Outbreak of Infectious Diseases and Their Implications for Environmental Health; Lessons from the COVID-19 Pandemic

Ebikapade Amasuomo[1*], James E. Okoko[1], Justina Ananga Adegba[2]

[1]Department of Environmental Management, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

[2]Department of Applied Biology/Microbiology, Federal Polytechnic, Nasarawa, Nasarawa State, Nigeria

[*]Corresponding Author

DOI: https://doi.org/10.51244/IJRSI.2026.1315PH00079

Received: 12 April 2026; Accepted: 18 April 2026; Published: 05 May 2026

ABSTRACT

Background: Towards the end of 2019, communities in Wuhan City, China, began noticing the spread of a mysterious disease with pneumonia-like symptoms. Many of those infected had visited the Wuhan food market, which was later linked to the early outbreak of the COVID-19 pandemic. The disease initially spread rapidly among market stall owners, shoppers, and workers. However, as individuals without any travel history to the market began showing symptoms, it became evident that community transmission had begun. This research investigates the environmental implications of the COVID-19 outbreak.

Materials and Methods: To achieve the research objective, a mixed method approach was adopted using a questionnaire survey with 36 participants drawn from five states affected by the COVID-19 outbreak. The sample was purposively selected to include only participants at the forefront of managing COVID-19 waste. Participants were drawn from various fields and organizations. The breakdown of participants (n = 36) included 24 workers and managers of waste management companies, 7 senior staff members of ministries and waste management agencies, 3 environmental health officers working in hospitals and 2 laboratory scientists.

Results: The research found that outbreaks of infectious diseases act as a catalyst for increased waste generation. The study showed that COVID-19 waste is generated in three phases: home treatment and observation phase, diagnostic phase, and hospital treatment phase. The study revealed that waste management practices varied across these phases. For instance, waste generated in laboratories during diagnosis and treatment are often autoclaved and disposed of in landfills, incinerated, or subjected to open burning, while waste generated during home observation are collected and managed as domestic waste.

Conclusion: The study concluded that the current infectious waste management process in Nigeria have a negative implication for the environment with the potential to degrade overall environmental quality.

Keywords: COVID-19, Environmental Health Officers, Frontline Workers. Healthcare Waste, Pandemic

INTRODUCTION

Towards the end of 2019, communities in Wuhan City, China began noticing the spread of a mysterious disease with pneumonia-like symptoms. Many of the infected people had been in the Wuhan seafood market where the epidemic started (Oosterhoff, 2020). The disease spread among stall owners, shoppers and workers in the market. Eventually, people who had no history of travel to the market began contracting the infection thus indicating the onset of community spread. It became clear that the virus was spreading from person to person (Santos, 2020). Residents of Wuhan were particularly worried as the disease spread rapidly within the city with increasing mortality rate. By early 2020 the disease had spread quickly to other cities outside Wuhan in China.

Before long people outside China began exhibiting symptoms and mortality rates were increasing quickly. It was clear that the disease had spread to other countries. By March 2020, having infected over 100,000 people, the World Health Organization (WHO) declared COVID -19 a pandemic. As of December 2021, the disease had evolved and continue to be a serious public health emergency across the globe with many countries reporting mutated strains of the virus (Santos, 2020; Ohia et al, 2020; WHO, 2020).

The outbreak of the pandemic was sudden. Many nations were unprepared for the scale of medical emergencies that greeted the spread of the virus. Even in countries with the most advanced medical facilities, healthcare systems were overwhelmed (Jimoh Amzat et al, 2020).

Healthcare practitioners expressed worry about the potential damage the COVID-19 pandemic could have on health, well-being and the economy of poorer countries in Africa where the quality of existing healthcare infrastructure is substandard. Since the first reported case of coronavirus infection in Egypt in February, 2020, the rate of new infections increased across the continent. As of 7th of June, 2020 all African countries had confirmed cases of coronavirus with a total number of 192,721 persons infected and about 5200 deaths recorded, six months later, the total number of confirmed cases in the continent had risen to 3,021,769 with about 72,121 deaths and 2,450,492 recoveries recorded (WHO, 2020; Africa CDC, 2021).

As the pandemic spread globally, the Nigerian government, anticipating the spread of COVID-19 to the country announced the formation of a working group on the 28th of January 2020. The group which was termed Coronavirus Preparedness Group was to help the country with strategies to strengthen surveillance measures to effectively mitigate the impact of the virus should it spread to the country (Amzat et al, 2020; Suleiman, et al, 2020; Chinenyenwa et al, 2020). Shortly after the formation of the group, the World Health Organization listed Nigeria among high-risk countries.

On 27 February 2020, Nigeria recorded its first COVID-19 case from an initially asymptomatic traveller who fell ill in Ogun State and was later transferred to Lagos State (Suleiman, et al, 2020). A breakdown of the states with the highest confirmed cases within the first 30 days of the infection in Nigeria showed that Lagos State had more than 50% of all cases while Abuja had confirmed 20.3% of the total figure (NCDC, 2020).

According to Mogaji, (2020); Amzat et al, (2020) and Suleiman et al, (2020), during the early phase of COVID-19 pandemic in Nigeria, the distribution of the disease was elitist in nature. Most infected people had a history of air travel, a medium of transportation mostly used by financially stable Nigerians.

In its COVID-19 situation report of 23 June 2020, the NCDC revealed that they had tested 120,108 samples of which 2539 tests were conducted within 24 hours of the report. It added that Nigeria had confirmed about 21,371 cases of the coronavirus, of that number, 452 cases were recorded within 24hours before the report was published. As of 23 June, 35 states of the federation had confirmed cases of coronavirus. 7,338 people had been discharged, 533 infected people had died of the virus, a case fatality rate of 2.5% (NCDC, 2020).

The COVID-19 pandemic, though unprecedented in its global reach, was not an isolated incident in history. Throughout history, there have been several outbreaks of infectious diseases, including polio, measles, bubonic plague, cholera, influenza, and smallpox, among others. However, COVID-19 became a significant global concern due to the scale of its spread, affecting nearly every country and crippling the world economy.

While extensive research has been conducted on the public health implications of disease outbreaks, their effects on the environment have not received sufficient attention. A key consequence of pandemics, such as COVID-19, is the increase in waste generation and the subsequent need for management. The unprecedented deployment of single-use personal protective equipment (PPE), diagnostic kits, and other medical supplies during the COVID-19 pandemic led to a surge in medical and non-medical waste. This study seeks to establish that outbreaks of infectious diseases often result in environmental degradation, particularly through waste generation, using COVID-19 as a case study.

The negative environmental impact of the COVID-19 pandemic was not only due to the increase in waste generation but also due to the nature of waste. Most of the single-use items, such as face masks, gloves, gowns,

and testing kits, were made of synthetic materials, which are more challenging to manage than organic materials. However, these materials played a critical role in protecting healthcare workers and the public, limiting the spread of COVID-19 (WHO, 2020; Nwachukwu, Orji, & Ugbogu, 2013). Despite their effectiveness, the frequent disposal of single-use items created significant waste management challenges.

The restoration of health and preservation of life inevitably generate waste materials. These materials are produced in various facilities, including physician's offices, hospitals, dental practices, laboratories, medical research facilities, and veterinary clinics (Oruonye & Ahmed, 2020). Globally, healthcare activities contribute significantly to waste generation. These waste materials can be harmful to the environment and the health of those exposed to them (Manyele & Mujuni, 2010; Amasuomo and Baird, 2016; National Research Council, 2000). Unwanted materials from healthcare activities can become a pathway for the spread of diseases such as Ebola, COVID-19, and HIV. Healthcare waste includes materials such as body parts, radioactive materials, non-sharps, sharps, containers, pharmaceuticals, PPE, body fluids, chemicals, and medical devices (Rodriguez-Morales, 2013; Oruonye and Ahmed, 2020).

During the COVID-19 pandemic, PPE materials constituted a large percentage of the waste generated. Apart from PPE, sharps such as needles and syringes were produced on a large scale during the treatment of COVID-19 and other diseases in Nigeria. Globally, the healthcare industry is estimated to produce about 16,000 million injections annually, with Nigeria contributing a fraction of these, many of which are not properly disposed of (Nwachukwu, Orji, & Ugbogu, 2013).

Healthcare waste management in Nigeria requires a thorough assessment. Waste management in the country often involves informal players such as scavengers, middlemen, and industries that buy recycled materials from middlemen. This long chain of stakeholders exposes many individuals to infectious waste materials. Although there have been efforts to address COVID-19 waste in Nigeria, strategies that include informal waste actors are lacking during and after the pandemic. This exclusion of the informal sector in waste management and policy processes is a significant gap (Nzeadibe and Ejike-Alieji, 2020).

The percentage of COVID-19 infections caused by exposure to infected waste materials in Nigeria is unknown. Tracing illnesses to healthcare waste requires extensive investigations that are often not conducted (Nwachukwu, Orji, and Ugbogu, 2013). However, it is evident that the risk of exposure to contaminated waste extends beyond hospital premises as the virus can persist for up to a day or more on metal and plastic surfaces (Calma, 2020).

Research on healthcare waste in Nigerian tertiary facilities has shown that about 73.9% of the waste generated was general waste, while 20% was infectious waste, with the remainder being sharps and pathological waste (Abah and Ohimain, 2011). This indicates that the bulk of healthcare waste is non-hazardous but still needs to be managed in an environmentally friendly manner to prevent environmental contamination. Abah and Ohimain (2011) also pointed out that Nigerian hospitals need guidance on strategies to reduce waste volume, as healthcare waste generation often exceeds WHO guidelines.

The risks associated with infectious medical waste far outweigh those of general non-hazardous waste. The incineration of hazardous waste can lead to the emission of dioxins, furans, and mercury, increasing the risk of environmental pollution and health issues (Oruonye & Ahmed, 2020).

Additionally, certain practices within the health sector further endanger life by contributing to environmental hazards associated with COVID-19 and healthcare waste. For instance, some healthcare institutions in Nigeria engage in the open burning of sharps and non-sharp materials in both protected and unprotected pits as observed in other African countries (Manyele and Mujuni, 2010; Oyekale and Oyekale, 2017). Careless management of healthcare waste can increase airborne pathogenic bacteria, adversely affecting both the hospital environment and the surrounding community (Oli et al., 2015; Alhassan, and Daniel, 2020). As a result, healthcare policymakers have recognized the management of healthcare waste as a crucial component of healthcare service delivery (Health Professions Council of South Africa, 2008).

The COVID-19 outbreak introduced new challenges and new forms of hazardous waste produced in isolation and quarantine facilities. Infectious waste poses significant health risks to patients, health workers, and the

general public (Dos Santos, 2020). Emissions from incinerators and other waste management techniques can contribute to the spread of diseases (Oruonye & Ahmed, 2020). In Africa, it has been estimated that around 700 million PPE items, such as face masks, are used daily (Nzeadibe & Ejike-Alieji, 2020).

MATERIALS AND METHODS

Study Design: The study employed a mixed-method approach, combining both qualitative and quantitative data collection to ensure that research objectives were met. In the absence of a sampling frame, the study employed purposive sampling techniques. This sampling techniques allows for selection of participants that were already identified as suitable for the study based on their contacts with COVID-19 waste. A total of 36 people from various fields and organizations participated in the survey. In order to participate in the survey, participants were required to have worked in their organization and current capacity for at least 6 months. A breakdown of the participants (n = 36) and their roles were as follows: 24 workers or managers of waste management companies, 7 senior staff of ministries and waste management agencies, 3 environmental health officers working in hospitals and 2 laboratory scientists.

Study Location: The study collected data from five states including: Anambra, Lagos, Jos, Gombe and Kano respectively.

Study Duration: The Study was conducted between December 2020 and May 2021

Sample size: 36 people were selected for the study.

Statistical analysis: Data analysis was a critical component of the research. After the fieldwork, information gathered from field notes and survey instruments was carefully converted into an electronic dataset using Statistical Package for the Social Sciences (SPSS) software. Interviews were transcribed, and key information was extracted based on themes derived from participants' responses. The study primarily used SPSS for data analysis, Excel was employed to a lesser extent.

RESULTS

Question 1 - *Are you noticing healthcare waste in communal collection points since the outbreak of COVID-19?*

When companies were asked about healthcare waste in communal collection points after the pandemic began, 75% of them confirmed that they had been noticing healthcare waste in municipal collection points. On the other hand, 25% of participants reported no healthcare waste in communal collection points in areas where they provide collection services.

Question 2 - *Is your hospital generating more waste as a result of COVID-19?*

The research asked hospitals participating in the survey about the level of COVID-19 waste generation in their facilities. Their responses show that all hospitals visited, 100% generated more waste in their facilities as a result of the COVID-19 pandemic compared to pre-COVID-19 era.

Question 3 - *Has there been an increase in indiscriminate dumping of COVID-19 waste?*

Waste management companies were asked about their observations on indiscriminate dumping of COVID-19 waste in their areas of operation. Responses show that 62.5% of the companies observed an increase in indiscriminate dumping of COVID-19 waste, while 37.5% of respondents observed no increase in indiscriminate dumping activities.

Interview: *How does your facility manage COVID-19 waste?*

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI | Volume XIII Issue XV May 2026 | Special Issue on Public Health

Among the healthcare facilities managing COVID-19 patients that were visited, the most popular forms of management for waste generated are presented below:

- Open burning
- Burying
- Incineration

Interview: *What types of waste are generated by patients and healthcare facilities during the management of COVID-19?*

Table 1 – COVID-19 Waste Generated During Asymptomatic phase

Asymptomatic phase	Waste Materials Generated
	Fabrics – disposed clothes, beddings, rags, handkerchiefs, bathroom or hand towels etc Cans – kitchen items such as milk, tin tomato packs, can fish, can fruits among others Cardboards – packaging materials Tissue paper Paper – newspapers, book fragments, etc Plastics – bags, bottle water, lotion containers, pure water bags, food wrappings and packaging,

A breakdown of materials generated when patients at the early stage of exposure to the virus are shown in Table 1. Most of the materials include everyday domestic items.

Table 2 – COVID-19 Waste Generated During Home Treatment and Observation Stage

Symptomatic home treatment and observation stage	Waste materials produced
	Sharps and needles Surgical and fabric masks Bandages, cannulas, intravenous line and bags, Hand sanitizer containers Hand gloves, fabric PPEs Wet/socked hand towels, clothes (produced during hot water/herbal therapy) Materials from Table 1

During the second stage of COVID-19 waste generation, it was revealed by health officials that waste generated at the stage include infectious waste materials mixed with domestic waste. These are disposed to regular communal storage points from where city authorities evacuate waste for disposal. Health officials listed waste materials from this stage to include the materials shown in Table 2.

Table 3 – Waste Generated During Laboratory Diagnosis

Diagnosis	Waste Materials Produced
	Disused swab stick, used catriages, hand gloves, sanitizer containers, nose mask, disposable gowns.

Patients at the hospitals are first diagnosed to ascertain their health status so that treatments can be made according to the peculiarity of individuals. The process of diagnoses involve:

- Interview
- Sample collection
- Processing of samples

Most waste generated at this stage include laboratory types of waste as shown in Table 3.

DISCUSSION

Whilst this study reveals several new findings, only a summary of the most relevant results is presented for discussion:

Scope of Healthcare Waste Problems Resulting from COVID-19

The research found that waste generation increased significantly during the COVID-19 pandemic in all states visited. Information gathered from waste management companies, ministry officials, and environmental health officers at healthcare facilities managing COVID-19 patients revealed that COVID-19 has had far-reaching implications for healthcare waste management in many cities across the country.

Apart from the noticeable increase in healthcare waste, companies responsible for evacuating municipal waste in Anambra and Lagos reported a significant rise in the volume of healthcare waste disposed of in municipal waste collection points in their states during the lockdown.

In Anambra, for instance, an official from the waste management agency reported that some healthcare institutions were found to be disposing of their waste at communal storage points. He confirmed that there were instances where the agency investigated healthcare facilities located near communal collection points due to the large volume of healthcare waste improperly disposed of at collection points.

An official at Jos Teaching Hospital pointed out that the pandemic highlighted the importance of environmental health officers in the Nigerian healthcare sector. He explained that prior to the pandemic, there was a general reluctance to classify environmental health officers as frontline workers, thereby denying them additional financial benefits available to healthcare workers in Nigeria. However, the large volume of hazardous waste generated in facilities treating COVID-19 patients and the need for careful infection control measures has led to increased discussion about the importance of trained environmental officers in healthcare facilities.

The environmental officer added that COVID-19 patients in isolation facilities produce more waste compared to other patients. This is because unlike many other diseases being treated in Jos Teaching Hospital, COVID-19 patients are managed using full personal protective equipment (PPE) much of which is single-use. Therefore, COVID-19 patients generate significantly more waste.

In addition, it was gathered that when hospitals are busy with many patients, more waste is generated. Since COVID-19 began, particularly during the first lockdown, Jos Teaching Hospital experienced a high influx of patients. An environmental health official shared his experience:

"At a point we had no beds for additional patients. We do not usually generate a lot of waste during the Christmas period as people usually stay home due to festivities at that period of the year. However, last Christmas (December, 2020) was different; we were generating large quantities of waste as the hospital was full due to COVID-19."

The situation was similar in Anambra where officials pointed out that the COVID-19 pandemic placed significant pressure on healthcare facilities as more people were admitted as a result of COVID-19.

Furthermore, the large number of people tested for COVID-19 suggests a significant level of waste generation. For instance, data from the NCDC website (15 April 2021) showed that 1,838,174 samples had been tested. From the findings of the survey, it is clear that the testing process generates waste. For every sample collected, a pair of gloves is required to avoid cross-contamination. It therefore follows that, as of (15 April 2021) a minimum of 1,838,174 pairs of gloves, in addition to other PPE materials had been generated as waste during the diagnostic process alone. It is safe to assume that several million PPE items, used cartridges, paper and other materials have been generated since testing for the virus began in Nigeria.

Stages of Waste Generation During COVID-19 Infestation

This research revealed new insights and provided major contributions. First, it was revealed that during the life cycle of COVID-19 infection in humans, different types of waste is generated at different stages of the infection. The stages of waste generation during treatment and management of COVID-19 include:

Stage 1 - Asymptomatic waste generation phase
Stage 2 - Symptomatic/home treatment waste generation phase
Stage 3 - Diagnostics waste generation phase
Stage 4 - Hospital treatment waste generation phase.

The research revealed that the type of waste generated largely depends on the stage of infection and management of COVID-19.

Waste Generated during the Asymptomatic Stage

Environmental health officials at the hospitals visited and Ministry of Environment officials revealed that COVID-19 waste generation starts at home before patients arrive at the hospitals for diagnosis and treatment. From experience, some patients do not show symptoms of the disease, however, it is suspected that they may still transmit the infection to people around them either through contact or from the waste they produce.

The research found that almost all COVID-19 waste generated before patients get to the hospitals in the five states that participated in the survey make their way into the regular municipal waste stream. Environmental health officials stated that at the asymptomatic stage, waste generated are disposed of in regular bins at home before being transferred to communal storage points for collection by officials of ministry of environment, waste management agencies or their contractors. Hence, it is clear that a significant percentage of COVID-19 waste generated during the asymptomatic phase of the disease in the five states surveyed are managed as municipal waste. It is suspected that this is the same across the country.

It is therefore likely that stakeholders in the waste management industry and others such as scavengers, municipal waste collectors and children could come into contact with infected waste generated during this phase of COVID-19. Although information on waste generated during this stage of COVID-19 are lacking, the current research reveals that in Nigeria materials generated during this phase are mainly contaminated fomites, as shown in Table 1. However, it is important to note that not all materials retain droplets from infected persons. Nonetheless, most waste materials generated at this stage are regular household waste materials that may harbor the COVID-19 virus.

Symptomatic Home Treatment and Observation Stage of COVID-19 Waste Generation

Information obtained from interviews in Anambra, Lagos, Kano, Jos and Gombe shows that the next stage of COVID-19 waste generation is the symptomatic stage. At this stage of COVID-19 waste generation cycle, infected people begin to exhibit symptoms of coronavirus infection. However, they may not be confirmed cases. It was revealed by health officials that even when people begin to feel ill, they tend to remain at home for between 3 and 5 days before seeking medical help in healthcare facilities.

For instance, health official in Jos revealed that many patients only present themselves at hospitals after exhausting all other options. At this stage patients and their relatives may already suspect coronavirus. Nonetheless, they stay home for a few days taking malaria medications, natural herbs, multivitamins, inhaling vapor from hot herbs among other management methods. While some patients show signs of recovery after a few days, others do not, resulting in hospital visits.

Another category of symptomatic patients at home are those who insist on treating themselves at home rather than in isolation units or hospitals. Health officials stated that for both confirmed and suspected cases treating

themselves at home generate waste materials. However, unlike the first stage where most materials generated are regular waste that may host coronavirus, confirmed and unconfirmed symptomatic patients taking treatment at home generates a different type of waste materials. Materials generated at this stage bear semblance with those generated at healthcare facilities.

For instance, symptomatic but unconfirmed patients often take medications at home, hence, producing medical packaging waste. Their relatives, suspecting coronavirus infection also adopt preventive measures at home, thereby producing waste such as: single use PPE materials, sanitizer containers, in addition to fabrics that would normally have been washed for reuse at home. This results to higher waste generation compared to an average household.

For confirmed patients treating themselves at home, it was revealed that they generate waste similar to that produced in isolation wards as shown in Table 2. It was revealed that although private hospitals are discouraged by the Nigerian Government from admitting COVID-19 patients to ensure proper tracking and management, many confirmed home based patients still engage the services of private doctors alongside family carers. Consequently, more specialized waste is generated in these cases, including blood stained cotton wool (used to stop bleeding after injections), sharps and needles, bandages, cannulas, intravenous line and bags, surgical mask, face masks, gloves and sanitizers, among others.

It was reported that majority of the waste produced by both suspected and confirmed coronavirus patients in Lagos, Anambra, Jos, Gombe and Kano is disposed of in regular domestic bins. However, unlike waste generated in the first stage of infection, waste at this stage is more carefully packed by household members and healthcare providers assisting patients. Hence, it is common to find properly tied bags containing materials such as blood stained cotton wool and other used medical items in domestic waste bins.

Waste Generated from Laboratory Diagnosis

For patients in hospitals and other confirmed cases, waste is generated in two stages: during diagnosis and treatment stage.

During interactions with laboratories, it was observed that a significant amount of waste is generated during COVID-19 diagnosis. In addition to symptomatic patients, some individuals also present themselves for testing either due to contact with infected persons or general health concerns. When patients arrive for testing, health officials conduct interview before taking samples them. In most cases, samples are taken from nose and throat.

It was revealed that patients are attended to individually using gloves, with a new pair worn and discarded after each sample collection. This means that for every sample collected, a new set of gloves is used. After samples have been collected, they are transferred to a different section of the laboratory for processing using diagnostic machines. Table 3 presents the types of waste generated at this stage.

Waste Generated from Hospital Treatment Stage

During treatment phase of COVID-19, it was found that a large quantity of waste is generated from patients and healthcare personnel providing care. Patients receiving treatment produce general waste in an attempt to improve comfort for themselves while receiving treatment. Hence, they generate waste such as bags, food packaging materials and newspapers, among others. Those caring for them produce protective materials (PPE) such as gloves and mask. The treatment process also generates materials such as packaging materials for medications amongst others. Most items produced at this stage may include materials generated in stage 1, 2 and 3 of COVID-19 waste generation cycle.

Management of COVID-19 Waste

The COVID-19 pandemic has had profound effects on public health and the global economy, but one area that is yet to be studied extensively is the impact of the COVID-19 pandemic on the environment, particularly the

sudden increase in medical waste and how its management could affect the environment. However, this research shows that indeed the massive increase in the production and disposal of single-use personal protective equipment (PPE), testing kits, and other healthcare materials has led to significant environmental challenges.

The storage pattern for COVID-19 waste was found to be similar in most facilities visited. The most common storage method observed for COVID-19 waste in wards is to store the waste in biohazard bags.

In many states visited, it was observed that the most popular methods of management include:

- Open burning
- Burying
- Incineration

Open Burning

In some facilities, healthcare waste is collected from hospital wards and disposed of in makeshift brick-style burn barrels as shown in Figure 1. Waste placed in the burn barrels is burned to reduce its volume.

Figure 1 - Brick style burn barrel used for burning COVID-19 waste.

Residues are left for a period of time in the barrels after burning. In some cases, waste is taken away for disposal at municipal landfill sites. Large quantities of PPEs were said to be produced in the centres including disposable bed covers. This method of waste management does not ensure environmental protection as no technology is deployed to control air emissions.

Burial of Medical Waste

In some cases, waste generated was buried in a deep pit located within the healthcare facility. The pit was located away from the wards. COVID-19 waste in the pit was burned to reduce volume and then buried. In one of the facilities visited, the environmental health officer at the General Hospital expressed reservations about the practice of dumping infectious coronavirus waste in a pit. In some cases waste is taken away for disposal at municipal landfill sites where they are buried in makeshift landfills without prior treatment.

Figure 3 – COVID-19 Disposal Pit

Use of Incinerators

Some healthcare facilities utilize incinerator plants for treatment of medical waste before final disposal. While in some cases the incinerator facilities included an emission control strategy, in other instances they do not include this vital control.

In Gombe State, the facility uses waste bags to store COVID-19 waste in isolation wards from where the waste are evacuated to the incinerator room once or twice a day depending on need. In a bid to prevent operating the hospital incineration plant every few minutes, hazardous waste is stored properly in the incinerator room until they are enough to be loaded onto the incinerator plant. Once the appropriate volume of hazardous waste is generated, they are loaded onto the incinerator. The plant treats 25kg of waste within 15 minutes and consumes about 15 litres of diesel.

According to Gombe Teaching Hospital Head of Safe Burial who is also an environmental health officer in the hospital, the incineration plant was described as environmentally friendly with minimal soot emissions. The healthcare official added that before COVID-19, the hospital usually operated the machine a maximum of two times a week, however, since the outbreak of the virus, the hospital now operates the plant at least three times a week, suggesting that there are weeks when the plant is operated more than three times per week. This submission suggests that since the outbreak of the pandemic, Gombe State has been generating more hazardous waste.

Figure 1 – Incineration plant, Gombe

Implications for the Environment

These mode of management can have the following impacts on the environment.

Soil and Water Contamination

One of the most immediate environmental threats posed by the increase in medical waste is the contamination of soil and water resources. Medical waste, particularly when disposed of improperly, can contain hazardous materials such as pathogens, toxic chemicals, and heavy metals. These substances can leach into soil, contaminating agricultural land and reducing soil fertility. Contaminated soil can also impact plant growth and lead to the bioaccumulation of toxic substances in crops, thereby posing risks to human health.

Moreover, when medical waste is improperly disposed of in landfills or through illegal dumping, it can enter water bodies through runoff processes. This can result in the contamination of rivers, lakes, and groundwater, which are crucial for drinking water and agricultural irrigation. Polluted water can harm aquatic life, leading to a decline in biodiversity. Additionally, the presence of infectious materials in water bodies can pose a direct threat to public health, as pathogens may spread more easily through contaminated water.

Air Pollution from Incineration and Open Burning

As reported in this study, open burning of COVID-19 waste was widely practiced across the country. This method of waste management has severe implications for air, land and water environments. Open burning releases toxic pollutants that may cause respiratory difficulties, coughing, asthma, lung diseases among others.

The incineration of medical waste is a common disposal method, particularly for infectious waste that cannot be safely landfilled (WHO, 2018; National Research Council, 2000). However, this process can have severe environmental consequences if not properly managed. Incineration of medical waste can release harmful pollutants into the atmosphere, including dioxins, furans, and particulate matter. These pollutants are known for their toxicity and potential to cause long-term health effects, including respiratory problems, cancer, and endocrine disruption.

Air pollution from incineration not only affects human health but also contributes to broader environmental issues such as climate change. The release of greenhouse gases, such as carbon dioxide (CO2) and nitrous oxide (N2O), during incineration exacerbates global warming. Furthermore, the toxic emissions from incinerators can settle on soil and water surfaces, leading to secondary contamination of the environment.

Marine Pollution and Impact on Aquatic Life

Another significant implication of increased medical waste during the COVID-19 pandemic is the pollution of marine environments. Many PPE items, such as masks, gloves, and face shields, are made from non-biodegradable plastics. When these items are improperly disposed of, they can end up in oceans and other water bodies, contributing to the growing problem of marine plastic pollution.

Marine pollution has dire consequences for aquatic life. Marine animals, including fish, seabirds, and turtles, can mistake plastic waste for food, leading to ingestion, suffocation, and starvation. Additionally, plastics can act as vectors for invasive species and harmful pathogens, disrupting marine ecosystems. The degradation of plastic waste in the ocean also leads to the formation of microplastics, which can be ingested by a wide range of marine organisms, entering the food chain and potentially impacting human health.

CONCLUSION

The intention of the research is to examine the impacts of the COVID-19 pandemic on the environment. The study showed that the main environmental challenges that accompanied the pandemic was the increase in medical waste generation. The process of managing these waste was found to have adverse effects on air, water and soil quality.

The study showed that COVID-19 had a significant impact on infectious waste generation and management in all states visited. Data collected from the field revealed a sharp increase in waste generated across hospitals and municipal systems. Most waste management contractors confirmed the presence of healthcare waste in communal collection points. Similarly, all facilities managing COVID-19 patients that took part in the study reported a noticeable increase in the level of waste generation since the outbreak of the pandemic. The increase in waste generation was revealed to be from increase in the use of PPE, increased diagnostic activities as well as increased hospital admissions. Due to the infectious nature of COVID-19, more hospitals are adopting strict guidelines on the disposal of PPEs after single use. These strict guidelines have resulted in a sharp increase in waste burden.

In addition, the high rate of testing conducted during the pandemic saw several tons of materials such as gloves and testing kits enter into the waste stream.

The findings show a gap in waste management practices, as cases of indiscriminate dumping were reported alongside the discovery of healthcare waste in municipal collection points. These practices could lead to the spread of infectious diseases if not properly handled, in addition to potential to cause harm to the environment, ecosystems and general public health. This is because many facilities rely on burning and burying of waste due to lack of adequate infrastructure for managing healthcare waste.

The outbreak of the COVID-19 pandemic reveals several areas of weaknesses in healthcare waste management in Nigeria. Therefore, it is important to begin a system overhaul with proper policies and enforcement mechanisms in addition to adequate investment in modern waste treatment technologies. The poor disposal practices noticed should also be addressed through increased public awareness. These measures will increase the sustainability of healthcare waste management system in the country.

RECOMMENDATIONS

1. A major management flaw noticed is that hospitals in the states surveyed do not separate waste. Going forward arrangements should be put in place to ensure that medical waste is segregated at the point of generation in the hospitals.

2. Emphasis on restoration of health in the management of disease outbreaks must be reviewed to include every aspect of prevention, including limiting contact to infectious waste through appropriate collection, storage and disposal strategies.

3. Routine staff training on safe handling and collection of infectious waste should be conducted to mitigate spread of infectious diseases among healthcare workers.

4. In the absence of a separate collection system for hazardous waste generated at home, those managing infectious diseases outside healthcare facilities must be made to dispose of waste materials in special bags. Such bags should be properly labelled as infectious waste before disposal to communal storage facilities.

5. Agencies of government must embark on a massive campaign to inform scavengers about the introduction of special bags containing hazardous materials in municipal waste. This will likely dissuade them from opening infectious waste bags found at dumpsites.

6. Policies and guidance regarding the management of infectious waste should be well spelled out and members of staff of waste management companies must be abreast of the provisions of the law regarding handling and management of infectious waste.

7. Recruitment process for waste management contractors especially those providing services in healthcare facilities must be thorough to ensure that companies have the capacity and experience necessary to manage hospital waste.

8. Environmental health officers tasked with the responsibilities of managing hospital waste should be recognized as frontline workers to enable them to benefit from special allowances available to healthcare workers involved in the restoration of health. This will serve as motivation to this category of workers in healthcare institutions.

9. The burning of COVID-19 and other healthcare waste in hospitals and laboratories must be discouraged due to the adverse effect of such practices on human health and the environment.

10. As a matter of urgency, government should fund ministries and agencies responsible for health and environment by providing buses, drivers and logistics to enable them carry out their enforcement duties effectively as the absence of enforcement is fuelling sharp practices across the country.

11. Funding of waste management infrastructures in hospitals should be considered an important component of healthcare administration. As such, the local development of incineration plants with appropriate air pollution devices in place should be explored.

REFERENCES

1. Abah, S. O., & Ohimain, E. I. (2011). Healthcare waste management in Nigeria: A case study. Journal of Public Health Epidemiology, 3(3), 99-110.
2. Africa CDC. (2021). Coronavirus disease 2019 (COVID-19) weekly epidemiological update - 22 December 2020.
3. Alhassan, A., & Daniel, D. (2020). Apprehension in Abuja as pallbearer dumps COVID-19.
4. Amasuomo, E., & Baird, J. (2016). The concept of waste and waste management. Journal of Management and Sustainability, 6(4). Canadian Center of Science and Education.
5. Amzat, J., Aminu, K., Kolo, V. I., Akinyele, A. A., Ogundairo, J. A., & Danjibo, M. C. (2020). Coronavirus outbreak in Nigeria: Burden and socio-medical response during the first 100 days. International Journal of Infectious Diseases, 98, 218-224. https://doi.org/10.1016/j.ijid.2020.06.067
6. Calma, J. (2020). The COVID-19 pandemic is generating tons of medical waste. The Verge.
7. Chinenyenwa, O., Bakarey, A. S., & Ahmad, T. (2020). COVID-19 and Nigeria: Putting the realities in context. International Journal of Infectious Diseases, 95, 279-281. https://doi.org/10.1016/j.biopha.2020.110493
8. Dos Santos, W. G. (2020). Natural history of COVID-19 and current knowledge on treatment therapeutic options. Biomedicine & Pharmacotherapy. https://doi.org/10.1016/j.biopha.2020.110493
9. Manyele, S. V., & Mujuni, C. M. (2010). Current status of sharps waste management in lower-level health facilities in Tanzania. Tanzania Health Research Journal, 12, 257-264. http://dx.doi.org/10.4314/thrb.v12i4.53362
10. Mogaji, E. (2020). Impact of COVID-19 on transportation in Lagos, Nigeria. Transportation Research Interdisciplinary Perspectives, 6, 100154.
11. National Research Council. (2000). Waste incineration and public health. Washington, DC: The National Academies Press. https://doi.org/10.17226/5803
12. NCDC. (2020). COVID-19 situation report: Weekly epidemiological report 10: Epi week 51: 14th December – 20th December 2020. https://ncdc.gov.ng/diseases/sitreps/?cat=14&name=An%20update%20of%20COVID-19%20outbreak%20in%20Nigeria
13. Nwachukwu, N. C., Orji, F. A., & Ugbogu, O. C. (2013). Health care waste management – Public health benefits, and the need for effective environmental regulatory surveillance in the Federal Republic of Nigeria. IntechOpen.
14. Nzeadibe, T. C., & Ejike-Alieji, A. U. P. (2020). Solid waste management during COVID-19 pandemic: Policy gaps and prospects for inclusive waste governance in Nigeria. Local Environment, 25(7), 527-535. https://doi.org/10.1080/13549839.2020.1782357
15. Oli, et al. (2015). Healthcare waste management in selected government and private hospitals in Southeast Nigeria. Asian Pacific Journal of Tropical Biomedicine, 6(1), 84-89. http://dx.doi.org/10.1016/j.apjtb.2015.09.019

16. Oruonye, & Ahmed. (2020). COVID-19 and challenges of management of infectious medical waste in Nigeria: A case of Taraba State. Research, 10(3).
17. Oosterhoff, B., et al. (2020). Adolescents' motivations to engage in social distancing during the COVID-19 pandemic: Associations with mental and social health. Journal of Adolescent Health, 67(2), 179-185.
18. Oyekale, A. S., & Oyekale, T. O. (2017). Healthcare waste management practices and safety indicators in Nigeria. BMC Public Health, 17, 740. https://doi.org/10.1186/s12889-017-4794-6
19. Rodriguez-Morales, A. J. (2013). Current topics in public health. InTech.
20. Suleiman, A. A. (2021). Estimation of the case fatality rate of COVID-19 epidemiological data in Nigeria using statistical regression analysis. Biosafety and Health, 3(1), 4–7. https://doi.org/10.1016/j.bsheal.2020.09.003
21. World Health Organization. (2020). Coronavirus disease 2019 (COVID-19) situation report – 94.

Statement & Declaration:

This research was conducted between December 2020 and May 2021 after the initial spread of COVID-19 virus across Nigerian. This is an excerpt from a large consultancy report for UNDP.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

All authors contributed to the preparation of this study. Material preparation, data collection and analysis were jointly performed by all authors. The first draft of the manuscript was written by Ebikapade Amasuomo, Okoko James and Justina Ananga Adegba reviewed and contributed to all versions.

Human Ethics and Consent to Participate

The current research is survey based, nonetheless, it was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all individuals who participated in the survey.

Consent to Participate

The authors can confirm that informed consent was obtained from all participants included in the study.

Consent to Publish

All authors have reviewed and approved the final version of the manuscript and give their full consent for its publication

Data Availability Statement

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