

CASE STUDY

Healthcare waste characteristics and management in regional hospital and private clinic

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ABSTRACT

BACKGROUND AND OBJECTIVES: Good health and a safe environment are essential for sustainable development, including the appropriate management of healthcare wastes. The study intends to assess the generation rate and management methods of healthcare waste in the regional hospital center and a private clinic in Tangier, Morocco, with a focus on potential risks to health workers from infectious diseases.**METHODS:** The study collected data on healthcare waste generation over a period of two months by measuring and analyzing general and hazardous waste using an electronic scale. The data was presented as averages in kilograms per bed per day and as percentages. A questionnaire was provided to 100 healthcare workers. It included questions on their sociodemographic characteristics and their knowledge and attitudes regarding healthcare waste management.**FINDINGS:** The case study revealed that the healthcare waste production in the two institutions varied, with the private clinic producing 0.76 kilograms per day per bed and the regional hospital center producing 1.84 kilograms per day per bed. The survey also discovered that the hazardous fraction of waste generated in the regional hospital center was 40 percent, which was much higher than the World Health Organization's estimation. The daily amount of hazardous waste generated increased from 260.49 kilograms to 436.81 kilograms post-COVID-19. The survey found gaps in knowledge, attitudes, and daily challenges in waste management practices among the health workers in both facilities.**CONCLUSION:** The survey findings suggest that the healthcare waste management methods in Tangier are unsafe and may endanger the health workers and patients. The study found that the lack of monitoring and control contributed significantly to noncompliance with good practices. These findings can be used by the regional divisions of the Ministry of Health to develop specific protocols for managing sanitary emergencies and perform routine observation and training at all levels in the two facilities studied.DOI: [10.22035/gjesm.2023.04.10](https://doi.org/10.22035/gjesm.2023.04.10)This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

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INTRODUCTION

Healthcare activities are essential for global public health. The rising number of hospitals and medical facilities has increased the healthcare waste (HCW) generation (Gunawardana, 2018). The quantity of HCWs has increased in many nations due to the spread of the coronavirus disease (COVID-19) (WHO, 2022; Tamang et al., 2020). As a result, HCW generation in China (Wuhan) increased significantly from 40 tons to 240 tons per day (Ilyas et al., 2020). Prior to the pandemic, in India, waste production averaged 1.93 kilograms per bed per day (kg/bed/day). A profound increase in waste production (7.76 kg/bed/day) was recorded during the outbreak (Gowda et al., 2021). Turkey recorded an average waste production of 1.34 kg/bed/day in 2021, whereas it was 0.86 kg/bed/day in the pre-COVID-19 period (Hanedar et al., 2022). The volumes of HCW generation have increased during the past two years in Morocco (Khazraji et al., 2022). The national average estimated HCW increased from 1.5 to 3 kg/bed/day (Bouزيد et al., 2016). Decree No. 2-09-139 took effect on May 21, 2009, and acted for the laws governing the classification, collection, transportation, and disposal of HCW (El Morhit et al., 2021). HCW includes all the wastes generated by the hospitals, medical centers, clinics, and laboratories (Gunawardana, 2018). It is categorized into general or nonhazardous waste, such as household waste (Mugabi et al., 2018; Masum and Pal, 2020) which is generated by dietary, pharmacy, and administrative departments. The second category is hazardous waste, which includes infectious wastes, anatomical wastes, sharps, pharmaceutical, chemical, radioactive wastes, and many other physically harmful substances (Andeobu et al., 2022). The World Health Organization (WHO) estimates, 75%-85% general waste and 15%-25% hazardous waste are produced (Alwabr et al., 2016). Approximately 80% of the general waste is mixed with a hazardous component (Uloma et al., 2022), which amplifies the rate of waste generation and increases threats to the safety of health workers and patients (Al-Khatib et al., 2020 ; Araiza-Aguitar et al., 2020). Workers in contact with hazardous medical waste (HMW) are at the highest risk of acquiring human immunodeficiency virus (HIV), hepatitis B and C, and bacterial infections (Begum et al., 2021). According to the WHO reports, in developing countries, 21 million new cases of hepatitis B, 2 million new cases of hepatitis C, and 260.000 new

cases of HIV were caused by unsafe injections with sharps (contaminated syringes and needles), which represented 32% of all new hepatitis B infections, 40% of all new hepatitis C infections, and 5% of all new HIV infections (Pépin et al., 2014). Various other health problems, including genital deformities, hormone-related cancers, neurological disorders, asthma, and dermatitis, have been reported, which put healthcare workers, patients, and the public at risk (Javid and Manoj, 2019). Healthcare workers includes the primary handlers of HCW, and their role in appropriate waste management is crucial. Good practice depends on their level of expertise and attitude toward HCW management (Deress et al., 2019). Singh et al. (2022) showed that a significant amount of HCW generated in healthcare facilities in countries with transitional economies is inadequately handled. Only 45% of health workers were aware about appropriate HCW management. A recent study has shown that the private sector has difficulty implementing national and international protocols, with particularly negative responses from healthcare workers compared with the other sectors (Alzghoul et al., 2022). Previous investigations conducted in various healthcare facilities in Morocco have revealed that the health workers lack adequate knowledge about efficient procedures of waste handling and separation. Bajjou et al. (2019) highlighted the importance of establishing a biosafety policy and conducting training programs. Oussibrahim and Nadir (2020) demonstrated a significant deficiency in internal waste management systems, as well as gaps in regulatory knowledge among the staff. In their case survey, Mbarki et al. (2013) showed that the management practices in the hospitals selected did not adhere to the guidelines of the Moroccan Decree. An assessment of the current medical waste management systems is crucial for national policymakers to define specific protocols. The data regarding the volume of HCW production in the city are inadequate and require updating. The present study aimed to assess the quantity of medical waste and the effectiveness of the waste management system. The waste generation rate was investigated in two health institutions: the public regional hospital center (RHC) and a private clinic. Then, the knowledge, status, and practices of health workers in the HCW management were investigated. This study is expected to provide a different perspective

in developing a strategy for HCW management. The study was conducted in the RHC and a private clinic in Tangier, north of Morocco in 2022.

MATERIALS AND METHODS

Study location

The RHC is regarded as the city's most important public health institution, with a 250-bed capacity and several departments. It offers services to other provinces. The private clinic (44-bed capacity) provides pregnancy services and care for infants. Each location has been visited for two months to conduct interviews, observations, and discussions. In the studied institutions, HMW collection, transport, and treatment are provided by the accredited private company ATHISA.

Waste production rate

Obtaining precise information on the medical waste generation rate is critical to improve techniques for appropriate waste management. Bakiu and Durmishaj (2018) affirm that the common norm for weighing the amount of HCW is kg/bed/day. Waste collection and separation were performed by cleaning agents twice a day for four weeks to obtain the typical waste quantity. Wastes were separately disposed in a particular container, where the type of healthcare unit is identified. The containers were removed and measured on an electronic scale. In this study, no anatomical, radioactive, or chemical wastes were included. A descriptive analysis was conducted using computer software (Excel) for data summary and configuration into necessary graphs. The quantitative data are expressed as averages, kilogram per week (kg/week), kg per day (kg/day), kg/bed/day, and percentages. The HCW daily production (P) per bed was determined using Eq. 1 (Bouzid et al., 2016).

$$P = \frac{Q}{\frac{OR \times LC}{D}} \quad (1)$$

Where, the quantity of HCW (Q) is measured in kg; the occupancy rate (OR) is measured as %; the litter capacity (LC) represents the total number of beds in the facility; and (D) represents the number of days.

Socio-professional survey

An anonymous questionnaire was provided to 100

healthcare workers (depending on availability and willingness to participate), including doctors, nurses, and sanitation workers, via a hard copy and an electronic version of Google forms to evaluate their practices, behaviors, and knowledge regarding HCW management. The questionnaire was designed to evaluate the characteristics including in the following sections:

Section A: Included items on sociodemographic information: profession, age, sex, and years of experience.

Section B: Consisted of questions on HCW management based on many factors, such as understanding of legislation references, definition of the word "waste," risk assessment for healthcare professionals, and risk of disease transmission. The questions covered issues including waste management training, worker vaccination status, attitudes, and practices related to HCW labeling and color-coding, and challenges faced in efficient waste management.

RESULTS AND DISCUSSION

Production of healthcare waste

The quantity of waste generated were recorded using sheets made specifically for this purpose and expressed in kg/week, kg/bed/day scale, and % for total general and hazardous wastes (infectious, pathological waste, and sharps). Table 1 shows the quantity of HMW generated in various healthcare facilities of the RHC of Tangier.

In the first level, a high amount of HMW was found to be generated by patients in the critical care unit (3.40 kg/bed/day), followed by those in resuscitation room (3.12 kg/bed/day), hemodialysis (1.60 kg/bed/day), emergency service (1.12 kg/bed/day), and pediatric surgery (0.37 kg/bed/day). Intensive care and resuscitation room (reserved for critically ill patients) services compose the hospital interface; they can handle the most extreme situations, which require personal protective equipments (PPE), supplies, medical devices, and therapies that produce a sizeable amount of HMW. The emergency and hemodialysis services use a uniform infrastructure, enabling simultaneous management of several patients, thereby increasing the daily output of HMW, which mostly comprises dressing care products, plaster waste, and PPE. The HMW production rate (kg/bed/day) in different care units varied depending on

Table 1: Hazardous medical waste production in different units of the regional hospital

Healthcare unit	HMW (kg/week)	Active bed	HMW (kg/bed/day)
Emergency	102.24	13	1.12
Intensive care	190.15	8	3.40
Resuscitation	109.24	5	3.12
Woman surgery	91.74	24	0.55
Man surgery	82.80	29	0.41
Pediatric surgery	78.12	30	0.37
Hemodialysis	90.05	8	1.60
Maternity	168.89	50	0.48
Pediatric/Neonatology	105.90	33	0.45
Traumatology	91.19	26	0.50
Neurosurgery	85.12	24	0.51

Table 2: Total generation of general and hazardous waste per week and the ratio average (kg/bed/day)

Hospital	Week	General waste (kg/week)	HMW (kg/week)	Total waste (kg/day)	OR (%)	Ratio average (kg/bed/day)
Regional	Week 1	1960.00	1193.12	436.81	94.5	1.84
	Week 2	1890.23	1416.83			
	Week 3	2000.60	1290.20			
	Week 4	2050.98	1302.46			
Private	Week 1	153.00	10.74	18.60	55	0.76
	Week 2	110.65	17.15			
	Week 3	120.56	16.62			
	Week 4	106.13	23.22			

activities, specificity of services, and LC. The large LC at the level of the services reduces the importance of the quantity of HCW. The quantity of HMW generated as a result of the maternity service was the largest of all units, at approximately 170 kg/week. The quantity suggests merely 0.48 kg/bed/day with an overall 50-bed capacity. The amount collected remains within the national average regarding the care and treatment activity performed in these services.

Table 2 shows that the average quantity of HCW generated at the RHC was 1.84 kg/bed/day with a high litter OR at 94.5%. The RHC of Tetouan City (Morocco) recorded an average waste generation rate of 3.82 kg/bed/day; the hospital has a higher LC (330 beds) with litter OR at 66% (Raoui *et al.*, 2018). During the COVID-19 pandemic, the average waste generation rate at the King Abdullah University Hospital in Jordan is 3.95 kg/bed/day in terms of 100 active beds (Abu-Qdais *et al.*, 2020). The total amount of HCW and HMW (kg/day) generated have doubled as compared with those before the pandemic. The amount of HCW has increased from 260.49 kg/day to 436.81 kg/day, whereas the hazardous fraction has increased from

78.14 kg/day to 173.42 kg/day in the RHC (Ouzekhti Yettefti *et al.*, 2019). The outcomes of the present study are analogous to the previous findings by Khazraji *et al.* (2022) made at the Provincial Hospital Center Moulay Abdellah in Sale, Morocco; the daily production increased from 266 kg to 433 kg in the post-pandemic period. The widespread use of PPE as a preventive measure against the second wave of the COVID-19 pandemic and the provisional inclusion of surgical intervention units in the RHC have increased the workload for the new staff of the University Center Hospital (UCH), including resident and intern physicians, faculty members, and nurses. Morocco's public health facilities are currently working at capacity. The total waste collected was 18.53 kg/day in the private clinic, and the average rate was 0.76 kg/bed/day with 55% of litter OR. Oduro-Kwarteng *et al.* (2021) found that the average waste produced in a private hospital specializing in gynecology in Ghana was 1.34 kg/bed/day. The average rate less than that was found by Rani and Rampal (2019) in the gynecology and obstetrics hospital department with an average of 0.31 kg/bed/day.

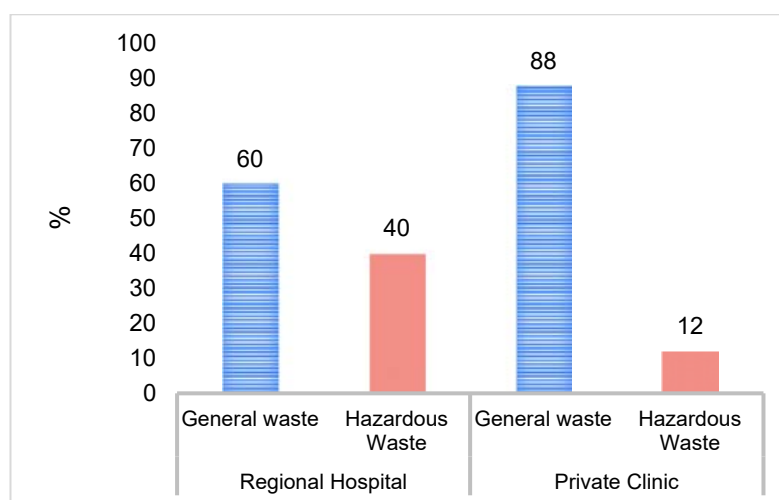


Fig. 1: Distribution of general and hazardous medical waste

Fig. 1 demonstrates that the general waste quantity collected daily for a month is more than the HMW amount collected for the same time in the two institutions. At the RHC, 60.30% of the waste was general, and 39.70% was hazardous. Al-Khatib *et al.* (2019) found that the HMW was in the range of 42%–55%. The RHC generates greater amounts of HMW than the private clinic. It might be primarily explained by several variables, including LC (Zamparas *et al.*, 2019), bed OR, instrumentation level, and healthcare category (Al-Momani *et al.*, 2019). In the private clinic, 88.11% of the waste was general, and only 11.82% was hazardous; these results were consistent with the WHO estimation (WHO, 2014).

Socio-professional survey

The purpose of conducting a socio-professional survey was to better understand the participants' backgrounds and experiences. This information can be used for decision-making and identifying areas of improvement.

Demographic characteristics of participants

The study included 100 participants from various departments of the two hospitals, and were categorized depending on their occupation, age, sex, and seniority of position (Table 3).

In the present study, most participants were nurses

(49.60%), and the nursing staff frequently come into contact with medical waste. A total of 37.50% of the participants aged less than 30 years, 35.40% aged 30–39 years, and 25.40% aged 40–49 years, whereas only 3.40% of them were older than 50 years. Approximately 65.10% of the participants were females, and 34.90% were males. More than half (53.30%) of the participants from the RHC had between five and 14 years of work experience, 28.30% had more than a year of work experience, and 6.70% of them had less than a year in their position. Whereas 53.80% of the private clinic participants had seniority between one and four years, 20.60% between five and 14 years, and 20.50% less than a year.

Knowledge of HCW management

Table 4 assesses the knowledge of the participants regarding HCW management – legislative references, risk assessment, definition of “waste,” and risk of disease transmission – to determine their needs and offer them training and courses to fulfill those needs.

Knowledge of legislative references

Among the 100 participants, 70 from both institutions lacked knowledge regarding national regulations, whereas only 29 participants were familiar with the regulations, including law 28_00 addressing the HCW administration.

Table 3: Demographic characteristics of participants

Characteristics		Regional hospital (sum= 60) Staff (%)	Private clinic (sum=40) Staff (%)
Profession	Doctors	18.30	17.50
	Nurses	46.70	52.50
	Nursing major	11.70	7.50
	Caregiver	13.30	10
	Sanitation staff	6.70	12.50
Age	<30	15	60
	30-39	58.30	12.50
	40-49	23.30	27.50
	>50	3.40	-
Sex	Male	44.80	25
	Female	55.20	75
Seniority of position	Less than year	6.70	20.50
	Between one and four years	28.30	53.80
	Between five and nine years	25	10.30
	Between 10-14 years	28.30	10.30
	More than 15 years	11.70	5.10

Table 4: Knowledge of healthcare workers regarding HCW management

Variables	Frequency % (N)		Total
	Public	Private	
Knowledge of legislative references			
Yes	45% (24)	12.8% (5)	29
No	60% (36)	87.2% (34)	70
Significance of the word "Waste"			
Dirt	61.7% (37)	69.2% (27)	64
Unusable residue	66.7% (40)	46.1% (18)	58
Worthless/Valueless objects	55% (33)	30.8% (12)	45
Disposable items	76.7% (46)	79.5% (31)	77
Risk assessment for the health workers			
Biological	95% (57)	50% (20)	77
Radioactive	61.7% (37)	22.5% (9)	46
Chemical	86.7% (52)	37.5% (15)	67
Psychological stress	50% (30)	52.5% (21)	51
Infectious disease risk	96.7% (58)	92.5% (37)	95
Risk of disease transmission			
Hepatitis B	95% (57)	66.7% (26)	83
Hepatitis C	85% (51)	51.3% (20)	71
HIV	50% (30)	89.7% (35)	65
Others	1.7% (1)	23.2% (9)	10

Definition of "Waste"

According to the findings, 77 participants from both institutions viewed medical waste as something that can be eliminated, 64 considered it as dirt, 58 viewed it as residue and useless, and 45 perceived it as worthless.

Risk assessment of health workers

In general, 94.6% of the participants recognized

the risk of infectious diseases, 72.5% were aware of biological risks, 51.25% acknowledged the psycho-emotional problems associated with medical waste contamination, and only 42.1% were cognizant of the radioactive risks.

Risk of disease transmission

In both hospitals, the participants' knowledge of different types of disease transmission revealed

that the awareness level of HIV and hepatitis C and B is above 50%. The transmission of other infections (COVID-19, tuberculosis, and tetanus) is at 23.2% for the private clinic and 1.7% for the RHC staff.

Status, attitudes, and practices of the HCW management

HCW management is a critical component for ensuring patient safety and preventing the spread of infectious diseases in healthcare settings. The status, attitudes, and practices of health workers in HCW management affect patient outcomes and the overall quality of the care provided. Understanding these factors can help healthcare organizations identify areas of improvement and implement effective strategies for HCW management.

Status of healthcare worker vaccination

The status of vaccination of health workers is the key indicator of the overall health and safety of the workplace. Most private clinic participants (77.50%) were unvaccinated against hepatitis B, C virus, and tetanus. Whereas 71.20% of RHC participants stated they had received all recommended doses of hepatitis B and C and tetanus vaccines. By contrast, 28.80% of the participants were unvaccinated (Fig. 2). Approximately 60% of total participants reported cases of blood exposure accidents. This estimate was higher than that reported by a study conducted in Ethiopia, where the exposure prevalence was 46.5% (Semere *et al.*, 2021). Previous investigations showed

that the main blood-borne infection to which the health workers were exposed was hepatitis B (Deuffic-Burban *et al.*, 2011; Yuanyi *et al.*, 2022). Complete vaccination of the workers of the studied institutions is necessary to prevent infections (Maltezou *et al.*, 2019).

Status of the training of the healthcare workers

As depicted in Fig. 3, 74.40% of the private clinic staff had never benefited from any training on medical waste management; it could be attributed to most of the clinic staff having a maximum of four years of work experience. On the contrary, 46.70% of the RHC healthcare workers had already received training on medical waste practices.

Attitude and practices on HCW labeling and color-coding

The attitude toward the color coding of various waste categories was determined to demonstrate that the medical staff can adequately separate HCW in the hospital (Letho *et al.*, 2021).

The medical staff from the private clinic displayed a positive attitude toward color-coding (Fig. 4). The percentages of correct responses about the use of yellow bins and various colored plastic bags were 52.40%, 82.20%, and 60.40% (Fig. 4). A survey found that 69.1% of healthcare workers accurately categorized waste into color-coded containers (Jalal *et al.*, 2021). By contrast, 35.10% of the RHC staff responded that sharp waste was disposed into yellow bins, 31% knew that red

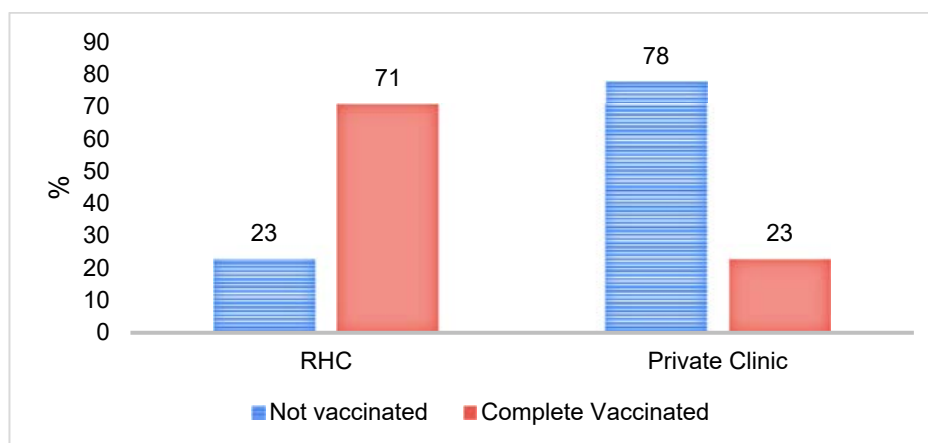


Fig. 2: Status of health workers' vaccination in the regional hospital and the private clinic

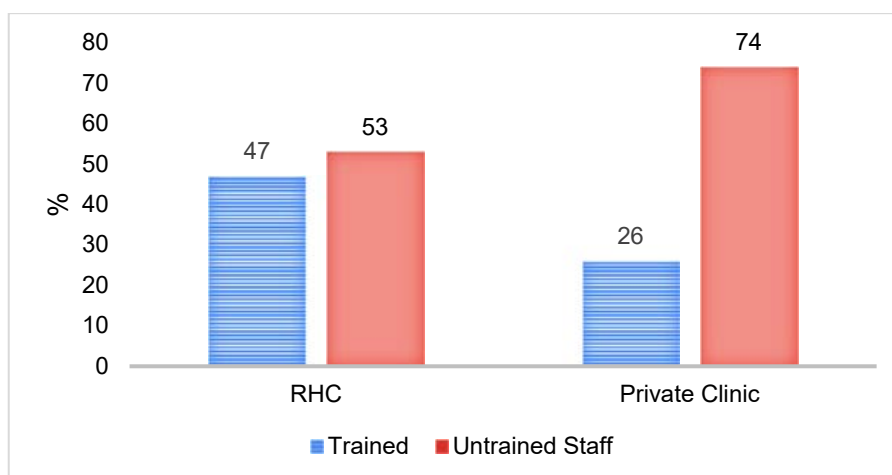


Fig. 3: Status of health workers' training in the regional hospital and the private clinic

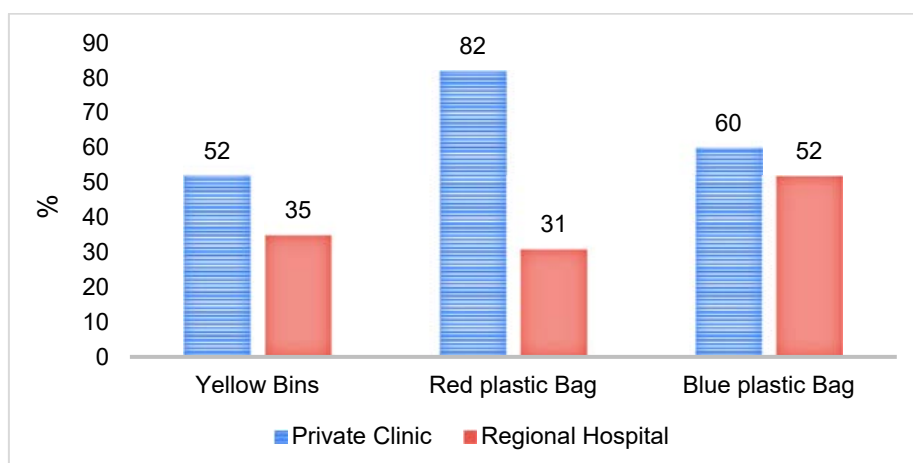


Fig. 4: Adequate responses on color-coding (Frequency in %)

plastic was for infectious waste disposal, and 51.70% of the participants could distinguish general waste from blue plastic bags. The remaining participants were unfamiliar with color-coding.

Fig. 5 demonstrates the disposal of sharps by health professionals. In the RHC (Fig. 5a), 46.7% confirmed that the collectors of sharp objects are filled, and 40% confirmed the overfilling of the collectors; only 18.30% said that three-quarters (3/4) of the collectors are filled. A total of 60.50% of the private clinic staff (Fig. 5b) acknowledged that the collectors are full and 15.80% are overflowing; 39.50% said that the collectors are filled, respecting the 3/4 standards.

Sharp collectors must be filled up to the point that they are 3/4 full to reduce the likelihood of needles and syringes poking out of the bin and endangering the user (Torkashvand *et al.*, 2022). These findings are believed to pose a serious infectious risk for the health staff and patients (Andeobu *et al.*, 2022). During our visits to the hospitals, waste disposal and separation procedures were evidently subpar (Fig. 6). Appropriate segregation of waste using color-coded plastic bags and the suitable disposal of sharps in designated bins constitute an essential component of an effective waste management strategy (Barbosa and Mol, 2018; Kalpana *et al.*, 2016).

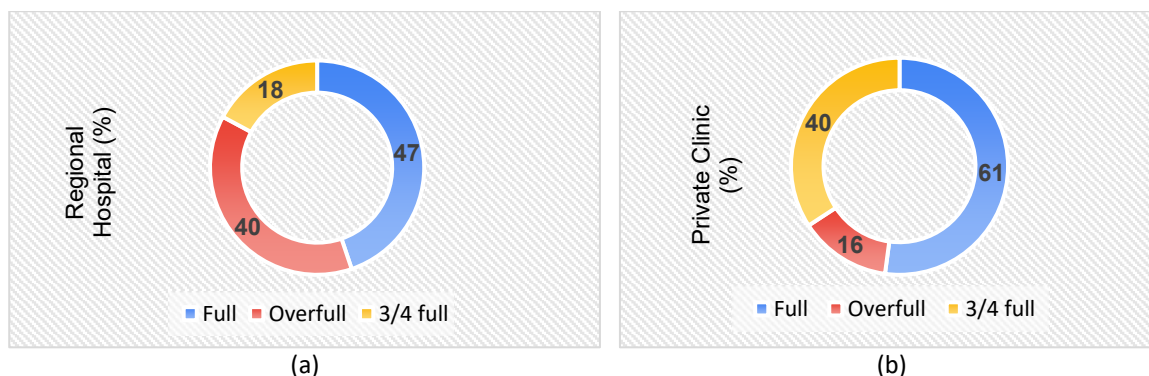


Fig. 5: Disposing of sharps in yellow bins: (a) in the regional hospital and (b) in the private clinic.



Fig. 6: Improper disposing and separation of medical waste in the hospitals sampled

Identification of healthcare waste management challenges in the two institutions studied.

The final part of Section B required participants to select from a list of obstacles: the difficulties they encountered in their daily work activity (Fig. 7). The findings were compared between RHC and the private

clinic and found that they were experiencing similar issues to inadequate training/information (84.25% on average), absence of protocols/procedures (67.20% on average), and ineffective monitoring (61.25% on average). For the RHC, the critical hurdle was the lack of equipment/materials (84.70%). The increase in

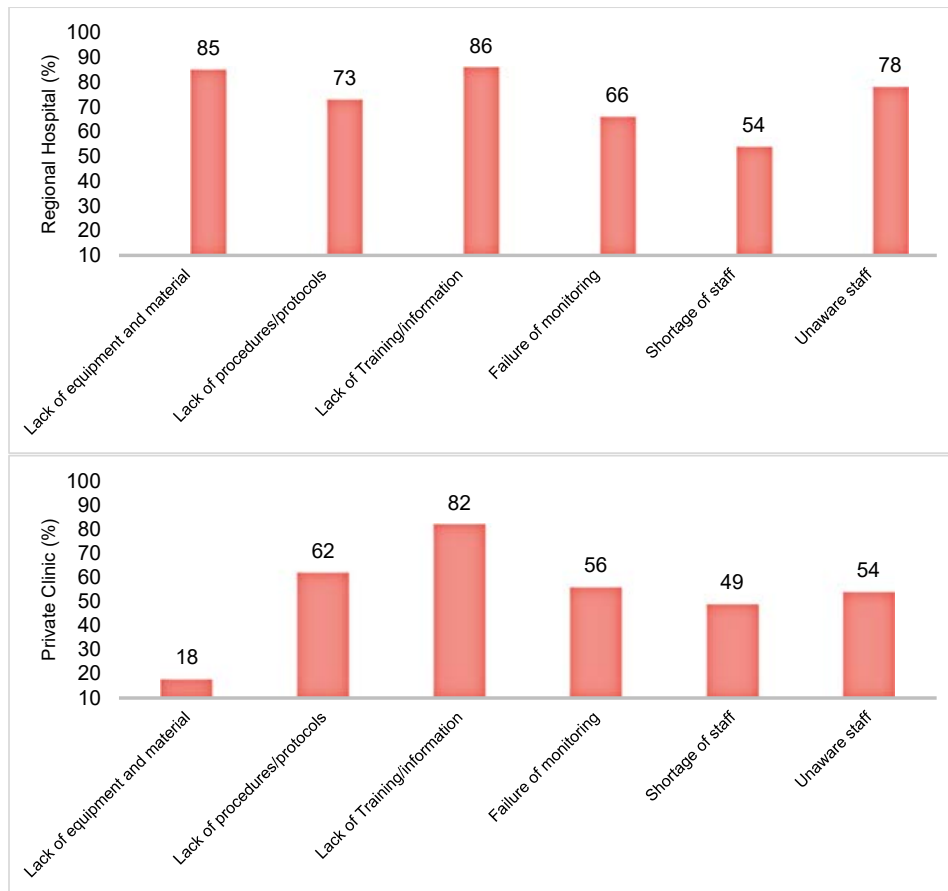


Fig. 7: Comparison of HCW challenges facing the RHC and the private clinic (%)

the number of UCH healthcare workers and medical activities in the hospital during the pandemic has led to a lack of tools and supplies required for medical waste management. A case study from various healthcare facilities in Sudan has documented the HCW management workers' challenges including lack of waste segregation at the source, lack of policies, failure of planning, inadequate training, lack of awareness of the hazardous nature of waste, weak infrastructure, and lack of suitable treatment technologies (Hassan et al., 2018).

The management of HCW represents a serious concern for health professionals to protect themselves against acute infections and the environment from any potential contaminations (Kumarasamy and Jeevaratnam, 2017). The responsibility to achieve this condition is not limited to the health professionals but also the decision-makers in authority (Nangbe,

2018). The process for sustainable management of HCW requires planning at all levels: enforcement of policies, appropriate handling, and segregation at the source (Olaniyi et al., 2021), continuous training programs of healthcare personnel, quantification, and strengthening of monitoring (Yousefi and Rostami, 2017). The health facilities studied should enhance their waste segregation practices by providing necessary materials, equipment, and appropriately labeled containers for storage. PPE, such as gloves, masks, clinical coats, and shoes, should be available to reduce the risk of infection and injury. Vaccination campaigns for all health professions should be organized. Surveys and quality assurance monitoring can improve healthcare worker management (Solomon et al., 2019). Staff training in appropriate hazardous waste handling and disposal, including emergency response procedures, is crucial.

Accurate records of HMW management practices should be maintained, including waste generated and any incidents that occur. Clear guidelines for managing hazardous waste should be established in each facility. International organizations, such as the WHO, can support these efforts by providing funding and expertise to create good practice guidelines for managing medical waste during health crises (Chisholm *et al.*, 2021).

CONCLUSION

HCW management practices in Tangier (Morocco) are unsafe and may negatively impact the health of staff and patients. As a result of the COVID-19 pandemic, an exponential increase in waste output has been observed, and various management procedures have become dysfunctional. Healthcare workers discussed the challenges they encounter daily, the majority of which are brought on by the lack of training, absence of protocols, and lack of monitoring. The institutions assessed herein had no waste management officer. The finding evidently shows the non-application of the national Decree n°2-09-139. HCW management is a critical aspect of maintaining a safe and healthy community and environment. In the lack of financial resources, steps including adequate waste source separation; waste reduction, such as single-use medical devices; and promoting the use of environmentally friendly products can help lessen the environmental impact of the HCW, as well as the cost of their treatment. Continuous training of the responsible staff is also important. In conclusion, secure management of medical waste necessitates the formulation of proactive strategies. To date, this subject has received minimal consideration and requires increased awareness. By cooperating with the regional divisions of the Ministry of Health, and international organizations such as the WHO or the environmental protection agency, a thorough investigation can help in the enforcement and implementation of a national management plan for healthcare workers during healthcare crisis. The perspectives of this work recommend the following: 1) adequate and ongoing training for the healthcare staff, 2) appropriate procedures and protocols on good practices, 3) appointment of a person responsible for safety and hygiene in the institution, 4) organization of mandatory vaccination campaigns for all health workers, 5) provision of the necessary

materials and equipment, and 6) an efficient protocol for measuring and quantifying waste. Effective HCW management benefits the community and wider society by reducing the risk of environmental pollution, preventing the spread of disease, and conserving resources. It also contributes to a cleaner, safer, and healthier environment, which can have positive impacts on the health and well-being of the local communities.

AUTHOR CONTRIBUTIONS

S. Ajbar El Gueriri, the first author, has conducted the survey research, contributed to analyzing data, interpreted the results, and prepared the manuscript. F. El Mansouri, the corresponding author, has participated in the preparation, creation, and presentation of the published work by those from the original research group, specifically critical review, commentary, or revision – including pre- or post-publication stages. S. Lachaal, performed the management activities to annotate (produce metadata), scrub data, and maintain research data. F. Achemlal, designed the field experiment and conducted field data acquisition. J. Brigui, contributed to the preparation, creation, and presentation of the published work, specifically writing the initial draft. A. Fakhil Lanjri, has contributed to supervising the first author in the data analysis, and interpreting the results.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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ABBREVIATIONS

$\frac{3}{4}$	Three quarters
%	Percent
COVID-19	Coronavirus disease
D	Day
Eq.	Equation
Fig.	Figure
HCW	Healthcare waste
HIV	Human immunodeficiency virus
HMW	Hazardous medical waste
kg	Kilogram
kg/bed/day	Kilogram per bed per day
kg/day	Kilogram per day
kg/week	Kilogram per week
LC	Litter capacity
N	Number of staff
NO.	Number
OR	Occupancy rate
P	Daily production
PPE	Personal protective equipment
Q	Quantity of waste
RHC	Regional hospital center

UCH

University center hospital

WHO

World health organization

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