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Assessment of the knowledge, attitudes and practices on the management of biomedical waste among health care workers in Traghin City Public Hospital

Running title: Awareness and behavior of healthcare workers regarding biomedical waste management at Traghin General Hospital.

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ABSTRACT

Biomedical waste management (BMWM) is critical for public health and environmental protection, especially in resource-limited countries like Libya, where gaps in awareness and practices increase risks. This study evaluated awareness and behaviors related to BMWM among healthcare workers at Traghin General Hospital, aiming to identify areas for improvement. Using a descriptive cross-sectional design, a structured questionnaire was distributed to 200 healthcare workers, with 173 completed responses collected over five months. The questionnaire included demographic details, awareness assessment, and behavioral practices in handling biomedical waste.

The findings highlighted significant gaps in awareness, as only 43.9% of participants acknowledged the increased risk of infectious diseases due to improper waste management. Notably, 90.75% emphasized integrating BMWM into academic curricula to address these gaps. Behaviorally, 90.18% of respondents adhered to proper procedures for disposing of sharp waste, while practices related to daily waste management showed lower compliance.

The study highlights the urgent need for targeted interventions, such as mandatory training programs to enhance healthcare workers' knowledge and skills. Additionally, ensuring adequate infrastructure and resources are essential to support proper BMWM practices. These measures are crucial for fostering a safe healthcare environment and mitigating the health and environmental risks associated with improper waste disposal.

تقييم المعرفة والمواقف والممارسات المتعلقة بإدارة النفايات الطبية الحيوية بين العاملين في مجال الرعاية الصحية في مستشفى تراغن العام.

العنوان المختصر : وعي وسلوك العاملين في الرعاية الصحية حول إدارة النفايات الطبية مستشفى تراغن العام

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الكلمات المفتاحية

التعليم الطبي
النفايات الطبية الحيوية
العاملون في المجال الصحية
مكافحة العدوى
الوعي
مستشفى تراغن

المخلص

تعد إدارة النفايات الطبية الحيوية (BMWM) أمراً بالغ الأهمية لحماية الصحة العامة والبيئة، لا سيما في البلدان ذات الموارد المحدودة مثل ليبيا، حيث تؤدي الفجوات في الوعي والممارسات إلى زيادة المخاطر. هدفت هذه الدراسة إلى تقييم الوعي والسلوكيات المتعلقة بإدارة النفايات الطبية الحيوية بين العاملين في الرعاية الصحية في مستشفى تراغن العام، بهدف تحديد المجالات التي تحتاج إلى تحسين. تم استخدام تصميم وصفي مقطعي، حيث تم توزيع استبيان منظم على 200 من العاملين في الرعاية الصحية، وتم جمع 173 استجابة مكتملة على مدى خمسة أشهر. شمل الاستبيان تفاصيل ديموغرافية، وتقييماً للوعي، وممارسات التعامل مع النفايات الطبية الحيوية. أظهرت النتائج فجوات كبيرة في الوعي، حيث أقر 43.9% فقط من المشاركين بزيادة

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خطر الأمراض المعدية بسبب سوء إدارة النفايات. ومن الجدير بالذكر أن 90.75% أكدوا أهمية دمج إدارة النفايات الطبية الحيوية في المناهج الأكاديمية لمعالجة هذه الفجوات. سلوكيًا، التزم 90.18% من المشاركين بالإجراءات الصحيحة للتخلص من النفايات الحادة، بينما كانت الممارسات المتعلقة بالإدارة اليومية للنفايات أقل امتثالاً. تؤكد الدراسة الحاجة الملحة إلى تدخلات مستهدفة، مثل برامج التدريب الإلزامية لتعزيز معرفة العاملين في الرعاية الصحية ومهاراتهم. بالإضافة إلى ذلك، فإن توفير البنية التحتية والموارد الكافية أمر ضروري لدعم الممارسات الصحيحة في إدارة النفايات الطبية الحيوية. تُعدّ هذه التدابير ضرورية لضمان بيئة رعاية صحية آمنة والحد من المخاطر الصحية والبيئية المرتبطة بالتخلص غير السليم من النفايات.

Introduction

Biomedical waste management (BMWM) has emerged as a crucial component of healthcare systems worldwide, particularly given the risks that improper waste disposal poses to public health and the environment. Biomedical waste includes any material generated during diagnosis, treatment, or immunization of humans and animals, as well as during biological research activities and tests. This waste encompasses a broad range of hazardous materials, including chemical agents, infectious substances, and radioactive elements, which necessitate careful and effective handling to prevent health risks [1]. Proper management of biomedical waste is thus vital to hospital infection control and overall public safety [2].

Healthcare facilities generate large amounts of waste, approximately 80% of which is considered general waste. However, the remaining 20% is classified as hazardous waste, which includes infectious materials and sharps that could lead to the transmission of diseases if not managed correctly [3]. The World Health Organization (WHO) emphasizes the need for effective biomedical waste segregation, treatment, and disposal, considering that untreated waste increases the likelihood of spreading infections such as hepatitis and HIV, particularly in areas lacking adequate waste management infrastructure [4].

Developing countries often face significant challenges in biomedical waste management due to limitations in resources, infrastructure, and training of healthcare personnel. Insufficient awareness and inadequate disposal practices are further exacerbated by limited enforcement of regulations, resulting in the improper handling of hazardous waste, which can lead to environmental contamination and increased health risks for both healthcare workers and the surrounding communities [5,6]. In Southeast Asia, for instance, improper waste disposal has contributed to a 10% increase in deadly infections due to inadequate segregation and containment of infectious waste [7].

Biomedical waste management in Libya is governed by Environmental Law No. (7), which provides a legal framework for handling waste across healthcare facilities. However, the implementation of this law faces several challenges, most notably the limited awareness among healthcare workers and the lack of effective oversight by regulatory authorities. Although the law sets out clear requirements for the safe disposal of medical waste, its enforcement remains inconsistent particularly in smaller healthcare institutions, which often lack adequate training on waste management protocols. Additionally, Decision No. (-) of 2022 regarding the Executive Regulation for Integrated Medical Waste Management, as published in the Legal Compendium, was introduced to strengthen the legislative framework in this area [5].

A significant aspect of biomedical waste management lies in educating healthcare personnel on the risks associated with improper handling of hazardous waste. Studies have shown that when healthcare workers are adequately trained and aware of the risks, their compliance with waste disposal guidelines improves, which in turn enhances safety within healthcare facilities [7,9]. For instance, research conducted in India revealed that only 26% of physicians and 43% of healthcare employees were aware of the risks associated with biomedical waste, indicating a substantial gap in knowledge that impacts safety practices in healthcare settings [5].

In a related context, research conducted in Libya highlighted the broader challenge of risk perception and the level of preparedness during health emergencies, such as the COVID-19 pandemic, which

similarly requires strict adherence to health protocols and awareness campaigns [10]. Additionally, previous studies have explored the relationship between awareness, disease control, and health education factors that are also vital in the context of biomedical waste management [11,12].

Recognizing these challenges, the present study focuses on evaluating the awareness and behavior of healthcare personnel at the public hospital in Traghin City, Libya, regarding biomedical waste management. By assessing the knowledge and practices of these healthcare workers, this study aims to identify areas where improvements are necessary to ensure a safer healthcare environment. Implementing regular training sessions and strengthening waste management protocols could play a critical role in protecting healthcare workers and the community from potential health risks [7]. Furthermore, this research hopes to contribute to the broader understanding of how waste management practices can be optimized in low-resource settings and promote a culture of environmental and health responsibility among healthcare personnel.

Methods and Materials

Type of Study:

This study employed a descriptive survey cross-sectional design to evaluate the knowledge, awareness, and practices of healthcare providers regarding biomedical waste management. It was conducted across various departments of Traghin Hospital, targeting medical staff, including technicians, paramedics, and doctors.

Study Period:

The study was carried out over five months, from August 2024 to December 2024.

Study Tools:

A structured questionnaire was designed based on previous studies related to biomedical waste management [4]. The questionnaire was divided into three main sections:

Section A: Focused on demographic information of participants, such as age, gender, educational background and job.

Section B: Evaluated participants' awareness of biomedical waste through 15 questions with predefined answers: "Yes," "No," or "I do not know".

Section C: Explored participants' behaviors and practices in handling and managing biomedical waste, along with their perceptions of its impact on their health, the health of patients, and the environment surrounding the healthcare facility. A total of 200 questionnaires were distributed among healthcare workers, and 173 completed responses were returned for analysis.

Data Analysis:

The data collected from the questionnaires were sorted and validated before analysis. The Statistical Package for the Social Sciences (SPSS) version 19 was used for statistical analysis. Descriptive statistical methods were applied to summarize the findings, which were then presented in tabulated formats for better understanding and interpretation

Ethical considerations

The study was approved by the management of Traghin Hospital, and written informed consent was obtained from participants before they completed the anonymous survey. It was ensured that no personal or identifiable patient data were collected during the study.

Results

A total of 200 questionnaires were distributed to healthcare workers in public hospitals in Traghin City, with 173 completed responses received for analysis. The demographic data of the participants included information on sex, age, and educational level and Job. The results showed that the majority of participants were female, and the largest age group was between 25 and 34 years old. Most participants held a bachelor's degree.

Table (1) the general characteristics of the participants in the study

Characteristics	No	%
Gender n=173		
Male	30	17.3
Female	143	82.7
Age Distribution of Participants n=173		
< 25 years	15	8.67
25 - 34 years	74	42.77
35 - 44 years	58	33.53
> 45 years	26	15.03

Job n=173		
Nursing	80	46.2
(hemodialysis) Technician	9	5.2
Laboratory Technician	24	13.9
Anesthesia Technician	9	5.2
Environmental Services (EVS) Worker	18	10.4
Pharmacist	7	4.0
Radiology Technician	11	6.4
Infection Control Technician	12	6.9
Doctor	3	1.7

This table summarizes the demographic and occupational characteristics of the 173 participants included in the study. The majority of participants were female (82.7%), while males represented 17.3% of the sample. Regarding age distribution, the largest proportion (42.77%) were between 25 and 34 years old. In terms of job roles, the most common occupation was nursing (46.2%), followed by laboratory technicians (13.9%) and environmental services workers (10.4%). Other professions included radiology technicians, infection control technicians, pharmacists, anesthesia technicians, hemodialysis technicians, and a small proportion of doctors. These characteristics provide a comprehensive overview of the study population and help contextualize the findings.

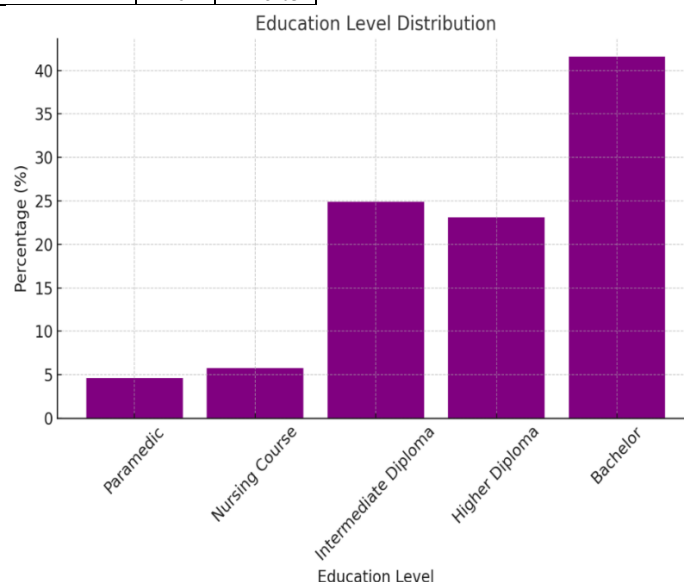


Figure 1: Education Level Distribution

This figure illustrates the distribution of educational attainment among study participants. The majority of participants held a Bachelor's degree (over 40%), followed by those with Intermediate Diplomas and Higher Diplomas, representing approximately 25% and 23%, respectively. Lower proportions were observed among

those who completed only a Nursing Course or held a Paramedic certificate. These findings reflect a generally high level of education among the study population, which may positively influence their awareness and practices in healthcare-related fields.

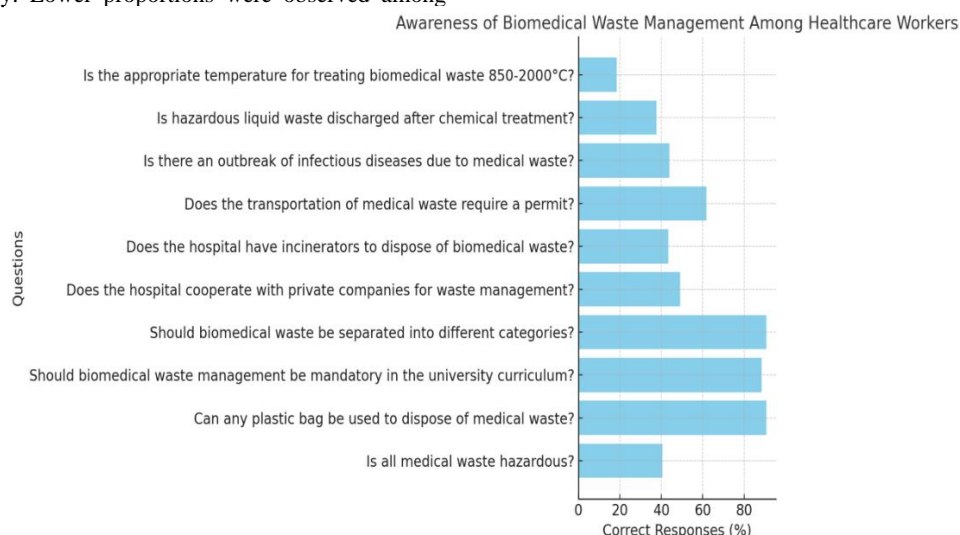


Figure 2: Correct response for questions on awareness regarding bio-medical waste

This figure presents the percentage of correct responses to various questions assessing healthcare workers' awareness regarding biomedical waste management. The highest levels of correct knowledge were observed for questions related to waste segregation, the necessity of integrating biomedical waste management into the university curriculum, and the use of appropriate disposal methods (above 70%). In contrast, lower awareness was noted regarding the appropriate temperature for treating biomedical waste and chemical treatment of hazardous liquid waste. These results highlight both strengths and gaps in the participants' knowledge, emphasizing the need for targeted educational interventions to improve comprehensive understanding and practices in biomedical waste management.

Table 2: Percentage of Response Choices for Questions on Awareness Regarding Bio-Medical Waste (Based on Personal Responses).

No	Questions	Responses	%
Q1	Have you received any training in biomedical waste management ?		
•	Yes	58	33.53
•	No	114	65.9
•	I don't know	1	0.6
Q2	Do you think your knowledge of (regarding) biomedical waste management is sufficient ?		
•	Yes	25	14.5
•	No	134	77.5
•	I don't know	14	8.1
Q3	Do you think you need advanced training in biomedical waste management ?		
•	Yes	156	90.7
•	No	13	7.5
•	I don't know	4	2.3

This table summarizes participants' responses to questions assessing their training experience and perceived knowledge regarding biomedical waste management. Only 33.5% of respondents reported having received prior training, while 65.9% indicated no previous training experience. When asked about the sufficiency of their knowledge, 77.5% believed their knowledge was inadequate, and merely 14.5% considered it sufficient. Notably, a high percentage (90.7%) of participants expressed a need for advanced training in biomedical waste management. These findings highlight a significant gap in both training coverage and self-perceived competency among healthcare workers, emphasizing the urgent need for targeted educational initiatives.

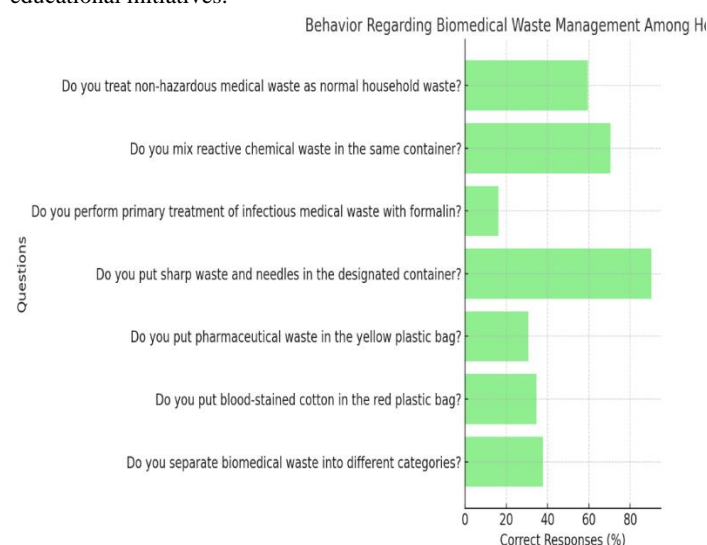


Figure 3: Correct response for questions on the behavior based on biomedical waste management.

The results indicate that while a high percentage of healthcare workers properly disposed of sharp waste and separated biomedical waste into different categories, there were notable deficiencies in

behaviors related to chemical and pharmaceutical waste management.

Table 3: Percentage of Response Choices for Behavior-Based Questions on Bio-Medical Waste Management (Based on Personal Responses).

No	Questions	Responses	%
Q1	Do you throw all types of waste into the general waste?		
•	Yes	70	40.46
•	No	98	56.6
•	I don't know	5	2.9
Q2	Do you wish to join medical waste management courses inside hospitals if the opportunity allows you or in the future ?		
•	Yes	157	90.75
•	No	10	5.8
•	I don't know	6	3.5
Q3	Did you benefit from the educational stages during your studies in how to deal with medical waste ?		
•	Yes	112	64.74
•	No	59	34.1
•	I don't know	2	1.2
Q4	Do you throw biomedical waste in the yellow plastic bag ?		
•	Yes	54	31.21
•	No	99	57.2
•	I don't know	20	11.6

This table presents the distribution of participants' responses to behavior-related questions concerning biomedical waste management. More than half of the participants (56.6%) reported that they do not mix all types of waste with general waste, whereas 40.46% admitted doing so. A significant majority (90.75%) expressed willingness to join medical waste management training programs if opportunities arise. Furthermore, 64.74% acknowledged benefiting from their educational training on waste management during their studies. However, only 31.21% reported properly disposing of biomedical waste in the yellow plastic bags, indicating the need for reinforcement of correct disposal practices.

Training Needs for Biomedical Waste Management

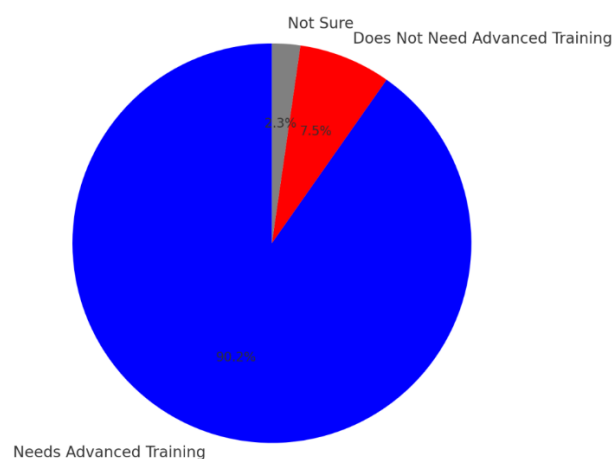


Figure 4: Training Needs for Biomedical Waste Management

The pie chart clearly illustrates that a vast majority (90.2%) of healthcare workers in the study reported a need for advanced training in biomedical waste management. This significant finding highlights a major gap in the current knowledge and preparedness of staff, indicating that without targeted training programs, proper waste handling and safety protocols may not be followed. Only 2.3% felt that they do not need further training, while 7.5% were uncertain, further emphasizing the urgent need for structured educational interventions.

Discussion

Improper management of medical waste from initial collection to final disposal has been observed in many healthcare settings. The mismanagement of medical waste is primarily attributed to a lack of well-trained staff, insufficient awareness and education, and inadequate legislation. Recently, the management of medical waste has gained significant attention among researchers due to the infectious nature of these wastes. Without proper and effective control measures, healthcare centers, particularly in developing countries, may face serious financial challenges. This study highlights the critical importance of properly educating healthcare workers on biosafety and biosecurity practices related to medical waste management.

The studies conducted in Traghin, indicated that over 70% of the participants were female, reflecting the prevalence of women in nursing and primary healthcare roles in Libya (Table 1) [13]. The most represented age group was between 25–34 years, showcasing a young workforce that is well-suited for targeted training programs to improve biomedical waste management practices (Table 1). Similarly, the findings in Benghazi revealed that 79.2% of participants were female, with 41.7% aged between 25–35 years, confirming consistent demographic patterns across Libyan cities. These similarities highlight the importance of unified national training programs focused on young female healthcare workers to address gaps in biomedical waste management effectively [14].

Awareness of biomedical waste management varied among cities. In Traghin, 90.75% of participants acknowledged the importance of using specialized bags for medical waste, reflecting a relatively high level of awareness (Figure 2). However, in Sabratha, participants demonstrated a lower understanding of basic practices [13]. In Benghazi, only 63.7% of participants reported having an infection control committee in their facilities, while 53.9% lacked a clear guide for handling medical waste (Table 2). Additionally, 58.1% of participants in Benghazi had no prior training on biomedical waste management, illustrating significant knowledge gaps [14]. These findings collectively underscore the necessity of enhancing training and education programs to standardize biomedical waste management practices across Libyan cities (Figure 2&4). Similar trends have been observed in other developing nations, where studies reported that lack of training leads to improper handling of biomedical waste, posing environmental and public health risks [15,16].

Behavioral practices also showed significant disparities. In Traghin, 90.18% of workers adhered to proper disposal practices for sharp waste, while Sabratha reported a slightly lower compliance rate of 87% [13]. However, both cities exhibited weak practices in the classification and disposal of daily waste, such as blood-contaminated materials. In Benghazi, 59% of participants admitted to mixing medical waste with general waste, significantly increasing the risk of contamination [14]. While 60.7% used specialized containers for collecting waste, 43.7% did not use personal protective equipment during handling, further highlighting risky behaviors (Table 2). Similar challenges have been reported in Puducherry, India, where 50% of nursing staff and most laboratory technicians lacked awareness of proper biomedical waste disposal protocols [1]. Despite relative progress in sharp waste disposal across all cities, daily waste management practices require significant improvement and stricter adherence to protocols.

Training remains a critical issue in all cities. Most participants in Traghin, Sabratha, lacked formal training, although there was a significant interest in attending future programs to improve their skills (Figure 4). Similarly, in Benghazi, 58.1% of participants had not received any training in biomedical waste management. Despite this, 87% emphasized the importance of following guidelines and using protective tools to reduce risks [13,14]. A study conducted in New Delhi, India, also highlighted the importance of continuous education, showing that regular training improves compliance rates by over 70% [5,17]. These findings demonstrate that training is a vital factor in improving both awareness and behavior and should be a core component of national efforts to enhance biomedical waste management.

Conclusion

The analysis of biomedical waste management practices in Traghin reveals several critical challenges. A major issue is the lack of awareness among healthcare workers regarding proper waste handling and classification. Most staff had not received formal training, which negatively affected their daily practices particularly in handling non-sharp biomedical waste, which was often inconsistent and unsafe.

Additionally, the study found that healthcare facilities in Traghin suffer from a lack of essential resources such as protective gear, proper waste containers, and clear management protocols.

In conclusion, biomedical waste management in Traghin is inadequate and poses risks to health and the environment. Improving awareness, training, and resources at the local level is essential for safer healthcare practices and better patient outcomes.

Recommendations

1. Capacity Building and Sustainable Awareness:

Organize mandatory and regular training programs for healthcare workers on biomedical waste management, and integrate this topic into the curricula of medical and allied health colleges to ensure early awareness and instill proper professional practices.

2. Infrastructure Development and Resource Enhancement:

Provide essential supplies such as protective equipment, specialized containers, and incinerators, along with issuing standardized and user-friendly guidelines accessible in all healthcare institutions.

3. Strengthening the Legal Framework, Oversight, and Awareness:

Work towards adopting a unified national law to regulate healthcare waste management, ensuring accountability and the enforcement of penalties, in line with the 2024 draft law prepared under the supervision of the Legal Assembly. Additionally, conduct regular awareness campaigns targeting healthcare workers and the public to highlight the health and environmental risks associated with improper waste management.

Authors' contributions

K. R. Mukhtar conceptualized the study design, supervised the project, analyzed the data, and wrote the first draft of the manuscript. K. M. Ahmad contributed to writing and editing the manuscript. A. I. Altabet served as the overall supervisor of the project.

Conflict of interest

All authors declare that they have no competing interests and have no relationship with the industry or organizations.

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