Determinants of the Choice of Biomedical Waste Management Methods in Tertiary Health Facilities in Ekiti State, Nigeria

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ABSTRACT

Improper treatment and disposal of biomedical waste are much more dangerous to the health status of the community and/or health facility than the disease itself. This study therefore assessed factors influencing the choice of biomedical waste management and treatment methods/equipment in use at the Ekiti State tertiary health facilities. The survey questionnaire was used to obtain data from health practitioners of different cadres in the wards and laboratories while the study employed a descriptive research design. Statistical evidence based on ninety-eight purposively selected respondents revealed that all tested factors were significant at 0.01 level as the infectious/hazardous nature of the waste, and cultural and social basis emerged as the most and least influencing factors with 0.831 and 0.597 relative importance indexes, respectively. The study concludes that tested factors inform the choice of biomedical waste handling equipment/methods employed. It is therefore recommended that efforts should not only be geared towards adequate consciousness of these factors by the waste handlers when determining the method to be used, but the government, leadership of healthcare facilities, and health practitioners should also ensure the availability of appropriate management and treatment technologies/methods to inhibit accidental outbreaks of epidemics in the community.

Keywords: Biomedical, Environmental, Epidemics, Waste.

1. INTRODUCTION

On a daily basis, different forms and quantities of biomedical waste are generated at all levels of healthcare facilities. This situation is very particular to tertiary medical facilities otherwise referred to as teaching hospitals where quantum of medical waste is generated from variegated kinds of medical functions performed on a daily basis. Consequently, environmental waste generation is generally set on the increase.

According to Dehghani et al. [1], biomedical wastes (BMW) consist of waste materials spawning from various health protection, medical treatments and diagnosis, and scientific research activities employed in the production or testing of biologicals. These forms of waste could be classified as municipal solid waste and special bio-medical waste [2]. In line with World Health Organisation (WHO), BMW is classified as general waste, pathological, radioactive, chemical, infectious to potentially infectious waste, sharps, pharmaceuticals, and pressurized containers [3].

It is quite paradoxical that health care ‘undertakings’ that are expected to protect general public health, cure patients and save lives have been identified as sources of precarious medical waste generation [4], [5]. This is inimical and detrimental not only to the immediate healthcare ecosystem but the public health at large. Nevertheless, these forms of waste are expected to be managed and/or treated using different techniques/methods by way of hampering probable health hazards emanating from it.

Furthermore, according to Mastorakis et al. [6], and Rutala et al. [7], biomedical waste management is a process that involve planning and procurement, staff training and behaviour, proper use of tools, machines, and pharmaceuticals, proper methods applied for segregation, reduction in volume, treatment, and disposal of biomedical waste.
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in order to ensure suitable and hygienic health institution. Failure to ensure the adequacy of this process in any healthcare facility could orchestrate endemic health hazards. However, certain steps are involved while managing the waste items which include generation; segregation, collection, and storage; handling and transportation; and treatment (as the case may be) and disposal [6], [8].

Moreover, BMW management and/or treatment including disposal are expected to be done using some techniques (methods) and/or equipment such as autoclave, incineration, microwave irradiation, chemical disinfection method, plasma pyrolysis [3], [9] among others. Since the nature of a particular BMW determines the treatment and disposal method to use, certain factor(s) tend to inform the choice of method and technique to be used to manage BMW items. According to Wahab and Adesanya [9], financial capability, technical know-how and type/size of the hospital were observed as the most significant factors influencing methods and facilities used to manage BMW generated in selected public hospitals. Whereas, logistics, institutional framework, and cultural/social basis were noted as least significant factors. This evidence is a pointer that BMW management and treatment methods/equipment are informed by certain intrinsic and/or extrinsic factors. That is, there is a likelihood that efficient BMW management and treatment could be hampered due to the absence or ineffectiveness of any of the methods or facilities. Thus, there is a need to examine the factor determining adequate BMW management and treatment in tertiary healthcare situated in the least populated and economically disadvantaged State in the South-western state part of Nigeria, i.e., Ekiti State.

Economic and environmental consequences of poor biomedical waste management have become concerns in developing countries lately [10], [11]. According to WHO, about 85% of hospital wastes are actually non-hazardous while 10% are infectious, and 5% are non-infectious but included in hazardous wastes [12]. This small proportion of BMW identified as infectious could be life threatening to the health status of the general public if not properly managed and/or treated before disposal. Also, in the event of rampant unguarded medical waste classification, coding, treatment, and disposal [9], [11] especially the use of subcontracting BMW disposal, there is a need to ensure that appropriate treatment and disposal method is channelled to certain medical waste items. Whereas, the use of appropriate method/equipment is contingent on certain influencing factors. These factors should be well noted by the healthcare facilities’ management board and the government so as to ensure adequate and timely supply or availability, operationalisation, and replacement of the methods/equipment. It is therefore the main objective of this study to investigate factors that determine the choice of biomedical waste management methods/equipment at the tertiary healthcare facilities located in Ekiti State based on the perception of the facilities’ health practitioners.

2. Literature Review

2.1. Conceptual Review

This subsection presents a review of the fundamental concept of concern as related to the course of this study.

2.2. Biomedical Waste Management Methods

There are several methods or equipment used to manage and treat medical waste items before they are eventually disposed-off. This becomes necessary because of the infectious and injurious nature of some of the wastes. Some of these methods or techniques involve the use of autoclave, hydroclave, microwave, chemical disinfection, sanitary and secured land filling, plasma pyrolysis, and incineration among others.

According to Jacquelyn [13], autoclave is used to perform sterilization in medical applications and to cure coatings, vulcanize rubber in the chemical industry. According to Ghasemi and Yusuff [14], ‘autoclave is the second most commonly used waste treatment method which is designed to sustain high pressures and heat with a scalable door and an arrangement of pipes and hatches, through which steam is introduced to and removed from the vessel’. It is a medical waste treatment method that involves steaming of the waste items in order to kill their pathogens and destroy probable potential infectious effects exhuming from microbial culture, sharp, etc. before inhumation [15]. Its benefits include low cost of operation, the method is easy to operate, environmentally friendly as it involves no hazardous emission etc. [16]. On the other hand, it is characterised by certain deficiencies such as foul odour, the need for a shredder to condense the waste size as well as the fact that it is not suitable for all types of waste unlike incinerator. This is an indication that there may be a need for the healthcare facility to evaluate forms of BMW generated, its hazardous nature, and various intrinsic potentials at its disposal before choosing any method to be employed in treating the waste.

Incineration is one of the BMW treatment/disposal methods that involve treatment of waste that cannot be reused, recycled or disposed-off in a landfill site by reducing organic and combustible waste to inorganic, incombustible matter leading to substantial reduction of waste volume and weight [17], [18]. As pointed out by Singh and Prakash [19], incineration is designed to treat medical waste using thermal decomposition through thermal oxidation at very high temperatures ranging between 900 °C and 1200 °C to destroy organic part of the waste. Its usefulness includes but is not limited to its ability to reduce huge varieties of waste to ashes and totally sterilise the waste. Nevertheless, its shortcomings are not only that it is expensive to construct, it also creates air quality emission problems, ashes residues contain heavy metal remains, and a major source of dioxin and furan emissions [18]. These suggest possible conditionality that could engender determination of the use of certain waste management technology or otherwise. However, Klansing and Harding [20] observed that this technique was no longer in use in Oregon and Washington due to stringent air pollution regulation, whereas, Manupati et al. [18] confirmed its most appropriateness for waste disposal during the latest global COVID-19 pandemic.
Also, chemical disinfection is another method of treating BMW. This is waste management/treatment process that involves adding certain chemicals to waste in order to kill or render pathogen around medical equipment and environ (floor and wall) inactive. According to Prüss et al. [17], this method is most suitable for treating solid and highly infectious waste such as microbiological cultures, sharps, etc., as well as liquid waste including stool, urine, blood, and hospital sewage among others.

Succinctly, it could be drawn from the above brief review of some of the BMW treatment methods or technologies that each of them has specific usefulness, uniqueness, advantages, and disadvantages. Intrinsic importance of each of them could be constricted by other exogenous factors which may exert influence on their availability for use and/or putting the available one to use. Some of these factors as examined by Wahab and Adesanya [9] and Ezeudu et al. [11] include waste characteristics, financial capability, infectious and hazard nature of the waste, technical know-how of manpower, type/size of the hospital, logistics, institutional framework, and cultural/social basis among others. In addition, the dearth of education, awareness, and trained personnel as well as the paucity of funds have been identified as key concerns to the proper management of BMW [12].

2.3. Factors Influencing the Choice of BMW Management Methods

According to International Atomic Energy Agency—IAEA [21], factors affecting the selection and implementation of waste management technologies could be classified as technical including waste characteristics, anticipation of future needs, volume reduction etc., and non-technical factors such as manpower and personnel competence, physical infrastructure, cost and resources, socio-political condition and so on. In line with the objective of this study, seven factors were identified and examined. These factors are technical know-how of the manpower, waste characteristics, type/size of the hospital, infectious nature of waste, maintenance or repair of the disposal method, number of beds/patient capacity, and cultural and social basis. The choice of these factors is also based on the research area and its peculiarity.

The availability of technical know-how of a certain level of manpower and competence in handling (operating and maintaining) certain waste treatment technology may inform its acquisition or being put in regular use. For instance, the level of competence can influence the choice of waste management technology that will be selected. As a case, in a small healthcare facility with limited waste generation activities, the availability of qualified manpower may be a difficult condition in the selection of a treatment technique [21]. In addition, waste characteristics could be a determinant of the technology that is made available for use. This situation is very peculiar to how waste is managed among levels of healthcare facilities as infectious nature of waste generated in any tertiary health facility would not be expected to be the same as that of primary healthcare centres. The same fundamental is applicable to other factors identified.

It is therefore the argument of this study that each of these influencing factors drives the choice of BMW treatment technology adopted differently. Hence, a need to investigate their possible role in this regard. However, the current study is different from Anbazu et al. [22] which focused on waste disposal methods among households in Ghana.

2.4. Empirical Review

Fundamentally, Wahab and Adesanya [9] conducted a study to determine quantities of medical waste generated in selected eight hospitals situated in Ibadan Metropolis, Nigeria using random sampling out of sixty-three private and public hospitals. The study documented that infectious waste has highest rate of waste generation while financial capability was noted as the most important factor that influences public and private hospitals in the choice of BMW treatment facilities and methods used with the highest relative importance index of 4.05 and 3.76. The study further recommended that there is a need to develop better policies that will engender improved BMW management practices. Nevertheless, the submission of the study is restricted by dearth of inference based statistical analysis.

Vassanadumrongdee and Kittipongvises [23] examine factors influencing source separation (for recycling) intention and willingness of 1076 residents to pay for improving waste management in Bangkok, Thailand by extending the theory of planned behaviour. The study employed survey questionnaire administered to 1100 respondents. It was documented that subjective norms and knowledge of the municipal solid waste situation were positively correlated with the residents’ source separation intention and willingness to pay with a rider that the residents have a preference for recycling programs. However, even though the study explored factors influencing source separation of municipal solid waste, it did not capture medical waste, thereby creating a lacunary for further investigation in the study area.

IAEA [21] review factors affecting selection and implementation of waste management technologies. The study identified technical and non-technical factors capable of influencing waste management facilities employed especially among the member state as well as waste management strategies and emerging technological options being developed and used by the member States.

Manyele and Lyaengesa [24] investigate factors affecting medical waste management in low-level health facilities in Tanzania. The research method includes the use of survey questionnaire, inspection visit, interview, and observation for data collection. The study documents that over average of the health facilities burn in poorly designed incinerators, surveyed disposal site are not fenced and in close proximity to settlements, and lack of standard operating procedure for incinerator usage in some quarters with a conclusion that there was poor medical waste management in the sampled facilities. Although the central aim of the study was achieved, it is obvious that a vacuity regarding factors influencing the choice of the method or technology use was created, necessitating the importance of this study.

practices, medical waste treatment and disposal practices as well as the operating status of hospital incinerators in the regions. Data were obtained using questionnaire to elicit responses from surveyed 225 hospitals with a 72.5% response rate. The finding of the study shows that infectious waste was not generally separated from other wastes, private haulers were mostly used to convey the waste to treatment facilities, while techniques used are municipal sewage, landfill, and autoclaving in the order of most used. It was also noted that incinerator was no longer operated in Washington and Oregon as a result of regulation on air pollution emission. Nevertheless, the study did not examine factors that could inform adequate use or otherwise of medical waste.

2.5. Theoretical Background and Hypothesis Development

2.5.1 Contingency Theory

This study was built on the theoretical ideology of contingency theory. The theory seeks to find a solution to a problem based on a contingent approach which could be informed by internal and/or external situations. As against one-standard-fit-all approach, contingency theory according to Olden [25] showcases that contingent factors influence effectiveness in a certain approach to managing resources. This theory has been employed in various discipline such as leadership in line with Verkerk [26], Pere-tomode [27], organisation design such as Donaldson [28], management accounting by Islam and Hu [29], and clinical IT investment by Lamminen et al. [30] among others. As an organisation theory that believes that there is no best way to organise, lead or make business decision order than prevailing situational factors, the theory is found relevant to the course of this study as it helped to uncover factors that drive the choice of BMW treatment method employed by the management of the tertiary health facilities investigated in this study. That is, availability and choice of usage of certain medical waste treatment technology in healthcare facility is postulated to be informed by what IAEA [21] regards as technical and non-technical factors. Consequently, the following statistical hypothesis was made.

H01: There is no significant effect of influencing factors on the choice of BMW management and treatment methods/equipment used.

3. DATA AND METHODS

The study adopted explorative research design and captured the only two tertiary healthcare facilities situated in Ekiti State. The State was located on latitude 7° 15’ to 8° 5’ North of the equator and between longitude 4° 45’ and 5° 45’ East of the Greenwich Meridian with about 6,353 km2. One of the two facilities is owned by the state government while the other is owned by the federal government.

The population of the study comprised all healthcare practitioners including the core medical and para-medical specialists who are disposed to medical waste generation, treatment, and disposal in their various units within the healthcare facility. A well-structured close-ended item-based survey questionnaire consistently with extant literature like Wahab and Adesanya [9] was used to elicit data from the targeted population. The data were categorical in nature using 4-item Likert scale ranging from strongly agree to strongly disagree on a scale of 4 to 1 in that order. This implies that the survey was cross-sectional in nature. Convenience sampling method was employed to obtain a sample of 98 healthcare workers from the population.

In order to ensure the content and face validity of the instrument, it was distributed to 6 purposively selected healthcare workers consisting of a doctor, nurse, CHEW, laboratory scientists, pharmacy, and sanitary worker in one of the facilities. This step helped to improve the content of the survey questionnaire. Reliability test was conducted on the seven items drawn as factors that could determine the choice of the medical waste treatment methods. The result of Cronbach Alpha Test as presented in Table I showed that the internal consistency of the items was above 0.7 which Pallant [31] considers acceptable.

Table 1: Reliability Statistics Results

<table>
<thead>
<tr>
<th>Factors influencing the choice of BMW methods/Techniques</th>
<th>Cronbach’s alpha</th>
<th>Cronbach’s alpha based on standardized items</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIS CRONBACH’S ALPHA</td>
<td>0.812</td>
<td>0.808</td>
</tr>
<tr>
<td>NO OF ITEMS</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1. Descriptive Analysis of the Respondents Demographic Information

The descriptive analysis commenced with demographic information about the respondents. Concerning specialisation of the respondents, 15.3% (i.e., 15) of the respondents were Doctors, 36.7% (36) and 12.3% (12) were Nurses and MLS in that order, 7.1% (7) and 10.2% (10) were Pharmacists and Community Health Extension Workers (CHEW) correspondingly, while 10.2% (10) were Health Assistants and 8.2% (8) Environmental Health Officers (EHO). Nurses recorded the highest response rate of 36.7%
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percent followed by the Doctors with 15.3%. Pharmacist has the lowest response rate of 7.8%. The result as indicated in Table II suggests that different forms of health professionals were reasonably well captured in this study both at high and low sensitive levels or cadre of the medical practices, involving people who are directly engaged in actual disposal of the waste (i.e., health assistant).

Table III presents descriptive statistics of the respondents’ work experience. In this regard, 34 of the respondents accounting for about 35% had between one to five years of experience at work while the highest number of the respondents (i.e., 35) representing 35.7% had between six to ten years of work experience. The study was able to capture respondents with above ten years of work experience indicating 14 respondents who have between 11 and 15 years, 10 having between 16 and 20 years of experience, and 5 respondents who had been in the healthcare practice for over 20 years. Slightly, a larger proportion of the respondents had less than ten years and this is not believed to hamper the goal of this study in any substantial way.

4.2. Analysis of Factors Influencing Choice of Methods/Equipment Used for BMW Management

In a bid to find out possible factors influencing the choice of methods used to treat medical waste, 7 questionnaire-item on four-item based Likert scale were employed. Results of both descriptive and semi-parametric analyses performed are shown in Tables IV–VI. RII was employed to unearth how each of the factors influences the choice of the method used based on the respondents’ submission.

As regards technical know-how of the healthcare manpower, about 49% and 33% strongly agreed and agreed respectively that the factor can influence the choice of method used while 12% and 7% disagree and strongly disagree in that order. This suggests that the majority of the respondents are of the opinion that this factor influences the choice of equipment employed to treat or manage medical waste by healthcare facilities in Ekiti State. A similar result was obtained on waste characteristics as an influencing factor as 42% and 37% of the respondents indicated strongly agree and agree positions correspondingly. On the other hand, about 13% and 9% of them disagreed and strongly disagreed with this assertion. Thus, this factor influences the choice of the method employed but is a little below manpower technical know-how.

The type and size of the facility were also identified as another influencing factor as approximately 74% of the respondents jointly indicated their strong agreement to this but by lower number of the respondents compared to their view about waste characteristics and technical know-how. The remaining 26% of them are of the opinion that the factor does not influence the choice of BMW treatment methods employed by the tertiary health facilities.

The respondents appear to be more in agreement with the infectious and hazard nature of the waste as the most influencing factor regarding the choice of the method used as about 87% of them indicated their strongly agree and agree support about the factor. 10% and 6% disagreed and strongly disagreed with it. Maintenance of the method or equipment employed by the health facility was also found as another influencing factor only that about 25% and 48% strongly agreed and were in agreement with this while about 27% of them jointly disagreed that this factor can influence the choice of equipment used.

The majority disagreed that bed/patient capacity and cultural/social bases are capable of influencing the choice of equipment used for medical waste treatment. Roughly 58% and 65% jointly disagreed and strongly disagreed with the two factors respectively.

Drawing from the descriptive analysis, it is apparent that the respondents believed that other than bed/patient capacity, and cultural and social bases, other factors are capable of influencing the choice of BMW management and treatment methods/equipment used by the sampled tertiary healthcare facilities. To uncover the relative importance of these factors, RII was employed consistently with prior studies like Wahab and Adesanya [9]. The findings are presented in Table V.

Relative importance index (RII) measures, strongly agree, agree, strongly disagree Likert scales stand for 4, 3, 2, 1 in that order using the following formula.

$$RII = \frac{\sum f_x}{\sum f} \times \frac{1}{k}$$

where $\sum f_x$—this is the total weight given to each attribute by the respondents, $\sum f$—this is the total number of respondents in the sample, $K$—this is the highest weight on the Likert scale here $k = 4$.

Based on the result of RII test presented in Table V, most significant factor that influences the choice of method or technology used for BMW management/treatment is "Infectious and hazardous nature of waste" having indicated...
RII value of 0.834 while manpower technical know-how with RII = 0.814 coming second and cultural and social basis (RII = 0.551) appeared as the least influencing factor. This finding is not in consonance with Wahab and Adesanya [9] who observed that financial capability is the significant factor influencing the method used at both private and public health facilities situated in Ibadan metropolis of Nigeria. However, since infectious and hazardous nature of the waste is obtained in this study as the most influencing factor, appropriate medical waste technologies to manage it is a necessity. Thus, all efforts should be geared towards prompt acquisition and adequate use of these methods/equipment as proactive measure against occurrence of avoidable health risk connected if left unaddressed.

4.3. Chi-Square Test of Factors Influencing the Choice of BMW Management Methods/Equipment

Analysis of frequencies using One-Way Contingency Method was conducted to unveil a statistical test of relationship regarding factors influencing the choice of methods and facilities used for BMW management and treatment in Ekiti State tertiary health facilities. The expected value for each row is equal to the sum of the observed frequencies divided by the number of rows in the table. In this survey, there were 98 observed responses, resulting in approximately 24.5 responses per opinion using 4-point Likert scale. Finally, the residual is equal to the observed frequency minus the expected value. The test summaries are presented in Table VI.

The null hypothesis (H0) that there is no significant effect of influencing factors on the choice of BMW management and treatment methods/equipment is rejected in all the tests conducted (p-value < 0.01 in each case), showing that all the above factors have a significant effect on the choice of methods employed to manage and treat BMW at the Ekiti State tertiary health facilities. Thus, the concerned health facilities’ leadership would be expected to adequately consider these factors by prioritising them when opting for methods/equipment to be used in managing various forms of BMW.

5. Conclusion

The essence of this study is to examine certain factors capable of influencing the choice of BMW treatment methods or technologies used by health facilities in Ekiti State, Nigeria. This study therefore found out that all the seven factors examined were statistically significant based on one way contingency chi-square statistic test performed. However, the respondents generally believe that cultural and social bases as well as bed/patient capacity could not strongly influence the choice of method/equipment used in handling BMW. RII tests further helped to identify that the infectious nature of the waste is the most influencing factor that drives the choice of method used followed by health workers technical know-how as culture and social bases come as the least possible factor. This study concludes in this regard that tested factors do not only significantly influence the choice of methods/equipment used for managing and treating BMW statistically but that some factors influence the choice than the others. Thus, there is a relationship between the choice of BMW management and
treatment methods/methods in use and their influencing factors which are mostly informed by infectious nature of the waste.

In the event of unprecedented epidemics that have become prevalent recently, based on the findings of this study, it is recommended that both governments, the owner of the facility, and health management boards should ensure the provision and effective use of modern equipment/methods that could be employed to manage and treat BMW wastes properly. This can also serve as one of the ways to pragmatically address rampant unprecedented disease outbreaks trending lately. It will also ensure safer medical facilities for the health workers, their immediate family members, and other innocent members of the public as well as hospital patients, etc.

**Conflict of Interest**

Authors declare that they do not have any conflict of interest.

**References**


