

The Current Status and Future of Medical Waste Disposal in China

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Abstract—Medical waste is a kind of hazardous waste with complicated components and particular damage, which easily contaminates the surrounding soil, atmosphere, underground water, and human health. Based on the analysis of the gap between the current situation and disposal demand of medical waste disposal, this study expounds on the problems of the centralized medical waste disposal system in each link, which can be roughly classified as lagging treatment capacity, lack of modern medical waste disposal process in rural and remote areas, and imperfect management system. At the same time, in response to the above problems, this paper proposed to add specific medical waste treatment guidance manuals to the system and clarify the standards and norms of each link. In rural areas, this paper suggested actively training medical staff and increasing modern medical waste disposal technology. In technology, this paper advises using more environmentally friendly disposal equipment and recycling uncontaminated high-value medical plastics to reduce the cost of medical institutions.

Keywords—COVID-19, medical waste, medical plastic

I. INTRODUCTION

The document, which was published by WHO, clearly indicates that the term medical waste encompasses all waste generated in healthcare facilities, research centres, and medical laboratories. It also includes waste from smaller, decentralized sources, such as waste produced during home healthcare activities like home dialysis, self-administration of insulin, and recuperative care. Medical waste is also divided into two categories (Fig. 1): non-hazardous waste, like ordinary domestic waste that does not require special disposal, accounting for about 85% of medical waste. The other category is hazardous waste, which accounts for only 15% of medical waste [1].

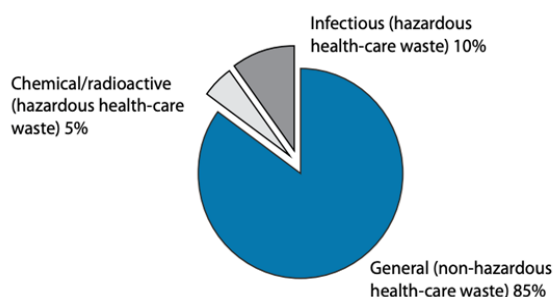


Fig. 1. Typical waste compositions in medical waste facilities [1].

In China, according to the Medical Waste Management Regulation (the original title is Chinese version) published by the State Council [2], medical waste refers to waste generated by medical and health institutions during medical, prevention, healthcare, and other related activities that may pose direct or indirect infectious, toxic, or other harmful

risks.

Medical waste can transmit more than 30 types of microbial diseases through blood and other body fluids [3]. So, the unregulated disposal of medical waste poses a significant health risk to the public environment, which can lead to the exposure of healthcare professionals, waste handlers, and the local community to infections, harmful substances, injuries, and environmental contamination. Furthermore, speaking of undeveloped place, the disposal mechanism of medical waste without any circulation systems of disposal of noxious substances is more likely to release many great amounts of toxic gases: dioxins, sulfur dioxide, suspended particulate matter, nitrogen oxides, benzene compounds are scattered with the wind and seriously pollute the atmosphere. Apart from the atmospheric contamination, medical waste is also the pollution of the water environment. After the landfill, wastewater was leached by fermentation and rainwater, washout, and immersion of surface and groundwater, which are major factors in serious contamination of the surrounding surface and groundwater [4].

With the growth of the population and the development of the social economy in China, the production of medical waste has also gradually increased in the past decade (Fig. 2).

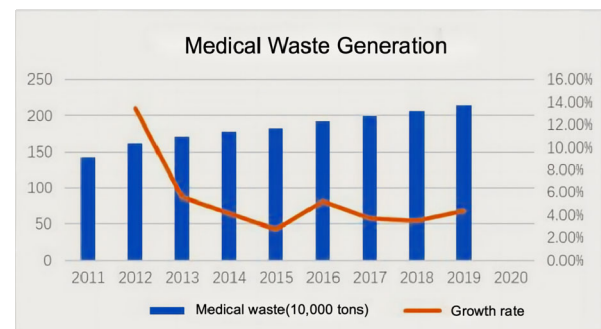


Fig. 2. Medical waste generation in the last decade [5].

Especially during the period of the outbreak of the COVID-19 pandemic, the enormous quantity of medical waste generated continues to increase, with an annual total exceeding 5.8 million tons, of which hazardous waste constitutes over 20% [6], posing serious challenges for management.

This amount of medical waste generated in severely affected areas far exceeds their existing disposal capacity [7], especially in rural areas. Meanwhile, the COVID-19 virus is not easily sterilized, Kampf *et al.* [8] found that the COVID-19 virus can exist for approximately 9 days on various surfaces like steel, plastic, and glass. Thus, epidemic-related medical waste has a great risk of infection, especially in the

case of under-developed or developing countries which have limited medical waste management systems [9].

In early 2020, the national government urgently issued requirements for the emergency control and management of medical waste during the pandemic. Through various means, disposal capacity was enhanced, which allowed for the overall proper disposal of medical waste in severely affected areas. However, during this process, it also became evident that China's emergency medical waste handling capabilities have weaknesses. Local medical waste emergency response plans had limited practicality, there was a shortage of emergency supplies, and the primary approach relied heavily on large-scale administrative measures, resulting in an overall passive emergency response [6].

Medical institutions in many middle- and lower-income regions have few or no arrangements for the organized collection and disposal of the waste that they produce [10]. Historically, there haven't been nationally standardized requirements for medical waste disposal facilities in counties and lower-level administrative regions. How to dispose of medical waste depends on the determinations of county-level authorities [11]. Moreover, since these clinics are too scattered, the relevant authorities are beyond their reach in management, which makes it difficult to track and monitor medical waste. Therefore, harmfulness caused by the segregation, safe storage and handling of health care waste from township hospitals and village clinics in regions under the county level is usually neglected, compared with household waste. Before the outbreak of COVID-19, the capacity for handling medical waste in township hospitals and village clinics was very weak [12]. Through searching this topic, there is little research about medical waste in rural areas in China.

Therefore, this paper aims to reveal the current issues of disposal of medical waste in an entire procedure and put forward some suggestions for improving medical waste management strategies from multiple aspects. In addition, this paper provides an overview and future direction of medical waste management and emphasizes the realization of the harmlessness of medical waste, to carry out a circular economy that conserves resources and strengthens the overall construction of the ecological environment.

II. LITERATURE REVIEW

A. Classification of Medical Waste (Characteristics of Medical Waste)

Medical waste is mainly divided into infectious waste, sharps waste, pathological waste, pharmaceutical waste and chemical waste [13].

1) Infectious waste

Infectious healthcare waste is considered waste that includes infective pathogens, leading to disease incidence and progression [14], materials tainted with blood and body fluids, human excreta, laboratory cultures, and microbiological products belong to infectious healthcare waste [1].

2) Sharps waste

Used or unused hypodermic, intravenous, or other needles, auto-disable syringes, syringes with attached needles,

infusion sets, scalpels, pipettes, knives, blades, and broken glasses are regarded as the sharp waste [1, 15].

3) Pathological waste

Pathological waste includes tissues, organs, body parts, blood, body fluids and other waste, which are taken from surgical or microbiological specimens from humans and animals whether they contain infectious disease or not [1].

4) Pharmaceutical waste

Chartier *et al.* [1] articulated that overdue and polluted pharmaceutical products are considered pharmaceutical waste. Moreover, according to Malsparo which is a public website made of people who are devoted to reaching overall goals of medical waste management, used biological products for therapy and transdermal patches, and contaminated pharmaceuticals including vaccines, are also listed as pharmaceutical waste. Besides, according to medical institutions that promote the classification and management of domestic waste [2], infusion bags involving cytotoxic drugs (such as tumour chemotherapy drugs, etc.) are disposed of as pharmaceutical medical waste.

5) Chemical waste

Chemical waste contains laboratory reagents, film-developing reagents, expired/unused disinfectants, solvents, and waste containing heavy metals (batteries, broken thermometers, blood-pressure gauges, etc.) [1]. However, Das *et al.* [14] stated that a great number of facilities in both developing and developed countries still utilize these toxic chemicals and have a paucity of chemical waste management measures.

6) Plastic medical waste during epidemics

During the special period, any plastic products used or given to patients in quarantine are included as medical waste. According to the proportions of different types of medical plastic [16], there are two types of medical plastics (Fig. 3), one is used outside the human body and the other is implanted into the human body for use. Because the treatment of medical waste needs to be discussed, only medical plastics that need to be used outside the human body need to be considered.

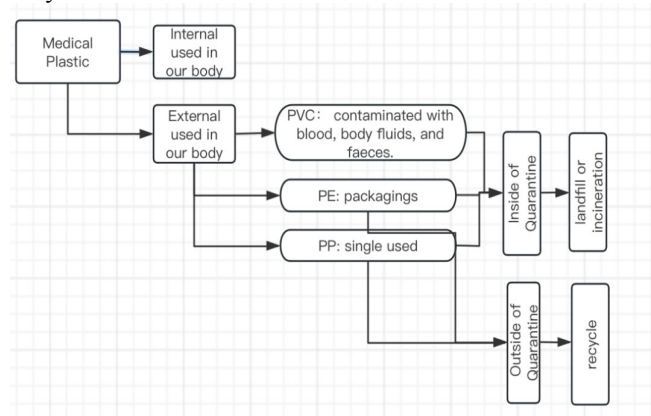


Fig. 3. The classifications of medical plastic.

Polyvinyl Chloride (PVC) and Polyethylene (PE) are the two most extensively used materials in the medical industry, followed by Polypropylene (PP) (Fig. 4). Notably, PVC stands out as the predominant material employed in the production of single-use sterile medical instruments. By

incorporating a plasticizer known as di(2-ethylhexyl) phthalate (DEHP), PVC transforms into a material with enhanced chemical stability and cost-effectiveness, commonly referred to as plasticized PVC [17]. replacing traditional materials such as natural rubber and glass in medical devices. Additionally, plasticized PVC possesses transparency and ease of sterilization, making it a preferred choice in the manufacturing of medical equipment. Examples: Blood bags, hemodialysis lines, respiratory masks, oxygen tubing, urine bags, IV tubing, artificial ears and noses [18].

Polyethylene (PE) is the largest general-purpose plastic, which is suitable for food and drug packaging materials, tableware, medical equipment, etc. Examples: vials, needle caps, syringe pushers, infusion set flow regulators, pouches for infusion sets and syringes [18].

Polypropylene (PP) has excellent chemical resistance, fatigue resistance, and heat resistance, and can be sterilized at temperatures above 100 °C. Easy to process with no environmental stress cracking issues [19]. Medical PP has high transparency, good barrier and radiation resistance. Examples: Infusion bags, disposable syringes, disposable gloves, intravenous zona pellucida tapes, connectors, parenteral nutrition packaging, dialysis membranes, etc. In the new coronavirus epidemic prevention, the most common PP medical products are medical masks, which are composed of melt-blown cloth and non-woven fabric (Fig. 5).

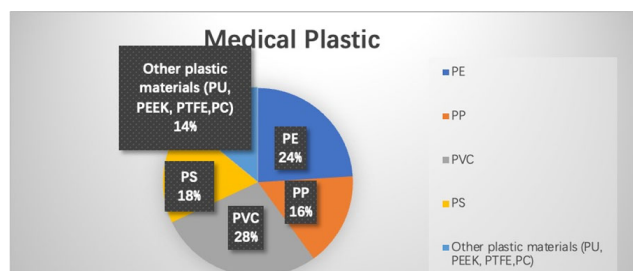


Fig. 4. The proportions of different medical plastic.

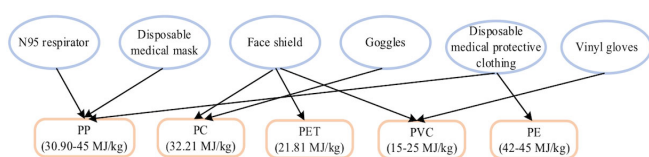


Fig. 5. The main ingredient of PPE and the calorific value of plastic polymers [7].

B. Hazards of Medical Waste

Medical waste typically contains a significant number of organic compounds (such as human organs, plastics, cotton swabs, paper, textiles). If the medical waste generating unit is allowed to dispose of it at will, it is not only difficult for these medical wastes to be completely degraded in nature through the self-cleaning ability of the environment,

but also damages the ecological environment due to viruses, chemicals, radioactive materials, etc., like attracting and supporting the breeding of mosquitoes, flies, rodents, and cockroaches, and thereby contribute to disease transmission [20]. At the same time, long-term exposure to environmental conditions such as wind, sun, and rain will inevitably cause serious pollution to the surrounding soil, air,

and water resources. This is also the root cause of the high potential pollution risk and high disposal cost of medical waste [21].

During COVID-19, people used a lot of masks and can be seen throwing them on the ground at will. Masks are also plastic fibres. If they are not handled properly, they will cause fires and the plastic will enter the land [22].

C. Current Status of Medical Waste in China

1) Developing legislation

Cheng *et al.* [23] presented that the safe disposal of medical and hazardous waste in China started late, and the ‘SARS’ epidemic in 2003 was a watershed moment in pushing the standardization of the disposal of medical and hazardous waste in China. In the same year, the State Council approved the implementation of the ‘National Construction Plan for Facilities for the Disposal of Hazardous Waste and Medical Waste’ which is the first regulation focused on medical waste in China. This regulation significantly enhanced the standardization of medical waste management [23]. The National Development and Reform Commission (2008) offered a comprehensive plan for the subsequent implementation of these objectives [24]. Cheng *et al.* [23] presented that the manufacturing industry has experienced rapid growth over the past decade. However, variations in industrial distribution across regions have led to significant changes in the types, quantities, and distribution of waste. The disposal devices’ layout and capacity have been struggling to meet the actual demand for medical waste treatment. Gradually, there were various loopholes in aspects such as management, collection, and disposal of medical waste [25]. In 2020, the National Hazardous Waste List was revised again, and the new version of the Hazardous Waste List lists three categories of medical waste. In 2020, the newly revised Law on the Prevention and Control of Environmental Pollution by Solid Waste strengthened the supervision of medical waste in response to the epidemic, clarified the regulatory responsibilities, highlighted the main position and arranged funds for major infectious disease emergencies.

2) Negative impacts

A majority of disposal constructions were built in 2003 and 2011, which are old and outdated, resulting in not satisfying the increasing demand for medical waste treatment in each city [26]. Therefore, before the pandemic, there were already some medical waste disposal facilities with high load rates. According to the research of the Guangzhou Green Network Environmental Protection Service Center, which is a non-profit organization dedicated to pollution prevention and control by utilizing environmental data analysis to encourage public participation and amend environmental policies, demonstrated that elementary healthcare institutions produced the majority of medical waste which far exceeds their ability to cope with. Under the public information on the disposal of medical waste in 2018 (total of 158 cities), They discovered that there are 74 cities, in which the load rate of disposal medical waste facilities is over 80% [27].

This has also led to a significant gap in the disposal of medical waste. In addition, since plastic medical waste is

usually made from better quality polyethene and Polypropylene (PP) materials and the granulation yield of this type of plastic is as high as 70%, which is a competitive raw material for recycled plastics, and the purchase price of plastic medical waste is lower than that of traditional waste plastics [28], many people took the risk of recycling plastic-based medical waste, which was then widely used as a high-transparency material in the fields of culture, entertainment, food, health care, interior decoration, etc. It was difficult to trace the destination of these materials. Similarly, because of the neglect of medical plastic waste recycling supervision at that time, the collusion between the relevant staff of medical institutions and medical waste disposal centres was further intensified.

According to China News's report [29], the illegal trading of medical waste has occurred in various regions across the country. They reported that these source materials were sold without being cleaned and contained a significant amount of potential viral and bacterial contaminants, like transfusion bags contaminated with patients' blood and bodily fluids, and infusion tubes with needles not removed (Fig. 6).

To avoid supervision by regulatory authorities, recycling production lines are often hidden in remote rural areas. At the same time, during the processing, wastewater discharge can cause serious pollution to local groundwater, soil, agriculture, etc., and the emission of large amounts of toxic gases can also pollute the air and affect human health (Fig. 7).



Fig. 6. Contaminated medical waste (Source: crime scene photo provided by the law enforcement agency).



Fig. 7. Medical waste in a village (Source: crime scene photo provided by the law enforcement agency).

Some experts believed that the reason for this is that the centralized collection, transportation, recycling or disposal of medical waste relies heavily on manual labour and has poor traceability [30]. When the arrival of the epidemic, this emergency accelerated and exposed the shortcomings of

China's medical waste treatment system.

3) During the pandemic

Due to the impact of the epidemic, national medical waste generation has increased rapidly over the past three years, according to the 'legal daily' report done by Qie [31], after the outbreak of COVID-19, at the early stages of outbreak, the daily disposal was only slightly over 2000 tons, but when reaching the peak of disposal, the daily disposal of medical waste nationwide (including medical wastewater and medical garbage) reached a peak of over 3200 tons, increasingly 60%. Furthermore, according to the "press conference", the person in charge replied to reporters that in 2021, a total of 1.4 million tons of medical waste were generated across the country (of which 201,000 tons were related to the epidemic), an increase of 18.6% and 11.1% respectively compared with 2019 and 2020.

In some cities or regions that lack proper medical waste disposal facilities, the amount of medical waste generated had increased, resulting in a multiplication of disposal loads. The accumulation of medical further escalated the risk of the spread of the epidemic.

Subsequently, on January 21, 2020, against the COVID-19 pandemic, the Ministry of Ecology and Environment released the "Technical Guidelines for Emergency Disposal Management of Medical Waste during the Pneumonia Epidemic of Novel Coronavirus Infection (Trial)" [11]. It standardized medical waste treatments, which effectively guided each region to manage medical waste in an organized, efficient, and harmless manner [25], resulting in the disposal of medical waste and sewage across the country being stable and well-organized without any environment issues caused by the epidemic. Meanwhile, there are also many regions that have successively reserved a considerable number of collaborative emergency disposal facilities, which has greatly improved China's medical waste disposal capacity. As of the end of 2021, there are a total of 540 centralized medical waste disposal units across the country, with a centralized disposal capacity of 2.15 million tons per year, representing a 39% increase compared to pre-pandemic levels (as of the end of 2019) [32]. The person who oversees the management of medical waste stated 'From the recent situation, the disposal of medical waste in medium and high-risk areas nationwide remains stable. In the past three months, across cities (prefectures) and municipalities directly under the central government in these areas, the daily average load of medical waste disposal facilities has been below 90%. In these regions, all medical waste is appropriately disposed of, and pandemic-related medical waste is cleared daily.

During the epidemic period, in addition to the regular regulatory and law enforcement tasks, a large number of new tasks will be added, such as medical waste incineration waste gas monitoring, medical waste incineration waste gas monitoring, medical institution wastewater monitoring, medical wastewater treatment sludge monitoring, water source water quality safety monitoring, and other emergency tasks water source safety monitoring. At the same time, the temporary decentralized emergency disposal of large quantities of medical waste has also brought more pressure on environmental supervision and law enforcement.

4) Urban areas—Using Hengshui as an example

Hengshui City has taken various measures to ensure effective management of medical waste. Firstly, a comprehensive medical waste management system has been established. At least one medical waste transfer point is set up in each township or community, and medical and health institutions with more than 20 beds have temporary storage points. Medical waste is collected and transported directly by the centralized disposal unit every two days. Currently, the city has established 124 medical waste transfer points and 108 temporary storage points, achieving full coverage of medical waste collection and a 100% rate of centralized disposal.

Secondly, strict supervision responsibilities for medical waste have been implemented. A sound comprehensive medical waste supervision and management mechanism has been established, expanding the coverage of medical waste supervision and law enforcement while intensifying supervision and inspections. Typical cases are inspected and handled to resolutely curb illegal activities such as the illegal transfer, dumping, utilization, and disposal of medical waste. Moreover, a sound responsibility system for medical waste management in medical and health institutions has been established, with clear job responsibilities and dedicated personnel responsible for supervision and inspections.

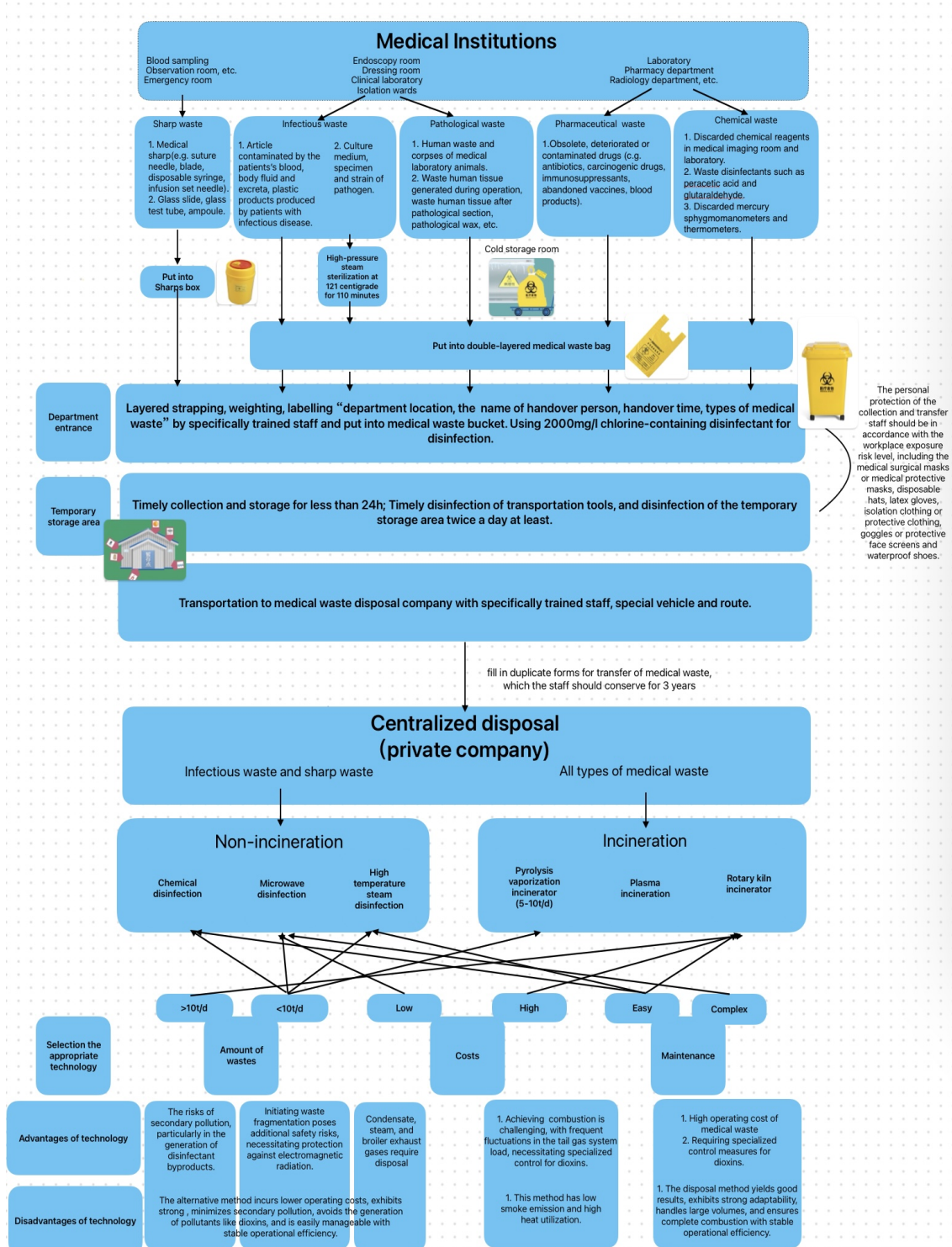


Fig. 8. The process of treatment of medical waste during the epidemic.

Thirdly, information-based management of medical waste has been realized. Leveraging information technology, closed-loop intelligent management of medical waste throughout its “generation, collection, temporary storage, and handover” has been comprehensively achieved. A full-process information-based supervision model has been adopted to ensure traceability throughout the medical waste management process, effectively preventing risks. Presently, medical institutions in the city that generate more than 3 tons of medical waste per year have completed the installation and networking of the provincial solid waste information management platform. Additionally, grassroots medical institutions with fewer than 20 beds have achieved standard sewage treatment [13].

5) Rural areas—Using my hometown as an example

During the field research in the author’s hometown, a small villages in Hebei province, it observed strict adherence to guidelines, especially during special circumstances. Medical waste was handled meticulously—for instance, they carefully removed strings from needles before disposal. Each type of medical waste generated by township or community clinics was diligently documented. Upon the arrival of the medical waste collection trucks, an electronic form was used to coordinate the staff involved in the process. After thorough confirmation by the staff, they would digitally sign the form, signifying their responsibility for the collection process. At the end of the work shift, the area would be sterilized using spray disinfectant and ultraviolet radiation. If the quantity of medical waste did not align with the purchased amount, the responsible government department for medical waste management would be alerted via the Internet. Medical waste in rural areas will eventually be returned to cities to process.

6) Process of treatment medical waste during epidemic

Liu *et al.* [33] conducted a study involving 125 hospitals in China and discovered that the primary types of hospital waste are infectious waste and sharp waste, making up 87.00% and 11.34% of the total hospital waste, respectively. It can be concluded that most medical waste facilities produce a larger percentage of infectious waste.

This paper summarized the process of medical waste disposal based on many documents [10, 14, 34–36] (Fig. 8).

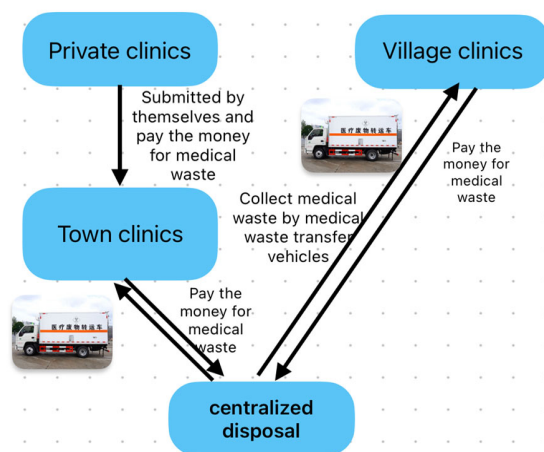


Fig. 9. Collection of medical waste in rural areas.

Otherwise, in rural areas, clinics provide timely basic

health security to residents during COVID-19. The medical waste generated during operation is mainly infectious waste, with a very small amount of damaging waste [37]. According to my field research and Lv’s study, I made this diagram to show how medical waste can be collected in rural areas (Fig. 9).

7) Medical waste emergency disposal techniques

According to the trial, mobile medical waste disposal facilities, hazardous waste incineration facilities, and municipal solid waste incineration facilities have been included in the list of emergency medical waste disposal resources. These mobile facilities utilize incineration, microwave disinfection, and steam disinfection technologies, with microwave disinfection having the highest usage rate (55.88%), followed by incineration (32.35%) [38]. On March 21, 2020, the total disposal capacity of the mobile facilities reached 75.6 tons per day. For microwave disinfection, although the maintenance or disposal procedure is complex, it has low operating costs and can effectively reduce secondary pollution, thus it is suitable for the disposal of small amounts of medical waste. However, for the fixed huge disposal facilities, adopting incineration is better than adopting non-incineration.

III. DISCUSSION

A. Issues with Medical Waste in China

Through a literature survey method and some reports, this paper summarized that the following problems in the emergency management and collection and disposal of medical waste in public health emergencies in China were exposed during COVID-19.

1) Classification issues

1. Our country divided medical waste into five categories according to the “Medical Waste Catalog”, which has lasted for nearly 20 years, but because of economic development and technological progress, the types of medical waste have gradually increased. There will be new medical waste-related substances such as radioactive substances.

2. The classification method of China’s current medical waste directory requires the operator to have strong professionalism, and the boundary between categories is blurred, which has led to confusion about medical waste classification in the actual operation process. Therefore, in rural areas or economically undeveloped areas, village doctors or staff who are not highly specialized, or they usually do not need very professional knowledge are puzzled by that classification method. Luo *et al.* [25] surveyed the situation of medical waste classification. They found that the problems of classified of disposal pathological, pharmaceutical, and chemical waste are prominent, as the classified disposal methods of other common waste, like disposal products are not uniform.

In rural areas, there is a lack of separate containers, such as sharps boxes, so the separate collection is not strictly implemented [37].

2) Collection issues

During the medical disposal process, staff may not follow standardized or complete safety protection measures. Although elementary medical institutions conduct regular

training on safety precautions, monitoring the safety practices of relevant staff in real-time is challenging. The protective procedures are complex and require a significant amount of time, leading to insufficient awareness of safety precautions among personnel. Zhang *et al.* [39] researched and concluded that the degree and age of staff in elementary medical institutions are low.

By the requirements of the Medical Waste Management Regulations, the temporary storage facilities for medical waste in medical institutions should be situated away from medical and personnel activity areas [40]. These facilities are expected to implement measures to prevent theft and oversight, undergo regular disinfection and cleaning, and display clear warning signs. However, it has come to attention that some hospitals still have parking spaces adjacent to their medical waste storage areas.

As China's medical waste disposal management work started late, the construction of earlier hospitals did not include medical waste storage-related sites. Hospitals had only begun to transform the ageing buildings and yards into medical waste storage rooms and other related places. However, many early private hospitals, village health offices, clinics and other primary healthcare institutions were in the predicament of insufficient area, so the improvement of medical waste storage cannot be promoted. There are no clear warning signs, and there is a lack of washing, disinfection and sterilization, drainage facilities and equipment, no anti-seepage treatment of the ground, and no a professional staff to manage medical waste, leading to the medical waste is often piled up in the back of the clinics, the aisles, the consultation room or miscellaneous goods room, and other places where people frequently pass by [37].

In elementary medical institutions (e.g., village health offices and clinics), where, in the absence of effective monitoring, the managers of temporary storage areas are more likely to engage in non-standard operating behaviours due to a lack of self-consciousness, such as not installing ultraviolet lamps in the staging rooms. These problems on the one hand increase the risk of nosocomial infection of medical waste and the risk of environmental pollution of medical waste, and on the other hand, will have an impact on the subsequent handover and harmless disposal.

3) Transportation issues

In urban areas or developed areas, electronic forms and QR codes have already been used by staff to connect centralized disposal centres, which is convenient and efficient for tracing the process and weight of medical waste.

However, in the remaining areas, staff should fill out the data and information: registration of medical waste generated by each medical waste-generating department, the registration of the handover of the hospital's cleaning personnel and each department, the records of the temporary storage room and the handover of the centralized disposal centre. This method leads to all the data being prone to omissions, errors and delays, and the amount of calculation and storage is very large and prone to subjective bias, increasing the cost of medical waste disposal in the clinics.

4) Treatment and disposal issues

In fact, centralized disposal centres as private disposal agencies dispose of medical waste by regularly charging

fees from hospitals because the "polluter pays principle" is the cornerstone of the establishment of China's medical waste disposal fee system, which means that those who produce are responsible for waste. For most higher-level medical institutions, medical waste disposal fees are paid according to the bed [41]. Although China has established a medical waste disposal fee system, there are still many places that need to be further clarified and improved. The reason is that the public cannot ensure that centralized disposal centres dispose of medical waste completely. The centralized disposal centres are not nationalized, which is likely to be an unstable factor affecting national security. And, usually, an area only has a centralized disposal centre to dispose of medical waste.

5) Regulatory issues

There is a lack of a coordinated regulatory mechanism for medical waste treatment in China. According to the Regulations of Management of Medical Waste, the environmental protection department is responsible for environmental pollution work, and the health department is responsible for disease prevention and health protection of medical waste management. They have not set up a regulatory department with professional knowledge and expertise to improve the efficiency of supervision.

The regulations do not explicitly require these two departments to carry out regular testing and evaluation of the environmental pollution prevention and health and safety effects of medical waste disposal facilities. However, all testing activities are submitted or reported to officers by centralized disposal themselves. Moreover, the usual medical waste-related data are kept separately by the hospitals and the centralized disposal centres, so supervisory officers do not have specific data about the situations of medical waste facilities. This fully reflects the lack of uniformity of data in the process of medical waste disposal management and the closed state of information of various departments, having a certain impediment to improve the legal awareness of the whole population.

B. Analysis of Causes

By analyzing the above problems, we can see that there are imperfections in the legal system from the national level to the local level, resulting in the occurrence of issues.

1) China's medical waste legal system

China has increasingly emphasized the management of medical waste disposal in the past decade, and a comprehensive legal framework has been establishing. The definition of management processes and boundaries remains unclear, and there is a lack of detailed constraints in various aspects of medical waste disposal management. This ambiguity often hinders supervisors from accurately finding corresponding standards for guidance and penalties. Currently, the existing regulations and measures only provide a framework for disposal, lacking specific and operational implementation details.

Different departments (organizations) with varying social responsibilities, work objectives, profit models, work methods, and industry norms, coupled with regional and institutional specificities, contribute to potential discrepancies. Coordination issues among departments may

lead to fragmented management or ineffective oversight, resulting in both manpower waste and increased interdepartmental conflicts. This situation renders medical waste disposal management a vulnerable point.

2) Emergency disposal

China's medical waste disposal system lacks norms to deal with emergencies. At present, the emergency disposal of medical waste during the epidemic period is mainly guided by the temporary issuance of documents. The overall load factor of centralized medical waste disposal facilities in China is relatively high. The emergency response capacity of centralized disposal facilities is insufficient. The medical waste emergency disposal facility system in most cities is blank, even mobile disposal facilities. Most cities do not have a medical waste emergency disposal facility system, mobile disposal facilities and co-disposal facilities to be directly deployed to dispose of medical waste. Co-disposal facilities such as hazardous waste incineration, domestic waste incineration, and cement kilns generally do not have the supporting conditions for direct emergency disposal of medical waste. At present, because most cities and municipalities have only one centralized disposal, the risk tolerance for disposal facilities is mostly operated by small and medium-sized companies, which have insufficient capacity to deal with public health emergencies with lack sufficient funds. In addition, there is a serious shortage of emergency supplies in all cities. The lack of medical waste transport vehicles, collection and transfer equipment, protective gear and other materials during the COVID also adversely affected the timely collection, transport and disposal of medical waste.

3) Medical waste emergency disposal regulatory capacity

The technical reserves of emergency and temporary medical waste, wastewater treatment, domestic sewage treatment and other related technologies are insufficient, and the corresponding technical support for secondary disaster prevention and control is also insufficient. The composition of medical waste has changed due to the mixing of large amounts of domestic waste produced by infected people, which leads to more burden on disposal facilities.

C. The Future of Disposal of Medical Waste

Medical waste is the most complex type of hazardous waste. It inherently carries viruses or pathogens, and any loopholes in handling it could lead to serious harm to human health. It is crucial for the government, disposal companies and specialized staff to collectively strengthen the regulations for medical waste disposal and promote comprehensive utilization, such as optimizing the recycling of medical plastics.

1) System and policy determinants

The existing medical waste disposal standards should be enhanced and updated, and operational manuals should be issued to clearly define the responsibilities of each staff member.

Regulatory: The relevant departments should establish dedicated teams, either independently or in collaboration with government environmental regulatory agencies, to regularly supervise and manage medical waste. Simultaneously, for disposal companies failing to meet

standards or inadequately addressing corrective measures, terminate the entrusted contracts.

2) In rural area

According to the operational manual, the government should organize medical staff training on medical waste disposal every three months in each grassroots healthcare institution. This involves sending staff to urban areas to enhance knowledge exchange and learning between urban and grassroots healthcare professionals.

Simultaneously, as we accelerate rural modernization, efforts can be made to modernize medical waste disposal in rural areas. Initiatives such as promoting electronic forms and QR codes can enable comprehensive tracking of medical waste, ensuring traceability. Additionally, strengthening the establishment of medical waste transfer stations is essential.

3) Medical plastic high-value utilization

Currently, in China, the focus on classifying medical waste is more oriented towards assessing potential hazards based on their characteristics and subsequently eliminating or reducing such risks. However, according to the principles of circular economy, the resource utilization of medical waste is achievable.

Single-use plastic medical instruments, uncontaminated by patient blood, bodily fluids, or excreta (including plastic infusion bags, infusion bottles, excluding infusion tubes, and syringes, etc.), can be separately recycled. Through sorting, crushing, friction cleaning, water rinsing, drying, and processes involving rubber separation and airflow separation, Polypropylene (PP) shredded material is obtained. This high-quality plastic can be sold to reduce hospital costs, which eliminates the burden of disposal of medical waste facilities. Based on the above discussion, this paper proposed a new system (Fig. 10).

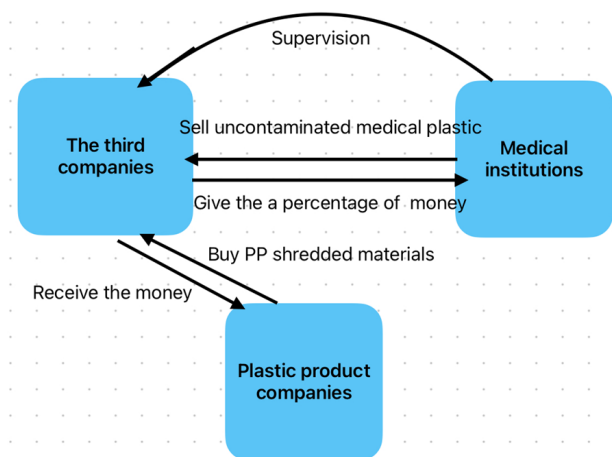


Fig. 10. The new mode of recycling medical plastics.

Fig. 10 indicates that medical plastics can be recycled by third-party companies, processed into high-quality PP materials and sold to plastic manufacturing companies. In the end, the revenue generated is split proportionally between the third-party company and the hospital. This model helps alleviate issues related to impurities in raw materials during incineration, ultimately reducing the disposal costs for hospitals and achieving a genuine cycle of plastic reuse.

4) Disposal technology

Pyrolysis incineration technology can reduce carbon dioxide and sulphur dioxide emissions using clean energy sources such as wind power, hydroelectricity and natural gas, and the use of clean energy sources to reduce carbon dioxide and sulphur dioxide emissions [42].

IV. CONCLUSION

Medical waste stands out as the most intricate category among hazardous wastes. Laden with viruses and pathogens, it poses a significant risk to human health if mishandled in the disposal process. This paper analyzes the problems from these three parts: emergency disposal, China's medical waste legal system, and medical waste emergency disposal regulatory capacity. It is imperative for collaborative efforts between the government, disposal entities, and healthcare professionals to reinforce regulations governing medical waste disposal and advance towards its comprehensive utilization. And optimizing the recycling of medical plastics, contributing to a more sustainable and efficient management of medical waste.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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