

PROBLEMS OF MEDICAL WASTE LOGISTICS IN A SELECTED CITY HOSPITAL

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Purpose: The aim of the article is to analyze problems related to the logistics of medical waste in the Silesian Municipal Hospital. The research issues focused on the analysis of currently used solutions, the causes of existing problems and proposals for improvements aimed at improving the quality of medical waste management processes in the hospital. The research will focus on analyzing areas related to the collection, storage, transport, and disposal of medical waste.

Design/methodology/approach: In the research presented in this article, an analysis of the literature on the processes of the waste management was used. The research focused on analyzing areas related to the collection, storage, transport, and disposal of medical waste. The analysis covered also procedures related to the segregation of medical waste and compliance with applicable regulations. The research focused also on assessing the effectiveness of existing logistics processes in waste management and identifying potential areas requiring improvement. IGrafx program was used for research and modeling.

Findings: The research showed some problems related to human resources, waste storage, transportation of medical waste and disinfection of carts and storages. Therefore, carrying out this assessment and analysis of the medical waste logistics management system allowed to propose corrective actions and improvements in the areas that most require improvement and adversely affect the waste logistics process.

Research limitations: The research limitation was an access to some data in the hospital. In the future similar research should be carried out in another hospitals in Silesia region.

Practical implications: Carrying out this assessment and analysis of the medical waste logistics management system allowed to propose corrective actions and improvements in the areas that most require improvement and adversely affect the waste logistics process. The introduction of the proposed improvements will increase the efficiency of the process and contribute to minimizing the risk of current problems occurring in the future.

Originality/value: The article shows the scale of the problem that can occur in many hospitals in Poland. Additionally, the article presents some recommendations for hospital staff, which aimed at minimizing the health risk to patients and staff, as well as improving compliance with standards and procedures set in the hospital.

Keywords: medical waste, hospital waste, medical waste logistics.

Category of the paper: Case study.

1. Introduction

Nowadays, medical facilities such as the Silesian Municipal Hospital, which is analyzed in the work, play a key role in providing appropriate health care for patients. With the increase in the number of patients and constantly developing medical technology, the amount of generated medical waste also increases, which creates various types of problems for the medical waste management area in the hospital. Medical waste logistics is an important element leading to the proper functioning of the hospital and maintaining appropriate sanitary standards. Improper management of medical waste may lead to various consequences for medical staff, patients, and the entire natural environment.

The aim of the work is to thoroughly analyze problems related to the logistics of medical waste in the Silesian Municipal Hospital. The research issues focused on the analysis of currently used solutions, the causes of existing problems and proposals for improvements aimed at improving the quality of medical waste management processes in the Municipal Hospital. The research will focus on analyzing areas related to the collection, storage, transport, and disposal of medical waste. The analysis will also cover procedures related to the segregation of medical waste and compliance with applicable regulations. The research will also focus on assessing the effectiveness of existing logistics processes in waste management and identifying potential areas requiring improvement. The work will also present practical solutions that can contribute to more efficient and effective management of medical waste at the Silesian Municipal Hospital. The research was conducted in 2023-2024.

2. Conceptual background

2.1. Waste definition

Waste is objects and substances that are most often created because of human activity, they are useless, which means that the person who has them gets rid of them. The Waste Act of December 14, 2012 defines waste as "any substance or object that the holder gets rid of, intends to get rid of, or is obliged to get rid of" (Dz.U. 2022, poz. 699). These may be various types of products that are unused, damaged or past their expiration date, as well as residues from various types of production or food processes. Waste is also harmful to the environment and human health; its toxicity can contaminate the air, water, and soil. They are also dangerous to all types of living organisms, because during decomposition they produce various bacteria and viruses, which pose a direct threat to the lives of animals and other organisms. Waste logistics mainly involves the creation of logistic chains that connect the place of waste generation with the place of its use, processing, and reuse. This process should be carried out in a comprehensive and

orderly manner. Considering the logistic systems used in waste management, they include a waste processing subsystem, i.e., segregation, storage, movement, processing and making secondary raw materials available for reuse (Gajdzik, 2009).

2.2. Waste classification and main sources

Waste classification can be done using various criteria, such as the chemical and physical properties of the item, toxicity, and using different categories divided depending on the origin of the waste. The classification should show the genesis of waste, its properties, ecological harmfulness, usefulness, and its production (Lipińska, 2016).

The main source of waste is human activity, waste is generated in various spheres of human functioning. According to Rosik-Dulewska (2015), the main cause of excessive waste is irrational resource management. They are produced in households through normal human functioning, because of economic, industrial, and service activities, and they are also residues from various types of substances and objects. The next aspect is human consumerism, namely people buy items that they do not really need, replacing old things with new ones, even though the old ones still serve their purpose. They buy single-use items that they quickly throw away. An important issue in this topic is also ineffective segregation causing environmental pollution. It extends the recycling process, making it more time-consuming and expensive. However, an increase in the amount of waste in landfills leads to their faster filling, which means that new storage places must be created, which are a burden on the natural environment. Improper segregation leads to wastage of resources that could be used to produce new products and raw materials in the future. It is also a threat to human health - ineffective segregation of, for example, medical and hazardous waste directly exposes people to harmful substances that pose a threat to their health. Garbage surrounds us on all sides, it is thrown onto sidewalks, along roads, and it litters forests, ponds, and lakes. This waste includes unburned cigarettes, chewing gum, bottles, tissues, and many other things that pollute the environment and atmosphere and pose a threat to the lives of animals. The generation of waste should be eliminated or limited by those who produce it and those who are its recipients, regardless of the degree of harmfulness or threat to human life and health and to the environment, regardless of the quantity or place of its production (Gwoździewicz, Witkowska-Kita, 2007).

2.3. Medical waste characteristic and classification

Medical waste that people encounters every day comes in the form of solid and liquid substances. According to the Waste Act, medical waste is "waste generated in connection with the provision of health services and conducting research and scientific experiments in the field of medicine" (Dz. U. 2022, poz. 699). They arise because of medical activities carried out in closed and open medical facilities, research facilities, veterinary units, in facilities that conduct experiments on living organisms, and occur in various types of institutes, clinics and sanatoriums. Medical waste is a substance that is very dangerous to the health and life of

hospitalized patients, as well as to the entire staff of a hospital. Medical waste includes waste in the form of blood and its derivatives, all types of tools and sharp objects such as scalpels, needles and syringes, waste generated during procedures, namely dressings and surgical gloves. The next type is biological and contaminated waste, medical waste also includes human remains. All the previously mentioned wastes are substances and objects that carry viruses, bacteria and other pathogenic substances that can lead to serious illnesses and, in the worst cases, even death. Medical waste that is generated because of direct contact with patients' blood is very dangerous. People can get a serious infection through contact with used syringes or gauze pads that have been in contact with a sick person. Patients may have very serious infectious diseases, which can cause diseases such as HIV, hepatitis B or plague to be contracted even in the slightest contact with their blood (Topolska, 2017; Bataduwaarachchi et al., 2018). Medical waste management in Poland is defined by several regulations that aim to ensure safe and compliant waste management procedures. These include waste segregation, storage, transport, and disposal (Bilitewski et al., 2006).

In Poland, approximately 200,000 tons of medical waste are generated annually, approximately 15% of which is infectious waste. This waste requires special treatment - it is infectious and pathological waste. They are characterized by the presence of various types of chemicals, bacteria, fungi, and toxins. Hazardous medical waste is generated in almost all stages of hospital operations, and this process cannot be avoided. Waste is generated in hospitals, starting from performing surgeries and treatments, through diagnoses and tests, to admitting patients. In a proper waste management process, each stage should be carefully described and scrupulously followed, and each hospital should have its own, well-developed procedure on how medical waste should be handled. Workplaces should have instructions on how employees should handle this waste to minimize occupational risk. The proper process of medical waste management must include appropriate waste storage, collection, transport, segregation, and safe disposal (Forowicz, 2012).

Medical waste is divided into (BDO, 2023, Procedura Nr QP-12/E):

Infectious medical waste - this is hazardous waste that contains live microorganisms or their toxins that are known or there are reliable grounds for assuming that they cause infectious diseases in humans or other living organisms. Waste codes: 18 01 02*, 18 01 03*, 18 01 80*, 18 01 82*.

Hazardous non-infectious medical waste "SPECIAL" - this is hazardous waste that contains chemical substances known or for which there are reliable grounds for believing that they cause infectious diseases in humans or other living organisms or may be a source of environmental infection. Waste codes: 18 01 06*, 18 01 08*, 18 01 10*.

Non-hazardous medical waste "OTHER" - this is medical waste that does not have hazardous properties. Waste codes: 18 01 01, 18 01 04, 18 01 07, 18 01 09, 18 01 81.

Highly infectious medical waste - i.e. waste that has been identified or is reasonably suspected to contain biological pathogens that pose a particular threat to humans.

Hazardous waste has at least one hazardous property that is characteristic of this type of waste. However, hazardous medical waste is characterized by the fact that it contains biological pathogens, i.e., "cellular microorganisms with the ability to cause disease symptoms or the products they produce, external and internal human parasites or the products they produce, cell-free particles capable of replicating or transferring genetic material, including genetically modified cell cultures or products produced therefrom" (Dz.U. 2008, poz. 1284). The waste catalog contains the previously mentioned waste numbers marked 18 01. These wastes marked with the additional symbol "*" are hazardous medical waste - they include, for example, body parts, organs and blood containers marked with the code 18 01 02*. All waste listed with "*" contains pathogenic pathogens associated with the content of organic tissue, biological infectious agents and hazardous chemicals derived from drugs that are used in the treatment of malignant tumors using chemical methods (Stelmasiak, Pieprzny, 2012).

The following types of containers can be distinguished (Regulation of the Minister of Health of October 5, 2017, on the detailed method of dealing with medical waste (Dz.U., 2017, poz. 1975, EKOMED, 2023):

- **red containers** – intended for collecting waste with codes: 18 01 02*, 18 01 03*, 18 01 80*, 18 01 82*, e.g., residues from feeding people from infectious disease wards, blood, waste containing toxins or microorganisms,
- **yellow containers** – intended for collecting waste with codes: 18 01 06*, 18 01 08*, 18 01 10*, e.g., chemical reagents – containing dangerous substances, cytotoxic drugs,
- **different colour containers e.g., blue** – intended for collecting waste with codes: 18 01 01, 18 01 04, 18 01 07, 18 01 09 18 01 81, e.g., surgical and treatment tools, dressings, including plaster casts, bedding.

Due to the potential danger associated with infectious waste, this waste should be stored in an appropriate manner. Special rules for the collection of infectious waste apply to infectious waste that has been identified or is reasonably suspected of containing biological pathogens that are classified in category A in accordance with point 2.2.62.1.4.1 of Annex A to the so-called ADR agreements (Dz.U., 2023, poz. 891). This waste is collected at the place of its generation to:

- inner packaging consisting of:
 - a single-use bag made of red polyethylene foil, durable and resistant to moisture and chemicals, which can be closed once, which, after filling and closing, is placed in a second bag meeting the same requirements,
 - a rigid, moisture-resistant, mechanically resistant to puncture or cut red container (in the case of medical waste with sharp ends and edges),
- outer packaging, which is a red container, durable, resistant to moisture and chemicals, made in a way that allows disinfection, and can be tightly closed.

It is also worth considering the proper arrangement of medical waste containers. "Proper" placement should be understood as a place where the risk of exposure to external factors, such as moisture or chemicals, is minimized. The location of containers should also exclude their contact with people other than those who segregate or transport them. The basic mistake made when it comes to the proper arrangement of waste containers is relying solely on the easy accessibility of the container. Unfortunately, there are still cases in which waste (just before being placed in the container) is transferred over a "clean" area where sterile instruments are located - e.g., a countertop. The container should therefore be placed in a place that minimizes the risk of intersection of the "sterile" and "non-sterile" zones, while maximally shortening the path of waste to the place of its collection (Reinhardt, 2017).

The amount of medical waste generated in Poland each year makes its proper disposal extremely important. Medical waste is largely considered hazardous waste, which is why its recovery and storage often proves impossible. One of the most frequently practiced methods of waste disposal is still thermal transformation of waste.

However, very important is the way in which this type of waste is disposed of. In accordance with the applicable legal provisions, it should be carried out by thermal transformation on the counter (D10) in a facility adapted for this purpose, while respecting the so-called Principles of Proximity. Proper segregation of medical waste allows to minimize their dangerous impact on people, animals, and the natural environment, which nowadays remains one of the key aspects of the joint effort. Implementing these few simple rules, as well as establishing cooperation with a reliable and competent entity, allows the highest safety standards to be maintained during the entire waste transport and disposal process (Windfeld, Brooks, 2015). The NIK report showed that the "proximity principle" applicable to infectious medical waste was not observed: 60% of entities disposing of such waste accepted it from outside the voivodeship, and 80% of such entrepreneurs transferred the accepted infectious medical waste to other entities. The main reason for the problems was the collapse of the medical waste management system on a national scale, caused by, among others, closing or stopping the operation of parts of installations processing such waste. Consequently, prices for waste disposal increased significantly during the audited period, from approximately 7% to almost 67% on average. During the period under review, the total costs of collection and disposal of infectious medical waste incurred by the audited hospitals amounted to almost PLN 38.3 million. The largest increase in costs - by almost 640% - was recorded in the Provincial Infectious Diseases Hospital in Warsaw and in the District Hospital in Zakopane - by over 578% (NIK, 2023).

3. Problems with medical waste logistics in selected hospital

Silesian Municipal hospital has been operating successfully for 47 years and has two units. The hospital provides medical services in the field of inpatient treatment and specialized outpatient health care. It serves approximately 12,000 patients annually from the whole Silesia region. Hospital is divided into 6 buildings numbered A-F. Each building houses different hospital wards and produces different medical waste. All waste from the above-mentioned buildings and departments must be properly segregated and disposed of in accordance with applicable medical waste management regulations. Ensuring proper waste management is crucial to maintaining high hygiene standards and, above all, the safety of patients and medical staff.

3.1. Analysis of disruptions related to human resource problems in medical waste management

1. In the hospital, there is a clear disproportion between the amount of waste generated and the number of employees responsible for segregating and removing waste from individual hospital departments, which generates several problems related to maintaining hospital procedures at the highest level. The number of trolleys and employees in the hospital is limited, so following the procedures is practically impossible. Due to the shortage of employees, problems such as irregular emptying of containers and lack of immediate response to excess waste occurring in the departments occur. This causes garbage to accumulate on the hospital premises, thus having a greater impact on hospital patients. Garbage accumulates in the wards, which reduces the quality of hygiene standards in the hospital and reduces the safety and satisfaction of patients who may feel discomfort caused by the presence of accumulated garbage.
2. Another problem related to staff shortages leads to delays in the entire logistic process of medical waste management. When a specialist company dealing with the removal of waste for disposal arrives, it may encounter the problem of a lack of people who will be able to hand it over the waste, for example because they will be on the round.
3. The next problem concerns the too few cleaners employed in the hospital staff. This leads to a situation in which there is one person in each department who is responsible for maintaining proper order and segregating and collecting waste. This situation may lead to overload for a given person, and therefore may reduce the effectiveness of their activities and may affect various types of health problems.

3.2. Analysis of disruptions related to the problem of waste storage and waste collection for disposal

1. Limited storage space is the main problem in the proper management of medical waste. The small number of waste containers and shelves in the warehouse makes the segregation process significantly more difficult, which deviates from the established standards and procedures. The result is that properly sorted waste in the wards, despite careful segregation of the cleaners in the waste warehouse, ends up in one container regardless of the color of the bag. Blue, yellow, and red bags in the warehouse should be stored in separate containers but are thrown into one due to lack of space in the warehouse. This situation quite seriously violates the principles, sanitary standards, and procedures for proper management of medical waste.
2. The next problem in warehouse management is water drainage in the warehouse and old equipment. After collecting waste for disposal, employees must thoroughly wash the warehouse using special cleaning agents. The staff does not have modern equipment, so the warehouse is cleaned using a garden hose, which has low pressure, so the accuracy of washing the warehouse is not effective.
3. Another problem of waste storage management is the lack of appropriate waste monitoring systems. A significant problem resulting from the lack of such a system is the difficulty in precisely determining the amount and type of waste generated in the warehouse. Monitoring systems also make it possible to precisely determine how long a given type of waste can be safely stored in warehouse conditions. The lack of a monitoring system also affects the accumulation of waste in the warehouse, which significantly worsens hygienic conditions, which may negatively affect the health of personnel dealing with medical waste.
4. An additional problem is the lack of waste collection by an external company during the weekend, which leads to waste overflowing into the storage space, which not only complicates the work of the staff responsible for waste but may also pose a threat to the health of employees. During weekends, the amount of waste generated in the hospital does not decrease and may even increase compared to individual days of the week. Waste workers are unable to do anything about this fact and are forced to store waste collected from hospital wards on the warehouse floor, which significantly violates the designated procedures and increases the chances of infection of the body, for example with a used needle.

3.3. Disturbance analysis related to problems with the route and road intended for the transport of medical waste

The problem of the route and transport route of medical waste is an important element in the context of efficient and proper management of medical waste management in the hospital. Currently, the waste transport process within the hospital is as shown in Figure 1.

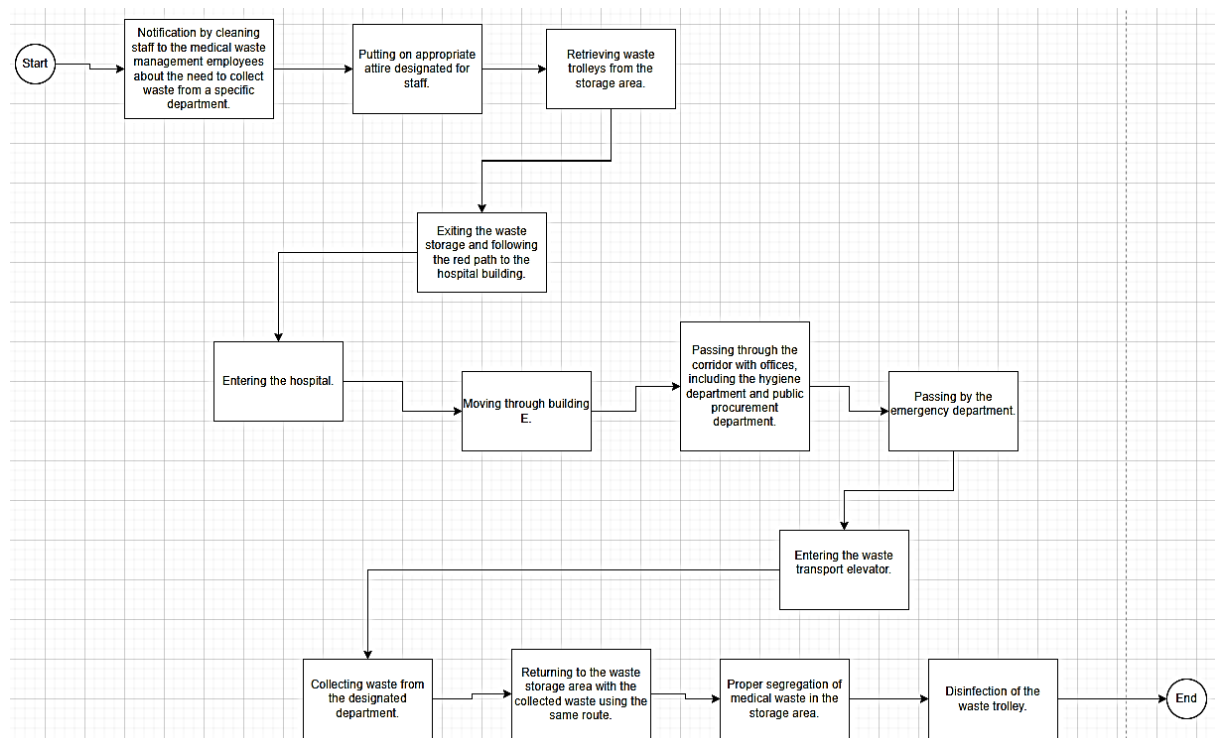


Figure 1. Waste transport route.

Source: own work.

1. The first problem concerns the need to always transport waste using the same transport route designated in the procedures, which causes problems when the route is blocked and impassable for the waste trolley or when the elevator fails. Such situations cause significant downtime in waste collection and extend the entire process of collecting medical waste. Moreover, in the event of an elevator failure, another problem arises, namely, employees responsible for medical waste are forced to use the elevator intended for patients and hospital staff to get to a given ward, which may lead to a situation where medical waste will move in the same elevator as lunches. for patients as well as the patients themselves. This situation significantly violates hygiene standards and increases the risk of infection, but also causes discomfort for patients because medical waste leaves an unpleasant smell in the elevator.
2. Further problems related to the extension of the process related to the collection of waste from the departments, and at the same time the entire process, are generated by the fact that in the event of an elevator failure, the staff dealing with medical waste cannot use the elevator at any time, because patients are the priority, so if there is patient, then the waste worker must wait until the elevator is empty. Considering the number of patients and the frequency of their movement using the elevator, the time needed to collect garbage from the wards and the entire process of medical waste management is significantly extended.

3. The next problem causing disruptions in the appropriate medical waste management process is the transport route designated in the procedures for collecting waste from hospital wards. To follow the procedures, employees must walk with garbage along the entire building E of the hospital. This route is too long and completely unsuitable for equipment such as medical waste carts, which poses significant challenges to employees due to its structure. There are numerous holes and unevenness on the road, and it is not an asphalt road, but a road covered with gravel and stones. Additionally, after crossing this road and reaching the interior of the hospital building, employees must cover a large part of the hospital to get to the elevator intended for transporting medical waste. After collecting waste from the site, waste management staff must return to the warehouse with a full cart of waste via the same transport route, which is an even bigger problem. The disruption that comes with unsuitable routes and too few workers on shift is when waste handlers break rules and procedures to avoid accidents, cause delays in the overall process, and effectively manage medical waste. Employees follow their route through the ambulance ramp, which is much shorter but does not comply with established procedures. An additional problem related to the road occurs in winter. The presence of snow and ice makes it significantly difficult for employees to move around with a waste cart. Irregularities covered by a layer of snow or ice make it difficult to control the truck, may damage it and are also dangerous for the employees themselves, who may be exposed to injury caused by such conditions. Large amounts of snow can also make the route completely impossible and then the waste management staff is forced to clear the snow from the route with a shovel, which has a significant negative impact on the regularity of waste collection and causes significant delays in the entire process.

4. Proposals for improvements to problems identified in the city hospital

4.1. Improving the process related to the lack of human resources

1. To improve the process of managing available human resources, attention should be paid to optimizing the staff's work schedule. For this purpose, an analysis should be carried out to determine the hours at which the greatest amount of waste is generated in given wards and the employees' schedules should be adjusted accordingly to these periods to avoid the problem of excessive amounts of waste in wards and to limit patients' contact with medical waste in the hospital. Another proposal that will certainly improve and optimize the waste management process is to hire a new employee for this area. This idea will involve additional costs for the hospital, but it also brings many benefits that will significantly improve the efficiency of waste management. Improving

the efficiency of operations, increasing safety, accelerating the entire process and the ability to assign tasks to a new employee in areas where deficiencies are noticeable may exceed the expenses incurred related to his employment. The introduction of a new employee will also allow for more accurate segregation and removal of medical waste, will contribute to greater compliance with waste management procedures and will improve the response to an increase in the amount of waste at specific hours.

2. The above-mentioned improvement proposals will also help solve the problem of lack of staff at the pickup site when a specialist external company arrives. An additional proposal to avoid this problem is to automate the process of notifying employees about planned garbage collection. Using mobile notifications will be a simple but effective option. Thanks to notifications, medical waste area employees will be able to adjust their duties to be available when collecting waste from the warehouse. The use of these improvements will minimize delays and problems related to waste collection, increase liquidity and efficiency, and improve cooperation with an external company.
3. The next step is to implement activities that involve one cleaning person taking care of the entire department. To solve this problem, it is necessary to analyze which wards involve the most cleaning and segregation work and apply improvements to specific places. The best solution to this problem is, of course, to employ an additional cleaning person, which will allow for better planning of human resources and employ two cleaners in a department that requires more work compared to others. Implementing all the above-mentioned proposals and applying them appropriately will significantly contribute to minimizing the hospital's problems related to the insufficient number of employees responsible for medical waste management.

4.2. Proposals for improvements to the problems of medical waste storage and waste collection for disposal

To solve problems related to waste storage, it is necessary to take actions that will increase the optimization and improve processes related to waste storage and segregation.

1. The most logical and best solution to this situation is to expand the existing medical waste warehouse and, at the same time, increase the storage space intended for waste. This process will allow for better organization of space, purchase of new containers and shelves, which will make the segregation process easier for employees and will allow for proper storage of waste in accordance with the established rules. For this purpose, the arrangement of waste containers should be carefully considered, and the shelves should be installed appropriately. Another activity that should be considered when building a new warehouse is ensuring appropriate conditions for storing medical waste. For this purpose, an appropriate air conditioning system should be used to maintain the appropriate temperature required for appropriate storage of medical waste. An important aspect is also thorough and tight protection of the warehouse against moisture to

maintain dry conditions for storing waste. It is also important that no insects or rodents enter the warehouse, and that the storage complies with all sanitary standards.

2. Another improvement that needs to be implemented is the introduction of a new water drainage system to the warehouse. For this purpose, the drain grid should be enlarged, and a minimum slope should be used, which will direct the disinfected water towards the drain grid. Additionally, modern tools should be introduced to disinfect the warehouse. It will be a great help for employees to purchase a pressure washer, which will be much better for disinfection than a garden hose. At the same time, the use of modern equipment will allow for faster and more thorough cleaning of the warehouse from dirt, blood and germs remaining after medical waste. This equipment will shorten the warehouse disinfection process and make the work of the staff much easier. This will also increase the level of maintaining appropriate hygiene requirements.
3. The next improvement concerns the introduction of waste monitoring systems to the warehouse. The implementation of modern systems will enable effective management of medical waste during storage and will facilitate the entire process. Technologies that can be implemented include, for example, weight sensors for containers and an RFID system. Weight sensors in the containers will allow continuous control of the amount of collected waste, it will allow employees to better manage storage space, and the hospital will obtain data on how many kilograms of waste are collected on a given day. Thanks to these measurements, waste management staff will be able to constantly check how much waste is in the warehouse, and this process will improve the efficiency of sorting and help in timely removal of waste from the warehouse. Another improvement is the use of RFID technology, which will allow each waste container to be marked in a unique way. Thanks to this technology, it will be possible to control how much of each type of waste has been collected by dividing the waste into individual bag colors, and it will be possible to precisely determine the storage time. The RFID system will improve logistics processes by quickly and effectively finding specific waste and will allow for the control of specific containers individually.
4. The next improvement aims to solve the problem of lack of medical waste collection on weekends. To effectively deal with this problem, improvements should be implemented to improve this process. The first is negotiation with the company with which the hospital has a contract to establish a new waste collection schedule, which would assume waste collection at least 6 times a week, and if necessary, even 7 times. During the conversation, it should be emphasized that the change is forced due to logistical reasons and the hospital's problems related to maintaining proper order in the medical waste warehouse, and without this change it is practically impossible to maintain applicable sanitary standards, hospital procedures, or occupational hygiene rules. The introduction of this improvement will, of course, not be possible without increasing the costs associated with concluding a contract for waste collection from 6 to 7 days

a week, but to comply with any standards, such a step is inevitable. This process will generate additional expenses, but thanks to this, the hospital will improve employee safety and the efficiency of the medical waste management process. The benefits that will result from the new contract will exceed the potential costs of concluding it. Thanks to the fact that waste will be collected more often than before, the hospital and employees responsible for waste will get rid of the problem of having to store waste on the warehouse floor, which poses a potential threat to employees' health and significantly flexes hospital procedures. An emergency option that can be used if none of the companies collecting waste for disposal agrees to sign a contract for 6 to 7 days a week will be the need to organize additional containers in the warehouse. Additional containers will also mean that it will be necessary to organize a place in the warehouse or in the entire hospital building where these containers can be placed. The location of new containers must be easily accessible and enable appropriate waste segregation for the employees responsible for it. The introduction of this solution will help avoid problems that occur when waste accumulates excessively in the warehouse and will help maintain order during the period when waste collection is limited.

4.3. Proposals for improvements to the transport route for medical waste storage and waste collection for disposal

To effectively solve problems related to waste transport, a number of actions should be taken to facilitate the process of moving medical waste within the Silesian Municipal Hospital.

1. The first improvement, which will eliminate problems related to blocking the waste transport route, avoid the problem of elevator failure and at the same time optimize the waste management process at the Municipal Hospital, will be the use of an innovative idea that assumes the creation of a special warehouse with a chute for medical and other waste. For this purpose, a room must be developed on the hospital premises that can be used for this type of waste storage. In each of the departments, a special waste chute will be created in a designated waste room called the "dirt room". The cleaners stored the previously collected and properly sorted garbage in a dirt bin and when the garbage from the entire ward was collected, the staff responsible for the cleanliness of the ward called the people collecting medical waste, and they had to follow the designated route in accordance with the procedures and move to a given floor at elevator assistance. After introducing this improvement, people cleaning the ward, after cleaning the entire ward, will throw the collected and properly sorted garbage into the waste chute located in the dirt bin, and the garbage thrown into it will go directly to the waste warehouse, from which the staff will someone responsible will take them away. Thanks to this solution, the need to use an elevator will be eliminated and problems that may occur along the waste transport route will disappear. This idea will significantly increase the flexibility of waste transport and facilitate the work of staff responsible for waste

generated within the hospital. Of course, the use of such a solution involves costs, which include, among others: installation of special waste chutes, development of the hospital room and its modernization to meet specific requirements. However, the use of such a solution will shorten the entire process of waste collection and transport, reducing the need for employees to walk through each of the hospital departments to collect waste, thus increasing the efficiency of the entire process. An important aspect of this improvement is also the fact that contact with patients and hospital staff is reduced to practically a minimum. By throwing garbage into a special chute, from which the garbage goes to a collection point in a special room, the risk of possible threats related to patient infection and other sanitary problems is eliminated. To sum up, the creation of a warehouse with special chutes in each of the departments will significantly facilitate and speed up the entire waste collection process, and at the same time will make the process much more effective and safer.

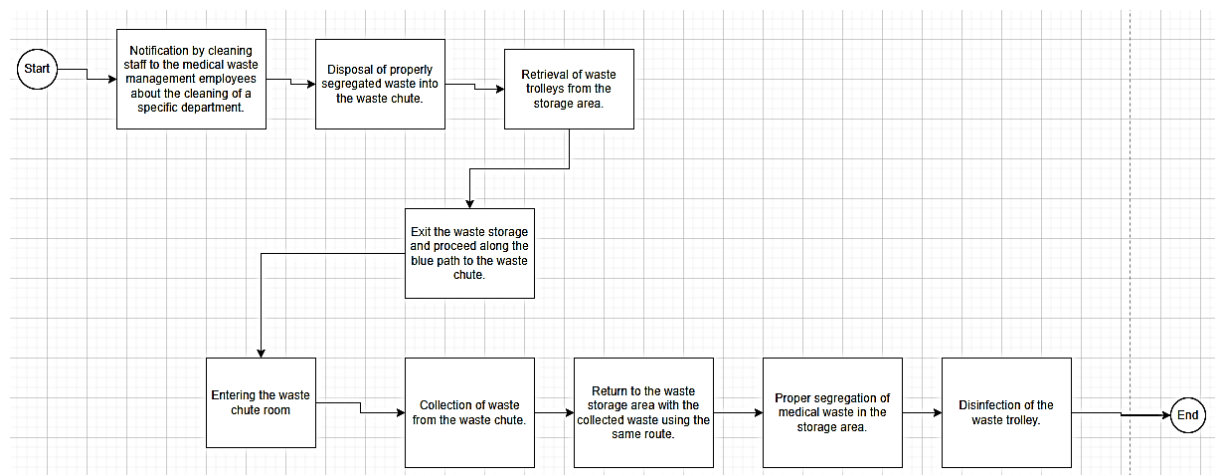


Figure 2. Waste transport route after the improvement.

Source: own work.

Figure 2 shows the simulated waste transport process after introducing an improvement in the form of a waste warehouse in the hospital and the use of chutes in each of the departments. The presented process shows that the introduction of this improvement will shorten the entire process of transporting medical waste within the Municipal Hospital by over 16 minutes.

- Another improvement aims to determine a new, more optimal medical waste transport route compared to the current one. The current medical waste transport route leads along the red path shown in Figure 2. The new route assumes that employees responsible for waste transport would enter the hospital building from the side of building C. The introduction of this change assumes shortening the transport time and improving the efficiency of this process. After entering building C, employees only need to go through one corridor, and they will find themselves at the elevator intended for waste transport. The introduction of the route change will eliminate the need for staff

responsible for waste to travel through a large part of the hospital area, shortening the time needed to cover the route along Building E and reducing the contact of waste with hospital staff and patients. Another feature that will make navigating the new route easier will be the use of the asphalt road leading to building C, which will allow employees to move the truck freely and reduce the risk of damaging it. The introduction of this route will increase the efficiency of the waste transport process, shorten transport time and eliminate unnecessary maneuvers and difficulties in moving with a trolley on a gravel surface. Changing the route will facilitate the daily work of medical waste management staff and minimize delays.

5. Summary and conclusion

During the research related to the problems of medical waste logistics at the Silesian Municipal Hospital, it was possible to become thoroughly acquainted with the applicable hospital procedures and regulations governing the management of medical waste. The acquired knowledge allowed for understanding the problems, responsibilities of the staff responsible for waste and existing work standards. Thanks to this knowledge, it was possible to propose improvements at work to improve staff working conditions, compliance with regulations and changes in the management system.

Regarding potential threats that may occur during the transport of medical waste, the analysis of transport processes at the Municipal Hospital allowed for the identification of threats related to, among others: inappropriately planned waste transport route and problems related to the construction of the road along which the waste moves. The analysis carried out allows for the proposal of actions to streamline the transport process and improve staff safety.

In the context of quality and risk management in waste transport, the subject of risk and quality management during transport was introduced, which allowed to identify areas requiring improvement and propose effective solutions that will contribute to minimizing the risk occurring in the process of transporting medical waste.

The problem of technology and tools supporting waste logistics- getting acquainted with the equipment and technology used at the Silesian Municipal Hospital, which supports the process of waste logistics at the hospital, allowed us to see the shortcomings in this process related to inappropriately adapted equipment. Thanks to this, it was possible to propose the introduction of more modern equipment and automated technology, which will contribute to the optimization of the process and increase its efficiency.

Additionally, disruptions occurring in medical waste management were identified. The identification of disruptions occurring around waste management allowed for the introduction of improvements in those areas that require them and are crucial in the context of

efficient management of medical waste logistics and the effective operation of individual processes occurring in this area.

In addition, recommendations have been prepared for medical staff and patients to increase safety and minimize the risk of infection. Activities related to the introduction of recommendations for hospital staff and patients have been appropriately analyzed and specific actions have been introduced aimed at minimizing the health risk to patients and staff, as well as improving compliance with standards and procedures set in the hospital.

In case of identification of disruptions that may occur during the transport of medical waste, specific actions were proposed to minimize the risk of problems occurring during the transport of medical waste. Their use will significantly contribute to increase the safety of the entire process.

Therefore, carrying out this assessment and analysis of the medical waste logistics management system allowed to propose corrective actions and improvements in the areas that most require improvement and adversely affect the waste logistics process. The introduction of the proposed improvements will increase the efficiency of the process and contribute to minimizing the risk of current problems occurring in the future.

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