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Research article

Job Safety Analysis of Drainage Pipe Cleaning Tasks Performed by Inmate Workers: Insights and Recommendations

Worrawit Nakpan,[1] Saisattha Noomnual[2*]

[1] School of Health Science, Sukhothai Thammathirat Open University
[2] Department of Occupational Health and Safety, Faculty of Public Health, Mahidol University

*Corresponding author, e-mail: saisattha.noo@mahidol.ac.th

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Abstract

Background: Inmate workers are considered a vulnerable group within society, and they engage in public work initiatives in Thailand, including sewage network cleaning, which may be associated with several hazards. **Objectives:** This study aims to systematically observe and identify potential hazards connected with the excavation and cleaning of drainage pipes, as performed by inmate workers. **Methods:** Job safety analysis (JSA) is employed to identify and quantify risks across six main tasks using a risk matrix to provide a detailed hazard evaluation. **Results:** The findings reveal significant occupational hazards, encompassing environmental and traffic safety risks during area preparation and physical and ergonomic challenges during waste retrieval and pipe cleaning tasks. These risks are heightened by the use of tools, the physical strain of manual labor, and challenging environmental conditions. **Conclusions:** There is a need for safety protocols and training specifically designed for the unique circumstances of inmate workers. Recommendations include appropriate personal protective equipment, regular risk assessments, and policy reforms that align inmate labor practices with established occupational health and safety standards. This study reveals the specific risks associated with inmate labor in public works, supports the development of targeted safety measures, and promotes the adoption of continual risk evaluations and ethical concerns in policy formulation, thus ensuring the well-being and safety of this unique workforce.

Keywords: Drainage pipe cleaning, Inmate workers, Job safety analysis, Occupational safety, Risk assessment

Introduction

Flooding is a recurring issue in urban communities, often attributed to the insufficient capacity of drainage systems to manage heavy rainwater[1-2]. To address this challenge effectively, the Department of Corrections, under the directive of the Ministry of Justice, has launched a public works initiative aimed at benefiting various government agencies that extend beyond the confines of correctional facilities. Inmate workers, individuals incarcerated in prisons and employed within the corrections system, play a pivotal role in this endeavor. They are entrusted with diverse tasks, from manual labor, such as landscaping and maintenance, to more technical responsibilities, such as manufacturing and computer programming[3]. For instance, the utilization of inmate labor for tree cutting and sewer cleaning is prevalent in Thailand[4]. Their role in resolving

drainage system issues cannot be understated. Despite the significant contributions of inmate workers to public works, research on the occupational hazards they face remains limited, particularly regarding high-risk activities such as drainage and sewer cleaning. Previous studies have indicated that incarcerated workers' health and safety are often overlooked, resulting in limited access to personal protective equipment (PPE), inadequate safety training, and challenging work environments [5-7]. Studies from other countries have shown that inmate laborers frequently encounter physical and environmental hazards with limited oversight[5-7], but no reports have examined the hazards experienced by Thai inmate workers engaged in drainage work.

It is essential to recognize that inmate workers belong to a vulnerable group within society[3,8-9]. Incarcerated individuals often confront specific challenges and risks during their participation in public work initiatives. To the best of our knowledge, the hazards and risks associated with sewer networks, particularly in Thailand, remain unexplored. Therefore, a comprehensive assessment of their working conditions and safety is required. To address this knowledge gap, our study aims to systematically assess the hazards associated with drainage pipe cleaning by focusing on specific risks and protective measures for this vulnerable workforce.

Job safety analysis (JSA) is a methodical approach enabling the identification of workplace hazards and accidents that may occur during task execution, as well as the development of appropriate countermeasures to mitigate these risks[10-13]. By employing this methodology, we observe and identify potential hazards associated with the excavation and cleaning of drainage pipes performed by inmate workers. This research helps to enhance the safety of inmate workers while contributing valuable insights into their work conditions and occupational challenges.

Methods

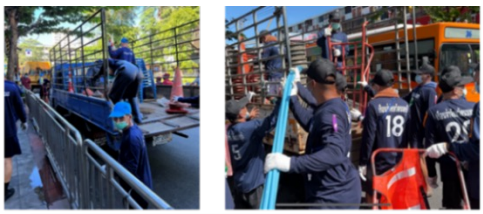
We employed a cross-sectional design to conduct JSA over four months—September to December 2022.

Study Population and Sampling

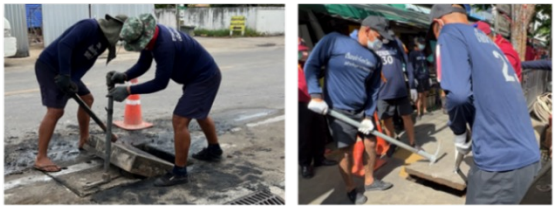
Our research targeted male inmate workers aged 18 years or above who actively engaged in drainage pipe cleaning during the fiscal year of 2022–2023. Due to the unique status of these workers and the associated restrictions, detailed demographic data, including age and work experience, were not obtainable. Inmates from each correction facility worked in a group of 10–15 at. Data were obtained from five groups, for a total of 60 samples.

The observed tasks included work area preparation, opening pipe covers, waste retrieval, cable dragging, waste loading, and cleaning the area (Figure 1). Each task was scrutinized to identify work behavior patterns and potential hazards, albeit without the granularity provided by detailed demographic data.

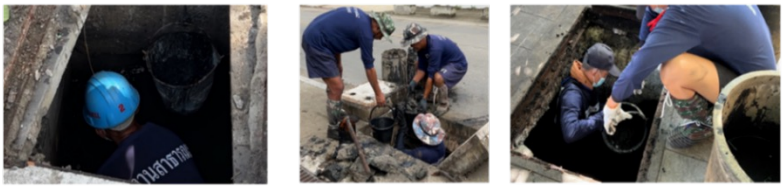
Two occupational health and safety experts observed each group to ensure thorough data collection and accuracy. Prior to the fieldwork, these experts fine-tuned the JSA process through preliminary observations with a non-sample group to ensure the applicability of the method in this context. The experts independently observed each task and documented the hazards. Following these independent observations, the experts engaged in a structured discussion to review, compare, and combine their findings. This process allowed for a consensus-based approach to hazard identification, which provided a robust qualitative assessment without relying on inter-rater reliability statistics. By integrating insights from each expert and resolving any discrepancies through discussion, we ensured that the final hazard assessment represented a comprehensive and consistent evaluation.



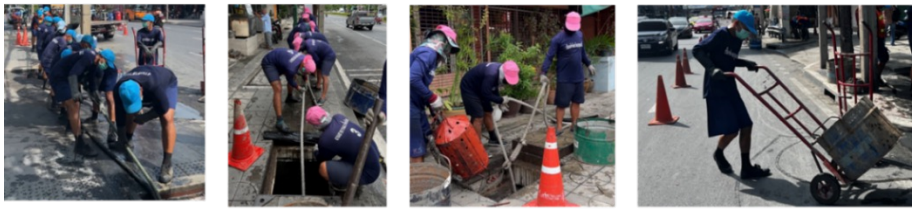
Task 1: Preparing the Work Area



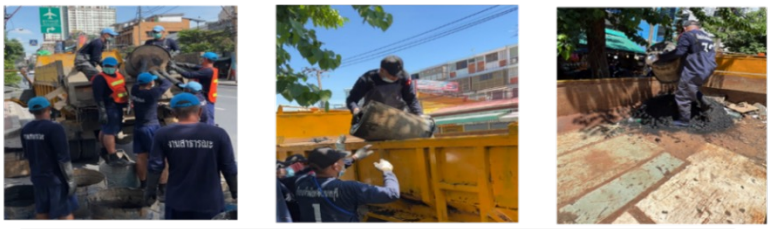
Task 2: Opening the Drain Cover



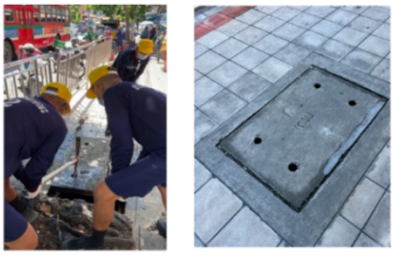
Task 3: Waste/Debris/Foreign Object Retrieval in the Sewer Pipe



Task 4: Dragging the Cable Inside the Pipe (between access points 1 and 2)



Task 5: Loading Waste/Debris/Foreign Objects onto a Truck



Task 6: Cleaning the Area and Closing the Drain Cover

Figure 1 Processes performed by inmate workers while cleaning the drainage pipes

JSA Methodology

JSA was applied to systematically identify and evaluate potential hazards in each task. The process entailed the following:

1) Decomposing each task into distinct steps.
2) Identifying potential hazards linked to each step.
3) Assessing the risk level of each hazard, considering its likelihood and potential severity.
4) Proposing preventive strategies to mitigate identified risks.

Additionally, a risk matrix method was utilized to quantify the probability (frequency) and severity (consequences) of potential events (Table 1), categorizing risks based on the total scores i.e., the product of their occurrence probability and impact severity (Table 2)[11,14-15]. A risk matrix was used to categorize and quantify the probability and severity of hazards, ranging from minimal risk to no acceptable risk, observed during each task, following the method outlined in ISO 45001:2018, Occupational health and safety management systems[16]. This approach was selected for its applicability in environments with high-risk factors and was tailored to assess the unique occupational conditions of inmate labor in confined and hazardous spaces.

The probability of incidents was assessed using the framework established by the Department of Industrial Works in the 'Regulation on Hazard Identification, Risk Assessment, and Risk Management Planning, B.E. 2542 (1999).'[17] This regulation provides standardized criteria for evaluating the likelihood of various hazards in industrial settings. By adhering to these established guidelines, our study ensures a consistent and systematic approach to risk assessment that aligns with national standards for occupational health and safety.

Table 1 Criteria used for describing the probability and the severity of the identified risks.

Level (degree)	Probability	Severity
1	Rare (very low incidence rate)	Incident or accident can be managed by first aid
2	Low (once every 5–10 years)	Incident or accident can be managed by medical treatment and the healthcare team
3	Moderate (once a year)	Incident or accident causes severe illness or injury
4	High (once a month)	Incident or accident causes death or is life-threatening

Table 2 Descriptive criteria for assessing the risk level

Total score	Risk level
1–2	Minimal risk
3–7	Acceptable risk (Need to review working procedure and control of hazard)
8–11	High risk (Need to directly manage and control the hazard)

Ethics

Given the sensitive nature of working with inmate populations, ethical compliance was a top priority. The research team worked collaboratively with the Department of Correction at the Penological Operation Bureau throughout the process (i.e., preparation, observation, and publication). The research adhered to ethical guidelines and received approval from the Ethics Committee on Research at the School of Health Science, Sukhothai Thammathirat Open University, Thailand (IRB-SHS 2020/1004/95). Personal information was not collected to protect privacy. Participants who willingly allowed the research team to observe their work activities were included in the study. All participants were thoroughly informed about the research project, and permission was secured from the correctional facility authorities prior to their enrollment in the study.

Results

Task 1: Preparing the Work Area

The JSA for Task 1 focused on identifying hazards associated with preparing the work area (Table 3). The first four steps showed no significant hazards, as indicated by the total score of N/A. However, in Step 5, a notable traffic safety hazard was identified. Setting up work zone barriers and warning signs was associated with the risk of injuries from vehicle collisions, scoring 12 (No acceptable risk or tolerance).

Table 3 JSA Task 1: Preparing the Work Area

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	All inmate workers have access to the designated work areas.	N/A	N/A	N/A	N/A	N/A
2	Supervisors plan, organize workspaces, hold meetings to assign job roles, provide instructions, emphasize safety, and inspect attire.	N/A	N/A	N/A	N/A	N/A
3	The supervisor calls a meeting with the inmate workers to: 1. Assign and define job responsibilities within the groups. 2. Provide instructions and explanations about the tasks. 3. Emphasize general safety reminders or special precautions. 4. Conduct inspections of the attire of inmate workers.	N/A	N/A	N/A	N/A	N/A
4	Prepare the work area by setting up work zone barriers, traffic cones, and warning signs to prevent unauthorized access to the work area as planned.	N/A	N/A	N/A	N/A	N/A

5	Inmates transport equipment. Heavy lifting requires at least two inmates. Work must occur only within designated, barricaded areas.	1. Handle heavy equipment with bare hands	1. Muscle pain from lifting heavy objects	3	2	6
		2. Traffic	2. Injury from vehicle collision	3	4	12

Task 2: Opening the Drain Cover

The JSA for Task 2 identified several potential hazards when handling sewer covers (Table 4). In Step 1, the use of a steel pipe as a lever to open the cover posed a risk of foot injuries if the pipe were to slip, with a total score of 8 (High risk), necessitating improved handling techniques. Step 2 involved hazards related to muscle strain from physical exertion during lifting, scoring 6 (Acceptable risk), suggesting that a review of the procedures is required. For example, an alternative method using a winch and lever presented no identified hazards and could be a safer option. In Step 3, the potential for accidental foot injuries while moving the cover scored 6, also meriting caution.

Table 4 JSA Task 2: Opening the Drain Cover

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	The inmate workers use a steel pipe to tap the area around the sewer cover, preparing it for opening. They utilize a steel pipe to strike the surrounding surface, loosening any debris or obstructions.	1. Using a steel pipe as a lever to open or remove the lid of a pipe	1. A situation where a steel pipe unintentionally hits someone's foot or toes	4	2	8
2	The inmate workers use a lever to apply force and lift the cover, allowing for entry into the sewer network.	1. Using physical strength or a tool to loosen or remove the cap from the pipe	1. Muscle pain or muscular discomfort	3	2	6

	Alternatively, the inmate workers use a winch to pull the sewer cover, and then they use a lever to guide and move it in the desired direction. The winch provides the pulling force while the lever helps control the movement of the sewer cover.	N/A	N/A	N/A	N/A	N/A
3	After lifting the sewer cover and leaving it suspended, the inmate workers use a steel pipe to support the cover underneath. This allows for seamless transportation and placement of the sewer cover in the appropriate position.	1. The lifted and transported sewer cover	1. The sewer cover is accidentally stepped on or touched during the process of lifting, moving, and placing it.	3	2	6

Task 3: Waste/Debris/Foreign Object Retrieval in the Sewer Pipe

The JSA for Task 3 identified various hazards associated with waste retrieval in the sewer pipe (Table 5). Steps 1 and 2 involved the risk of slipping and falling into the pipe, scoring 6 (Acceptable risk) but indicating a need for cautious ladder use. Step 3 presented multiple hazards, including confined spaces, high temperatures, wastewater exposure, and potential eye injuries from debris, scoring 8 (High risk). These findings highlight the need for protective measures, such as confined space training and PPE. Step 4, which involved lifting containers overhead, also scored 8 owing to potential muscle strain, suggesting the need for ergonomic training. Step 5 scored 6 for slipping and falling risks during exiting; thus, caution is advised.

Table 5 JSA Task 3: Waste/Debris/Foreign Object Retrieval in the Sewer Pipe

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	The inmate workers clean the sewer pipe before entering.	1. Slipping/falling into the pipe	1. Injuries from slipping and falling from the ladder	3	2	6
2	The inmate workers go down into the sewer pipe.	1. Slipping/falling into the pipe	1. Injuries from slipping and falling from the ladder	3	2	6
3	The inmate workers place the debris/waste/ scrap into the prepared containers.	1. Working environment (heat, noise)	1. Heatstroke due to hot weather	2	4	8

		2. Working in confined spaces	2. Risk of asphyxiation, which is dangerous for both workers and rescuers	2	4	8
		3. Working with damaged tools	3. Noise-induced hearing loss	3	2	6
		4. Material/debris flying into the eyes	4. Eye irritation from material/debris flying into the eyes	3	2	6
		5. Sharp objects/ hazards inside the pipe	5. Injuries from sharp objects or materials hitting the body	3	2	6
		6. Water level higher than chest level	6. Drowning due to rising water levels	2	4	8
		7. Working in wastewater areas	7. Skin irritation/infection from contact with wastewater	3	2	6
4	The inmate workers hand over the containers filled with debris/waste/ scrap to the receiving personnel above.	1. Posture when lifting heavy objects above the head	1. Muscle injuries from lifting and receiving containers	4	2	8
		2. Posture when receiving containers with waste/debris from the pipe	2. Injuries from slipping and falling	3	2	6
5	The inmate workers climb out of the pipe.	1. Slipping/falling while climbing out of the pipe 2. Damaged ladder	1. Injuries from slipping and falling	3	2	6

Task 4: Dragging the Cable Inside the Pipe (between access points 1 and 2)

The JSA for Task 4 identified several risks associated with dragging the cable between access points in the pipe. Step 2, inserting the pipe connectors, showed a score of 8 (High risk) owing to multiple hazards, including confined spaces, high temperatures, and wastewater exposure. Step 4, which involves releasing the cable reel, also scored 8 because of posture strain and the potential for slipping. Step 6 presented the highest risk with a score of 9, mainly from the physical exertion of lifting heavy containers and the risk of cable reels hitting workers. Enhanced ergonomic support and training are recommended to mitigate these risks.

Table 6 JSA Task 4: Dragging the Cable Inside the Pipe (between access points 1 and 2)

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	The workers enter the pipe.	1. Slipping or falling while descending into the pipe	1. Injuries from slipping and falling from the ladder	3	2	6
2	They insert PVC or wooden pipe connectors between the designated drainage pipes.	1. Working environment (heat, noise)	1. Heatstroke due to hot weather	2	4	8
		2. Working in confined spaces	2. Risk of asphyxiation, dangerous for both workers and rescuers	2	4	8
		3. Working with damaged tools	3. Noise-induced hearing loss	3	2	6
		4. Material/debris flying into the eyes	4. Eye irritation from material/debris flying into the eyes	3	2	6
		5. Sharp objects/ hazards inside the pipe	5. Injuries from sharp objects or materials hitting the body	3	2	6
		6. Water level higher than chest level	6. Drowning due to rising water levels	2	4	8
		7. Working in wastewater areas	7. Skin irritation/ infection from contact with wastewater	3	2	6
3	The workers climb out of the pipe.	1. Slipping or falling while ascending from the pipe 2. Damaged ladder	1. Injuries from falling down the stairs	3	2	6
4	The workers at access point 1 release the cable reel down into the pipe.	1. Posture while working, lifting heavy objects above the head 2. Posture while receiving waste containers	1. Muscle injuries from lifting and carrying containers	4	2	8
		3. Slipping or falling into the pipe	2. Injuries from falling due to slipping	3	2	6

5	The workers stationed at access point 2 (6–10 people) pull the rope to draw the cable reel.	1. Slipping or falling while exerting force to pull the waste	1. Injuries from slipping/ falling	3	2	6
		2. Straining while twisting	2. Muscle injuries	4	2	8
		3. Using bare hands to grip and pull the rope	3. Hand injuries from exertion and rope-related injuries	3	1	3
6	They lift the cable-containing container and place it at the pipe's opening.	1. Slipping or falling while exerting force to lift the reel	1. Injuries from slipping/ falling	3	2	6
		2. Cable reel hitting the worker's body	2. Hand injuries from impacts with the pipe	3	3	9
		3. Exerting force to lift the waste (sometimes performed by one person)	3. Muscle injuries from lifting heavy loads in unnatural positions	4	2	8
		4. Working in hot environments	4. Heatstroke due to hot conditions	2	4	8
7	They transfer the cable from the container to a large bin.	1. Slipping or falling while exerting force to lift the reel	1. Injuries from slipping/ falling	3	2	6
		2. Cable reel hitting the worker's body	2. Hand injuries from impacts with the pipe	3	3	9
		3. Exerting force to lift the waste (sometimes performed by one person)	3. Muscle injuries from lifting heavy loads in unnatural positions	4	2	8
		4. Working in hot environments	4. Heatstroke due to hot conditions	2	4	8

Task 5: Loading Waste/Debris/Foreign Objects onto a Truck

The JSA for Task 5 identified several hazards related to lifting posture, environmental conditions, and exposure to biological and chemical agents. Step 1, lifting waste containers, was given a score of 6 (Acceptable risk), suggesting that a review of the procedures may help reduce strain and fall risks. Step 2, during which workers receive containers, got a score of 8 (High risk) owing to heat exposure, eye hazards from debris, and muscle strain, indicating the need for management controls, including PPE and heat stress prevention. Step 3, loading waste on the truck, also scored 6 and involved risks from damaged tools and potential eye injuries, which is manageable with procedural reviews.

Table 7 JSA Task 5: Loading Waste/Debris/Foreign Objects onto a Truck

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	2–3 workers lift the waste container and send it up to the workers on the truck for them to receive	1. Posture during work: Lifting heavy objects above the head	1. Muscle injuries from lifting and carrying heavy containers	3	2	6
		2. Falling from a standing platform	2. Injuries from falling	3	2	6
2	1–2 workers on the truck receive the container	1. Working environment (heat)	1. Heatstroke due to hot conditions	2	4	8
		2. Materials/debris striking the eyes	2. Eye inflammation from materials/debris striking the eyes	3	2	6
		3. Being struck by sharp or heavy objects in the workspace	3. Injuries from sharp or heavy objects	3	2	6
		4. Biological hazard	4. Skin inflammation from infections	2	3	6
		5. Chemical hazard	5. Illness from heavy metals	2	3	6
		6. Posture when lifting heavy containers	6. Muscle pain	4	2	8
3	Workers on the truck proceed to load the waste	1. Working with damaged tools	1. Injuries from sharp or heavy objects	3	2	6
		2. Materials/debris striking the eyes	2. Eye inflammation from materials/debris striking the eyes	3	2	6
		3. Biological hazard	3. Skin inflammation from infections	2	3	6
		4. Chemical hazard	4. Illness from heavy metals	2	3	6

Task 6: Cleaning the Area and Closing the Drain Cover

The JSA for Task 6 identified potential hazards associated with cleaning the area and closing the drain cover. Step 1, cleaning around the drain, was rated a score of 6 (Acceptable risk) owing to the possibility of slipping and falling, manageable through procedural reviews. Step 2, closing the drain cover, was rated a score of 8 (High risk) because of hazards from heat exposure and the physical strain of lifting, indicating the need for improved handling techniques and heat management strategies.

Table 8 JSA Task 6: Cleaning the Area and Closing the Drain Cover

Order	Work steps	Hazards	Potential impacts	Probability	Severity	Total score
1	Clean the area around the drain cover and the nearby area.	1. Slipping/Falling into the drain	1. Injuries from falling	3	2	6
2	Close the drain cover.	1. Working environment (heat)	1. Heatstroke due to hot weather	2	4	8
		2. Forcing to move the drain cover	2. Muscle pain from heavy lifting	4	2	8
		3. Working with damaged tools	3. Injuries from using equipment	3	2	6

Discussion

The JSA provides a comprehensive understanding of potential hazards and their associated risks among inmate workers. This analysis is crucial for ensuring the safety of the inmate workers and supervisors involved in these tasks.

Task 1: Preparing the Work Area

The initial steps of preparing the work area, where the inmate workers access the designated areas and supervisors oversee the tasks, showed no immediate hazards. This indicates that the preliminary stages are well-organized and adhere to safety protocols. However, a potential hazard related to traffic safety was revealed during Step 5, requiring work zones to be adequately barricaded and warning signs to be visible to prevent accidents. The risk of injuries from being struck by vehicles on the road is significant, and a total score of 12 suggests that this risk is unacceptable, which is consistent with previous studies[18-19].

Task 2: Opening the Drain Cover

The use of tools, such as steel pipes, to open sewer covers presents potential hazards. The risk of unintentional injuries, such as the steel pipe hitting someone's foot, is evident. This observation is consistent with previous reports, showing that proper tool handling and safety precautions are necessary when working in construction or maintenance environments[20].

Task 3: Waste/Debris/Foreign Object Retrieval in the Sewer Pipe

The confined space of a sewer pipe inherently poses multiple hazards, including slipping or falling inside the pipe, exposure to wastewater, and the presence of sharp objects. Additionally, workers in drainage pipe cleaning are exposed to significant biological risks. Confined spaces have been widely recognized as high-risk environments, and our findings are consistent with previous work, suggesting the need for specialized training and safety measures for workers operating in such environments[21].

Task 4: Dragging the Cable Inside the Pipe

Dragging the cable inside the pipe poses hazards ranging from high to unacceptable levels of risk, especially when lifting heavy objects or working in hot environments. The potential for physical strain and dangerous conditions to adversely affect workers' health and safety is evident. Previous studies have considered ergonomic practices and the provision of appropriate PPE to mitigate such risks[22-23].

Task 5: Loading Waste/Debris/Foreign Objects onto a Truck

Loading waste or debris onto a truck involves several steps with potential hazards related to posture, the working environment, and the use of damaged tools. Therefore, it is necessary to review working procedures and implement hazard controls, especially when lifting heavy objects or working in hot conditions. This is consistent with studies on manual handling in waste management, suggesting that regular ergonomic training and the use of mechanical aids reduce the strain on workers[18-19].

Task 6: Cleaning the Area and Closing the Drain Cover

The final task of cleaning the area and closing the drain cover involves hazards primarily associated with environmental factors, such as heat, and the physical strain of moving the drain cover. The need for preventive measures to ensure worker safety is evident, including ergonomic practices and the provision of appropriate PPE[22-23].

Conclusions

Through this investigation of the occupational hazards associated with drainage pipe cleaning tasks performed by inmate workers in Thailand, we identified a range of risks, from environmental hazards to physical, ergonomic, and biological challenges, emphasizing the unique and often overlooked circumstances of inmate labor. Although this study specifically focuses on inmate workers involved in drainage pipe cleaning in Bangkok, Thailand, the findings are broadly applicable to other workers performing similar tasks in comparable environments. This study follows a framework that can be applied and compared across various sectors with similar work characteristics, emphasizing standardized safety protocols and training to reduce risks.

Additionally, the safety management of inmate workers raises several ethical considerations, especially considering that they represent a vulnerable population with limited autonomy over their work conditions. Accordingly, it is essential to prioritize inmate safety through comprehensive risk assessments, provision of adequate PPE, and appropriate training. Ensuring that inmate workers are not exposed to conditions that would be deemed unacceptable for other workers is a core ethical responsibility, reinforcing the need for rigorous safety standards and oversight in these work settings.

Our key findings indicate that specific tasks, such as work area preparation and waste retrieval, present significant risks related to traffic hazards, the use of improper tools, and the physical demands of working in confined spaces. Moreover, biological hazards, including exposure to leptospirosis, tetanus, and fungal infections, pose serious health risks owing to the humid and contaminated conditions commonly found in drainage systems. These risks are exacerbated by inmate workers' unique working conditions, including limited access to proper safety training and equipment.

To address these findings, we recommend specific targeted measures. For traffic safety during work area preparation, it is essential to install physical barriers or traffic signals to minimize collision risks. For biological hazards, enhancing PPE standards to include gloves, boots, and waterproof protective clothing can mitigate exposure to infectious agents. Regular, specialized safety training tailored to inmate workers is also recommended to ensure that they understand the hazards associated with each task and can take proactive steps to protect themselves. Furthermore, the provision of tools specifically designed for drainage tasks is advised to reduce the risk of injury from using improper tools.

Overall, this research highlights the broader social and ethical implications of utilizing inmate labor for public works, calling for a reevaluation of policies and practices to ensure that they align with occupational health and safety standards, including protocols for biological hazard prevention, thereby safeguarding the well-being of this vulnerable workforce. The insights gained from this study have significant implications for both policy and practice, not only providing a foundation for developing more effective safety protocols and interventions but also supporting the enhancement of workplace safety and the well-being of inmate workers engaged in drainage pipe cleaning tasks.

Limitations and Future Research

This study's reliance on JSA without quantitative exposure measurements or health surveillance data may limit the generalizability of the findings. Additionally, as a short-term study, the long-term health impacts on inmate workers were not captured. Future research should consider longitudinal studies to evaluate long-term health effects and the effectiveness of implemented safety improvements.

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References

1. Majumder T, Chakraborty P, Das B. Chapter 23:Management of Urban Flood-Induced Solid Waste in Some Metropolitan Cities: An Overview. In: Ghosh S K, Samanta S, Hirani H, da Silva, C R V, eds. *Effective Waste Management and Circular Economy Legislative Framework Strategies*. 1st ed. CRC Press;2023; 255-266.
2. Toei K, Atitruangsiri A, Belz M, Holman G, DiMassa D, Page D, et al. Mitigating the Effects of Flooding in the Khlong Toei Slum of Bangkok, Thailand 2017. https://bsac.chemcu.org/wp-content/uploads/2021/02/Mitigating_the_Effects_of_ Flooding_in_the_Khlong_ Toei_Slum_of_Bangkok_Thailand.pdf (accessed April 5, 2024)
3. Guilbaud F. Working in prison: Time as experienced by inmate-workers. *Rev Fr Sociol*. 2010;51: 41–68. doi:10.3917/RFS.515.0041
4. Limited BPPC. Prison labour hired to clean Bangkok's drains. *Bangkok Post* n.d.
5. Captive Labor Exploitation of Incarcerated Workers. *ACLU AND GHRC RESEARCH REPORT*; 2022. https://assets.aclu.org/live/uploads/publications/ 2022-06-15-captivelaborresearchreport.pdf
6. Segule MN, LeMasters K, Peterson M, Behne MF, Brinkley-Rubinstein L. Incarcerated workers: overlooked as essential workers. *BMC Public Health*. 2022;22(1): 506. doi:10.1186/s12889-022-12886-7
7. Montoya-Barthelemy A. The Occupational Health of Prison Inmates: An Ignored Population and an Opportunity. *J Occup Environ Med*. 2019;61(2): e74–e76. doi:10.1097/JOM.0000000000001514
8. Lombardo LX. Mental health work in prisons and jails: Inmate adjustment and indigenous correctional personnel. *Crim Justice Behav*. 1985;12(1): 17–27. doi:10.1177/0093854885012001003
9. Boudoukha AH, Altintas E, Rusinek S, Fantini-Hauwel C, Hautekeete M. Inmates-to-staff assaults, PTSD and burnout: Profiles of risk and vulnerability. *J Interpers Violence*. 2013;28(11): 2332–2350. doi:10.1177/0886260512475314
10. Albrechtsen E, Solberg I, Svensli E. The application and benefits of job safety analysis. *Saf Sci*. 2019;113: 425–437. doi:10.1016/j.ssci.2018.12.007
11. Ghasemi F, Doosti-Irani A, Aghaei H. Applications, Shortcomings, and New Advances of Job Safety Analysis (JSA): Findings from a Systematic Review. *Saf Health Work*. 2023;14(2): 153–162. doi:10.1016/j.shaw.2023.03.006
12. Ibrahim F, Lebowitz J. Essentials of job hazard analysis. *Chem Eng Prog*. 2018;114(11): 52–56. https://www.proquest.com/magazines/essentials-job-hazard-analysis/docview/2140866110/se-2
13. Li W, Cao Q, He M, Sun Y. Industrial non-routine operation process risk assessment using job safety analysis (JSA) and a revised Petri net. *Process Saf Environ Prot*. 2018;117: 533–538.
14. Thepaksorn P, Thongjerm S, Incharoen S, Siriwong W, Harada K, Koizumi A. Job safety analysis and hazard identification for work accident prevention in para rubber wood sawmills in southern Thailand. *J Occup Health*. 2017;59(6): 542–551. doi:10.1539/joh.16-0204-CS

15. Pramitasari R, Haikal H, Yuantari MC, Dwi KIK, Treesak C. Job Safety Analysis and Hazard Identification of Welding Process in Semarang-JSA Method AS/NZS 4360: 2004. *Dis Prev Public Health J.* 2022;16: 62–69. doi: 10.12928/dpphj.v16i1.4613
16. International Organization for Standardization: (2018). Occupational health and safety management systems - Requirements with guidance for use (ISO 45001:2018). Geneva: ISO.
17. Regulation on Hazard Identification, Risk Assessment, and Risk Management Planning, B.E. 2542. 1999: 2–19 https://www.diw.go.th/webdiw/wp-content/ uploads /2021/07/law-fac-saft-17112543.pdf
18. Battini D, Botti L, Mora C, Sgarbossa F. Ergonomics and human factors in waste collection: analysis and suggestions for the door-to-door method. *IFAC-PapersOnLine*. 2018;51(11): 838–843. doi:10.1016/j.ifacol.2018.08.443
19. Botti L, Battini D, Sgarbossa F, Mora C. Door-to-door waste collection: Analysis and recommendations for improving ergonomics in an Italian case study. *Waste Manag*. 2020;109: 149–160. doi:10.1016/j.wasman.2020.04.027
20. Wong JM, Arico MC, Ravani B. Factors Influencing Injury Severity to Highway Workers in Work Zone Intrusion Accidents. *Traffic Inj Prev*. 2011;12(1): 31–38. doi:10. 1080/15389588.2010.525569
21. Debnath AK, Blackman R, Haworth N. Common hazards and their mitigating measures in work zones: A qualitative study of worker perceptions. *Saf Sci*. 2015;72: 293–301. doi:10.1016/j.ssci.2014.09.022
22. Arciniega-Rocha RP, Erazo-Chamorro VC, Szabo G. The Prevention of Industrial Manual Tool Accidents Considering Occupational Health and Safety. *Safety*. 2023;9(3): 51. doi: 10.3390/safety9030051
23. Burlet-Vienney D, Chinniah Y, Bahloul A, Roberge B. Occupational safety during interventions in confined spaces. *Saf Sci*. 2015;79: 19–28. doi:10.1016/ j.ssci.2015. 05.003

การอ้างอิง

Nakpan W., Noomnual S. Job Safety Analysis of Drainage Pipe Cleaning Tasks Performed by Inmate Workers: Insights and Recommendations. J Chulabhorn Royal Acad.2024; 6(4): 204-218. https://he02.tci-thaijo.org/index.php/jcra/article/view/268673

Online Access

https://he02.tci-thaijo.org/index.php/jcra/article/view/268673