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Impact of an educational training about healthcare waste management on practices skills of healthcare workers: a prexperimental study in a tertiary Tunisian hospital

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Abstract

Background Healthcare waste (HCW) poses a global hazard, particularly in developing country hospitals where mismanagement is common due to poor practices among staff. Training healthcare workers has shown promise in enhancing practices and behaviors. The aim of this study was to assessHCW management at Sahloul University Hospital (2019–2021) before and after training sessions.

Methods This study was conducted at Sahloul University in Sousse, Tunisia, spanned two years (2019–2021) and consisted of three distinct stages. Two audits of Healthcare Waste Management (HCWM) were conducted using a predetermined assessment framework derived from ANGED's guidelines, with an educational session separating the two audits.

Results In terms of sorting practicesthere was a substantial improvement in sorting practices following training. Specifically, the overall compliance rate for sorting sharps increased from 60.3 to 77.6% ($p < 10-3$), and for sorting soft and solid waste, it rose from 32.5 to 72.4% ($p < 10-3$) in 2021. Overall, resource indicators demonstrated improvement between 2019 and 2021, the compliance rate for the intra-service collection step increased from 31.3 to 58.2%. However, we observed persistent inadequacies in container and bag labeling, as well as challenges in tracing the time of healthcare waste collection.

Conclusion Training led to significant improvements in HCW management practices among healthcare workers, though some areas still need enhancement.

Keywords Healthcare, Waste, Management, Training, Improvement; Tunisia

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Introduction

Healthcare waste (HCW) is widely recognized as a global hazard [1], with growing awareness of its associated risks and the imperative for proper management. These risks are becoming increasingly acknowledged due to the significant disease burdens linked to inappropriate practices, [2], encompassing exposure to infectious agents and harmful substances. According to the World Health Organization (WHO), healthcare waste encompasses all waste generated by healthcare facilities, research institutions, and laboratories [3]. Remarkably, a substantial portion, ranging from 75 to 90%, of the waste generated by healthcare providers is non-hazardous or akin to ordinary domestic waste. The remaining 10–25% of HCW is categorized as hazardous, posing a variety of health risks [4].

Inadequate healthcare waste management (HCWM) practices can lead to unwarranted health hazards for patients, healthcare staff, waste handlers, and the surrounding community [5]. Negligent waste management in healthcare settings elevates the risk of blood exposure incidents and the transmission of blood-borne infectious diseases such as Hepatitis B, Hepatitis C, and the Human Immunodeficiency Virus (HIV) among hospital staff, patients, and the general public [6]. Furthermore, the improper disposal of untreated HCW in the environment can result in health hazards stemming from the release of toxic substances and pathogens into the soil [7]. Additional risks arise during the handling and sorting of HCW within healthcare facilities and during scavenging at disposal sites. During epidemic outbreaks, medical waste generation surges exponentially, potentially accelerating the spread of diseases if not collected or treated correctly, thus posing a significant risk to both medical staff and patients. [8].

Improper HCWM practices are particularly concerning in developing countries, where resources are often insufficient for waste management. Frequently, the responsibility for waste management is delegated to poorly educated and untrained laborers who operate without proper guidance or adequate protection [9]. Training healthcare workers has proven to be among the most effective strategies for enhancing practices and promoting health-conscious behaviors [10]. It has been demonstrated that regular training of healthcare workers can significantly improve their waste management practices in healthcare settings [11]. However, research on the impact of such training models remains scarce especially in African countries.

In Tunisia, the decree of application *n* ° 2008–2745 dated July 28th, 2008 mandated the creation of waste management units in each health care facility [12]. This decree strongly advocated for information sharing and the use of training as means to efficiently manage HCW, including improved waste segregation practices. It also prescribed the use of color-coded bins and storage facilities to facilitate effective waste segregation by nursing staff. In 2015, Tunisia adopted a national standard (NT 106.85–106.93) regulating the packaging of infectious healthcare waste (IHCW) [13]. Nevertheless, there has been limited empirical assessment to date regarding the effectiveness of the decree or the state of HCWM in Tunisia.

The objective of this study was to evaluate HCWM practices before and after a series of training sessions conducted at Sahloul University Hospital between 2019 and 2021.

Materials and methods

Study design and period

Study design

A pre-experimental study was conducted to evaluate healthcare waste management (HCWM) practices at Sahloul University Hospital from 2019 to 2021. The data collection process was completed in three stages over two years (Fig. 1).

1. Baseline Assessment (2019): This initial stage involved an audit of resources and practices.
2. Intervention - Training Session (2020): The intervention program implemented in 2020 comprised two phases: system changes and educational activities.
3. Post-Intervention Assessment (2021): The final stage included an audit of resources and practices to evaluate the impact of the interventions.

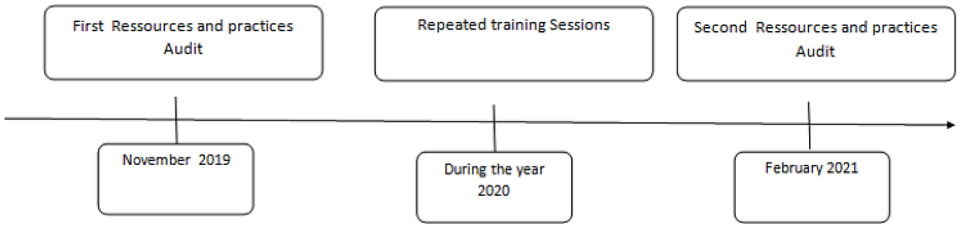

Fig. 1 Flowchart of the different stages of the survey

Study setting

Sahloul university Hospital is a tertiary hospital center with a comprehensive infrastructure, comprising 8 surgical departments, 7 medical departments, 7 intensive care units, an emergency department, and an advanced technical platform. Additionally, it encompasses radiology, nuclear medicine, health care prevention and safety services, as well as medical analysis laboratories (microbiology, biochemistry, and hemato-biology). This tertiary-level teaching hospital boasts 690 beds and is staffed by 1,141 healthcare professionals, including 173 physicians and 647 paramedical staff.

Sample selection

All departments and units engaged in healthcare activities were included in the assessment, except those without a care activity (e.g., outpatient, laundry room, sterilization unit, internal and external pharmacies) were excluded. The statistical units for data collection were defined as follows: care carts for services, operating rooms for the surgical departments, and laboratory benches for the medical analysis laboratories.

Data collection

Step1:baseline assessment: audit of resources and practices

Data collection was carried out using a pre-established grid divided into two parts:

Resource Indicators Audit: This part consisted of a suvey comprising 10 elementsand assessing the availability of HCW bins, the presence of yellow bags, black bags, and sharp containers in sufficient quantities, the condition of wheeled trolleys, and a checklist for Waste Collection Agents.

Audit of Practices: An observation grid was designed based on ANGED's guide to good management practices for HCW [14]. This grid encompassed 52 criteria categorized into three domains: sortingand packaging steps, intra-service collection steps, and extra service collection steps.

Step 2: intervention - training Session (Year 2020)

The intervention program was executed during the year 2020 and consisted of two phases :

- *System Change*: A checklist was employed regularly to monitor the presence of yellow bags, black bags, and sufficient sharp containers.
- *Educational Activities*: The training program was conducted in various formats:
- Door-to-door training sessions were conducted every three months for all wards, involving all staff regardless of their rank. These sessions were led by professionals from the healthcare security service.
- Theoretical and practical training days were organized for hospital staff at the Sahloul hospital training center. These sessions were centered on safe HCWM practices as recommended by the World Health Organization [15]. The program included presentations of pre-intervention results, educational film screenings, and interactive discussions covering topics such as the definition, sources, and categories of HCW, the public health impacts of improper HCW management, standard operating procedures for safe waste management, waste segregation, collection, and handling techniques [15].
- Reminders in the workplace: Technical sheets and posters on HCWM practices were distributed and displayed strategically within hospital departments. These materials conveyed key messages emphasizing the importance of HCWM in infection control and provided guidance on waste segregation techniques.
- Institutional safety climate: Efforts were made to secure formal commitment and support from senior hospital management to promote HCWM. A communication-based strategy was employed to engage stakeholders in creating an environment that fosters and encourages patient safety.

Step 3: post-intervention assessment

This step consisted of the post-intervention audit of the HCWresources and practices.This audit took place in 2021, using the same grid as the baseline audit.

Definitions of variables

HCW, as defined by the WHO, encompasses "All the waste generated by healthcare facilities, medical laboratories, and biomedical research facilities, as well as waste from minor or scattered sources" [3]. In this study, three types of HCW were of interest:

Infectious waste Defined as waste containing or reasonably expected to contain pathogens of sufficient virulence and quantity to pose an infectious disease risk. This category includes waste from isolation rooms, materials previously in contact with patients' body fluids (e.g., blood, vomit, urine, feces, surgical or wound dressings), contaminated and used medical gloves, vascular infusion sets, and catheters [16].

Sharp waste Encompasses used needles, scalpel blades, broken glass, and patient nails, or any items capable of causing harm or injury [17].

Non-infectious waste Refers to waste typically found in households and not capable of harming individuals, including paper, leftover food, disposable containers, or

Table 1 Units audited between 2019 and 2021

	2019	2021
Units	Rate (%)	Rate (%)
Surgicalward	29 (18.1)	18 (13.6)
Medicalward	41 (25.6)	22 (16.7)
Intensive care units	19 (11.9)	21 (15.9)
Operating rooms	18 (11.3)	12 (09.1)
Laboratories	20 (12.5)	19 (14.4)
Others	28 (17.5)	37 (28.0)
Emergency	5 (03.1)	3 (02.3)
Total	**160 (100.0)**	**132 (100.0)**

Table 2 Evolution of HCW resource indicators between 2019–2021

	2019	2021	*p*
Sufficient number of HCW bins	86.0%	93.0%	0.330
Sufficient number of ordinary HCW bins	92.3%	84.0%	0.940
Presence of yellow bags in sufficient numbers	54.9%	83.3%	**0.003**
Presence of black bags in sufficient numbers	63.9%	82.2%	**0.003**
Presence of Sharp containers in sufficient numbers	86.9%	98.0%	**0.020**
Presence of wheeled trolley for HCW transport	34.1%	82.0%	**0.000**
HCW transport trolley is functional	97.0%	98.0%	**0.000**
HCW transport trolley is in good condition	91.2%	92.3%	0.640
HCWM procedure is displayed	76.6%	65.3%	0.150
Presence of checklist of agents visit	12.5%	07.2%	**0.000**

empty intravenous bottles if uncontaminated with blood [18].

Data processing and analysis

The data collected through measurement and observation checklist were entered and compiled by using SPSS computer software packagesfor windows.Categorical variables were reported as count and percentages. Quantitative variables were expressed in terms of means and standard deviation. For the comparison of the proportions, we used the Chi2 test.

Results

Audit of resources and practices

The audit of resources and practices was conducted across 160 units in 2019, compared to 132 units in 2021 (Table 1).

During the period from 2019 to 2021, notable improvements were observed in several resource indicators: There was a significant increase in the presence of "yellow bags in sufficient numbers" (54.9% vs. 83.3%; $p=0.003$), "black bags in sufficient numbers" (63.9% vs. 82.18%, $p=0.003$), and the availability of "wheeled trolleys for HCW transport" (34.1% vs. 82%, $p<0.001$). However, a regression was observed in the indicator "presence of a checklist for agent visits" (12.5% vs. 7.2%, $p<0.001$) (Table 2).

Assessment of sorting and packaging practices

The overall rate of HCW sorting increased from 44.7% in 2019 to 68.9% in 2021.

Sorting by discipline In 2021, medical laboratories and medical wards demonstrated the highest adherence to HCW sorting recommendations. In fact, significant improvements in HCW sorting were noted between 2019 and 2021 in surgical wards (63.7% vs. 75.6%; $p=0.003$), medical wards (52.4% vs. 81.80%; $p=0.002$), and laboratories (47.4% vs. 90.2%; $p=0.040$) (Fig. 2).

Sorting and packaging steps A marked improvement in HCW sorting was observed between the pre- and post-training periods. Compliance rates for sorting sharps increased from 60.3 to 77.6% ($p<0.001$), while those for sorting soft and solid waste rose from 32.5 to 72.4% ($p<0.001$) in 2021 (Table 3).

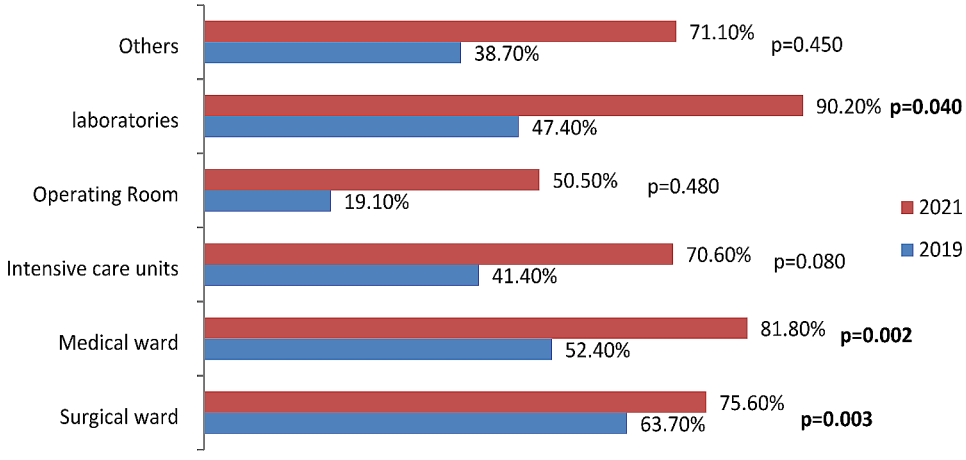

Fig. 2 Evolution of HCW Sorting practices by Discipline Between 2019 and 2020

Table 3 Evolution of HCW sorting and packaging steps between 2019 and 2021

Criteria	2019	2021	*P*
	Rate (%)	Rate (%)	
Sharps			
The parts of the Sharp containers are correctly assembled	93 (71.3)	94 (71.2)	0.920
The Sharp container is fixed in its support	73 (45,0.7)	75(56.8)	**0.000**
The containers are well sized	113 (90.4)	125(85.0)	0.600
Absence of HCW other than Sharp in the containers	109 (68.2)	116(87.8)	**0.050**
overall compliance rate	97 (60.6)	102 (77.6)	**0.000**
soft and solid waste			
The yellow bags are fixed in their holders	71 (36.2)	125(85.0)	**0.000**
The black bags are fixed in their holders	66 (33.6)	116(78.4)	**0.000**
No ordinary waste in the yellow bags	47 (23.9)	59 (48.8)	**0.000**
Absence of infectious waste in the black bags	69 (35.2)	73 (70.9)	**0.000**
overall compliance rate	52(32.5)	96 (72.4)	**0.000**

Table 4 Evolution of HCW intra-service collection between 2019 and 2021

	2019	2021	*P*
	Rate (%)	Rate (%)	
The sharp container is well labeled (service and date)	22 (13.7)	4 (03.2)	**0.000**
The filling level of the container is respected	142(72.4)	88 (70.4)	0.310
After filling, the sharp container is firmly closed.	93(47.4)	85 (68.0)	**0.010**
The yellow bag is well labeled (service and date)	0 (00.0)	1 (00.9)	0.200
The filling level of the yellow bags is respected	54 (28.6)	95 (76.6)	0.750
Absence of HCW apart from sharps containers and waste bags (benches, flower beds, etc.)	53 (27.0)	100 (90.9)	**0.050**
After filling, the bags are firmly closed.	39 (19.9)	92 (74.8)	**0.000**
Absence of yellow bags in bulk in the service	39 (19.9)	106 (89.1)	0.980
The wheeled trolley reserved for HCW is well labeled	0 (00.0)	32 (29.1)	**0.000**
The trolley contains a large bag that covers the upper limit	11(29.9)	75 (67.0)	**0.000**
The wheeled trolley reserved for HCW is placed in a clean room	26 (50.0)	69 (69.7)	0.190
Absence of black bags in the bins reserved for infectious HCW	33(63.4)	95 (88.0)	**0.000**
Absence of yellow bags in the bins reserved for ORDINARY HCW	12 (23.1)	81 (77.9)	0.130
The waste bag evacuation schedule is set in advance and respected	33 (63.4)	74 (64.9)	0.360
The traceability for HCW collection time	0 (00.0)	8(07.3)	**0.080**

Table 5 Participation of health care professionals in training session

Sub groups		*N*	%
Total		320	100
Professional category			
Physicians		14	04.4
Nurses		261	81.5
Housekeepers		45	14.1
Medicalspeciality			
Medicalward(*N* = 64)	Physicians	1	1.6
	Nurses	57	89.1
	Housekeepers	6	9.3
Intensive care units (*N* = 54)	Physicians	2	3.7
	Nurses	46	85.1
	Housekeepers	6	11.2
Operating Room (*N* = 43)	Physicians	0	0
	Nurses	34	79.1
	Housekeepers	9	20.9
Surgical ward(*N* = 66)	Physicians	2	3.1
	Nurses	53	80.3
	Housekeepers	11	16.6
Others(*N* = 81)	Physicians	7	8.7
	Nurses	62	76.5
	Housekeepers	12	14.8
emergency (*N* = 12)	Physicians	2	16.7
	Nurses	9	75
	Housekeepers	1	8.3

Intra-service collection step

The overall compliance rate for the intra-service collection step increased from 31.3 to 58.2%. Comparing 2021 to 2019, there was an improvement in the scores of certain indicators, such as "absence of HCW apart from sharps containers and waste bags (benches, flower beds, etc.)," which increased from 27 to 90.9% ($p = 0.05$), and "the wheeled trolley reserved for HCW is well-labeled," which improved from 0 to 29.1% ($p < 0.001$) (Table 4).

However, some deficiencies persisted, particularly in the labeling of containers and bags, as well as the traceability of the timing of HCW collection.

Training sessions

Regarding the training sessions, a total of 290 health professionals participated, with a majority comprising nurses, laboratory technicians, and sanitary staff. These training sessions were conducted by medical doctors and nurses from the hospital's preventive medicine department, with nurses accounting for 81.5% of the participants (Table 5).

Discussion

Principal findings This study represents a significant contribution as one of the few investigations to delve into the influence of training on Healthcare Waste Management (HCWM) practices within a university hospital

setting in Tunisia. It is well-acknowledged that waste generated by healthcare institutions poses substantial health risks to hospital personnel, patients, and the environment. If these wastes are not managed through appropriate collection, storage, and disposal methods, they can evolve into severe environmental and public health concerns [19]. According to guidelines established by the World Health Organization (WHO), effective waste management necessitates regular and comprehensive training programs, along with the development of robust information systems [20]. One of the most efficacious strategies to curtail improper HCWM is the continuous education of healthcare workers at their respective workstations [21].

Since 1991, the Department of Prevention and Security of Care (DPSC) at Sahloul University Hospital has been overseeing hygiene indicators. Over the years, DPSC has conducted annual audits of HCWM practices and intermittently organized training sessions. However, these previous sessions were partial, non-continuous, and lacked evaluation of effectiveness. In contrast, our study adopts a comprehensive approach, particularly highlighted during the COVID-19 outbreak. Our findings illustrate that regular HCWM training sessions have significantly improved overall waste sorting practices.

Strength and limitations of the study To the best of our knowledge, this study is among the few that have addressed the impact of training on HCWM practices within a university hospital in Tunisia. While the literature review uncovered several studies that have explored the influence of training on the knowledge, attitudes, and practical skills of healthcare professionals in relation to HCWM in Tunisia [12, 22] and globally only a limited number have evaluated daily HCWM practices within the workplace. [9, 11, 16, 19, 23] ,

In Sahloul University Hospital, we have embraced a waste segregation system at the source, employing color-coded high-density polyethylene bags and bins for easy identification and separation of infectious and non-infectious waste. Infectious waste is carefully packaged to mitigate potential injury and the transmission of diseases [24]. Standard color-coded plastic bags (black for general waste and yellow for infectious waste) and sharps containers are consistently distributed to various hospital departments. These bags and containers are appropriately labeled to specify the place of generation, collection date, and sample number. Wastes are collected daily and weighed using a scale. Over the years, we have made efforts to enhance our HCW resources. Between 2019 and 2021, there was an improvement in certain resource indicators such as the "Presence of sufficient numbers of yellow bags" (54.9% vs. 83.3%; $p=0.003$), "Presence of sufficient numbers of black bags" (63.9% vs. 82.18%, $p=0.003$), and "Presence of wheeled trolleys for HCW transport" (34.1% vs. 82%, $p<0.001$). However, we observed a decline in the "Presence of a checklist for agent visits" indicator (12.5% vs. 7.2%, $p<0.001$). Overall, the total units surveyed decreased from 160 in 2019 to 132 in 2021, primarily due to the exclusion of units hospitalizing COVID- 19 patients in 2021.

The overall compliance with recommended practices improved between 2019 and 2021 after the implementation of training sessions, This training sessions were conducted for all hospital healthcare workers, including nurses, physicians, and support staff. The comprehensive training program ensured participation across all departments to promote a unified approach to healthcare waste management (HCWM). New hires during the study period also received training to maintain consistency in practices. Given the continuous growth in hospital waste generation, it is imperative that all healthcare personnel receive "Hospital Medical Waste Plan" guidance and regular training on the appropriate disposal of each waste type [25]. Globally, an estimated 16 billion injections are administered annually, posing potential infection risks responsible for 30%, 1.8%, and 0.3% of HBV, HCV, and HIV infections, respectively. WHO guidelines recommend the disposal of used syringes/needles in safety boxes, which can then be disposed of through burial, incineration, autoclaving, or shredding, depending on the country's scenario [26]. In our study, the overall compliance rate for sorting sharps increased from 60.3 to 77.6% ($p<0.001$). Significant improvements were noted in two dimensions: "The sharp container is securely affixed in its support" and "Absence of non-sharp HCW in the containers." A study in Pakistan also highlighted that regular training and monitoring of healthcare professionals substantially improved sharp waste management by nearly 80% [18].

Regarding the sorting of soft and solid waste, the overall score increased from 32.5% in 2019 to 72.4% in 2021 ($p<0.001$), with significant improvements in all four dimensions. Notably, significant improvements were observed in the intra-service collection step, particularly in the indicators "Absence of non-sharp HCW apart from sharps containers and waste bags (benches, flower beds, etc.)" (Increased from 27 to 90.9%, $p=0.05$) and "The wheeled trolley reserved for HCW is well labeled" (increased from 0 to 29.1%, $p<0.001$).When reviewing the literature, many studies have stressed the importance of recurrent training sessions to enhance waste handling practices among healthcare staff and the necessity for consistent information and reinforcement concerning infectious waste management [10, 16]. Additionally, it is suggested that improving the performance of healthcare professionals might require comprehensive initial training, complemented by regular refresher training sessions [27].

Persistent inadequacies were noted in the labeling of containers and bags, as well as the traceability of HCW collection times. This labeling deficiency has been reported in multiple studies, including one conducted in Jordan [9]. The absence of labeling can be attributed to insufficient training for workers responsible for waste transportation or a shortage of supplies such as marker pens [28].

Similar to previous research, our findings indicate that nurses attend training sessions more frequently than physicians and exhibit higher compliance with HCWM recommendations compared to other professionals. Effecting changes in HCWM practices and addressing established routines can be challenging in our context. While HCWM involves relatively simple actions, it appears to be inadequately integrated into clinical practice, especially among physicians, who show limited interest in HCWM training. Therefore, it is imperative to understand the factors hindering physicians' attendance at training sessions in order to enhance adherence to HCWM best practices.

Implications for policy, practice and research In light of our findings, we recommend the following.

- Continue and strengthen training programs targeting all healthcare professionals, regardless of their roles or grades.
- Engage hospital managers in HCWM to ensure the sustained adherence to recommended practices.
- Investigate the reasons behind resistance to employer adherence to recommendations related to dimensions with the lowest scores, such as labeling and traceability.
- Enhance training efforts regarding indicators that continue to exhibit deficiencies.
- Integrate and reinforce a culture of safety and risk management into basic training programs for paramedics and future doctors.
- Addressing these recommendations will be crucial for advancing HCWM practices in our hospital and similar healthcare settings.

Conclusion

The provided training courses were effective; indicating a significant improvement of healthcare workers adherence to recommended practices of HCW management. Nevertheless, there were still some indicators to be improved concerning especially the labeling and traceability of HCW collection time.

Our study emphasizes the importance of training for proper and complete knowledge on HCWM. The need for reinforcement on some dimensions is required so that their behavior practices will change for better care. This will ensure patient safety and control health care associated infections. So, the importance of training regarding HCWM cannot be overemphasized. Therefore we suggest to study the causes of resistance to the adherence to the recommendation regardingthe least noted dimensions and to strengthen the program of continuous training sessions, targeting all healthcare workers regardless their ranks.

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Author contributions
All authors contributed to the manuscript and were involved in study planning, data acquisition, analysis, and interpretation. R.B and A.BC participated in Research concept and design of the work, the data analysis and interpretation and writing the article. S.B contributed at the Collection and assembly of data and the Critical revision of the article. H.G contributed at the writing the article and the Critical revision of the article. S.K supervised the collection and/or assembly of data and the critical revision of the article. M.BR and H.SL supervised the critical revision of the article and the final approval of the article.

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Data availability
Data is available under reasonable request by mail: raniaa.bannour@gmail.com.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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