative data were analyzed using Braun and Clarke's six-step thematic analysis. Coding and theme development were conducted

independently by the researchers, with consensus achieved through discussion.

Ethical Considerations

Ethical approval was obtained from the Texila American University Ethics Committee, the Saint Vincent and the Grenadines Ethics Committee, and the Hospital Administration of the Milton Cato Memorial Hospital. Participation was voluntary, informed consent was obtained, confidentiality was maintained, and no foreseeable risks were identified.

Results

Quantitative Analysis

Table 1. Frequency and Percentage of Sociodemographic Characteristics of Registered Nurse (N-103)

Sl. No	Sociodemographic variables	Frequency (F)	Percentage (%)
1	**Age (in years)**		
	20-25	6	5.8
	26-30	12	11.7
	30-35	15	14.6
	36-40	31	30.1
	41-45	15	14.6
	46-50	11	10.7
	51 and over	12	11.7
2	**Gender**		
	Male	16	15.5
	Female	86	83.5
3	**Ethnicity**		
	African Descent	84	81.6
	East Indian	1	1.0
	Mixed	17	16.5
	Other	1	1.0
4	**Education**		
	Registered Nurse	47	45.6
	Midwifery	8	7.8
	Bachelors	28	27.2
	Masters	19	18.4
5	**Marital Status**		
	Single	52	50.5
	Married	39	37.9
	Divorced	3	2.9
	Separated	3	2.9
	Cohabiting	6	5.8
6	**Religion**		
	Catholic	5	4.9

	Anglican	7	6.8
	Methodist	11	10.7
	Seventh day Adventist	27	26.2
	Pentecostal	37	35.9
	Jehovah witness	1	1.0
	Other	11	10.7
7	**Monthly Income**		
	> $4000	23	22.3
	$3000–$4000	43	41.7
	$2600–$3000	28	27.2
	< $2500.	9	8.7
8	**Length of time**		
	<1 year	11	10.7
	2-5 years	18	17.5
	6-10 years	15	14.6
	11-15 years	23	22.3
	16-20 years	11	10.7
	0ver 20 years	22	21.4
9	**Family Status**		
	Living alone	13	12.6
	Joint/ extended	30	29.1
	Nuclear	54	52.4
	Other	3	2.9
10	**District**		
	Georgetown	4	3.9
	Calliaqua	24	23.3
	Chateaubelair	6	5.8
	Marriaqua	16	15.5
	Kingstown	32	31.1
	Cedars	1	1.0
	Pembroke	19	18.4

Table 1 shows the frequency and percentage of demographic characteristics of respondents Regarding age the majority were within the 36–40 age group (30.1%), followed by those aged 30–35 (14.6%) and 41–45 (14.6%). With respect to gender, the profession was heavily skewed toward female respondents (83.5%), reflecting established global trends in the nursing field. Males accounted for just 15.5%, with 1% not disclosing gender. Regarding the ethnicity, majority (81.6%) were of African descent followed by those of mixed ethnicity (16.5%). This reflects the general demographic distribution of the national population, where African heritage is dominant.

According to the educational background, majority (45.6%) were registered nurses, (27.2%) has a bachelor's degrees, (18.4%)

master's degrees, and (7.8%) with midwifery certification. This suggests a well-qualified nursing workforce. With respect to marital status most participants were single (50.5%) and (37.9%) were married representing a small proportion were cohabiting, divorced, or separated. This may be influenced by work-related migration, long hours, or other professional pressures impacting personal relationships.

The most common religious affiliation was Pentecostal (35.9%), followed by Seventh Day Adventist (26.2%) and Methodist (10.7%). With respect to family structure, over half (52.4%) lived in nuclear families, followed by (29.1%) in joint/extended family settings. Only (12.6%) lived alone. The largest proportion of respondents earned between $3000–$4000 monthly (41.7%), suggesting a modest income distribution. About (27.2%) earned $2600–$3000, while (22.3%) earned more than $4000. Only (8.7%) earned less than $2500.

Regarding the length of employment, most respondents had been in service for over 10 years, with the largest groups being those employed for 11–15 years (22.3%) and over 20 years (21.4%). This demonstrates a relatively experienced workforce. These results indicate that familial responsibilities and support systems may influence decisions to migrate or remain in the current job setting. The largest group of respondents (31.1%) were from Kingstown, followed by Calliaqua (23.3%) and Pembroke (18.4%). These are predominantly urban districts, suggesting that urban centers are hubs for healthcare employment.

Six themes emerged:

1. Increasing visibility of nurse migration
2. Strategies to prevent migration
3. Influence of family and social networks
4. Push factors within the health system
5. Influence of salary and cost of living
6. Political and workplace governance issues.

Participants consistently cited low salaries, poor working conditions, limited career advancement, outdated infrastructure, and political interference as major reasons for migration.

The Rationale Behind Nurses' Relocation

Accordingly figure 1 depicts participants views about job satisfaction. The majority (47.6%) of respondents reported dissatisfaction with their current work environment, while only (31.1%) expressed satisfaction. The remaining (21.4%) were uncertain. In table 2 when asked about the intention to migrate (69.9%) of participants responded yes while (26.2%) responded no and (3.8%) did not answer that question , Table 3 shows that among possible migration destinations, England emerged as the most favored location, with (69.9%) of respondents indicating interest, followed by the United States (25.2%), Canada (20.4%), and the British Virgin Islands (17.5%). In table 4 the findings revealed that age (χ^2 -4.893, p-0 .961); gender (χ^2-2.267, p-0.687); ethnicity (χ^2 -0 .622, p-0.996); education level (χ^2- 6.580, p-0 .361); marital Status (χ^2- 11.405, p -0 .180); income (χ^2- 2.561, p -0 .862); family status (χ^2- 7.526, p- 0.275) and length of time in organization (χ^2- 7.782, p-0.650) were found to have no significant association. Only religion (χ^2- 21.753, p-0.040) had significant association. Suggesting there is a tendency for people to migrate based on their religion. In table 5 the findings re); income and religion (χ^2-7.816, p-0.799); gender (χ^2-4.869, p-0.301); ethnicity (χ^2 -6 .143, p-0.407); education level (χ^2- 4.184, p-0 .652); marital Status (χ^2- 5.331, p -0.722);income (χ^2- 6.262, p -0 .394; family status (χ^2- 5.191, p- 0.520) and length of time in organization (χ^2- 11.259, p-0.338) were found to have no significant association. Only age had (χ^2-21.647, p-0 .042) significant association.

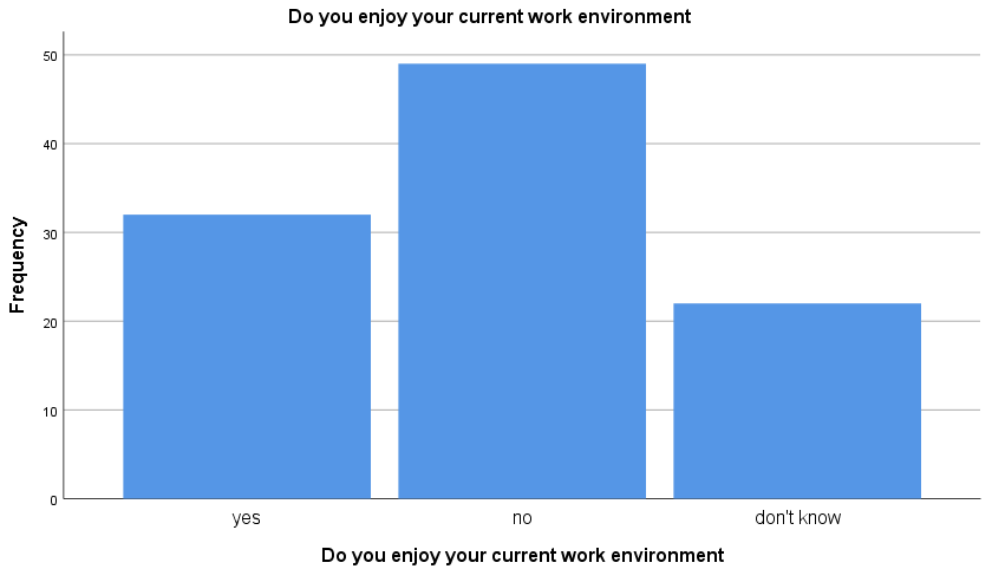

Figure 1. Job Satisfaction Among Registered Nurses (N-103)

Table 2. Intention to Migrate Among Registered Nurses (N-103)

Responses	Frequency (F)	Percentage (%)
Yes	72	69.9
No	27	26.2
Don't Know	0	0

Table 3. Countries Selected for Migration by the Registered Nurses (N-103)

Countries	Status	Frequency (F)	Percentage (%)
England	Yes	72	69.9
	No	27	26.2
America	Yes	26	25.2
	No	72	69.9
Canada	Yes	21	20.4
	No	77	74.8
BVI	Yes	18	17.5
	No	80	77.7
Trinidad	Yes	2	1.9
	No	96	93.2
Barbados	Yes	2	1.9
	No	96	93.2
Other	Yes	9	8.7
	No	89	86.4

Table 4. Association Between the Migration Factors with Socio-Demographic Variables of Registered Nurses (N-103)

Sl. No	Sociodemographic variables	Yes	No	Don't Know	χ^2 value (df)	p-value
1	**Age (in years)**					
	20-25	5	0	1	4.1893 (12)	0.961
	26-30	10	0	2		
	30-35	13	1	1		
	36-40	27	1	3		
	41-45	12	1	2		
	46-50	10	0	1		
	51 and over	11	1	0		
2	**Gender**					
	Male	12	1	3	2.267 (4)	0.687
	Female	76	3	7		
3	**Ethnicity**					
	African Descent	73	3	8	0.622 (6)	0.996
	East Indian	1	0	0		
	Mixed	14	1	2		
	Other	1	0	0		
4	**Education**					
	Registered Nurse	41	1	5	6.580 (6)	0.361
	Midwifery	5	1	2		
	Bachelors	24	2	2		
	Masters	18	0	1		
5	**Marital Status**					
	Single	44	2	6	11.405 (8)	0.180
	Married	35	1	3		
	Divorced	1	1	1		
	Separated	3	0	0		
	Cohabiting	6	0	0		
6	**Religion**					
	Catholic	4	0	1	21.753 (12)	0.040
	Anglican	7	0	0		
	Methodist	6	1	4		
	Seventh day Adventist	22	9	5		
	Pentecost	34	3	0		
	Jehovah witness	1	0	0		
	Other	11	0	0		
7	**Monthly Income**					
	> $4000	20	1	2	2.561 (6)	0.862
	$3000–$4000	37	2	4		

	$2600–$3000	25	0	3		
	< $2500.	7	1	1		
8	**Length of time**					
	< 1year	10	0	1	7.782 (10)	0.650
	2-5 years	13	1	4		
	6-10 years	12	1	2		
	11-15 years	21	0	2		
	16-20 years	10	1	0		
	0ver 20 years	20	1	1		
9	**Family Status**					
	Living alone	10	0	3	7.526 (6)	0.275
	Joint/ extended	27	0	3		
	Nuclear	47	4	3		
	Other	3	0	0		

Table 5. Association Between Intention to Migrate with Socio-Demographic Variables of Registered Nurses (N-103)

Sl. No	Sociodemographic variables	Yes	No	Don't Know	χ^2 value (df)	p-value
1	**Age (in years)**					
	20-25	0	1	5	21.647 (12)	0.042
	26-30	6	0	6		
	30-35	6	0	9		
	36-40	14	6	11		
	41-45	4	5	6		
	46-50	4	0	6		
	51 and over	3	5	4		
2	**Gender**					
	Male	5	5	5	4.869 (4)	0.301
	Female	31	13	42		
3	**Ethnicity**					
	African Descent	32	17	34	6.143 (6)	0.407
	East Indian	0	0	1		
	Mixed	5	1	11		
	Other	0	0	1		
4	**Education**					
	Registered Nurse	14	6	26	4.184 (6)	0.652
	Midwifery	3	2	3		
	Bachelors	11	5	12		
	Masters	9	4	6		
5	**Marital Status**					
	Single	19	6	27	5.331 (8)	0.722
	Married	14	9	16		
	Divorced	0	1	1		

	Separated	1	1	1		
	Cohabiting	3	1	2		
6	**Religion**					
	Catholic	1	0	3	7.816(12)	0.799
	Anglican	3	0	3		
	Methodist	4	1	5		
	Seventh day Adventist	13	9	11		
	Pentecost	11	3	17		
	Jehovah witness	0	0	1		
	Other	2	0	6		
7	**Monthly Income**					
	> $4000	10	5	7	6.262 (6)	0.394
	$3000–$4000	17	8	18		
	$2600–$3000	9	3	16		
	< $2500.	1	2	6		
8	**Length of time**					
	< 1year	3	1	7	11.259 (10)	0.338
	2-5 years	7	0	11		
	6-10 years	5	3	7		
	11-15 years	11	4	8		
	16-20 years	5	2	4		
	0ver 20 years	6	7	8		
9	**Family Status**					
	Living alone	3	2	7	5.191 (6)	0.520
	Joint/ extended	10	8	12		
	Nuclear	22	7	25		
	Other	0	1	2		

Discussion

This study investigated the relationship between sociodemographic characteristics and outward migration from informal settlements, with a focus on three primary hypotheses: (1) sociodemographic factors influence outward migration (2) lack of upward mobility drives migration and (3) relationship between increased salary and migration. Age and religion were the only sociodemographic variables significantly related to migration. Data showed that the age group 36-40 represented 30.1% of the persons surveyed. This finding is similar to several studies conducted by [8-12], most nurses who migrated were under 40 years old.

On the other hand, a study by [8], nurses in industrialized nations like Australia, New Zealand, and the United States were comparatively younger, with over 60% of them being 34 years of age or younger, whereas nurses in developing nations like India and Pakistan tended to be older than 40. Age and the likelihood of migration are strongly correlated, according to numerous research. Due to their increased adaptability, desire for school or work, and lack of familial responsibilities, younger people are typically more mobile [13, 14] According to research, age also affects the

kind of migration; younger individuals are more inclined to travel abroad or to an urban area, whereas elderly persons may relocate for retirement or to be with their family [15]. Through political, social, and cultural channels, religion can have a big impact on migratory decisions. Migration may be a way for religious minority to seek asylum or better religious freedom in situations where they are persecuted or discriminated against [16, 17]. Furthermore, religious networks frequently aid migration by offering networks of support in the places of destination [18]. Additionally, according to some research, religious identity may influence integration experiences in host nations, affecting both individual adaptation and policy responses [19]. Over the past decade, the World Health Organization (WHO) has reported a 60% increase in health workforce emigration to higher income countries (HICs) [20, 21]. The shortage of nurses in HICs has led to this situation. For example, the United States projected a 550,000-nurse employment gap in 2019 [22].

Economic factors (specifically income and job satisfaction) were strong push factors. Numerous nurses cited higher pay in another nation as a driving force behind migration [10, 23-30]. Due to the weakening economies of several source countries [24, 27], international migration was a "life-changing strategy" for these nurses [3]. According to [32], a larger proportion of foreign-trained nurses registered in the UK were from low- and middle-income nations than from high-income ones. According to other research [12, 31] migrant nurses were motivated by the desire to support their families back home by sending money as remittances. Additional economic justifications mentioned included a stronger benefit package, a means of increasing income, and financial betterment [10, 23, 31, 33]. The majority of the studies' findings confirmed the widely held belief that the potential income from migrating determined the motivation to relocate [32]. One of the most frequently cited causes of nurse migration is low pay in the nation of origin. Salary differences between source and destination countries are a significant motivator for migration, according to studies conducted in Sub-Saharan Africa, South Asia, and Southeast Asia [1]. Due to economic stagnation and a lack of performance-based incentives, nurses in developing nations sometimes look for better-paying jobs elsewhere. According to [34, 35] they found that health professionals emigrate due to various push and pull reasons, which are similar to this study's findings. They proposed that staff nurses (SNs) are motivated to move for a variety of reasons, including economics, professional advancement, social issues, the health system, and politics. According to [36] the departure of SNs is mostly driven by economic factors, either pulling or pushing. Similarly, [37, 38] migration in Ghana may be caused by a poor socio-economic climate, poor living conditions, currency devaluation, desire to work in a different environment, low professional satisfaction, and colonial connections.

The nursing profession is female-dominated and relatively well-educated. According to two surveys, a greater percentage of male nurses had either moved or planned to move [25, 26, 29] also discovered a discernible trend of university-degree-holding nurses migrating in comparison to those with technical general nursing qualifications. Nursing is a highly educated and female-dominated profession, especially for those looking for work abroad. Formal credentials like degrees or diplomas are usually held by migrant nurses, who frequently seek additional credential recognition or bridging programs in their new countries [39]. Safety concerns, social acceptance, and family-related travel decisions are just a few of the gendered ways that the feminized nature of the profession affects migration.

Most respondents reside in urban districts and come from nuclear families. According to a few studies, the majority of migrant nurses come from cities because they have greater

access to higher-quality education and more opportunities to travel abroad [40]. Additionally, compared to those in extended or multigenerational households, many came from nuclear families, which may offer fewer caregiving responsibilities and greater personal autonomy, making relocation easier.

The qualitative data also indicates that nurse migration is driven by a combination of economic necessity and aspirational motivations**.** Nurses in St. Vincent and the Grenadines are increasingly seeking employment overseas due to inadequate compensation, limited professional growth, and difficult working conditions at home. Conversely**,** foreign opportunities provide the hope of financial stability, better working environments, and enhanced personal and family well-being. The increase in migration is not seen as a temporary trend but rather a structural shift that reflects deeper systemic issues within the local healthcare and economic landscape. The pull factors associated with migration are centered around the availability of better opportunities overseas. Respondents mentioned access to higher-quality healthcare systems, educational opportunities for their children, and improved living conditions. The promise of working in technologically advanced environments and the possibility of family migration were also noted as major motivators. Example: A respondent noted that nurses "would have more options in terms of where they want to go," reflecting a perception that foreign countries offer both professional flexibility and personal security**.**

Migration is not only seen as an escape from local difficulties but as a strategic move toward professional and personal growth**.** The reference to "greener pastures" by one respondent captures the sentiment that migrating can lead to a higher quality of life and greater career fulfilment**.** Nurses appear to view migration as a pathway to upward mobility—a chance to escape limitations imposed by their current working conditions and socio-economic environment.

There is a strong consensus across responses that nurse migration has increased in recent years. This perception is shared regardless of how detailed the response is, suggesting that nurse migration is a visible and impactful trend within the healthcare sector in St. Vincent and the Grenadines. Even brief affirmations like "Yes, definitely," or "I strongly believe that..." reflect a collective awareness and concern about the implications of this migration pattern.

Many participants highlighted working conditions as a determinant of whether nurses remain in the profession locally. Concerns about outdated equipment, poor infrastructure, and stressful work environments were common. "We need a better hospital… in clinics, we are unable to properly assess patients because we don't have this or that. "This indicates that poor infrastructure not only affects patient care but also contributes significantly to staff dissatisfaction and burnout.

Family and friends often offer practical assistance, such as helping nurses navigate foreign job markets, providing housing or referrals, and supporting initial transitions. Respondent 4 highlighted that *"*they have a friend or a family member who can canvas the area and see what is available and give them feedback about these opportunities.

Respondents were vocal about the disconnect between decision-makers and front-line workers. They urged policymakers to actively listen to nurses and involve them in policy formation. "Policymakers need to sit down and draft policies that are going to make nurses comfortable. Listen to their grievances". Additionally, some respondents felt that the health system itself needed structural and operational reform, including leadership renewal, merit-based promotions, and youth inclusion in management roles. Additionally, one respondent believed "The whole system just needs reshuffling bring in fresh perspectives." This highlights a desire for a

more dynamic, progressive, and transparent healthcare system.

Some respondents also identified systemic governance issues, such as nepotism and bureaucratic favoritism, which hinder merit-based promotion and professional satisfaction. Respondent 10 commented: "Because of nepotism, persons with qualifications are not given the jobs they require." This suggests that institutional dysfunction and perceived unfairness are also contributing to nurses' decisions to seek better-governed professional systems abroad.

The majority of respondents described natural disasters—such as hurricanes or volcanic eruptions—as common, manageable occurrences that have become a normal part of life in the Caribbean. Many emphasize that since such events are expected and people are acclimatized to them, they do not act as migration motivators. Respondent 15 stated: "We were born in the Caribbean. By now we have gotten accustomed to those things. That doesn't have anything to do with it." Similarly, Respondent 1 noted: "Anywhere you go, natural disaster is natural disaster… I don't think that contributes to migration." These comments suggest that nurses are familiar with this disruption and thus they do not see them as compelling reasons to leave the country. Most participants explicitly dismissed religion as a motivating factor. Respondents 1, 3, 5, 6, 7, 8, and 9 all responded unequivocally with *"no"* or similar expressions, emphasizing that spiritual beliefs do not typically impact migration intentions or decisions**.** Even for those who maintain religious convictions, migration does not appear to disrupt their practices significantly. Some participants mentioned that while individuals may not find the same denomination or church abroad, they adapt spiritually or find alternatives. Respondent 16 reflected: "Having a faith-based religion, like believing in Christ—yes. But to say that it influences migration? No. This shows that even among devout individuals**,** religious faith is not a deterrent nor a compelling motivator for migration. Instead, there is a sense of religious adaptability across borders, particularly in multicultural societies.

Contribution to Knowledge

Beyond politics and pay**,** broader systemic and administrative frustrations within the healthcare system also emerge as significant motivators for migration. Respondents expressed concerns about lack of opportunities for professional growth, the disconnect between qualifications and job placement, and minimal support for continuing education or specialization. There is a growing sense that the current system fails to reward ambition or innovation, often penalizing those who advocate for change. This lack of institutional support is compounded by outdated practices and a resistance to modernized approaches to healthcare delivery, further alienating younger or more progressive nurses. Underlying all these factors is a shared aspiration among respondents for a better standard of living and professional fulfillment. Migration is not solely a financial decision, but also a means to achieve personal growth, job satisfaction, and family well-being. Participants noted that overseas employment allows for greater respect, career advancement, and work-life balance, contrasting with their experiences of stress and burnout in SVG's health sector.

Suggestion for Further Research

While there is extensive study on nurse emigration, gaps remain in understanding the specific consequences on healthcare systems in understudied locations such as Saint Vincent and the Grenadines. Additional empirical research is required to design targeted policies and interventions to address these difficulties. Future research should consider longitudinal data and qualitative methods to further explore how religious affiliation and economic hardship interact in shaping migration behaviour.

Limitations

This study was limited to registered nurses trained in Saint Vincent and the Grenadines, those employed by the Government of Saint Vincent and the Grenadines and registered nurses who migrated during the period 2013-2023 were sampled.

Recommendation

Based on the findings of this study the following recommendations are suggested:

Policy-Level Recommendations

1. Develop and implement a five-year national nursing workforce strategic plan.
2. Review and improve salary structures, allowances, and incentives.
3. Upgrade healthcare infrastructure and modernize equipment.
4. Establish transparent, merit-based promotion systems.
5. Introduce retention incentives such as duty-free vehicle concessions and annual bonuses.
6. Engage nurses in evidence-based policy formulation.

Institutional-Level Recommendations

1. Improve staff-to-patient ratios and workplace safety.
2. Provide rest areas and supportive work environments.
3. Offer flexible scheduling and specialization opportunities.
4. Strengthen leadership training for nurse managers.
5. Implement recognition and reward programs for outstanding performance.

Conclusion

Overall, the findings highlight the nuanced role of sociodemographic variables in influencing outward migration. While most variables examined were not significantly associated with migration, religion and age emerged as influential factors, particularly in relation to perceived opportunities for upward mobility. Most notably, economic factors were the strongest predictor of outward migration, underscoring the importance of livelihood security in migration decisions. The findings reveal that while many demographic factors do not directly influence migration, economic insecurity and dissatisfaction with work conditions play central roles in the decision to migrate. Religious affiliation and age also appear to affect outward migration intentions. These results underscore the importance of improving work environments, compensation, and career mobility to retain skilled professionals within the local healthcare system. These insights contribute to a better understanding of the complex motivations behind migration from informal settlements and can inform targeted policy interventions. Politics is a powerful and often demoralizing force in the nursing profession in St. Vincent and the Grenadines. Whether through overt favoritism, systemic inequity, or political retaliation, nurses feel that their careers are constrained by forces unrelated to their competence or effort. This political interference fuels a deep frustration that significantly contributes to their decision to migrate, in hopes of finding a professional environment driven by equity, opportunity, and respect.

One of the most prominent themes identified is the influence of salary and financial incentives on migration decisions. Most respondents explicitly cited low wages and financial insecurity as a major push factor. Many described living "paycheck to paycheck" and being unable to save, invest in their families' futures, or maintain a comfortable standard of living. Several respondents noted that nursing salaries in SVG are among the lowest in the Caribbean, prompting feelings of undervaluation and frustration. In contrast, the prospect of earning three to four times more overseas, especially in countries like Canada or the United States, acts as a strong pull factor. Enhanced remuneration abroad not only allows

for better personal financial management but also enables nurses to support extended family members, pay off mortgages, and build long-term financial security. Additionally, overtime pay and comprehensive benefits offered overseas serve as further incentives.

Overall, the data illustrate that nurse migration from SVG is a multifaceted phenomenon, with financial strain, political interference, workplace frustration, and aspirations for better living forming the core drivers. Unless these systemic issues are addressed—through salary reform, depoliticized promotion systems, and investments in professional development, the country is likely to continue facing challenges in retaining its nursing workforce. A holistic, policy-driven response is therefore essential to stem the ongoing migration and build a resilient, motivated health system.

Acknowledgement

I take this opportunity to thank God for health, strength and endurance, my parents for their constant support, my husband, my work colleagues and my close friends Herona, Avette, Jasmine, Simone, Michelle and Cherry Ann for motivating me in times of giving up. Thank you to the Government of Saint Vincent and the Grenadines for granting me a tuition scholarship to complete my degree. Thank you to Mr. Wayne Young who guided me in the analysis of the quantitative data and Mr. Asif Dover who assisted in analyzing the qualitative data.

Conflict of Interest

The author declared that there is no conflict of interest related to this paper.

Data Availability

The data that support the findings of this study are openly available in crossref, academia, google scholar, International scientific indexing, ICN.

Author Contribution

SBH wrote the manuscript, conducted interviews and analysed the data. JJ assisted with analysis, supervision and review and editing. All authors reviewed the final manuscript.

Funding

“This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors”.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art005

Vitamin D Knowledge, Attitudes, and Practices among Nurses and Patients in Tertiary Care Hospitals: Implications for Nursing-Led Patient Education

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Abstract

Differences in knowledge and practices related to vitamin D may reduce the effectiveness of preventive interventions. The study is carried out to assess nurses and patients' knowledge, practices, and attitudes toward vitamin D in tertiary healthcare facility. Nurses and patients of such tertiary care hospital-based units above 18 years were included in the cross-sectional study. A validated questionnaire was used to extract the personal characteristics of the samples and to assess knowledge, practices, and attitudes with regard to vitamin D The data were analyzed using SPSS version 25 with independent t-tests, chi-square tests, analysis of variance (ANOVA) at $p < 0.05$ level. Nurses demonstrated a higher level of knowledge compared to patients, particularly in the domains of calcium absorption and bone health, as well as dietary sources of vitamin D. Both groups expressed positive perceptions of vitamin D, and nurses exhibited a higher degree of consensus regarding their responsibility to educate patients. A discrepancy was observed between nurses' and patients' perceptions regarding the assessment of vitamin D levels, with 46.6% of nurses reporting that they routinely assess their patients' levels. The study showed that less than half of the patients followed the recommended practices. Only a few of them took supplements and got enough sun. The results showed a strong connection between age and education levels, on one side, and knowledge, attitudes, and actions, on the other. Both patients and nurses had trouble applying vitamin D in practice, but nurses had more knowledge and were more positive about it.

Keywords: *Knowledge Attitudes and Practices, Nurses, Nursing-Led Education, Patients, Tertiary Care Hospitals, Vitamin D.*

Introduction

Vitamin D is one of the essential fat-soluble vitamins, produced in the skin after exposure to sunlight [1]. Foods such as fatty fish and egg yolks are sources of vitamin D [2, 3]. People in Asia suffer from vitamin D deficiency [4], which has led them to overuse vitamin D supplements (2-4), resulting in vitamin D toxicity due to their lack of exposure to sunlight or poor diet [5-7]. Vitamin deficiency is caused by insufficient or incorrect consumption or poor absorption at a time when the body needs the vitamin, leading to numerous complications in body systems such as the digestive and liver systems, which in turn leads to metabolic problems [8]. Vitamin D deficiency remains a widespread medical problem throughout the world [8], and therefore one of the most important measures to reduce this problem is to raise public awareness about the importance of this vitamin [8, 9].

Levels of knowledge and practices related to vitamin D, as well as attitudes, vary greatly, which is consistent with the importance of the

Received: 20.01.2026 ***Accepted: 30.02.2026*** ***Published on: 29.04.2026***
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vitamin. This variation occurs among most populations, as some surveys of adults in the Middle East have revealed a low level of awareness among the general public about the sources and benefits of vitamin D, as well as practices related to it [10]. Surveys conducted on adults in the Middle East have revealed a lack of awareness among the general public about the sources and benefits of vitamin D, in addition to their practices not being at an acceptable level with regard to nutritional supplements and exposure to sunlight [10]. Similarly, a study in Oman showed that university students' knowledge of vitamin D was moderate and their health practices were insufficient to address vitamin D deficiency [11]. Additional research in clinical environments has demonstrated a deficiency in knowledge regarding vitamin D among healthcare professionals and has advocated for the implementation of programmers to enhance understanding and management of vitamin D [12]. To implement such programs, context-specific assessments are needed to understand attitudes and practices regarding vitamin D, particularly in healthcare settings where every care giver must influence patients to improve health outcomes [11, 12].

Statistics in Iraq indicate that nurses and patients have limited knowledge and practical experience with vitamin D in tertiary care hospitals. Despite the limited scope of knowledge, a recent study in Baghdad found that most people have good knowledge of vitamin D but remain unaware of the factors that affect it. vitamin D absorption and its sources [13]. Such knowledge gaps can lead to unhealthy behaviors that reduce the effectiveness of clinical interventions, which in turn can make nurses less likely to provide information aimed at improving patient knowledge in different settings [14]. Numerous studies have investigated the knowledge and practices of nurses and patients regarding vitamin D individually, but no study has compared them. Therefore, this study aimed to compare the knowledge, practices, and attitudes of nurses and patients toward vitamin D in tertiary hospitals.

Materials and Methods

A cross-sectional design was carried out to compare knowledge, attitudes, and practices (KAP) related to vitamin D among nurses and patients in tertiary care facilities in medical, surgical, and critical care units. The study sample were randomly selected 477 adult patients and nurses from medical, surgical, and critical care units then divided into two groups by using Cochran's approach for cross-sectional research at a 95% confidence level, the sample size was found by assuming the most variability ($p = 0.5$) and a margin of error of 0.05. The researcher excludes nurses on leave or engaged in administrative duties, while those employed in the selected units with a minimum of six months of clinical experience in their current department. All participants in the research were required to be 18 years or older and capable and willing to complete the questionnaire; those with serious mental illness or other conditions that precluded participation were excluded.

A comprehensive questionnaire was used to collect data, using relevant literature and previous KAP studies. The survey started with simple questions about the patients and nurses, then went on to questions regarding vitamin D knowledge, how important it is, health education, and protocols for testing, counselling, and taking vitamin D supplements. Five-point Likert scales were used to measure attitudes and actions, whereas one point was given for each right response to a question about knowledge. The poll also questions patients about their vitamin D experiences, such as whether they followed their supplement prescriptions and if they felt better.

Nursing and nutrition specialists evaluated the questionnaire to confirm its content validity, and a pilot study involving about 10%

of the population assessed its clarity and reliability. Using Cronbach's alpha, we looked at the internal consistency and found that a value of 0.70 or above was acceptable. The researcher told the research participants what it was about and gained their written consent after the appropriate hospital review boards given their ethical approval. After that, questionnaires were sent out and collected. Then, they were reviewed to make sure they were complete before being analyzed.

The researcher used SPSS version 25 to look at the data. The researcher utilized many types of descriptive statistics to summarize the data, such percentages, means, standard deviations, and frequencies. Inferential statistics were used to compare the KAP evaluations of nurses and patients, as well as to investigate the relationships among knowledge, attitudes, and practices. These included analysis of variance, chi-square tests, Pearson or Spearman correlation coefficients, and independent t-tests. A p-value of less than 0.05 was utilized. It was completely up to the participants whether or not to take part, their data was kept private and anonymous, and they may quit the study at any time without consequence. All of these things were considered while making ethical decisions.

Results

Nurses showed higher levels of correct responses across most knowledge items, particularly regarding the role of vitamin D in calcium absorption and bone health (75.2% vs. 57.6%) and dietary sources of vitamin D (83.1% vs. 65.1%) as shown in (Table 1).

Table 1. Comparison Between Nurses' and Patients' Knowledge of Vitamin D

Question	True		False		I Don't Know	
	Nurse	Patient	Nurse	Patient	Nurse	Patient
Vitamin D is essential for calcium absorption and bone health.	75.2	57.6	14.2	40.3	10.6	2.1
Sun exposure is the main natural source of Vitamin D.	87.3	75.5	6.4	18.3	6.4	6.2
Vitamin D deficiency can contribute to osteoporosis.	63.1	43.4	15.6	34.5	21.3	22.1
Vitamin D plays a role in immune system regulation.	59.3	62.7	25.8	16.6	14.8	20.7
Food sources such as fatty fish, egg yolks, and fortified dairy provide Vitamin D.	83.1	65.1	6.4	24.8	10.6	10.1
Vitamin D deficiency may affect cardiovascular health.	44.5	50.2	23.3	16.6	32.2	33.2

The results showed that nurses had more positive attitudes than patients toward vitamin D, especially regarding vitamin D relationship to general health and its role in promoting health as (72.1%) and patients (73.0%) agreed that adequate vitamin D levels are important for overall health. Nurses demonstrated stronger agreement regarding their role in educating patients about vitamin D compared with patients (65.6% vs. 56.4%) (Table 2).

Table 2. Comparison of Nurses' and Patients' Attitudes Toward Vitamin D

	Nurse			Patient		
	Positive	**Negative**	**Neutral**	**Positive**	**Negative**	**Neutral**
Adequate Vitamin D levels are important for overall health.	72.1	17.3	10.6	63	26.6	10.4
Education about Vitamin D can improve health outcomes.	66.1	10.6	23.3	68.9	20.8	10.4
Nurses play an important role in educating patients about Vitamin D.	65.6	15.3	19.1	56.4	14.5	29.0
I feel confident discussing Vitamin D-related issues with healthcare providers.	57.2	25.4	17.4	52.4	10.3	37.3
Raising awareness about Vitamin D deficiency should be part of routine healthcare.	68.2	12.7	19.1	58.5	12.5	27

Overall, nurses demonstrate better practices than patients across most items. A high proportion of nurses report good practice in recommending Vitamin D supplementation (68.8%) and educating patients about its importance (53%), while assessing patients' Vitamin D intake or status shows a comparatively lower level of good practice (46.6%). In patients, adherence-related behaviours are fair. Over half (58.1%) heed advice from health professionals, whereas obtaining sunlight exposure on a regular basis exhibits lower good practice (39.8%). The percentage of eating or eating foods/supplements rich in vitamin D is moderate (41.5%), suggesting partial adherence, not full adherence (Table 3).

Table 3. Comparison of Responses to Vitamin D Practices Among Nurses and Patients

	Practice	**Good**	**Moderate**	**Poor**
Nurse	I assess patients' Vitamin D intake or status.	46.6	29.7	23.7
Patient	I follow advice given by nurses or healthcare providers regarding Vitamin D.	58.1	20.7	21.2
Nurse	I educate patients about the importance of Vitamin D.	53	21.6	25.4
Patient	expose myself to sunlight regularly.	39.8	37.3	22.8
Nurse	I recommend Vitamin D supplementation when appropriate.	68.8	16.9	14.8
Patient	I consume foods rich in Vitamin D or take supplements as prescribed.	47.7	41.5	10.8

Age was found to have a significant relationship with patient outcomes ($F = 3.948$, $p = 0.021$), with most patients (64.7%) with optimal results having a mean age of 37.5 ± 8.19 years. Gender was not found to have a statistically significant relationship with patient outcomes despite having a higher proportion of patients in each category ($F = 3.382$, $p = 0.067$). Education had a strong and highly significant relationship with patient outcomes ($F = 14.402$, $p < 0.001$), with higher education being linked to optimal results and lower education to acceptable or suboptimal results. However, Vitamin D supplements were not found to have a statistically significant relationship with patient outcomes ($F = 0.918$, $p = 0.134$), although there was a slight trend towards improved patient results (Table 4).

Table 4. Differences in Patients' Level of Knowledge and Demographic Data (n=241)

			Patients				
Variables			**Good**	**Accept**	**Poor**	**F**	**P-value**
Age	Mean= 37.5	SD=8.19	64.7	20.7	14.5	3.948	0.021
		%	Good	Accept	Poor	F	P-value
Gender	Male	79.3	50.2	16.5	12.4	3.382	0.067
	Female	20.7	14.6	4.2	2.1		
Education	Not read	4.1	0	2.1	2.1	14.402	0.0001
	Primary	2.1	0	0	2.1		
	Secondary	18.7	10.3	2.1	6.4		
	Institute	54.4	35.6	16.9	2.1		
	Bachelor	20.7	20.3	0	2.1		
Supplements	Yes	49.8	42.5	6.2	6.1	0.918	0.134
	No	50.2	33.6	2.1	9.3		

Apart from gender, all other demographic parameters were affected patients level of attitudes in the studied group. Age was found to have a statistically significant relationship with patient outcomes of a higher proportion of patients in each category ($F = 21.410$, $p = 0.0001$). Education had a strong and highly significant relationship with patient outcomes ($F = 36.742$, $p < 0.001$), with higher education being linked to optimal results and lower education to acceptable or suboptimal results. Moreover, Vitamin D supplements were found to have a statistically significant relationship with patient outcomes ($F = 19.992$, $p = 0.0001$), (Table 5).

Table 5. Differences in Patients' Level of Attitudes and Demographic Data (n=241)

Attitude with demographic data			**Patients**			
Variables			**Positive**	**Negative**	**F**	**P value**
Age	Mean=37.5	SD=8.19	73.1	26.9	21.410	0.0001
		%	Positive	Negative	F	P-value
Gender	Male	79.3	58.5	20.7	1.057	0.305
	Female	20.7	14.5	6.3		
Education	Not read	4.1	0	4.2	36.742	0.0001
	Primary	2.1	2.1	0		
	Secondary	18.7	10.4	8.3		
	Institute	54.4	41.9	12.6		
	Bachelor	20.7	22.6	2.1		
Supplements	Yes	49.8	33.2	16.7	19.992	0.0001
	No	50.2	39.8	10.3		

Age was found to have a highly significant association with patients' attitudes toward Vitamin D, with a majority of patients (73.1%) holding positive attitudes. Similarly, a strong association was observed between patients' education levels and their attitudes, with higher education levels being associated with more positive perceptions. Furthermore, Vitamin D supplement use was observed to have a significant association with patients' attitudes, with patients taking supplements holding more positive attitudes. However, gender was not observed to have a significant association with patients' attitudes. Based on the results, it can be concluded that age, education, and Vitamin D supplement use are

important determining factors for patients' attitudes toward Vitamin D, but gender lacks any significant influence (Table 6).

Table 6. Differences in Patients' Practices and Demographic Data (n= 241)

with demographic data			**Patients**				
Variables			**Good**	**Fair**	**Poor**	**F**	**P-value**
Age	Mean=37.5	SD=8.19	78.8	14.9	6.3	2.077	0.151
		%	Good	Fair	Poor	F	P-value
Gender	Male	79.3	62.2	10.7	6.2	1.057	0.305
	Female	20.7	16.5	4.1	0		
Education	Not read	4.1	0	4.1	0	36.743	0.0001
	Primary	2.1	2.1	0	0		
	Secondary	18.7	14.5	2.1	2.1		
	Institute	54.4	43.5	6.6	4.1		
	Bachelor	20.7	18.6	2.1	0		
Supplements	Yes	49.8	41.4	8.2	0	4.973	0.027
	No	50.2	37.3	6.6	6.2		

Age and gender did not have significant associations with the levels of practice of the patients related to Vitamin D ($F = 2.077$, $p = 0.151$; $F = 1.057$, $p = 0.305$). In contrast, educational level was highly significantly associated with practice ($F = 36.743$, $p < 0.001$), with higher education linked to better practices. Vitamin D supplement use was also significantly related to practice levels ($F = 4.973$, $p = 0.027$), as supplement users demonstrated better practices than non-users. Overall, education and supplement use were key determinants of good Vitamin D–related practices among patients (Table 7).

Table 7. Differences in Nurses' Level of Knowledge and Demographic Data (n= 236).

Knowledge with			**Nurses**				
			Good	**Accept**	**Poor**	**F**	**P-value**
Age	Mean=27.4	SD=5.29	76.7	16.9	6.4	4.086	0.018
		%	Good	Accept	Poor	F	P-value
Gender	Male	51.3	40.6	8.4	2.1	1.088	0.339
	Female	48.7	36.1	8.4	4.2		
Education	Secondary	4.2	2.1	2.1	0	6.349	0.002
	Institute	51.3	36.4	10.6	4.2		
	Bachelor	44.5	38.1	4.2	2.1		
Experiences	< 1 year	4.2	4.2	0	0	2.393	0.094
	1-5 years	76.7	59.7	10.6	6.3		
	6-10 years	12.7	6.3	6.3	0		
	> 10 years	6.4	6.3	0	0		

Age, gender, and years of experience showed significant associations with nurses' attitudes toward Vitamin D ($F = 4.086$, $p = 0.018$; $F = 6.393$, $p = 0.012$; $F = 32.942$, $p < 0.001$). Most nurses (65.7%) demonstrated positive attitudes, particularly those aged around the mean of 27.4 ± 5.29 years and those with 1–5 years of experience. In contrast, educational level was not significantly related to attitude ($F = 0.481$, $p = 0.489$). Overall, demographic and experiential factors, rather than formal education, were key determinants of nurses' attitudes toward Vitamin D (Table 8).

Table 8. Differences in Nurses' Level of Attitudes and Demographic Data (n= 236)

			Nurses			
			Positive	**Negative**	**F**	**P-value**
Age	Mean=27.4	SD=5.29	65.7	34.3	4.086	0.018
		%	Positive	Negative	F	P-value
Gender	Male	51.3	29.6	21.6	6.393	0.012
	Female	48.7	36	12.7		
Education	Secondary	4.2	29.6	21.6	0.481	0.489
	Institute	51.3	36	12.7		
	Bachelor	44.5	29.6	21.6		
Experiences	< 1 year	4.2	0	4.2	32.942	0.0001
	1-5 years	76.7	48.7	27.9		
	6-10 years	12.7	10.6	2.1		
	> 10 years	6.4	6.3	0		

Age, gender, and educational level showed significant associations with nurses' practice related to Vitamin D ($F = 4.086$, $p = 0.018$; $F = 12.990$, $p < 0.001$; $F = 11.494$, $p < 0.001$). However, a large proportion of nurses (42.8%) demonstrated poor practices despite a relatively young average age of 27.4 ± 5.29 years. Conversely, there was no significant correlation between experience and levels of practices ($F = 0.242$, $p = 0.785$). Taking together, these findings indicate that demographic and educational variables are crucial in defining nursing practices rather than experience (Table 9).

Table 9. Differences in Nurses' Practices and Demographic Data (n= 236)

Practice with			**Nurses**				
			Good	**Fair**	**Poor**	**F**	**P-value**
Age	Mean=27.4	SD=5.29	33.9	23.3	42.8	4.086	0.018
		%	Good	Fair	Poor	F	P-value
Gender	Male	51.3	10.6	16.9	23.7	12.990	0.0001
	Female	48.7	23.3	6.3	19.1		
Education	Secondary	4.2	2.1	0	2.1	11.494	0.0001
	Institute	51.3	23.3	8.4	19.4		
	Bachelor	44.5	8.4	14.8	19.4		
Experiences	< 1 year	4.2	0	2.1	2.1	0.242	0.785
	1-5 years	76.7	27.5	16.9	32.2		
	6-10 years	12.7	4.2	2.1	6.3		
	> 10 years	6.4	2.1	2.1	2.1		

Discussion

It is the need of the day to define the gaps between the knowledge and attitude of nurses and patients concerning the practices of vitamin D, and thus the importance of health education for improving outcomes can be identified. Therefore, the aim of the current research is to explore and compare the KAP of patients and nurses concerning vitamin D at the tertiary care hospitals. The findings of the research revealed that the nurses' level of knowledge and attitude towards vitamin D is better than patients', but there is a significant gap in the practices of patients.

The results show that the level of knowledge of nurses is greater than that of patients concerning vitamin D, especially with respect to its involvement in the absorption of

calcium, the health of the bones, and its presence in food. This is consistent with previous studies, which have already shown that the level of knowledge of health professionals is greater than that of others concerning vitamin D due to their educational background and working experience [15]. This has also been the case with the Middle Eastern population, where the scores of health professionals were significantly higher than those of patients [16].

However, there existed a gap in the level of knowledge in both categories in relation to the non-skeletal effects of vitamin D, particularly its association with cardiovascular health. It has also been observed in previous research that there exists a lack of awareness in relation to the non-skeletal uses of vitamin D even among medical practitioners [17, 18].

In various regions of the Middle East countries such as Iraq, Oman, and Saudi Arabia, there was found to be a satisfactory level of knowledge among the general public regarding vitamin D. More than half of the healthcare practitioners had been found to have good knowledge and practice in the study conducted in Ethiopia [19]. This has been supported by other studies [20, 21]. A similar gap was found in nursing students in North India by Khanna et al. [22], who, despite being aware of the importance of Vitamin D and its main source being sunlight, lacked adequate practical skills in relation to Vitamin D supplements and its levels in the blood.

The nurses and patients showed positive attitudes towards Vitamin D, with most appreciating its role in health. This study consists of knowledge, attitudes, and practices (KAP) surveys, which show positive attitudes despite moderate or low knowledge levels [23, 24]. Positive attitudes may be due to increased knowledge among people through various sources, such as health care and health education.

The nurses had stronger levels of agreement compared to patients in regard to educating patients on vitamin D. This reinforces the literature that has long acknowledged the pivotal role that nurses play in health promotion, prevention of diseases, as well as educating patients [25, 26]. On the other hand, the patients had lower levels of confidence in discussing issues pertaining to vitamin D. This has also been reinforced by literature that has shown that patients tend to look towards healthcare providers in order to start nutritional conversations [27, 28].

A positive attitude of most healthcare practitioners towards the evaluation and management of vitamin D deficiency is greatly related to improved practice [19]. Contrasting trends were found in students in health-related faculties at universities, in which most students showed moderate attitudes towards the use of vitamin D, reflecting a gap in attitudes towards actual practices like exposure to the sun and the intake of vitamin D supplements [20, 21].

About half of the nurses portrayed a satisfactory level of practice regarding vitamin D, while unsatisfactory practices did not reach a quarter of the nurses. The results are in line with the existing studies on healthcare practitioners, including nurses, suggesting that practices regarding vitamin D were of average adequacy in about fifty percent of the samples, while unsatisfactory practices occurred in twenty-five percent [21, 20].

The practices among patients in the use of vitamin D were also explored in this research, and the findings indicated that less than half the patients showed good practices, while over a quarter showed moderate practices. Further, the practices among patients in the use of vitamin D were observed to be suboptimal, with less than half the patients showing good practices and over a quarter showing merely moderate practices [29-31]. Though various studies have indicated a relatively higher utilization of vitamin D among patients, the findings in this research seem to reflect a relatively lower transfer of awareness to

practices. Interestingly, it has been observed in this research, and in various similar studies, that while patients are largely aware of the importance of vitamin D, this is not necessarily reflected in proper preventive practices, such as regular supplementation and adequate sun exposure. This is a significant reflection of the knowledge-practice gap and seems to imply the presence of factors not directly linked to the level of patients' awareness, such as perhaps unavailability for supplementation, a lack of proper professional advice, and certain lifestyle and cultural constraints, among patients in the use of vitamin D. Cultural, lifestyle, and environmental factors may significantly impact patients' practices in vitamin D, especially in areas where sun exposure is relatively limited.

While nurses practiced better than patients, there were no regular measurements of vitamin D intake or status among patients. This gap between knowledge and practice has been widely reported in literature, implying that knowledge alone is not enough to change practice [15, 26]. In the case of patients, the practices related to vitamin D supplement, sun exposure, and dietary intake were mostly moderate.

Similar results have also been found in Middle Eastern and Asian communities, which have been associated with poor vitamin D practices despite having good attitudes toward vitamin D [23, 24]. These findings stress the significance of planned interventions conducted by nurses that help promote changes and encourage long-term adherence to vitamin D recommendations.

Level of education was found to be a major predictor for the knowledge, attitudes, and practices of patients regarding vitamin D, as is the case worldwide, where greater levels of health literacy and preventive practices result from greater levels of health education [32,28]. Age was also a predictor for greater positive practices, possibly because they possess greater awareness about health and greater exposure to health care. For the nurses, the impact of education was greater than the impact of the number of years they had been in practice.

These statistically significant relationships have been found in various studies, including studies involving nurses and patients [19, 21, 30, 31]. On the other hand, there are studies that found that there were no statistically significant relationships between practices, knowledge, attitudes and age and education [19, 22, 27]. The results emphasize the importance of nurses in filling the gap between knowledge and practice with regard to vitamin D. Although nurses have a higher level of KAP compared to patients, the presence of suboptimal practices among nurses indicates a need for education. Vitamin D assessment, counseling, and documentation by nurses can be integrated with patient care to increase patient involvement. Evidence has been generated by systematic reviews that education programs led by nurses have been effective in increasing patient knowledge, adherence, and health behaviors [25, 26].

The cross-sectional study design limits the possibility of establishing causation. Moreover, the reliance upon self-reported practices might affect the study by introducing the possibility of recalling bias or social desirability bias. Despite these limitations, the study provides significant information concerning the KAP of nurses and patients with regard to vitamin D.

Conclusion

In summary, nurses scored higher in terms of both knowledge and attitudes toward vitamin D compared to patients, but there were some deficits in both. These results emphasize the need for specific education interventions by nurses aimed at improving both vitamin D knowledge and practices among both health care personnel and patients.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgement

Tameem Thamir would like to thanks the College of Nursing at the University of Mosul for their provided facilities to accomplish this research.

Ethical Approval

The study was registered and approved by College of Nursing at the University of Mosul.

Data Availability

Data available on request.

Author Contributions

All required work and written done by Tameem Thamir.

Funding

Self-funded.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art006

A Cross-Sectional Survey of the Public Health Implications of Farmers' Knowledge and Self-Reported Practices of Pesticide Usage in Vegetable Production in South Central, Jamaica

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Abstract

Agriculture plays a crucial role in Jamaica's economy, with some parishes serving as a major hub for crop production. A recent survey of farmers in South Central Jamaica examined pesticide usage practices in ready-to-eat vegetable farming. Twenty-nine farmers participated, most of whom were male, middle-aged, and had secondary-level education with over a decade of farming experience. Findings revealed that all farmers relied on multiple pesticides, with half using insecticides, herbicides, and fungicides together. While most followed label instructions and consistently used protective gear, comprehension of technical terms such as "Maximum Residual Limit" was limited. Farmers showed stronger awareness of pre-harvest intervals, drawing knowledge from labels and training programs. The findings highlight both strengths, such as adherence to safety practices, and gaps in knowledge dissemination. It calls for enhanced education, standardized guidelines, and policy development to safeguard public health while supporting sustainable agriculture in Jamaica. The study concluded that although farmers demonstrated significant experience and a commitment to safety, there are still gaps in knowledge dissemination and training. It further underscores the need for improved educational initiatives and standardized practices to reduce health risks, highlighting the importance of ongoing research and policy development to promote sustainable agriculture and public health in Jamaica.

Keywords: *Gross Domestic Product, Maximum Residual Limit, Pre-harvest Intervals.*

Introduction

Agriculture, though less dominant than Jamaica's services sector, remains vital for rural livelihoods and economic stability. In 2012, it contributed 6.8% to Gross Domestic Product and employed one third of the labour force [1]. In Jamaica, agriculture is a major economic activity with some southern parishes having up to 11.6% of national farmland and 91.3 hectares dedicated to ready-to-eat vegetables. Parishes in South Central Jamaica are also a major agricultural hub supported by over 23,000 registered farmers, though fewer than half of that number are active [2-5].

To sustain productivity and meet national food security goals, Jamaica imports 2,700–3,500 tons of synthetic pesticides annually, including hazardous varieties [6]. While pesticides protect crops, they pose serious health risks, being neurotoxic, teratogenic, and carcinogenic [7]. Locally, misuse has led to poisoning cases, with pesticide exposure accounting for 16.3% of all poisoning incidents in 2020 and 18 confirmed accidental cases in 2021 [8]. Global evidence also shows that farmers rely heavily on pesticides despite health hazards [9]. In Jamaica, the National Surveillance Unit of the Ministry of Health and Wellness has emphasized stricter monitoring

Received: 10.01.2026 ***Accepted: 10.03.2026*** ***Published on: 29.04.2026***
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and safer practices [10, 20], and the Ministry has also initiated studies to evaluate pesticide use and its impacts, aiming to guide preventative strategies [11]. Farmers' knowledge and practices are critical to these efforts, as awareness of safety measures directly influences pesticide usage patterns [12]. Examining farmers' behaviour and knowledge in South Central Jamaica provides insights for policy development to strengthen food safety, public health, and sustainable agriculture.

Agricultural pesticides represent a broad and diverse category of chemicals widely used in agriculture to protect crops from insects, weeds, and other pests [6]. While these chemicals play a critical role in sustaining large-scale farming, they are also potentially hazardous to human health. Many pesticides are classified as neurotoxic, with the ability to impair the nervous system; teratogenic, affecting reproductive health; and carcinogenic, carrying the risk of cancer in humans [7]. Despite these dangers, farmers globally have become increasingly reliant on pesticides as agriculture has expanded and industrialized over the decades [9]. This reliance underscores the importance of continually reviewing the list of approved pesticides and reinforcing safety precautions for their use in Jamaica [11].

Data from Jamaica's National Surveillance Unit (NSU) Ministry of Health and Wellness, Jamaica highlight the public health risks associated with pesticide exposure. In 2021, there were 18 confirmed cases of accidental pesticide poisoning, and prior to that year, pesticide poisoning accounted for 16.3% of all poisoning incidents [8, 10]. In response to these concerns and to safeguard food safety, the Government of Jamaica initiated a study to examine pesticide usage in the agricultural sector and its impact on the environment [11]. A key element of this issue is farmers' knowledge of pesticides and whether such knowledge translates into safe and responsible agricultural practices [12]. Addressing this gap will provide policymakers and relevant agencies with valuable insights to strengthen existing regulations and design effective campaigns promoting safe pesticide use. Against this backdrop, the present cross-sectional study was conducted to explore the public health implications of farmers' knowledge and practices regarding pesticide usage in ready-to-eat vegetable production in South Central Jamaica.

The aim of the study was to evaluate the public health implications relating to the knowledge and self-reported practices of farmers regarding pesticide usage in ready-to-eat vegetable production in South Central Jamaica. To achieve this aim, the study pursued three objectives: first, to determine the knowledge of farmers regarding the use of pesticides in the production of ready-to-eat vegetables; second, to determine the self-reported practices of farmers regarding the use of pesticides in the production of ready-to-eat vegetables; and third, to identify the public health significance associated with the knowledge and practices of pesticide usage on ready-to-eat vegetables.

Materials and Methods

A descriptive cross-sectional study with a quantitative approach was conducted in South Central Jamaica to assess farmers' knowledge and self-reported practices of pesticide use in ready-to-eat vegetable production. One farming extension area was randomly selected for inclusion in the study. According to the Rural Agricultural Development Authority (RADA), there were 353 registered farmers in the area [5]. Based on this population, a sample size of 183 was calculated to achieve a 95% confidence level with a ±5% margin of error.

Farmers who met the inclusion criteria; residing in the selected area and cultivating ready-to-eat vegetables were contacted directly. Ethical approval was obtained from the Research Ethics Committee of the Joint Colleges of Medicine, Oral Health, and

Veterinary Sciences at the University of Technology, Jamaica. Participants were informed of the purpose of the study, assured of confidentiality, and reminded of their right to withdraw at any time without consequence.

Despite the intended sample size of 183, only twenty-nine farmers consented to participate, resulting in a 15.8% response rate. Data were collected using structured questionnaires and face-to-face interviews. The instrument consisted of twenty-one closed-ended questions covering demographic characteristics, types of pesticides used, frequency and methods of application, safety precautions, training exposure, storage and disposal practices, and perceived public health implications.

Interviews were conducted in person, with responses recorded consistently to ensure accuracy. Farmers were asked to describe their practices in detail, including whether they followed label instructions, used protective equipment, observed pre-harvest intervals, and understood technical terms such as Maximum Residual Limits (MRLs). Questions also probed their experiences with pesticide poisoning, either personally or within their communities.

Results

A total of twenty-nine farmers participated in the study, representing a 15.8% response rate from the intended sample of 183. The demographic profile revealed that the majority of respondents were male (79.3%), while females accounted for a smaller proportion. Most participants were middle-aged, with 37.9% falling within the 44–55 age group. Educational attainment varied, but secondary-level education was most common, reported by 51.7% of respondents. Farming experience was extensive among participants, with 76% indicating that they had been engaged in agriculture for more than ten years. All respondents reported that ready-to-eat vegetables were among the first crops they cultivated, underscoring the importance of these crops in their farming practices.

Tomatoes were the most widely cultivated vegetable, grown by 79.3% of farmers. Hot peppers followed at 58.6%, while cabbage was cultivated by 55.5% of respondents. Sweet peppers were grown by 44.8%, and lettuce by 31%. Less frequently cultivated crops included cucumbers, onions, carrots, and scallions, which were mentioned by smaller proportions of farmers. This distribution highlights the diversity of vegetable production in South Central Jamaica, with tomatoes and peppers dominating the crop profile.

All farmers reported using pesticides in their farming practices. Among them, 44.8% applied insecticides, herbicides, and fungicides simultaneously, while 27% also incorporated rodenticides into their pest control strategies. Just over half of the farmers (51.7%) applied the same chemicals across all crops, whereas 48.3% varied their pesticide usage depending on the crop type. Nearly all respondents (96.6%) claimed to follow label instructions when applying pesticides, although 3.4% admitted to having trouble in understanding these instructions.

Safety practices were widely observed among the farmers. Every respondent acknowledged the importance of personal protective equipment (PPE), and 97% reported using overalls, gloves, masks, boots, and goggles during pesticide application. Despite this high level of compliance with PPE use, knowledge gaps were evident in other areas. For instance, 89.7% of farmers were unfamiliar with the term “Maximum Residual Limit,” a critical concept in food safety, while 93.1% demonstrated understanding of pre-harvest intervals. Sources of knowledge about PHIs included pesticide labels (34%), formal training programs, traditional knowledge passed down through generations, and personal research.

Formal training in pesticide use was reported by 59% of respondents, with most training sessions facilitated by RADA [5]. The majority

of these farmers attended training annually, though attendance was not universal. Chemical mixing practices varied among participants: 89.7% prepared their own mixtures, while 10.3% relied on pre-mixed products. Storage methods also differed, with 44.8% storing pesticides in general farm areas or designated spaces, 27% using chemical closets, and 17% restricting storage to farm-only areas.

Disposal practices were inconsistent. Approximately 24% of farmers disposed of pesticides through burning, burying, or garbage collection, while others employed combinations of these methods. Such practices raise concerns about environmental contamination and community health risks.

Awareness of the dangers of improper pesticide use was high, with 96.6% of respondents recognizing risks such as cancer, poisoning, and environmental pollution. Despite this awareness, half of the farmers (48.3%) reported personal or observed experiences of pesticide poisoning. Symptoms described included vomiting, headaches, dizziness, and skin irritation. Some respondents also reported knowing individuals who had died as a result of pesticide poisoning, underscoring the serious public health implications of unsafe pesticide practices.

Overall, the findings reveal a complex picture: farmers in South Central Jamaica demonstrate strong adherence to certain safety practices, such as PPE use and awareness of PHIs, but significant gaps remain in their understanding of technical food safety concepts, pesticide storage and disposal, and the broader environmental and health consequences of pesticide misuse.

Discussion

The study found that farmers producing ready-to-eat vegetables in South Central Jamaica were mostly male, middle-aged, and with limited formal education, though experienced [13]. All participants relied on synthetic pesticides, making their use a standard practice. As seen from research not only in Jamaica but across the Caribbean, pesticide use is intensive, with imports of highly hazardous chemicals posing risks to health and biodiversity [14, 15]. Despite Jamaica banning 22 pesticides, illegal imports and unregulated use persist [16], raising concerns about consumer safety and environmental pollution [18]. Training gaps and literacy challenges hinder safe pesticide use [17], with some farmers mixing or buying repackaged chemicals without labels, increasing exposure risks.

While most farmers used protective equipment, unsafe storage, and disposal practices such as burning, burying, or discarding near water sources were common [18]. Farmers understood Pre-Harvest Intervals (PHIs) but lacked knowledge of Maximum Residue Limits (MRLs), heightening the risk of residues in food [19, 20]. Health impacts were significant: half reported pesticide poisoning cases, with symptoms such as vomiting, headaches, dizziness, and skin irritation, and 14% knew individuals who had died. These findings confirm that agricultural workers are highly vulnerable to pesticide-related illnesses.

The results also highlight the paradox between farmers' awareness of immediate safety measures and their limited understanding of long-term food safety concepts. While protective equipment use was high, knowledge of MRLs was poor, suggesting that training programs emphasize personal safety but insufficiently address consumer protection and environmental health. This gap is critical, as pesticide residues in food can contribute to chronic health conditions among consumers, including cancers and reproductive disorders [7, 14].

Another important observation was the inconsistency in pesticide storage and disposal practices. Although some farmers used designated chemical closets or farm-only storage, others stored pesticides in general farm areas or disposed of them by burning or

burying. These practices pose risks of soil and water contamination, which can affect entire communities. International evidence shows that improper disposal contributes to long-term environmental degradation and biodiversity loss [15, 18].

The reliance on multiple pesticide formulations, including insecticides, herbicides, fungicides, and rodenticides, reflects the intensity of pest pressures in vegetable farming. However, this practice increases the likelihood of chemical interactions, resistance development, and cumulative health risks. Integrated Pest Management (IPM) strategies, which combine biological, cultural, and chemical controls, are underutilized in Jamaica despite their proven effectiveness in reducing pesticide reliance [14].

Formal training provided by RADA was reported by 59% of farmers, but attendance was inconsistent. This suggests that while training opportunities exist, barriers such as time, accessibility, or perceived relevance may limit participation. Strengthening farmer engagement in training programs and tailoring content to local literacy levels could improve outcomes.

Finally, the findings underscore the broader public health implications of pesticide use in ready-to-eat vegetable production. Consumers are exposed to residues when vegetables are harvested before PHIs are observed or when MRLs are exceeded. Farmers themselves face acute and chronic health risks from direct exposure, while communities are affected by environmental contamination. Addressing these issues requires a multi-sectoral approach involving government agencies, farmer organizations, and public health stakeholders.

Conclusion

Despite having a smaller sample size than anticipated, the insights gained into farming practices and pesticide usage among the twenty-nine participating farmers (15.8% response rate) are of significant value. The demographic analysis revealed a diverse group in terms of age, gender, and education, with the majority being male and most having attained secondary-level education. This distribution provides a nuanced understanding of the farming community and highlights the comprehensive nature of the study.

Most farmers had over ten years of farming experience, with tomatoes and hot peppers being the most cultivated ready-to-eat vegetables, reflecting local preferences and market demand. All respondents reported using a combination of pesticides, with many following label instructions, though some expressed difficulty with comprehension. Importantly, all farmers recognized the need for personal protective equipment, demonstrating a commitment to safety.

Formal training in pesticide use, primarily facilitated by the Rural Agricultural Development Authority (RADA), was reported by some farmers. However, notable gaps persist, leaving a segment of the farming community without sufficient knowledge of safe pesticide practices. In addition, storage methods varied, highlighting the urgent need for standardized protocols to mitigate both environmental and public health risks.

The findings are expected to inform targeted interventions, guiding both policy and practice to strengthen farmer training, promote standardized storage protocols, and safeguard public health in the region. Overall, the study successfully met its aim by identifying critical knowledge gaps, unsafe practices, and their implications, thereby providing evidence to support improved training and regulatory measures.

Conflict of Interest

The researchers declare that there were no personal, financial, or professional conflicts of interest that could have influenced the design, conduct, or reporting of this study.

Ethical Approval

This research was approved by the Research Ethics Committee of the Joint Colleges of Medicine, Oral Health, and Veterinary Sciences at the University of Technology, Jamaica.

Data Availability

Data were collected directly from participants through structured interviews and surveys. Due to confidentiality agreements, raw data are not publicly available. Aggregated results may be shared upon reasonable request.

Author Contributions

- **Richard Forrester:** Conceptualization, data collection, analysis, manuscript drafting.
- **Lyjian Bradnock:** Data collection, literature review, manuscript editing.
- **Crystal Brooks:** Data analysis, results interpretation, manuscript preparation.
- **Dr. Karlene Atkinson:** Supervision, methodological guidance, critical review, final approval of manuscript.

Funding

This research received no external funding. It was supported internally by the University of Technology, Kingston, Jamaica.

Acknowledgements

The researchers thank the Research Ethics Committee, participating farmers, RADA, and academic staff at the School of Public Health and Health Technology for their support.

Recommendations

Based on the findings of this study, the following recommendations are proposed to the Ministry of Agriculture, Fishereies and Mining, The Ministry of Health and Wellness and other agricultural stakeholders. To strengthen safe pesticide, use and reduce public health risks in South Central Jamaica:

- Expand farmer training programs to ensure all farmers receive updated guidance on safe pesticide handling, storage, and disposal.
- Simplify technical information by providing user-friendly guides and visual aids to explain complex terms such as Maximum Residual Limits (MRLs) and Pre-Harvest Intervals (PHIs).
- Establish community-based initiatives for the safe collection and disposal of empty pesticide containers to reduce environmental contamination.
- Strengthen regulatory oversight with stricter enforcement against illegal imports and repackaged chemicals without labels.
- Promote Integrated Pest Management (IPM) and Integrated Crop Management (ICM) practices to reduce reliance on synthetic pesticides while maintaining crop productivity.
- Launch public campaigns to educate both farmers and consumers about the risks of pesticide misuse and the importance of food safety.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art007

Histopathological Findings and Relationship with Liver Function Tests on Patients with Chronic Hepatitis B Infection Attending Federal University Teaching Hospital, Lafia, North Central Nigeria

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Abstract

Objective: The study aims to determine the histopathological findings in patients with chronic Hepatitis B infection and their relationship to liver function tests. Materials and methods: A total of 200 HBV-positive patients aged 16 years or older who attended the gastroenterology unit of the Federal University Teaching Hospital, Lafia, were recruited using convenience sampling. The socio-demographic characteristics were recorded; venous blood was sampled for HBV serological marker testing using Enzyme-linked immunosorbent assay kits; a Tru-Cut biopsy needle was used for liver biopsy; and liver pathology was assessed using a magnetic resonance imaging machine. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. The results were presented in the table, with a significance level of $p < 0.05$. Results: The mean age of patients was 34.87 ± 10.78 years. There were (70.5%) males, and (29.5%) females. Histology results revealed ballooning degeneration (9.5%), Fibrosis (5.5%), inflammation (6.0%), Steatosis and ground-glass (1.5%), fatty liver and necrosis (1.0%). The liver function test revealed that (15.0%), (52.5%), (32.5%), and (6.5%) had elevated platelet prothrombin ratio, international normalization ratio, protein, and albumin, with (35.5%), (44.0%), and (29.0%) had elevated alkaline phosphatase, alanine transaminase (ALT), and aspertase transaminase (AST). The patient with normal AST had the greatest ballooning compared with those with elevated AST (13.6% vs 4.5%), a difference that was statistically significant. Patients with normal ALT had higher inflammation than those with high ALT (9.2% vs 1.4%), with a statistically significant difference (p=0.033). Conclusion: Liver biopsy will be recommended for patients with chronic hepatitis B showing normal AST and ALT levels.

Keywords: *Ballooning Generation, Fatty Liver, Fibrosis, Hepatitis, Histopathology, Liver Biopsy.*

Introduction

Background Study

The liver is the largest digestive organ in the human body and plays a role in metabolizing most substances [1]. Therefore, liver damage, which can occur for various reasons, significantly impacts a large proportion of the body's metabolism, including the metabolism of blood lipids, blood sugar, uric acid, and

Received: 25.02.2026 ***Accepted: 08.03.2026*** ***Published on: 29.04.2026***

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proteins [2]. However, histopathological evaluation of liver biopsy specimens remains the gold standard for diagnosing liver injuries, including steatosis, lobular inflammation, hepatocellular ballooning, and fatty liver [3]. Hepatitis B virus (HBV) is a Hepadnavirus belonging to the family of Hepadnaviridae with small enveloped spherical virions that contain a circular-double-stranded Deoxyribonucleic acid (DNA) molecule that infects liver cells, and subsequently develops hepatocellular carcinomas (HCC). However, more than 2 billion people worldwide are estimated to have had hepatitis B virus (HBV) infection, with 350–400 million being chronic carriers of the virus [4]. Also, HBV accounts annually for an estimated one million deaths worldwide [5]. An estimated 3.6% of the global population was affected by chronic Hepatitis B virus infection [6]. An estimation of 5–15% of adults in sub-Saharan Africa are chronically infected with HBV [7]. There was a 15–25% risk of dying prematurely in adulthood from HBV-related cirrhosis and hepatocellular carcinoma. At the same time, a small proportion of those with acute infections may succumb to fulminant liver failure [6]. In Africa, approximately 60 million people live with chronic HBV infection with an estimated prevalence of 6.2% [8]. In Africa, Nigeria was ranked among the countries with hyperendemic HBV infection (>8%) [9]. Approximately nine in ten Nigerians who live with chronic HBV are unaware of their infection status and are missing from the global public health statistics due to a lack of resources, awareness, and political will for addressing Nigeria's HBV plight [10]. Consequently, Nigeria has one of the highest rates of HBV-attributable cancer in West Africa, with an age-standardized incidence estimate of 2.6 to <5.1 cases per 100,000 person-years [11]. HCC is a highly aggressive cancer with limited treatment options, often lacking in resource-constrained settings [12]. The lack of affordable diagnostics, especially specialized immunoassays and nucleic acid tests, as well as the out-of-pocket cost for vulnerable populations, constitute potential barriers in eliminating viral hepatitis B in Nigeria, thus making HBV a significant threat to public health. North Central Nigeria was a highly endemic region that experienced higher morbidity and mortality from this disease, which is why this study was conducted [13, 14]. Liver biopsy was considered the most accurate method for assessing neuroinflammatory activity (grading) [15]. The degree of aminotransferase elevation does not adequately reflect disease severity and correlates poorly with histologic grading. Therefore, a histological study was the easiest way to determine the disease stage by assessing the type and extent of fibrosis, along with the recognition of architectural disturbances (staging) [16]. According to the European Association for the Study of the Liver (EASL) and the Society for Gastroenterology and Hepatology in Nigeria (SOGHIN) Guidelines [17], treatment for CHB were indicated in patients with an HBV DNA level above 2000 IU/ml and serum alanine aminotransferase (ALT) levels more than twice the upper limit of normal in Hepatitis B envelope antigen (HBe-Ag) negative CHB. However, liver biopsy was indicated if there was a discordance between the ALT and HBV-DNA levels. Also, the clinical guidelines published by the American Association for the Study of Liver Diseases (AASLD) recommend liver biopsy only for specific groups of patients, stating that it is usually unnecessary in young patients who are HBe-Ag negative and have persistently normal ALT levels [18]. The Nigerian guidelines for HCC surveillance recommend surveillance for all hepatitis B surface antigen (HBsAg) positive individuals over 20 years of age, including CHB patients in the inactive phase and those with cirrhosis [19]. This excludes individuals younger than 20 years, and many of these patients may be lost to follow-up, later presenting with complications of CHB. The present study, aimed at assessing

histopathological findings and correlating them with liver function tests in patients with chronic hepatitis B viral infection attending a specialist hospital in north central Nigeria, was designed to determine the histopathological impairments, the liver function tests, and their relationship. The outcomes of this research could be very useful to the Federal Ministry of Health, the Pharmacists' Council of Nigeria, the State Ministry of Health, and, especially, to gastroenterologists in making informed decisions when managing patients with chronic hepatitis B.

Materials and Methods

Study Area

The research was conducted at Federal Teaching Hospital, Lafia, North Central Nigeria. Nasarawa State was one of the 36 states in Nigeria, with its Capital in Lafia. The State Capital was one of the 13 local government areas of the state, located at 8.480° North latitude and 8.520° East longitude, with an elevation of 290 meters above sea level and a land area of 27,117 km. Nasarawa State and its surroundings were in Nigeria's middle belt (north-central region), characterized by an average temperature of 31 °C and an average humidity of 64% [20]. Nasarawa State was bounded in the North by Plateau State, South by Benue State, East by Cross-River State, and West by the Federal Capital Territory (FCT) Abuja.

Study Site

The study was carried out at the Department of Internal Medicine [Gastroenterology unit], Federal University Teaching Hospital, Lafia, North Central Nigeria. This clinic serves over 10,000 hepatitis B-positive patients, including adolescents on antiviral therapy. The clinic operates every Tuesday, with all positive patients in attendance.

Study Design

This research work was a hospital-based cross-sectional study.

Study Population

The study population comprises all patients with chronic hepatitis B aged 16 years or older who attend the Federal University Teaching Hospital in North Central Nigeria.

Inclusion Criteria

1. All patients diagnosed with Hepatitis B were recruited for this study.
2. All the patients who signed the consent were recruited for this Study.
3. All the patients who are 16years and above were recruited for this study.

Exclusion Criteria

1. Patients co-infected with hepatitis C, the Delta virus, or human immunodeficiency virus.

Sample Size Determination

The sample size was determined using the Leslie Kish formula for calculating proportions in a large population [21].

$$Sample\ Size\ (n) = \frac{Z^2pq}{\delta^2}$$

n = the desired minimal sample size when the population is more than 10,000.

z = is the standard normal deviation corresponding to the level of significance and is constant at 95% confidence interval (1.96). therefore $Z^2 = 1.96^2 = 3.842$.

p = Prevalence of the outcome of interest, which is histopathological findings and relationship with liver function test on patients with hepatitis B, and was found to be 35.7% [22] = 0.36.

q = 1-p, the power of the study is 1 – 0.36 = 0.64.

δ= the expected precision is 5% = (p value of 0.05), therefore $\delta^2 = 0.05^2 = 0.0025$.

$$n = \frac{3.84(0.36 \times 0.64)}{0.0025}$$

n = 347.

The population N was 38 (the number of chronic hepatitis B patients who attended the clinic per week) × 4 weeks × 3 months (the study duration) = 456. Therefore, N = 456.

nf = the desired sample size when the population is less than 10,000. For this study, the population was 200.

$$nf = \frac{n}{1} + \frac{(n-1)}{(N)}$$

$$nf = \frac{347}{1} + \frac{(347-1)}{(200)}$$

nf =203.7 (approx. 200).

Sample Techniques

Convenience sampling was used to recruit participants. This sampling method involved recruiting individuals primarily because they are available, willing, or easy to contact. A total of 200 participants were recruited for the study, and the target population size was 456; any additional participants who could be reached will be recruited. An average of 38 participants attends the clinic every week. This means that, to recruit 200 participants, the duration will be 200 divided by 38, which is 10.97 (approx. 11) weeks. This will be approximately 2.75 months (approx. 3 months).

Data Collection Method

The data collection was in four phases.

1. **First phase**: The first phase involved the social demographic characteristics, such as age and sex, by the staffing nurse during the clinic.
2. **Second phase**: The second phase involved the venous blood sampling for testing of Hepatitis B Virus profile, such as (HBsAg, HBsAb, HBcAb, and HBeAB, respectively). It was assayed using an enzyme-linked immunosorbent assay (ELISA) kit from Diagnostic Bioprobes Srl, Milan, Italy, with sensitivity and specificity of 100% and 98.8%, respectively. In contrast, the HBV surface antigen (HBsAg) was assayed using the ELISA kit by Bio-Rad Laboratories, Berkeley, CA, with a sensitivity of 100% and specificity of 99.4%. Other parameters assayed include packed cell volume, white blood cell, platelets, and serum biochemical parameters such as alkaline phosphatase, aspartate aminotransferase, gamma-glutamyl transferase, creatinine, albumin, total bilirubin, conjugated bilirubin, platelets thrombin ratio (PTR), partial thromboplastin time (PTT), international normalization ratio (INR), etc. The laboratory test results for individuals were anonymously linked to individual and household questionnaire information through their unique identifiers.
3. **Third phase**: it involved the liver biopsy, which was performed using a liver biopsy needle (Trucut biopsy needle). The biopsy samples were fixed in buffered formaldehyde for 24 hours and then processed by routine procedures. It was evaluated by a pathologist who was blinded to clinical and virological findings, using hematoxylin- and eosin-stained sections and periodic acid-Schiff stain. Masson's trichrome and Sweet's reticulin stains were reviewed for fibrosis and structural change. Other pathological lesions studied included ballooning degeneration, steatosis without fibrosis, chronic inflammatory cells, mild to moderate microvascular steatosis, plasma cell infiltration, Periportal inflammation, etc.
4. **Fourth phase**: it involved the use of a scanning machine to obtain pathological features such as fatty livers, hepatomegaly, shrunken liver, masses, ascites, etc.

Data Management

Measurement of Variables

The variables were the dependent and independent variables. The dependent variable, also known as the outcome variable, was Histopathological findings and hepatitis B. In contrast, the independent variables were the factors that determined the spread of Hepatitis B infections, liver function test results, and sociodemographic characteristics.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 23.0 was used to process data, and statistical analyses were performed and summarized using appropriate measures of central tendency and dispersion. Significance tests were conducted using the chi-square test; p-values < 0.05 were considered statistically significant at the 95% confidence level. Results were displayed in tables.

Limitations

1. This study was a single facility-based study that included only clients who were in care at the time, which limits its generalizability.
2. There was limited research concerning hepatitis in Nigeria, which made it difficult to access information.

Results

Table 1. Shows the Socio-Demographic Characteristics of Study Participants (n=200)

Variables	Frequency	Percent
Age (in years)		
15-25	46	23.0
26-35	74	37.0
36-45	45	22.5
46-55	26	13.0
56-65	9	4.5
Mean=34.87±10.78		
Sex		
Male	141	70.5
Female	59	29.5
Occupation		
Farmers	5	2.5
Civil Servant	118	59.0
Students	36	18.0
Housewife	19	9.5
Traders	22	11.0

A total of 200 patients were recruited for the study; their ages ranged from 15 to 65 years, with a mean age of 34.87±10.78 years. There were (70.5%) males, and (29.5%) females. The majority (59%) of the patients were civil servants, and the fewest (5; 2.5%) were farmers (Table 1).

Table 2. Histological Findings of Study Participants (N=200)

Variables	Yes (%)	No (%)
Ballooning	19(9.5)	181(90.5)
Fibrosis	11(5.5)	189(94.5)
Inflammatory cells	12(6.0)	188(94.0)
Steatosis	3(1.5)	197(98.5)

Ground glass	3(1.5)	197(98.5)
Fatty liver	2(1.0)	198(99.0)
Necrosis	2(1.0)	198(99.0)

Histology results of participants showed ballooning generation (9.5%). Fibrosis (5.5%), inflammation (6.0%). Steatosis and ground glass (1.5%), fatty liver and necrosis (1.0%), respectively (Table 2).

Table 3. Liver Function Tests of Study Participants (n=200)

Variables	**Frequency**	**Percent**
Platelet Prothrombin ratio		
Normal	125	62.5
High	30	15.0
Not documented	45	22.5
International normalization ratio		
Normal	50	25.0
High	105	52.5
Not documented	45	22.5
Protein		
Normal	125	62.5
High	65	32.5
Not documented	10	5.0
Albumin		
Low	54	27.0
Normal	123	61.5
High	13	6.5
Not documented	10	5.0
Bilirubin Total		
Low	1	0.5
Normal	160	80.0
High	30	15.0
Not documented	9	4.5
Bilirubin Conjugated		
Normal	141	70.5
High	50	25.0
Not documented	9	4.5
Alkaline Phosphatase		
Normal	134	67.0
High	58	29.0
Not documented	8	4.0
Alanine Transaminase (ALT)		
Normal	120	60.0
High	71	35.5
Not documented	9	4.5
Aspartate Aminotransferase (AST)		

Normal	103	51.5
High	88	44.0
Not documented	9	4.5

The liver function test of the participants showed that (15.0%), (52.5%), (32.5%), and (6.5%) had elevated platelet prothrombin ratio, international normalization ratio, protein, and albumin, respectively. The result also showed that (15.0%), (25.0%), and (29.0%) had elevated total bilirubin, conjugated bilirubin, and alkaline phosphatase, respectively. The liver function test also revealed that (29.0%), (35.5%), and (44.0%) had elevated alkaline phosphatase, alanine transaminase (ALT), and aspartate transaminase (AST), respectively (Table 3).

Table 4. Association Between Fibrosis, Ballooning Histology, and Liver Function Tests

Variables	**Fibrosis**		**Test statistics**	**p-value**	**Ballooning**		**Test statistics**	**p-value**
	Yes n(%)	**No n(%)**			**Yes n(%)**	**No n(%)**		
Platelet Prothrombin ratio			0.47	0.490			2.07	0.150
Normal	8(6.4)	117(93.6)			13(10.4)	112(89.6)		
High	3(10.0)	27(90.0)			6(20.0)	24(80.0)		
International normalization ratio			2.90	0.088			0.20	0.648
Normal	1(2.0)	49(98.0)			7(14.0)	43(86.0)		
High	10(9.5)	95(90.5)			12(11.4)	93(88.6)		
Protein			0.25	0.617			0.19	0.662
Normal	8(6.4)	117(93.6)			12(9.6)	113(90.4)		
High	3(4.6)	62(95.4)			5(7.7)	60(92.3)		
Albumin			2.62	0.269			0.28	0.869
Low	2(3.7)	52(96.3)			4(7.4)	50(92.6)		
Normal	7(5.7)	116(94.3)			12(9.8)	111(90.2)		
High	2(15.4)	11(84.6)			1(7.7)	12(92.3)		
Bilirubin Total			3.79	0.150			0.72	0.695
Low	0(0.0)	1(100.0)			0(0.0)	1(100.0)		
Normal	7(4.4)	153(95.6)			14(8.8)	146(91.3)		
High	4(13.3)	26(86.7)			4(13.3)	26(86.7)		
Bilirubin Conjugated			0.62	0.429			0.52	0.468
Normal	7(5.0)	134(95.0)			12(8.5)	129(91.5)		
High	4(8.0)	46(92.0)			6(12.0)	44(88.0)		
Alkaline Phosphatase			0.21	0.647			0.05	0.813
Normal	7(5.2)	127(94.8)			13(9.7)	121(90.3)		
High	4(6.9)	54(93.1)			5(8.6)	53(91.4)		
Alanine Transaminase (ALT)			0.34	0.558			0.75	0.386
Normal	6(5.0)	114(95.0)			13(10.8)	107(89.2)		
High	5(7.0)	66(93.0)			5(7.0)	66(93.0)		
Aspartato transaminasi (AST)			0.06	0.798			4.55	0.033*
Normal	5(4.9)	98(95.1)			14(13.6)	89(86.4)		
High	5(5.7)	83(94.3)			4(4.5)	84(95.5)		

Table 4: Association between fibrosis, ballooning, and liver function test. The results show no statistically significant association between fibrosis and any of the liver function tests. (P>0.05). On the other hand, only patients with normal AST had the highest prevalence of ballooning compared with those with elevated AST (13.6% vs 4.5%), a statistically significant difference.

Table 5. Association Between Fatty Liver, Ground Glass, and Liver Function Tests

Variables	**Fatty Liver**		**Test statistics**	**p-value**	**Ground Glass**		**Test statistics**	**p-value**
	Yes n(%)	**No n(%)**			**Yes n(%)**	**No n(%)**		
Platelet Prothrombin ratio			0.48	0.486			0.38	0.536
Normal	2(1.6)	123(98.4)			2(1.6)	123(98.4)		
High	0(0.0)	30(100.0)			1(3.3)	29(96.7)		
International normalization ratio			0.29	0.589			1.45	0.22
Normal	1(2.0)	49(98.0)			0(0.0)	50(100.0)		
High	1(1.0)	104(99.0)			3(2.9)	102(97.1)		
Protein			0.22	0.636			0.00	0.974
Normal	1(0.8)	124(99.2)			2(1.6)	123(98.4)		
High	1(1.5)	64(98.5)			1(1.5)	64(98.5)		
Albumin			6.14	0.046*			1.66	0.436
Low	0(0.0)	54(100.0)			0(0.0)	54(100.0)		
Normal	1(0.8)	122(99.2)			3(2.4)	120(97.6)		
High	1(7.7)	12(92.3)						
Bilirubin Total			1.79	0.407			0.59	0.744
Low	0(0.0)	1(100.0)			0(0.0)	1(100.0)		
Normal	1(0.6)	159(99.4)			3(1.9)	157(98.1)		
High	1(3.3)	29(96.7)			0(0.0)	0(0.0)		
Bilirubin Conjugated			0.59	0.441			0.08	0.776
Normal	1(0.7)	140(99.3)			2(1.4)	139(98.6)		
High	1(2.0)	49(98.0)			1(2.0)	49(98.0)		
Alkaline Phosphatase			0.87	0.350			0.01	0.905
Normal	2(1.5)	132(98.5)			2(1.5)	132(98.5)		
High	0(0.0)	58(100.0)			1(1.7)	57(98.3)		
Alanine Transaminase (ALT)			1.19	0.274			0.01	0.890
Normal	2(1.7)	118(98.3)			2(1.7)	118(98.3)		
High	0(0.0)	71(100.0)			1(1.4)	70(98.6)		
Aspartato transaminasi (AST)			0.01	0.911			2.60	0.107
Normal	1(1.0)	102(99.0)			3(2.9)	100(97.1)		
High	1(1.1)	87(98.9)			0(0.0)	88(100.0)		

Table 5: Association between fatty liver, ground glass, and liver function test. The result shows that patients with high albumin had the highest prevalence (7.7%) of fatty liver

compared with those with normal (0.8%) and low (0.0%) albumin. This was statistically significant (p<0.05). On the other hand, there is no statistically significant association between ground glass and any liver function test. (P>0.05).

Table 6. Association Between Steatosis, Inflammation, and Liver Function Tests

Variables	**Steatosis**		**Test statistics**	**p-value**	**Inflammation**		**Test statistics**	**p-value**
	Yes n(%)	**No n(%)**			**Yes n(%)**	**No n(%)**		
Platelet Prothrombin ratio			0.73	0.392			0.06	0.806
Normal	3(2.4)	122(97.6)			10(8.0)	115(92.0)		
High	0(0.0)	30(100.0)			2(6.7)	28(93.3)		
International normalization ratio			0.00	0.968			0.00	0.934
Normal	1(2.0)	49(98.0)			4(8.0)	46(92.0)		
High	2(1.9)	103(98.1)			8(7.6)	97(92.4)		
Protein			0.22	0.636			1.75	0.186
Normal	1(0.8)	124(99.2)			10(8.0)	115(92.0)		
High	1(1.5)	64(98.5)			2(3.1)	63(96.9)		
Albumin			1.10	0.577			6.87	0.032*
Low	0(0.0)	54(100.0)			2(3.7)	52(96.3)		
Normal	2(1.6)	121(98.4)			7(5.7)	116(94.3)		
High	0(0.0)	13(100.0)			3(23.1)	10(76.9)		
Bilirubin Total			0.59	0.744			17.02	0.000*
Low	0(0.0)	1(100.0)			1(100.0)	0(0.0)		
Normal	3(1.9)	157(98.1)			11(6.9)	149(93.1)		
High	0(0.0)	30(100.0)			0(0.0)	30(100.0)		
Bilirubin Conjugated			8.59	0.003*			0.599	0.439
Normal	0(0.0)	141(100.0)			10(7.1)	131(92.9)		
High	3(6.0)	47(94.0)			2(4.0)	48(98.0)		
Alkaline Phosphatase			0.01	0.905			1.11	0.291
Normal	2(1.5)	132(98.5)			10(7.5)	124(92.5)		
High	1(1.7)	57(98.3)			2(3.4)	56(96.6)		
Alanine Transaminase (ALT)			1.13	0.287			4.56	0.033*
Normal	1(0.8)	119(99.2)			11(9.2)	109(90.8)		
High	2(2.8)	69(97.2)			1(1.4)	70(98.6)		
Aspartato transaminasi (AST)			0.19	0.655			0.10	0.752
Normal	2(1.9)	101(98.1)			7(6.8)	96(93.2)		
High	1(1.1)	87(98.9)			5(5.7)	83(94.3)		

*= *Statistically significant*

Table 6: Association between steatosis, inflammation, and liver function tests. The result shows that only patients with high conjugated bilirubin had the highest prevalence of steatosis compared with those with normal conjugated bilirubin. (6.0% vs 0.0%) This was statistically significant (p<0.05). On the other hand, patients with a high albumin level (23.1%) had the highest prevalence of inflammation, whereas those with a low albumin level (3.7%) had the lowest. This was statistically significant (p=0.032). Patients with low total bilirubin (100%) had a higher prevalence of inflammation than those with

normal (6.9%) or high (0.0%) bilirubin. This was statistically significant ($p<0.01$). Patients with normal ALT had the highest prevalence of inflammation compared with those with high ALT (9.2% vs 1.4%). This was statistically significant ($p=0.033$).

Discussion

This study recruited 200 patients with CHBV aged 15-65 years, with a mean age of 34.87±10.78 years. In this study, more patients contracted this virus between the ages of 15 and 35. This was similar to the findings of Mei-hwei (2008), who reported that HBV acquisition occurs in early childhood in areas of high endemicity, such as Nigeria, and is mostly asymptomatic [23]. According to Andersson et al. (2015), early HBV acquisition was either vertical or horizontal, both of which are common in sub-Saharan Africa [24]. Age was an important factor in the prevalence and incidence of HBV infection, particularly in the age at acquisition [25]. The early acquisition of HBV was similar to that reported by Moses *et al*. (2010) [26]. In this Study, the majority of the patients were Males because males indulge in activities that predispose them to the acquisition of HBV, such as sexual harassment, alcoholism, non-adherence to HBV medications, etc. This finding was similar to that of Oje et al. (2024), in which males were more than females [27]. In this study, the histology reports include ballooning degeneration, Fibrosis, inflammation, steatosis, ground-glass appearance, fatty liver, and necrosis. However, hepatocyte ballooning was characterized by enlarged hepatocytes with pale, rarefied cytoplasm, usually with a large, hyperchromatic nucleus and a prominent nucleolus, indicating hepatocellular injury [28]. Again, hepatic fibrosis recorded in this study was caused by the excessive production, deposition, and net accumulation of extracellular matrix by activated hepatic stellate cells and other myofibroblasts [29]. According to Leow et al., steatosis, or fatty change, was the accumulation of fat droplets in the hepatocyte cytoplasm and could be classified as macrovesicular or microvesicular based on the size of the lipid droplets [30, 31]. Fatty liver was caused by excessive accumulation of fat in hepatocytes [32]. The findings in this study were similar to those of Cataldo et al. [33].

The results of this study also showed that both ALT and AST levels were significantly higher in patients with liver disease than in normal subjects ($p=0.000$). ALT and AST are both useful in assessing liver function alterations, although ALT is more specific [34, 35].

The results showed that alkaline phosphatase levels were significantly elevated in patients with liver disease compared with those in normal individuals. Alkaline phosphatase is useful in assessing liver injury but may not specifically indicate liver disease [36]. The findings above were similar to those of Asirri et al. [37]. The results showed that patients with liver disease had significantly elevated bilirubin levels compared with normal persons ($p=0.000$). This is consistent with other studies in which elevated bilirubin levels reflect damage and inflammatory conditions [38]. According to Musarrat (2009), patients with chronic hepatitis B have prothrombin time prolonged along with significantly raised bilirubin, albumin, and transaminase, which is similar to the findings in this study [39]. According to li *et al*. [2023], revealed that liver enzymes (AST and ALT) are indicators of hepatocyte injury, which do not correlate well with the severity of underlying histological changes like inflammation, fibrosis, or ballooning since the patients can have normal liver function tests with significant non-alcoholic fatty liver disease (NAFLD) or non-alcoholic steatohepatitis (NASH) and active liver damages [40]. This is because in many liver diseases, like cirrhosis, the number of functional hepatocytes decreases, which can lead to near-normal levels of AST and ALT, even in advanced stages of hepatocyte

ballooning, which was a critical feature in the diagnosis of steatohepatitis (both alcoholic and non-alcoholic) and was strongly associated with the progression to more severe fibrosis and adverse liver-related outcomes [40]. The study underscores the importance of assessing histological features directly (via biopsy or advanced imaging techniques like FibroScan) rather than relying solely on standard blood tests for accurate disease staging and prognosis. The lack of a significant association between fibrosis and all liver function tests ($P>0.05$) further supports the idea that traditional LFTs are poor standalone markers for assessing the presence or severity of liver scarring (fibrosis) [41]. There was a statistically significant association between fatty liver and high albumin levels, with patients having high albumin showing the highest prevalence of fatty liver (7.7%) compared to those with normal (0.8%) or low (0.0%) albumin. The liver synthesizes albumin, the most abundant protein in plasma, and low albumin indicates liver dysfunction. According to Takahashi *et al*. (2023), cases of significant liver damage, such as advanced fatty liver disease (cirrhosis), show that the liver's ability to produce albumin decreases, leading to low blood albumin levels. Low albumin was a key indicator of severe or long-term liver issues and is associated with a poorer prognosis and increased mortality risk [42].

Conclusions

This study concluded that standard liver function tests do not capture the full extent of liver pathology, including significant microscopic damage, such as hepatocyte ballooning, which is seen in some patients with normal or near-normal AST levels. However, this study suggested that a comprehensive diagnostic approach, potentially involving liver biopsy or non-invasive imaging, is necessary for accurate assessment of liver health in patients with chronic hepatitis B.

Ethical Consideration

Ethical approval for this Research was sought and obtained from the Research and Ethics Committee of the Federal University Teaching Hospital, Lafia, North Central, Nigeria, with reference number FUTHREC/578. Informed and written consent were obtained from all participants.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding

The article received no funding from any agency.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon request.

Authors' Contributions

BRN and NAN were involved in the experiment and data processing, as well as in revising the original draft. AE and NJ contributed to data curation, experiment, methodology, and project administration. AE, DN, and MRK were involved in writing, review, editing, and data curation.

Acknowledgement

The authors acknowledged the management of Federal University Teaching Hospital, Lafia, North Central Nigeria, for approving this research in their health facility.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art008

Seroprevalence of Hepatitis B and C and Associated Risk Factors among Healthcare Workers and Medical Students in the Southwest Cameroon

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Abstract

Hepatitis B (HBV) and Hepatitis C (HCV) are major viral infections affecting the liver and contribute significantly to global morbidity and mortality. Healthcare workers (HCWs) and medical students are particularly vulnerable to these infections due to frequent exposure to blood, sharp instruments, and bodily fluids during clinical practice. Identifying the burden of these infections among these groups is important for strengthening infection prevention policies and targeted interventions. A cross-sectional study was conducted to determine the seroprevalence of HBV and HCV among three cohorts: HCWs with at least one year of clinical experience, first-year medical and paramedical students with minimal clinical exposure, and final-year medical, nursing, and paramedical students with multiple clinical placements. Participants were screened for HBV and HCV serological markers using Enzyme-Linked Immunosorbent Assay (ELISA) technique and panel rapid test kits, and potential risk factors were collected. Statistical Package for Social Sciences (SPSS) version 25 was used to get proportions and binary logistic regression for associations. A total of 374 participants were included, 51.3% HCWs and 48.7% students. The overall seroprevalence of HBV was 4.8% (95% CI:2.9-7.4), with the highest prevalence observed among final-year students (9.3%, 95% CI:8.8-9.9), compared with 3.7% (95% CI:1.0-7.1) among first-year students and 3.6% (95% CI:1.5-7.3) among HCWs. The overall prevalence of HCV was 2.1% (95% CI:0.9-4.2), with slightly higher prevalence among students (2.7%;95% CI:0.3-9.3) than among HCWs (1.6%;95% CI:0.3-4.5). No demographic or occupational factors were significantly associated with HBV or HCV seropositivity. This study demonstrated a relatively low seroprevalence of HBV and HCV among healthcare workers and medical and paramedical students. Strengthening screening, vaccination programs, and infection prevention strategies is essential to protect these high-risk groups.

Keywords: *Healthcare Workers, Hepatitis B, Hepatitis C, Medical Students, Seroprevalence.*

Introduction

Hepatitis B and C viral infections continue to pose a significant global health challenge, as reported by the World Health Organisation (WHO) [1]. Globally, an estimated 254 million people are living with chronic hepatitis B virus (HBV) infection, while approximately 50

Received: 30.03.2026 ***Accepted: 15.04.2026*** ***Published on: 29.04.2026***
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million are affected by hepatitis C virus (HCV) infection [2]. Although the incidence of new viral hepatitis infections declined from 2.5 million cases in 2019 to 2.2 million in 2022, the burden remains substantial [3]. Of these new infections, about 1.2 million were attributed to HBV, and nearly one million to HCV, with the highest incidence observed in the WHO African and Western Pacific regions [4]. In 2022, viral hepatitis was responsible for an estimated 1.3 million deaths globally, underscoring its increasing contribution to communicable disease mortality. Specifically, HBV and HCV were responsible for 1.1 million and 244,000 deaths, respectively [3]. Despite advances in prevention and treatment, progress towards global elimination targets remains insufficient. By the end of 2022, nearly seven million individuals were receiving treatment for HBV infection, and 12.5 million had completed curative treatment for HCV infection, falling short of established global targets [5].

The burden of viral hepatitis varies across regions. In the WHO African region, 63% of new HBV infections are reported, yet only 18% of newborns receive the birth-dose vaccine [5]. The prevalence of HBV in Africa ranges from 6.1% to 8.5%, with Cameroon experiencing a notably higher prevalence of approximately 11.2% [5]. This highlights an urgent need to strengthen public health measures. For HCV, prevalence rates in the African region vary from 1% to 3%, while in Cameroon, it varies from 1.1% to 13.8%, indicating a substantial and heterogeneous public health burden [5].

Healthcare workers (HCWs) and medical students are at increased risk of HBV and HCV infections due to frequent exposure to bloodborne pathogens through contact with patients, sharps, and bodily fluids [6]. Regular screening, vaccination, and strict adherence to infection prevention and control practices are essential and cost-effective strategies to reduce this risk [7]. Similarly, medical training exposes students to comparable occupational hazards, and assessing the prevalence of these infections among them underscores the importance of early education on preventive measures and safe clinical practices [8]. In the South West region of Cameroon, Buea and Limbe regional hospitals serve as major referral facilities to a large and diverse patient population. They also function as key clinical training sites for HCWs, medical and paramedical students. As such, these institutions provide an appropriate setting for investigating HBV and HCV infections and vaccination practices among HCWs and students.

This study investigated the seroprevalence of HBV and HCV among HCWs and medical students at Buea Regional Hospital and Limbe Regional Hospital. It further sought to identify potential risk factors associated with HBV and HCV seropositivity in these cohorts. The insights gained will be pivotal in developing targeted interventions to minimise the prevalence of these infections and enhance health and safety protocols for healthcare providers in the South West region of Cameroon.

Methods and Materials

Study Design and Setting

This cross-sectional study was conducted between 20/06/2025 to 31/09/2025 to assess the seroprevalence of HBV and HCV infections in three cohorts: health care workers with at least one year of work experience in a hospital or clinic, first-year medical and paramedical students (with little or no placement outings), and final year medical, nursing, and paraclinical students (with several placement outings). The study was conducted in the Buea and Limbe Regional Hospitals. The Buea Regional Hospital is in the Fako Division of the South West region of Cameroon. The hospital comprises several clinical and support units, including medical, surgical, paediatrics, maternity, HIV/AIDS, tuberculosis, laboratory, radiology, and outpatient department (OPD), as well as specialized centres such as

haemodialysis and diabetes units. Each unit or department is headed by a specialist doctor, such as surgeons, gynaecologists, or paediatricians. However, the day-to-day control of the wards is managed by ward supervisor ("*ward charges*"), including senior nurses and midwives. The hospital employs nurses of various categories, ranging from nursing assistants (NAS) to State Registered Nurses (SRN), Higher National Diploma Nurses (HND), and Bachelor of Nursing Science graduates (BNS). The Buea Regional Hospital (B.R.H) serves clients from Buea and the surrounding areas. Patients come for consultations and treatments or are referred from other health centres and clinics. The hospital admits clients for as long as necessary for their recovery and performs both minor and major surgeries.

Similarly, the Limbe Regional Hospital (LRH) serves as a secondary referral and teaching hospital for medical students. It is situated in the zone two health area of the Limbe Health District, providing comprehensive services across multiple specialties: radiology, surgery, obstetrics and gynaecology, dental surgery, ophthalmology, paediatrics, physiotherapy, maternity care, and general medicine. Both institutions function as principal clinical training sites for medical, paramedical, and healthcare professionals of the University of Buea and were selected for this study due to their large workforce and training capacity.

Sample Size Determination

Sample size was calculated using the single-population proportion formula as described in the WHO manual for sample size determination in health studies [9]. The study was primarily powered on the expected prevalence of HBsAg among HCWs, as this group was anticipated to have the highest prevalence and occupational exposure risk. Separate sample size calculations were then performed for cohorts with finite-population correction (FPC) size and allowance for non-response.

$$n_0 = \frac{Z^2_{1-\frac{\alpha}{2}} p(1-p)}{d^2}, n_{\text{deff}} = n_0 \times \text{DEFF}, n_{\text{FPC}} = \frac{n_{\text{deff}}}{1+\frac{(n_{\text{deff}}-1)}{N}}, n = \frac{n_{\text{FPC}}}{1-r}$$

Where p is the estimated prevalence (10%), d the precision (0.03), Z the standard normal deviate at 95% confidence level (1.96), N the finite source population from the hospital roster (650: 399 from Buea Regional Hospital (BRH) and 251 from LRH), r the anticipated non-response rate 10%). For HCWs, assuming an HBsAg prevalence of 10% (p=0.10), a precision of 3%, a 95% confidence level, a source population of 650 HCWs from both hospitals (399 from RH Buea and 251 from RH Limbe) and a 10% non-response rate, the minimum required sample size was n=299.95 ≈300 after finite population correction and non-response rate adjustment. This sample was allocated proportionally to hospital size, yielding 184 HCWs from BRH and 116 from LRH.

For students, separate calculations were performed using an assumed HBV prevalence of 5.8% (as per WHO, the estimated prevalence of Hepatitis B in the general population is 5.8%), a precision of 5%, a 95% confidence level, a source population of 312 eligible students, and a 10% non-response rate [5]. The minimum required sample size was 85 participants per student stratum, giving 85 first-year students and 85 final-year students. The total sample size for the study was therefore 470 participants.

Sampling Technique

A stratified random sampling technique was used to ensure adequate representation across departments and job categories within BRH and LRH. For HCWs, staff rosters were used as sampling frames, and participants were selected proportionally to the size of each stratum. For students, stratification was based on level of training (first year or final year) and program

(medical, nursing, or paramedical). Participants were randomly selected from a prepared list within each stratum. To account for potential non-response, an additional 10-15% of participants were pre-selected within each stratum as replacements, thereby preserving proportional allocation. This approach minimized selection bias and ensured adequate representation of all cohorts and subgroups.

Data Collection Methods

Serological Testing Procedures

Blood samples were carefully collected from consenting individuals by trained healthcare professionals using sterile venipuncture techniques. These samples were appropriately labelled and transported to the laboratory for serological analysis. Initial screening for HBV infection was performed using the HBV 5-in-1 Hepatitis B virus markers rapid test panel, which simultaneously detects multiple HBV markers, including Hepatitis B surface antigen (HBsAg), Hepatitis B surface antibody (anti-HBs), hepatitis B e antigen (HBeAg), Hepatitis B e antibody (anti-HBe), and Hepatitis B core antibody (anti-Hc). Screening for HCV infection was also initially conducted using rapid diagnostic dipstick test for anti-HCV antibodies. Confirmation of both infections was performed using enzyme-linked immunosorbent assay (ELISA). ELISA tests are specifically designed to identify Hepatitis B surface antigen (HBsAg) for Hepatitis B infection and Hepatitis C antibodies (anti-HCV) for Hepatitis C infection. This method is widely recognized for its ability to accurately diagnose viral infections, providing reliable results to determine the prevalence of Hepatitis B and C within the specific group under study.

Questionnaire for Risk Factors and Demographic Data

We used a structured questionnaire/data capture form to gather comprehensive data on factors that may influence the transmission and prevalence of Hepatitis B and C. This was done during sample collection. The questionnaire/data capture form collected demographic information, including age, gender, and educational background, as well as occupational history, including job title and years of service. This approach helped us analyze the association between seroprevalence rates and specific risk factors and demographic characteristics, providing valuable insights into the epidemiology of Hepatitis B and C among healthcare workers and medical students in the South West region of Cameroon.

Data Variables

The study examined several categories of variables, including demographic, health status, exposure-related, and healthcare policy variables.

Demographic variables included the age of participants, gender, job role (such as nurse, doctor, laboratory technician, or medical student), and years of experience in healthcare settings. These variables were used to describe the study population and assess potential differences across professional groups.

Health status variables focused on the seroprevalence of Hepatitis B and Hepatitis C infections. Hepatitis B seroprevalence was determined by the presence of Hepatitis B surface antigen (HBsAg), while Hepatitis C seroprevalence was assessed through the presence of anti-HCV antibodies. Exposure and risk factor variables included participants' occupational exposure history, particularly incidents of needlestick injuries or contact with infected blood, which are common routes of transmission among healthcare workers. The study also assessed protective practices, including the use of personal protective equipment (PPE), safe needle handling, and other preventive measures to reduce occupational risk.

Healthcare and policy-related variables examined the availability of occupational health policies within healthcare institutions

addressing the prevention and control of HBV and HCV infections.

Data Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics were used to summarize demographic characteristics and risk factor data, and included calculating the prevalence of Hepatitis B and C, with confidence intervals. Associations between risk factors and HBV and HCV seroprevalence were assessed using binary logistic regression analysis. Adjusted odds ratios (aOR) were calculated using multivariate logistic regression models with infection status as the outcome variable. Statistical significance was set at *P*-values less than 0.05.

Ethical Consideration

Ethical clearance was obtained from the Regional Ethics Committee for Human Health Research of the Southwest Region of Cameroon (04/CRERSH/SW/C/01/2025). Authorisations were sought from the Southwest Regional Delegation of Public Health (P42/MINSANTE/SWR/RDPH/RCB.PT/) and from the administrations at Buea Regional Hospital (01/MPH/SWRDPH/BR H/IRB) and Limbe Regional Hospital (334/ MPH/SWR/RDPH/RHL/DO05/2025). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and national research committees and in compliance with the principles of the Declaration of Helsinki. Written informed consent to participate was obtained from all study participants before data collection. The study was conducted in accordance with the International Council for Harmonisation Good Clinical Practice (ICH-GCP) guidelines and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.

Results

Demographic and Baseline Characteristics

In this study, 374 participants were involved, comprising 192 (51.3%) HCWs, 107 (28.6%) first-year students, and 75 (20.1%) final-year students as indicated in Figure 1. The ages of respondents ranged from 18 to 60 years, with a mean age of 28 years (SD = 7.9). The median age was 26 years with an interquartile range (IQR) from 22 to 31 years. Majority of the participants, 278 (74.3), were single. Out of the 374 participants, 314 were females. Among HCWs, 105 (54.7%) were nurses, and 161 (83.9%) had worked for less than 10 years. For students, 122 (67%) were nursing students (Table 1).

Table 1. Demographic and Baseline Characteristics of HCWs with HBV and HCV Infections (n=374)

Variable		**Frequency n (%)**	**HBV seropositive n (%)**	**HCV seropositive n (%)**
Age	15 - <25	154 (41.2)	7(4.5)	4 (2.6)
	25 - <35	152 (40.6)	7(4.6)	2 (1.3)
	35 - <45	48 (12.8)	3(6.3)	2 (4.2)
	45 - <55	18 (4.8)	1(5.6)	
	55 - <65	2 (0.5)		
Gender	Female	314 (83.9)	12(3.8)	6 (1.9)
	Male	60 (16.1)	6(10.0)	2 (3.3)
Marital Status	Single	278 (74.3)	12(4.3)	6 (2.2)
	Married	91 (24.3)	6(6.6)	2 (2.2)
	Widowed	3 (0.8)		

	Divorced	1 (0.3)		
	Separated	1 (0.3)		
Religion	Christian	371 (99.2)	18 (4.9)	8 (2.2)
	Muslim	3 (0.8)		
Designation	HCW	192 (51.3)	7 (3.6)	3 (1.6)
	First-year student	107 (28.6)	4 (3.7)	3 (2.8)
	Final year student	75 (20.1)	7 (9.3)	2 (2.7)
Field of Work	Nursing	105 (54.7)	5 (4.8)	2 (1.9)
	Laboratory	53 (27.6)	2 (3.8)	1 (1.9)
	Medicine	6 (3.1)		
	Other Paramedics	28 (14.6)		
Longevity of Service	≤ 10 years	161 (83.9)	6 (3.7)	2 (1.2)
	> 10 years	31 (16.1)	1 (3.2)	1 (3.2)
Field of Studies (Students)	Nursing Students	122 (67)	7 (5.7)	3 (2.5)
	Medical Students	46 (25.3)	4 (8.7)	1 (2.2)
	Paramedical Students	14 (7.7)		1 (7.1)
BRH	HCW	109 (56.2)	2 (1.8)	
	First-year student	54 (27.8)	3 (5.6)	1 (1.9)
	Final year student	31 (16)	3 (9.7)	2 (6.5)
LRH	HCW	83 (46.1)	5 (6)	3 (3.6)
	First-year student	53 (29.4)	1 (1.9)	2 (3.8)
	Final year student	44 (24.4)	4 (9.1)	
Hospital	RHB	194 (51.8)	8 (4.1)	3 (1.5)
	RHL	180 (48.1)	10 (5.6)	5 (2.8)
Prior screening for HBV or HCV	Yes	194 (51.9)	8 (4.1)	2 (1)
	No	180 (48.1)	10 (5.6)	6 (3.3)
Needlestick Injury	No	187 (50)	12 (6.4)	5 (2.7)
	Yes	187 (50)	6 (3.2)	3 (1.6)
Adherence to IPC	Always	288 (77)	12 (4.2)	5 (1.7)
	Frequently	57 (15.2)	4 (7)	1 (1.8)
	Sometimes	22 (5.9)	2 (9.1)	2 (9.1)
	Never/Rarely	7 (1.9)		
Use PPE	Always	216 (57.8)	10 (4.6)	4 (1.9)
	Frequently	87 (23.3)	5 (5.7)	1 (1.1)
	Sometimes	59 (15.8)	3 (5.1)	3 (5.1)
	Never/Rarely	13 (3.2)		

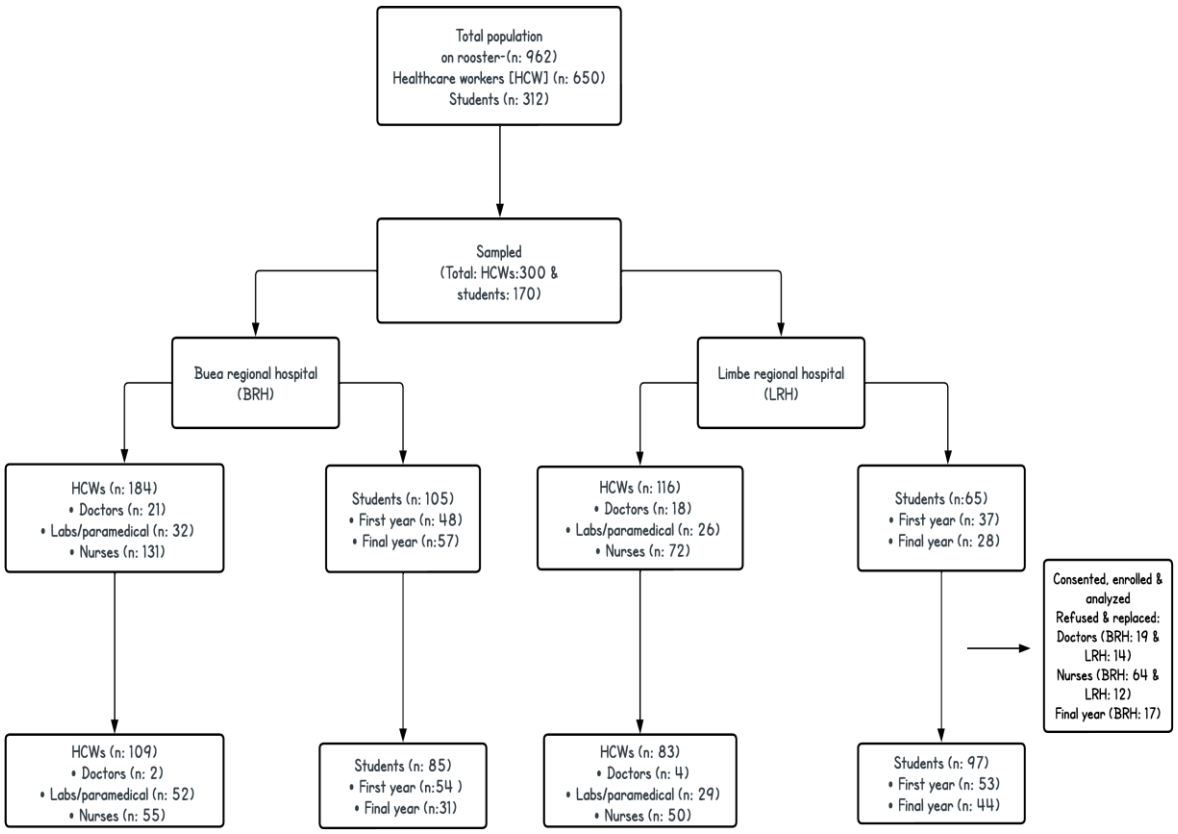

Figure 1. Study Flow Diagram showing Study Population Mix by Site of Recruitment. The Diagram Illustrates Participant Flow from Eligibility through Sampling, Enrolment, and Analysis

Seroprevalence of HBV and HCV Infections among Participants

The overall seroprevalence for HBV was 18 (4.8%; 95% CI: 2.9 – 7.4), and for HCV was 8 (2.1%, 95% CI: 0.9 – 4.2). The co-infection rates (HBV and HCV) were 2 (0.53%,95% CI: 0.1 -4.2). Final year students had the highest HBsAg prevalence of 9.3% (95% CI: 8.8-9.9) as shown in Figure 2.

First-year students had a lower prevalence of 3.7% (95% CI: 1.0-7.1). Among all the students combined, HBsAg prevalence is 6% (95% CI: 3.1-7.8). HCWs showed the lowest HBsAg prevalence, 3.6% (95% CI: 1.5-7.4). Final-year and First-year students had similar HCV seroprevalence of 2.8% (95% CI: 0.6-7.9) and 2.7% (95% CI:0.3-9.3) respectively, with a combined seroprevalence of 2.8% (95% CI: 0.9-6.3). HCWs showed a relatively lower HCV prevalence of 1.6% (95% CI: 0.3-4.5). Males had higher HBV and HCV seroprevalences of 10% and 3.3%, respectively. Married participants had a higher HBV prevalence (6.6%). HBV prevalence was higher (3.7%) among participants who had worked for less than 10 years, while HCV was higher (3.2) among those who had worked for more than 10 years.

Among students, the highest HBV prevalence was among medical students, 8.7%. Those who have never been screened for HBV or HCV showed higher prevalences of 5.6% and 3.3%, respectively. Participants who had never had a needlestick injury had higher prevalence: 6.4% for HBV and 2.7% for HCV. Additionally, it was observed in participants who sometimes adhere to IPC measures (9.1%) for both infections (Table 1).

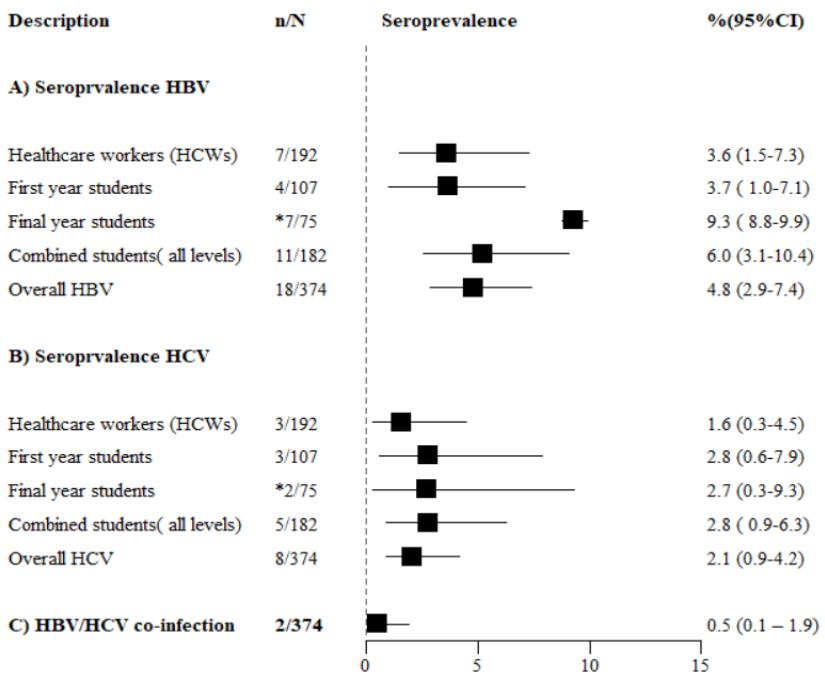

Figure 2. Forest Plot-Seroprevalence of Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), and HBV/HCV Co-infection among Healthcare Workers and Students

Risk Factors Associated with HBV and HCV Seropositivity

Multivariable logistic regression analysis showed no statistically significant associations between the investigated factors and HBV seropositivity ($p > 0.05$). Variables including age, marital status, designation (healthcare worker or student), hospital location, prior HBV screening, history of needlestick injury, adherence to infection prevention and control (IPC) practices, and use of personal protective equipment (PPE) were not significantly associated with HBsAg positivity.

However, gender demonstrated a borderline association with HBV infection. Males had higher odds of HBsAg positivity compared to females in the crude analysis (cOR 2.80, 95% CI: 1.00-7.80; $p = 0.05$), although this association did not remain statistically significant after adjustment (aOR 2.62, 95% CI: 0.92–7.45; $p = 0.07$). A non-significant trend was observed for adherence to IPC practices, with participants who did not always adhere to IPC measures showing higher odds of HBV seropositivity compared to those who consistently adhered (cOR 1.73, 95% CI: 0.63-4.74; aOR 1.54, 95% CI: 0.55-4.33). Similarly, final-year students exhibited higher odds of HBV seropositivity compared to first-year students (cOR = 2.65, 95% CI: 0.73-9.63), although this association was not statistically significant. (Table 2).

With respect to HCV, bivariate and multivariable logistic regression analyses showed no statistically significant associations between the assessed variables and HCV seropositivity. Variables including age, gender, marital status, designation (healthcare worker or student), hospital location, prior screening for HBV/HCV, history of needlestick injury, adherence to infection prevention and control (IPC) practices, and use of personal protective equipment (PPE) were not significantly associated with HCV positivity.

Although no statistically significant, some trends were observed. Males had higher odds of HCV seropositivity compared to females (cOR 1.77, 95% CI: 0.34-8.98), and participants who did not consistently adhere to IPC practices also showed higher odds of infection (cOR 2.05,

95% CI: 0.48-8.74). Similarly, individuals who did not always use PPE had slightly higher odds of HCV seropositivity (cOR 1.38, 95% CI: 0.34-5.59) (Table 3).

In contrast, prior screening for HBV or HCV appeared to be associated with a much lower odds of HCV seropositivity (cOR 0.30, 95% CI: 0.06–1.52; aOR 0.32, 95% CI: 0.05–1.80), although this association did not reach statistical significance. No meaningful differences were observed between students and healthcare workers (aOR = 1.17, 95% CI: 0.25–5.53), nor between first-year and final-year students (Table 3).

Table 2. Bivariate and Multivariate Analysis of Risk Factors associated with HBV Seropositivity

Variable		**HBV negative-n(%)**	**HBV positive n(%)**	**cOR (95% CI)**	**P-value**	**aOR (95% CI)**	**P-value**
Age	<30	238 (95.2)	12 (4.8)	1			
	>30	118 (95.2)	6 (4.8)	1.01 (0.37-2.75)	1.000		
Gender	Female	302 (96.2)	12 (3.8)	1			
	Male	54 (90)	6 (10.0)	2.80 (1-7.8)	0.051	2.62 (0.92-7.45)	0.073
Marital Status	Single	271 (95.8)	12 (4.2)	1			
	Married	85 (93.4)	6 (6.6)	1.59 (0.6-4.4)			
Designation 1	Students	171 (94.0)	11 (6.0)	1			
	HCW	185 (96.4)	7 (3.6)	0.59 (0.2-1.6)	0.400	2.23 (0.74-6.68)	0.150
Designation 2	First Year	103 (96.3)	4(3.7)	1			
	HCW	185 (96.4)	7(3.6)	0.97 (0.28-3.35)	0.960		
	Final Year	68 (90.7)	7(9.3)	2.65 (0.73-9.63)	0.150		
Hospital	HRH Buea	186 (95.9)	8 (4.1)	1			
	RH Limbe	170 (94.4)	10 (5.6)	1.37 (0.53-3.55)	0.685		
Prior HBV or HCV screening	No	170 (94.4)	10 (5.6)	1			
	Yes	186 (95.9)	8 (4.1)	0.73 (0.28-1.90)	0.686		
Needlestick injury	No	175 (93.6)	12 (6.4)	1			
	Yes	181 (96.8)	6 (3.2)	0.48 (0.18-1.32)	0.227	0.53 (0.9-1.49)	0.215
Adherence to IPC	Always	276 (95.8)	12 (4.2)	1			
	Not Always	80 (93.0)	6 (7.0)	1.73 (0.63-4.74)	0.435	1.54 (0.55-4.33)	0.436
Use PPE	Always	206 (95.4)	10 (4.6)	1			
	Not Always	150 (94.9)	8 (5.1)	1.09 (0.42-2.85)	1.000		

***n:** number of participants, **cOR:** crude estimates, **aOR:** Adjusted OR adjusted for marital status, designation (cohort type HCW or student), needle stick injury & adherence to IPC*

Table 3. Bivariate and Multivariate analysis of Risk factors Associated with HCV Seropositivity

Variable		**HCV negative n(%)**	**HCV positive n(%)**	**cOR (95% CI)**	**P-value**	**aOR (95% CI)**	**P-value**
Age	<30	244 (97.6)	6 (2.4)	1			
	>30	112 (98.2)	2 (1.8)	0.73 (0.13-3.35)	0.472		
Gender	Female	308 (98.1)	6 (1.9)	1			
	Male	58 (96.7)	2 (3.3)	1.77 (0.34-8.98)	0.376		

Marital Status	Single	277 (97.9)	6 (2.1)	1			
	Married	89 (97.8)	2 (2.2)	1.04 (0.21-5.23)	0.618		
Designation 1	Students	171 (97.2)	5 (2.8)	1			
	HCW	189 (98.4)	3 (1.6)	0.56 (0.13-2.38)	0.332	1.17 (0.25-5.53)	0.834
Designation 2	First year student	104 (97.2)	3 (2.8)	1			
	HCW	189 (98.4)	3 (1.6)	0.55 (0.11-2.86)	0.743		
	Final year student	189 (98.4)	2 (2.7)	0.95 (0.15-6.08)	1.000		
Hospital	HRH Buea	191 (98.5)	3 (1.5)	1			
	RH Limbe	175 (97.2)	5 (2.8)	1.82 (0.43-7.72)	0.489		
Prior screening for HBV or HCV	No	174 (96.7)	6 (3.3)	1			
	Yes	192 (99.0)	2 (1.0)	0.30 (0.06-1.52)	0.161	0.32 (0.05-1.8)	0.196
Needlestick injury	No	182 (97.3)	5 (2.7)	1			
	Yes	184 (98.4)	3 (1.6)	0.59 (0.14-2.52)	0.723		
Adherence to IPC	Always	283 (98.3)	5 (1.7)	1			
	Not Always	83 (96.5)	3 (3.5)	2.05 (0.48-8.74)	0.391		
Use PPE	Always	212 (98.1)	4 (1.9)	1			
	Not Always	154 (97.5)	4 (2.5)	1.38 (0.34-5.59)	0.726		

n: *number of participants,* ***cOR:*** *crude odds ratios (OR) estimates,* ***aOR:*** *multivariate OR adjusted for marital status, designation (cohort type HCW or student), & Prior screening for HBV or HCV*

Discussion

HBV and HCV Seroprevalence among First-Year Students, Final-Year Students, and Healthcare Workers

This cross-sectional study assessed the seroprevalence of hepatitis B virus (HBV) and hepatitis C virus (HCV) infections, as well as associated risk factors among healthcare workers (HCWs) and medical and paramedical students in two major referral and teaching hospitals in the South West region of Cameroon. The overall HBV seroprevalence of 4.8% observed in this study suggests an intermediate level of endemicity within this sampled population. Notably, HCWs had a lower prevalence of 3.6% compared to the combined student cohort, while final-year students exhibited the highest prevalence (9.3%), followed by first-year students (3.7%). This pattern may reflect the increasing exposure to clinical environments and potential gaps in infection prevention and control practices among trainees, however, causality cannot be inferred due to the cross-sectional design. Notably, the number of positive cases observed is relatively small, resulting in wide, imprecise confidence intervals around the seroprevalence rates. Nonetheless, the observed gradient from HCWs to first-year and final-year students is consistent with epidemiological patterns seen in other sub-Saharan African studies, overall HBV and HCV seroprevalence of 6.1 % and 4.7% [10, 11], respectively.

Our findings are consistent with evidence from other African settings, which demonstrate increased HBV exposure with advancing clinical training. Tawiah et al. (2022) reported a significant rise in HBV exposure among Ghanaian medical laboratory students during clinical training, attributed to high rates of needlestick injuries and mucosal exposures, often occurring under inadequate supervision [12]. Similarly, Funeh et al. (2013) found that senior clinical students in Cameroon had significantly higher HBV exposure compared to pre-clinical students, largely due to cumulative occupational contact with blood and contaminated sharps. Both studies also highlighted low vaccination coverage as an important risk factor as students transition into clinical environments [4, 12, 13]. As students progress from pre-clinical to clinical phases, they are increasingly exposed to blood and body fluids, often in settings where sharps handling and PPE availability is sub-optimal [14]. Overall, the results reaffirm that HBV infection remains endemic among HCWs and medical students, with a particularly concerning burden among final-year students.

In contrast, the overall HCV seroprevalence of 2.1% observed in this study was relatively low and showed no marked differences across cohorts. This is consistent with previous reports indicating lower HCV prevalence compared to HBV in healthcare settings [15]. However, the presence of HCV infection still reflects ongoing exposure risks within clinical environments. The lower prevalence may be explained by the relatively inefficient occupational transmission of HCV compared to HBV. The risk of infection following a needlestick injury from an HCV-positive source is estimated at approximately 1–2%, compared to over 30% for HBV in unvaccinated individuals [16-18].

Risk Factors Associated with Seropositivity

Consistent with the overall findings, multivariable analysis did not identify any statistically significant risk factors for HBV or HCV seropositivity, likely due to the relatively small number of positive cases and limited statistical power. Although a borderline association with gender was observed in crude analysis, this did not persist after adjustment. Similar findings have been reported in other settings, where initial associations with sociodemographic and occupational factors were not sustained in multivariate models, often attributed to low event rates and overlapping exposure pathways [19, 20]. Conversely, other studies in Africa (Ghana, Nigeria) identified factors such as needlestick injury, male sex, and occupational blood exposure as significant predictors of hepatitis seropositivity, highlighting contextual variability in risk profiles [19, 21-23].

Despite the lack of statistically significant associations, the higher prevalence observed among final-year students aligns with previous studies from Cameroon, Congo, and Sudan, which report increased HBV burden among senior trainees due to cumulative exposure to blood and body fluids and lower vaccination coverage [24, 25]. These findings reiterate existing evidence highlighting the role of prolonged clinical exposure and suboptimal adherence to infection prevention measures as key contributors to infection risk in this population.

Strengths and Limitations

Although this study assessed seroprevalence, the findings have important implications for chronic HBV and HCV infection [26]. HBsAg indicates current infection, a proportion of which may progress to chronic disease, while anti-HCV positivity reflects exposure with a high likelihood of persistence. Chronic infection can lead to serious complications, including cirrhosis and hepatocellular carcinoma, particularly in settings where infections remain asymptomatic and undiagnosed [5]. Among students, cumulative clinical exposure and inconsistent

adherence to infection prevention measures may further increase this risk without access to routine screening.

A key strength of this study is the use of rapid immunochromatographic screening followed by ELISA confirmation, which enhances the reliability of seroprevalence estimates. While rapid tests may introduce some misclassification due to lower sensitivity and specificity, ELISA's high diagnostic accuracy minimizes this limitation [5]. However, reliance on serological assays alone limits differentiation between acute and chronic HBV infection and does not confirm active HCV infection in the absence of molecular testing [27]. Consequently, the reported seroprevalence likely reflects a mix of current and past infections. In addition, despite an adequate sample size for prevalence estimation, the low number of positive cases and sub-optimal recruitment reduced the statistical power to detect significant associations, as reflected by wide confidence intervals for odds ratios.

Conclusion

This study demonstrated a relatively low seroprevalence of HBV and HCV among healthcare workers and medical and paramedical students. It provides important insights into the burden of HBV and HCV in these high-risk populations and underscores the need for routine screening, early diagnosis, HBV vaccination, and strengthened infection prevention practices.

Acknowledgements

The author expresses sincere thanks to the entire staff of the Buea and Regional Hospitals for the authorisation and support provided during data collection. The author also expresses appreciation to the medical and paramedical students on internship during the data collection process.

Data Management

Survey data were not accessible to participants at participating Health facilities. Responses were transmitted electronically to Kobocollect, linked to the investigator's account, and subsequently exported to GitHub for secure storage. Access to the dataset was restricted to the study statistician for analysis**.**

Authors' Contributions

O.E.A., N.T., and E.B.B participated in the study design. O.E.A oversaw pilot testing and data collection. O.E.A., N.T., and E.B.B contributed to the writing and review of the manuscript and approved the final version. O.E.A and E.B.B assisted in statistical analysis and interpretation of results. O.E.A had overall responsibility for the study design, overseeing survey distribution and interpretation of results.

Funding

This research received no funding.

Data Availability

The datasets generated and analysed in this study are not publicly available due to institutional regulations but can be obtained from the corresponding author upon reasonable request. All data access requests will be subject to review by the Ethics Committee of the Cameroonian Ministry of Public Health and the Regional Ethics Committee for Human Health Research for the South West Region, to ensure adherence to ethical and legal requirements.

Ethical Approval

Ethical clearance was obtained from the Regional Ethics Committee for Human Health Research of the South West Region of Cameroon (04/CRERSH/SW/C/01/2025). Authorisations were sought from the South West Regional Delegation of Public Health (P42/MINSANTE/SWR/RDPH/RCB.PT/) and from the administrations at Buea Regional Hospital (01/MPH/SWRDPH/BRH/IRB) and Limbe Regional Hospital

(334/MPH/SWR/RDPH/RHL/DO05/2025).
All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and national research committees and in compliance with the principles of the Declaration of Helsinki. Written informed consent to participate was obtained from all study participants before data collection.

Competing Interests

The authors declare no competing interests.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art009

Healthcare Workers Adherence to Occupational HIV Post-Exposure Prophylaxis and Seroconversion Rate in a Tertiary Health Facility, Southwestern Nigeria

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Abstract

Human Immudeficiency Virus (HIV) transmission remains a global public health challenge particularly among healthcare workers (HCWs). HCWs are susceptible to occupational exposures because they often handle blood and body fluids or contaminated materials. This retrospective cross-sectional study aimed to determining the HCWs' HIV exposure characteristics, adherence to occupational postexposure prophylaxis (PEP) and seroconversion rate. Information was extracted from all the 114 medical records of HCWs who sought for PEP at the Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria, between 2011 and 2023. The data comprised sociodemographic details, exposure characteristics, adherence to PEP and seroconversion rate at 6 months. The HCWs age ranged from 20 to 59 years with a mean age of 32.34 ± 8.757 years. The females were 51.8%. Medical doctors (30.7%) were the most exposed to HIV, follow by the laboratory scientists 15.8% and nurses 14.9%. Types of exposure were mostly needle stick injury (80.7%), blood/body fluid splashes (14.9%), and cuts from sharps (4.4%). Majority of these exposures were high risk, 79%. High proportion of HCWs 85.1% started PEP within the recommended 72 hours. The study showed low adherence rate of 67.5%, and poor post-PEP HIV screening. No seroconversion was observed among the HCWs who completed follow-up. Dolutegravir-based regimen showed significant association (p=0.026) with improved adherence to PEP. The flaws noticed in this study should provide bases for the stakeholders and hospital policy makers to formulate policies that will improve HCWs safety. Hospital administrators should create more awareness about hospital policies and procedures when HIV exposure occurs.

Keywords: *Adherence, Healthcare, Occupational, Post-Exposure Prophylaxis, Seroconversion.*

Received: 17.04.2026 ***Accepted: 20.04.2026*** ***Published on: 29.04.2026***

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Introduction

Human immunodeficiency virus (HIV) exposure and transmission are still global challenges of public health concern especially when that occur among the dwindling health care workforce [1]. Despite decades of global response, funding and advances achieved in HIV management to reduce transmissions, healthcare workers (HCWs) still have about 3 million HIV exposures and 170,000 seroconversions [1, 2, 3]. This is quite disturbing, considering how funding cuts recently complicated the global response, consequence of which negatively impacted availability of antiretroviral (ARVs) medications and other preventive services [4, 5]. As a result, it has been projected that HIV transmission and HIV/AIDS-related deaths may rise especially in low-income and middle-income countries (LMICs) [4, 5]. This will further increase HCWs susceptibility to acquiring HIV since occupational postexposure prophylaxis (oPEP) supply chain is going to be affected due to these compromised HIV preventive and interventional services. HCWs risk is not only due to the fact that they are particularly prone to accidental exposures to HIV and other blood-borne pathogens such as HBV and HCV due to the nature of their work but because it also has impact on depleting health workforce especially [1, 3].

Globally, WHO reported 40% decline in the incidence of people who acquired HIV in 2010 from 2.2 million [1.7–2.8 million] to 1.3 million [1.0–1.7 million] in 2024 [3]. People living with HIV at the end of 2024 were estimated to be 40.8 million [37.0–45.6 million] [6]. Sub-Sahara Africa (SSA) despite being made up of only 12% of the world's population is the worst hit by the scourge carrying 70% of the global burden of the disease, estimated to be 26.3 million people living with HIV as at 2024 [6, 7]. Regrettably also, more than two-thirds of HIV/AIDS-related deaths also occur in SSA [8]. Nigeria also shares a high proportion of this scourge, with a prevalence of 1.4% estimated to be about 1.7 million people living with the virus as of 2020 [9]. The high HIV burden in SSA are compounded when HCWs have occupational exposure or infected with HIV at their workplace making them not available or accessible to care for their patients. The rate of HIV occupational exposures varies from region to region but has been shown to be generally high and in some cases, greater than 50% of the health workforce [10-14]. However, the rate of seroconversion was relatively low in occupational exposure depending on many factors like high or low risk exposures. Examples of high-risk exposure include HIV-positive sources, sources with unknown HIV status, large-bore needles, and large-volume body fluid exposure. In contrast, the client was classified as low-risk exposure when post-exposure prophylaxis is not advocated. This category of exposure is observed in solid needle stick injury, superficial exposure on intact skin, a small volume (drops of blood) on mucous membranes or non-intact skin exposures, and a negative source [15].

Before the introduction of oPEP, HIV transmission to HCWs was 0.3% after percutaneous exposure to HIV-positive blood, and 0.09% after a mucous membrane exposure [16, 17]. With the introduction of antiretroviral (ARVs) medications as means of preventive strategy, rate of seroconversion among exposed HCWs has been reduced to 0% in the majority of cases [16, 18]. However, to reduce the rate of transmission of HIV in HCWs, completion of 28 days ARVs and total adherence to all other postexposure preventive strategies must be strictly complied with. These preventive strategies include the initial response following HIV exposure which should include proper institution of first aid for the exposed and must include washing of the site with water, pretest and post-test counselling, risk assessment for eligibility of both exposed and source person, necessary laboratory investigation, provision of antiretroviral therapy for 28 days, monitoring and follow-up planning [17, 18]. As part of the

pragmatic approach to reduce HIV exposure, HCWs must be aware of PPE and use them, injection safety protocol must be complied with, wearing of barriers, and observe universal precautions in body fluid handling. Healthcare facility must make adequate provision for safety equipment and enforce their usage. The present research aims at documenting the HCWs pattern of exposure, adherence to occupational postexposure prophylaxis, and rate of seroconversion among exposed HCWs.

Definition of Terms

Occupational HIV exposure occurs when HCWs are exposed to potentially HIV infected body fluids within the healthcare settings in the course of performing their health related duties [15]. Occupational postexposure prophylaxis is the initiation of antiretroviral medications following occupational HIV exposure as soon as possible, ideally within 72 hours of the exposure for 28 days. Adherence to ARVs (PEP) means starting the right dose of PEP exactly as prescribed, and at the right time. Adherence to PEP must be total for it to be effective in reducing HIV transmission and to reduce the risk of viral resistance.

Materials and Methods

Research Design and Settings

A retrospective cross-sectional descriptive study was utilized for this research. The study was conducted at the Virology Research Clinic (VRC) at the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, Osun State, Nigeria. OAUTHC is a government-run specialist centre that provides services to an ethnically diverse population. VRC is a specialised clinic in OAUTHC providing comprehensive and multidisciplinary HIV care including prevention, diagnosis and treatment.

Data Collection Method and Instrument

Data collection was carried out using the medical records of all the 114 HCWs who sought for HIV occupational postexposure prophylaxis (oPEP) following exposure to potentially infected body fluids from January 2011 to 31st December, 2023, a period of 12 years. The data was collected using a proforma designed by the investigators. The information extracted with the proforma from the medical records included: sociodemographic data, exposure characteristics of both the HCWs and the source - date and time of exposure, types of exposure, risk of exposure, the delay between exposure and initiation of ARVs, HIV status of the source and the HCWS, identity of the source, antiretroviral therapy regimen (PEP), number of days ARV was used, follow-up HIV screening at 12 and 24 weeks.

Inclusion Criteria

Only HCWs with complete information were collected for the study.

Exclusion Criteria

Medical records with missing data were excluded from the research.

Data Analysis

Data were input into IBM Statistical Package for Social Science (version 25) and subsequently cleaned before analysis. The results were presented using descriptive statistics such as frequency, percentage, and mean. Association between two categorical variables of interest was determined using chi-square and the level of significance was set at $p < 0.05$. Logistic regression analysis was used to find association between sociodemographic profile and adherence of HCWs to postexposure prophylaxis.

Ethical Approval

Ethical clearance for the study was granted by the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife. (Registration Numbers: International - IRB/IEC/0004553, National - NHREC/27/02/2009a). The proforma and data

entry were anonymous to ensure confidentiality. The data was protected from unauthorized individuals using a password-protected computer.

Results

Sociodemographic Characteristics of Healthcare Workers Exposed to HIV at Workplace

A total of one hundred and fourteen (114) HCWs presented for HIV postexposure prophylaxis through various healthcare-related sources. The participants' age ranged from 20 to 59 years with majority within the age of 20-29 and 30-39 years. Mean age of the HCWs was 32.34 ± 8.757 (Mean ± SD). The female clients were 51.8% (59/114). Among the HCWs who sought for occupational PEP, medical doctors were the most exposed affecting 35 (30.7%) while the least exposed to HIV were the pharmacists with only 2 (1.8%) affected and sought for PEP. Majority of the HCWs 109 (95.6%) are educated up to tertiary levels. Half 57 (50%) of the participants were married while the remaining half were single. More than 98% of the health care workers agreed to be screened at presentation before the commencement of ARVs. (Table 1).

Table 1. Sociodemographic Characteristics of Healthcare Workers Exposed to HIV at Workplace

Healthcare Workers variables	**Sex N (%) = 114 (100.0)**		**Total**	**Statistics**
	Male n (%) = 55 (48.2)	**Female N (%) = 59 (51.8)**		**X2, p-value**
Age Group				
20-29 years	17 (14.9)	32 (28.1)	49 (43.0)	X2 =9.581, p =0.022
30-39 years	29 (25.4)	16 (14.0)	45 (39.5)	
40-49 years	7 (6.1)	6 (5.3)	13 (11.4)	
50-59 years	2 (1.8)	5 (4.4)	7 (6.1)	
Mean Age	33.16 ± 7.25	33.16 ± 7.25	32.34 ± 8.757	
Occupation				
Medical doctor	20 (17.5)	15 (13.2)	35 (30.7)	LR=8.254, p =0.220
Nurse	5 (4.4)	12 (10.5)	17 (14.9)	
Lab scientist	10 (8.8)	8 (7.0)	18 (15.8)	
Allied Health worker	10 (8.8)	6 (5.3)	16 (14.0)	
Pharmacy	1 (0.9)	1 (0.9)	2 (1.8)	
Students (Health-related)	2 (1.8)	7 (6.1)	9 (7.9)	
Others	7 (6.1)	10 (8.8)	17 (14.9)	
Ethnicity				
Yoruba	45 (39.5)	50 (43.9)	95 (83.3)	LR=1.501, p =0.472
Igbo	8 (7.0)	5 (4.4)	13 (11.4)	
Others	2 (1.8)	4 (3.5)	6 (5.3)	
Educational				
Secondary	4 (3.5)	1 (0.9)	5 (4.4)	FE= 0.195, p =0.161
Tertiary	51 (44.7)	58 (50.9)	109 (95.6)	
Marital status				
Single	27 (23.7)	30 (26.3)	57 (50.0)	X2=0.035, p =0.851
Married	28 (24.6)	29 (25.4)	57 (50.0)	

LR=Likelihood Ratio, X2= Chi square, FE = Fixed Effects, p=p-value

Healthcare Workers' Exposure and Occupational PEP (ARVs) Adherence Characteristics

Table 2 and table 3 showed the HCWs exposure characteristics. The most common type of exposure was needle stick injuries (NSIs) seen in 92 (80.7%) HCWs. The doctors and the health workers (cleaners, health attendants and refuse disposal officers) were more exposed to needle stick injury. Ninety (79.0%) and 24 (21.1%) were classified as high and low risks respectively. Ninety seven (85.1%) HCWs presented within the recommended 72 hours. Among these HCWs, only 34 (29.8%) of them sought for occupational PEP within the golden first 2 hours when ARVs is most effective. Less than 9.7% presented beyond 72 hours. The mean hours of presentation for both males and females were 27.44 ± 51.96 and 33.90 ± 51.67 respectively. Eighty (70.2%) of the sources of exposure were screened for HIV and nearly half 56 (49.1%) were found to be HIV positive. The HIV status of the source were not available for screening in 34 (29.8%) of the cases.

The overall HCWs adherence/ARVs completion rate of 67.5% was observed in this study. The adherence rate was not statistically significantly related to the sex of the HCWs. The mean adherence (days) for all HCWs in the study was 22.84 ± 8.32 (mean ± SD). Of the 30 (26.3%) HCWs with poor adherence to oPEP (ARVs), 28 (24.6%) was attributed to default and 2 (1.8%) were due to side effects of the ARVs. Reasons for non-adherence is statistically significantly varied between males and females ($p < 0.05$). Only a third 38 (33.3%) of the study population returned for post-PEP HIV screening, and majority 25 (21.9%) of whom were females. All the 38 (33.3%) HCWs who had post-PEP HIV screen done were found negative at 3 and 6 months given a seroconversion rate of 0%. Post-PEP screening was statistically significantly associated with the sex of the HCWs ($p < 0.05$).

Table 2. Healthcare Workers' Exposure and Occupational PEP (ARVs) Adherence Characteristics

Variables	All HCW (114)	Males	Females	Statistics
	N (%)	N (%) = 55 (%)	N (%) = 59 (%)	
Types of Exposure				
Needle stick injury	92 (80.7)	44 (38.6)	48 (42.1)	X2 = 1.922, p = 0.589
Blood/body fluid splashes	17 (14.9)	8 (7.0)	9 (7.9)	
Cuts from sharps (blades)	5 (4.4)	3 (2.6)	2 (1.8)	
Risk of Exposure				
High risk	90 (79.0)	46 (40.4)	44 (38.6)	X2 = 1.406, p = 0.236
Low risk	24 (21.1)	9 (7.9)	15 (13.2)	
HCW Exposure to ARVs Initiation				
≤ 2 hours	34 (29.8)	18 (15.8)	16 (14.0)	LR = 1.510, p = 0.912
3 – 72 hours	63 (55.3)	29 (25.5)	34 (29.9)	
>72 hours	11 (9.7)	5 (4.4)	6 (5.3)	
No ARVs	6 (5.3)	3 (2.6)	3 (2.6)	
Mean (Hours)	30.79 ± 51.68	27.44 ± 51.96	33.90 ±51.67	
HIV Status of the Source				
Positive	56 (49.1)	31 (27.2)	25 (21.9)	LR = 2.491, p = 0.290
Negative	24 (21.1)	9 (7.9)	15 (13.2)	
Unknown (Not available)	34 (29.8)	15 (13.2)	19 (16.7)	
HIV Status of the HCWs				
Negative	112 (98.3)	54 (47.4)	58 (50.9)	p = 0.960

Positive	0	0	0	
Unknown	2 (1.8)	1 (0.9)	1 (0.9)	
HCWs Adherence/Completion Rate for 28 days Regime				
No (< 28 days)	30 (26.3)	14 (12.3)	16 (14.0)	X2 = 0.006, p = 0.939
Yes (28 days)	77 (67.5)	38 (33.3)	39 (34.2)	
No ARVs	7 (6.1)	3 (2.6)	4 (3.5)	
Mean Adherence	23.00 ± 8.16	23.16 ± 8.07	22.84 ± 8.32	
Reasons for HCWs non-Adherence to ARVs				
Default	20 (17.5)	13 (11.4)	7 (6.1)	LR = 10.811, p = 0.004
Side effects	2 (1.8)	0	2 (1.8)	
Undisclosed	8 (7.0)	1 (1.8)	7 (6.1)	
No ARVs	7 (6.1)	3 (2.6)	4 (3.5)	
Seroconversion Rate of HCWs at 3 & 6 Months				
No screening	76 (66.7)	42 (36.8)	34 (29.8)	X2 = 4.497, p = 0.0034
Negative	38 (33.3)	13 (11.4)	25 (21.9)	
Positive	0	0	0	
ARVs Used by the HCWs				
3TC/AZT/EFV	13	8	5	X2 = 9.270, p = 0.159
TDF/3TC/EFV	39	21	18	
ABC/3TC/AZATANAVIR	1	0	1	
ALLUVIA/AZT/3TC	1	1	0	
TDF/3TC/DTG	48	20	28	
AZT/3TC	5	5	0	
No HAART	7	3	4	

NB: ARVs – Antiretrovirals, AZT- Zidovudine, 3TC – Lamivudine, EFV – Efavirenz, TDF – Tenofovir, ABC – Abacavir, DTG – Dolutegravir.

Table 3. Other Healthcare Workers' Exposure and Occupational PEP (ARVs) Adherence Characteristics

Variables	**All Healthcare Workers N = 114**						
	Doctors N = 35 n (%)	**Nurses N = 17 n (%)**	**Lab. Sci. N = 18 n (%)**	**H. W. N = 16 n (%)**	**Pharmacist N = 2 n (%)**	**Students N = 9 n (%)**	**Others N = 17 n (%)**
Time							
72 hrs or less	30 (26.3)	15 (13.2)	16 (14.0)	13 (11.4)	2 (1.8)	7 (6.1)	2 (1.8)
Greater than 72 hrs	3 (2.6)	1 (0.9)	2 (1.8)	3 (2.6)	0 (0)	0 (0)	2 (1.8)
No oPEP	2 (1.8)	1 (0.9)	0 (0)	0 (0)	0 (0)	2 (1.8)	1 (0.9)
Type of Exposure							
NSI	25 (21.9)	13 (11.4)	15 (13.2)	16 (14.0)	2 (1.8)	7 (6.1)	14 (12.3)
Cuts	2 (1.8)	1 (0.9)	1 (0.9)	0 (0)	0 (0)	0 (0)	1 (0.9)
Body fluid	2 (1.8)	1 (0.9)	1 (0.9)	0 (0)	0 (0)	1 (0.9)	2 (1.8)
Blood splash	6 (5.3)	2 (1.8)	1 (0.9)	0 (0)	0 (0)	1 (0.9)	0 (0)
Status of the Sources							
Positive	25 (21.9)	7 (6.1)	13 (11.4%)	4 (3.5)	0 (0)	2 (1.8)	5 (4.4)
Negative	7 (6.1)	3 (2.6)	3 (2.6%)	2 (1.8)	0 (0)	4 (3.5)	5 (4.4)

Unknown or Not Available	3 (2.6)	7 (6.1)	2 (1.8%)	10 (8.8)	2 (1.8)	3 (2.6)	7 (6.1)

H. W. = Health Workers (cleaners, health attendants, refuse disposer officers)

Assessment of the Predictors of Adherence to Occupational PEP (ARVs)

In table 4, several predictors of adherence were analysed and only sex of the participants and use of Dolutegravir (DTG) based regimen were found to be statistically significantly predict adherence to ARVs. Sex of the HCWs was found to be statistically significantly predict post-PEP HIV screening $p < 0.05$.

Table 4. Assessment of the Predictors of Adherence to oPEP services

Predictor variables	**p -value**	**OR (adjusted)**	**95% CI**	
			Lower	**Upper**
Predictors of Adherence (non-completion of PEP Treatment) n=107				
Sex of Respondents	0.775	1.196	0.352	4.060
Age Bracket				
20 – 29 years	0.228	0.350	0.063	1.929
30 – 39 years	0.973	0.968	0.147	6.377
40 years and above				
Occupation				
Doctors	0.570	1.561	0.336	7.254
Nurses	0.657	0.671	0.115	3.917
Laboratory scientists	0.982	1.019	0.195	5.324
Others				
Level of Education	0.756	0.677	0.058	7.938
Type of Risk	0.490	1.864	0.318	10.931
HIV Status of Source	0.545	1.527	0.388	6.016
Type of Exposure	0.138	3.159	0.690	14.463
Regimens				
Efavirenz based regimen	0.854	1.260	0.107	14.823
Dolutegravir based regimen	0.026	0.032	0.002	0.657
Others based regimen	0.153	0.327	0.071	1.515
Predictors of Early Presentation vs Late Presentation (<72 hrs)				
Sex of Respondents	0.409	1.642	0.506	5.327
Age	0.164	1.915	0.768	4.775
Occupation	0.958	0.987	0.600	1.624
Level of education	0.231	0.291	0.039	2.188
Type of risk	0.309	2.326	0.458	11.824
HIV status of source	0.790	1.095	0.562	2.132
Type of exposure2	0.998	0.000	0.000	-
Marital status	0.970	0.972	0.224	4.223
Predictors of Post Exposure Screening Test				
Sex of Respondents	0.028	2.973	1.089	0.494
Age bracket	0.279	0.642	-0.444	0.410
Occupation	0.447	1.167	0.155	0.203
Level of education	0.774	0.696	-0.362	1.257
Type of risk	0.151	0.414	-0.881	0.614

HIV status of source	0.142	0.626	-0.468	0.319
Type of exposure2	0.635	1.407	0.341	0.719
Marital status	0.852	0.892	-0.114	0.608
Completion of treatment	0.001	16.204	2.785	0.819

NB: Those not on occupational PEP (ARVs) n = 7 were excluded from this particular analysis

Figure 1 showed non-linear progressive increase in seeking occupational PEP by the HCWs between 2011 and 2017 with increasing number of adherence from 2018 to 2023 when single daily dose combination of DTG was introduced into Nigeria regime (dotted red line in Figure 2).

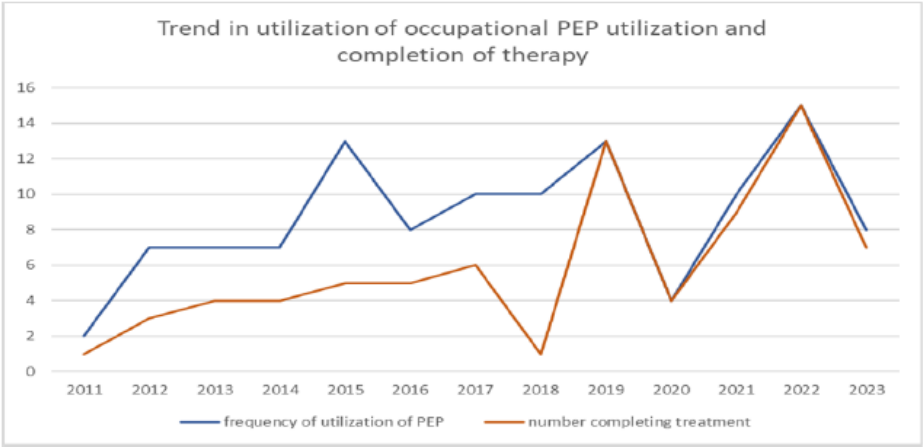

Figure 1. Twelve years Trend of Utilization of Occupational PEP and Adherence to 28 Days Therapy

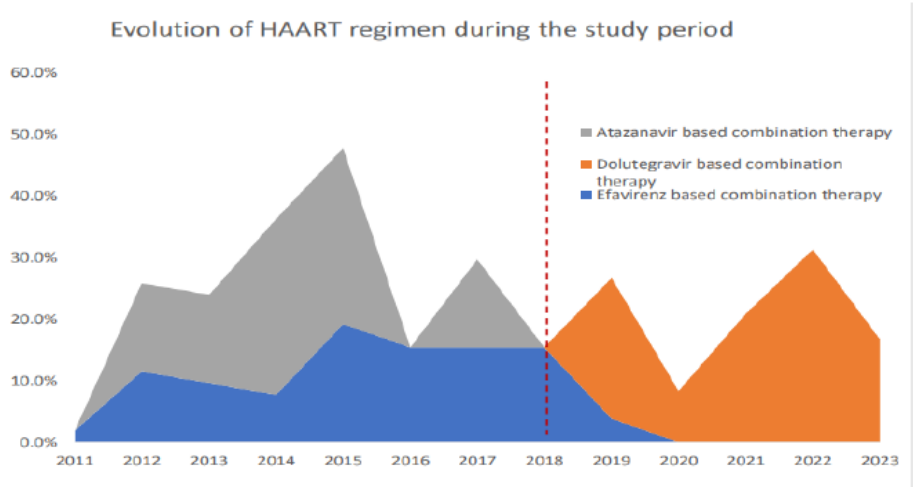

Figure 2. Evolution of Occupational PEP (ARVs) Regimen During the Study Period

Discussion

HCWs are well known to be susceptible to blood-borne pathogens and other infectious agents especially HIV while performing their legitimate duties of caring for patients [19]. These occupational exposures are not only due to inability to observe standard (universal) precautions or carelessness but multiple factors such as non-use of PPE, barriers, inadequate HCWs staffing and overwork [20]. This is particularly concerning in LMICs where HIV occupational exposures are very rampant but under-reported [19, 21, 22]. HCWs unwillingness to report HIV exposures may be due to the inadequate knowledge, high level of stigmatizations and discriminations in SSA [8, 19, 20, 23]. This attitude may unfortunately

increase HIV transmission among HCWs. Hence, this study met the principal objective of documenting the characteristics of exposures, adherence to ARVs and rate of seroconversion among exposed HCWs, with a view to suggesting policies that will improve PEP services.

In this present study, most of the HCWs who presented for oPEP were medical doctors, laboratory scientists, and nurses in that order. In contrast, other studies have noticed nurses, health attendants and cleaners as most affected by occupational hazards [2]. The higher proportion of these categories of HCWs who sought for oPEP was in agreement with many previous studies [1, 24, 25]. This may be due to the fact that the laboratory scientists handle a lot of blood/body fluids while doctors and nurses involved in both invasive and non-invasive procedures that put them at higher risk of HIV exposures [1, 24]. The mean age of presentation for oPEP was 32.3 years with majority belong to the young adult age group similar to other studies [25, 26]. The females were slightly more than their male counterparts. Our study is similar to studies in Nigeria and Serbia where female preponderance were also reported [27]. Majority of the HCWs in the study were married and Yoruba tribe, reflecting the dominant tribe in the study location in consonance with study by Aluko et. al. [20].

The type of exposure explored in our study indicated that needle stick injuries (NSIs) (80.7%) were the most common among the HIV exposed HCWs with doctors and other health workers (cleaners, health attendants, waste disposal officers) mostly affected. The high proportion of NSIs as the most common type of exposure has been similarly reported in previous studies [17, 25, 27, 28]. This has been attributed to HCWs non-adherence to standard precautions, institutional and psychosocial factors [20]. Many HCWs do not comply with healthcare facility safety protocols like standard (universal) precautions. Other factors that may be responsible are absence of personal protective equipment (PPE), inadequate staffing leading to excessive workload, inadequate knowledge of HIV oPEP, recapping of needles, and lack of safety materials, especially in developing countries [1, 20]. Majority of our cases under review were high risk (79%) exposures which warranted them to be commenced on oPEP with 3-drug standard regimen PEP protocol according to Nigerian national guideline [29, 30]. The prevalence of high risk exposures noticed in this study has also been observed by other researchers [31].

An indispensable aspect of PEP is the time of initiation of antiretroviral medication following HIV exposure which must be within 72 hours for PEP to be effective. Our study showed that less than one-thirds of the HCWs initiated oPEP within the first 2 hours of exposure when oPEP is most effective. Onyedum et. al. [30] also reported significant number of HCWs presented within 24 hours, however, non-occupational PEP were included in their study. It is noteworthy that greater proportion 84.1% presented within 72 hours as recommended by the Nigeria national guideline in agreement with earlier studies [1, 29, 30]. These may be due to increasing awareness of occupation hazards by health workers as majority of them were graduates [20, 30].

Our study revealed that almost all the HCWs (98.3%) who presented for oPEP were screened for HIV as an essential part of PEP services and were HIV negative making them eligible for oPEP. However, the source HIV screening is still poor as slightly less than half (49.1%) were available for screening, similar to low HIV screening of the source reported in previous studies [32, 33].

This study showed the adherence to oPEP (ARVs) to be slightly above average, similar to study done by Tetteh et. al. in Ghana, another developing country, in which both studies were less than 100% adherence recommended for effective HIV PEP [34]. Other developed countries have similarly reported moderate to low adherence to oPEP following HIV

exposures [35]. Side effects, defaults and fear of stigma and discrimination have been associated with poor adherence to PEP and low rate of follow-ups (33.3%) [8, 31, 34, 35]. Follow-up as low as 0% has previously been documented [32]. It is heartwarming to note from our study that, despite many high risk exposures, positive HIV sources and low to moderate adherence, seroconversion rate was 0% which is in agreement with other studies emphasizing the effectiveness of ARVs in preventing HIV transmission [25, 28, 34].

Dolutegravir based regimen, often comprising TDF/3TC/DTG, were found to be significantly predict adherence to ARVs because of increased tolerability, convenient dosing and lesser side effects compared to efavirenze-based regime. Being female HCWs was found to be significantly predict post-PEP follow-up screening $p < 0.05$. This is probably reflecting better health-seeking behavior of females [30]. In the twelve years under review of our occupational services (Fig. 1 & 2), atazanavir and efavirenz were the mainstay of oPEP before 2019 and a subsequent shift to dolutegravir based therapy in 2019. The shift resulted in non-linear progressive increase in utilization of PEP services over the years as well as progressive improvement in completion rate (adherence) in patients accessing occupational PEP starting from 2019 upwards. This improvement in adherence to oPEP (ARVs) may be partly due to dosing convenience with dolutegravir-based combination [30].

Conclusion

The shortcomings observed from this study has demonstrated that occupational PEP services is still a great concern that needs urgent attention as the results have not shown significant improvement from what was obtained in the past. The study still showed high risk exposures especially NSIs, low HIV screening of the sources, presentations beyond recommended 72 hours, low adherence rate and poor follow-up visits. HCWs should therefore be empowered through training, awareness campaigns and availability of safety equipment, with a view to improving the compliance to safety protocols at workplace. Healthcare facility managers should formulate policies that will address the flaws found from this studies.

Strengths of the Study

This study is one of the few occupational PEP research among healthcare workers in this environment that study the exposure characteristic, use of oPEP, shortcomings of PEP services and seroconversion rate. The 12 years of study gave an insight into the trend in the oPEP services and revealed flaws that may need improvement. The study also provided relevant evidence-based data from a tertiary health facility, a model of best practices in health care, [20] which can be relied upon, with a view to using the data for optimising oPEP services and for policy making.

Weaknesses of the Study

The study was a retrospective study and documentation may be inadequate. The exact hours between HIV exposure and initiation of oPEP may be inaccurate due to recall bias by the HCWs and low level of awareness about institutional policies and procedures following occupational HIV exposure [35]. Despite almost half of the sources were positive, information about their viral load and ARVs medications were not available. The study is a single tertiary facility-based study, exposure characteristics could have been worse elsewhere at lower or community health facilities. The reported outcome of no seroconversion could have been different also if majority had presented for post-PEP HIV screening. Adherence to ARVs though the mainstay of PEP was self-reported and not objectively assessed, therefore prone to errors and bias. The specific side effects developed by HCWs were unavailable in the medical records. These gaps noticed from this study can be a

very useful tool for future research and to improve on PEP services, as we encourage more data from other regional HIV/PEP treatment centres across the country.

Conflict of Interest

There is no conflict of interest to declare.

Acknowledgement

We acknowledge all the health care workers at the Virology Research Clinic of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun state, Nigeria for their support in the course of this study. We also specially acknowledge the contributions of our administrative staff, Mrs Adewuyi Bukola all through the years of this study.

Funding

This study did not receive any grant or funding from any individual, public, commercial, or non-profit organisation.

Data Availability Statement

The data produced for this study are available and can be requested from the corresponding author upon request.

Author's Contribution

Fatai O. Olanrewaju conceptualized, designed, and wrote the first draft of the manuscript. Muphy M. Oripelaye also engaged in conceptualizing, study design and supervision of data collection. Atinuke A. Ajani designed, data curation and formal analysis of the data. Olufikemi T Fabusuyi, Sally J. C. Chuhwak, Olufemi M. D. Ologun, Toyin Obafemi were collaboratively involved in critically reviewed, proofreading, editing, drafting of table 3. Oluwatobiloba A. Sobayo, and Olatunde P. Olanrewaju were involved in data collection, data entry and management. All authors reviewed, edited and approved the final manuscript.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art010

Scaling Up Tuberculosis Contact Investigation: Implementation Strategies, Outcomes, and Challenges — A Narrative Review

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Abstract

Tuberculosis (TB) contact investigation is a key strategy recommended by the World Health Organisation (WHO) to help detect cases early, increase preventive treatment, and reduce TB transmission. Even though many countries have adopted these policies, putting them into practice is still limited in places with high TB rates. This review brings together global evidence and highlights important areas such as how programs are run, what works well, ongoing challenges, and where more research is needed. The review covers thirty studies from different settings, including household and community interventions, digital tools, programs led by community health workers, public–private partnerships, and integrated service models. TB contact investigation has been effective in finding more cases and increasing preventive treatment. Household-based strategies work well but have not been widely expanded. Using community contact clusters could help find more cases in high-burden areas, but this can require a lot of resources. Digital tools might make the process more efficient and improve data quality if they are adapted to local needs. Programs led by community health workers can reach more people, but they often cost a lot to run. Expanding TB contact investigation can help with early detection and prevention if enough resources are provided. However, there are still many operational, social, and health system barriers that make it hard to implement these programs widely. To put the evidence into practice, ongoing investment, stronger health systems, local adaptation, and real involvement of affected communities are needed.

Keywords: *Contact Investigation, Contact Tracing, Implementation Research, Preventive Therapy, Resource-Limited Settings, Tuberculosis.*

Introduction

TB is one of the top ten causes of death worldwide and one of the leading causes of death from a single infectious agent (COVID-19 pandemic notwithstanding). It is estimated that nearly 30% of people with TB disease worldwide remain undiagnosed or are not notified to national TB programs, representing most cases in high burden countries [1]. Contact investigation is the systematic screening of individuals exposed to infectious cases of TB with the goals of ensuring TB treatment initiation among people with active disease and enrolment into TB preventive treatment for those with latent TB infection [2, 3]. TB contact investigation is an evidence-based strategy recommended by WHO, endorsed by global policymakers [2], and recognized as a high-value intervention [3]. Scaling up TB contact investigation is important for early case detection and interrupting TB transmission. TB contact investigation has been implemented widely in lower burden settings and among selected populations, such as children and household contacts of persons living with HIV,

Received: 30.01.2026 ***Accepted: 16.03.2026*** ***Published on: 29.04.2026***
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in high-burden countries [6]. However, TB contact investigation has not been implemented consistently or at scale in many high-burden, resource-constrained settings [6]. Disparities between policy and practice are notable where transmission intensity is high, and diagnostic capacity is limited [4, 5]. To reach targets identified at the UNHLM, programs would need to screen an estimated 18.5 million contacts of bacteriologically confirmed TB cases and initiate TPT in eligible persons each year [6]. Operational, financial, and societal barriers continue to pose substantial challenges to programmatic scale-up. Here we summarize the current evidence for TB contact investigation including descriptions of diverse implementation models, measurable impacts, barriers to scale-up, promising innovations, and gaps in the current evidence base. We searched published and grey literature for peer reviewed studies and programs evaluating TB contact investigation programs using PubMed with mesh terms (Supplemental Digital Material). We included descriptions of qualitative research, literature reviews, and program evaluations that described key components of contact investigation including screening of contacts, initiation of TPT, and treatment of active TB disease. We excluded papers not written in English or French. Thirty studies met our inclusion criteria and are summarized in this narrative review. We discuss evidence by the type of contact investigation strategy described including household-based, community-based, digital, community health worker-led, public–private, and integrated service delivery models. This review aims to strengthen the efforts of policymakers and practitioners by highlighting promising approaches to advancing TB contact investigation globally.

The first step in TB contact investigation is ensuring identification and enumeration of contacts for all people with infectious TB disease. These individuals have a significantly higher likelihood of being infected with MTB and progressing to TB disease than the general population. Source cases can either self-report their contacts to the public health department, or contacts can be identified by interviewing the index case. Upon identification, contacts should ideally be screened for TB symptoms, evaluated with a diagnostic test if indicated (reactive to screening), and linked to TB preventive treatment or TB treatment as appropriate. However, loss to follow-up can occur at each step of this cascade, which can result in low efficiency of case detection and poor preventive treatment yield. Recent evidence indicates that significant drop-offs are common at each stage: for example, up to 60% of initially identified contacts may not complete screening, and among those eligible for preventive treatment, only 20–40% may initiate or complete therapy (Global Tuberculosis Report 2025). These losses highlight critical bottlenecks in the cascade and underscore the importance of targeted efforts to strengthen program performance at each stage. By convention, TB contact investigations have historically focused on contacts within households of index patients. Transmission is frequent within households, and household contacts have a disproportionately high risk of infection and illness. This approach is appropriate and likely sufficient to optimize preventive treatment yield in low-incidence settings with sporadic transmission [7]. However, as the epidemiology of TB transmission varies by context, populations at greatest risk of infection may vary. Population attributable risk from household contacts vs. non-household contacts has not been well studied. While household contact investigation should remain a cornerstone of programs globally, extending efforts beyond households to include “contact clusters” may allow programs to find additional cases in areas of high burden [8]. Further consideration should be given to targeted active case finding strategies and transmission assessments when incidence is low.

Public Health Lessons Learned from HIV

There is extensive experience with similar approaches used to find additional cases of HIV. HIV contact investigation has been used by many health departments to augment existing HIV surveillance and identify newly diagnosed HIV infections. Interviews and behavioural assessment of people newly diagnosed with HIV have demonstrated extensive unrecognized transmission networks, many involving HIV care providers [9]. Leveraging the longstanding experience with HIV contact investigation, researchers have conducted qualitative studies to assess motivations, barriers, and best practices for TB contact investigation with household contacts of TB patients. An iterative human-centered design process conducted with parents of children with TB in Peru identified several barriers to household TB contact investigation, including structural barriers such as lacking contact information for all household members and long turnaround times for diagnostic tests, parent-specified needs including efficient communication between providers and families, and concerns regarding disruption of TB transmission in the family [10]. A second qualitative study conducted with family members of persons with HIV and TB highlighted several desirable features of digital TB contact investigation tools, including automated workflows with built-in logic, real-time transmission of information, and addressing potential concerns about digital tools such as misinformation and patient understanding of digital platforms [11]. Both studies identified important opportunities to harness innovations in digital health to improve past strategies for TB contact investigation.

Borrowed HIV tactics: Practical approaches for TB programs

- Proactive provider-assisted notification: Train TB care providers to assist index cases in identifying and reaching their contacts through structured interviews, similar to partner notification in HIV programs.

- Immediate, confidential follow-up: Establish rapid follow-up for named contacts with personal communication and counseling, ensuring privacy to reduce stigma and maximize engagement.

- Use of digital tracking and reminders: Implement automated systems for follow-up messages and appointment reminders to both index patients and contacts, building on the digital outreach models developed in HIV contact tracing.

Translation of this evidence to programs will be critical to improving outcomes for programmatic contact investigation.

Implementation of Contact Investigation for TB

Household Investigation: Evidence and Gaps

Household TB contact investigation is the most described implementation strategy in the literature. Across studies in high-burden settings, common success factors for effective household contact investigation include integration into existing clinics and services, dedicated training and supervision for providers, and strong programmatic support. Integrating contact investigation into national TB program operations and routine TB services has resulted in higher contact tracing rates and improved detection of active TB and eligibility for preventive therapy. For example, programs that embedded contact investigation within TB clinics were able to achieve high screening coverage among children under five, as well as increased identification of new TB cases. Training and supervisory activities for providers further encouraged systematic screening practices. However, several studies highlighted missed opportunities and inconsistent implementation, indicating that even successful approaches are not being applied on a scale. Overall, household-based contact investigation is both feasible and

impactful when built into routine systems and supported by adequate resources but remains underutilized despite demonstrated benefits.

Community-Based and Extended Contact Investigation

Extending "contact clusters" beyond households has been evaluated as a strategy to improve yield in high burden settings. One study from Pakistan describes extending contact investigation to individuals who live within 50 feet of smear-positive pulmonary TB cases [8]. Over 780,000 contacts were screened identifying 4710 TB cases. Screening of these additional contacts resulted in an increase in TB case detection of nearly 8%. Yield was found to be similar between household contacts and close community members, suggesting that community-based strategies may be highly useful in areas of high TB burden [12]. (Community-Based Tuberculosis Preventive Treatment Among Child and Adolescent Household Contacts in Ethiopia, 2024) However, implementing expanded contact investigation requires consideration of clear epidemiological and programmatic triggers. For example, programs should consider extending beyond households when the proportion of TB cases attributable to known household contacts is below 60%, or when ongoing community transmission is evident based on contact tracing data. Other triggers may include evidence of clusters of new cases with no clear household link, high rates of loss to follow-up among household contacts, or when health system capacity (such as human resources or logistics) is sufficient to support broader screening efforts. Defining these thresholds in advance allows national and local TB programs to make data-driven decisions that optimize resource allocation and expand contact tracing when it is most likely to increase TB case detection.

Mobile & e-Health Tools

Digital innovations have been leveraged to improve efficiency and completeness of contact investigation data. A theory of change underpinning these approaches assumes that mHealth tools can improve the cascade yield by reducing data loss, expediting the reporting of results, and enabling more targeted follow-up with contacts. For example, in Botswana, an mHealth application replaced paper contact investigation forms resulting in faster contact tracing and reduced missing data items [14]. The application allowed real-time reporting of information and collection of GPS coordinates, enabling health workers to accurately map where contacts lived. Simple logic algorithms were used to prevent users from skipping steps in the process or missing information, with the expectation that this would lead to more thorough screening and higher treatment initiation rates. In contrast, a complex digital TB contact investigation intervention in Uganda did not demonstrate improvement in outcomes [15]. This approach incorporated multiple innovations, including fingerprint identification, electronic decision support algorithms, and automated reporting into contact investigation. However, contact investigation yield did not improve compared to standard of care. In this case, the complexity and the introduction of multiple new tools at once may have overwhelmed users or did not address the primary barriers in that context. Costs were high, and multiple complex technologies were introduced at once. These findings illustrate that the causal pathway from digital innovation to program outcomes depends on whether a chosen technology fits local needs, workforce capacity, and addresses the known gaps in the contact investigation process. Innovations and technology must be adapted to the local context in which they are implemented.

Community Health Worker-Led Models

Contact investigation delivered by community health workers (CHWs) has been implemented in several countries. In Uganda, community health workers completed home visits to screen for TB symptoms, collect sputum samples, and link individuals to care [16]. Community health workers also conducted contact investigation in Mongolia [3]. While these programs demonstrated promise in reaching populations with limited facility-based capacity, both studies described high costs associated with these programs. Costs from the Uganda study were unable to be assessed at scale but were over $300 per contact and $8996 per TB case diagnosed at the household-level because of the digital application developed for use by CHWs [16] [17]. Public investments of this size are unsustainable over the long term. However, these high costs represent an opportunity for pragmatic efficiency trials to identify sustainable models. Specific cost-reduction strategies could be piloted, such as pooled transport for CHWs operating in the same geographic areas, task-shifting to involve lower-cadre health workers where appropriate, group contact screening visits, or integration with existing outreach services. Inviting research into these approaches could help identify feasible pathways to scaling up CHW-led contact investigation while keeping programs cost-effective. Readers are encouraged to consider these pilot designs as a means of advancing the evidence base for efficient TB contact investigation implementation.

Public–Private Partnerships and Social Franchising

Contacts have also been investigated through the engagement of private sector providers. Nigeria implemented the Social Franchising for TB Contact Investigation (SOFT) model enlisting social franchised healthcare providers to help increase TB contact investigation [18]. Pakistan also used public-private partnerships linked to international funding to implement large-scale contact tracing [4]. Partnerships with private providers may allow programs to expand coverage but are likely to be highly resource-intensive and require careful consideration of sustainability and equity.

Integration with Existing Health Services

Integration of contact investigation activities with existing health services has been used to improve efficiency of services. Integrated child health clinics were used to screen children for TB in Ethiopia [5]. While children were primarily screened in their home by healthcare workers, over 1,991,401 children were screened during this intervention and additional TB cases were identified [19]. Several considerations were necessary to implement this integration successfully including training and supervision, collaboration between clinics and TB centers, and established referral mechanisms.

Impact of Contact Investigation Strategies

As described in previous sections, multiple strategies have been used to implement contact investigation for TB. Household contact investigation has the most evidence globally and was implemented within routine health care systems in most studies described. Across these studies, contact investigation led to increased case detection and preventive treatment for TB. Although the percent of household contacts that tested positive for TB varies, implementing contact investigation at the scale necessary to reach global targets would lead to identification of many additional TB cases [1 ,8, 13]. Delivery of tuberculosis preventive treatment (TPT) also improved with intensified contact investigation efforts, though coverage remained far below targets [20]. Cost-effectiveness of these interventions has not been studied widely [21, 22]. Despite major differences in the type of contact investigation strategy implemented, studies frequently reported improvements in

efficiency with electronic data collection tools. Programs that used complex technologies saw little to no benefit [15]. High-income countries have additional opportunities to consider integration of digital innovations into existing infrastructure. Cost and sustainability remain important challenges, particularly for community-based and digital TB contact investigation interventions [6, 16].

Lessons Learned and Knowledge Gaps

It is well accepted that TB contact investigation and preventive treatment are efficacious [23]. The challenge moving forward is to adapt current best evidence to the local context and implement these interventions routinely. Key barriers including weak health systems, shortages in TB workforce, lack of access to quality diagnostics, stigma, and incomplete data systems must be addressed [3, 24, 25]. Additionally, it is clear there remains a gap between policy and program implementation in many countries with supportive TB policies [4]. Poverty and stigma create additional societal barriers that prevent contacts from participating in care.

There are several emerging innovations that show promises to improve outcomes from TB contact investigation. Digital tools have been leveraged to enhance both efficiency and data quality of contact investigation. Implementation of quality improvement measures and other approaches such as using social network analysis or geographic information system data to inform where contact investigation is conducted should be considered [2,10,11]. Innovations require validation and longitudinal follow-up to determine their effect on outcomes. Future implementation research should prioritize operationalizing and costing these innovations before they are introduced at scale.

Conclusion

TB contact investigation is a high-value strategy to expand early case detection and preventive treatment for TB. While existing evidence demonstrates that multiple implementation strategies can be successful at improving TB preventive treatment coverage and case detection, country programs have not consistently implemented this intervention at scale. Operational, societal, and health-system barriers must be overcome to expand coverage of TB contact investigation. Implementation research to understand the operational details and costs associated with these innovations will be critical to translation of evidence into practice. Contextualization of current best evidence will be key as programs work to expand services to reach UNHLM targets. Only by bridging the gap between policy and programmatic reality will global efforts be able to translate evidence into population-level reductions in TB.

Ethical Approval and Consent to Participate

Not applicable.

Conflict of Interest

There is no conflict of interest.

Acknowledgements

None.

Data Availability

Not applicable.

Funding Section in the Manuscript

None.

Author Contributions

Alexander Agada Akor: conceived, designed, prepared, revised and approved the final manuscript to be submitted.

Toyin Dare Kayode: prepared, revised and approved the final manuscript to be submitted.

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Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art011

Seasonal and Post-Hurricane Assessment of Non-Municipal Drinking Water Sources in East Rural St. Andrew, Jamaica: Case Study of Craig Hill and Cozy Nook, February 2026

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Abstract

Roadside entombments remain critical non-municipal water sources in rural Jamaica, serving both residents and commercial operators who harness water for resale. This study integrates findings from a seasonal descriptive analysis conducted prior to Hurricane Melissa with post-hurricane water quality assessments in Craig Hill and Cozy Nook. Pre-hurricane data revealed consistent microbial contamination across seasons, with total coliforms detected in 100% of samples, while physiochemical parameters such as pH and total dissolved solids (TDS) remained within national limits. Seasonal variation showed higher microbial loads during wet months, reflecting increased runoff and pathogen transport. Post-hurricane results demonstrated elevated heterotrophic plate counts and a significant increase in TDS in Craig Hill, suggesting contamination from soil erosion and infrastructural disruption. Together, these findings underscore the chronic vulnerability of rural water supplies to microbial contamination and their acute susceptibility to disaster impacts. The study aimed to assess the seasonal and post-hurricane variations in the quality and safety of non-municipal drinking water sources in East Rural St. Andrew, Jamaica (Craig Hill and Cozy Nook).The findings highlights the urgent need for a national water governance policy that includes the management of non-municipal water sources, and other policy reform which includes health education that will safeguard public health and advance Jamaica's progress toward achieving the United Nations Sustainable Development Goal 6 by the year 2030.

Keywords: *Non-Municipal Water, Water Governance, Water Insecurity.*

Introduction

Potable water is defined as water that is free from harmful pathogens and disinfected with a minimum chlorine residual of 0.2–1.0 ppm [1]. Globally, approximately 2.2 billion people lack access to safe water [2], and currently, less than 1% of the world's water is available as fresh water. Impacted by climate change and other factors, the global water insecurity situation is expected to worsen in years to come. Water supplies on land have fallen significantly over the past decade to a rate of 1 cm per year [3]. As issues with climate change continue to spiral globally due to a lack of political will and policies to support well-needed actions, water insecurity will remain a significant public health concern throughout the world.

In the Caribbean and Latin America alone, more than 25% of the population lacks access to water and sanitation [1]. Jamaica is also one of the countries in the Caribbean that has experienced water shortages due to uneven water distribution [1]. Despite the country having numerous freshwater sources throughout its landscape, water scarcity

Received: 13.02.2026 ***Accepted: 10.03.2026*** ***Published on: 29.04.2026***
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remains a constant reality for many individuals living within the country. Similar to the global situation, water insecurity is a persistent challenge in Jamaica, particularly in rural communities where municipal supplies are limited or absent. Roadside entombments, often centuries old, have become vital sources of drinking water for residents of East Rural St. Andrew. These sources are not metered, regulated, or routinely monitored, yet they provide water for domestic use and commercial distribution. Previous research conducted by Atkinson and Bellal [6] established a seasonal baseline for Craig Hill and Cozy Nook, showing that while physiochemical parameters such as pH and TDS were within acceptable ranges, microbial contamination was present year-round.

Currently, water insecurity issues in Jamaica are continuously exacerbated by droughts and other harsh weather conditions as temperatures exceeded 93.7°F (34.2°C) in several areas [4]. Given the harsh realities and the importance of water in ensuring hygiene and sanitation, Jamaican householders have continuously turned to sources other than those provided by government for this scarce commodity [5]. To worsen the water insecurity issues faced by Jamaican residents in November 2025, Hurricane Melissa struck Jamaica, disrupting infrastructure and increasing the risk of contamination in rural water supplies. By integrating pre-hurricane seasonal data with post-hurricane results, this study provides a comprehensive view of both chronic and acute risks associated with non-municipal water sources. It situates these findings within the broader context of public health, environmental management, and policy gaps, offering valuable insights for disaster preparedness and water governance.

Materials and Methods

The pre-hurricane study was cross-sectional descriptive survey conducted to assess seasonal variation in water quality. Sixteen samples were collected from Craig Hill and Cozy Nook during wet (December–June) and dry (September–November) months. Parameters assessed included pH, TDS, total coliforms, and heterotrophic plate count (HPC). Samples were analysed using calibrated handheld devices for physiochemical parameters, and for microbiological analysis the assessments were conducted using standardized procedures outlined in the Standard Methods for the Examination of Water and Wastewater [7]. For the post-hurricane study following Hurricane Melissa in November 2025, eight water samples were collected from Craig Hill and Cozy Nook. Parameters assessed mirrored those of the seasonal study, allowing direct comparison. The study aimed to assess the seasonal and post-hurricane variations in the quality and safety of non-municipal drinking water sources in East Rural St. Andrew, Jamaica (Craig Hill and Cozy Nook). The following five research questions guided the study ; how does the quality of non-municipal drinking water sources in Craig Hill and Cozy Nook vary between dry and rainy seasons, what changes in microbial and physicochemical parameters occur in these water sources following a hurricane, are there significant differences in contamination levels between water from Craig Hill and Cozy Nook across seasons and post-hurricane periods, what potential health risks are associated with the observed seasonal and post-hurricane water quality changes and how can findings inform strategies for improving water governance in rural Jamaican communities dependent on non-municipal sources. Data analysis was done by comparing water quality results against the World Health Organization [8] and Ministry of Health and Wellness Jamaica standards [9]. Seasonal baselines were used to contextualize post-disaster changes, highlighting both long-term contamination patterns and acute disaster impacts.

Results

The results of this study integrate both seasonal baseline data and post-hurricane assessments**,** providing a comprehensive view of the chronic and acute vulnerabilities of non-municipal drinking water sources in Craig Hill and Cozy Nook. Seasonal monitoring established patterns of microbial contamination and physicochemical stability across wet and dry months, while post-hurricane sampling highlighted the immediate impacts of Hurricane Melissa on water quality. The findings are presented in two parts namely: Pre-Hurricane assessment which is a comparative analysis of pH, total dissolved solids (TDS), total coliforms, and heterotrophic plate counts (HPC) across wet and dry seasons and Post-hurricane assessment which is an evaluation of the same parameters following the passage of Hurricane Melissa, with emphasis on deviations from seasonal norms as well as national and the World Health Organization standards. By juxtaposing seasonal and disaster-related data, the results illustrate both the persistent microbial risks inherent in roadside entombments and the heightened contamination associated with extreme weather events. Tables 1 and 2 summarize the measured parameters, followed by narrative commentary that interprets the findings in relation to public health standards and vulnerability.

Table 1. Seasonal Water Quality Parameters Pre Hurricane

Parameter	Craig Hill (Wet)	Craig Hill (Dry)	Cozy Nook (Wet)	Cozy Nook (Dry)	National Standard	WHO Guideline Limit
pH	7.13	8.21	7.4	7.2	7.0–8.4	6.5–8.5
TDS (mg/L)	204	144	167	86	≤300	≤1000
Total Coliform (CFU/100 mL)	170	33	79	<1.8	0	0
HPC (CFU/mL)	1×10^2	1.8×10^2	1.4×10^2	1	1	No health-based limit (<500 recommended)

Table 1 demonstrates that pH values were stable and within national standards, with Craig Hill slightly higher in dry months whilst the TDS levels remained below the 300 mg/L limit; Cozy Nook showed lower values in dry months. Microbiological findings revealed coliforms in 100% of samples, with higher counts during wet months. HPC levels were elevated but within WHO's acceptable limit.

Table 2. Post-Hurricane Water Quality Parameters

Parameter	Craig Hill	Cozy Nook	National Standard	WHO Guideline Limit
pH	7.4	7.2	7.0–8.4	6.5–8.5
TDS (mg/L)	363	140	≤300	≤1000
Total Coliform (MPN/100 mL)	2.0	<1.8	0	0
HPC (CFU/mL)	1.2×10^2	9.8×10	1	No health-based limit (<500 recommended

Table 2 showed that Craig Hill had a sharp rise in TDS (363 mg/L), exceeding national limits, likely due to hurricane related runoff and erosion. Coliforms were detected (2.0 MPN/100 mL), and HPC remained elevated. Cozy Nook maintained TDS within safe limits (140 mg/L), with minimal coliform detection (<1.8 MPN/100 mL) and relatively low HPC counts.

Discussions

The integration of seasonal and post-hurricane data reveals a layered picture of vulnerability in rural water supplies, particularly those harnessed from roadside entombments in East Rural St. Andrew. Seasonal data confirmed that microbial contamination is a persistent issue, with coliforms detected in 100% of samples across both Craig Hill and Cozy Nook [6]. This chronic contamination reflects the influence of pit latrines, agricultural runoff, and inadequate sanitation practices in surrounding communities [10]. The seasonal analysis revealed higher microbial loads during wet months, highlighting the role of rainfall in transporting pathogens into entombments [6]. Increased runoff during rainy periods likely carries organic matter, animal waste, and human excreta into water sources, elevating coliform counts and heterotrophic plate counts [10]. Conversely, dry months showed lower coliform counts, suggesting reduced runoff and dilution of contaminants. Contamination persisted even in dry months, demonstrating that residents are never fully protected from the risk of waterborne illnesses.

Post-hurricane results demonstrated acute changes, particularly in Craig Hill, where TDS spiked to 363 mg/L, exceeding national limits [9]. This sharp increase likely reflects soil erosion, debris inflow, and infrastructural damage caused by Hurricane Melissa [8]. Cozy Nook fared better, with TDS remaining within safe limits, but microbial contamination persisted, reinforcing the notion that disasters amplify existing vulnerabilities rather than creating new ones. The presence of coliforms and elevated HPC levels pose risks for diseases such as typhoid fever, leptospirosis, and rotavirus, which are endemic in Jamaica [10]. Seasonal increases in microbial loads during wet months coincide with higher incidence of gastroenteritis and diarrheal diseases [10], while post-hurricane contamination increases the likelihood of outbreaks due to disrupted sanitation systems and limited access to safe alternatives.

Both the seasonal and post-hurricane studies highlight the absence of monitoring and regulation for non-municipal supplies. Despite Jamaica's Water Resource Act and Water Sector Policy [12, 13], roadside entombments remain outside formal governance structures. Bulk water trucking and resale of untreated entombment water exacerbate risks by extending unsafe supplies beyond local communities. Without intervention, rural populations will continue to face chronic contamination and acute disaster risks, undermining Jamaica's progress toward Sustainable Development Goal 6 [2, 11].

Globally, countries such as India have identified heavy metals and other contaminants in drinking water through surveillance and epidemiological research, linking environmental health to disease incidence [14]. In contrast, Jamaica's water quality surveillance focuses exclusively on municipal supplies, neglecting non-municipal sources that serve rural populations. On the other hand, countries such as Canada and the United States have recognized the importance of regulating private water supplies, thereby indirectly protecting citizens through policy and oversight [15, 16, 21]. As seen from the results, the pH or Hydrogen Ion concentration is an important parameter indicating the acid or alkalinity characteristics of the water [17]. In surface water, pH is also influenced by the geological nature of the drainage basin [18]. While chemical and physical parameters of drinking water are known to be of major public health significance, most emphasis including research has always focused on biological risk associated with water. In Jamaica, there are established water quality standards monitored by the Ministry of Health and the National Environment and Planning Agency. These parameters are as follows: Zero CFU/Coliforms, 0.2 ppm residual chlorine, Chloride 5-20 mg/L, Nitrate 0.1-7.5 mg/L, pH

7-8.4, Total Dissolved Solids 120-300 mg/L [9].

Similar to this research, in villages of Barwari Bala, Duhok, Kurdistan Region Iraq, the chemical quality of spring water was assessed; a total of 120 spring water samples were collected from ten villages during the dry and wet seasons in 2018. The samples were analysed for major physicochemical characteristics, including Ca^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, pH, and TDS. All parameters except sulphate (SO_4^{2-}) were found to be higher in the wet season than the dry season [19]. During each season, six water samples at 10–15-day intervals were collected from each spring. The sampling method and intervals employed allowed for a comparative analysis of the water quality and the elimination of bias. Based on the methodology employed in collecting the samples, the data generated could be considered generalizable and reliable, thereby informing policy decisions.

Surface water or shallow groundwater should not be used as a source of drinking water without sanitary protection or treatment. In most natural waters used for drinking, the pH lies within the range 6.5-8.5 and is controlled by the carbon dioxide and bicarbonate-carbonate equilibrium system. Increased carbon dioxide concentration will therefore lower pH, whereas a decrease will cause it to rise [18]. Temperature also affects the equilibria of pH measurements for water. In pure water, a decrease in pH of about 0.45 occurs as the water temperature is raised by 25 °C [20]. All the results were in the slightly alkaline range. Alkaline drinking water has been proposed by proponents of alternative medicine as a remedy to counteract the effects of an abiogenic diet. While many claims of health-promoting effects of alkaline water are scientifically unsubstantiated, changes in drinking water pH have been reported to affect both gut microbiota composition and host metabolism, as evidenced by two recent studies in diabetes-prone non-obese diabetic mice [18]. Neutral water (pH ≈ 7) compared to acidic water (pH ≈ 3) increased the incidence of diabetes [18, 19]. TDS and pH of water should be monitored directly on a continuous basis since they tend to change rapidly and have a significant adverse effect on humans if allowed to operate out of range [20].

Altogether, the findings underscore the urgent need to reframe rural water governance in Jamaica. Roadside entombments, though historically significant, remain outside the scope of formal regulation, leaving communities chronically exposed to microbial contamination and acutely vulnerable during disasters. Effective governance must extend beyond municipal systems to include non-municipal sources, integrating them into national monitoring frameworks, disaster-response protocols, and community education initiatives. By establishing clear policies for registration, routine testing, and safe distribution from entombment water, Jamaica can bridge the gap between informal practices and public health protection. Strengthening rural water governance is therefore not only a matter of infrastructure but also of equity, ensuring that marginalized communities have access to safe, reliable water in line with Sustainable Development Goal 6 and the human right to water recognized by the United Nations [2, 11]

Recommendations

The recommendations from this study are directed to the Ministry of Health and Wellness and other key stakeholders in Jamaica's water sector. Based on the findings, the following actions are advised:

- Extend monitoring beyond municipal supplies to include non-municipal and community-based sources such as roadside entombments, springs, and tributaries.
- Establish routine microbial and chemical testing protocols aligned with WHO standards for community-based water sources a such as roadside entombments.

- Amend Jamaica's Water Sector Policy to explicitly include non-municipal supplies under national water safety frameworks.
- Require registration, oversight, and periodic inspection of private and community-operated water sources.
- Promote household-level technologies such as ceramic filters, UV treatment, and safe storage containers as a part of water safety and governance framework.
- Implement rapid testing and emergency water treatment protocols following hurricanes and floods.
- Develop contingency plans for rural communities to ensure access to safe water during disasters.
- Launch intensified community education campaigns on the health risks of untreated water, proper disinfection methods, and safe storage practices.
- Train community leaders and health workers to function as water safety advocates.
- Conduct longitudinal studies to explore associations between water quality and chronic illnesses such as kidney disease and dermatological conditions.
- Strengthen surveillance systems to capture both communicable and non-communicable disease outcomes linked to water quality.
- Modernize rural water sources, replacing colonial-era entombments with improved catchment and distribution systems.
- Encourage public-private partnerships to fund safe water infrastructure in underserved communities.
- Accelerate national efforts to meet Sustainable Development Goal 6.2 by prioritizing rural water safety.
- Benchmark Jamaica's progress against countries that regulate private water supplies, such as Canada and the United States, to identify best practices.

Conflict of Interest

The researcher declares that there were no personal, financial, or professional conflicts of interest that could have influenced the design, conduct, or reporting of this study.

Data Availability

All data generated and analysed during this study are included in this published article. The water quality parameters, seasonal and post-hurricane datasets, and epidemiological survey findings are presented in full within the tables and narrative sections. No additional unpublished data are available.

Ethical Approval

This study involved environmental sampling of water. No personal health information was collected. As such, formal ethical approval was not required; however, the research was conducted in line with national and international ethical standards for public health research.

Artificial Intelligence Use

Artificial intelligence tools were used to support the preparation of this manuscript, specifically for language refinement and formatting assistance. No AI systems were involved in data collection, analysis, or interpretation of results. The author reviewed and verified all AI-assisted outputs to ensure accuracy, integrity, and compliance with ethical standards for academic writing.

Author Contributions

Dr. Karlene Atkinson: Conceptualization, data collection, analysis, manuscript drafting.

Funding

This research received no external funding. The costs associated with sampling and fieldwork were self-funded by the researcher. Institutional support was provided by Texila University during the student's pursuit of her PhD studies in Public Health.

Acknowledgements

The researcher acknowledges the Scientific Research Council for conducting analysis of the water samples, family members and church family for their encouragement and prayers, and to the Almighty God for strength and guidance throughout the study.

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