

The Economic Impact of Increasing Awareness on the Medical Waste Disposal in Egypt: *Challenges and Opportunities*¹

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ABSTRACT

Improving medical waste management has become a challenge for many governments in all countries around the world, especially after the spread of COVID – 19 which had it's negative impact on increasing medical waste generation.

The study revealed that in case of Egypt, reducing hazardous medical waste generation could reduce the direct costs that results from disposal of the medical waste from 1.5 Billion EGP to 735.85 million EGP per year. The study has shown that the key to effective management of healthcare waste (HCW) is segregation at point of generation, and increasing awareness of the good practices of healthcare waste management could have positive impact on reducing hazardous medical waste generation.

Keywords: *Medical waste- Short-lived climate pollutants (SLCPs) - Healthcare waste (HCW)- Healthcare waste management system (HCWM) - Personal protective equipment (PPE) - Incineration.*

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I. INTRODUCTION

Medical waste is one of the most important challenges that facing the whole world nowadays, especially after the spread of COVID-19 pandemic during the last three years.¹

Medical waste could be defined as healthcare waste generated during the testing, treatment, diagnosis, research or production of biological products for humans or animals. Medical waste might also be contaminated by blood, body fluids or other infectious materials generated at hospitals, laboratories and other healthcare facilities (World Health Organization, 2015).

On one hand, inappropriate waste management of healthcare waste can expose healthcare workers and medical staff to infection and injury, which leads to serious public health consequences and other related deaths, diseases and harmful effects. On the other hand, open burning and incineration of healthcare wastes may result in the emission of dioxins, furans, and particulate matter, which are considered among the main causes of global warming and air-pollution. In fact, between 75 and 90% of the total amount of waste generated by health-care activities is considered non-hazardous waste as mentioned before, and the remaining is considered hazardous material that may be infectious, toxic or radioactive (World Health Organization, 2015; UN Environment Programme, 2020).

Today, healthcare activities in Egypt generate a daily amount of about 294 tons of HHCW (Ministry of Environment, 2020). In fact, success in medical waste management is considered one of the main challenges that facing the government.

Many studies have confirmed that lack of awareness of proper ways of medical waste disposal among many of healthcare staff and healthcare workers is considered one of the main challenges that is facing the current system of medical waste management system, and that measures to ensure safe and environmentally appropriate management of healthcare wastes should be considered to decrease environmental pollution, and to help in preventing harmful health impacts which are resulted from inappropriate management of

¹ In this paper, the terms medical waste or healthcare waste, are used interchangeably.

these wastes. These measures involve segregation, transport, treatment and final disposal of waste.

In this respect, the present study reviews the prevailing literature about medical waste management; the types of medical waste, the impact of economic development on medical waste generation, the impact of medical waste generation on environment, and it then briefly shows some countries' experiences in this field, the study also presents the repercussions of Covid-19 on the medical waste disposal. Then, the study extends to the current advantages and challenges in medical waste management system in Egypt, and it analyzes the economic impact of increasing awareness on reducing costs of medical waste disposal. Finally, the study provides a package of policies that could help in improving medical waste management in Egypt.

1.1 RESEARCH PROBLEM

The current system of medical waste management in Egypt have many elements of strengths. On the other side, the system faces many challenges, one of the main challenges is the limited awareness of proper medical waste management among medical staff and healthcare workers that results in increasing costs of medical waste disposal. Therefore, the research problem will be: "What is the impact of increasing awareness on the costs of medical waste disposal in Egypt?"

1.2 RESEARCH HYPOTHESES

The study is based on essential hypothesis that increasing awareness of proper techniques of medical waste disposal can have a positive impact on improving medical waste management, and it can help in decreasing the costs of disposal of these wastes.

1.3 SIGNIFICANCE OF THE STUDY

Due to the limited literature currently available on the economic side of medical waste management, the current study fills vacancy of related research about medical waste management in Egypt. The study analyzes the importance of increasing awareness of proper techniques of medical waste disposal on the current system of medical waste management in Egypt, and it sheds light on the required policies that could be taken by the government to reduce the economic costs of medical waste disposal.

1.4 RESEARCH OBJECTIVES

The study aims to determine the impact of increasing awareness on reducing costs of medical waste disposal in Egypt. In this respect, the study discusses the experiences of India and Jordan in medical waste disposal to draw lessons from these experiences that could be applied in the case of Egypt. In addition, the study analyzes the current system of medical waste management in Egypt to determine the possible ways to improve this system in the light of the results of the study.

1.5 METHODOLOGY

The research is a qualitative study, adopts the descriptive and statistical analysis approach, using information from the literature review articles, government documents and official statistics which are relevant and closely related to the medical waste management in Egypt.

2. LITERATURE REVIEW

2.1 TYPES OF MEDICAL WASTE

Medical waste refers to all wastes produced in health-care activities or in diagnostic activities. It's is one of the main sources of pollutant which might cause health threats if not treated efficiently (International Committee of the Red Cross, 2011).

The major sources of health-care waste includes: hospitals and other health facilities, laboratories and research centers, mortuary and autopsy centers, animal research and testing laboratories, blood banks and collection services, nursing homes for the elderly. In addition, healthcare waste are usually classified into two main types, hazardous waste and non-hazardous waste (Ministry of Environment, 2020).

World health organization stated that about 85% of the total amount of waste generated by healthcare activities is considered non-hazardous waste, while the remaining 15% is considered hazardous material that may be infectious, toxic or radioactive (World Health Organization, 2018).

In general, hazardous healthcare waste (HHCW) can be generated from different types of healthcare activities, for instance, the treatment beds, surgical operations

rooms, dialysis sections, intensive care units (ICU), dental clinics, emergency departments, or laboratories, and many other activities.¹ In fact, the generation waste can vary between those different activities (Ministry of Environment, 2020).

The World Health Organization (WHO) classifies medical waste according to risks, the WHO classification includes the following five categories with their sub-groups (International Committee of the Red Cross, 2011). Category one: Sharps: waste may results in risk of injury - for example, disposable needles, syringes, blades, broken glasses. Category two: A) Waste may results in risk of contamination (for example, Waste containing blood, secretions). B) Anatomical waste includes, body parts, tissue entailing a risk of contamination. C) Infectious waste: includes waste containing large quantities of material, substances or cultures entailing the risk of propagating infectious agents (cultures of infectious agents, waste from infectious patients placed in isolation wards). Category three: A) Pharmaceuticals waste (for example, drugs and chemicals that are returned, spilled, expired or contaminated). B) Cytotoxic waste (for example, expired cytotoxic drugs, equipment contaminated with cytotoxic substances. C)Waste containing heavy metals (for example, substances with high heavy metal content: broken mercury thermometers, blood pressure gauges. D) Chemical: waste: resulting from diagnosis, or cleaning material (for example, leftover laboratory solvents, disinfectants, photographic developers and fixers. Category four: Pressurized containers: include gas cylinders, aerosol cans. Category five: Radioactive, includes waste contaminated with radioactive substances used in diagnosis and treatment of diseases (for example, in laboratories or nuclear medicine, urine or excreta of patients treated (International Committee of the Red Cross, 2011).

¹ In addition to the above mentioned HCW generated from hospitals, clinics, and healthcare units, there is also chemical waste generated in pharmaceutical factories can be classified as HHCW. In general, there is a need for an environmental review of the waste generated by these factories to classify waste and determine whether hazardous or non- hazardous. Also to determine the appropriate methods for its disposal (Ministry of Environment, 2020).

In general, infectious, pathological and sharps are the most dominant types of medical waste (Shareefdeen, 2012). In this respect, infectious waste is defined as waste that is might contain pathogens (for example, disease-causing bacteria, viruses, parasites, or fungi) in concentration or quantity that can cause disease in susceptible hosts (Un Environment Program, 2020).

It is worth nothing that if hazardous waste and non-hazardous waste are mixed together then the whole waste becomes harmful (Khedre et al., 2020). This fact explain the importance of segregation of medical wastes, which is considered one of the main important determinants in proper management of medical waste.

In addition, a study by International Committee of the Red Cross revealed that high percentage of hospital wastes (75 to 90%) are much like household waste or municipal waste, which means they do not contain any specific hazard. Whilst, the other 10% to 25% of hospital wastes is hazardous medical waste, and this type of waste entails health risks. (International Committee of the Red Cross, 2011). In fact, this percentage is considered by many studies as the main indicator of the percentage of hazardous waste and percentage of non- hazardous waste of the waste produced by healthcare facilities (Un Environment Program, 2020; Khedre et al., 2020).

2.2 IMPACT OF ECONOMIC FACTORS ON MEDICAL WASTE GENERATION

In general, the main principle in good medical waste disposal is based on the concept of 3Rs, which means, reduce, recycle, and reuse. More specifically reducing medical waste volumes requires reducing medical waste generation. There are many factors that affect medical waste generation, amongst these factors economic growth is the most one, in developing countries economic growth and health spending is highly correlated, in general economic growth is usually increases health expenditure, and this might results in improving access to modern medical services, and in and increasing in number of visits to doctors which means increasing in medical waste generation. In addition, there is a significant relationship between level of economic development of the country or the region and medical waste generation. Whilst medical waste volumes is increasing with the increasing economic growth - defined as GDP per capita - the rate at which it is increasing is not stable. The main reason for this is that

increasing growth rate usually accompanied by improvement in using medical technology which results in increasing medical waste generation - for example, transforming from using multi-purpose medical equipment into single-purpose medical equipment (Datta et al., 2018).

Besides economic growth, there are many factors that affect medical waste generation, for example, the size of the population and the degree of aging, government regulations, the number of beds in medical institutions and the number of medical institutions. Also, participating in environmental treaties have a positive effect on reducing medical waste generation (Ma et al., 2022).

In addition, the quantity of medical waste that a hospital may produce depends on the level of national income and also on the type of facility (International Committee of the Red Cross, 2011). Globally, an estimated 16 billion injections are administered yearly. In fact, not all needles and syringes are disposed of safely, which cause a risk of injury and infection and may be chances for reuse. Today, high-income countries generate around 0.5 kg of hazardous waste per hospital bed per day, while low-income countries generate only around 0.2 kg. In addition, in low-income countries medical waste is not separated into hazardous or non-hazardous wastes in most cases, which result in much higher quantities of hazardous (World Health Organization, 2015).

In general, reducing medical waste generation requires effective management of Healthcare waste (HCW) which mainly depends on segregation at point of generation, since that if hazardous waste and non-hazardous waste are mixed together then the whole waste becomes harmful as explained before (Khedre et al., 2020).

Furthermore, 3 out of 10 healthcare facilities worldwide are suffering of lacking systems to segregate waste. Also in many least developed countries, less than 1 in 3 healthcare facilities have a basic healthcare waste management service. In this respect, most of studies warned against the negative effects of the non-segregation of waste at the point of generation and the non-availability of color-coded bins were prevalent in all types of facilities. In addition, most studies have concluded that the knowledge of the healthcare workers was found to be satisfactory, that one of the most important problems that were listed was that

the lack of training and lack of availability of budget regarding the same (World Health Organization, 2022).

2.3 IMPACT OF MEDICAL WASTE GENERATION ON ENVIRONMENT

Healthcare sector is one of the main contributors to greenhouse gas emissions, healthcare sector is responsible for about 4–5% of total emissions globally. In fact, the ways of treatment and disposal of medical waste may result in health risks indirectly through the release of pathogens and toxic pollutants into the air. Also, the improper treatment of healthcare waste with chemical disinfectants may result in releasing chemical substances into the air. In addition, the disposal of healthcare wastes without treatment in landfills, especially if they were not well designed and built, can lead to pollution of all kinds of waters, for instance, drinking, surface, and ground waters (World Health Organization, 2022).

In this respect, incineration of waste is one of the challenging issues related to medical waste disposal, for instance, inappropriate incineration or the incineration of unsuitable materials like heavy metals, may result in the release of dangerous pollutants into the air. In addition, incinerated materials containing or treated with chlorine can generate dioxins and furans, which are human carcinogens (World Health Organization, 2015).

Ways to face these challenges include using modern incinerators operating at 850-1100 °C and fitted with special gas-cleaning equipment which are able to comply with the international emission standards for dioxins and furans. Also, If it is financially feasible, other ways of incineration such as, autoclaving, microwaving, steam treatment integrated with internal mixing could be effective. In general, due to the accelerating environment and climate crisis, there is growing attention that healthcare investments must consider environmental and climate implications (World Health Organization, 2018).

2.4 COUNTRIES EXPERIENCES IN MEDICAL WASTE DISPOSAL

The present part of the study sheds light on the experiences of India and Jordan in medical waste disposal management, the two countries were chosen because of the socio-economic similarity between Egypt and the two countries.

India: India was one of the first countries in the world that initiated measures for good management of medical waste disposal, and in 2016 Ministry of

Environment, Forest and Climate Change have modified and issued new rules for improving healthcare waste management. One of the main goals of these rules was to decrease environmental pollution through improving the segregation, transportation and disposal of medical waste. Datta et al. (2018) revealed that the most important steps in medical waste disposal is segregation of waste at source. In addition, India new rules were issued to organize the role of incinerators, as they considered as one of the main sources of air pollution. In fact, this problem results many years ago from considering incinerators the first solution for the medical waste disposal, but, after discovering the negative effects of burning waste; for example operation of incinerators produces incomplete combustion (PIC) and dioxins, the operation of shifting to alternative methods of medical waste disposal which are considered environmental friendly have been encouraged, especially that governments in many countries, for example Denmark and The Philippines have banned incinerators. It worth nothing that, up to date, there is no estimation for the level of dioxin in India (Datta et al., 2018).

Moreover Dixit et al. (2021) explained the importance of increasing awareness with the medical waste guidelines and explained the need of providing the appropriate mechanisms for the implementation of these techniques. Many issues were addressed; for example, awareness about segregation of waste, and about hazards and prevention of hazards. They also confirmed that all health facilities should maintain proper management for medical waste, regardless of it's size either it is large, medium or small and regardless of it's type whether it is governmental or private entity. Whilst India already have many rules to arrange medical waste disposal since more than one decade, yet many hospitals still lacking behind achieving the required standards (Dixit et al., 2021).

A study by Ranjan et al. (2016) assessed the awareness of medical waste management among dental students of Bhubaneswar in India. The study warned that wrong ways of medical waste disposal, for example incinerated or leave it untreated might lead to many health hazards like Hepatitis B and C, and many other dangerous hazards. Overall, the study concluded that there is lack of sufficient knowledge among dental students regarding management of biomedical waste and recycling or reusing of dental materials. Whilst, the knowledge of the healthcare workers was found to be satisfactory, the problems

listed were ignoring the issue in education programs in dental colleges, and lack of training among dentists and healthcare workers. It is worth nothing that the main challenge facing the government hospitals and small healthcare facilities is lack of financial resources (Ranjan et al., 2016).

In Jordan: a study conducted in King Abdullah University Hospital (KAUH) which is the largest hospital in north Jordan revealed that the main challenges facing waste management practices are poor collection services, improper disposal tetchiness, and lack for appropriate laws that organizes medical waste disposal in Jordan. The study warned that the increase in population complicated the problems. In addition, the study confirmed that the using improper techniques practices in segregation of medical waste is the main reason for increasing generation rate of waste in the hospital especially in specific departments, for instance, the general surgery and maternity departments.

The study concluded that segregation of hazards waste would reduce the cost of treatment of medical waste since segregation results in lowering the quantities of waste that require special treatment. Besides, using proper techniques in segregation of plastic bottles will reduce the cost of hazards waste treatment by 1.45 JD each day for such item. Moreover, the study confirmed that importance of raising awareness of the medical staff with the proper practices of medical waste disposal (Aukour, 2008).

3. REPERCUSSIONS OF COVID-19 PANDEMIC ON MEDICAL WASTE DISPOSAL

Spread of COVID-19 pandemic resulted in increasing burden of medical waste disposal due to increasing number of patients which resulted in increasing volume of medical waste. In addition, panic after the widespread of COVID-19 pandemic resulted in rising demand of personal protective equipment (PPE) and global efforts was directed to increase the availability of (PPE), but less efforts were directed to the apply proper practices in management healthcare waste which was highly increased due to the spread of COVID-19 especially in most of low- and middle-income countries, which in general lack for proper techniques in managing medical waste.

Moreover, many countries wrongly classified 100% of COVID-19 healthcare waste as hazardous, which complicated the problem of medical waste disposal, whilst the fact is that only 10–15% of waste should be classified as hazardous. In addition, during the spread of the pandemic many countries considered all waste generated by COVID-19 patients as infectious. Also, all these wastes were treated as infectious. The essential items include masks, gloves and non-essential items. According to WHO African region has received the largest share (47%) of these items (World Health Organization, 2018).

To sum up, main challenges facing medical waste managements are:

First, lack of adequate waste management and disposal systems, and insufficient financial resources especially in many of the developing countries, that some of these countries do not have suitable regulations to arrange medical waste management, and the others do not enforce these regulations.

Second, lack of awareness about medical waste management especially among healthcare workers, especially those who are responsible for these substances, and need to give more importance for training on the suitable techniques on medical waste disposal, especially in developing countries (World Health Organization, 2015).

4. CURRENT SITUATION OF MEDICAL WASTE MANAGEMENT IN EGYPT

The three previous sections explained that adopting good practices in healthcare waste management system can help in preventing negative health and environmental effects that result from improper treatment of such waste. In this section the study sheds light on the current situation of the healthcare management disposal in Egypt, and provides a package of policies that could help in facing the current challenges regarding this issue in Egypt.

4.1 LEGISLATIVE FRAMEWORK

Concerning the legislative framework that regulates the healthcare waste management (HCWM) system in Egypt, there are many laws and executive decisions in this respect, the most effective legislations on the system are:

- Environmental Protection Act No. 4 of 1994 and its amendment No. 9 of 2009, and its executive regulations issued by the Prime Minister's Decision No.

338 of 1995 and its amendments numbers 495 for 2001, 1741 for 2005, 1095 for 2011.

- Public Hygiene Law No. 38 of 1967, and the Executive Regulations issued by the Decision of the Minister of Housing and Utilities No. 134 of 1968,
- The liquid waste law act no. 93 of 1962, and the executive regulations issued by the decision of the minister of housing and utilities No. 649 of 1963 and No. 9 of 1989.
- The irrigation and protection of the Nile river and water resources act no. 48 of 1983, and the executive regulations issued by the decision of the minister of irrigation no. 8 of 1983.
- Labor Law No. 12 of 2003 and relevant ministerial decisions.
- Social Insurance Act No. 79 of 1975 and its amendments, and ministerial decisions related to ensuring the health of workers.

In addition, the Environmental Protection Act and its executive regulations is the most relevant law to the hazardous waste management system, including HHCW (Ministry of Environment, 2020).

4.2 THE CURRENT STATE OF THE HCWM SYSTEM IN EGYPT

According to the world bank reports, Egypt has succeeded in improving population health over the past few decades, but on the other hand, population growth and the rapid urbanization led to the growth of demand for more number of hospitals and private clinics and other healthcare facilities (World Health Organization, 2015).

In this context, according to Central Agency for Public Mobilization and Statistics (2019) there are 1782 registered hospitals, 652 in government sector, 1130 in private sector, and these registered hospitals have about 92,599 beds. The number of hospitals and the number of beds increased gradually during the period 2010- 2019 as shown in Figure (1) and figure (2) (Central Agency for Public Mobilization and Statistics, 2021).

In addition, number of treatment facilities in government sector and in private sector has also increased from 7403 in 2018 to 7344 in 2019.¹ Keeping these points in consideration, this continuous increase in the number of hospitals and other treatment facilities may in turn resulted in increasing in medical waste generation (MWG).

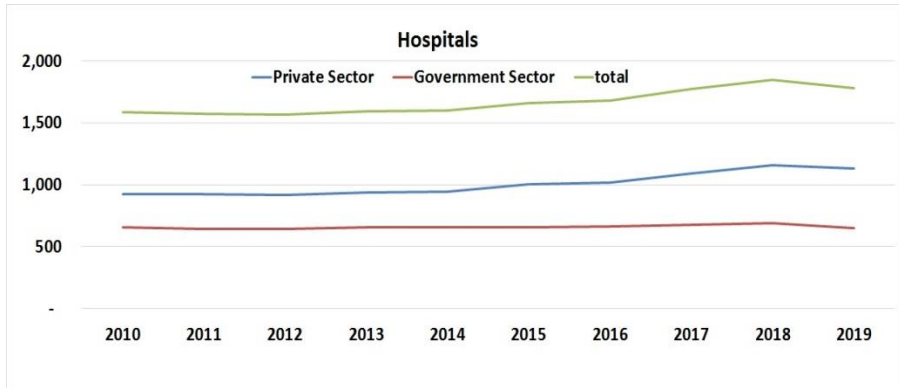


Figure 1: Number of Hospitals (Government Sector and Private Sector).

Source: Author, Based on Central Agency for Public Mobilization and Statistics. (2021).

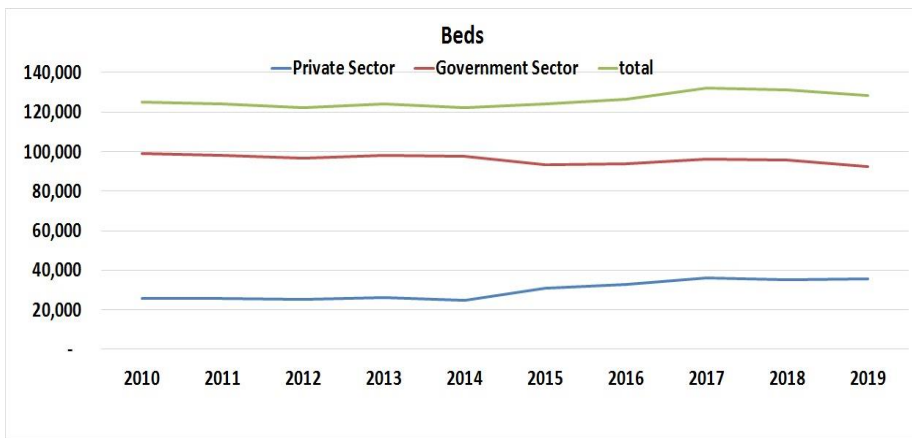


Figure 2: Number of Beds (Government Sector and Private Sector)

Source: Author, based on Central Agency for Public Mobilization and Statistics. (2021).

¹ Treatment facility is a facility that is providing therapeutic service and it has all the required facilities to help providing these services, for instance, beds, rooms... etc. It also include general, central and specialized hospitals, treatment facilities that do not have inpatient clinic, but private clinics of doctors is not included in private sector according to this definition (Central Agency for Public Mobilization and Statistics. 2021).

In this regard, according to estimations of Ministry of Environment, healthcare activities in Egypt generate a daily amount of about 294 tons of HHCW in the year 2017 (Ministry of Environment, 2020). Table (1) represents the estimation of hazardous waste quantities generated daily (Kg/day) from all healthcare activities in Egypt (2017). In fact, these estimations is the latest published figures about the volume of health care waste. It was not possible for the researcher to estimate the volumes during the period 2019-2022 since these years have witnessed the spread of COVID- 19, which resulted in increasing the volumes of medical waste, and increasing burden of medical waste disposal as explained in the previous part of the study.

Table 1: Estimation of Hazardous Waste Quantities Generated Daily (Kg/day) from all Healthcare Activities in Egypt (2017)

Facilities beds/ units & waste	Total estimated waste generated from all hospitals and units equipped with beds		Total estimated waste generated from all HCFs without beds		The total estimated waste generated from all registered HCF in Egypt	
	Beds	Waste	Unit	Waste	Beds and units	Waste
Total	130,766	155,521	168,085	138,239	298,851	293,760

Source: Ministry of Environment (2020).

According to Table (1) The percentage of total estimated hazardous waste generated from all hospitals and units equipped with beds to the total estimated waste generated from all registered HCF in Egypt is nearly 49,3% comparing with 40,6% generated from all HCFs without beds. Also, figure (3) represents the estimation of hazardous waste quantities generated daily (Kg/day) during healthcare activities in HCF with beds in Egypt, whilst figure (4) is the estimation of hazardous waste quantities generated daily (Kg/day) during healthcare service activities of HCFs without beds in Egypt (Ministry of

Environment, 2020). In fact, it seems that the difference between the two kinds of healthcare facilities (with/ without beds) in generating hazardous waste is not significant, therefore, all types of healthcare facilities (with/ without beds) should take the proper procedures to reduce the generation of hazardous waste, taking into consideration that population growth which results in increasing the number of healthcare facilities which is needed to face the rising demand on medical services would inevitably result in more generation of medical waste as stated earlier.

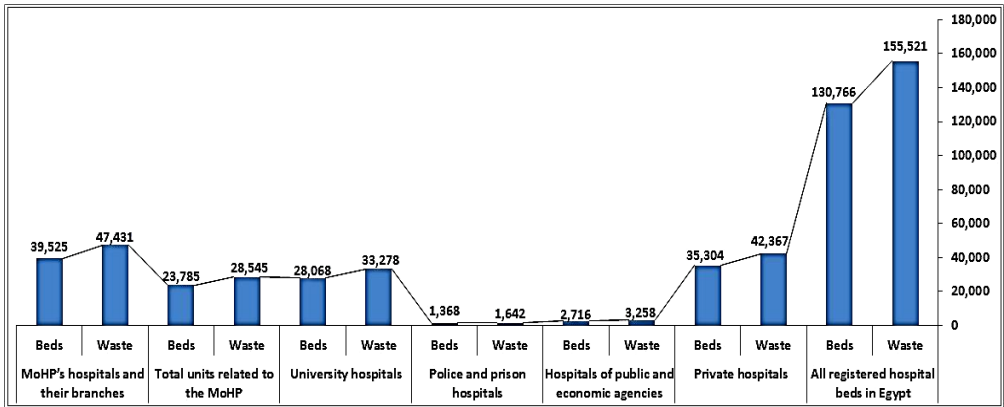


Figure 3: Estimation of Hazardous Waste Quantities Generated Daily (Kg/day) during healthcare activities in HCF with beds in Egypt

Source: Author, based on data from Ministry of Environment. (2020)

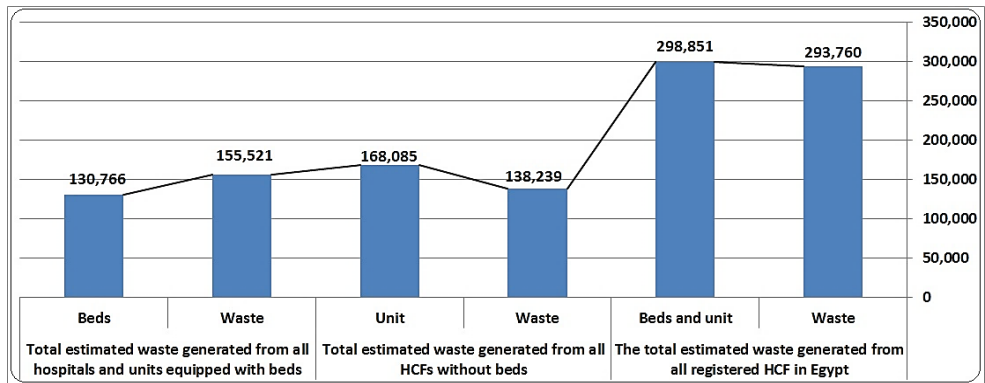


Figure 4: Estimation of Hazardous Waste Quantities Generated Daily (Kg/day) from all healthcare activities of HCFs without beds in Egypt

Source: Author, based on data from Ministry of Environment. healthcare waste management guidelines. Ministry of Environment. Unpublished report. (2020)

Furthermore, there are three categories for segregation of healthcare waste which are produced by healthcare facilities in Egypt which are: Black bags for general waste, red bags for infectious waste, and safe box for sharp waste, alarmingly, due to lack of awareness the separation of waste is not done efficiently; about 13%-40% of the general waste bags have hazardous waste, and 49%-67% of the infectious waste bags contains general waste in them. On the other hand, the percentages of hazardous waste generation to the total waste generated daily in the healthcare facilities were found between 51%-71%. This is a very high percentage, especially when compared to international averages and best practices values ranging between 10-25% only, as mentioned before (Elnagdy, 2020). Fortunately, the percentage of hazardous waste generation to the total waste generated daily in the healthcare facilities in most Egyptian governorates is not exceeding 51% in most cases. In fact, the high percentages that reaches to 71% was existed in the some rural areas and border regions (Elaraby, 2022). For instance, the estimated amount of the hazardous healthcare waste (HHCW) generated daily from all healthcare facilities ranges between 1.3 tons in the Wadi Al-Jadeed governorate to about 55 tons in Cairo governorate (Ministry of Environment, 2020). Figure (5) represents the average quantities of hazardous waste generated daily in HCF in each governorate in Egypt.

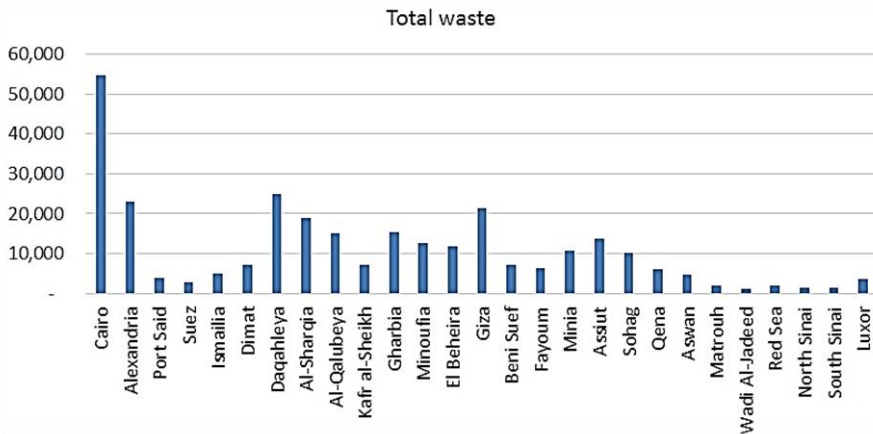


Figure 5: Average quantities of hazardous waste generated daily in HCF in each governorate in Egypt

Source: Author's estimation, based on data from Ministry of Environment. (2020).

4.3 CHALLENGES AND OPPORTUNITIES FACING HHCW TREATMENT IN EGYPT

- On the one hand, the main features of hazardous healthcare waste (HHCW) treatment in Egypt could be summarized as follows:
- There is already a legislative framework for the HCWM system as explained, despite it has to be developed to face many challenges which are considered as weakness points in the legislative framework, For instance, there is no reference to any economic incentives for the institutions that establish an appropriate healthcare waste management system, also there is no reference to the possibility of converting waste to use it in energy production.
- There is a ministerial decision on that determine the procedures of handling healthcare waste on the central levels and also on the level of the health departments of the provinces, that arrangements include providing a waste official. Also, there are departments that is specialized in infection control, quality and occupational in many of healthcare facilities. In fact, there are many challenging issues that facing this regulatory and institutional frame is the lack of qualified and well educated persons that can train medical staff and healthcare workers in hospitals and other healthcare facilities results in poor knowledge and weakness of awareness among healthcare professional and healthcare workers about proper ways of handling and treating with medical waste. In addition, insufficient financial resources that is directed to manage healthcare waste complicates these problems (Ministry of Environment, 2020; Elaraby, 2022).
- Interestingly, most studies confirmed that whilst there are lack of awareness among doctors and administrators of healthcare facilities about managing healthcare waste, there is some degree of awareness among nurses regarding healthcare waste management, despite that they don't receive enough education and training about HCWM . It is worth nothing that nurses is one of the most important factors that affect healthcare management system, that they are the link between all the parties of the system.
- The ministry of health and population contributes in the financing of safe handling activities for healthcare waste, but the finance is limited. Also, there is no contributions from other ministries and authorities, for instance,

ministry of environment and ministry of housing, and no contributions also from localities, which results in shortages in funding and financial resources directed to healthcare management activities.

- The financial regulation (265/2012 resolution) regulates the financial participation of healthcare facilities in healthcare waste system (Ministry of Environment, 2020).
- Now, Turning to the challenging issues related to medical waste management in Egypt, the main challenges that are facing the system are:
 - High percentages of hazardous waste generation to the total waste generated daily in the healthcare facilities which ranging between 51% -71% especially when compared to international averages that ranging between 10% -25%.
 - Improper separation of waste which is not done efficiently as explained before, complicates the problem.
 - Despite the disadvantages of using incineration (controlled burning) to the extent that many countries encourages shifting to another environmental friendly methods of medical waste disposal as stated earlier, but using incineration is still considered the most commonly used method for treating HHCW in Egypt. In general nearly all these incinerators are locally manufactured, most of them have primitive design and lacking full burning operation control and gas treatment mechanisms. Unfortunately, the imported incinerators is much more qualified, and even more cheaper than those locally manufactured. In fact, most of incinerators suffer from technical problems with varying degrees. Also, technicians responsible for the operation and maintenance are not qualified and/or lacking for good training. In addition the majority of incinerators are located near residential areas or in some cases inside them. Also, many incinerators operate nearly for most of the day, and some of them are suspended for many reasons, for instance, being under repair. It is worth nothing that the ash residues of the incinerated healthcare waste is a threat to the residents near the incinerators (Ministry of Environment, 2020; Elaraby, 2022).
- The total actual treatment capacity including all treatment technologies in Egypt is about 206 tons/day, whilst the treatment capacity in use is nearly 93.5

tons/day, which means that only 31.8% of all hazardous healthcare waste (HHCW) generated in all governorates is treated, and untreated HHCW using any of treatment mechanisms is estimated to be 200 tons/day on average. In fact, this is a high percentage (nearly 68%) of all daily hazardous health-care waste (Ministry of Environment, 2020). However, there are many factors that complicate this problem. For instance, untreated waste might be exposed to open burning which could be implemented randomly, or it might be reused or recycled with its dangerous contents. On the other side, 293,760 kg/day hazardous health-care waste is generated, of which 208,593 kg/day are exposed to open burning and the rest (85,167 kg/day) are treated. In fact, the high percentage of waste that is exposed to open burning to the total hazardous health-care waste (71%) bears many risks as stated earlier, especially for healthcare workers who have to deal directly with these waste, it also bears risks for environment inside and outside healthcare facility. In general, poor treatment of hazardous healthcare waste has many harmful effects not only on health but on environment due to pollution results from emission of harmful gases and other fumes (Ministry of Environment, 2020). Moreover, the rest 29% of total hazardous health-care waste is treated using shredding and sterilization devices, and health-care waste incinerators, and all the three ways of treatment suffer from technical problems with different degrees. In fact, this issue is considered one of the weakness points of the healthcare management system in Egypt (Elnagdy, 2020).

- In addition to the above mentioned difficulties related to the legislative, regulatory and institutional frame, and the difficulties that result from insufficient financial resource which are required to achieve proper system for healthcare waste management, one fact leaps out from the previous analysis, that the lack of awareness is considered the main challenge facing healthcare management in Egypt. In general, there is a limited awareness of the importance of hygiene and the necessity to maintain public health requirements within many healthcare facilities. Also, there is lack of proper degree of awareness between healthcare personnel including doctors, nurses, technicians, and workers who are responsible for the different processes of disposal of healthcare waste generated by healthcare activities in healthcare facilities. More specifically, awareness of the healthcare waste risks is extremely

limited among hospital administrations and doctors (Ministry of Environment, 2020).

- In this regard, there is a lack of awareness regarding health care waste segregation process, and a limited awareness among workers responsible for the collection, storage, transportation, and treatment HCW, especially in rural areas and border governorates, for instance, the red bags should not be placed in patients' rooms to prevent the mixing between hazardous waste with non-hazardous waste which could be disposed of by visitors of patients. In addition, there are illogical fears among infection control officials in hospitals, for example, the wastes resulting from liposuction can be buried directly without need to use the method of incineration or sterilization, but the officials insist on burning these wastes. Moreover, neither nursing staff nor any of the personnel receive any proper education or training regarding healthcare waste management (Elaraby, 2022).

In this respect, many studies have investigated the impact of increasing awareness on improving medical waste management in many developed countries, for instance, in India and in Jordan as indicated in previous part of this research. Also, many studies have confirmed that lack of awareness is the main challenge facing medical waste management in Egypt. Elnagdy (2020) conducted that lack of proper information, knowledge and training between healthcare staff results in wrong classification of non- hazardous waste as hazardous waste, which in turn results in high percentage of hazardous waste generation, which raises the cost of medical waste treatment, which is a financial burden for many healthcare facilities that might try to avoid bearing that high costs via many improper ways like open burning of their medical waste, which have many dangerous and harmful effects on the whole environment and society.

Abd El Raouf et al. (2020) confirmed that health education programs should give more importance to increasing awareness among healthcare related personnel, especially about sorting of hospital waste; they also found that the waste storage items were sufficient in most hospitals in Menoufia Governorate that were surveyed by the study.

Khedre et al. (2020) also verified that there was good knowledge among all health care workers in Qotour general hospital in Gharbia Governorate about waste

segregation and color-coded bags and also about medical waste storage and medical waste transport despite that workers have not even read the policies of waste management. The study recommended that increasing in-service training programs for health care workers.

Besides, the spread of the COVID-19 pandemic has also led to a high increase in the volume of medical waste such as personal protective equipment, as mentioned above. Spread of the COVID-19 pandemic had also led to a significant increase in the volume of waste of hospitals resulting from the use of plastic food plates and other plastic tools used in eating (spoons, forks, and knives) as an alternative to the plates and eating tools that are made of metal, which were considered as a source of infection, and therefore should be replaced with plastic tools as a precaution to avoid infection. In fact, using metal plates and tools in hospitals is considered safe; as they are cleaned using a good sterilization process which is usually excited inside hospitals, and at the same time using metal plates and other metal eating tools could help in reducing waste volume resulted from hospitals. However, raising awareness of hospital officials about the safety of using plates and other eating tools that are made of metals have succeeded in reducing hospitals' waste volume to a good extent recently (World Health Organization, 2022; Elaraby, 2022).

- To sum up, one of the main challenges that is facing the current system of medical waste disposal in Egypt is the lack of awareness among doctors and among healthcare facilities' administrations about the risks of healthcare waste and about the appropriate practices of healthcare management, despite there is a degree of awareness among nurses concerning these issues. This lack of awareness might be explained by ignoring teaching healthcare waste management in medical colleges and not giving enough care to training programs on these issues among doctors and administration' staff in hospitals and other healthcare facilities. In addition, there is a need for increasing awareness among healthcare workers, especially in rural areas and border governorates.

4.4 THE ECONOMIC BURDEN OF NON- SAFE MANAGEMENT FOR MEDICAL WASTE

Lack of appropriate awareness about healthcare management among doctors, healthcare facilities administrations, and healthcare workers is one of the main causes of non-safe management for the medical waste, which results in many negative effects, for instance, non-significant separation of medical waste, and to increasing in the volume of hazardous waste generation in all healthcare facilities. Also, increasing the percentages of hazardous waste generation to the total waste generated daily in the healthcare facilities comparing to the international levels as stated in previous sections. Keeping these facts into consideration, non- safe management for medical waste represents an economic burden. The present section provides an analysis for the economic burden of non-safe management for medical waste.

Currently, the cost of treatment and transportation per kilogram (kg) of medical waste is 20 Egyptian Pound for the private hospitals, while it costs only 8 Egyptian Pound for public hospitals. In fact, the difference between the costs that private hospitals bears and that the public hospitals bears is directed to compensate the low cost of the public hospitals. In addition, the fair price treatment and transportation per kilogram (kg) of medical waste should be 14 Egyptian Pound only (Elaraby, 2022). Table (2) shows the cost of transfer and treatment of hazardous waste generated currently from all registered healthcare facilities in Egypt 2020.

Therefore, the researcher estimates that medical waste treatment costs the Egyptian economy 4.1 Million EGP per day, and approximately 1.5 Billion EGP per year.

Table 2: Estimation The Cost of Transfer and Treatment of Hazardous Waste Generated Currently from all Registered HCF in Egypt (2020)

The total estimated hazardous waste generated currently from all registered HCF in Egypt (Kg/day)	The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Daily) Million EGP(1)	The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Yearly) Million EGP(2)
293,760	4.1	1500 Million EGP

(1), (2) Based on the assumption that the average cost of treatment and transportation per kilogram (kg) of medical waste is 14 EGP.

Source: Author's estimation, based on data from Ministry of Environment (2020) and data from Interview with Dr. Tarek Alaraby, Head of Waste Regulatory and Management Authority, on 8 October 2022.

Besides, the Egyptian economy also bears the economic burden of diseases that result from non-safe management for the medical waste, for instance, the diseases that result from the exposure to the risk of injury and/or infection during handling and disposal of medical waste. Also, the economy bears the burden results from straining healthcare facilities in treatment of those diseases that result from improper treatment of medical healthcare waste. Last but not least, the there are costs required to contain environmental impacts from medical waste which were previously explained. Notwithstanding, from the economic point of view some improvements could be achieved; that in the light of previous analysis the study explained that the percentage of hazardous waste generation to the total waste generated daily in the healthcare facilities in most Egyptian governorates is nearly 51% on average, which is considered a very high percentage, when compared to international averages that ranging between 10-25% as stated earlier, then it's recommended that more efforts should be directed to reduce this high percentage from 51% to at least 25% (which is the highest international percentage). Table (3) and Figure (5) show that success in reducing this high percentage to the targeted percentages will result in reducing the volume of hazardous waste generated currently from all registered HCF from 293,760 Kg/day, to nearly 144 Kg/day. In other words, reducing costs of treatment and

¹ More advanced research could be done on the indirect economic burden of the non- safe treatment for the medical waste.

transportation of the hazardous waste from 4.1 Million EGP daily, and approximately 1.5 Billion EGP per / year to 2.01 Million EGP daily, and 735.85 Million EGP per/ Year. In this respect, reducing the high percentage of hazardous waste will result in saving nearly 2.09 Million EGP daily and about 764.15 million EGP yearly for the economy, as explained in Table (4) and Figure (6).

Table 3: The Impact of Reducing Hazardous Waste on the Quantities Generated Daily of the Hazardous Waste from all Healthcare Activities in Egypt (Kg/day)

The total estimated hazardous waste generated currently from all registered HCF in Egypt (Kg/day) (Current)	The total estimated hazardous waste generated from all registered HCF in Egypt (Kg/day) (Targeted) (1)
293,760	144,000

(1) Based on the assumption of reducing the percentage of hazardous waste from 51% to at least 25%.

Source: Author's estimation, based on data from Ministry of Environment (2020) and data from Interview with Dr. Tarek Alaraby, Head of Waste Regulatory and Management Authority, on 8 October 2022.

Table 4: The Impact of Reducing Hazardous Waste on the Cost of Transfer and Treatment of Hazardous Waste from all Healthcare Activities in Egypt (Million / EGP)*

The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Daily) Million EGP	The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Daily/Targeted) Million EGP	The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Yearly) Million EGP	The cost of transfer and treatment of hazardous waste generated currently from all registered HCF (Yearly/Targeted) Million EGP
4.1	2.01	1500	735.85

* Based on the assumption of reducing the percentage of hazardous waste from 51% to at least 25%, and on the assumption that the average cost of treatment and transportation per kilogram (kg) of medical waste is 14 EGP.

Source: Author's estimation, based on data from Ministry of Environment (2020) and data from Interview with Dr. Tarek Alaraby, Head of Waste Regulatory and Management Authority, on 8 October 2022.

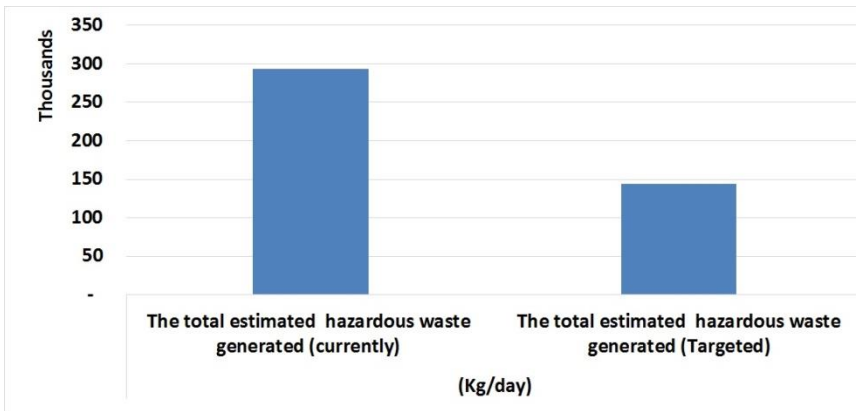


Figure 6: The Impact of Reducing Hazardous Waste on the Quantities Generated Daily of the Hazardous Waste from all Healthcare Activities in Egypt (Kg/day)

Source: Author's estimation, based on data from Ministry of Environment (2020) and data from Interview with Dr. Tarek Alaraby, Head of Waste Regulatory and Management Authority, on 8 October 2022.

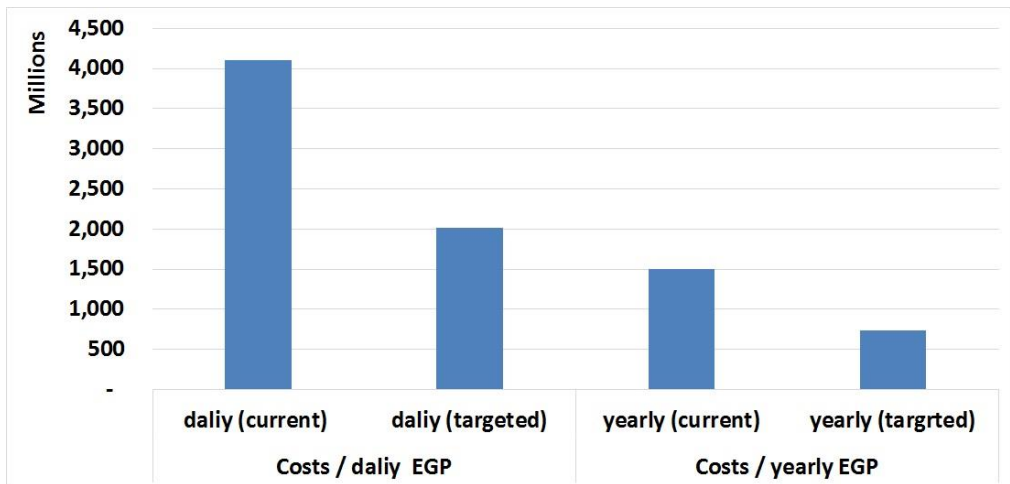


Figure 7: The Impact of Reducing Hazardous Waste on the Cost of Transfer and Treatment of Hazardous Waste from all Healthcare Activities in Egypt (Million / EGP)

Source: Author's estimation, based on data from Ministry of Environment (2020) and data from Interview with Dr. Tarek Alaraby, Head of Waste Regulatory and Management Authority, on 8 October 2022.

It is worth noting that these savings approaches nearly to 49% of the current costs of medical waste disposal, which could be directed to many activities that help improving the whole system of healthcare waste management, especially in increasing training and awareness of HCWM and its related issues.

In addition, If taking into consideration the advantages of decreasing the volume of these hazardous waste on the economic and on improving health and the other positive impacts on the environment we can improve the whole picture.

5. POLICY RECOMMENDATIONS

In the light of the previous analysis, the present section presents a package of polices that helps to improve medical waste management in Egypt:

5.1 SEGREGATION AT POINT OF GENERATION

The most important step in improving medical waste disposal and management is segregation at point of generation. One of the main challenges that face this process is lack of proper information, knowledge and training among healthcare workers hospital administrations, medical staff and healthcare workers. In this respect, increasing awareness and training among these categories will have a negative impact on medical waste generation.

5.2 INCREASING AWARENESS AND TRAINING

In order to decrease the generation of medical waste, the current study has confirmed the importance of increasing awareness of the proper practices of healthcare management among healthcare workers and healthcare staff. In this context, countries experiences that was explained in this study has revealed that increasing awareness could play a significant role in improving healthcare waste management. In India, wrong practices in segregation process is considered the main cause of increasing hazardous medical waste. In Jordan, it was proved that using proper techniques in segregation of plastic bottles will reduce the cost of hazards waste treatment, as was explained in previous part of the study.

In addition, there are many other procedures that could be undertaken to help decreasing the medical waste generation, for instance, improving legislative and regulatory framework and increasing financial resources which are directed to developing healthcare management system. In fact, most studies have focused on increasing awareness as a main factor that affect medical waste generation.

In general, increasing awareness among medical staff and healthcare workers of proper practices of medical waste separation, collection, transportation, storage, treatment, and final and safe disposal is already arranged via many training programs that world health organization has developed. Many specialized

training programs have been arranged during the past few years with the corporation between world health organization and ministry of health and population (Elnagdy, 2020; Elaraby, 2022).

In fact, increasing awareness was proven to be a good measure in reducing hospitals' waste volume after it had highly increased due to the spread using plastic food plates and other plastic tools used in eating after the spread of COVID - 19 during the last three as it stated earlier.

Moreover, as many studies confirmed that there is an increasing importance for developing education programs in medical collages to present more information and improve knowledge of medical waste disposal issues.

In general, increasing awareness and training among medical staff and healthcare workers of proper techniques of medical waste disposal will result in reducing costs of healthcare waste management, and many other positive impacts on public health and on environment.

5.3 USING ALTERNATIVES FOR MEDICAL WASTE INCINERATION

Lessons learned from countries experiences have shown that there are many safe and friendly environmental methods of treatment of hazardous healthcare wastes, instead of medical waste incineration which causes many harmful effects on public health and on environment. These ways include, autoclaving, microwaving, steam treatment integrated with internal mixing, and chemical treatment (World Health Organization, 2018).

5.4 INCREASING FINANCIAL RESOURCES

Improving healthcare waste management requires increasing financial resources to adopt proper technologies and apply friendly environmental methods in various steps of disposal of medical waste, starting from segregation, transport, and treatment of wastes and even in reuse of wastes.

5.5 CONCLUSION

Reducing percentages of hazardous waste generation to the total waste generated daily in the healthcare facilities in Egypt to meet the international percentages is a critical issue. Success in reducing hazardous waste generation from 51% to only 25% would result in reducing direct economic costs of medical waste disposal

from 1.5 Billion EGP to 735.85 million EGP per year. In addition to saving costs, there will be other indirect benefits that results from the safe management for healthcare wastes, for instance improving public health and other positive impacts on the environment.

The most important procedure that could be undertaken to achieve this goal is increasing awareness of proper practices of medical waste disposal among medical staff and healthcare workers. In this regard, developing education programs in medical colleges to give more importance to medical waste management issues would have a positive impact on improving the whole picture.

Last but not least, similar to previous studies, there are some limitations to the study. There is a need for more studies in future to determine the indirect costs of the improper management of medical waste, for instance the economic burden of diseases resulted from using wrong ways in medical waste management.

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الأثر الاقتصادي لزيادة التوعية على التخلص من النفايات الطبية في مصر: التحديات والفرص

د. داليا رضا حسن أبو العلا

ملخص البحث باللغة العربية

أصبحت الإدارة الجيدة للنفايات الطبية تمثل تحديًا رئيسيًا أمام العديد من الحكومات في جميع البلدان حول العالم، وهو الأمر الذي ازدادت أهميته في أعقاب انتشار فيروس كوفيد-19 الذي كان له العديد من الآثار السلبية على دول العالم ومنها زيادة كمية النفايات الطبية. وكشفت الدراسة أنه في حالة مصر فإن تقليل كمية النفايات الطبية الخطرة يمكن أن يقلل التكاليف المباشرة الناتجة عن التخلص من النفايات الطبية من 1.5 مليار جنيه إلى 735.85 مليون جنيه سنويًا. وأظهرت الدراسة أن المبدأ الأساسي في الإدارة الناجحة لنفايات الرعاية الصحية يتمثل فصل النفايات الخطرة عند المنبع. كما أظهرت الدراسة أن زيادة التوعية بالممارسات الجيدة لإدارة نفايات الرعاية الصحية يمكن أن يكون لها تأثير إيجابي في الحد من توليد النفايات الطبية الخطرة.

الكلمات الدالة: النفايات الطبية- ملوثات المناخ قصيرة العمر- نفايات الرعاية الصحية- نظام إدارة نفايات الرعاية الصحية- معدات الحماية الشخصية- المحارق.

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