Application of Hazard Analysis of Critical Control Points (HACCP) Method to Describe Critical Points in Healthcare Waste Management of Razi Hospital in Ghaemshahr, Iran During COVID-19 Pandemic in 2020

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Abstract

Background: During the outbreak of COVID-19 in developing countries such as Iran, the management of healthcare waste has become a very important issue. It is necessary to investigate the risk of virus transmission through direct contact, inhalation, and environmental pollution to reduce transmission risk. The Hazard Analysis of Critical Control Points framework is used to simplify quick responses of waste management for facing the novel infectious disease.

Objectives: The aim of this study was to use risk analysis frameworks to describe hazard critical control points (HACCP) and make recommendations and corrective actions for staff who work in healthcare facilities and communities experiencing the COVID-19 outbreak.

Methods: In the present descriptive-analytical study, a team of environmental health experts identified the critical control points of healthcare waste produced in Razi Hospital and divided them into three categories and six steps. A tested and verified hazard analysis flow diagram was prepared to determine critical points in different steps of healthcare waste management. Critical control points were identified and analyzed by the team at each step. Recommendations and corrective actions were made for each control point.

Results: The production rate significantly increased from 580 to 1,733 kg per day, probably caused by the increased use of disposable waste during the pandemic. Transportation, disinfection, and storage appeared to be associated with an individually high level of transmission risk of COVID-19 virus. Also, direct contact with infectious waste was often associated with a high risk of virus transmission. In the final disposal of healthcare waste, people were exposed to a lower level of risk.

Conclusions: Training staff in different wards of the hospital to use proper personal protective equipment (PPE), hand washing, disinfectants, and ventilation could reduce the risk of COVID-19 transmission through healthcare waste. Using the HACCP method for providing recommendations and corrective actions could simplify responses to reduce the transmission risk of COVID-19 during pandemics.

Keywords: COVID-19, HACCP Method, Healthcare Waste, Hazard Analysis

1. Background

Infectious diseases have become a great threat to human societies (1). On January 11, 2020, the World Health Organization (WHO) announced the sixth public health emergency in the world, which caused acute respiratory syndrome called COVID-19 (2, 3). In a short time, it spread to different countries all over the world, such as Thailand, Japan, Taiwan, and Iran (4-6). In February 19, 2020, the first case in Iran was officially announced, but it can be said that it was probably later than the real one (7). By March 2021, approximately 124,313,054 cases were confirmed in 221 countries, with more than 2,735,707 deaths (8). Given the importance of the issue, the pandemic caused unexpected challenges for local governments concerning how to deal with it (9). One of these progressive challenges, especially in populated cities, was how to safely dispose of healthcare waste (10). At the time of the outbreak of COVID-19 in Isfahan city, Iran, more than 1.49 and 2.98 million pieces of masks and gloves were disposed of as waste.
per day (11). Various types of medical and hazardous waste such as contaminated masks, gloves, and other protective equipment are producing every day, and proper waste management could cause a positive effect on health and the environment (12).

For the first time, the risk analysis method and critical control points were used to control healthcare waste and showed that this method provides a comprehensive and complete response in the shortest time to reduce the problems of landﬁlling, with the lowest cost (13). Also, the results showed that using HACCP risk analysis of four steps of chemical disinfection, personal protection, internal and external environment management, and life and medical waste management during the H1N1 inﬂuenza virus epidemic could lead to a rapid response and help reduce healthcare waste problems (14). Another study have shown that if the HACCP method performed continuously from the critical control point could do a proper management in shortest possible time (15). Implementing the HACCP method reduces the environmental load by modifying the waste segregation method (15). Due to the increasing use of disposable materials in these countries, the production rate of hazardous, infectious, and toxic waste has shown tremendous growth (16, 17). On the other hand, most test equipment such as nasopharyngeal test kits, personal protective equipment, and disinfectants are disposable and eventually change to waste (18). Disposal of COVID-19 contaminated waste is challenging. A study in India found that incineration of contaminated waste is the best option for disposal if it does not lead to environmental pollution (19). Healthcare wastes generated in a hospital in Sari-Iran, was 184,125 kg per day before the outbreak of COVID-19 (20). In Tehran-Iran, some healthcare waste is collected and treated, but in most cases, landﬁlled. According to the order of the relevant authorities Burning and preparing compost is prohibited (21). According to protocols collection of municipal solid waste and hospitals altogether considered as hazardous waste (22). About 75 & 25% of the wastes that have been generated in hospitals considered as public and hazardous waste, respectively (23, 24). Healthcare wastes in ﬁve hospitals-Iran increases 9%, compared to before the pandemic (25). One of the most important environmental issues for healthcare waste is to provide an efﬁcient and reliable management system (26), which categorized into six steps such as identiﬁcation, collection, separation, storage room, transportation, and disposal (27, 28). Plastic bags or containers with high-resistance is the best way to classifying healthcare waste (29). Steam incineration and sterilization (900 and 1200°) has been recommended by WHO for healthcare waste (30). Important production sources of healthcare waste in hospitals are diagnostics, laborato-

2. Objectives

With the spread of emerging infectious diseases and other threats to public health, healthcare systems and local governments face unexpected challenges. Existing health systems do not have a good solution to the emerging disease. Few studies have been conducted on healthcare waste management during the pandemic of COVID-19 in 2020. To begin the analysis, we divided the waste management steps into six basic steps: Production, collection, transportation, storage room, decontamination, and ﬁnal disposal. In this regard, we analyzed the risk levels of transmission routes such as direct contact, inhalation, and environmental pollution. The purpose of this study was to describe critical points in healthcare waste management of the studied hospital with the HACCP method.

3. Methods

To analyze the risk at critical points, we ﬁrst reviewed past studies, and then reviewed the guidance in studying HACCP development history and used examples of practical applications (43, 44). Based on the WHO guidelines, we referred to the 12 steps of the HACCP method. In the present descriptive-analytical study, we used the six-step HACCP method to describe critical control points
for healthcare waste management, similar to the study of recommendations for dealing with Ebola-contaminated waste (10). The six steps of the research were as follows: (1) gathering a team of environmental health experts with proper experience to analyze the risk of critical control points; (2) identifying healthcare waste in different wards of the hospital with acceptance of COVID-19 disease; (3) constructing a flow-diagram to determine critical points in different steps of healthcare waste management (Figure 1); (4) authenticating and testing the accuracy of the flow-diagram; (5) making a list of the types of healthcare waste and risk levels at critical points for staff (high, medium, and low-risk) associated with each step and running the analysis; (6) specifying critical control points for each step; and (7) making recommendations and corrective actions for each critical point.

3.1. Team

Our information was gathered via sending emails from environmental health experts to the research team. The analysis started when the members from the Universities of two provinces (Golestan and Mazandaran) feedbacked.

3.2. Process

In the present study, a systematic approach used to combine the opinions of experts and previous studies and the guidelines of WHO. After flow-diagram validation was fully examined, healthcare wastes were divided into three categories: Infectious, chemical-pharmaceutical, and sharp waste. In the initial steps of the study, we identified the most important healthcare wastes in terms of the type of waste and the risk levels in critical control points for employees (high, medium, and low risk). The risk of hazardous waste was calculated by previous studies, and the authors emailed the flow-diagram to a group of environmental health experts. They sent their recommendations and corrective actions to resolve problems in the shortest time. Also, for making the best recommendations and corrective actions, two health professionals who worked in the Health Ministry of Iran (a faculty and an environmental health expert) gathered WHO guidelines’ information and categorized emailed feedbacks. Critical virus transmission control points were identified, and recommendations and corrective actions were determined to reduce the risks.

3.3. Recommendations

We used the results of the HACCP method to describe critical points in the healthcare waste management of Razi Hospital, Iran, to make recommendations and corrective actions during the COVID-19 pandemic in 2020.

4. Results

4.1. Quantity of Healthcare Waste

Razi Hospital is one of the general hospitals in Ghaemshahr established in 1934. The different wards of this hospital included hospitalization, paraclinical, clinical, and COVID-19 hospitalization, with 234 active beds during the outbreak. In this regard, we classified the risk level in each critical point as follows: Direct contact, inhalation of particles, and environmental pollution.

Figure 2 shows the amount of waste generated in kilograms per day. The per capita amount increased from 1.49 to 3.84 kg/day-active bed during the COVID-19 pandemic.

4.2. Hazard Analysis

In the present study, we evaluated the healthcare waste management of Razi Hospital in Ghaemshahr during the COVID-19 pandemic at different steps related to production, collection, transportation, storage, disinfection, and final disposal (Table 1). Given the prevalence of various emerging diseases in the past, poor management of COVID-19 healthcare waste may cause high transmission in communities. Among the methods mentioned, we mentioned the stage where people were in direct contact with the waste as a high-risk step. There is an exception in the final disposal where disinfection operations are performed (Table 1). The other steps listed in Table 1 have a lower risk of transmitting the COVID-19 virus.

4.3. Analysis of Critical Control Points

In the present study, six important steps were identified to reduce the risks of virus transmission from healthcare waste. The types of healthcare waste generated at each step were determined as high, medium, and low-risk levels similar to past studies (10). Experts through emails and extensive searches of available articles, identified risk levels for each critical point. Recommendations and corrective actions were provided separately for each step (Table 1). For all waste management steps, we must prohibit direct contact with infectious materials and use (1) medical masks and N95 masks; (2) gloves; (3) shields (eye protection) and glasses; (4) long sleeve and apron; and (5) shoe cover. According to previous studies, changes in some behaviors reduce the risk of emerging diseases.

5. Discussion

The HACCP framework enables the rapid identification of hazards associated with the type of healthcare waste at each step (10). Using risk assessment to improve the healthcare waste management system increases the awareness
### Table 1. Recommendations of HACCP Method to Describe Critical Control Points in Healthcare Waste

<table>
<thead>
<tr>
<th>Waste Management Step</th>
<th>Types of Healthcare Waste</th>
<th>Risk Levels at Critical Points for Staff (High, Medium, and Low Risk)</th>
<th>Recommendations and Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Direct Contact</td>
<td>Inhalation</td>
</tr>
<tr>
<td>Production</td>
<td>Infectious</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td></td>
<td></td>
<td>High</td>
<td>Medium</td>
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<tr>
<td></td>
<td>Sharp</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Collection</td>
<td>Infectious</td>
<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
<td>Low</td>
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<td></td>
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<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Sharp</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Transportation</td>
<td>Infectious</td>
<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
<td>High</td>
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<td></td>
<td></td>
<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Sharp</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Storage room</td>
<td>Infectious</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
<td>High</td>
<td>High</td>
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<td></td>
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<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Sharp</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>Decontamination</td>
<td>Infectious</td>
<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
<td>High</td>
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<td></td>
<td></td>
<td>High</td>
<td>High</td>
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<tr>
<td></td>
<td>Sharp</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>Final disposal</td>
<td>Infectious</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Chemical-pharmaceutical</td>
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<td></td>
<td>Sharp</td>
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<td>Low</td>
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</tbody>
</table>
of the performance of health systems and environmental protection (54). Since 1960, the need for proper management has become more obvious and urgent with the increase in the production of healthcare waste in Asia (55). A study conducted during the COVID-19 pandemic in Wuhan, China, in 2020 showed that the reverse logistics network design model was used for short-term decisions to reduce the risks of transportation and disposal and the total cost of healthcare waste (18). A study in the United Kingdom showed that risk analysis at critical control points could be used to respond to infectious diseases to quickly identify hazards (56). We used the HACCP risk analysis method to describe the critical points in the healthcare waste management of Razi Hospital, Ghaemshahr, to protect the staff of different wards. The clinical profile of the virus is changing daily (57). Overcrowding is the most effective factor in the transmission of COVID-19 (58, 59). Using adequate ventilation in public places could reduce the risk of aerosols transmission (53, 60). Currently, the only way to control COVID-19 is to maintain good personal hygiene, increase immunity, and avoid to present in crowded places (61, 62).

Due to changes in the pathogenicity of COVID-19, it is possible that our recommendations and corrective actions to be change. A study in China showed the transmission of the virus from an infected person in the early steps of the disease and before the onset of symptoms (63, 64). In this regard, it is recommended to separate confirmed cases in the shortest possible time. During the pandemic, the amount of per-capita waste for each patient was higher than the average waste generated in normal conditions (65). Due to the high percentage of infection transmission from healthcare waste, it is better to dispose of it safely as

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**Figure 1.** Hazard analysis diagram and determination of critical points in different steps of healthcare waste management.

**Figure 2.** Amount of healthcare waste generated in kilograms per day in the studied hospital before (1) and after (2) the COVID-19 outbreak in Iran.
soon as possible (66). According to the United Nations Environment Program, incineration at 1000°C has been recommended for residual waste to eliminate the COVID-19 virus (67). If incineration is not available, a disinfectant containing sufficient chlorine can be used for disinfection (68, 69), and a low volume of pharmaceutical waste could be incinerated with infectious waste (70). A study conducted in China recommended using more automated facilities to reduce direct contact with infectious waste and healthcare waste (71). Also, transferring the healthcare waste from a virus-infected home or care center can spread the virus to other wider environments (10). To reduce the risks of healthcare waste in the UK and other countries exposed to the virus, they developed and installed sanitation systems in hospitals and health centers (72). In the event of a pandemic, it is possible to reduce the risk of transmitting the virus by switching from traditional to automated waste treatment systems (73). Waste collection in less than two days after production and burning infectious waste with a flawless incinerator and complete combustion should be a priority in emergencies (74). Waste management is necessary because of a lack of trained personnel, transportation equipment, inadequate waste segregation, and air conditioning (75). Hazard analysis of critical control points framework was used to simplify quick responses of waste management for facing the novel infectious disease and provides recommendations and corrective actions to avoid the existing hazards. However, by the rapid change of the way of infection transmission, it will be possible that our current recommendations are modified in future research.

5.1 Conclusion

By training staff in different parts of hospitals and encouraging them to use personal protective equipment (PPE), hand washing, disinfectants, and proper ventilation, the risk of COVID-19 transmission through healthcare waste can be reduced. Appropriate training programs and awareness should be provided for developing countries with a lack of technical management systems. We can use the HACCP method to provide recommendations and corrective measures to reduce the risk of transmitting the virus during emerging epidemics.

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Footnotes

Authors’ Contribution: Study concept and design, F.G.; Acquisition of data, SEM; Analysis and interpretation of data, F. G; Drafting of the manuscript, SF.M; Critical revision of the manuscript for important intellectual content, F. G; Statistical analysis, F. G; Administrative, technical, and material support, SF.M; Study supervision, F. G. All authors read and approved the final manuscript.

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