

Biomedical Waste Management and Its Role in Containing Leprosy Transmission and Resistance: A Case Study from the Centre National Dermato-Lèpre (CNDL) of Niamey

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Abstract: *Despite advancements in multidrug therapy (MDT), leprosy transmission persists globally. This study investigates the role of biomedical waste management at the Centre National Dermato-lèpre (CNDL) in Niamey as a preventive measure against the transmission and resistance acquisition of *Mycobacterium leprae*. The evaluation covered waste handling practices across departments, examining waste classification, containment, decontamination and disposal. Results indicate adherence to basic safety protocols, though infrastructural gaps, particularly the absence of a secure pit for ash disposal remain a concern. The findings underscore the importance of systematic biomedical waste handling in minimizing environmental reservoirs and potential resistance traits in leprosy pathogens.*

Keywords: Biomedical waste, *Mycobacterium leprae*, leprosy transmission, antimicrobial resistance, hospital waste management

1. Introduction

The proper disposal of biomedical waste is an important process in the management of public health risks, the control of environmental pollution, and the acquisition and transmission of resistance traits to pathogenic microorganisms. This practice must be properly implemented, given its importance in reducing community exposure to bacteria that have become resistant to drugs [1].

The projection of aerosols during coughing, sneezing and speaking evacuates the bacilli into the environment, mixed with the products of blowing the nose and spitting [5]. This can lead to the infection of individuals via the respiratory route, as well as via the cutaneous route through entry points (wounds, scratching lesions). Indeed, in spite of the leprosy prevalence reduction in endemic regions due to MDT the new cases rate is still high [2]. This indicates that MDT alone may not suffice in halting leprosy transmission [3]. A crippling infectious disease, leprosy is one of the worst illnesses from which humans can suffer. The social stigma associated with leprosy further exacerbates the problem [11]. The transmission mechanisms of *Mycobacterium leprae* are not fully understood, and risk factors for the development of leprosy have been identified:

- Close contact with untreated or resistant multibacillary patients
- Human susceptibility genes [4]
- Soil-borne helminthic infestation [6]
- Food shortage

Numerous field studies carried out on soil samples taken from areas where leprosy patients live have demonstrated

the existence of viable *Mycobacterium leprae*. Its long survival in the environment may be a factor in the transmission of the disease.

The viability of *Mycobacterium leprae* in moist soil is 46 days [6]. In India, viability was studied in 25 soil samples by 16S ribosomal RNA gene analysis. These samples were taken from areas where leprosy patients live. All samples contained 16S ribosomal RNA, suggesting the presence of viable *Mycobacterium leprae* in the soil [8]. *Mycobacterium leprae* can also survive for up to 8 months in living amoebic cysts outside the environment, cultured in the laboratory and artificially infected [7]. The environment can play a major role in the transmission of *Mycobacterium leprae* and even in the acquisition of new resistance traits through biomedical waste that is not properly treated and disposed of. Biomedical waste management, which can be defined as waste collection (after production and storage), transport, recycling and disposal operations, including monitoring of disposal sites [9], must eliminate the danger of environmental pollution and the risks to public health.

Poor management of biomedical waste represents a real risk for the transmission and acquisition of bacterial drug resistance. This phenomenon is all the more worrying as biomedical waste is not always well managed in our health facilities, hence the need for proper biomedical waste disposal.

A good biomedical waste treatment system contributes to maintaining a healthy sanitary environment, avoiding public health risks, notably nosocomial infections, odor nuisance and the circulation of pharmaco-resistant bacteria. It must respect all the stages of its implementation. This evaluation is significant as it bridges the gap between

environmental hygiene and infectious disease control, particularly in low-resource settings where biomedical waste mismanagement may facilitate the persistence and evolution of drug-resistant *Mycobacterium leprae* strains.

This study aims to evaluate the biomedical waste management practices at the CNDL in Niamey, Niger, in relation to their effectiveness in minimizing the risk of leprosy transmission and the acquisition of antimicrobial resistance by *Mycobacterium leprae*.

2. Materials and Methods

The CNDL is located in Niamey's second municipal district. It comprises several departments, 4 of which generate waste are the laboratory, the injection room, the dressing room and the operating theatre. A waste management protocol is posted in the departments that generate waste. Some of the items used may or may not be recyclable, as summarized in the following table:

Table 1: Types of biomedical waste generated

Type of object	Sharps	Sharp objects	Products of dressing or surgery	Other
Not recyclable	- Needles - Lancets	- Scalpel blades - Punches	- Soiled cotton pads - Old bandages - Soiled compresses - Soiled gloves	- Used antibiotic vials - Used syringes - Stool and urine containers - Blood tubes - Blades, slides and cover glasses
Recyclable	-	- Scissors - Tweezers - Curettes - Other metal - Objects	-	-

Waste is stored in containers adapted to its type. Sorting begins with storage. The waste collection and processing equipment used by each department is shown in the following table:

Table 2: Type of collection equipment used by department

Departments	Laboratory	Dressing room	Injection rooms	Operating room (minor surgery)
Equipment for collection and treatment				
Safety box for piquant and sharp objects	Yes	Yes	Yes	Yes
Waste garbage cans with plastic	Yes	Yes	Yes	Yes
Chlorinated decontamination	Yes	Yes	Yes	Yes
Poupinel	Yes	-	-	Yes
Autoclave	-	-	-	Yes

NB: Poupinel and autoclave are used by all departments.

- Non-reusable and therefore non-recyclable sharps are stored in safety boxes.
- Gloves, used alcohol swabs and compresses from dressings or contaminated with blood are placed in a plastic bag in a waste garbage can.
- Used syringes and slides that have been freshly spread in the laboratory are decontaminated with a bleach solution before disposal.
- Blood, stool and urine samples are contained in a plastic bag placed in a pedal garbage can.
- Reusable and recyclable sharps are cleaned with foaming solutions, rinsed, dried and sterilized in a hot-water sterilizer.

Personnel handling and transporting waste wear personal protective equipment (thick gloves, boots, bibs, smocks, apron and goggles). Waste is autoclaved before disposal. Autoclaves are ideal for reusable materials and instruments, and for sterilizing disposable sharps prior to disposal. Contagious biological waste is also sterilized by autoclaving prior to disposal. The treated waste is then transported in wheelbarrows to the sites where it is disposed of on a daily basis. Some waste is treated by incineration. There are several types of incinerator, including single-chamber and double-chamber. The CNDL uses a single-chamber incinerator.



Figure 1: CNDL single-chamber incinerator

Source: Photo Ahamed Issoufou

The single-chamber incinerator operates at low temperatures (300 to 400°C), providing good disinfection efficiency, effective waste volume and weight reduction, and does not require the intervention of a highly qualified operator. However, this method has the disadvantage of emitting significant quantities of atmospheric pollutants. It is ineffective in destroying chemical substances or certain heat-resistant drugs, and does not destroy sharp waste [10]. Sharps are disposed of in the large refuse garbage can in a hermetically sealed box, if not in the secure pit. Empty bins are decontaminated with a 0.5% chlorine solution, cleaned with soapy water, rinsed and dried before re-use. So far, all the parameters that have enabled us to manage waste effectively have been respected.

However, there is no secure pit for the controlled burial of incineration ash and other treated waste, particularly that which is not destroyed by heat. They are stored in a large garbage can placed on the premises of the CNDL by the local council, which then arranges for their transport and disposal in controlled public landfill sites.

3. Results

Waste is collected and processed on a daily basis, with the exception of sharps, whose boxes are only disposed of once they have been filled and sealed. It should be noted that sharps are always decontaminated with chlorine solution or autoclaved before disposal. Some waste, such as cotton swabs, compresses and syringe packaging, is incinerated. The ashes produced, if not deposited in the secure pit which has not been rebuilt, are collected and disposed of in the large waste garbage can in a sealed plastic bag. Non-recyclable autoclave-sterilized waste, such as blood samples, also goes into the large garbage can in a well-sealed plastic bag. Recyclable items such as scissors, forceps and curettes are decontaminated, then cleaned and sterilized in the poupinel. The CNDL generates approximately 1.75 cubic meters of biomedical waste per week.

The absence of a secure pit represents a critical gap in the biomedical waste management system. Thanks to the large waste garbage can, this gap has been temporarily filled.

4. Discussion

Effective biomedical waste management can:

- Ensure the hygiene of the hospital environment, the safety of staff working there and of the surrounding communities
- Help control nosocomial infections
- Reduce community exposure to drug-resistant bacteria
- Greatly reduce the transmission of certain viral infections (HIV, hepatitis, septicemia) from contaminated needles (by avoiding reconditioning) and other poorly cleaned biomedical instruments
- Control zoonosis: infectious animal diseases transmitted to humans via insects, birds, rats and other animals
- Break infection cycles.

Despite the proven efficacy of MDT in eliminating leprosy in most countries of the world, its transmission has remained stable for over a decade [12]. Studies have demonstrated the presence and long survival of *Mycobacterium leprae* in the moist soil of areas where leprosy patients reside, and may constitute a risk factor for its transmission. All the factors involved in the transmission of *Mycobacterium leprae* are not yet fully understood.

Bottles containing antibiotic residues and waste from old dressings in contact with the soil can induce *Mycobacterium leprae* to acquire new resistance traits. Antibiotic resistance is now a real public health concern, throwing many treatment regimens into disarray.

The management of biomedical waste generated during care and diagnostic activities at the CNDL begins as soon as it is produced, and respects its storage and treatment, depending on its nature. Despite the absence of a secure burial pit for incineration ashes and decontaminated objects that cannot be destroyed by the incineration process (between 300 and 400°C), waste management is well managed. Waste is transferred to a large refuse bin and stored in controlled landfill sites for disposal.

However, it is essential to provide staff with sufficient training in the management of biomedical waste, in terms of sorting and sharps management. Waste handlers need to master collection and transport procedures, while ensuring personal protection measures.

Proper disposal of biomedical waste must be an unrestrictedly applied provision in healthcare institutions in order to guarantee a healthy environment and reduce risks to public health. The World Health Organization (WHO) indeed offers various tools for healthcare waste management evaluation such as the HealthCare Waste Management Rapid Assessment Tool (HCWM RAT), the Individualized Rapid Assessment Tool (I-RAT). These tools aim to prevent morbidity caused by poor biomedical management [13].

5. Conclusion

Proper biomedical waste management is essential for disrupting the transmission pathways of leprosy and limiting the development of drug resistance in *Mycobacterium leprae*. Despite infrastructural gaps such as the absence of a secure burial pit, the CNDL demonstrates a structured and conscientious approach to waste handling. Continued staff training and infrastructural enhancements will further strengthen public health safeguards.

6. Future Scope

A secure pit needs to be built to bury treated waste without risk to the environment, thus completing the chain of proper disposal. It is essential to provide staff with sufficient training in the management of biomedical waste.

Conflicts of interest

The authors declare no conflicts of interest.

Author contributions

Alzouma Mayaki Zoubeirou coordinated the final drafting of the manuscript. All authors participated in the proofreading and revision of the final version of this manuscript and gave their agreement for publication.

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