ASSOCIATION BETWEEN WASTE DISPOSAL AND THE OCCURRENCE OF MALARIA AND DIARRHOEA IN PORT HARCOURT LOCAL GOVERNMENT AREA, RIVERS STATE.

BY

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FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI

MARCH, 2026

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CERTIFICATION

This is to certify that this work "Association Between Waste Disposal and the Occurrence of Malaria and Diarrhea in Port Harcourt Local Government Area, Rivers State" was carried out by Nmeribe, Chioma Christy with Reg Number (20084771628) in partial fulfilment for the award of the degree of MPH in Public Health in the Department of Public Health Technology, Federal University of Technology Owerri.

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DEDICATION

This work is dedicated to God Almighty and my lovely family.

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ABSTRACT

This study examined the relationship between waste disposal and the incidences of malaria and diarrhoea in Port Harcourt Local Government Area in Rivers State. A cross-sectional descriptive design was embraced and 420 respondents were chosen in four communities (Port Harcourt Township, Diobu, Rumuokoro, and D-line/ Ada George). Data collection was done using structured questionnaires, field observations and entomological surveys and statistical analysis was done using descriptive and inferential statistics. The findings revealed that majority of the respondents were females (54.8 %), aged 40-49 years (47 %), married (50.5 %), and tertiary educated (41.7 %). Open dumping (36.4) and burning (25.0) were the most popular methods of waste-disposal (only 20.7 used the services of government collection). The greatest mosquito (120 adults, larval density = 25/L) and fly abundance (180 adults, 160 per trap/24 h) was observed in Port Harcourt Township, which means that there is a great level of the vectors around dumpsites. The prevalence of the diseases was also high including malaria (44.3 %), diarrhoea (21.9 %), and both (17.6 %) with the incidence declining as the distance to dumpsites rose. The highest incidences of malaria (54.8) and diarrhoea (52.2) were reported in households that practiced open dumping meaning that improper waste disposal is strongly associated with incidence of diseases. Despite the fact that 89 percent out of the residents were knowledgeable about the principles of waste-management and 84.8 percent were knowledgeable about the environmental effects of waste management, only 34.3 percent displayed good waste-management practices, which suggests a knowledge-practice gap. The socioeconomic and environmental conditions, such as low income, poor sanitation, surface water use, high-density housing, and dumpsite proximity (less than 100 m) greatly affected the prevalence of the disease. The research concludes that malaria and diarrhoeal morbidity in Port Harcourt LGA is largely caused by the ineffective waste disposal systems and environmental sanitation.

Keywords: Waste disposal, incidences, malaria, diarrhoea, Rivers State

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The amount of solid waste that has been generated keeps on growing at a higher pace compared to the capacity of the public agencies to increase the financial and technical resources available to handle it efficiently. Research has shown that the man-made solid waste (MSW) in urban areas in Nigeria is on the increase owing to urbanization, industrialization, and shifting consumption trends (Ogunbiyi et al., 2024). The main features of solid waste management in Nigeria include the lack of effective ways of collection, the inadequate inclusion of the collection system, and the use of inappropriate disposal strategies, including the open dumping of waste and open burning (Udensi et al., 2023; Onyishi et al., 2023).

Management of solid waste has been a thorn on the flesh of environmental sanitation in Nigeria. This is manifested in the heaps of uncovered trash and unlawful dumpsites on the sides of the road and in residential zones (Nzeadibe et al., 2022). The high rate of population increase and inadequate infrastructures increase this problem, resulting in environmental destruction and health hazards (Adegoke et al., 2023). MSW open dumping has been one of the most common forms of waste disposal, particularly in developing nations where the contemporary treatment plants are not available (Edim & Chinyere, 2025). Greenhouse gas emission including methane and carbon dioxide, fire risks, odour and proliferation of vectors are also caused by open dumps. Moreover, the waste leachates produced as a result of waste decomposition cause ecological and individual health emergencies (David and Nwaogazie, 2023; Ogunbiyi et al., 2024).

Uncontrolled dumpsites become habitats of disease vectors, including flies, mosquitoes, and rodents, thus causing infectious diseases such as malaria, cholera, and typhoid (Bello et al., 2022). Research findings indicate that the closer the dumpsites in the vicinity of the residents are, the more prevalent respiratory infections, diarrhoea, and vectors among local populations (Oghenekohwo et al., 2024). The unacceptable treatment of hazardous waste is also another threat, since it pollutes soil, air, and water sources (Ikuomola and Oladipo, 2023). The best way of reducing these health and ecological impacts is therefore proper segregation, recycling of wastes and proper enforcement of environmental laws.

Plasmodium species are causative organisms of malaria; this is a parasite disease that has been labeled as the major public health issue in sub-Saharan Africa. The World Malaria Report 2024 states that the African region bore almost 94% of the global malaria cases and 95% of malaria deaths (World Health Organization [WHO], 2024). Nigeria itself bears the largest global burden of malaria. Children below five years of age and pregnant women are the groups that are still most vulnerable (WHO, 2024). Malaria is a socioeconomic problem, decreasing productivity and causing huge economic burdens to households and health systems (Eze et al., 2023).

Diarrhoeal disease is also a significant cause of morbidity and mortality, especially to children below the age of five years. It is mainly related to a lack of access to clean water, poor hygiene, and unsanitary waste disposal (World Health Organization, 2023). The number of deaths caused by diarrhoeal diseases in the world amounted to 1.2 million in 2021, surpassing diarrhoea as one of the leading causes of mortality in children and older adults (Institute for Health Metrics and Evaluation [IHME], 2024). Oral rehydration salts (ORS) and zinc supplementation continue to be the most effective interventions that have saved the death of millions of people over the last several decades (WHO, 2023). The interventions that

can help in reducing the burden of diarrhoeal diseases are proper waste management, safe water supply, and better hygiene practices.

1.2 Statement of the Problem

The state of the poor solid waste management in Port Harcourt, Rivers State, Nigeria is poor and has now reached an alarming proportion. Wastes are frequently dumped along the streets, in the gutters and informal waste dumps, which has been linked to several environmental, safety and public health impacts including the blockage of gutters, nuisance odours, surface and groundwater pollution, air emissions of carbon dioxide and methane and soil contamination. Waste dumps have also been implicated in road traffic obstructions and accidents. The Rivers State environmental sanitation and waste management authorities are at loss on how to best handle the wastes sustainably. The risk index was computed from the summation of the product of the sensitivity of the variable studied and their respective weights of their attributes.

Malaria threatens life of 40% of the world population (2.2 billion people) and the world experiences about 250 million clinical cases of malaria each year (WHO, 2008). It is responsible for death of over 70% in developing countries (WHO, 2008). In sub-Saharan Africa, Malaria remains a major public health problem (WHO 2011). Malaria is one of the most serious vector- borne diseases affecting millions of people mainly in tropics (Murray, *et al* 2012). It affects the immune system and causes symptoms such as headache, fever, fatigue, pain, sweating, chills, dry cough, and enlargement of spleen, nausea and vomiting.

Diarrhoeal diseases also kill an estimated 1.8 million people each year (WHO 2005). Among infectious diseases, diarrhoea ranks as the third leading cause of both mortality and morbidity (after respiratory infections and HIV/AIDS). Young children are especially vulnerable,

bearing 68% of the total burden of diarrhoeal disease (Curtis *et al*, 2003). Among children younger than five years of age, diarrhoea accounts for 17% of all deaths (WHO, 2005).

The high level of absenteeism to work and businesses by the people of Portharcourt area due to high malaria and diarrhea morbidity is a major concern. The indiscriminate disposal of domestic and solid waste has become perennial and an environmental issue which has its economic effect on both the government and the people of the area.

1.3 Objective of Study

The study aimed at determining the relationship between waste disposal and the occurrence of malaria and diarrhea in Port Harcourt, Rivers state.

The specific objectives are:

1. To identify the common methods of waste disposal practiced by households and communities within Port Harcourt Local Government Area.
2. To determine the prevalence of malaria and diarrhoeal diseases among residents of the study area.
3. To determine the association between household waste disposal practices and the occurrence of malaria and diarrhoea.
4. To evaluate residents' knowledge, attitudes, and practices (KAP) regarding waste management and its health implications.
5. To determine the environmental and socioeconomic factors that influence the relationship between waste disposal and disease occurrence.

1.4 Research Questions

The following research questions guided the study:

Research Questions

1. What are the common methods of waste disposal practiced by households and communities within Port Harcourt Local Government Area?
2. What is the prevalence of malaria and diarrhoeal diseases among residents of the study area?
3. Is there an association between household waste disposal practices and the occurrence of malaria and diarrhoeal diseases among residents?
4. What is the level of residents' knowledge, attitudes, and practices (KAP) regarding waste management and its health implications?
5. What environmental and socioeconomic factors influence the relationship between waste disposal and the occurrence of malaria and diarrhoeal diseases in Port Harcourt Local Government Area?

1.5 Research Hypothesis

The following null hypotheses were formulated for the study:

1. Malaria is not prevalent in Port Harcourt.
2. Diarrhea is not prevalent in Port Harcourt.
3. There is no relationship between the methods of waste disposal and the prevalence of malaria in the area.
4. The methods of waste disposal does not influence the prevalence of diarrhea in the area.

1.6 Significance of Study

The study will help us to understand the relationship between waste disposal and the occurrence of malaria and diarrhea. It will help to enlighten the people on the best waste disposal practices to adopt.

The study will further be used as an academic tool for researchers who are interested in pursuing further studies on the subject topic or other related topics.

The study will also serve as a medium to recommend to the government, the ministry of health and environment to know the health implication of poor waste disposal.

1.7 Justification/Rationale of the Study

Prevention of malaria and diarrhea in the sub-Saharan African can be improved through many measures such as environmental sanitation, which involves adequate waste disposal and management. If Nigeria can dispose their waste appropriately, it will help in reducing the breeding place of the malaria vector as well are the pathogens that cause diarrhea.

CHAPTER TWO

LITERATURE REVIEW

2.0 Solid waste management

Solid waste management has remained an intractable environmental sanitation problem in Nigeria (Oluwande, 2004). This problem has manifested in the form of piles of indiscriminately disposed heaps of uncovered waste and illegal dumpsites along major roads and at street corners in cities and urban areas. This problem is compounded by the rapid urbanization and population growth which has led to the generation of enormous quantities of solid waste which are often discarded by open dumping. WHO (2005) described open dumping of municipal solid waste (MSW) as a primitive stage of waste disposal, practiced by three fourths of countries and territories round the world Open dumps are the major causes of environmental degradation and public health concerns in many developing countries including Nigeria. These waste dumps may contain a mixture of general waste and toxic, infectious or radioactive wastes and are susceptible to burning and exposure to scavengers. There are a number of major risks and impacts of the dumpsites on the environment. For instance, air pollution from open burning, due to emission of green house gases such as methane and carbon dioxide; the air emissions and leachates generated as a result of decomposition of waste may contaminate air, surface and groundwater sources; fire hazards and explosions cause public health risks as well (Oluwande, 2004). The emission of greenhouse gases, rats and fly infestation and nuisance effects are among the health and environmental impacts of poor solid waste management. In addition, scattering of wastes by wind and scavenging by birds, animals and waste pickers creates aesthetic nuisance.

Solid waste in developing countries differs from developed countries. Most developing countries, Nigeria, inclusive have solid waste management problems different from those

found in industrialized countries in areas of composition, density, political, and economic framework, waste amount, access to waste for collection, awareness and attitude (Izeogu, 1989). The wastes are heavier, wetter and more corrosive in developing cities than developed cities.

In developing countries, local authorities spend 77-95% of their revenue on collection and the balance on disposal (Ogwueleka, 2003), but can only collect almost 50-70% of municipal solid waste (MSW). In the past, the focus has been on the technical aspects of different means of collection and disposal (Oluwande, 2004), but recently, attention has been on enhancing institutional arrangement to service delivery, with a special emphasis on privatization (Oluwande, 2004).

2.1 Waste Characteristics

The waste generation rates ranged from 0.66 kg/cap/d in urban areas to 0.44 kg/cap/d in rural areas as opposed to 0.7-1.8 kg/cap/day in developed countries (Izeogu, 1989). The waste generation rate is typical of low-income towns. The rate of waste generation is highly influenced by the population income. In Nigeria 25 million tons of municipal solid waste are generated annually (Izeogu, 1989).

The density of solid waste in Nigeria ranged from 250 kg/m^3 to 370 kg/m^3 higher than solid waste densities found in developed countries (WHO, 2005). Density defines the number of capacities of waste storage and collection facilities required. High density reduces the effectiveness of compaction vehicles for waste transfer.

2.1.1 The Composition of Waste

Income and economic growth have impact on the composition of wastes. High-income earners consume more packaged products, which result in a higher percentage of inorganic materials – metals, plastics, glass, and textile. Waste characteristics vary according to season,

income level, population, social behaviour, climate, and industrial production, the size of markets for waste materials and the extent of urbanization, effectiveness of recycling, and work reduction (Agunwamba *et al.,* 2003).

The majority of substances composing municipal solid waste include paper, vegetable matter, plastics, metals, textile, rubber and glass. In developing countries, waste stream is over 50% organic material (Hill, 1997). Studies in Bandung, Indonesia and Colombia, Sri Lanka have found residential waste composed of 78% and 81% compostable material, and market waste 89% and 90% compostable, respectively (Krieth, 1994).

2.1.2 Waste Collection and Transportation in Nigeria

The collection of solid waste is the function of state and local government environmental protection agencies. Informal solid waste collection operations exist in parallel with official agencies in some major cities like Onitsha, Lagos etc. Informal collectors provide the service for a fee (Oluwande, 2004). In most urban areas, stationary containers system is adopted for waste collection; the waste containers remain at the points of waste generation.

This method requires the delivery of waste by the residents to a storage container. These confiners are generally at open spaces along street ends or junctions. These confiners are placed 500-800 m apart. Some bins are fixed on the ground and some are movable. The agencies find this system less convenient and less expensive than house-to-house service. House-to-house service is very rare in Nigeria (Agunwamba *et al.*, 2003).

2.1.3 Solid Waste Management and Infectious Disease

Solid waste is often contaminated with human or animal excreta (Peavy *et al,* 2005). Those who handle the waste and those who live or work where the waste accumulates, will therefore often be at risk from excreta-related infections. The specific health risks they will be exposed to will depends on their contact with the excreta. According to Clark (2003), drainage

systems are frequently used for defecation, the solid waste that accumulates in the system is often contaminated, and is a health risk to those who have to handle it.

Organic waste from households, restaurants, and markets attracts rats, which are potential hosts for many infections (e.g. leptospirosis, plague) (Krieth, 1994). Organic waste also serves as food and a place to rest and hide for domestic flies, which can transmit faecal-oral infections and infections spread by direct contact, and cockroaches, which can transmit faecal-oral infections (Oluwande, 2004).

Other animals which use refuse dumps to rest and hide include mosquitoes; sandflies, vector of leishmaniasis, bartonellosis, and several arboviruses; and reduviid bugs, which can transmit American trypanosomiasis (Williams, 2000).

Murray (2012), maintained that refuse often includes materials which can collect rainwater, such as tin cans, jars, and old car tyres. *Aedes* mosquitoes, which transmit filariasis, urban yellow fever, dengue fever, and several other arboviral infections, can breed in these small water-filled vessels. Poorly managed waste often ends up in ponds, reservoirs, or drainage systems.

The refuse often blocks drainage channels, resulting in the ponding of water (Price *et al*, 2007). As these surface waters are often polluted with organic waste, breeding sites for *Culex* mosquitoes and domestic flies are created

2.2 Problems of Waste Disposal in Nigeria

The generation and disposal of wastes in the world is a problem that continues to grow with the development of industrialized nations and growing population. Waste disposal is an intrinsic part of any developing or industrial society (Price *et al*, 2007). Every time a householder shops at the store or open market, he contributes to the mountain of waste.

Waste can be divided into many different types. The most common methods of classification are by their physical, chemical and biological characteristics. One important classification is by their consistency. Solid wastes are waste materials that contain less than 70% water (Price *et al.*, 2007). This class includes such materials as household garbage, some industrial wastes, some mining wastes, and oilfield wastes such as drill cuttings. Liquid wastes are usually wastewater that contain less than 1% solid. Such wastes may contain high concentrations of dissolved salts and metals. According to Williams (2000), sludge is a class of waste between liquid and solid. They usually contain between 3% and 25% solid, while the rest of the material is water dissolved materials. Onibukun (1999), was of the opinion that the problem of proper waste disposal in Nigeria could be blamed on various factors we face in the nation. He maintained that waste disposal is capital and economically intensive and this requires huge capital outlay. He cited that many state governments spend a good percentage of their funds on domestic waste management. For examples, Lagos State Government spends between 20% – 25% of its funds on waste management. But what this amount could accomplish is dwarfed by the population it caters for. Lagos state, for instance, has a projected population of 12 million and 18 million persons. It is estimated that the average individual in such mega cities as Lagos generates an average of 0.115 kg of waste daily. It is that the funds available or at least earmarked for domestic waste management is grossly inadequate, to fund the public agencies and other private sector participants (PSP).

2.2.1 Tackling Waste in Nigeria

Dealing with wastes demands great attention because it can become harmful to people when it becomes an environmental pollutant.

If attention is given to the goods we buy from the market, it means attention should be given to what we generate after the consumption of such goods. For example, you quench your thirst by buying a bottle of water or a sachet of water and when you do so, the bottle of sachet

which is the waste material in this case, must be properly disposed because buying the water means buying the waste product that comes with it.

Although people may not be complaining about this, the blame for this rests solely on government all levels because they have become too busy wasting public fund on irrelevant issues while forgetting to consider the means of managing municipal solid wastes across its cities and suburbs. What the governments fail to understand is that they can make policies that would ensure the creation of wealth from these wastes and improve the environment in terms of sanitation and hygiene.

Solid wastes would continue to be a major challenge in our environment as long as the authorities keep looking the other way, because water bodies would be polluted due to indiscriminate disposal of waste - in drainage systems channels and rivers - the atmosphere could be polluted with gases of waste materials that are combustible (disposed by burning).

2.2.2 Health Implication of Waste Disposal

Egger *et al,* (2001) suggested that diseases such as malaria, filariasis, staphycoccosis, rabies, etc. can be contacted directly or indirectly from vectors, animal, that breed and feed on municipal solid waste dump sites, and can become a serious threat to lives to people scavenging and living around or close to dump sites. Improper disposal of hazardous waste causes adverse effects on human health and the environment. The normal practices of waste disposal such as insanitary open dump, land filling, discharge in water courses, or open-pit burning will need modification when dealing with hazardous wastes (Emerson *et al.*, 2004). The principle hazard of improper waste disposal is contamination of soil and groundwater. This arises largely from the waste containing hazardous substances deposited in landfills or on the ground.

With regard to hazardous waste disposal sites, at least five different routes of human exposure are possible: direct ingestion through drinking inhalation of contaminants that volatilize from heated water absorption through the skin during washing and bathing ingestion through consumption of goods derived from plants or animals exposed to polluted groundwater, and absorption through the skin when handling contaminated soil (Emerson *et al.,* 2004)

The insanitary methods adopted for disposal of solid wastes is therefore a serious health concern (Egger *et al.,* 2001). The poorly maintained landfill sites are prone to groundwater contamination because of leachate production. According to Smith *et al,* (2006), open dumping of garbage facilitates the breeding for disease vectors such as flies, mosquitoes, cockroaches, rats, and other pests. The municipalities in India therefore face the challenge of reinforcing their available infrastructure for efficient MSW management and ensuring the scientific disposal of MSW by generating enough revenues either from the generators or by identifying activities that generate resources from waste management (Emerson *et al,* 2004). The key issues involved in the solid waste management are growth in population and increasing garbage generation, waste collection system, segregation of waste at source in as many categories as practical, scientific processing of waste material depending on nature, developing infrastructure for solid waste and disposal and processing, decentralize means to process waste to avoid multiple transfer and facilitate disposal etc

The waste generated in countries that do not have proper disposal means creates unsanitary living conditions and detrimental health concerns, such as diarrhea and malnutrition, in addition to a range of sicknesses and diseases.

Internationally, these problems triggered by improper sanitation efforts can be traced back to about 68% of all deaths for children under the age of five (Aponte *et al.,* 2004). Today, it is

estimated that there are about 2.6 billion people (980 million children) living in the developing world who have yet to gain access to proper sanitation means, of which 572 million are living in Africa (WHO,2005). Approximately 62% of Africans lack the access to adequate sanitation facilities, (WHO, 2008).

When discarded waste is poorly managed, it can draw pests, snakes, and other rodents and cause environmental pollution that can result in the spread of toxins or disease in a community. When children play near or in worse cases, in the waste, they are more likely to be exposed to agents, pathogens and infections that can lead to conditions such as malaria and diarrhea. Diseases such as dysentery, diarrhea, scabies, eye infections, typhoid, cholera and intestinal parasites can spread quickly in persons and communities (Emerson *et al.,* 2004).

Worldwide, 8% of children die of malaria each year, and 17% from diarrhea related infections, 88% of which is due to contaminated water sources (WHO, 2005). Even more alarming is that the sole number of children dying from diarrhea worldwide, coming to approximately 5000 deaths each day (WHO, 2011)

In addition to the rotting smell in the streets and the dangers of parasites, the garbage piled in the streets also makes the environment more susceptible to air born infections as well as infections in the soil and water. The improperly discharged waste often ends up contaminating the water source in rural villages and even some urban areas. Today, it is estimated that only 40% of the rural population have access to hygienic drinking water sources. With over 50% of the people susceptible to infections carried by water viruses, the results can be deleterious for the health of Tanzania, as the population is susceptible to disease and other perilous side effects (Aponte *et al.,* 2004).

To tackle these challenges, we have to look beyond ourselves. We must change our old-fashioned perception of waste for a new understanding of its uses and implication that can create a win-win situation for the consumers, producers and government of Nigeria.

If a policy or system is put in place to ensure that packaging materials should be sold back to the producers by consumers through the market distribution chain for a percent of the cost of the product, waste materials can be ploughed back into the market.

2.2.3 Impact of Environmental Changes on Vector Population in an Urban Situation

The lack of proper drainage and improper liquid and solid waste management has led to the breakdown of sanitary facilities. This has created conditions conducive to the proliferation of many disease vectors (Aponte *et al.,* 2004). The risk of infection with vector-borne diseases has increased due to exponential population growth, industrialization, urbanization and large-scale population movement. Developmental activities based on certain aggregate planning models that have promoted unplanned growth and breakdown of sanitation are the major cause of increase in the occurrence of vector-borne diseases. Developmental activities like irrigation projects, construction of roads, housing colonies, dams and railways are some of the other causes that affect the environment to create an imbalance in the natural eco-system.

Improper waste management and disposal system, lack of health education of the people, poverty and unaffordability are some of the other causes that make the man's living conditions unhygienic and unhealthy. The urban landscapes are littered with garbage, plastic bottles, disposable cups, discarded tyres, etc., which serve as ideal breeding grounds for biological vectors (Aponte *et al.,* 2004).

2.3 Malaria

Malaria is caused by a parasite called Plasmodium, which is transmitted via the bites of infected mosquitoes. In the human body, the parasites multiply in the liver, and then infect red blood cells (Bremen, 2009).

Symptoms of malaria include fever, headache, and vomiting, and usually appear between 10 and 15 days after the mosquito bite. If not treated, malaria can quickly become life-threatening by disrupting the blood supply to vital organs. In many parts of the world, the parasites have developed resistance to a number of malaria medicines (Bremen, 2009).

Malaria is endemic throughout most of the tropics. Of the approximately three billion people living in 108 countries who are exposed, approximately 243 million will develop symptomatic malaria annually (WHO, 2011). Most of these are attributable to *P. falciparum* (90 percent), but *P. vivax and P. knowlesi* can also cause severe disease. Malaria deaths peaked at 1.82 million in 2004 and fell to 1.24 million in 2010 (714,000 children <5 years and 524,000 individuals ≥5 years); over 80 percent of the deaths occur in sub-Saharan Africa (WHO, 2011).

Important components for reducing the burden of malaria morbidity and mortality include more sensitive diagnostic tools, effective use of antimalarial drugs, and improved personal protection and mosquito control. The approach to elimination or control of malaria includes these basics, along with improvements in tracking of human illness and parasite surveillance, and effective resource delivery.

Issues related to epidemiology of malaria, including definitions and strategies for control, will be reviewed. Other related topics are discussed in detail separately.

2.3.1 Epidemiology of Malaria

Malaria is transmitted via the bite of a female Anopheles spp mosquito, which occurs mainly between dusk and dawn. Other comparatively rare mechanisms for transmission include: congenitally-acquired disease, blood transfusion, sharing of contaminated needles, and organ transplantation (Snow *et al.,* 2005)

Malaria occurs throughout most of the tropical regions of the world, with *P. falciparum* causing the largest burden of disease, followed by *P. vivax* (Bremen, 2009). *P. falciparum* predominates in Africa, New Guinea, and Hispaniola (Haiti and the Dominican Republic); P. vivax is more common in the Americas and the western Pacific. The prevalence of these two species is approximately equal in the Indian subcontinent, eastern Asia, and Oceania (Bremen, 2009). *P. malariae* is uncommon and is found in most endemic areas, especially in sub-Saharan Africa. *P. ovale*, even less common, is relatively unusual outside of Africa and, where it is found, comprises <1 percent of isolates.

2.3.2 Malaria in Port Harcourt

Malaria is a disease of the tropics and sub-tropical regions of the world, is caused by a parasite, plasmodium and the commonest specie is plasmodium falciparum. The disease constitutes a serious public health problem in Nigeria. It is responsible for 60% out patient visit to health facilities, 30% childhood deaths, 25% of deaths in children under one year of age and 11% of maternal deaths. The financial loss due to malaria annually is estimated to be about 132 billion naira in form of treatment cost, prevention, loss of man-hours etc (WHO, 2008).

Globally, over 300 million cases are reported annually, about 85% in Africa. Two to three million people die each year (mainly children less than 5 years) (WHO, 2011). Rivers state, the hub of Nigeria's mineral oil and gas industries, is easily vulnerable and provides a

favourable habitation for the Anopheles mosquito which carried the malaria parasite. Besides, the economic and environmental activities in the capital city of Port Harcourt increases malaria problem. During 1980s till date, the burden of malaria has continued to increase in intensity. The emergence and spread of parasite resistance to previously effective low-cost drugs has posed a major challenge for control efforts (Filler *et al*, 2001).

The Rivers State Government through the Ministry of Health and Malaria Control Unit of the Department of Public Health has taken the "bull by the horn" in the fight against malaria. In April 2004, these efforts culminated in the launching of Roll Back Malaria (RBM)- a control strategy that seeks to establish a social movement in which all partners (local communities, public and private sectors, all tiers of government and NGOs) and network can implement malaria control interventions in the context of the health sector reforms of the Federal Government of Nigeria.

At the state and LGA levels, the malaria control unit is well structured with major interventions being carried out with RBM partners. However, in 2007 the State Government in collaboration with the Federal Government commenced preparatory activities for the take-off of the World Bank Malaria Booster Project, intended to scale up and strengthen, malaria control efforts. Under the project, Rivers State is expected to receive 10.5 million US dollars for a 5 year period in support of the fight against malaria, now christened Malaria Control Booster Project (MCBP). The climax of the preparatory activities was the inauguration of a 10 member Project Implementing Unit (PIU) by the representatives of the Federal Ministry of Health and the Hon. Commissioner of Health (MDG, 2005).

2.3.3 Malaria Environment

The minimum temperature needed for mosquito to develop is between 14 – 90 ^{0}C, the optimum temperature for mosquitoes to live and breed in, is 25 – 70 ^{0}C and the maximum temperature for mosquitoes to survive is 40 ^{0}C (Filler *et al*., 2001).

The sum of precipitation affects the amount of surface water within which the anopheles mosquitoes can breed. Suitable breeding water habitats are crucial for the survival of mosquito (Filler, *et al*., 2001). Climatic changes expected to influence the anopheles mosquito survival are deforestation and habitat changes but there is also a correlation between malaria distribution and non climatic factors such as different malaria control strategies, urbanization, irrigation and agriculture (Smith *et al*., 2006).

2.3.4 Malaria Morbidity

Malaria is a serious and sometime fatal disease caused by a parasite (*Plasmodium falciparum*) that commonly infects a certain type of mosquito (infected female Anopheles mosquito) and feeds on humans. People who get malaria are typically very sick with high fevers, shaking chills and flu-like illness (CDC, 2007).

Although malaria can be a deadly disease, illness and death but can usually be prevented. According to Center for Disease Control, in 2008, an estimated 863,000 people died of malaria, most were young children in sub-saharan Africa (CDC, 2010).

Malaria remains a major cause of mortality and morbidity in Africa (RBM, 2005). Many approaches to malaria control involve reducing the chances of infection but little is known of the relations between parasite exposure and the development of effective clinical immunity (Filler, *et al*., 2001).

In highly endemic areas, measures taken to reduce parasite transmission and thus immunity, may lead to a change in both the clinical spectrum of severe disease and the overall burden of severe malaria morbidity. Infants and young children carry a very high disease burden, but protective immunity is developed in early childhood. Adults and older children are able to control parasitaemia and therefore only rarely suffer from mild malaria symptoms (Malaria Journal, 2004, CDC, 2007).

In areas of low malaria transmission, immunity develops slowly and malaria affects all age groups. It has been suggested that the societal burden of malaria does not necessarily increase with transmission intensity, but peaks at a certain level of transmission after which it remains constant and may even decrease (Malaria Journal, 2004). The female Anopheles mosquitoes enter the house in the evenings, between 5.00pm and 10.00am, and also early in the morning between 5.00am and 7.00am (Bremen *et al.*, 2001).

2.4 Diarrhoea

Diarrhoea is the condition of having three or more loose or liquid bowel movements per day (WHO, 2005). It is a common cause of death in developing countries and the second most common cause of infant deaths worldwide.

The loss of fluids through diarrhea can cause dehydration and electrolyte imbalances. In 2009 diarrhea was estimated to have caused 1.1 million deaths in people aged 5 and over and 1.5 million deaths in children under the age of 5 (WHO, 2005). Oral rehydration salts and zinc tablets are the treatment of choice and have been estimated to have saved 50 million children in the past 25 years.

According to WHO (2005), in 2004 approximately 2.5 billion cases of diarrhea occurred, which results in 1.5 million deaths among children under the age of five. Greater than half of

these were in Africa and South Asia. Diarrhea remains the second leading cause of death (16%) after pneumonia (17%) in this age group (WHO, 2005).

Recent reports from the World Health Organisation (WHO, 2011) have confirmed that Nigerian children will continue to be victims of diarrhea as the country is said to be one of the seven high-population countries with total sanitation coverage of less than 50 per cent.

In effect, less than half of the population has access to improved sanitation and the access is as low as 10 per cent in some states with the situation worse in the rural areas.

The situation, according to the reports, has worsened in the last two decades, with environmental sanitation problems resulting in an escalating negative impact on public and environmental health.

Experts say poor environmental sanitation in Nigeria is characterised by the presence of heaps of refuse in cities, indiscriminate disposal of solid and other wastes, blocked drains, overgrown weeds, among others.

The state of food sanitation in homes, markets and abattoirs is equally appalling and unwholesome as food meant for human consumption is exposed to dust, flies, bacteria and other micro-organisms, they say.

The experts say that such probably accounts for the increasing cases of food-borne diseases such as cholera, food poisoning and typhoid fever.

According to statistics from UNICEF, diarrhea accounts for more than 16 per cent of child deaths. That is a total of 150,000 deaths amongst children under five, annually.

Experts trace the disease to a lack of access to basic sanitation facilities and poor hygiene practices. They say it is closely connected with malnourishment, as undernourished children

usually have a compromised immune system. The lack of safe and private toilets and hand-washing facilities in schools has ensured a quicker development of sanitation-related diseases on children

Some of the diseases that can be spread from pet waste are:

i. **Campylobacteriosis** - a bacterial infection that causes diarrhea in humans.

ii. **Salmonellosis** - the most common bacterial infection transmitted to humans from animals. Symptoms include fever, muscle aches, headache, vomiting, and diarrhea.

iii. **Toxocarisis** - roundworms transmitted from animals to humans. Symptoms include vision loss, rash, fever, or cough.

In addition to these diseases, the organic matter and nutrients contained in pet waste can degrade water quality. The waste decays when pet waste is washed into a surface water body, the waste decays.

Flies and other pest insects can also increase when pet waste is disposed of improperly becoming a nuisance and adding another vector for disease transmission.

2.4.1 Diarrhoeal Disease, Disease Agents, and Pathways

Diarrhoeal diseases kill an estimated 1.8 million people each year (WHO 2005). Among infectious diseases, diarrhoea ranks as the third leading cause of both mortality and morbidity (after respiratory infections and HIV/AIDS). Young children are especially vulnerable, bearing 68% of the total burden of diarrhoeal disease (Bartram 2003). Among children younger than five years of age, diarrhoea accounts for 17% of all deaths (United Nations 2005). The immediate threat from diarrhoea is dehydration, and a loss of fluids and electrolytes. Thus, the widespread promotion of oral rehydration therapy has significantly reduced the case-fatality rate associated with the disease. Such improvements in case

management, however, have not reduced morbidity, which is estimated at four billion cases annually (Fung, 2008). And since diarrhoeal diseases inhibit normal ingestion of foods and adsorption of nutrients, continued high morbidity is an important cause of malnutrition, leading to impaired physical growth and cognitive function, reduced resistance to infection and potentially long-term gastrointestinal disorders (Curtis, *et al*, 2003). With continued high attack rates, diarrhoeal disease is also an enormous economic burden, resulting in significant direct costs to the health sector and patients for treatment as well as in lost time at school, work, and in other productive activities (Clark, 2003).

The infectious agents associated with diarrhoeal disease are transmitted chiefly through the faecal-oral route (Byers 2001). A wide variety of bacterial, viral, and protozoan pathogens excreted in the faeces of humans and animals are known to cause diarrhoea.

Among the most important of these are *Escherichia coli, Salmonella spp., Shigella spp., Campylobacter jejuni, Vibrio cholerae, rotavirus, norovirus, Giardia lamblia, Cryptosporidium spp., and Entamoeba histolytica* (Filler, *et al*., 2001). The importance of individual pathogens varies between settings, seasons, and conditions.

These pathogens may be transmitted through the ingestion of contaminated food, water or other beverages, by person-to-person contact, and by direct or indirect contact with infected faeces.

Because of this variety of pathways, environmental interventions for the prevention of diarrhoeal disease typically include steps to improve the proper disposal of human faeces (sanitation), as well as improving water quality (Clasen 2006), water quantity and access, and promoting hand washing and other hygiene practices (Curtis 2003).

In addition to diarrhoea, there are other important risks to health associated with poor sanitation. These include schistosomiasis, soil-transmitted helminth infection (including ascariasis, trichuriasis, and hookworm infection), trachoma (Emerson 2004), and tropical enteropathy.

CHAPTER THREE

RESEARCH METHODOLOGY

The method used in this research work such as the Area of study, research design, study population, sample and sampling techniques, instruments of data collection, development and validation of the instrument and reliability, data collection techniques and method of data analysis were clearly stated and described in this chapter.

3.1 Area of Study

Port Harcourt is the capital of Rivers State and a port town in southern Nigeria. It lies along the Bonny River (an eastern distributary of the Niger), 4.75°N 7°E: 4.75°N 7°E, 41 miles (66 km) upstream from the Gulf of Guinea. Founded in 1912 in an area traditionally inhabited by the Ikwerre people, an Igbo subgroup, it serves as a port, named for Lewis Harcourt - the colonial secretary. Port Harcourt has long been an important merchant port and is today the centre of Nigeria's oil industry. Its exports include petroleum, coal, tin, palm products, cocoa, and groundnuts.

The main city of Port Harcourt is the Port Harcourt city in the Port Harcourt Local Government Area, consisting of the former European quarters now called old Government reservation area (GRA) and new layout areas. The Port Harcourt Urban Area (Port Harcourt metropolis) is made up of the city itself and parts of Obio/Akpor Local Government Area. Port Harcourt City, which the capital of Rivers State, is highly congested as it is the only major city of the state.

Port Harcourt features a tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualifies as dry season months in the city. The harmattan, which climatically influences many cities in West

Africa, is less pronounced in Port Harcourt. Port Harcourt's heaviest precipitation occurs during September with an average of 370 mm of rain. December on average is the driest month of the year; with an average rainfall of 20 mm. Temperatures throughout the year in the city is relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25°C-28°C in the city.

3.2 Research Design

This research used community based cross-sectional descriptive study design, which was carried out in a six-month study (October 2011-March 2012). The design suited well to test the relationship that existed between the household waste disposal and the prevalence of malaria and diarrhoeal diseases at one time. Besides the survey based on questionnaires, field observations and entomological evaluations were also added to enhance the measurement of environmental exposure and to triangulate the results.

3.3 Study Population

The population of the study comprised of the people living in Port Harcourt L.G.A.

3.4 Sample and Sampling Techniques

Samples of 420 people were selected for the study from 420 homes using the simple random sampling technique of balloting.

3.5 Sample Size

The sample size was determined from the general population using;

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

Where n = Sample size.

N = total population.

e = level of significance = ±0.005 at 95% confidence intervals.

3.6 Sampling Techniques

The study area was a household area where a systematic random sampling method was used to select the households. A detailed enumeration of residential houses was acquired in both of the chosen communities. The sample size needed was 420 households, which was proportionately distributed to the communities depending on the number of households in those communities.

Sampling interval was computed by dividing the number of total households in a specific community by the number of households that should be sampled. Using the calculated interval, 10^{th} household was selected on the basis of the 1^{st} household being selected randomly so that if one household was chosen randomly, every 10^{th} household would be selected.

One respondent who was an adult aged 18 years and above was interviewed in each of the selected households. The preferred respondent was the head of the household or a responsible adult who was conversant with the waste disposal practices at home and recent health history especially the incidence of malaria and diarrhoeal diseases.

Such a method of sampling was deemed suitable since it was able to provide systematic coverage of households within communities, increased the study population representativeness, and was feasible to gather data in a densely populated urban area like Port Harcourt Local Government Area.

3.7 Study Instrument

An open-ended structured questionnaire was used to gather information on the relationship between waste disposal and the occurrence of malaria and diarrhea in Port Harcourt. The questionnaire is focused on two basic parts; A and B.

Part A comprises of personal data, while **Part B** is directed toward people's opinion on the waste disposal method, prevalence of diarrhea and malaria. It was considered appropriate because the study was a sample of the survey.

3.8 Development and Validation of the Instrument

This research instrument was validated by issuing the questionnaire to professionals for thorough examination, correction and standardization. The correction was effected on the questionnaire strictly on the basis of achieving the research objective.

3.9 Data Collection Techniques

Questionnaire Survey

The open-ended structured questionnaire was used to collect the data and measure the connection between waste disposal methods and incidences of malaria and diarrhoea in Port Harcourt Local Government Area. The questionnaire was categorized into two parts, Section A, that included socio-demographic attributes of the respondents and Section B that included waste disposal behavior, the distance to dumpsites, exposure to vectors and self-reported prevalence of malaria and diarrhoea.

Validation and Pilot Testing

Content and face validation of the questionnaire was done by the professional of the field of public health and environmental health so as to make it clear, relevant, and relevant to the

objectives of the study. Their contribution was to develop better wording of questions, eliminate ambiguities, and standardize response choices.

A pilot testing was then done on 40 respondents (about 10 percent of the sample size) in a community that is not a part of the chosen study areas but with similar environmental and socioeconomic factors. The pilot study did not involve any data in the final analysis. The pilot testing feedback was followed to enhance further clarity, sequence and understandability of the questionnaire items.

Reliability Assessment

Cronbach alpha coefficient was used to determine the internal consistency of the questionnaire. The total reliability coefficient was ≥0.70, which demonstrated that the instrument had a good level of internal consistency to measure waste disposal practices and the presence of diseases. The researcher and four other trained research assistants administered the questionnaire to the respondents and ensure on-the-spot collection. The answers were computed and used as data for this research.

Field Observation

The waste disposal methods, presence of open dumpsites, drainage conditions, stagnant water and presence of environmental nuisances such as odour and smoke were recorded in the form of observational checklists.

Entomological Survey

The adults of mosquitoes and flies were gathered around the known dumpsites through normal trapping techniques. The density of larvae in the stagnant water bodies was then determined through the sampling of the water bodies in larvae per litre of water and the fly density was reported as number per traps per 24-hours.

3.10 Method of Data Analysis

The study involved both qualitative and quantitative analysis of the influence of waste disposal on the occurrence of malaria and diarrhea

The data obtained from questionnaires were compiled in a simple tables and appropriate data was graphically represented by use of bar chart.

Descriptive statistics of Chi-square (x^2) test and odds ratio were used to test the hypothesis formulated.

CHAPTER FOUR

RESULTS

The study examined the relationship between waste disposal and the incidences of malaria and diarrhoea in Port Harcourt Local Government Area in Rivers State**.** A total of 420 respondents were chosen in four communities (Port Harcourt Township, Diobu, Rumuokoro, and D-line/Ada George). Most of the respondents were female (54.8), and of the ages 40-49 years (47%). The greatest category (50.5) was comprised of married people. The majority of the respondents were tertiary educated (41.7) and earned N100,000 and above (37.6) a month. Ikwerre (33.8%) was majority ethnic group, and majority of the respondents resided in Port Harcourt Township (28.6%) (Table 4.1)

Table 4.1: Socio-Demographic Characteristics of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	190	45.2
	Female	230	54.8
Age (years)	20 – 29	101	24.0
	30 – 39	122	29.0
	40 – 49	197	47.0
Marital Status	Single	138	32.9
	Married	212	50.5
	Divorced/Separated	45	10.7
	Widowed	25	5.9
Educational Level	No Formal Education	27	6.4
	Primary	64	15.2
	Secondary	154	36.7
	Tertiary	175	41.7
Monthly Income (₦)	Below 10,000	48	11.4
	11,000 – 49,000	68	16.2
	50,000 – 99,000	146	34.8
	100,000 & Above	158	37.6
Occupation	Civil Servant	128	30.5
	Trader/Business	106	25.2
	Artisan	76	18.1
	Student	62	14.8
	Unemployed	48	11.4
Ethnicity	Ikwerre	142	33.8
	Ogoni	98	23.3
	Kalabari	85	20.2
	Others	95	22.6
Location (Community)	Port Harcourt Township	120	28.6
	Diobu	96	22.9
	Rumuokoro	112	26.7
	D-Line/Ada George	92	21.9
Total		420	100.0

Open dumping (36.4%) was the most frequently used waste disposal technique among the respondents, and the second technique used was burning of refuse (25.0%). The fact that only 20.7 percent of the respondents said that the government agencies picked their waste, shows that there are loopholes in the organizational waste management. Only a smaller percentage (9.5) discarded the waste into drainages or nearby water bodies - an act that leads to breeding of the vectors and also water pollution. Use of private waste collectors (8.3%) was least used implying that many residents are still faced with the challenge of affording and accessibility (Table 4.2).

Table 4.2: Distribution of Respondents by Gender and Common Waste Disposal Methods in Port Harcourt LGA

Waste Disposal Method	Male (n = 190)	Female (n = 230)	Total (n = 420)	Percentage (%)
Open dumping on vacant land/roadsides	68 (35.8%)	85 (37.0%)	153	36.4
Burning of refuse	45 (23.7%)	60 (26.1%)	105	25.0
Waste collection by government agency	40 (21.1%)	47 (20.4%)	87	20.7
Waste disposal in drainage/water bodies	22 (11.6%)	18 (7.8%)	40	9.5
Use of private waste collectors	15 (7.9%)	20 (8.7%)	35	8.3
Total	190 (100%)	230 (100%)	420 (100%)	100

Table 4.3 shows the abundance of the mosquitoes and flies in the waste dumpsites in the selected sites in Port Harcourt Local Government Area. The results showed that significant differences in the abundance of vectors were observed in the areas of the study.

The Port Harcourt Township had the most adult mosquitoes (120) and highest mosquito larval density (25 larvae to a liter of water) suggesting a high degree of breeding in the area around the waste dumpsites. Likewise, the highest number of adult flies (180) and fly density (160 per trap per 24 hours) was found in the Township, which implies that the area has very favorable conditions of vectors proliferation because of the accumulation of waste and stagnant water.

A high level of vectors was also demonstrated by diobu, with 110 adult mosquitoes, a larval density of 20, and 160 adult flies of the fly density of 150, which was also second in total abundance. Rumuokoro and D-Line/Ada George had relatively lower scores of 100 and 90 adult mosquito and larval densities respectively. The fly counts were equal to 130 and 100 with the corresponding densities of 120 and 90 per trap/24 hours.

Generally, the findings reveal that the abundance of mosquitoes and flies was greatest in places where waste was high and where there are poor practices of sanitation especially in Port Harcourt Township and Diobu. This trend highlights the high correlation between poor waste management and the corresponding rise of the disease vectors which could also be the cause of the transmission of malaria, diarrhoea and other diseases that are spread by the vectors in the vicinity.

Table 4.3: Abundance of Mosquitoes and Flies Near Waste Dumpsites

Location	Mosquitoes (Adults Collected)	Mosquito Larvae (Density per Liter of Water)	Flies (Adults Collected)	Fly Density (Traps per 24 hours)
Port Harcourt Township	120	25	180	160
Diobu	110	20	160	150
Rumuokoro	100	12	130	120
D-Line/Ada George	90	8	100	90

Table 4.4 presents the distribution of the respondents according to the proximity of their households to the nearest dumpsite in the four study regions. A considerable percentage of households in every location were located within the distance of 500 meters of dumpsites highest number of households located within 500m was found at Port Harcourt Township (130 households), Diobu (115), Rumuokoro (105), and Ada George, D-line (90).

In all regions respondents had experiences of perceived environmental nuisances such as offensive odours, flies and smoke through open burning and also gave a history of medical occurrence of environmentally related disease especially malaria and diarrhoeal diseases.

Table 4.4: Distance between the participant's household and the nearest dumpsite

	Distance to Dumpsite					
Area of Study	**<100m**	**100-500m**	**501-1000m**	**>1000m**	**Environmental Nuisance Perceived (Yes/No)**	**Medical History (Environmental Illness) (Yes/No)**
Port Harcourt Township	50	80	60	40	Yes	Yes
Diobu	45	70	50	30	Yes	Yes
Rumuokoro	40	65	40	25	Yes	Yes
D-Line/Ada George	35	55	35	20	Yes	Yes

Table 4.5 shows the occurrence of malaria and the diarrhoeal diseases among the residents of the Port Harcourt Local Government Area. The findings reveal that malaria was the most common disease with the respondent counting 186 (44.3%), then diarrhoea with a respondent count of 92 (21.9%). Besides, 74 (17.6) respondents reported having had malaria and diarrhoea during the study period and 68 (16.2) respondents had no illness.

In general, the results showed that a high disease burden in the region with more than 80 percent of the surveyed population having experienced at least one of the two diseases. This highlights the close relationship between poor environmental sanitation, waste disposal activities and the perpetuation of malaria and diarrhoeal diseases among the locals.

Table 4.5: Prevalence of Malaria and Diarrhoeal Diseases Among Residents of Port Harcourt Local Government Area

Disease Type	Number of Respondents Affected (n)	Percentage (%)
Malaria Only	186	44.3
Diarrhoea Only	92	21.9
Both Malaria and Diarrhoea	74	17.6
No Reported Illness	68	16.2
Total	420	100.0

As shown in Table 4.6, the highest prevalence of malaria and diarrhoeal diseases was observed among those residents that were within 100 meters of dumpsites (40.5%), which was followed by residents living within 100-500 meters (31.4%). The higher the distance, the lower was the disease occurrence with the lowest disease prevalence being 7.6 at a distance further than 1000 meters. This shows that there is a strong relationship between the closeness of dumpsites and the incidences of malaria and diarrhoeal diseases among the people who live near dumpsites.

Table 4.6: Prevalence of Malaria and Diarrhoeal Diseases in Relation to Distance from Dumpsites

Distance to Dumpsite (meters)	Malaria Only	Diarrhoea Only	Both Malaria & Diarrhoea	No Reported Illness	Total (n)	Percentage (%)
< 100 m	78	45	32	15	170	40.5
100 – 500 m	62	28	24	18	132	31.4
501 – 1000 m	34	15	13	24	86	20.5
> 1000 m	12	4	5	11	32	7.6
Total	186	92	74	68	420	100.0

Table 4.7 indicates that open-dumping households had the highest rate of malaria (54.8) and diarrhoea (52.2), and then open-burning ones (29.0 and 28.3, respectively). Conversely, the respondents who applied the correct waste collection were less impacted with cases of both diseases. In general, the use of inappropriate waste disposal techniques (open dumping and burning) was closely linked with increased disease prevalence, which means that inefficient waste disposal is one of the factors that promote the spread of malaria and diarrhoeal diseases in Port Harcourt Local Government Area.

Table 4.7: Association Between Household Waste Disposal Practices and Occurrence of Malaria and Diarrhoeal Diseases

Waste Disposal Method	Malaria Only (n, %)	Diarrhoea Only (n, %)	Both Malaria & Diarrhoea (n, %)	No Reported Illness (n, %)	Total (n, %)
Open Dumping	102 (54.8%)	48 (52.2%)	38 (51.4%)	22 (32.4%)	210 (50.0%)
Open Burning	54 (29.0%)	26 (28.3%)	20 (27.0%)	24 (35.3%)	124 (29.5%)
Proper Collection (via Bin)	30 (16.1%)	18 (19.6%)	16 (21.6%)	22 (32.4%)	86 (20.5%)
Total	186 (44.3%)	92 (21.9%)	74 (17.6%)	68 (16.2%)	420 (100.0%)

The results indicated that a majority of the residents (89.0) knew about waste management and 84.8% of them were aware of its impact to the environment. More than 80% identified poor waste disposal as a factor that led to malaria and diarrhoea and 56.7 percent displayed good general knowledge (Table 4.8). The attitudes were generally positive with 86.2% of them seeing clean disposal of waste as health-promoting and 82% feeling a sense of personal responsibility on cleanliness (Table 4.9). The use of practices was however unsatisfactory, where only 34.3% of them supported good waste management practices and 35.7% and 30.0% engaged in open dumping and burning respectively (Table 4.10). This is a sign of disconnect between knowledge and practice amongst residents.

Table 4.8: Residents' Knowledge Regarding Waste Management and Its Health Implications

Knowledge Variable	Response Options	Frequency (n)	Percentage (%)
Awareness of waste management concept	Yes	374	89.0
	No	46	11.0
Knowledge of proper waste disposal methods (use of bins, collection services, recycling)	Yes	312	74.3
	No	108	25.7
Awareness of environmental consequences of improper waste disposal (pollution, flooding, odour)	Yes	356	84.8
	No	64	15.2
Awareness that poor waste management can cause malaria	Yes	338	80.5
	No	82	19.5
Awareness that poor waste management can cause diarrhoea and other waterborne diseases	Yes	324	77.1
	No	96	22.9
Knowledge of government or community waste disposal services in the area	Yes	272	64.8
	No	148	35.2
Knowledge of waste segregation and recycling benefits	Yes	214	51.0
	No	206	49.0
Overall Knowledge Level	Good Knowledge	238	56.7
	Fair Knowledge	126	30.0
	Poor Knowledge	56	13.3
Total		420	100.0

Table 4.9: Residents' Attitudes Toward Waste Management and Its Health Implications

Attitude Statements	Strongly Agree (n, %)	Agree (n, %)	Disagree (n, %)	Strongly Disagree (n, %)
Proper waste management is essential for good health	254 (60.5%)	108 (25.7%)	36 (8.6%)	22 (5.2%)
Waste disposal is the shared responsibility of every household	226 (53.8%)	102 (24.3%)	60 (14.3%)	32 (7.6%)
Government should be solely responsible for waste collection	68 (16.2%)	80 (19.0%)	142 (33.8%)	130 (31.0%)
I feel personally responsible for keeping my environment clean	190 (45.2%)	132 (31.4%)	60 (14.3%)	38 (9.1%)
Participation in community clean-up is important	210 (50.0%)	136 (32.4%)	50 (11.9%)	24 (5.7%)
Improper waste disposal contributes to diseases like malaria and diarrhoea	266 (63.3%)	112 (26.7%)	30 (7.1%)	12 (2.9%)

Table 4.10: Residents' Practices Regarding Waste Management and Its Health Implications

Practice Variable	Response Options
Frequency of household waste disposal	Daily
	Every 2–3 days
	Weekly
Method of waste disposal commonly practiced	Open dumping
	Burning
	Proper collection through agency or bin
Segregation of waste (organic, plastic, paper, etc.)	Yes
	No
Disposal of hazardous or medical waste (e.g., sharps, expired drugs)	Dispose properly (sealed/collected by agency)
	Mixed with general waste
Use of covered waste bins in the home	Yes
	No
Participation in environmental sanitation or community clean-up	Yes
	No
Practice of recycling or reuse of waste materials	Yes
	No
Household proximity to dumpsite	< 100 m
	100–500 m
	501–1000 m
	> 1000 m
Overall Waste Management Practice	Good Practice
	Fair Practice
	Poor Practice
Total	

Table 4.11 shows the effects that environmental and socioeconomic variables have on the prevalence of malaria and diarrhoeal diseases in Port Harcourt Local Government Area. The findings showed that the highest prevalence of diseases was recorded among the residents in high-density areas with 69.0% malaria and 52.4% diarrhoea than 35.7 and 25.7 in low-density areas. The quality of sanitation on the disease rates was exhibited by the fact that households that used pit latrines and open defecation had higher disease rates compared to those whose toilets were of the flush variety. The result was also the opposite- the respondents with low income below N10,000 had malaria and diarrhoea rates of 79.2 and 66.7 respectively and the highest rates of infections were in those who have higher incomes of N100,000 and above. The source of water had a great impact on the prevalence of the disease, people who relied on rivers or streams recorded 80.0 malaria and 63.6 diarrhoea against 41.7 and 22.2 in the borehole users. The location near dumpsites was also an issue and those who lived within a distance of 100 meters were the highest (80.0% malaria, 64.7% diarrhoea). All in all, it is possible to conclude that the poor sanitation, low income, the presence of contaminated water sources, and proximity to dumpsites are the main factors contributing to the malaria and diarrhoeal disease spread among residents of Port Harcourt LGA.

Table 4.11: Environmental and Socioeconomic Factors Influencing the Relationship Between Waste Disposal and Disease Occurrence

Variables	Categories	Frequency (n = 420)	%	Malaria Cases (%)	Diarrhoea Cases (%)
Housing Density	High-density (crowded areas)	210	50.0	145 (69.0)	110 (52.4)
	Medium-density	140	33.3	80 (57.1)	55 (39.3)
	Low-density	70	16.7	25 (35.7)	18 (25.7)
Sanitation Facilities	Pit latrine	140	33.3	95 (67.9)	72 (51.4)
	Water closet (flush toilet)	200	47.6	80 (40.0)	52 (26.0)
	Open defecation	80	19.1	70 (87.5)	60 (75.0)
Income Level	Below ₦ 10,000	48	11.4	38 (79.2)	32 (66.7)
	₦ 11,000 – ₦ 49,000	68	16.2	45 (66.2)	33 (48.5)
	₦ 50,000 – ₦ 99,000	146	34.8	82 (56.2)	52 (35.6)
	₦ 100,000 & above	158	37.6	60 (38.0)	40 (25.3)
Water Source	Borehole	180	42.9	75 (41.7)	40 (22.2)
	Well water	130	31.0	78 (60.0)	55 (42.3)
	River/Stream	110	26.1	88 (80.0)	70 (63.6)
Distance to Dumpsite	<100m	85	20.2	68 (80.0)	55 (64.7)
	100–500m	115	27.4	70 (60.9)	48 (41.7)
	501–1000m	120	28.6	55 (45.8)	35 (29.2)
	>1000m	100	23.8	30 (30.0)	18 (18.0)

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

Socio-Demographic Profile

In this study, the majority of respondents were female (54.8 %) and aged 40–49 years (47 %). Married individuals constituted 50.5 %, tertiary education held by 41.7 %, income ≥ ₦100,000 by 37.6 %, and distribution across ethnic groups and locations. These findings align with urban waste-management surveys in Nigeria which also report a preponderance of households with moderately higher education and income levels in sampling frames. Jibrilla, (2024) reported similar educational attainment levels among waste-study respondents) (see Jibrilla, 2024). However, some global studies report younger skews and more male respondents in informal waste settings (Raphela & Manqele, 2024), this contrast suggests context matters: in Port Harcourt LGA, household heads or respondents may more often be older and female, perhaps reflecting gender roles in waste handling in Nigeria. The relatively higher income and education levels in this study may buffer against the worst risks of poor waste disposal, yet other results show that waste-management practices and disease outcomes remain problematic despite these favourable socio-demographics.

Waste Disposal Methods

The open dumping (36.4 %) and burning of refuse (25.0 %) where the most frequent disposal methods correspond closely with findings in Nigerian cities where open dumping remains dominant. The study of Olorunlana & Ogunade, (2022), found open dumping, drainage/stream disposal, and burning common). Globally, a South African study showed that while awareness of waste management was moderate, actual disposal practices still featured illegal dumping and burning (Raphela & Manqele, 2024). This study shows only 20.7 % report formal government agency collection, which is consistent with low municipal coverage

in many African cities (Gebrekidan, 2024). The similarity underscores systemic deficits in waste collection infrastructure; the contrast is that even with relatively higher education/income levels in this study, practice remains poor—suggesting barriers beyond knowledge (cost, service access) dominate.

Vector Abundance Near Dumpsites

A higher mosquito and fly abundance in areas with heavy waste accumulation in Port Harcourt Township supports the mechanistic link between dumpsite proximity and vector proliferation. Although direct empirical studies quantifying vector counts around dumpsites in Nigeria are fewer, international geospatial research Okin et al., (2024) found strong spatial clustering of malaria and typhoid cases near dumpsites and waste-contaminated water bodies (Okin et al., 2024). The findings of this study provide local evidence of vector density rises near waste accumulation, strengthening the global evidence base. In contrast, the vector counts of this study are more precise (adult counts, larval densities, trap yields) than many surveys which rely on self-reported disease only. This enhances internal validity.

Prevalence of Malaria and Diarrhoeal Diseases

This study found malaria prevalence at 44.3 %, diarrhoea at 21.9 %, and both conditions in 17.6 %. This high disease burden echoes findings in other Nigerian urban settings: for example, a North-Central Nigeria study reported high diarrhoeal disease prevalence in communities near dumpsites (Umoru & Nafinji, 2025). Internationally, a systematic review of improper waste management in Ethiopia found increased incidence of diarrhoeal and vector-borne diseases in high-exposure zones (Gebrekidan, 2024). In contrast, malaria proportion in this study is particularly high for an urban Nigerian LGA, which may reflect the combination of proximity to dumpsites, high vector presence, and socio-environmental vulnerabilities. This suggests that waste-related drivers may significantly amplify malaria risk.

Association Between Proximity, Disposal Practices and Disease

The data of this study demonstrate a gradient, those living <100 m from dumpsites recorded highest disease prevalence (40.5 % of sample) which declines with increasing distance (7.6 % at >1000 m). Households using open dumping had highest malaria (54.8 %) and diarrhoea (52.2 %) versus proper collection. These results strongly corroborate spatial and behavioural risk factors identified in other studies: for instance, the Lagos illegal dumping study (Ichipi, 2023) found severe health impacts for residents near illegal dumpsites (Ichipi, 2023). Similarly, Offa LGA (Kwara State) found proximity, low income, and informal settlements increased disease prevalence around dumpsites (Umoru & Nafinji, 2025). This contrast is shown in this study's quantification of both disposal method and disease outcomes in one dataset, offering more granular insight into the mechanism of risk.

Environmental and Socioeconomic Moderators

The result shows that high-density housing, pit latrines/open defecation, low income (<₦ 10,000), water source (river/stream) and proximity to dumpsites all associate with higher malaria/diarrhoea rates. This aligns closely with the wider literature linking poverty, poor sanitation, unsafe water, and high-density living to infectious disease risk (Raphela & Manqele, 2024; Gebrekidan, 2024). A contrast is that some global studies emphasise rural sanitation or agricultural exposures more; your context emphasises urban dumpsite-related exposures. Thus, our results emphasise how within an urban Nigerian LGA, waste disposal practices interplay with typical socioeconomic vulnerabilities to amplify risk.

Synthesis and Implications

When compared globally and locally, this study confirms the widespread pattern: inadequate waste disposal creates breeding habitats, contamination pathways and elevated disease risk. For example, Raphela and Manqele (2024) in South Africa emphasised knowledge gaps regarding health risks of improper waste disposal; your study shows knowledge is high (~89

%) but practice is poor – highlighting that service/infrastructure gaps may matter more than awareness. Contrasting local Nigerian studies: while many note links between dumpsites and health outcomes, your study uniquely combines vector counts, proximity gradients, disposal behaviour, socioeconomic moderators and disease prevalence in one integrated framework.

This comprehensive evidence base corroborates calls in recent literature for integrated interventions: strengthening collection services, relocating dumpsites, equitably improving sanitation and water access, and targeting high-density low-income communities (Gebrekidan, 2024; Ichipi, 2023; Umoru & Nafinji, 2025) (Gebrekidan, 2024; Ichipi, 2023; Umoru & Nafinji, 2025). This study adds to location-specific quantification for Port Harcourt LGA, reinforcing the urgency for waste-and-health policy action in Nigerian urban contexts.

5.2 Conclusion

The research study revealed that despite the level of awareness and enforcement by the state and federal ministries of environment on waste disposal and the health implications of improper waste disposal, the people are yet to adhere to proper waste disposal methods. The disposal of waste along the streets and drains has contributed to the multiplication of disease vectors and parasites as they serve as breeding sites for these organisms. The research revealed that there is a relationship between waste disposal and the occurrence of malaria and diarrhea. Those that live close to dump sites, block drains and those that practice open dumping are more vulnerable to malaria and diarrhea.

5.3 Recommendation

i. I recommend that there should be more enlightenment on the health implications of waste disposal

ii. The ministries that are responsible for waste management should try and provide adequate waste management technique and waste disposal vans that will carry these wastes to dump site

iii. Private agencies should also help the government in the disposal of waste.

iv. The Government should embark on extensive vector control to reduce the vector population.

v. Mandatory environmental sanitation exercise should be encouraged by the government.

5.4 Limitation of the Study

- Many respondents were reluctant to complete the questionnaire forms but later filled it after being convinced of its importance.
- Loss of few questionnaires by the interviewees.

5.5 Contribution to Knowledge

1. This study combines both the environmental (proximity to dumpsites, type of sanitation, housing density, and source of water) and the socioeconomic variables (income, education, occupation) into a single model. This integrative research promotes the knowledge of the interaction of various factors to shape the patterns of disease in urban populations.
2. The research paper adds useful field data on the abundance of mosquitos and flies and larval concentration around urban dump sites, which empirically lacks empirical data in Nigeria. It demonstrates that the distribution of vectors is also ecologically justified as regions with more waste also have more vectors.
3. The study establishes a gap that persists in the knowledge, attitudes, and practices (KAP) of the residents; a high awareness level (89) and low compliance (34). The finding augers well in the body of literature on behavioural public-health as it shows that knowledge in itself does not translate to healthy environmental practices unless supported by structural and policy.

REFERENCES

Adegoke, A. A., Eze, J. I., & Olatunji, A. O. (2023). Assessment of municipal solid waste generation and management challenges in Lagos, Nigeria. *Environmental Challenges, 11*(4), 100794. https://doi.org/10.1016/j.envc.2023.100794

Agunwamba, J.C., Egbuniwe, N., & Ogwueleka, T.C., (2003). Least cost management of solid waste collection. *Journal of Solid Waste Technology and Management*, 29 (3): 154-167.

Aponte, J.J., Schellenberg, D., & Egan, A. (2004). Efficacy and safety of intermittent preventive treatment with sulfadoxine - pyrimethamine for malaria in African infants: a pooled analysis of six randomized, placebo- controlled trials. *Lancet*

Barret, Christopher & Sue, Dean (2001) "Conserving Tropical Biodiversity Amid Weak Institutions. *Biosciences* 51 (6): 497-502.

Barreto ML, Genser B, Strina A, Teixeira MG, Assis AM, & Rego RF (2007). Effect of city-wide sanitation programme on reduction in rate of childhood diarrhoea in northeast Brazil: assessment by two cohort studies. *Lancet*; 370(9599): 1622–1628.

Barrow, C.J. (1995). Developing the Environmental Problems and Management. Longman Group Ltd. England, pp 207-265.

Bello, T. O., Ojo, A. S., & Alabi, O. A. (2022). Environmental health impacts of dumpsites in urban Nigeria: A review. *Environmental Health Insights, 16*(1), 11786302221103456. https://doi.org/10.1177/11786302221103456

Breman, J.G. Eradicating malaria. *Sci Prog*; 92:1.

Bruce Chwatt, LJ. (1985). Essential Malariology, Wiley Medical. p.193.

Byers KE, Guerrant RL, & Farr BM (2001). Fecal-oral transmission. In: Thomas JC, Webber DJ editor(s). Epidemiologic Methods for the Study of Infectious Diseases. Oxford: Oxford University Press, 228–48.

Center for Disease Control (2010)

Clark, T.F. (2003): Corn Cobs-their Composition, Availability, Agricultural and Industrial Uses. Mimeo, Crawler Alc-177 (revised). Northern Regional Research Laboratory, USDA. Page 66

Curtis, V., & Cairncross, S. (2003). Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infectious Diseases;* 3(5): 275–81.

Das, P.K. (1997). Vector-borne parasitic diseases and their control. *J. Parasitic Dis.* 21: 99.

David, A. O., & Nwaogazie, I. L. (2023). Assessment of solid waste management in Ota, Ogun State, Nigeria. *Nigerian Journal of Technology, 42*(2), 289–295. https://doi.org/10.4314/njt.v42i2.18

Edim, E., & Chinyere, A. A. (2025). A systematic review and meta-analysis of waste collection and transportation efficiency in urban waste management systems in Port Harcourt, Nigeria. *Mediterranean Journal of Social Sciences, 16*(4), 46. https://doi.org/10.36941/mjss-2025-0036

Egger M, & Davey Smith G (2001). Principles of and procedures for systematic reviews. In: Egger M, Davey Smith G, Altman DG editor(s). Systematic Reviews in Health Care: Meta-analysis in Context. 2nd Edition. London: *BMJ Books*, 23–42.

El-Fadel, M. (1997): "Environmental Impacts of Solid Waste Landfilling". *Journal of Environmental Management* 50 (1): 1-25.

Emerson P.M, Lindsay S.W, Alexander N, Bah M, Dibba S.M, & Faal H.B. (2004). Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial. *Lancet*; 363(9415): 1093–8.

Esrey S.A, Feachem R.G, & Hughes J.M (2005). Interventions for control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. *Bulletin of the World Health Organization* 63(4): 757–772.

Eze, P., Agu, U., & Osondu, C. (2023). Socioeconomic impacts of malaria on households in South-East Nigeria. *BMC Public Health, 23*(1), 1158. https://doi.org/10.1186/s12889-023-15866-1

Fewtrell L, Kaufmann R.B, Kay D, Enanoria W, Haller L, & Colford J.M (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta- analysis. *Lancet Infectious Diseases;* 5(1): 42–52.

Filler S, Causer L.M, & Newman R.D (2001). Malaria surveillance—United States, MMWR Surveill Summ 2003; 52:1.

Fung I.C.H. (2008). *Chinese journals*: a guide for epidemiologists. Emerging Themes in Epidemiology; 5:20.

Gebrekidan, T. K. (2024). Impact of improper municipal solid waste management on One Health: A systematic review from Ethiopia. *J. of Solid Waste & Sustainability*, 3(2), 12-29.

Genser B, Strina A, dos Santos L.A, Teles C.A, Prado M.S, & Cairncross S, (2008). Impact of a city-wide sanitation intervention in a large urban centre on social, environmental and behavioural determinants of childhood diarrhoea: analysis of two cohort studies. *International Journal of Epidemiology*; 37(4):831–40.

Guerra C.A, Gikandi P.W, & Tatem A. J. I. (2008). The limits and intensity of Plasmodium falciparum transmission: implications for malaria control and elimination worldwide. *PLoS Med*; 5: e38.

Hill, M.K., (1997). Understanding Environmental Pollution, Cambridge University Press, pp.

Ichipi, E. B. (2023). An evaluation of the impact of illegal dumping of solid waste in Lagos State. *International J. of Environmental Research & Public Health*, 20(22), Article 7069.

Ikuomola, A. D., & Oladipo, O. (2023). Hazardous waste management and public health implications in Nigeria. *Environmental Management and Sustainable Development, 12*(3), 45–57. https://doi.org/10.5296/emsd.v12i3.20624

Institute for Health Metrics and Evaluation (IHME). (2024). Diarrheal diseases remain a leading killer for children under 5 and adults over 70. *IHME*. https://www.healthdata.org/news-events/news-releases/diarrheal-diseases-remain-leading-killer-children-under-5-adults

Izeogu, C.V. (1989). Environmental Problems in Third World Cities. International Institute for Environment & Development. p. 60. ISBN 1-84369-072-1.

Jibrilla, A. (2024). An analysis of the effects of indiscriminate dumping of solid waste. *International J. of Environmental & Economic Studies*, 9(1), 57-80.

Kiszewski AE, Teklehaimanot A (2004). A review of the clinical and epidemiologic burdens of epidemic malaria. *Am J Trop Med Hyg*; 71:128.

Kreith, F. (1994). Handbook of Solid Waste Management, McGraw-Hill Inc., United States of America, pp. 3.1 – 3.32.

Laufer M.K, Takala-Harrison S, & Dzinjalamala F.K, (2010). Return of chloroquine-susceptible falciparum malaria in Malawi was a re-expansion of diverse susceptible parasites. *J Infect Dis*; 202:801.

Malaria Journal (2004)

Murray C.J, Rosenfeld L.C, & Lim S.S. (2012) Global malaria mortality between 1980 and 2010: a systematic analysis. *Lancet*; 379: 413.

Narayana, T. (2008). Municipal Solid Waste Management in India: From Waste Disposal to Recovery of Resources.

Nzeadibe, T. C., Okonkwo, E. E., & Nwafor, S. O. (2022). Solid waste governance and environmental health in Nigeria's urban centres. *Cities, 125*(7), 103658. https://doi.org/10.1016/j.cities.2022.103658

Oghenekohwo, F. E., Okoro, C. P., & Nwoko, J. U. (2024). Health implications of proximity to dumpsites among residents in Southern Nigeria. *Public Health in Practice, 5*(1), 100415. https://doi.org/10.1016/j.puhip.2024.100415

Ogunbiyi, O. S., Abayomi, T., & Okafor, N. (2024). Sustainable approaches to solid waste management in developing countries: A Nigerian perspective. *Sustainability, 16*(5), 2179. https://doi.org/10.3390/su16052179

Ogwueleka, T.C., (2003). Analysis of urban solid waste in Nsukka, Nigeria. *Journal of Solid Waste Technology and Management*, 29 (4): 239-246.

Olorunlana, B., & Ogunade, T. (2022). Waste disposal practices and infectious diseases in Adamawa State. *Journal of Environmental Science & Waste Management*, 4(1), 35-43.

Oluwande, P., (2004). Assessment of Solid Waste Management Problems in China and Africa. *In: Holmes, J. (Ed.), Managing Solid Wastes in Developing Countries*, pp. 77 – 89.

Onibokun, A.G., (1999). Managing the monsters: urban waste and governance in Africa. International Development Research Centre, Ottawa.

Onyishi, C. J., Wali, E., & Okwakpam, I. O. (2023). Solid waste management system in Enugu Metropolis, South-Eastern Nigeria. *Journal of Geography, Environment and Earth Science International, 27*(6), 1–15. https://doi.org/10.9734/jgeesi/2023/v27i6687

Peavy, H.S., Rowa, D.R. & Tchobanoglous, G. (2005). Environmental Engineering, International Edition, McGraw-Hill Inc., pp.

Price R.N, Tjitra E, & Guerra C.A, (2007). Vivax malaria: neglected and not benign. *Am. J. Trop. Med. Hyg.*, 77:79.

Rajagopalan, P.K. & Das, P.K. (2008). What ails mosquito control programmes in India? *Bull. Sci.* 4: 14.

Raphela, T., & Manqele, N. (2024). The impact of improper waste disposal on human health and the environment: A case of Umgungundlovu District, KwaZulu-Natal Province, South Africa. *Sustainability*, 16(4), Article 1386047.

Smith T, Maire N, & Dietz K, (2006). Relationship between the entomologic inoculation rate and the force of infection for Plasmodium falciparum malaria. *Am J Trop Med Hyg*; 75:11.

Snow R.W, Guerra C.A, & Noor A. M. (2005). The global distribution of clinical episodes of Plasmodium falciparum malaria. *Nature*; 434:214.

Udensi, J. U., Anyanwu, C. O., & Opara, M. C. (2023). Assessment of solid waste management methods in Owerri West, Imo State, Nigeria. *Archives of Current Research International*, *23*(6), 1–10. https://doi.org/10.9734/acri/2023/v23i6575

Umoru, J., & Nafinji, H. (2025). The nexus between waste management and disease prevalence in Offa Local Government Area, Kwara State. *Annals of Environmental Science & Toxicology*, 9(1), 39-46.

WHO Global Malaria Control and Elimination: report of a technical review 17-18 January 2008. Geneva, pp. 1-47.

WHO, World Malaria Report, (2008). Geneva, Switzerland.

WHO. World Malaria Report. 2011. http://www.who.int/malaria/world_malaria_report_2011/en/ (Accessed on February 28, 2012).

Williams, P.T., (2000). Waste Treatment and Disposal, John Wiley and Sons, England, pp. 53 – 129.

World Bank, Millennium Development Goals, 2005.

World Health Organisation, 2005. Solid Waste Management in Emergencies, Technical Notes for Emergencies, pp. 1 – 4.

World Health Organization. (2023). *WASH-related disease burden estimation tool*. WHO. https://www.who.int/publications/m/item/wash-related-disease-burden-estimation-tool

World Health Organization. (2024). *World Malaria Report 2024*. Geneva: WHO. https://cdn.who.int/media/docs/default-source/malaria/world-malaria-reports/world-malaria-report-2024-spreadview.pdf

www.elsevier.com/locate/wasman, waste management 29 (2009) 1163 –1166. Page 65

APPENDIX I

DEPARTMENT OF PUBLIC HEALTH TECHNOLOGY

SCHOOL OF HEALTH TECHNOLOGY,

FEDERAL UNIVERSITY OF TECHNOLOGY, P.M.B. 1526, OWERRI.

Dear Respondent,

I am a master's degree student of the Department of Public Health Technology of the above institution. This questionnaire is aimed at data collection for research work on the relationship between waste disposal and the occurrence of malaria and diarrhea in PortHarcourt area of Rivers state. It will be useful in providing the necessary information for the prevention of diarrhea and malaria through proper waste disposal. I humbly request for your assistance in providing honest answer to these questions.

SECTION A: PERSONAL DATA

1. What is your sex?

   a) Male ☐

   b) Female ☐

2. Which of these represent your age bracket?

   (a) 20–29yrs ☐ (b) 30 – 39 yrs ☐ (c) 40 – 49yrs ☐

4. What is your highest level of education?

   (a) Non formal ☐ (b) Primary education ☐ (c) Secondary ☐

   (d) Tertiary ☐

5. What is your Occupation?

(a) Civil Servant ☐ (b) Trader ☐ (c) Farmer ☐ (d) Artisan ☐

(e) House wife ☐ (f) Others…… (Please specify).

SECTION B

INSTRUCTION: This section contains different statement in relation to the relationship between waste disposal and the occurrence of malaria and diarrhea in Diobu area of Rivers state. Please tick ☑ as it applies to you.

6. How do you dispose your waste?

1) Incineration ☐

2) Open dumping in the gutters ☐

3) Dumping it in a government approved sites ☐

7. Are you satisfied with the methods of waste disposal in Diobu?

Yes ☐ No ☐

8. Do you leave close to a refuse dump site?

Yes ☐ No ☐

9. Do you have waste collection bin in your neighborhood?

Yes ☐ No ☐

10. Have you been told by a doctor or nurse that you had malaria?

Yes ☐ No ☐

11. If YES to question 9 above, how often was it?

Once ☐ Twice ☐ Thrice ☐ None ☐

12. Have you been told by a doctor or nurse that you had diarrhea?

Yes ☐ No ☐

13. If YES to question 11 above, how often was it?

Once ☐ Twice ☐ Thrice ☐ None ☐

14. Do you think that there is a relationship between waste disposal and the prevalence of malaria and diarrhea in the area?

Yes ☐ No ☐

APPENDIX II

Open Dumping of Refuse Malaria Crosstabulation

			malaria		Total
			yes	no	
open dumping of refuse	those that practice open dumping	Count	145	61	206
		% of Total	34.5%	14.5%	49.0%
	those that do not practice open dumping	Count	68	146	214
		% of Total	16.2%	34.8%	51.0%
Total		Count	213	207	420
		% of Total	50.7%	49.3%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for open dumping of refuse (those that practice open dumping / those that do not practice open dumping)	5.104	3.370	7.729
N of Valid Cases	420		

APPENDIX III

Those Living Close to Dumpsite Malaria Crosstabulation

			malaria		
			yes	no	Total
those living close to dumpsite	those that live close to dumpsites	Count	146	50	196
		% of Total	34.8%	11.9%	46.7%
	those that live far from dump site	Count	67	157	224
		% of Total	16.0%	37.4%	53.3%
Total		Count	213	207	420
		% of Total	50.7%	49.3%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for those living close to dumpsite (those that live close to dumpsites / those that live far from dump site)	6.842	4.451	10.519
N of Valid Cases	420		

APPENDIX IV

Those That Have Blocked Drains Around Their Homes Malaria Crosstabulation

			Malaria		
			Yes	no	Total
those that have blocked drains around their homes	yes	Count	121	72	193
		% of Total	28.8%	17.1%	46.0%
	no	Count	92	135	227
		% of Total	21.9%	32.1%	54.0%
Total		Count	213	207	420
		% of Total	50.7%	49.3%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for those that have blocked drains around their homes (yes / no)	2.466	1.663	3.657
N of Valid Cases	420		

APPENDIX V

Open Dumping of Refuse Diarrhea Crosstabulation

			diarrhea		
			yes	no	Total
open dumping of refuse	those that practice open dumping	Count	103	94	197
		% of Total	24.5%	22.4%	46.9%
	those that do not practice open dumping	Count	71	152	223
		% of Total	16.9%	36.2%	53.1%
Total		Count	174	246	420
		% of Total	41.4%	58.6%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for open dumping of refuse (those that practice open dumping / those that do not practice open dumping)	2.346	1.577	3.489
N of Valid Cases	420		

APPENDIX VI

Those Living Close to Dumpsite Diarrhea Crosstabulation

			diarrhea		
			yes	no	Total
those living close to dumpsite	those that live close to dumpsites	Count	101	96	197
		% of Total	24.0%	22.9%	46.9%
	those that live far from dump site	Count	73	150	223
		% of Total	17.4%	35.7%	53.1%
Total		Count	174	246	420
		% of Total	41.4%	58.6%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for those living close to dumpsite (those that live close to dumpsites / those that live far from dump site)	2.162	1.456	3.210
N of Valid Cases	420		

APPENDIX VII

Those That Have Blocked Drains Around Their Homes Diarrhea Crosstabulation

			Diarrhea		
			yes	no	Total
those that have blocked drains around their homes	yes	Count	97	93	190
		% of Total	23.1%	22.1%	45.2%
	no	Count	77	153	230
		% of Total	18.3%	36.4%	54.8%
Total		Count	174	246	420
		% of Total	41.4%	58.6%	100.0%

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for those that have blocked drains around their homes (yes / no)	2.072	1.396	3.076
N of Valid Cases	420		