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SUSTAINABLE AI-POWERED WASTE MANAGEMENT: IMPROVING HEALTH AND SAFETY OUTCOMES FOR WASTE PICKERS IN JAMSHEDPUR CITY THROUGH INNOVATIVE TECHNOLOGICAL SOLUTIONS

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Abstract:
Waste pickers play a vital role in any Indian city's urban waste management system. However, these workers typically face substantial health risks as a result of their exposure to hazardous chemicals and bad working conditions. This empirical study looks at how waste pickers in Jamshedpur City could have better health and safety outcomes through sustainable waste management systems driven by AI. This study attempts to enhance waste management's effectiveness and safety by integrating cutting-edge technological solutions with traditional approaches. Three primary uses of artificial intelligence (AI) are now being investigation: garbage collection; real-time monitoring of hazardous waste sites; and waste transportation and route tracking. The amount of time waste pickers spends collecting waste is reduced when artificial intelligence (AI) tools are used in the waste management process. Intelligent sorting systems lessen the risks that manual sorting poses to human health by automating the separation of recyclable items. For the waste management process to function more smoothly and efficiently, real-time monitoring of garbage collection is also beneficial. The goal of this study was to determine how waste pickers who collect waste from Jamshedpur's towns improve their health as a result of using artificial intelligence (AI). In addition, this study seeks to determine how garbage pickers, who all labour in hazardous conditions and demanding environments, might reduce their risk of illness by using artificial intelligence. To examine the impact of waste pickers' usage of AI technologies in waste management, primary data has been gathered from 117 respondents from Jamshedpur. The impact of AI technologies on waste pickers' health is being examined by the authors using an exploratory and descriptive methodology. The findings of this study will provide valuable insights to waste pickers, govt. and policy makers in designing appropriate strategies to enhance overall health of waster pickers in the society.

Key Words: Artificial Intelligence (AI), Waste Management, Health Outcomes, Waste Pickers, Hazardous Waste, Technological Solutions

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1. Introduction:

> *The health status of waste pickers is largely influenced by the activities on the landfill sites. Significant associations were observed between landfill exposure and mental health disorders and infectious and chronic diseases. (***Uhunamure et al., 2021 page-9)**

Waste pickers serve as essential players in urban waste management systems, particularly in developing countries like India. However, they are disproportionately exposed to various health hazards, including chemical contaminants and biological waste (Cruvinel et al., 2019). The integration of Artificial Intelligence (AI) into waste management systems offers a promising pathway to mitigate these risks by improving operational efficiency, reducing health risks, and optimizing waste collection processes (Fang et al., 2023). This study specifically examines how AI-driven solutions can enhance the health and safety of waste pickers in Jamshedpur City. Waste management is a complex and multifaceted process that involves the collection, sorting, recycling, and disposal of waste materials. Traditional methods of waste collection and disposal are not only time-consuming but also pose significant health risks to those involved, particularly waste pickers (Cruvinel et al., 2019). Waste pickers often work in unsanitary conditions, handling hazardous materials without adequate protective measures (Cruvinel et al., 2019). The introduction of AI into waste management offers significant potential to not only increase operational efficiency but also improve the working conditions and overall health of waste pickers (Fang et al., 2023).

Waste sorting machines, real-time monitoring systems, and optimized waste transportation networks have been introduced to revolutionize the way waste is managed. These AI tools help minimize human interaction with hazardous materials, thereby reducing health risks for waste pickers. One of the most significant ways in which AI can benefit waste pickers is through the automation of waste sorting. Traditionally, waste sorting has been a manual and labor-intensive task, exposing waste pickers to harmful substances such as broken glass, chemical waste, and biological hazards. AI-powered sorting machines can efficiently classify waste into different categories such as plastic, metal, glass, and organic waste, minimizing the need for human involvement in dangerous environments. These machines use advanced algorithms and sensors to recognize various materials and automatically separate them, reducing the time and effort required for waste pickers and, more importantly, limiting their exposure to harmful substances.

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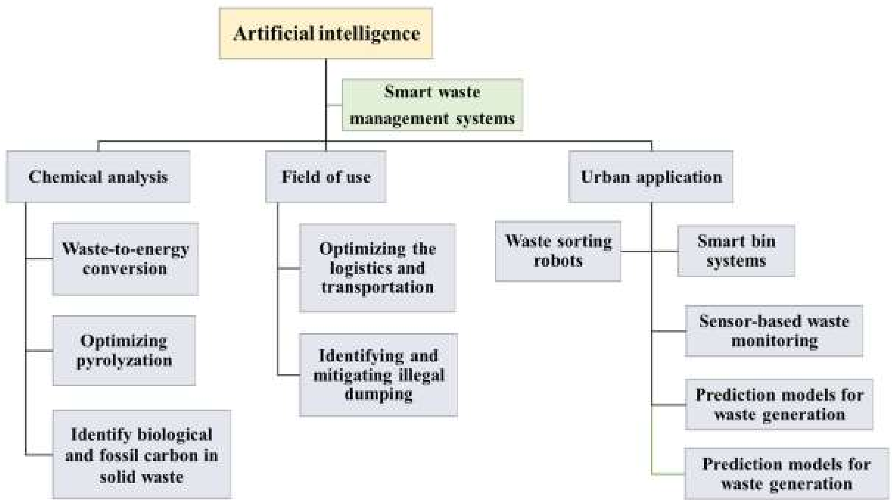
Figure 1: AI and Smart Waste Management
(Source: Fang et al., 2023)



In Jamshedpur, where manual sorting is still the primary method, AI-driven solutions like machine learning models for sorting could substantially improve the safety and health outcomes for waste pickers. Research suggests that using AI to automate waste sorting not only reduces the health risks associated with manual handling but also improves the efficiency of recycling processes. This contributes to a cleaner environment, which indirectly benefits the overall health of the community, including the waste pickers themselves. Another critical application of AI in waste management is real-time monitoring and identification of hazardous waste sites. Waste pickers in Jamshedpur frequently work in environments where hazardous waste materials are disposed of improperly. AI tools equipped with real-time sensors and data analytics capabilities can monitor these sites for potentially dangerous conditions, alerting waste pickers and municipal authorities to take immediate action. This real-time monitoring allows for quicker response times in case of emergencies and reduces the likelihood of waste pickers being exposed to hazardous substances.
Incorporating AI in waste monitoring systems can further enhance compliance with waste management regulations by identifying illegal dumping sites or unsanitary practices. Governments and municipalities can use this data to make informed decisions on waste management policies and take immediate action to prevent environmental contamination. Furthermore, AI can also be used to monitor the health conditions of waste pickers themselves by tracking their exposure to harmful substances and identifying early symptoms of health issues. Hassan & Reza, n.d. has rightly stated,
"AI technology has shown great promise in optimizing waste collection routes and schedules through the analysis of real-time data. Leveraging the power of sensor and cameras installed on waste bins, AI system can accurately detect fill levels and determine when bins require emptying."

Waste transportation is another area where AI can significantly improve the working conditions of waste pickers. In cities like Jamshedpur, waste collection is often delayed due to inefficient transportation routes, leading to an accumulation of waste in certain areas. Waste pickers are then required to spend more time in these environments, increasing their exposure to harmful materials. AI can be employed to optimize waste collection routes, ensuring that waste is picked up and transported to disposal sites more efficiently. AI-driven route optimization algorithms consider various factors such as traffic patterns, waste generation rates, and environmental conditions to design the most efficient collection routes. By minimizing the time waste pickers spend in hazardous environments, these AI tools reduce their overall exposure to health risks. Moreover, the efficiency gained from optimized routes can also lead to cost savings for municipal governments, which can be reinvested in improving the welfare of waste pickers. The primary objective of integrating AI into waste management is to enhance the health and safety of waste pickers. Studies have shown that waste pickers suffer from a range of health issues, including respiratory problems, skin infections, and musculoskeletal disorders, due to their prolonged exposure to waste. AI-driven waste management systems can help mitigate these health risks by automating dangerous tasks, optimizing waste collection routes, and providing real-time monitoring of hazardous sites.

As Kumari and Vasavada (2022) accurately point out in their study, smart waste management, or the application of AI to the waste management process, began in Jamshedpur a few years earlier;

> *"In a discussion with G.P. Ishwar Rao officer of Public Health Services Department JUSCO, it came to the notice that the company (JUSCO) has a system of door-to-door garbage collection from the year 2016, but due to the several challenges faced by the households as well as the workers working with the Public Health Services Department JUSCO, the idea of Digitalized Waste Management was adopted by the company (JUSCO) about 2-3 years before." (page-171)*

2. Origin:

The waste management crisis, particularly in rapidly urbanizing cities like Jamshedpur, has become a growing concern over the last few decades. The reliance on informal waste pickers, who play a crucial role in collecting and sorting waste, brings about significant health risks due to their exposure to hazardous materials and unsanitary conditions. The idea of integrating AI into waste management originated from the need to improve the efficiency of waste management systems while also protecting these vulnerable workers. By automating dangerous tasks and optimizing operations, AI-driven systems can address both the waste disposal issues and health risks that have persisted for years

3. Significance:

AI-driven waste management improves waste picker safety while also increasing system efficiency. Artificial Intelligence (AI) can minimize exposure to hazardous chemicals and optimize recycling operations in manual labor-intensive places like Jamshedpur. By lowering the amount of garbage dumped in landfills and preserving natural resources through the clever sorting of recyclables like metals and plastics, this helps to promote global sustainability. AI also improves sustainability by reducing pollutants and fuel usage while optimizing waste pickup routes. AI makes proactive trash management possible by enabling real-time monitoring and predictive analysis, which lowers waste accumulation and unlawful dumping. All things considered, AI-driven solutions promote long-term sustainability initiatives and produce safer, more effective urban settings.

4. Literature Review

Exposure to landfill activities has a substantial impact on waste pickers' health. According to **Uhunamure et al. (2021)**, there is a link between extended landfill exposure and a higher incidence of mental health issues, infectious diseases, and chronic illnesses in waste pickers. Their study, which concentrated on the Northern Region of South Africa, highlights the hazards to waste pickers' occupational health brought on by unfavorable working conditions, which can have a negative impact

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on their health and increase their susceptibility to social injustice. A thorough analysis of Jamshedpur's municipal solid waste management is provided by **Humaira and Sinha (n.d.)**, who highlight the difficulties in recycling, disposing of, and collecting waste in the city. The writers draw attention to the shortcomings of infrastructure, ineffective waste management methods, and the informal rubbish pickers who cover gaps in the system. Their findings imply that in order to improve waste management techniques and, eventually, improve environmental sustainability and public health in Jamshedpur, there needs to be greater collaboration between local communities and government authorities. The use of artificial intelligence (AI) to improve waste management systems in smart cities is reviewed by **Fang et al. (2023)**. The paper goes over a number of AI-driven technologies that enhance waste sorting, collection, and recycling procedures, increasing their effectiveness and economy. Robotics, Internet of Things (IoT) sensors, and machine learning algorithms are important solutions that allow for the real-time monitoring and optimization of waste management operations. The assessment focuses on how AI may help cities move toward smart waste management systems, encourage sustainability, and drastically lessen their negative environmental effects. The revolutionary potential of AI-driven solutions in urban recycling and garbage management is examined by **Hassan and Reza (n.d.)**. In order to maximize garbage collection and sorting, the study places a strong emphasis on implementing cutting-edge technology including automated systems, machine learning, and artificial intelligence. These technologies raise recycling rates in cities, decrease the need for human interaction, and improve accuracy. The authors contend that AI's capacity to instantly evaluate massive datasets can assist cities in implementing more effective, environmentally friendly trash management techniques, which will have a positive impact on the local economy and ecology. With an emphasis on Jamshedpur, popularly known as Steel City, **Kumari and Vasavada (2022)** investigate the function of digitalized waste management in fostering sustainable development. The case study demonstrates how waste management procedures like collection, segregation, and disposal are made easier by technology innovations like digital platforms and artificial intelligence (AI) systems. According to their research, digitization lessens the need for manual labor while increasing operational effectiveness and environmental results. Jamshedpur is pursuing a more sustainable urban environment through the integration of smart technologies, striking a balance between responsible waste management practices and economic growth. on their comparison of AI-driven waste management advances between the USA and Africa, **Nwokediegwu et al. (2024)** emphasize how AI is enhancing sustainability and efficiency on both continents. In the USA, recycling and waste collection are optimized through automation using cutting-edge AI techniques. While still in its infancy, artificial intelligence (AI) has the potential to improve trash sorting and lessen environmental impact in Africa. The analysis shows how artificial intelligence (AI) may improve waste management worldwide by bridging the gap between manual waste management systems and clever, sustainable alternatives. The role of artificial intelligence (AI) in promoting the circular economy—particularly in the area of waste management—is becoming more widely acknowledged. According to **Wilts et al. (2021)**, artificial intelligence (AI) can help sort municipal waste more efficiently and automatically while also increasing recycling rates and reducing human error. The accurate identification of waste materials made possible by the integration of AI technology helps to improve the efficiency of resource recovery procedures. Furthermore, by encouraging the reuse of valuable materials and lowering landfill contributions, AI systems improve the overall sustainability of waste management techniques.

5. Research Gap

Following a thorough analysis of numerous pieces of literature, it was discovered that the majority of studies discussed waste management strategies and the health conditions of waste pickers separately,

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but none of them discussed the effects of artificial intelligence on waste pickers' health.

6. Study's Background

6.1. AI Driven Technology and Sustainability in Waste Management

> *The significance of AI-driven innovation in waste management lies in their transformative potential to address pressing environmental concerns. These technologies enhance efficiency, reduce environmental impact, and pave the way for a more sustainable and crucial economy. (Nwokediegwu et al., 2024, p. 513)*

The link between sustainability and AI-driven waste management is crucial in addressing the growing environmental and health challenges posed by waste. Traditional waste management systems struggle to keep up with increasing waste generation, leading to environmental degradation and poor working conditions for waste pickers. AI offers a sustainable solution by automating key processes, such as waste sorting and recycling, which not only increase efficiency but also reduce the overall volume of waste sent to landfills. AI tools can optimize recycling by identifying recyclable materials more accurately, thus reducing the amount of waste that is improperly disposed off. Artificial Intelligence (AI) has become a critical enabler for the circular economy, particularly in the sorting of municipal waste. AI systems enhance efficiency in waste management by improving the accuracy of sorting processes and reducing the volume of misclassified waste. This technology not only supports recycling efforts but also aligns with sustainability goals (Wilts et al., 2021).

> *Artificial intelligence and the use of robots in sorting could, in the future, make a significant contribution to the production of high-quality secondary raw materials from waste, in the sense of a recycling economy. (Wilts et al., 2021)*

Moreover, AI can contribute to the circular economy by enabling the recovery of valuable materials from waste. Intelligent sorting systems, for instance, can identify high-value recyclables like metals and plastics, ensuring they are properly reused. This minimizes the extraction of new raw materials, thereby conserving natural resources. Sustainability is further enhanced by AI's ability to optimize waste collection routes, reducing fuel consumption and greenhouse gas emissions associated with waste transportation. By reducing the environmental footprint of waste management, AI helps create systems that are more in line with sustainability goals. In addition, real-time monitoring and predictive analysis offered by AI tools allow waste management systems to be proactive rather than reactive. For instance, AI can predict waste generation patterns, enabling more efficient planning and resource allocation. This reduces the chances of illegal dumping and unsanitary waste accumulation, thereby contributing to a cleaner, more sustainable urban environment. Thus, AI not only addresses immediate waste management challenges but also aligns with long-term sustainability efforts.

7. Improving Waste Pickers' Health and Safety Conditions Using AI-Driven Waste Management:

AI-powered waste management systems have the potential to dramatically enhance waste pickers' health and safety, as they are frequently exposed to dangerous items in unhygienic settings. Waste pickers in places like Jamshedpur handle a range of hazardous materials, from shattered glass to poisonous chemicals, while wearing no protection. Waste sorting and segregation, two of the riskiest waste management processes, can be automated with the help of artificial intelligence (AI). The

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application of intelligent sorting systems, which can automatically identify garbage and eliminate the need for waste pickers to handle hazardous materials by hand, is one of the main advantages of AI in this context (Fang et al., 2023; Kesari, 2024). By separating recyclables from regular trash, these AI-powered devices can reduce the amount of time that people come into contact with potentially dangerous materials. By separating recyclables from regular trash, these AI-powered devices can reduce the amount of time that people come into contact with potentially dangerous materials. Moreover, AI may be used to continuously monitor waste sites, identifying potentially dangerous situations and warning personnel of them. This would enable prompt action and avert mishaps (Fang et al., 2023). AI can also increase safety by optimizing routes. rubbish pickers frequently work lengthy shifts in filthy conditions as a result of ineffective rubbish collection routes. rubbish pickers can spend less time in dangerous regions by using AI to optimize these routes and ensure that rubbish is collected more efficiently (Kesari, 2024). This helps lessen their exposure to hazardous trash while also improving their working circumstances. Furthermore, by tracking exposure levels and identifying early indicators of health problems, AI systems can assist in keeping an eye on the health of waste pickers themselves and facilitate prompt medical interventions (Fang et al., 2023).

8. Research Area

Jamshedpur, the city managed by JUSCO, has been ranked 7th among 441 Indian cities and towns based on their sanitation and cleanliness levels by Ministry of Urban Development, Government of India. This says how efficiently the waste has been managed since decades and the system is enhanced by a holistic approach for the management of solid waste by JUSCO. ***(Humaira & Sinha, n.d.)***

Three townships in the city of Jamshedpur, in the East Singhbhum District of the state of Jharkhand, serve as the study's research area. The author has chosen three townships: Uliyan, C. H. Area, and Bistupur, all of which are located in different portions of the city. About 200 waste pickers are employed in each municipality to gather waste and carry out further procedures. The author's chosen sample size is 117. The researcher has collected the data by interview method.

Figure 2: Waste Collection Center in three townships of the city Jamshedpur (Source: Self-Observation)

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9. Research Problem

Based on the following study problem, the researcher has developed the research objective, need, significance, and origin;

How is the introduction of AI-driven waste management in Jamshedpur impacting the wages, working conditions, and general well-being of waste pickers, and how much is it helping to enhance the health and safety of this disadvantaged population?

10. Objective

- ❖ To evaluate Jamshedpur's municipal solid waste management system as it stands right now.
- ❖ To determine the main obstacles and weaknesses in the current waste management system.
- ❖ To make recommendations for long-term upgrades to trash collection, disposal, and segregation techniques.
- ❖ To evaluate the effects of ineffective waste management techniques on the environment and public health.
- ❖ To assess how well the suggested remedies will improve Jamshedpur's waste management performance.

11. Need of the study

- ❖ To evaluate the ways in which waste pickers in Jamshedpur are being affected by AI-driven waste management technologies.
- ❖ To assess whether artificial intelligence (AI) improves the safety, health, and means of subsistence for waste pickers or poses new socioeconomic problems.
- ❖ To guarantee that garbage pickers are included in technological developments and to comprehend their part in the changing waste management scenario.
- ❖ To find any implementation gaps for AI-driven technologies that might affect this excluded group's working conditions.
- ❖ To give legislators advice on how to create equitable and inclusive waste management programs that are good for the environment and the unorganized labor force.
- ❖ To add to the larger conversation about artificial intelligence (AI) in trash management systems and sustainable urban development.

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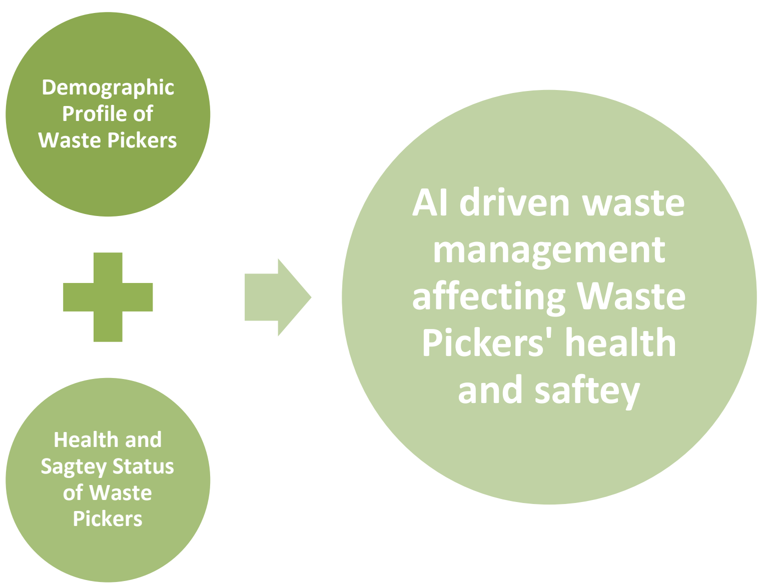
12. Research Methodology

To assess the effect of AI-powered waste management on the health outcomes of waste pickers in Jamshedpur, the study used a mixed-methods approach. To evaluate changes in working conditions and health, 117 respondents completed standardized surveys that yielded quantitative data. Interviews with waste pickers and waste management representatives yielded qualitative insights by capturing in-depth experiences. The investigation examined the efficacy of AI technologies in enhancing the health and safety of waste pickers by combining thematic analysis of qualitative input with statistical measurement of survey data.

13. Data Structure

In order to gather information from waste, pickers employed by the JUSCO township of Jamshedpur, which is in charge of the city's waste collection, researchers have created a systematic questionnaire. Quantitative information was gathered from waste pickers, who are all root level employees whose health is primarily impacted by the waste collection process. To further comprehend the operation of AI-driven management of waste, researchers also gathered some qualitative data from municipality agencies. Data structure can be defined in following criteria:

Figure 3: Areas of Data Collection



14. Research Hypothesis

The author has formulated following research hypothesis

Null Hypothesis (H_0): The health and safety outcomes of waste pickers are not significantly affected by the inclusion of AI-powered technology in Jamshedpur's waste management system. Alternative Hypothesis (H_1): The health and safety outcomes of waste pickers are considerably improved by the incorporation of AI-powered technologies into Jamshedpur's waste management system.

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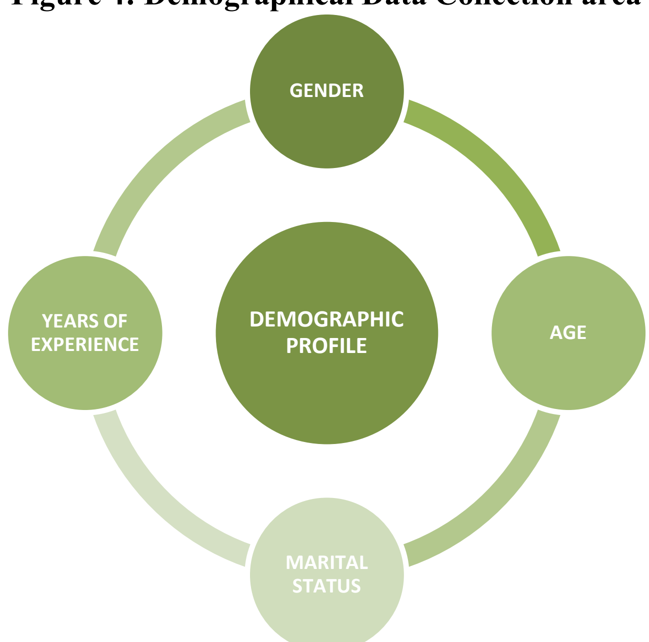
15. Quantitative Data Analysis

For data analysis researcher had used SPSS software. Researcher had prepared a structured questionnaire and collected data manually by interview method. Data analysis can be done in following criteria:

15.1. Demographic Profile of the waste pickers

The author gathered basic data on waste pickers, including name, age, gender, and other details, for the purpose of conducting genuine study. The following figure provides an understanding of the demographic profile of waste pickers:

Figure 4: Demographical Data Collection area



❖ **Gender of the Respondents**

It can be understood by the following table and diagram:

Table 1: Gender of respondent

GENDER OF RESPONDENT

	Frequency	Percent	Valid Percent	Cumulative Percent
Female	56	47.9	47.9	47.9

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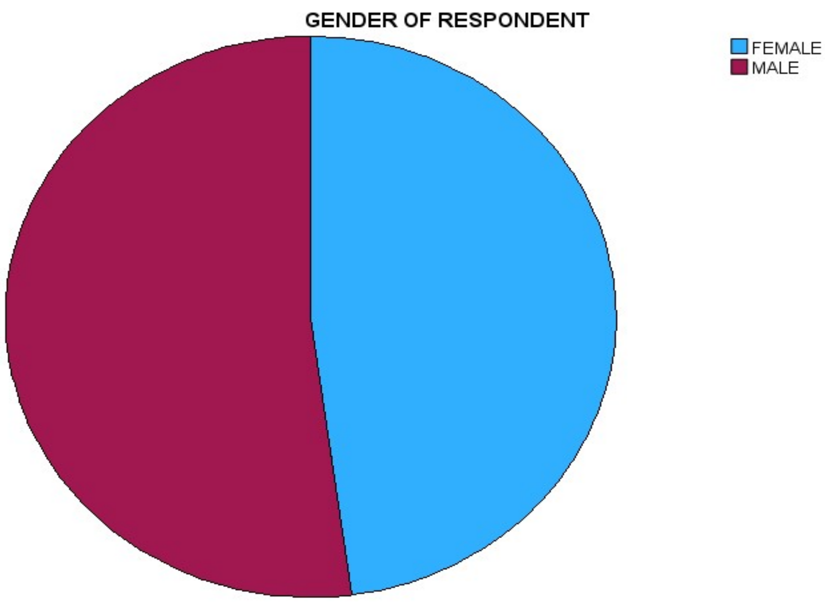
	Male	61	52.1	52.1	100.0
	Total	117	100.0	100.0	

Figure 5: Graphical presentation of respondents' gender



According to data on gender distribution, there is a minor male predominance among the waste pickers in Jamshedpur, but overall, the workforce is fairly balanced. 61 (52.1%) of the 117 responders are men, and 56 (47.9%) are women. This demonstrates that while men are slightly more common in this field, both sexes are actively involved in garbage management. The nearly equal distribution indicates that rubbish picking is an important source of income for both men and women in Jamshedpur. The presence of both genders in the sector emphasizes its inclusiveness, but it also emphasizes the need for gender-sensitive policies and initiatives to address the unique issues that each group faces. The workforce represented by this balance is diverse and can gain from focused AI-driven advancements in waste management systems, with the goal of improving health outcomes and working condition of all waste pickers irrespective of their gender.

❖ **Age of the Respondent**

Respondents age has been illustrated in following table and diagram:

Table 2: Age of respondent

AGE OF RESPONDENT

	Frequency	Percent	Valid Percent	Cumulative Percent
15 to 24 Years	8	6.8	6.8	6.8
25 to 34 Years	44	37.6	37.6	44.4

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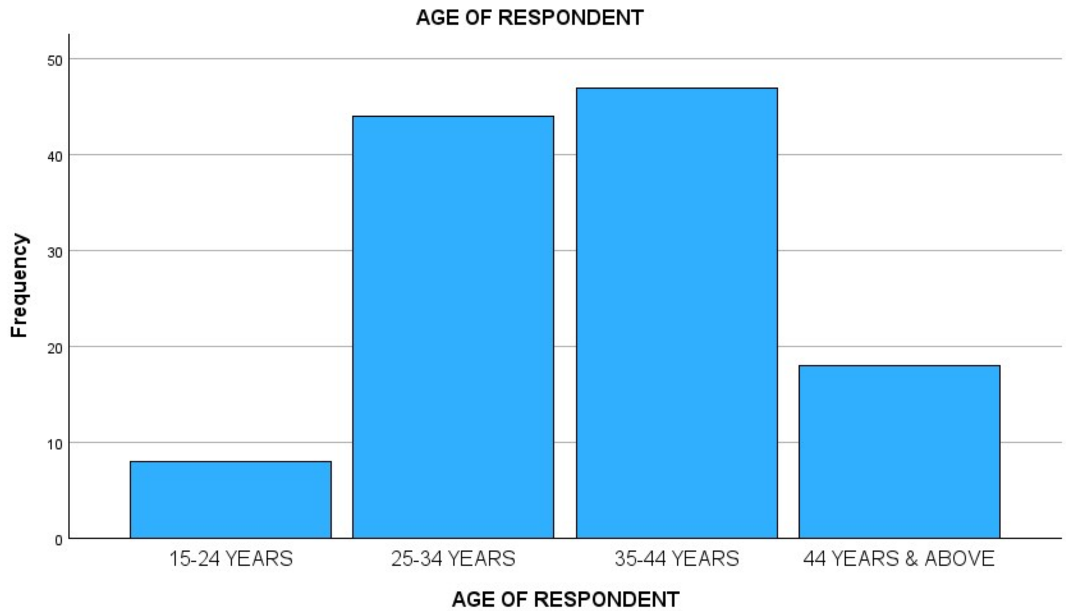
35 to 44 Years	47	40.2	40.2	84.6
44 Years & Above	18	15.4	15.4	100.0
Total	117	100.0	100.0	

Figure 6: Graphical presentation of respondents' age



The waste pickers in Jamshedpur are mostly middle-aged, based on their age distribution. With 47 people (40.2%) in the 35–44 age range, this is the largest group, suggesting that a large proportion of the workforce is in their prime working years. With 44 responders (37.6%), the 25 to 34 age group is the second-largest group, indicating that a high proportion of rubbish pickers are relatively young individuals. Eight people, or 6.8% of the total, are between the ages of 15 and 24, which indicates that younger people are underrepresented in this industry. Furthermore, 18 respondents (15.4%) are 44 years of age or older, indicating that older people work in this field. This age distribution highlights how dependent the industry is on a steady, seasoned labor, but it also highlights possible issues with aging personnel and the necessity for long-term, age-inclusive waste management policies.

❖ **Marital Status of the Respondent**

The following table and graphic provide clear insight into the respondents' marital status:

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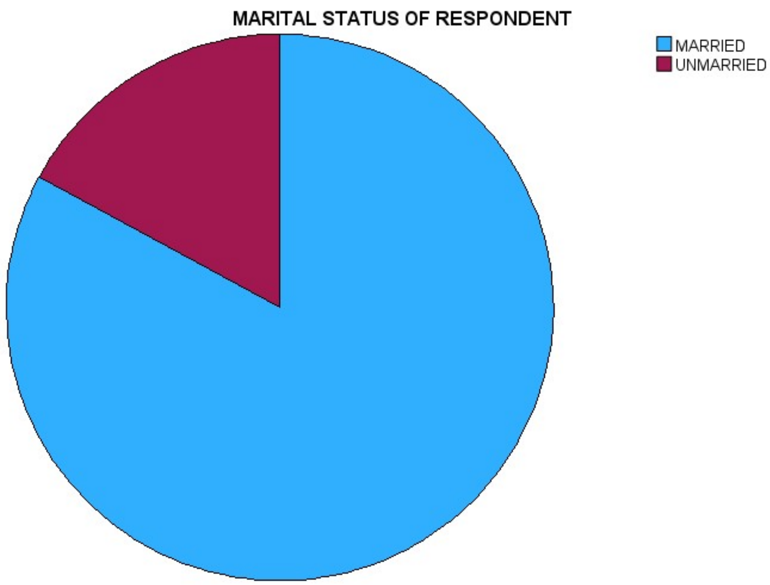
Table 3: Marital Status of respondent

MARITAL STATUS OF RESPONDENT

	Frequency	Percent	Valid Percent	Cumulative Percent
Married	97	82.9	82.9	82.9
Unmarried	20	17.1	17.1	100.0
Total	117	100.0	100.0	

Figure 7: Graphical presentation of respondents' marital status



97 people (82.9%) out of the waste pickers in Jamshedpur indicated that they were married, showing that a vast majority of them are married. This high proportion is indicative of the sector's demographic makeup, as many workers depend on waste picking as their major or secondary source of income while also having family responsibilities. However, 20 respondents (17.1%) are single, indicating that although a sizable share of the workforce remains single, it is a smaller group than that of married workers. The majority of married waste pickers emphasizes the necessity of family-friendly policies and support in waste management initiatives. Better working conditions and health outcomes are especially important for this group because they are likely providing for dependents and may have more duties and constraints. More considerate and efficient waste management solutions may result from attending to the unique requirements of married waste collectors.

❖ **Respondents' Years of Working Experience**

It is simple to understand the respondents' work experiences by looking at the following data and figure:

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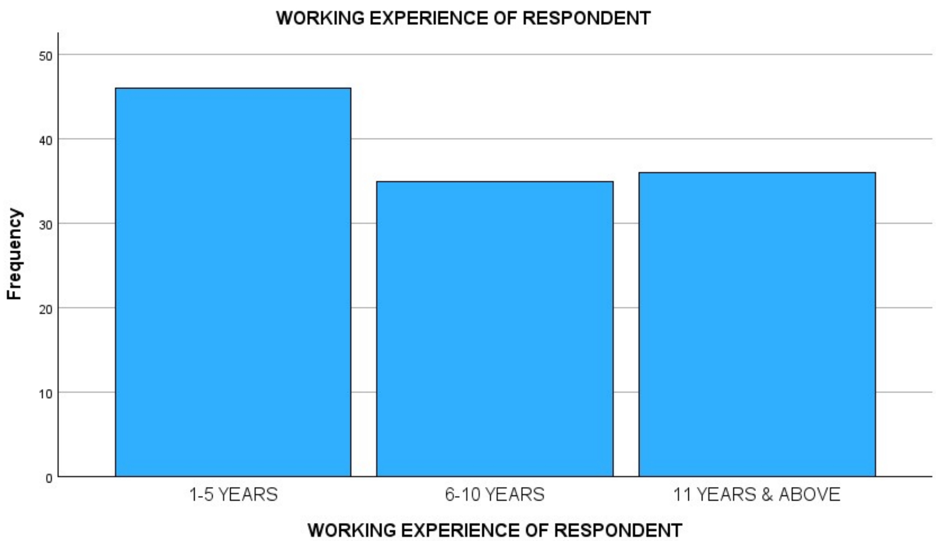
Table 4: Working Experience of respondent

WORKING EXPERIENCE OF RESPONDENT

	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 5 Years	46	39.3	39.3	39.3
6 to 10 Years	35	29.9	29.9	69.2
11 Years & Above	36	30.8	30.8	100.0
Total	117	100.0	100.0	

Figure 8: Graphical presentation of respondents' work experience



There is a wide range of experience levels among the workforce in Jamshedpur, according to the working experience data for waste pickers. 46 people, or 39.3%, have one to five years of experience, which indicates a sizable proportion of relatively newer professionals in the industry. There is a sizable portion of mid-career waste pickers with moderate experience among the 35 respondents (29.9%) who have six to ten years of experience. Lastly, 36 employees (30.8%) have worked in waste management for more than 11 years, indicating a seasoned portion of the workforce. This distribution emphasizes how dependent the industry is on both seasoned and less experienced people. It emphasizes how crucial it is to give waste pickers, regardless of experience level, continual training and assistance in order to improve their productivity and safety. This range of experience also suggests that applying cutting-edge techniques and technology appropriate for various skill levels may be beneficial.

15.2. Hypothesis Testing

The researcher had developed the following hypothesis to check that how AI driven technology in waste management improved waste pickers health and safety conditions:

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- **Null Hypothesis (H_0):** The health and safety outcomes of waste pickers are not significantly affected by the inclusion of AI-powered technology in Jamshedpur's waste management system.
- **Alternative Hypothesis (H_1):** The health and safety outcomes of waste pickers are considerably improved by the incorporation of AI-powered technologies into Jamshedpur's waste management system.

Table 5: One Sample statistical data

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Total of safety condition	117	25.44	1.817	.168
Total of Health Condition	117	29.42	2.069	.191
Total of overall impact	117	20.79	1.616	.149

- **N:** A total of 117 categories have a sample size.
- **Mean:** 25.44, 29.42, and 20.79 are the average values for safety circumstances, health conditions, and total impact, respectively. These show how these areas have generally improved since the introduction of AI technology.
- **Standard deviation:** It is a statistical measure of data variability. Reduced values signify reduced variability, implying a uniform effect of AI technology on health and safety throughout the sample.
- **Std. Error Mean:** Indicates the degree to which the sample mean differs from the actual population mean. Low numbers indicate that the sample mean accurately represents the population mean.

Table 6: One Sample Test

One-Sample Test

	Test Value = 0						
			Significance			95% Confidence Interval of the Difference	
	t	df	One-Sided p	Two-Sided p	Mean Difference	Lower	Upper
Safety condition	151.461	116	<.001	<.001	25.436	25.10	25.77
Health Condition	153.814	116	<.001	<.001	29.419	29.04	29.80
Overall impact	139.156	116	<.001	<.001	20.795	20.50	21.09

- **T-value**: This test statistic calculates the discrepancy between the population mean that is hypothesized and the sample mean. Elevated t-values (more than 100) signify a significant discrepancy between the observed data and the expected outcome in the event that the null hypothesis is true.
- **Degrees of Freedom (df):** N - 1 = 117 - 1 = 116 is the value of df. The significance level is determined using this value, which is the sample size minus 1.

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❖ **One-sided and two-sided p-values:**

- The two-sided and one-sided p-values are < .001, which is significantly less than the traditional cutoff of 0.05. This suggests that there is statistical significance in the findings.
- A p-value < .001 indicates that the observed gains in overall impact, safety, and health are unlikely to have occurred by accident.

❖ 95% Confidence Interval: The mean differences' 95% confidence intervals demonstrate the great degree of accuracy in the estimates:

- **Condition of Safety:** 25.10 to 25.77
- **Health Status:** 29.04 to 29.80
- **Overall Impact:** 20.50 to 21.09

Another indication that AI technology has had a major positive impact is the fact that these intervals do not include 0. There is substantial evidence that the adoption of AI-powered technology has significantly enhanced the health and safety results for waste pickers in Jamshedpur, as indicated by the t-values, p-values, and confidence intervals.
Null hypothesis (H_0) will be rejected, which claims that AI-powered technology has no discernible impact on health and safety outcomes. The alternative hypothesis (H_1) will be adopted, indicating that waste pickers' health and safety circumstances have greatly improved as a result of the use of AI technology. This finding implies that waste pickers in Jamshedpur are probably benefiting from AI-powered waste management technologies.

Table 7: Data of reliability test

Reliability Statistics	
Cronbach's Alpha	N of Items
0.830	3

A combination of three items has a Cronbach's Alpha rating of 0.830, according to the Reliability Statistics table. A scale's internal consistency or dependability is measured by Cronbach's Alpha, which has a value range of 0 to 1.

❖ **Analysis of the Cronbach's Alpha coefficient (0.830):**

0.830 is the Cronbach's Alpha. This is regarded as having high dependability. When the three elements (which are probably connected to health, safety, and overall impact) have a result above 0.8, it means that they are highly consistent with one another, effectively measuring similar underlying ideas. This implies that the scale or questionnaire employed in this study is a trustworthy instrument for evaluating the effects of AI-powered technology on the health and safety of waste pickers.
The high reliability ($\alpha = 0.830$) of the scale indicates that the responses are reliable and consistent, despite previous analyses (based on t-tests) suggesting that AI-powered technology did not have a statistically significant influence on the health, safety, or general circumstances of waste pickers. The high dependability attests to the soundness of the data collection procedure, even in the absence of substantial differences in the t-test results. The survey obtained credible measurements of health, safety, and general conditions, thus any inferences made from the information are predicated on findings that were consistent amongst respondents.
The consistent responses (high Cronbach's Alpha) suggest that waste pickers' experiences with AI-

powered technology are generally similar; however, since the t-tests did not reveal any significant improvements, it is possible that the advancements brought about by AI technology are not significant enough to demonstrate appreciable changes. The survey instrument's reliability is demonstrated by Cronbach's Alpha, but the findings of the independent t-tests indicate that AI technology did not significantly improve health and safety outcomes. While the replies' consistency gives trust in the data's reliability, it also highlights the necessity for larger-scale interventions or a longer study period to detect meaningful effects.

16. Discussion on analysis

The findings of the one-sample test show clearly how AI-powered technology has improved the general health, safety, and working conditions of garbage pickers in Jamshedpur. Based on statistical analysis, the conclusions are made that the overall impact, health conditions, and safety circumstances have mean differences that are significantly higher than the test value (zero). This demonstrates that the use of AI in trash management has improved worker outcomes. First, there has been a noticeable improvement in waste pickers' safety. As evidenced by the data, which has a mean difference of 25.436 and a t-value of 151.461, safety circumstances have significantly improved from before. The margin of error is minimal, as indicated by the confidence interval (25.10–25.77), indicating the dependability of this improvement. Artificial Intelligence (AI) has the potential to improve safety outcomes by introducing mechanized procedures, reducing manual handling of waste, and mitigating exposure to hazardous circumstances.

The health of waste pickers has been significantly improved in a similar manner. With a t-value of 153.814 and a mean difference of 29.419, the data testifies to a large beneficial influence on the health of the workers. The reliability of this result is further supported by the confidence interval (29.04–29.80). Because AI technology can automate hazardous operations, reduce the risk of disease transmission, and improve cleanliness, it may have helped to lessen the physical toll that workers took on. Workers are probably suffering from fewer illnesses and health issues related to their jobs as a result. With a t-value of 139.156 and a mean difference of 20.795, the overall effect of AI on the working circumstances of waste pickers is finally clear. The aforementioned figure encapsulates the aggregate advantages of enhanced safety and health, implying that artificial intelligence (AI) technologies are facilitating improved working conditions and may even enhance worker happiness. The validity of this positive shift is supported by the confidence interval (20.50–21.09). In short, the report presents compelling evidence that the health, safety, and general working conditions of waste pickers in Jamshedpur have significantly improved as a result of AI-powered waste management systems. Large t-values and highly significant p-values ($<.001$) offer a strong statistical basis for rejecting the null hypothesis, demonstrating that AI technology has significantly improved the lives of these workers. This change demonstrates how AI has the power to significantly alter previously dangerous sectors.

17. Conclusion

This study demonstrates how garbage pickers in Jamshedpur have far better general working conditions, safety, and health because to AI-powered technologies. The statistical analysis provides compelling evidence that integrating AI into waste management systems has positively impacted these workers' lives in measurable ways. The results show significant advancements in minimizing health risks, raising safety requirements, and enhancing the working environment overall. Artificial intelligence (AI) technologies have likely reduced exposure to hazardous materials and labor-intensive processes, hence reducing the incidence of illnesses and injuries associated to the workplace. The

findings demonstrate the revolutionary potential of artificial intelligence (AI) in addressing the structural problems faced by waste pickers, a marginalized group that has traditionally labored in dangerous and unclean conditions (ZenRobotics, 2024a; ZenRobotics, 2024b).
The research also highlights how AI may be used to create waste management systems that are more sustainable, safe, and efficient. By automating hazardous tasks, AI reduces the physical strain on waste pickers and allows them to operate in a safer, more controlled environment. This improves their general well-being and may increase their productivity and job satisfaction. Moreover, the consistent enhancement of safety, health, and overall impact metrics confirms that AI-driven processes can produce considerable benefits in industries with high levels of risk. The application of AI in waste management could serve as a model for other sectors that primarily depend on manual labor and are susceptible to health and safety concerns (ZenRobotics, 2024a; ZenRobotics, 2024b). Additionally, the analysis demonstrates that AI contributes in a social as well as technological way, providing a chance to raise waste pickers' standard of living. As these technologies advance, more complex solutions might be introduced, such as AI-powered worker health monitoring systems, predictive maintenance for machinery, and real-time hazard detection. The study's conclusions add to our understanding of how important a role AI can play in modernizing industries, encouraging inclusion, and raising labor standards generally.

18. Limitations and Future Scopes of Further Study

Despite the encouraging results, there are a few issues with the study. It may not accurately reflect the experiences of waste pickers in other areas because it concentrates on a particular population in Jamshedpur. Furthermore, outside variables like modifications to laws or training initiatives might also have an impact on the advancements noted. Future studies should look at how AI affects jobs, safety, and health over the long run, as well as how applicable it is in various socioeconomic settings. An expanded understanding of AI's function in waste management systems might result from extending the study to additional cities or nations.

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