

# A Case Study on Medical Waste Management During the COVID-19 Pandemic in China

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**Abstract.** The COVID-19 pandemic has had a profound impact on medical waste management globally. In China, following the cancellation of the zero-COVID policy, a rapid outbreak of COVID-19 occurred in December 2022. This case study was conducted in January 2023 in a local hospital in Hangzhou City, China, with the aim of investigating the waste management process during and after the COVID-19 outbreak. The study focuses on various aspects of waste management, including waste generation, collection, storage, disinfection, and disposal. The findings reveal a significant increase in the amount of medical waste generated during the COVID-19 ward, posing challenges to the existing waste management system in the hospital.

**Keywords:** COVID-19; Medical waste management; Medical waste; China.

## 1. Introduction

In December 2019, the emergence of the Coronavirus2019, which later developed into a global pandemic in early 2020, prompted the World Health Organization (WHO) to officially name it COVID-19 [1]. China experienced a rapid outbreak of COVID-19 in December 2022, following the suspension of the 'zero-COVID policy.' The COVID-19 pandemic has had far-reaching effects on various aspects of society, including social activities, the economy, and healthcare systems. In particular, the surge in patients and the increased use of health-protective products in hospitals have presented significant challenges in the management of medical waste.

Medical waste is a unique category of waste due to its potential health and environmental risks. It typically includes sharps, human tissues or body parts, and other infectious materials [2]. During the COVID-19 pandemic, the generation of infectious medical waste has substantially increased. Disturbingly, inappropriate disposal methods for medical waste have been observed in many developing countries, with rates ranging from 18% to 64% [4]. Given this context, it is essential to investigate the management and disposal of medical waste during the COVID-19 pandemic.

This case study focuses on a local hospital in Hangzhou City, China, conducted in January 2023, after the COVID-19 outbreak. The study aims to examine the current waste management process, including waste generation, collection, storage, disinfection, and disposal. By analyzing the data and outcomes, this research seeks to identify the challenges faced by the waste management system in the hospital and provide suggestions for improvement.

The remainder of this paper is organized as follows: Section 2 describes the methodology used in this study, including data collection techniques. Section 3 presents the results and discussion, covering the classification of medical waste, the generation of medical waste during COVID-19, and the medical waste management process. Section 4 highlights the challenges identified and provides suggestions for addressing them. Finally, the conclusion summarizes the findings and emphasizes the need for further investigation and improvement in medical waste management during the COVID-19 pandemic.

## 2. Methods

### 2.1. Data Collection

To ensure the reliability of the study, multiple data collection methods were employed. Qualitative and quantitative techniques, such as interviews, were utilized. In addition, secondary data in the form of academic literature was gathered.

#### 2.1.1 Interviews

Data collection through interviews was conducted in January 2023, during site visits and by administering questionnaires. The interviews followed the recommendations of the World Health Organization for evaluating medical waste management in developing countries [5]. The focus of the interviews was on waste generation, waste composition, and waste management. The participants were staff members responsible for waste management in the selected hospital. The information obtained was based on physical analysis of hospital wastes.

To ensure comprehensive and in-depth responses, a semi-structured interview approach was employed. Tailored follow-up questions were asked based on the participants' answers to gain a deeper understanding of specific topics. The participants were thanked for their participation, and the researcher promised to share the interview transcripts with them prior to using them in the research.

#### 2.1.2 Secondary Research

Qualitative data was collected through desk research and literature review. This involved reviewing relevant literature and policy guidelines to determine the current definition of medical waste, policy framework, and the development of waste management systems in China. The utilization of this qualitative data allowed for the identification of implications that could be compared with the outcomes of the interviews.

### 2.2. Study Area

The study was conducted in Tonglu County, located in Zhejiang Province, East China. Tonglu County is under the administration of Hangzhou, the capital city of Zhejiang. It shares borders with Zhuji, Pujiang, Jiande, Chun'an, and Fuyang District. The total area of Tonglu County is 1852 square kilometers, with a population of approximately 400,000 [6].

The selected hospital for the study is a comprehensive traditional Chinese medicine hospital, covering an area of 1.5 hectares and employing 316 staff members. The fever department of the hospital is designated for COVID-19 patients, with an annual patient count of around 700,000 (data from 2019).

## 3. Results and Discussion

### 3.1. Classification of Medical Waste

The classification of medical waste in China shows in Table 1. Table 1 provides a comprehensive classification of medical waste, categorizing them based on their components and characteristics [7]. Each waste category represents a distinct type of waste that requires specific handling and disposal procedures to ensure the safety of individuals and the environment.

**Tissues:** This category includes human or animal pathological wastes, such as tissues, organs, blood, pus, and body parts and fluids. These materials are considered potentially infectious and pose a risk of disease transmission. Therefore, they require special handling and appropriate disposal methods to prevent any potential health hazards.

**Infectious Waste:** Infectious waste consists of items that are contaminated with blood, blood products, or other infectious materials. This category encompasses a wide range of materials, including microbiological laboratory wastes, quarantine wastes, dialysis wastes, used surgical operating clothes, infectious organ pieces, blood, and anything else contaminated with these

substances. Due to the potential for spreading diseases, it is crucial to handle and dispose of infectious waste with utmost care, following strict protocols and guidelines.

**Sharp Objects:** This category includes sharps, which are objects that can cause cuts or punctures. Examples of sharps include needles, syringes, broken glass, blades, and similar items. Proper disposal of sharps is essential to prevent injuries to healthcare workers, waste handlers, and the general public. Sharps containers and specific disposal methods are employed to minimize the risk of accidents and potential transmission of infections.

**Chemical Waste:** Chemical waste comprises various types of hazardous materials, including hazardous chemicals, heavy metal-containing wastes, pharmaceutical wastes, amalgam wastes, and gynotoxic and genotoxic wastes. These materials possess chemical or toxic properties that can be harmful to human health and the environment if not managed properly. Specialized disposal methods are necessary to minimize the release of pollutants and mitigate potential risks associated with chemical waste.

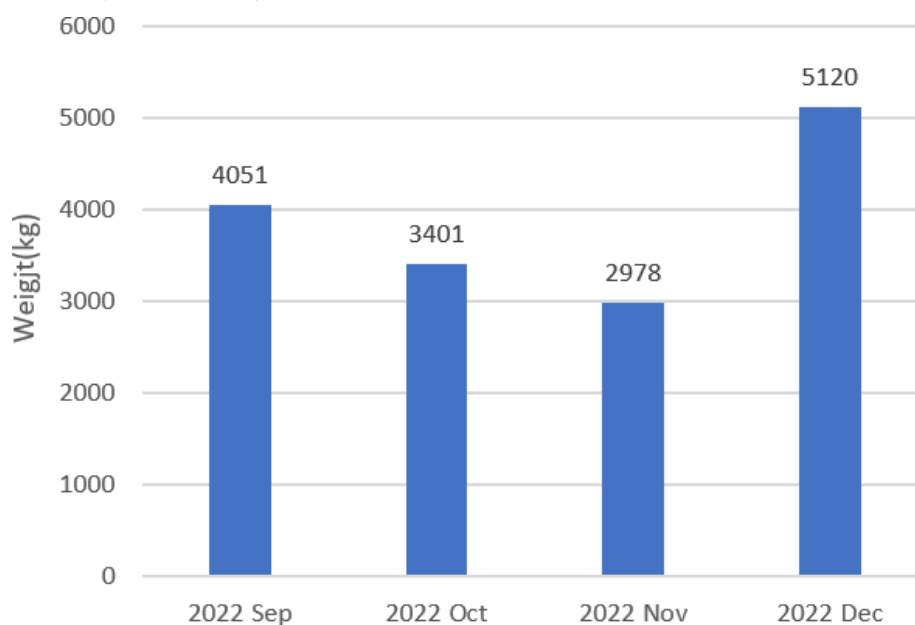
**Medicine Waste:** This category includes two types of medicine waste: expired or unwanted common medicines and discarded medicines that could cause cancers or genetic diseases. It also encompasses discarded vaccine products. Proper disposal of medicine waste is crucial to prevent the misuse or contamination of medicines and to minimize environmental impacts. Disposing of medicines safely helps prevent potential health risks and ensures the integrity of the medication supply chain.

Overall, Table 1 provides a comprehensive overview of the different categories of medical waste, highlighting the specific components and characteristics that define each category. This classification system serves as a foundation for implementing appropriate waste management strategies and protocols to ensure the safe and efficient disposal of medical waste.

**Table 1.** Classification of medical waste [7].

Waste Category	Components
Tissues	Human or animal pathological wastes, including tissues, organs, blood, pus, and body parts and fluids
Infectious Waste	Blood, blood products and objects that are contaminated with them; microbiological laboratory wastes; quarantine wastes; dialysis wastes; used surgical operating clothes; infectious organ pieces, blood and anything contaminated with these materials
Sharp Objects	Needles, syringes, broken glass, blades, and other items that could cause a cut or puncture
Chemical Waste	Hazardous chemicals, heavy metal containing wastes, pharmaceutical wastes, amalgam wastes, gynotoxic wastes, genotoxic wastes
Medicine Waste	Common medicines that are expired or are no longer required or are discarded; other medicines discarded that could cause cancers or genetic diseases; the discarded vaccine products

### 3.2. Medical Waste (COVID-19) Generation



**Fig. 1** Medical waste generated by COVID-19.

The hospital studied generated approximately 1.1 to 1.3 tons of medical waste per day, which doubled since the onset of the COVID-19 pandemic (see Fig. 1). The graph in Figure 1 illustrates the trend of medical waste generation specifically attributed to the COVID-19 pandemic. The y-axis represents the amount of medical waste generated, while the x-axis represents the timeframe, which can be daily, weekly, or monthly, depending on the available data. The graph indicates a significant increase in medical waste generation during the COVID-19 period compared to the baseline or pre-pandemic levels. The data points on the graph demonstrate the rise in medical waste quantities over time, highlighting the impact of the COVID-19 outbreak on waste generation in the studied hospital. By visually representing the data, Figure 1 provides a clear understanding of the magnitude of the increase in medical waste during the COVID-19 pandemic. This information is crucial for assessing the challenges faced by healthcare facilities in managing and disposing of the additional waste generated due to the pandemic. The graph can also help in identifying potential correlations between specific periods or events related to the COVID-19 pandemic and the corresponding increase in medical waste generation. This knowledge can aid in developing targeted waste management strategies and contingency plans to address the surge in waste during similar crises in the future.

Overall, Figure 1 serves as a visual representation of the significant rise in medical waste generation associated with the COVID-19 pandemic, providing valuable insights into the scale and impact of the waste management challenges faced by the studied hospital during this period.

### 3.3. Medical Waste Management Process

#### 3.3.1 Management Policy and Department

The Hospital Infection Management Department is responsible for medical waste management. They strictly follow the management policy and process. During the COVID-19 epidemic, medical waste generated as a result of COVID-19 cases is required to be packed in special containers—two layers of yellow medical waste packaging bags. These bags should be labeled with information such as the source, time, and recorder of waste generation. Transfer tools should have special red marks and corresponding marking characters to ensure that COVID-19-contaminated medical waste is not mixed with other waste. Proper handover of medical waste with transfer documents is necessary, and dedicated vehicles from centralized disposal units are used for transportation to prevent the loss of medical waste.

Medical waste centralized disposal units treat medical waste at high temperatures, converting it into harmless waste through incineration or landfill.

During the epidemic, plastic disposable infusion bottles were classified as household waste and required registration for recycling. Qualified plastic recycling companies are responsible for their disposal. These bottles should not be used in the production of plastic products that come into direct contact with the human body. Since the outbreak of COVID-19, all garbage needs to be treated at high temperatures to avoid the risk of COVID-19 contamination.

### **3.3.2 Medical Waste Collection**

The collection of medical waste is a critical step in the waste management process, ensuring the safe and proper handling of different types of waste generated within healthcare facilities. In the studied hospital, medical and health institutions follow the "Regulations on the Management of Medical Waste" for the classification and collection of medical waste. The collection process involves systematically gathering medical waste generated in the hospital according to its specific category. These categories include infectious medical waste, injurious medical waste, pathological medical waste, pharmaceutical medical waste, and chemical medical waste, as defined by the regulations. To ensure effective collection, hospitals should establish clear guidelines and protocols for waste segregation and collection practices. This includes providing appropriate waste collection containers that are properly labeled and color-coded to match the different waste categories. The containers should be designed to prevent leakage or spillage during collection and transportation. Healthcare staff play a vital role in waste collection, as they are responsible for segregating waste at the point of generation and placing it in the designated waste containers. Proper training and awareness programs should be conducted to educate staff on waste classification and collection procedures, emphasizing the importance of adhering to regulatory guidelines.

Regular waste collection schedules should be established to prevent the accumulation of waste and minimize potential risks associated with prolonged storage. The collection frequency may vary based on the volume of waste generated and the specific requirements of the healthcare facility. During the collection process, it is crucial to ensure the use of appropriate personal protective equipment (PPE) by healthcare workers to minimize the risk of exposure to potentially hazardous waste. This includes wearing gloves, masks, and other protective gear as necessary. Properly collected medical waste should be transferred to designated storage areas, such as waste transfer stations, where it can be stored safely until it is ready for transportation to waste treatment facilities.

By implementing effective medical waste collection practices, hospitals can ensure the proper segregation and handling of waste according to its category, minimizing the risk of cross-contamination and potential harm to healthcare workers, waste handlers, and the environment.

### **3.3.3 Medical Waste Storage**

Proper storage of medical waste is crucial to maintain a safe and hygienic environment within healthcare facilities. In the studied hospital, specialized medical waste bins are utilized for the storage of various types of medical waste. After work, the waste is uniformly collected and stored at the hospital's waste transfer station before being transported for further disposal. The medical waste bins used for storage are designed specifically for the containment of different types of waste, such as infectious waste, pathological waste, damaging waste, physical waste, or chemical waste. These bins are constructed to prevent leakage, spillage, or any other form of cross-contamination. They are also labeled appropriately to indicate the nature of the waste they contain. Once the waste is collected and stored in the designated bins, it is important to ensure that the storage area is properly managed. Protective clothing used during waste handling, such as gloves, masks, and gowns, should also be stored in specialized warehouses or designated areas. These storage areas should be well-maintained, clean, and organized to prevent any potential risks associated with improper storage practices.

Temporary storage of medical waste allows for consolidation and proper handling before transportation to waste treatment facilities. During the storage period, it is essential to adhere to recommended storage times to minimize the potential for odor, pest infestation, or any other factors that may affect the safety and hygiene of the storage area. Furthermore, temporary storage should also consider any specific requirements for waste segregation, such as keeping sharps separate from

other waste materials. This ensures the safety of waste handlers and reduces the risk of potential injuries or infections.

By implementing proper medical waste storage practices, hospitals can maintain a clean and safe environment, reduce the risk of disease transmission, and ensure compliance with waste management regulations. Effective storage procedures contribute to the overall efficiency and effectiveness of the waste management process, ensuring the well-being of healthcare workers, patients, and the community.

### **3.3.4 Infectious Waste Disinfection**

In the medical waste management process, the disinfection of infectious waste plays a crucial role in preventing the spread of diseases and ensuring the safe handling of potentially contaminated materials. In the studied hospital, infectious waste is centrally collected and subjected to disinfection procedures before being transported to waste treatment plants. The disinfection of infectious waste is carried out within the hospital premises, following specific guidelines and protocols. The exact disinfection methods employed may vary depending on the available resources and waste management practices in place. Commonly used disinfection techniques include thermal treatment, chemical disinfection, or a combination of both. Thermal treatment involves subjecting the infectious waste to high temperatures, typically through incineration or steam sterilization. Incineration is a thermal treatment method that utilizes high temperatures to combust the waste, effectively destroying pathogens and reducing the volume of waste. Steam sterilization, on the other hand, uses pressurized steam to sterilize the waste, rendering it safe for further handling and disposal.

Chemical disinfection methods may involve the use of disinfectant solutions or chemical agents that are effective in neutralizing pathogens present in the waste. These chemicals are carefully selected to ensure their efficacy in killing microorganisms while minimizing potential environmental impacts. The disinfection process aims to eliminate or inactivate infectious agents, reducing the risk of disease transmission. It is important for hospitals to follow established guidelines and regulations regarding the disinfection of infectious waste to ensure effective and safe practices. Proper documentation of the disinfection procedures, including time, date, and method used, should be maintained for record-keeping and auditing purposes. By implementing robust disinfection procedures, hospitals can ensure the safe handling and disposal of infectious waste, reducing the potential risks to healthcare workers, waste management personnel, and the general public. Disinfection plays a vital role in maintaining a hygienic healthcare environment and preventing the spread of infectious diseases.

### **3.3.5 Medical Waste Transportation and Disposal**

The transportation and disposal of medical waste is a critical aspect of the waste management process. Proper handling and transportation procedures are essential to ensure the safe and effective disposal of medical waste. In the studied hospital, medical waste is transported to centralized temporary storage units within the jurisdiction for further disposal. This transportation process should adhere to specific guidelines and regulations to minimize the risk of contamination and environmental pollution. To maintain the integrity of medical waste during transportation, dedicated vehicles should be used. These vehicles should be designed and equipped to prevent leakage or spillage of waste materials. They should also undergo regular cleaning and disinfection to maintain hygiene standards. Additionally, there should be clear regulations regarding the transportation time and route of medical waste within the hospital premises to minimize the potential for cross-contamination or accidental exposure. Once the medical waste reaches the centralized temporary storage unit, it undergoes appropriate disposal methods. In the case of the studied hospital, medical waste is treated at high temperatures. This treatment process involves either incineration or landfill, depending on the specific waste management practices in place.

Centralized disposal units are responsible for treating medical waste at high temperatures to convert it into harmless waste. Incineration is a common method used to eliminate infectious agents and reduce the volume of waste, while landfilling is employed for non-infectious waste that does not

require high-temperature treatment. It is crucial for hospitals to ensure that the transportation and disposal of medical waste comply with established guidelines and regulations. This includes having a well-defined transportation plan, proper vehicle maintenance, and coordination with authorized waste management facilities. Regular monitoring and audits should be conducted to verify compliance and identify any areas for improvement.

By ensuring proper transportation and disposal of medical waste, hospitals can minimize the risk of disease transmission, protect the environment, and maintain a safe and hygienic healthcare facility. Effective waste management practices contribute to the overall well-being of patients, healthcare workers, and the surrounding community.

## **4. Challenges and Suggestions**

### **4.1. Challenges**

#### **4.1.1 Insufficient understanding of the importance of medical waste management and disposal**

Hospitals lack adequate publicity and education on the management and disposal of medical waste. Medical staff often have limited familiarity with relevant laws and regulations. Insufficient knowledge in technology, safety protection, and emergency response further compounds the issue. This lack of environmental awareness and understanding of the importance of medical waste management can lead to improper disposal practices, such as mixing medical waste with household waste, thereby facilitating the spread of viruses.

#### **4.1.2 Backward construction of medical waste disposal facilities**

Although the state mandates the centralized incineration of medical waste, the majority of hospitals lack standard incineration facilities. Some hospitals may have in-house incinerators, but their incomplete incineration processes and limited environmental protection facilities result in secondary pollution. Additionally, high operating costs often render standard medical waste incinerators underutilized. Consequently, there is a delay in treatment or the misclassification of medical waste, leading to potential health hazards.

#### **4.1.3 Inefficient organizational structure and management system**

While county-level hospitals have established hospital infection management organizations, the implementation of these structures faces numerous challenges. Inadequate allocation of personnel, process design, and funding hampers effective implementation of management systems and measures. As a result, the supervisory role of management organizations is not fully realized.

#### **4.1.4 Inadequate organization of recycling and handover systems**

One of the challenges identified in medical waste management is the lack of a well-organized recycling and handover system. Each stage of the medical waste disposal process should have detailed handover procedures to ensure proper tracking and management. Additionally, the recovered medical waste should undergo registration for effective monitoring. For example, when medical waste is handed over from one entity to another, there should be a record of the source, name, weight or quantity, handover time, disposal method, final destination, and handler. This documentation is essential for accountability and traceability purposes. Furthermore, the data should be maintained for a specified period, typically three years, to ensure compliance with regulations and facilitate audits or investigations.

However, some hospitals face challenges in implementing a well-organized recycling and handover system. These challenges manifest in various ways. Some hospitals may have incomplete or insufficient registration practices, with missing or inaccurate information. In certain cases, medical waste may not be registered at all, leading to a lack of clear information on the waste generated and its subsequent management and disposal. Such gaps in the management and disposal of medical waste pose a risk of loss of accountability and undermined responsibilities at different stages of the waste management process. To address this challenge, it is crucial to establish a robust and standardized

recycling and handover system. This system should include comprehensive documentation and record-keeping practices, ensuring that all relevant information is accurately recorded and maintained. Clear guidelines and protocols should be established to guide the handover process and ensure consistency across different entities involved in medical waste disposal.

Implementing an efficient recycling and handover system will enhance transparency, accountability, and traceability in medical waste management. It will also contribute to the overall effectiveness and safety of waste disposal practices, reducing the potential risks associated with improper handling or disposal of medical waste. By addressing the challenges in the recycling and handover system, hospitals can improve the overall management and disposal of medical waste, ensuring compliance with regulations and best practices.

#### **4.1.5 Incomplete classification and collection management**

A significant challenge in medical waste management is the incomplete classification and collection of waste in many hospitals. Proper classification and collection are essential for implementing environmentally safe management of medical waste. However, current practices often fall short in ensuring strict adherence to these principles. Inadequate management of the quarantine process in hospitals leads to difficulties in the proper classification, packaging, and labeling of medical waste. As a result, different types of medical waste, such as infectious waste, pathological waste, damaging waste, physical waste, or chemical waste, are mixed together during collection. This lack of segregation makes it challenging to dispose of different waste types appropriately, increasing the risk of improper handling and potential harm to human health and the environment. To address this challenge, hospitals need to prioritize the implementation of strict waste classification and collection management procedures. This includes raising awareness among staff about the importance of proper waste segregation and providing training on waste management protocols. Clear guidelines and standard operating procedures should be developed and communicated to ensure consistent and accurate classification and collection practices. Furthermore, hospitals should invest in appropriate waste collection containers and equipment that facilitate proper segregation and ensure the safe handling of different waste types. Adequate signage and labels should be used to clearly indicate the nature of the waste and its associated risks. By improving the classification and collection management of medical waste, hospitals can enhance the overall efficiency and safety of waste disposal processes. Proper segregation of waste streamlines subsequent treatment and disposal procedures, reducing the risk of cross-contamination and minimizing the impact on the environment.

It is crucial for hospitals to recognize the importance of complete classification and collection management and allocate the necessary resources and training to ensure its effective implementation. By doing so, hospitals can mitigate potential risks and contribute to a more sustainable and environmentally responsible approach to medical waste management.

#### **4.1.6 Potential risks in the packaging, transportation, and storage process**

China has clear regulations regarding packaging materials, container standards, and warning labels for medical waste. However, many hospitals fail to comply with these regulations. For example, waste is often not packed into puncture and leakage-resistant sharp toolboxes, and medical waste is not sealed in yellow plastic bags designed to prevent leakage. Furthermore, transportation vehicles are not dedicated, resulting in littering during transportation and environmental pollution within the hospital. Temporary storage facilities may not meet national laws and regulations, as they are often located outdoors or stored in dilapidated buildings without proper sealing or dedicated management systems, thus posing a risk of environmental pollution.

## **4.2. Suggestions**

County-level hospitals should strengthen their management systems and disposal processes for medical waste throughout the entire lifecycle. This includes improving the management and awareness of hospital infections, providing training on relevant knowledge and skills to medical staff,

optimizing the management and disposal processes of medical waste, protecting the hospital environment, controlling hospital infections, and preventing the spread of pathogenic microorganisms.

## 5. Conclusion

The COVID-19 pandemic has presented significant challenges to the medical waste disposal system. The amount of medical waste generated during peak periods was approximately twice the daily average. The studied hospital demonstrated effective management of the high volume of medical waste generated by COVID-19 cases, including proper classification, collection, storage, disinfection, transportation, and disposal. However, several challenges were identified, including inadequate understanding of the importance of medical waste management among staff, backward construction of medical waste disposal facilities, inefficiencies in the organizational structure and management system, and shortcomings in the recycling and handover systems. Additionally, incomplete classification and collection management, as well as potential risks in the packaging, transportation, and storage process, were observed. To address these challenges, it is recommended that county-level hospitals prioritize the improvement of their management systems, enhance staff training, and establish more efficient and comprehensive medical waste treatment facilities. Furthermore, emphasis should be placed on strict adherence to waste classification and collection guidelines, as well as the implementation of proper packaging, transportation, and storage protocols. In conclusion, further investigation and improvement are necessary to enhance medical waste management during the COVID-19 pandemic.

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