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Water Availability and Quality Assessment in Health Facilities: A Case Study of Five Primary Health Care Centres in the Federal Capital Territory

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Abstract
This study evaluates water availability, quality, and the utilization of water-related funding in five Primary Healthcare Centres (PHCs) in Nigeria's Federal Capital Territory (FCT). The research focuses on compliance with the World Health Organization (WHO) and Federal Ministry of Environment (FMEnv) water quality standards, as well as service benchmarks defined by the Joint Monitoring Programme (JMP) for safely managed water. Primary data were collected through structured questionnaires and direct water sampling, with physical, chemical, heavy metal, and microbial analyses conducted. Findings reveal that most physical and chemical parameters, including pH (6.73–6.95), turbidity (0.02–0.15 NTU), and total dissolved solids (28.3–342 mg/L), met the WHO and FMEnv standards. However, phosphate levels at Karu PHC exceeded permissible limits, and significant microbial contamination was detected: Escherichia coli (6.0 × 10^1 CFU/100mL), total coliforms (6.5 × 10^1 CFU/mL), and Salmonella/Shigella were all present above the WHO and FMEnv safety thresholds. In terms of water availability, Garki and Gwarinpa PHCs lacked consistent access in critical areas such as toilets and operating rooms, falling short of JMP criteria. Bwari, Karu, and Kuje PHCs had better access, meeting the availability benchmark. Despite overall compliance with accessibility and contamination-free criteria, gaps in critical areas hinder full classification as "safely managed." Regarding funding, the Basic Health Care Provision Fund (BHCPF) allocation was found to be minimal (0–25%) or absent in some PHCs like Garki and Gwarinpa, where Drug Revolving Funds (DRF) are used instead but are not applied to water infrastructure. The study highlights the urgent need for targeted interventions, including microbial disinfection, phosphate control, infrastructure upgrades, and more strategic allocation of BHCPF resources. These measures are crucial for improving health outcomes and enhancing the quality of care in FCT PHCs, ensuring reliable access to safe water in line with global WASH standards.

Keywords: *BHCPF, FCT, PHCs, WASH, water quality.*

1.0 Introduction
1.1 Background of the Study

One in three people globally faces daily water scarcity (World Health Organization, 2019). Water is one of the most important factors in healthcare facilities. Without access to clean water, these facilities face challenges that can lead to an increase in diseases. In Nigeria, only 70% of the population has access to basic drinking water, and just 9% have access to comprehensive Water, Sanitation and Hygiene (WASH) services, despite the country's abundant water resources. However, federal, state, and local governments have not effectively utilized these resources to ensure long-term access to safe, sufficient, and improved water supply and sanitation for the population (Muta'a, 2012).

Access to WASH services remains challenging in Nigeria. According to (WASHNORM 2021), approximately 67% of the population has access to basic water supply services, but only 13% are classified as "safely managed." Basic sanitation is even less accessible, with only 46% of Nigerians having access, and just 18% being safely managed. In Nigeria, there are approximately 33,000 Primary Health Care (PHC) facilities; however, half of them lack access to clean water, 88% lack basic sanitation amenities, and 57% do not use soap to wash their hands. A hospital-based study on patient satisfaction in Nigerian healthcare facilities found that 71.7% of patients were dissatisfied with the toilet facilities (Ezegwui et al., 2014).

To better understand the role of water in healthcare, it is essential to define the facilities and services provided at the primary healthcare level. A healthcare facility is any recognized or governed establishment that provides healthcare services and is located in either urban or rural areas. Primary Healthcare facilities provide professional medical treatment for individuals within a specific region or community, before referring them to more advanced hospital-based care. The World Health Organization (WHO) emphasizes that adequate water supply in health facilities is a crucial component of effective healthcare delivery, particularly in low- and middle-income countries where the absence of reliable water access can exacerbate health risks

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(WHO, 2019). Without safe water, healthcare facilities are unable to sterilize equipment, maintain cleanliness, or provide safe drinking water to patients and staff.

Water availability and quality challenges are widespread in Nigeria, impacting various sectors, including healthcare. The Federal Capital Territory (FCT), as the nation's capital, is expected to have a robust healthcare infrastructure. However, many PHCs in the FCT face persistent challenges in accessing reliable and safe water supplies, highlighting significant issues with both the availability and quality of water.

According to Ademiluyi and Aluko-Arowolo (2009), poor water quality and supply disruptions in Nigerian PHCs contribute to increased infection rates and patient complications. These difficulties call into question the limitations of current policies and infrastructure in ensuring consistent and safe water access in healthcare settings, particularly in critical regions such as the FCT.

This research focuses on assessing the water availability, quality, and how funding is used for water infrastructure in five selected PHCs within the FCT to address challenges and propose actionable solutions.

1.2 Research Problem

There is a global consensus that water infrastructure development is key to attaining the Sustainable Development Goals (SDGs) (Adeniran et al., 2021). All healthcare facilities require water to function, particularly for infection prevention, personal hygiene, and the overall treatment of patients.

Existing policies and interventions do not address the specific water needs of PHCs in the FCT. Key gaps include the misallocation of the National Primary Health Care Development Agency (NPHCDA) Gateway and Basic Health Care Provision Funds (BHCPF), which prioritize drugs, vaccines, and facility maintenance while ignoring critical infrastructure such as WASH services and the quality of water (Ladi Abudu, 2020). Inefficient allocation of these resources hinders the provision of crucial healthcare services.

The research aims to assess how PHCs in the FCT utilize BHCPF, identify gaps in fund allocation, and propose strategies for improvement.

This research is vital because it addresses the fundamental problem that has a direct impact on the provision of WASH services and patient safety in the FCT.

To this effect, this research seeks to answer the following questions:

1. What is the primary source of water?
2. How consistent is the availability of water in PHCs in the FCT?
3. Do WASH facilities meet the JMP standard for safely managed access to the water supply?
4. Does the water in the facilities meet basic quality standards as prescribed by the NSDWQ?
5. What are the primary challenges PHCs in the FCT face in terms of water supply and quality?
6. How do the availability and quality of water challenges influence how healthcare is provided and safety for patients in FCT PHCs?
7. What are the potential solutions to improve water availability and quality in PHCs within the FCT?
8. What is the present use of BHCPF funds by PHCs in the FCT, and how can it be improved?

A questionnaire is utilized to collect information about fund allocation and usage.

1.3 Aim and objectives of the study

This study assesses the availability and quality of water in five selected primary healthcare centres (PHCs) within the Federal Capital Territory (FCT) and explores how these factors influence healthcare delivery. Specifically, it examines existing water supply systems, evaluates compliance with national and international water quality standards, identifies challenges affecting water access and safety, and investigates the implications for infection control and patient care. The study also evaluates the adequacy of water-related funding from the Basic Healthcare Provision Fund (BHCPF), and it proposes practical infrastructure and policy-based solutions to improve water supply in the selected PHCs.

1.4 Scope of the Study

The scope of this study is focused on assessing the availability, quality, and how funding is used for water infrastructure in five selected PHCs within the FCT, Nigeria. These healthcare centres are:

1. Primary Healthcare Centre, Garki village
2. Primary Healthcare Centre, Gwarinpa village
3. Primary Health Centre, Bwari Town
4. Karu Primary Healthcare Centre
5. Kuje Primary Healthcare Centre

The selection of Garki, Gwarinpa, Bwari, Karu, and Kuje PHCs aimed to ensure geographical representation across the FCT’s area councils, while also considering accessibility and practical feasibility. These locations reflect diverse infrastructure and water access conditions across urban and peri-urban settings.

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1.5 Significance of the Study

This research project establishes the current status of water supply in health facilities and associated challenges in PHCs in the FCT. The work elucidates the important role of safe water as an essential resource in healthcare service delivery. Some insights that can be gained from the research are as follows:

1. The study fills knowledge gaps by assessing water availability and quality in PHCs in the FCT, thereby improving understanding of water management in healthcare facilities.
2. It utilized tailored water quality testing methods that meet national and international standards while focusing on the needs of Nigerian healthcare facilities.
3. The study advocates for enhanced funding of water infrastructure in the PHCs in the city.

1.6 Review of similar studies

Water availability and quality are now one of the major issues with regard to public health and environmental studies due to their influence on human health, especially in hospitals. This chapter reviews some research works that have been done regarding water availability, WASH services, and water quality. The review explores key themes such as water supply infrastructure, quality standards, WASH services, and their impact on healthcare delivery, guided by the WHO Joint Monitoring Program (JMP).

1.7 Water Availability in Healthcare Facilities

Water Availability is defined based on the JMP Standards for "Improved Drinking Water Sources," which consider that improved drinking water sources are those which, by nature of their design and construction, have the potential to deliver safe water.

To meet the criteria for a safely managed drinking water service in PHCs, the water source must:

(i) Be accessible on the premises of the healthcare centre
(ii) Be available when needed for critical areas such as operating rooms and toilets, and
(iii) Be free from contamination, including fecal coliform and other priority chemical contaminants.

1.7.1 Importance of Water Availability in PHCs

Adequate water supply in healthcare facilities is crucial for maintaining hygiene, performing medical procedures, and ensuring the safety of both patients and staff. The WHO emphasises the importance of consistent access to water in achieving universal health coverage and Sustainable Development Goal 6, which focuses on clean water and sanitation. According to the WHO 2019, roughly 25% of healthcare facilities worldwide lack basic water services, which limits their ability to provide quality care.

1.7.2 Challenges of Water Availability in PHCs

The lack of a reliable water supply in critical areas of PHCs makes it difficult to maintain proper sanitation and hygiene, which in turn impacts infection control and the quality of care. Many PHCs rely on boreholes and other alternative sources, which are frequently insufficient to meet the high-water demand. These shortages jeopardise patient care and raise health concerns, particularly in facilities where WASH services are already limited. (Adebanjo 2021) discovered that water availability in ABUAD was primarily derived from boreholes that met WHO standards, even though cadmium ions and turbidity required treatment. According to Odjegba *et al*. 2021), WASH facility availability in 61 PHCs in Southwest Nigeria found that many rural PHCs relied on boreholes and hand-dug wells, with limited water treatment processes. The reliance on untreated sources highlighted the need for improved water availability and treatment, particularly in rural areas.

1.8 WASH Services in Healthcare Facilities

A 'basic water service' indicates that a health care facility has access to an on-site, improved water source. Many health care services are dependent on reliable access to a sufficient supply of water of adequate quality. Different facilities have varying water requirements depending on the type of health services offered and the scale of the facility. Measuring the reliability, sufficiency, and quality of water supplies can be challenging and often overlooked in monitoring systems. For global monitoring, the JMP prioritises basic service levels (WASH in Health Care Facilities 2023 Data Update: Special Focus on Primary Health Care | JMP, 2023).

1.9 Water Quality Assessment in Healthcare Facilities

Several studies examined the quality of water in different health care facilities, focusing on physicochemical and microbiological parameters. These studies consistently emphasise the difficulties of water contamination and the potential health risks associated with low water quality.

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(Stein *et al.* 2024) assessed the quality of water in schools after chlorination, to identify harmful by-products like trihalomethanes. Water samples were collected from 17 different locations and tested before and after storage in reservoirs. The analysis used standard methods, such as microbiological and physicochemical testing, as well as atomic absorption spectroscopy. The results showed that all parameters fell within the scope of current Brazilian legislation. THM concentrations were found to be below legal limits. However, comparisons were made solely with Brazilian standards, disregarding international guidelines such as those issued by the WHO and the United Nations (UN). Overall, the study concluded that filtered water supplied to schools is safe and meets local regulations.

(Kumar *et al.* 2024) Investigated drinking water quality at government hospitals in the Patna District. Water samples from ten hospitals were tested for physicochemical properties and heavy metals using standard laboratory techniques. Some samples exceeded the WHO and Bureau of Indian Standards (BIS) standards for total dissolved solids (TDS), hardness, and iron content. The study did not conduct extensive comparisons with WHO and BIS standards for all parameters, but it concluded that poor water quality, particularly high TDS and iron levels, posed potential health risks in hospitals.

(E.E. *et al.* 2022) Investigated drinking water and sanitation in secondary schools in Port Harcourt, Nigeria. Samples were collected from 40 randomly selected schools and tested for microbiological and physicochemical parameters. Except for magnesium levels, the physicochemical parameters generally met the WHO and Standards Organization of Nigeria (SON), with a pH in the recommended range of 6.5 to 8.5. However, the study found an alarmingly high level of heterotrophic bacteria in 30% of the water samples. Comparisons were not made with international guidelines such as the UN and European standards.

(Nathaniel Atamas Bahago and Gideon Wyasu 2019) Investigated the physicochemical and microbiological qualities of borehole and sachet water in Kaduna South, Nigeria. Heavy metals and bacterial content were measured in water samples collected from 12 different locations. The study found high levels of lead and cadmium, which exceeded WHO standards, as well as microbial contamination in many samples. The study focused on comparing findings to WHO standards and did not take into account national drinking water standards such as the Nigerian Standard for Drinking Water Quality (NSDWQ). Heavy metals and microbial contamination made borehole and sachet water unfit for consumption.

(Raad Humudat and Al-Naseri 2020) assessed water quality at four dialysis centres in Baghdad hospitals. Samples were collected at three locations in each centre and tested for physical and chemical properties. While most chemical parameters were below the threshold, some samples had microbial contamination levels that exceeded the recommended limits. The majority of the research focused on dialysis water quality, ignoring other environmental factors that contribute to contamination. Water from multiple hospitals did not meet the International Standards Organization (ISO) and Iraqi drinking water standards due to microbial contamination and specific chemical parameters.

(Olubunmi Ajike Mokuolu 2017) Investigated the physicochemical and microbiological properties of borehole and sachet water at a Nigerian tertiary hospital. Water samples from six boreholes and two brands of sachet water were tested. The results revealed elevated levels of lead in five samples, which exceeded the WHO and the NSDWQ standards. Most physicochemical parameters met the WHO and NSDWQ standards, but many samples were microbiologically contaminated.

(Muhammad Makki 2017) evaluated the safety of borehole water for drinking in the Albasu LGA. Water samples from six wards were tested for physicochemical parameters. The results showed that the pH, temperature, and turbidity levels met WHO standards, with no E. coli contamination detected. However, heavy metal concentrations were not measured, and the water was considered safe to drink.

(Omeire *et al.* 2015) investigated the quality of borehole water in the Federal Housing Estate and Sites and Services Areas of Owerri. Six household samples were tested for microbiological, chemical, and physicochemical characteristics. Water samples had coliform counts exceeding permissible limits, though no E. coli was detected. Viruses and organic pollutants were not considered. It was recommended that borehole water in these areas should be treated before consumption.

(Adebanjo 2021) assessed the quality of water from selected boreholes in an institution. Water samples from seven boreholes were analyzed for physicochemical and bacterial examination. Results showed compliance with WHO standards for all parameters except for cadmium ions. However, the study only measured a limited number of heavy metals and did not explore broader pollutants.

Research Gaps

Whereas there has been some research into water availability and quality in Nigeria, little in-depth analysis has looked into issues surrounding the availability and quality of water in the FCT PHCs of Nigeria. Few studies have determined the levels of availability of water in these health facilities using the JMP's "safely managed water services." It is an important feature of healthcare service provision, and most studies have thus failed to consider how PHCs are implementing the BHCPF in their efforts to improve infrastructure and other facilities for WASH services in FCT. The findings are useful in providing practical recommendations that enhance water supply and its qualities, judicious use of BHCPF funds, and improvement of water treatment systems in the PHCs.

2.0 Materials and Methods

2.1 General Description of the Study Area

The study area lies approximately between 9° 30′ 0′′N - 8° 30′ 0′′N latitude and 7° 45′ 0′′E - 7° 00′ 0′′E longitude and covers an area of about 7,315 square kilometers. It was established in 1976 from regions formerly parts of the old Kaduna, Kwara, Niger, and Plateau states, deriving most of its landmass from. It hosts Abuja, the capital city of Nigeria, and for that reason, the territory has become a beehive of all sorts of administrative and socio-economic activities.

The FCT is subdivided into six area councils: Abuja Municipal (AMAC), Bwari, Gwagwalada, Kuje, Kwali, and Abaji**.** However, this research focuses on three Area Councils: AMAC, Bwari, and Kuje, due to their strategic importance, population density, and distribution of healthcare facilities.

Focus Area Councils and Primary Health Centres (PHCs):

1. Abuja Municipal Area Council (AMAC): AMAC is the most urbanized and densely populated of the three councils, hosting the central business district and major government institutions. It has 36 public PHCs serving its population (Federal Capital Territory Administration, n.d.).
2. Bwari Area Council: Located in the northern part of the FCT, Bwari is a mix of urban and rural settlements. It is home to 23 public PHCs, which cater to both its urban and rural populations (Federal Capital Territory Administration, n.d.).
3. Kuje Area Council: Situated in the southern part of the FCT, Kuje is predominantly rural but has seen gradual urbanization in recent years. It has the highest number of PHCs among the three councils, with 42 public PHCs distributed across its communities (Federal Capital Territory Administration, n.d.).

This study focuses on these three councils due to their varying levels of urbanization, population distribution, and the availability of healthcare infrastructure, particularly PHCs, which play a critical role in providing primary healthcare services to residents.

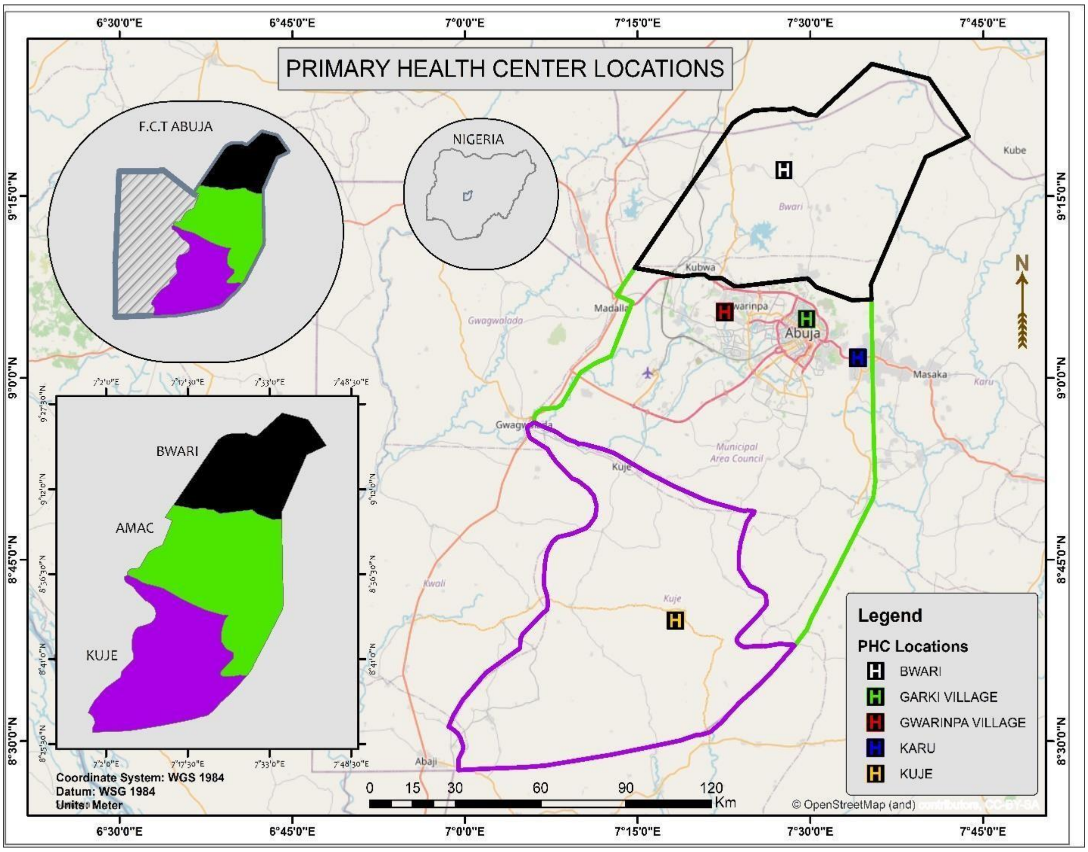

Figure 1: Map of Nigeria showing the PHCs' locations

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2.2 Data Collection and Analysis

This paper presents a study on water availability and quality of samples collected from five PHCs marked in the Geographic Information System (GIS) map situated in the FCT. In order to attain the objective of the research study, the methodology was divided into two parts: primary data and secondary data.

2.2.1 Primary Data Collection

The primary data on drinking water was collected through specific design questionnaires randomly filled out by the health practitioners. The questionnaire survey was conducted to know about the availability of water within the PHCs and also the WASH services. It was used to determine how accessible the water is to the critical areas in the PHCs, such as the toilets and the operating rooms. The questionnaire also served to know what the PHCs use their BHCPF for and what percentage of the BHCPF is allocated to the water infrastructure (e.g., borehole repairs, water treatment systems). The water availability results are determined based on the JMP Standards for "Improved Drinking Water Sources and also the JMP drinking water ladder.

Table 1: No of data collection locations and total number of administered questionnaires

Data collection location	5
Total questionnaires	25
Total questions in questionnaires	10
Total questionnaires filled	5 in each location

2.2.2 Secondary Data Collection

The water quality parameters are collected and analyzed from five PHCs. Thirty-two physicochemical, heavy metals, and microbial analyses were conducted, and the results were compared with water quality standards prescribed by WHO and the FMEnv.

The water quality parameters tested are the physical parameters, such as the Colour TCU, Odour. TN, Temperature °C, pH, Dissolved Oxygen mg/L, Total Dissolved Solid ppm, Salinity mg/L, Electrical Conductivity µS/, Turbidity NTU, the chemical analysis which are TSS mg/l, COD mg/l, BOD mg/l, THC mg/l, the heavy metals such as Phosphate mg/l, Nitrate, mg/, Sulphate, Fluoride mg/L, Calcium mg/L, Free Chlorine, Total Chlorine mg/L, Iron, mg/L, Lead, mg/L, Magnesium, mg/L, Manganese, mg/L, Potassium (K), Copper, mg/L, Zinc, mg/L, Arsenic, mg/L, and the microbial analysis are Salmonella/Shigella, Total Coliform Count, Faecal Coliform MPN/100mL, E. Coli, CFU/ml

2.2.3 Physical Analysis

All parameters were measured directly at the sampling site using the portable multiparameter meter to ensure real-time and accurate readings. The following steps were taken for each parameter.

Table 2: Methods used to conduct the water quality assessment

Method	Parameter	Protocol
Visual and sensory	Colour (Visual Comparison)	APHA 2120B
	Odour (Threshold Odour Test)	APHA 2150B
Thermometric	Temperature	APHA 2550B
Electrometric	pH	APHA 2120B
	Dissolved Oxygen	APHA 4500-O G
	Total Dissolved Solids	APHA 2540C
	Electrical Conductivity	APHA 2510B
	Salinity	APHA 2520C
Gravimetric	Total Suspended Solids	APHA 2540D
Nephelometric	Turbidity	APHA 2130B
Titrimetric	Total Alkalinity	APHA 2320B
	Total Hardness (EDTA Titrimetric)	APHA 2340C
Colorimetric	Chemical Oxygen Demand	APHA 5220D
	Nitrate (NO_3^-)	APHA 4500-NO3 B

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Method	Parameter	Protocol
	Nitrite (NO_2^-)	APHA 4500-NO3 B
	Phosphate (PO_4^{3-})	APHA 4500-P C
	Phosphorus (P)	APHA 4500-P C
	Free Chlorine	APHA 4500-Cl G
	Total Chlorine	APHA 4500-Cl G
	Fluoride (F^-) (SPADNS Method)	APHA 4500-F-D
	Chromium	APHA 3500-Cr B
	Magnesium (Mg)	APHA 3500-Mg B
Spectrophotometry	Ammonium	APHA 4500
Gas chromatography	Oil and Grease	APHA 5520G
	Polycyclic Aromatic Hydrocarbons (PAHs)	APHA 64401B
	BTEX	APHA 6200
	Hydrocarbons	APHA 5520
Atomic Absorption Spectroscopy (AAS)	Calcium (Ca)	APHA 3500-Ca B
	Potassium (K)	APHA 3500-K B
	Aluminium (Al)	APHA 3500-Al B
	Manganese (Mn)	APHA 3500-Mn B
	Iron (Fe)	APHA 3500-Fe B
	Copper (Cu)	APHA 3500-Cu C
	Lead (Pb)	APHA 3500-Pb B
	Cadmium (Cd)	APHA 3500-Cd B
	Arsenic (As)	APHA 3500-As B
	Vanadium (V)	APHA 3500-V
	Barium (Ba)	APHA 3500-Ba
	Zinc (Zn)	APHA 3500-Zn
	Mercury (Hg)	APHA 3500-Hg
	Sodium (Na)	APHA 3500-Na
Microbiological	Total Coliform Count	APHA 9225
	Total Bacteria Count	APHA 9215
	Escherichia coli	APHA 9221-F
	Hydrocarbon-Utilizing Bacteria	APHA 9215
	Fecal Coliform	APHA 9221-E
	Salmonella sp.	APHA 9260B

2.3 Field Work Methodology

2.3.1 Description of Fieldwork Activities

Fieldwork was conducted across five selected PHCs in the FCT, namely Garki, Gwarinpa, Bwari, Karu, and Kuje. The objective of the field visits was to assess water availability and quality, evaluate the status of WASH facilities, and gather insights from healthcare staff and patients.

Data was gathered during the visits by distributing five questionnaires per facility, four of which were given to randomly chosen patients and staff, and one to the PHC head. The purpose of the questionnaires was to collect data on water access, usage, and difficulties encountered within the establishment. In addition to the surveys, physical inspections were conducted to assess the availability of hygiene equipment such as handwashing stations and sanitizers, noting their quantity and functionality.

Critical areas such as toilets and operating rooms were also examined to determine water accessibility and sufficiency. Informal interviews were conducted with the PHC head and staff to gain further insights into their experiences and challenges regarding water supply and sanitation. Finally, water sampling was conducted on-site using specialized equipment for preliminary analysis before transporting samples to the laboratory for further testing.

2.4 Data Collection Process

The data collection process was carried out systematically to ensure a comprehensive assessment and accurate reporting. The steps involved in the data collection process were as follows:

a. Survey Administration:

i. Upon arrival at each PHC, five questionnaires were distributed—one to the facility head, two to staff, and two to patients present at the time of the visit.

ii. Responses were collected to gather information on water availability, hygiene practices, and challenges experienced by staff and patients.

a. Inspection of WASH Facilities: The number of available hygiene equipment, such as soap dispensers, handwashing stations, and clean water access points, was recorded. It was assessed whether water was available in critical areas such as toilets and treatment rooms.

b. Interviews with Key Personnel: Informal interviews were conducted with PHC heads and staff to obtain additional qualitative data regarding the water supply situation, maintenance practices, and potential areas of improvement.

c. On-Site Water Sampling: The on-site water quality assessment for the five Primary Health Centres (PHCs) was conducted using a multiparameter probe to ensure accurate and reliable data collection. The process began with thorough preparation, including inspecting the probe, calibrating sensors with standardized solutions, and selecting strategic water facilities based on accessibility and potential contamination sources. At each PHC location, the probe was carefully deployed, ensuring minimal disturbance, and the real-time measurements of key parameters such as pH, dissolved oxygen, conductivity, turbidity, and temperature were recorded once readings stabilized. Quality control measures such as preventing air bubbles in DO readings and avoiding cross-contamination by rinsing the probe between sampling points were adhered to maintain data integrity. After completing the sampling, the probe was thoroughly rinsed and stored to maintain sensor accuracy for future use. The collected data was transferred to a computer for further analysis to examine trends, correlations, and anomalies that could indicate potential water quality issues affecting PHCs.

d. Laboratory Sample Preparation: Further samples were collected for additional laboratory analysis. The water samples were properly labelled and preserved using appropriate containers, like sterilised specimen bottles, Polyethylene Terephthalate (PET) bottles, High-Density Polyethylene (HDPE) bottles, dark amber bottles, and were stored in a cooler filled with ice packs to prevent changes in composition during transport.

Plate 1: WASH Services available in Garki PHC

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Plate 2: Physical Analysis carried out on site

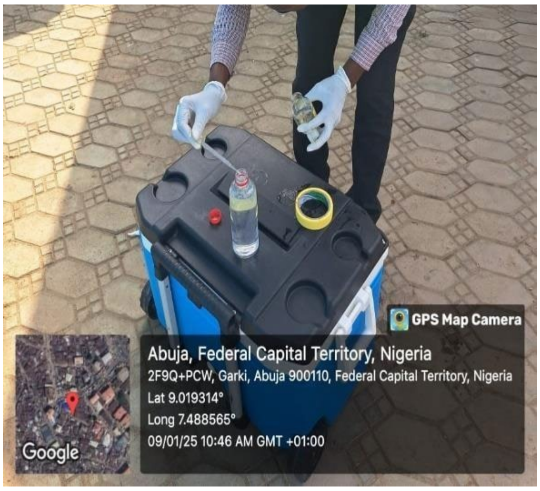

Plate 3: Sampling carried out on site

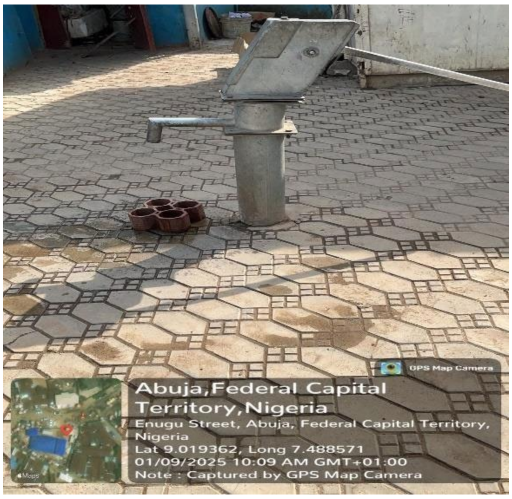

Plate 4: Manual Borehole in Bwari PHC

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f) Equipment Used
The following tools and equipment were utilized during the fieldwork to facilitate data collection and guarantee the accuracy of results:

Table 3: Equipment used during fieldwork

Equipment	Usage
Multiparameter water quality meter	This is used for on-site measurements of key water quality physical parameters, including the pH, dissolved oxygen, total dissolved solids, electrical conductivity, and salinity.
Sampling bottles	Sterile bottles were used to store samples for microbiological testing, amber bottles were used for organic sampling, and PET bottles were used for heavy metal analysis. Ice was added to these bottles to preserve sample integrity and prevent contamination during transportation.
Questionnaire	A structured set of questions designed to gather data from the PHCs' facility staff and patients regarding the water availability and how the BHCPF funds are utilized.
Interview guides	A set of guiding questions is used during informal interviews with facility heads and staff to collect qualitative insights.
Personal Protective Equipment (PPE)	Reflective jackets and face masks were worn during sample collection to maintain hygiene and safety standards.

3.0 Results and Discussion

3.1 Primary Data Collection

A structured questionnaire (**Appendix I**) was used to collect data on water usage behaviour, quality of water, and to assess the WASH services of the Healthcare Centres. The study was limited to 25 questionnaires. The findings of this primary data collection are as follows.

a) Primary Healthcare Centre, Garki Village

Table 4: Results of the questionnaire distributed in Garki PHC

Parameter	Responses	JMP Standard
Water source	Borehole and water board	Improved sources
Water availability	Every other day	Continuous availability required
Water accessibility	Not accessible to critical areas	Accessible in critical areas
Water storage	2 tanks	Adequate storage
Water quality testing	Not tested in the past year	Regular testing needed
WASH budget	Funded by DRF, not BHCPF	Sufficient dedicated funding is needed
BHCPF allocation	0–25%	Higher allocation for water infrastructure
Waterborne Diseases	No cases reported	Maintain safe water and hygiene practices

b) Primary Health Care Centre, Gwarinpa village

Table 5: Results of the questionnaire distributed in Gwarinpa PHC

Parameter	Responses	JMP Standard
Water Source	Borehole	Improved Source
Water Availability	Always available	Continuous availability required
Water Accessibility	Not accessible to critical areas	Accessible in critical areas
Water Storage	2 tanks	Adequate storage
Water Quality Testing	Not tested in the past year	Regular testing needed
WASH Budget	Funded by DRF, not BHCPF	Sufficient dedicated funding is needed

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Parameter	Responses	JMP Standard
BHCPF Allocation	0–25%	Higher allocation for water infrastructure
Waterborne Diseases	No cases reported	Maintain safe water and hygiene practices

c) Primary Healthcare Centre, Bwari Town

Table 6: Results of the questionnaire distributed in Bwari Town PHC

Parameter	Responses	JMP Standard
Water source	Borehole and water board	Improved source
Water availability	Always available	Continuous availability required
Water accessibility	Accessible to critical areas	Accessible in critical areas
Water storage	Storage facilities available	Adequate storage
Water quality testing	Not tested in the past year	Regular testing needed
WASH budget	Funded by BHCPF	Sufficient dedicated funding is needed
BHCPF allocation	0–25%	Higher allocation for water infrastructure
Waterborne diseases	No cases reported	Maintain safe water and hygiene practices

d) Primary Healthcare Centre, Aru

Table 7: Results of the questionnaire distributed in Karu PHC

Parameter	Observation	JMP Standard
Water source	Borehole and water board	Improved source
Water availability	Always available	Continuous availability required
Water accessibility	Accessible to critical areas	Accessible in critical areas
Water storage	Storage facilities available	Adequate storage
Water quality testing	Not tested in the past year	Regular testing needed
WASH budget	Funded by BHCPF	Sufficient dedicated funding is needed
BHCPF allocation	0–25%	Higher allocation for water infrastructure
Waterborne diseases	No cases reported	Maintain safe water and hygiene practices

e) Primary Healthcare Centre, Kuje

Table 8: Results of the questionnaire distributed in Kuje PHC

Parameter	Observation	JMP Standard
Water source	Borehole and water board	Improved source
Water availability	Always available	Continuous availability required
Water accessibility	Accessible to critical areas	Accessible in critical areas
Water storage	Storage facilities available	Adequate storage
Water quality testing	Not tested in the past year	Regular testing needed
WASH budget	Funded by BHCPF	Sufficient dedicated funding is needed
BHCPF allocation	25–50%	Higher allocation for water infrastructure
Waterborne Diseases	No cases reported	Maintain safe water and hygiene practices

3.1.1. JMP Standards for Safely Managed Water

Table 9: Result based on the JMP Standard

PHC Name	Drinking Water	Sanitation	Handwashing Facilities	BHCPF Allocation (%)
Garki	Limited	Basic	Limited	0–25%
Gwarinpa	Basic	Limited	Basic	0–25%
Bwari	Basic	Basic	Basic	0–25%

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PHC Name	Drinking Water	Sanitation	Handwashing Facilities	BHCPF Allocation (%)
Karu	Limited (contaminated water)	Unimproved	No facility	0–25%
Kuje	Basic	Safely Managed	Basic	25–50%

Figure 2: JMP Ladder for Drinking Water Standards

3.2 Secondary data collection results

Table 10: Result of water quality analysis

S/N	PARAMETERS	UNIT	RESULTS					DRINKING WATER STANDARDS	
			GW1 Garki Primary Health Care Centre	**GW2** Kuje Primary Health Care Centre	**GW3** Bwari Primary Health Care Centre	**GW4** Gwarinpa Primary Health Care Centre	**GW5** Karu Primary Health Care Centr	**WHO**	**FMEnv**
Physicochemical Analysis									
1.	Colour	TCU	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	15 (Colorless)
2.	Odour	TN	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	3.5 (Odourless)
3.	Temperature	⁰C	26.60	29.80	29.10	31.00	31.10	NA	NA
4.	pH	-	6.80	6.95	6.73	6.87	6.88	6.50-8.50	6.50- 8.50
5.	Dissolved Oxygen	mg/L	4.16	6.32	3.45	4.20	4.48	NA	7.50
6.	Total Dissolved Solids	mg/L	342.00	103.60	28.30	44.00	324.0	1000.00	500

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S/N	PARAMETERS	UNIT	RESULTS					DRINKING WATER STANDARDS	
			GW1 Garki Primary Health Care Centre	**GW2** Kuje Primary Health Care Centre	**GW3** Bwari Primary Health Care Centre	**GW4** Gwarinpa Primary Health Care Centre	**GW5** Karu Primary Health Care Centr	**WHO**	**FMEnv**
7.	Electrical Conductivity	µS/cm	685.00	207.00	56.70	197.50	649.00	<1500 µS/cm	NA
8.	Salinity	mg/L	0.34	0.05	0.03	0.05	0.32	NA	NA
9.	Turbidity	NTU	0.15	0.05	0.02	0.03	0.11	<1	1.00
10.	Total Suspended Solids	mg/L	7.00	<0.01	<0.01	<0.01	<0.01	NA	10.00
11.	Free chlorine	mg/L	0.05	0.09	0.07	0.08	0.20	≥0.2	0.2-0.4
12.	Total Chlorine	mg/L	0.08	0.10	0.17	0.11	0.71	NA	NA
13.	Biochemical Oxygen Demand	mg/L	5.15	10.25	0.53	4.225	5.15	NA	0.00
14.	Chemical Oxygen Demand	mg/L	71.280	47.520	23.760	83.160	46.332	NA	NA
15.	Total Hydrocarbon Content (THC)	mg/L	0.085	0.064	0.151	0.163	0.138	NA	NA
16.	Nitrate (NO_3^-)	mg/L	6.313	9.810	0.057	6.781	16.239	50.00	10.00
17.	Fluoride (F^-)	mg/L	0.122	0.244	0.253	0.111	0.176	1.50	1.50
18.	Phosphate (PO_4^{3-})	mg/L	3.202	3.340	3.468	3.457	9.617	NA	5.00
19.	Sulphate (SO_4^{2-})	mg/L	9.588	3.882	4.706	3.471	5.824	NA	500
20.	***HEAVY METAL ANALYSIS***								
21.	Copper (Cu^{2+})	mg/L	0.005	0.036	0.015	0.021	0.020	2.00	0.10
22.	Lead (Pb^{2+})	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.05
23.	Magnesium (Mg^{2+})	mg/L	62.232	71.122	68.158	38.228	65.195	NA	NA
24.	Calcium (Ca^{2+})	mg/L	4.701	3.648	1.247	3.964	23.813	NA	NA
25.	Potassium (K^+)	mg/L	0.836	0.563	1.383	1.344	3.492	NA	NA
26.	Manganese (Mn)	mg/L	0.560	<0.001	<0.001	<0.001	0.053	0.4	0.05
27.	Zinc (Zn)	mg/L	0.03	0.020	<0.001	<0.001	<0.001	3.00-5.00	5.00
28.	Arsenic (As)	mg/L	0.011	0.012	0.012	0.012	0.013	0.01	0.20
29.	***MICROBIAL ANALYSIS***								

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S/N	PARAMETERS	UNIT	RESULTS					DRINKING WATER STANDARDS	
			GW1 Garki Primary Health Care Centre	**GW2** Kuje Primary Health Care Centre	**GW3** Bwari Primary Health Care Centre	**GW4** Gwarinpa Primary Health Care Centre	**GW5** Karu Primary Health Care Centr	**WHO**	**FMEnv**
30.	Total Coliform Count	MPN/ 100ml	Absent	Absent	Absent	Absent	6.5×10^1	0.00	0.00
31.	Salmonella/Shigella a	FU/ ml	Absent	Absent	Absent	Absent	3×10^0	NA	NA
32.	Fecal Coliform	MPN/ 100ml	Absent	Absent	Absent	Absent	6.2×10^1	0.00	0.00
33.	E.coli	FU/ ml	Absent	Absent	Absent	Absent	6.0×10^1	0.00	0.00

3.2.1 Discussion

By combining WHO, FMEnv, and JMP standards to evaluate WASH performance in PHCs, this study provides a unique contribution. As highlighted in tables 4,5,6,7 and 8, it connects funding challenges to issues with water availability and quality. For policymakers, the JMP ladder (Figure 2, Table 9) offers an organized framework for evaluation. These results provide evidence-based recommendations for enhancing the FCT's healthcare water infrastructure.

a) Primary Water Sources and Availability

The findings from this study show that addressing WASH challenges in PHCs requires a multidimensional approach. For water availability, consistent supply and access in critical service areas remain essential, particularly in Garki and Gwarinpa PHCs, where toilets and operating rooms lack regular water access (Table 4 and 5). For water quality, the presence of microbial contaminants such as *E. coli* and *Salmonella/Shigella* in Karu PHC (Table 7) underscores the need for immediate treatment and strengthened hygiene protocols. Regarding funding, Table 9 reveals that BHCPF is either minimally allocated or absent for water infrastructure in PHCs like Garki and Gwarinpa. Without deliberate reallocation of funds, essential WASH improvements may remain unsustainable. These insights highlight the urgent need for integrated policy and operational actions to ensure safe and reliable water access in FCT healthcare settings.

b) Compliance with WASH Standards

In evaluating the WASH (Water, Sanitation, and Hygiene) facilities against the Joint Monitoring Programme (JMP) standards for safely managed water, three critical criteria were considered similar to E.E. et al. (2022), who reported inadequate handwashing and poor sanitation in Port Harcourt schools, this study confirms that WASH service levels vary widely among institutions. Karu PHC, which lacks safe water and sanitation, reflects similar "limited" or "no facility" service levels seen in underserved regions. Meanwhile, Kuje PHC’s strong WASH performance aligns more closely with institutional best practices.

(i) Accessibility on PHC premises – Met by all five facilities.
(ii) Availability in critical areas (e.g., toilets, operating rooms) – Gwarinpa and Garki PHCs fall short in providing reliable water access to critical areas, whereas Bwari, Karu, and Kuje meet this requirement.
(iii) Freedom from contamination – Karu PHC was found to be contaminated with microbes such as total coliform, Salmonella/Shigella, fecal coliform, and E. coli.

c) Water Quality Analysis

i. **Temperature**

Water temperature ranged from 26.6°C in Garki to 31.1°C in Karu. While the WHO does not provide specific limits, FMEnv recommends ambient temperatures. Although these readings are within acceptable limits, higher temperatures could impact palatability and microbial growth.

ii. **Turbidity**

The turbidity levels were low, ranging between 0.02 NTU in Bwari and 0.15 NTU in Garki, well within the WHO target of less than 1 NTU for effective disinfection and the FMEnv Standard of 5 NTU.

iii. Chemical Parameters

The pH ranged from 6.73 in Bwari to 6.95 in Kuje, which falls within the WHO and FMEnv's acceptable range of 6.5-8.5. Total dissolved solids ranged from 28.3 mg/L in Bwari to 342 mg/L in Garki, but remained below the WHO aesthetic limit of 1000 mg/L and FMEnv Standards of 500 mg/L. The nitrate concentration ranged from 0.057 mg/L in Bwari to 16.24 mg/L in Karu, which is well below the WHO and FMEnv limit of 50 mg/L, posing no significant risk of specific cancers and birth defects. Sulphate levels ranged from 3.47 mg/L in Gwarimpa to 9.59 mg/L in Garki, significantly lower than the WHO guideline value of 500 mg/L and the FMEnv Standard of 100 mg/L. However, Karu PHC exhibited phosphate levels exceeding the permissible limit, which poses risks such as scale formation in water systems and eutrophication.

iv. Microbial Analysis

Microbial analysis revealed concerns at the Karu PHC, where total coliforms were detected at 6.5×10^1 CFU/mL, exceeding the WHO guideline of 0 CFU/mL but within the FMEnv Standard of 10 CFU/mL. Escherichia coli was also detected at 6.0×10^1 CFU/100mL, surpassing both WHO and FMEnv Standards of 0 CFU/100mL, indicating fecal contamination and significant health risks. Additionally, Salmonella/Shigella were present at 3×10 CFU/mL and led to health risks such as Gastrointestinal infections, typhoid, and non-typhoid fevers. These findings necessitate immediate disinfection and infrastructure improvements to protect public health.

d) Utilization of BHCPF Funds and Recommendations for Improvement

Water infrastructure in all PHCs currently receives 0-25% of the Basic Health Care Provision Fund (BHCPF). Garki and Gwarinpa PHCs do not receive the BHCPF, but instead acquire funds for the PHC by Drug Revolving Funds (DRF), and these funds are not used to cater for any water infrastructures. Similar to findings by Kumar et al. (2024) in Indian government hospitals, where high TDS and iron levels were linked to inadequate infrastructure and oversight, this study also identifies insufficient BHCPF allocations as a barrier to water safety in Garki and Gwarinpa PHCs. e) Challenges in Water Supply and Quality

e) Challenges in Water Supply and Quality

Inconsistent water availability at Garki PHC, where water is only available every other day, affects sanitation and healthcare operations, and inadequate water access in critical areas like toilets and operating rooms in Garki and Gwarinpa PHCs and Karu PHC faces concerns with phosphate exceedance and microbial contamination. As presented in Figure 2 and Table 9, the JMP service ladders classify access levels for drinking water, sanitation, and hygiene into five tiers: safely managed, basic, limited, unimproved, and no facility (WHO & UNICEF, 2017). For drinking water, "safely managed" refers to improved sources located on-premises, available when needed, and free from contamination; "basic" indicates access to improved sources within 30 minutes; "limited" applies to improved sources requiring over 30 minutes or having quality or reliability issues. Sanitation is considered "safely managed" when facilities are not shared and waste is safely disposed of; "unimproved" includes rudimentary latrines. For hygiene, "basic" means handwashing facilities with water and soap, while "no facility" means none exists. Applying this framework, Kuje PHC achieved the highest level of WASH service among the five PHCs, while Karu PHC was the most underserved, with limited or no facilities across all categories.

In summary, the study found that although all five PHCs have water sources such as boreholes or municipal supply, water availability remains inadequate in Garki and Gwarinpa PHCs, particularly in critical areas like toilets and operating rooms. Water quality largely meets WHO and FMEnv standards in terms of physical and chemical parameters, but Karu PHC exhibited phosphate levels above permissible limits and microbial contamination involving *E. coli*, total coliforms, and *Salmonella/Shigella*, posing significant health risks. Regarding infrastructure funding, the use of the Basic Health Care Provision Fund (BHCPF) for water-related improvements was minimal (0–25%), with Garki and Gwarinpa receiving no BHCPF and relying instead on Drug Revolving Funds that are not used for water infrastructure. These findings reinforce the need for targeted interventions, including enhanced water treatment, infrastructure upgrades, and capacity-building efforts, to ensure safe and reliable water access in the selected FCT PHCs.

4.0 Conclusion and Recommendation

4.1 Conclusion

This study assessed the availability, quality, and funding of water infrastructure across five Primary Health Centres (PHCs) in the Federal Capital Territory (FCT), Nigeria. While all PHCs had access to water sources, such as boreholes or municipal supplies, water availability in critical areas, including toilets and operating rooms, was inconsistent, particularly in Garki and Gwarinpa PHCs.The quality of water in most PHCs met WHO and FMEnv standards for physical and chemical parameters. However, Karu PHC presented serious microbial contamination with the presence of total coliforms, *E. coli*, and *Salmonella/Shigella*, posing significant public health risks. Additionally, phosphate levels in Karu exceeded permissible limits, indicating potential for eutrophication and scaling issues. In terms of funding, the study found that water infrastructure receives minimal attention in BHCPF allocation, with Garki and Gwarinpa PHCs not receiving any BHCPF support. Instead, they rely on Drug Revolving Funds, which do not cater to water infrastructure needs. When assessed against the JMP WASH ladder, Kuje PHC ranked highest in WASH service delivery, while Karu PHC was the most underserved. These findings underscore the pressing need for targeted investments in water infrastructure, enhanced monitoring of water quality, and more effective utilization of health funds for WASH services. Improving water access and quality is essential to safeguard infection prevention, sanitation, and overall healthcare delivery in Nigerian PHCs.

4.2 Recommendation

Improving water availability and quality in PHCs within the FCT requires targeted interventions to address microbial contamination, chemical safety, and infrastructure gaps. The following recommendations are proposed:

1. Immediate chlorination and routine testing should be carried out in PHCs like Karu, where microbial contamination was found. Water should be stored securely to reduce post-treatment contamination.
2. BHCPF should be allocated specifically for water infrastructure improvements, especially in PHCs like Garki and Gwarinpa that lack funding. Water supply to critical areas such as toilets and operating rooms must be prioritized.
3. The JMP framework should guide water service assessments and upgrades. This helps track progress and ensures interventions target PHCs with limited or unimproved services.
4. Staff training on WASH standards and partnerships with agencies like UNICEF or USAID can help sustain improvements through technical and financial support.
5. To further strengthen future studies, additional methods such as key informant interviews, GIS mapping, and facility-based WASH Fit checklists are recommended. These approaches could provide broader insights into institutional practices, spatial disparities, and policy effectiveness related to water infrastructure in PHCs.

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APPENDIX I - QUESTIONNAIRE

WATER AVAILABILITY AND QUALITY ASSESSMENT IN HEALTH FACILITIES: A CASE STUDY OF FIVE FEDERAL CAPITAL TERRITORIES' PRIMARY HEALTH CARE CENTRES

Dear Respondent, This questionnaire is designed to assess water availability, water quality, and WASH (Water, Sanitation, and Hygiene) services in selected Primary Health Care Centres (PHCs) across the Federal Capital Territory (FCT). Your responses will be treated with strict confidentiality and will be used solely for academic research purposes by the Department of Civil Engineering, Baze University, Abuja.
Your participation in this study is voluntary, and by completing this questionnaire, you are providing informed consent to participate in the research. No personal identifiers will be collected.
For inquiries regarding this research, you may contact the Department of Civil Engineering, Baze University, Abuja.
Thank you for your cooperation.

SECTION A: GENERAL INFORMATION

1. Name of the Primary Healthcare Centre (PHC):

____

2. Location of the PHC:

____

3. Gender of interviewed staff (Tick as appropriate):

☐ Male ☐ Female

4. Is there a budget for the operation and maintenance of WASH facilities at the health centre?

☐ Yes ☐ No

5. Who is responsible for providing the budget for the operation and maintenance of WASH facilities at the health centre? (Select one)

☐ Health-centre administration

☐ Government (LGA, State, Federal Government)

☐ Ward Development Committee (WDC)

6. Has the health centre received any support from development partners (e.g., UNICEF, WaterAid, EU, etc.)?

☐ Yes ☐ No

7. Does this PHC receive monthly allocations from the Basic Healthcare Provision Fund (BHCPF)?

☐ Yes ☐ No

SECTION B: WATER AND AVAILABILITY

8. What is the primary source of water for this PHC? (Select one)

☐ Borehole

☐ Municipal Water Supply (Water Board)

☐ Surface Water (Stream, Lake, River, etc.)

☐ Other (please specify): ___________________________

9. How reliable is the water supply? (Select one)

☐ Always available

☐ Frequently available but with occasional shortages

10. Does this PHC have water storage facilities (e.g., tanks)?

☐ Yes ☐ No

If yes, what is the capacity of the storage facilities? ____________ litres

11. Is water from the main source typically available throughout the year?

☐ Yes ☐ No

12. In the last six months, how many cases of Cholera/Diarrhoea were diagnosed in this health centre?

Number of cases: _____________

SECTION C: SANITATION

13. Is there a toilet/latrine in this health facility?

☐ Yes ☐ No

14. What type of toilet/latrine do patients commonly use at the health centre? (Select one)

☐ Pour flush toilet

☐ Pit latrine with slab

☐ Pit latrine without slab

SECTION D: WATER QUALITY

15. Has the water quality been tested in the last year?

☐ Yes ☐ No

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If yes, were any contaminants (e.g., bacteria, heavy metals) found?
☐ Yes ☐ No

SECTION E: BHCPF FUND USAGE

16. Has this PHC received Basic Health Care Provision Fund (BHCPF) allocations in the last year?
☐ Yes ☐ No

17. If yes, what percentage of the BHCPF funds were allocated to water infrastructure (e.g., borehole repairs, water treatment systems)? (Select one)
☐ 0–25%
☐ 26–50%
☐ More than 50%
If funds were used for other purposes, please specify: ________________________________

Thank you for your valuable time and contribution to this study.

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