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RISK ASSESSMENT FOR WASTE COLLECTION WORKERS

Abstract: *This paper analyses the risk assessment process for waste collection workers, including activities such as container handling, waste collection, and operation on municipal vehicles. These workers are exposed to mechanical hazards, fall risks, physical, chemical, and biological hazards, as well as physical and ergonomic strain. The risk assessment is conducted in accordance with the Regulation on Risk Assessment, applying a risk matrix to evaluate the likelihood and severity of potential incidents. The process involves data collection, hazard identification, and the definition of protective measures. Particular emphasis is placed on preventing injuries during container handling, reducing exposure to harmful substances, and improving ergonomic conditions. The most common risks include mechanical injuries related to container manipulation, exposure to biological agents, and physical strain during waste unloading. Significant risks also arise from falls, noise and vibration exposure, and traffic related hazards during municipal vehicle operation. To mitigate these risks, the paper proposes technical safety improvements and enhanced worker training. The implementation of these measures can significantly improve occupational safety and reduce injury rates in the waste management sector.*

Keywords: risk assessment, risk matrix, mechanical hazards, physical hazards, biological hazards, strains

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INTRODUCTION

Waste collection is performed daily as part of the organized municipal services system. Although the waste itself is non-hazardous, the tasks involved in its collection include a number of situations that may pose a risk to workers' health and safety (Black et al., 2012). In their daily activities, workers handle municipal waste stored in bins and containers, operate lifting mechanisms, move through traffic and exposed environments, and frequently work outdoors under variable weather conditions. Such working conditions expose them to mechanical, physical, chemical, and biological hazards, as well as physical and ergonomic strain.

These factors increase the overall physical burden on workers and can affect their attention, concentration, and overall safety during operations (Ewis et al., 2013). Given the specificity of tasks and the dynamic nature of field work, it is essential to systematically assess the present hazards, harmful agents, and workload, as well as the level of exposure. This paper presents an example of risk assessment for waste collection workers operating in the city of Sisak and the municipalities of Lekenik, Martinska Ves, and Sunja in the Republic of Croatia. The risk assessment was

conducted using a risk matrix method, which evaluates the combination of the probability of an unwanted event and the severity of its consequences. The results provide a basis for recommending specific actions to enhance workplace safety and health.

EXPERIMENTAL

Risk assessment is one of the fundamental components of the occupational health and safety system. Its purpose is to identify potential hazards, and strains in a timely manner, analyse working conditions, and determine measures that can eliminate or reduce risks to an acceptable level. In accordance with the Regulation on Risk Assessment, it is a documented process that includes the analysis of hazards and strains associated with the workplace, work environment, and specific tasks. The procedure involves identifying sources of hazards and strains, assessing workers' exposure, evaluating risk levels, and defining appropriate protective measures (Narodne novine, 112/14, 129/19; Štajner et al., 2021).

The risk assessment process includes the following key steps:

1. Identifying all potential sources of hazards and strains,
2. Analysing existing occupational safety measures,
3. Assessing the residual risk that remains despite implemented measures,
4. Ranking risks based on their likelihood and the severity of consequences,
5. Proposing additional corrective measures to eliminate or reduce hazards and strains

In practice, the risk matrix method is frequently used. It combines two fundamental factors: the probability of an undesirable event occurring and the severity of its consequences. The resulting risk is classified as low, medium, or high. This approach allows for the prioritization of risks in the workplace and the effective proposal of protective measures. It is essential to highlight that risk assessment is an ongoing process, not a one-time task. It must be regularly updated and adapted to real changes in work organization and technological processes. Moreover, it must be understandable to workers and based on actual working conditions (ILO, 2019). This study analyses the risk assessment process related to municipal waste collection in the city of Sisak and the municipalities of Lekenik, Martinska Ves, and Sunja in the Republic of Croatia. The goal of the analysis is to identify the key hazards and work-related strains that workers face, and to propose protective measures that contribute to safer field operations.

WASTE COLLECTION

Municipal waste collection workers operate exclusively outdoors (Figure 1), typically along public roads. Their work tasks involve moving smaller waste bins (with capacities of 120, 240, or 360 litres) from their designated locations to the collection vehicle. In the case of larger containers, such as those with a capacity of 1100 or even 5000 litres, they are moved to the vehicle by being pushed on wheels.



Figure 1. Waste collection on a public roadway

A regular part of the work process includes the use of handheld scanners to identify bins. This step verifies the service user's status and records the emptying of

the container for monthly billing purposes. Following that, the waste is loaded into the municipal truck using an automated system located on the vehicle's hydraulic superstructure. This system enables emptying the bins without direct contact with the waste, although the worker must still operate the mechanism, monitor the process, and ensure that all actions are carried out safely. Once the vehicle is full, workers drive to the Goričica non-hazardous waste landfill near the city of Sisak. Depending on the waste type, the load is either deposited at a storage area next to the sorting facility (for paper, plastic, glass, and metal) or on the landfill surface (for mixed waste). Throughout the process, workers use specialized municipal vehicles equipped with hydraulic waste compaction systems. Standard work equipment also includes basic tools such as a shovel and broom, used for cleaning up spilled or scattered waste.

IDENTIFICATION OF RISKS IN WASTE COLLECTION OPERATIONS

Workers involved in waste collection are exposed to a range of hazards, including mechanical hazards and fall risks, as well as physical, chemical, and biological hazards, in addition to statodynamic and psychophysiological strains.

Mechanical hazards

Waste collection workers are routinely exposed to a variety of mechanical hazards. These risks arise from physical contact with waste bins, containers, lifting mechanisms, and municipal vehicles. One of the most common risks involves crushing and entrapment injuries during the operation of lifting mechanisms on waste collection vehicles. In cases of technical malfunction, faulty supports, or improper placement of bins or containers into the lifting mechanism, there is a risk of sudden movements or the bin/container unexpectedly falling. Such events pose a serious threat to workers nearby, particularly if they are positioned directly underneath or behind the container during lifting, emptying, or lowering.

To ensure safety during these processes, workers must stand to the side of the lifting mechanism (Figure 2), at a safe distance from its arms. Standing too close, especially directly behind the container, exposes them to the risk of impact or entrapment, which can result in serious injuries. In the rush of daily operations, workers may sometimes overlook safe distancing, particularly when actions are automated. For this reason, it is important to regularly remind them of proper body positioning and safe movement around the vehicle during work.



Figure 2. *Proper positioning of workers during bin lifting*

During manual handling of large-volume containers, such as those with capacities of 770, 1,100, or 5,000 litres, there is a risk of foot injuries caused by container wheels. This risk is especially pronounced when containers are pulled downhill, where the loss of control over the load can result in uncontrolled rolling. During the loading process itself, there is a risk of spinal and wrist injuries from lifting and manoeuvring containers. Improper handling of heavier containers without assistance from another worker can easily lead to musculoskeletal injuries. A particularly serious source of mechanical injuries is the presence of sharp or pointed objects inside the containers. Items such as broken glass, metal sheets, wires, and similar materials present a high risk of cuts and abrasions. These injuries are more likely when bins are emptied manually or when workers fail to wear gloves and other personal protective equipment.

Vehicles operating within the work area also pose a significant hazard. Traffic from other road users near waste collection points can compromise worker safety, especially if collection takes place on both sides of the road—practice that is strictly forbidden. In such scenarios, workers are at risk of being hit by moving vehicles or are forced to react very quickly, which increases the likelihood of an accident. Risks are also associated with riding on the rear platforms of collection vehicles during transport. Such transport is only permitted while the vehicle is moving forward and actively collecting waste. However, jumping onto moving platforms or riding over uneven terrain can lead to falls, impacts, serious fractures, or even fatalities (Beroš, 2020).

These risks are further intensified in conditions of reduced visibility, on slippery surfaces, and during sudden turns. Particularly dangerous is driving at a speed not adjusted to road conditions, which greatly increases the risk of traffic accidents. An additional serious risk is posed by manual loading of waste into

the vehicle. During such loading, workers may come into contact with the waste compaction mechanism. Inserting hands into the loading area, holding waste in place, or attempting to sort through its contents is strictly prohibited, as it may result in severe injuries or even amputations if the mechanism is accidentally activated.

During waste collection, workers frequently use digital tools such as handheld scanners. These systems are based on RFID technology and are used to identify containers, record locations, and track emptying frequency. This helps optimize collection routes and improve the overall efficiency of the waste management system. However, using handheld scanners in field conditions can introduce additional mechanical risks. While scanning, workers often hold the device in one hand while handling the bin with the other. This reduces body stability and makes it more difficult to control the container. The risk increases further on uneven terrain, in poor weather conditions, or when vehicles are present nearby. When working with large containers that require two-person handling, holding a scanner can interfere with proper grip and coordination. It is therefore recommended that workers use belt or shoulder-mounted scanner holders to keep both hands free for safe and stable container manipulation.

Fall hazards

One of the most common causes of injuries during waste collection are falls. Waste collection is performed outdoors, frequently in unfavorable weather conditions, which increases the risk of slipping on wet surfaces or tripping over curbs. Additionally, falls may occur from the rear platform of the collection vehicle or while handling bins on uneven ground (Beroš, 2020). Winter conditions, when the ground is covered with snow or ice, are particularly hazardous. In such cases, a fall may result in serious injuries such as fractures or sprains. Another contributing factor is loss of balance during pushing or pulling heavy bins. For this reason, large containers should always be handled by two workers cooperating as a team.

Physical hazards

While riding on the platform of the waste collection vehicle, workers are exposed to noise and vibration, both classified as physical hazards. Vibrations affect the hands, legs, and back, and prolonged exposure can lead to occupational diseases such as hand arm vibration syndrome (Poplašen, 2013). In addition to physical strain, work is often carried out in extreme weather conditions, including both high and low temperatures, which place additional stress on the body. Such conditions may result in exhaustion, dehydration, heatstroke, or frostbite (Abidin, 2025). Municipal vehicles and their lifting mechanisms generate noise during operation. Moreover, additional noise is produced by road traffic, resulting in average sound levels that often exceed 85 dB. Prolonged exposure to such noise can lead to hearing loss, increased irritability, fatigue, and reduced concentration (Klančnik, 2013).

Chemical hazards

Chemical hazards also represent a significant risk during waste collection. Workers may be exposed to various harmful substances improperly disposed of in waste bins, such as solvents, acids, cleaning agents, and similar materials. The highest risk arises from leaks of hazardous liquids from improperly sealed bottles or damaged packaging. Inhalation of such substances may cause dizziness and irritation of the eyes and respiratory system (Šarić, 2002). If exposure is frequent or prolonged, more serious health effects may occur (Ewis et al., 2013). During the emptying of containers with loose material, workers may also come into contact with various types of dust. Inhalation of dust particles can lead to respiratory irritation and allergic reactions.

Biological hazards

Exposure to biological hazards is one of the main risks in municipal waste collection. This includes contact with bacteria, viruses, fungi, and parasites that may be present in discarded waste (Madsen et al., 2020). During the opening and emptying of containers, especially in the summer months, aerosols and dust containing pathogenic microorganisms may be released. Potential consequences include skin and respiratory infections, and in more serious cases, diseases such as hepatitis A or leptospirosis. Biological hazards are particularly dangerous when they come into contact with broken or scratched skin or when personal protective equipment (gloves, masks, goggles) is not properly used. In addition to the previously described hazards, particular attention must be paid to biological materials disposed of without prior sterilization, including used diapers, animal faeces, and animal carcasses. These materials can be a source of infectious diseases, especially when they come into contact with the skin or respiratory system. High temperatures further promote microbial growth, increasing the risk of skin infections (dermatitis), eye infections (conjunctivitis), and respiratory tract infections (bronchitis) (Madsen et al., 2025). A particular concern is the presence of thermophilic actinomycetes and fungi, which spread from containers in the form of spores. Long-term exposure to these agents is associated with occupational diseases such as hypersensitivity pneumonitis (Štrkalj, 2024).

Statodynamic strains

Waste collection involves continuous statodynamic strains on the body. Workers perform repetitive tasks daily, such as pushing and pulling waste containers. Other repetitive tasks include lifting and moving container lids and climbing up and down from the vehicle platform, which places considerable stress on the spine, shoulders, and knees. Handling large containers requires two workers, and lack of coordination or improper posture may result in muscle strain or lower back pain. Workers often operate on uneven or slippery road surfaces and repeated movements and prolonged walking further burden the musculoskeletal system.

Accordingly, the physical strain experienced by waste collection workers is not limited to the weight of the objects being handled and transported, but also includes the frequency of repetitive movements, working conditions, and body posture.

Psychophysiological strains

Waste collection workers are also subject to psychophysiological strains due to the specific demands of their work. The work rhythm is continuous and requires precision and focus. Additionally, workers are constantly visible to the public, which can lead to chronic fatigue, decreased motivation, and emotional exhaustion factors that negatively impact attention, concentration, and overall workplace safety. Situations where other road users contribute to psychological burden are not uncommon, particularly when waste collection vehicles block traffic during collection activities. These situations may increase stress levels, potentially reducing workers' focus and increasing the likelihood of errors. Furthermore, prolonged exposure to stress can lead to burnout syndrome (Hooper et al., 2008).

RISK ASSESSMENT DURING WASTE COLLECTION

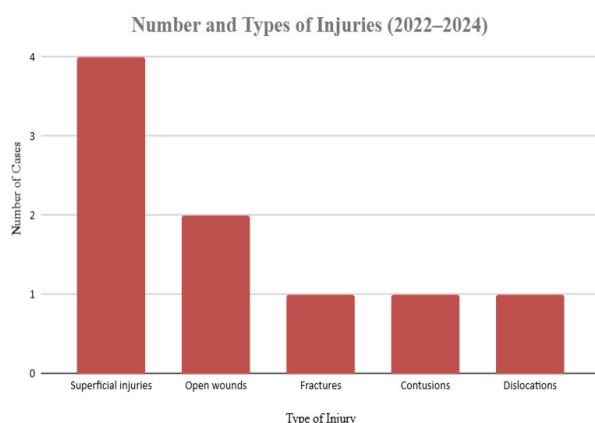
Risk assessment is based on the analysis of the frequency of specific hazards and their potential health consequences for workers. Risk assessment for identified factors (hazards and strains) was conducted using a risk matrix, which links the likelihood of occurrence with the severity of consequences. Table 1 presents the results of the assessment along with specific examples for each individual factor.

Mechanical hazards represent the most prevalent category of risk. They include the potential for crushing, impacts, entrapment, cuts, and contact with moving parts of the vehicle. Workers are exposed to these risks daily while handling bins and containers, operating lifting mechanisms, and moving within traffic environments. This conclusion is supported by data from the company *Gospodarenje otpadom Sisak*, presented in Figure 3, which shows recorded injuries among waste collection workers from 2022 to 2024. During this period, four superficial injuries, two open wounds, and one case each of fracture, contusion, and dislocation were reported. All incidents were directly related to mechanical hazards. Based on these findings, it can be concluded that mechanical hazards pose a high risk due to the combination of high probability and potentially severe consequences.

Falls have been identified as the second most prominent risk category. Their occurrence is most often associated with weather conditions and the nature of field locations, especially during the winter months. Although the severity of consequences varies, reported cases include sprains and fractures. Due to their frequency and potential severity, falls are classified as a high risk category.

Table 1. Risk assessment for waste collection operations using the risk matrix

Type	Example	Likelihood	Consequence	Risk level
Mechanical hazards	Crushing injuries during container loading, impacts from moving parts of the municipal vehicle	Very likely	Extremely harmful	High risk
Fall hazards	Falls while climbing onto or off the municipal vehicle platform; slipping on wet or uneven surfaces	Likely	Extremely harmful	High risk
Physical hazards	Exposure to noise, vibration, and extreme temperatures during work	Very likely	Moderately harmful	Medium risk
Chemical hazards	Inhalation of vapours from improperly disposed hazardous substances in waste	Unlikely	Extremely harmful	Medium risk
Biological hazards	Contact with decomposing organic waste, microbial growth in warm weather	Likely	Extremely harmful	High risk
Statodynamic strain	Repetitive lifting of bins, bending while handling containers	Very likely	Moderately harmful	Medium risk
Psychophysiological strain	Stress from fast-paced work, traffic exposure, conflicts with residents	Very likely	Moderately harmful	Medium risk

**Figure 3.** Number and types of injuries during waste collection operations (2022–2024)

Physical hazards are assessed as a constant source of risk. These include noise, vibration, and extreme temperatures. While they may not result in immediate injuries, they can cause long-term health effects, particularly with regard to the respiratory system

(WHO, 2014). Due to their everyday presence and cumulative effect, this category is classified as medium risk.

Chemical hazards are found to be less frequent but potentially serious. Exposure typically occurs due to the improper disposal of hazardous substances in waste, leading to leaks or vapours. Although the probability of occurrence is lower, the potential severity of consequences requires caution (Ewis et al., 2013). For this reason, chemical hazards are also classified as medium risk.

Biological hazards become more significant during warmer months. High temperatures support the growth of microorganisms, while the contents of waste bins often include materials with a high biological component. Prolonged exposure increases the risk of infections and allergic reactions (Štrkalj, 2024). Accordingly, this group has been assessed as high risk.

Statodynamic strains arise from repetitive movements and improper body posture. This type of strain acts daily and has a cumulative effect. The consequences include pain in the back, shoulders, and lower limbs (Kompelj et al., 2021). Due to its frequency and long-term impact, this category is classified as medium risk.

Psychophysiological strains result from dynamic working conditions. In addition to constant exposure to traffic and the pressure of a fast work pace, psychological stress caused by interactions with other road users is also present (Ruxton, 2016). Long-term effects include reduced concentration and fatigue, which is why this category is also considered medium risk.

A comprehensive analysis indicates that the workplace of waste collection workers is associated with multiple types of risk. Mechanical hazards and falls stand out due to their high frequency and the severity of their consequences, while other groups require continuous monitoring and the application of protective measures. Priority actions include technical maintenance, consistent use of personal protective equipment, and regular worker training.

The results of the conducted risk assessment indicate that mechanical hazards and fall risks are the most frequent and may lead to serious health consequences for workers. These two categories have therefore been rated as high risk. Physical, chemical, and biological hazards occur with lower frequency or involve less severe outcomes but remain present in daily work and are assessed as medium risk. Statodynamic and psychophysiological strains, although often overlooked, are also significant factors contributing to long-term strain on the body. Due to their daily presence, they are also defined as medium risk.

RISK REDUCTION MEASURES

Based on the identified hazards and strains, as well as the assessed risk levels, a set of measures has been proposed to help create a safer and healthier working environment for waste collection workers.

First and foremost, it is essential to regularly maintain municipal vehicles and their lifting mechanisms, including daily visual inspections before starting work. Special attention should be given to the use of cut-resistant protective gloves, sturdy footwear with steel toe caps, and high visibility clothing such as reflective shirts or vests.

To reduce the risk of traffic related accidents, workers are required to wear high visibility garments that incorporate fluorescent colours (most commonly orange) and reflective strips. Figure 4 shows a worker wearing a high-visibility shirt with integrated reflective strips. This type of shirt represents an improvement over the standard combination of a regular shirt and a separate reflective vest. Since the reflective elements are sewn directly into the shirt, the garment is more comfortable, more practical, and allows greater freedom of movement, which facilitates everyday use of personal protective equipment.



Figure 4. Worker wearing a high visibility shirt with reflective strips

Workers should follow internal work instructions, which define proper techniques for lifting and handling containers. These instructions also provide guidelines for hazard recognition and correct procedures in case of an incident. Riding on the rear platform of the municipal vehicle should be limited to the shortest possible distances and carried out only under safe conditions. When handling larger containers, tasks should be organized in pairs to reduce physical strain and the risk of injury. In extreme temperatures, work schedules should be adjusted, and exposure to heat or cold should be minimized as much as possible. Visual

and audible signals on the vehicle must be functional and effective in order to reduce traffic-related risks.

Work task rotation is also recommended to avoid prolonged exposure to repetitive movements and statodynamic strains. In addition to technical and organizational measures, it is important to regularly conduct worker training on proper procedures and occupational safety measures. During training, it is helpful to present real examples of common injuries, so that workers clearly understand the potential consequences of ignoring safety protocols. This approach encourages more cautious behaviour and helps integrate safety into daily work routines.

Finally, it is essential to ensure that safety instructions are accessible and understandable and that regular internal monitoring is conducted to ensure the consistent application of protective measures in daily operations.

CONCLUSION

Workers engaged in municipal waste collection are exposed daily to numerous hazards and strains that may adversely affect their health and safety. Mechanical hazards, fall risks, statodynamic and psychophysiological strains, as well as physical, chemical, and biological hazards, together constitute a complex risk that requires a systematic and responsible approach. The conducted risk assessment enabled the identification of the most prevalent hazards and their categorization according to severity and frequency. Mechanical hazards and fall risks emerged as the most significant due to their high occurrence and serious consequences. Although other hazard categories were assessed as medium risk, their daily presence requires constant attention and continuous improvement of safety measures. The findings of this analysis can serve as a basis for developing specific measures aimed at improving occupational safety.

Technical maintenance of equipment, use of personal protective equipment, worker training, and organizational adjustments are key components of effective prevention. It is important to emphasize that a significant number of injuries could be avoided at the very beginning if workers followed the prescribed safety instructions and took the potential consequences seriously. Workplace injuries often result in long-term effects that may permanently impact quality of life and working capacity, further emphasizing the importance of preventive action.

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