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EDITED BY
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National Institute of Technology, Hamirpur, India
Lovjeet Singh,
Malaviya National Institute of Technology, Jaipur, India

*CORRESPONDENCE
Tlou Raphela
✉ madeizen@gmail.com

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# The impact of improper waste disposal on human health and the environment: a case of Umgungundlovu District in KwaZulu Natal Province, South Africa

Tlou Raphela[1]*, Nelisiwe Manqele[1] and Mariana Erasmus[2]

[1]Disaster Management Training and Education Centre for Africa, Faculty of Natural and Agricultural Sciences, University of the Free State, Bloemfontein, South Africa, [2]Centre for Mineral Biogeochemistry, Faculty of Natural and Agricultural Sciences, University of the Free State, Bloemfontein, South Africa

**Introduction:** Waste generation has increased drastically around the world in recent decades, with less than 20% of waste recycled each year, and one-third of all food produced wasted. With Sustainable Development Goal 12 advocating for changing how we consume, produce, and dispose of items, the cruciality of driving a more sustainable future lies in how we dispose of our waste.

**Methodology:** This study assessed the impacts of improper waste disposal on human health and the environment in the KwaZulu Natal Province of South Africa. The study applied a mixed-method pragmatic research approach, using Statistical Package for Social Scientists, and applied a series of Chi-Squared tests of independence, regression, and descriptive statistics to analyse data. This study has shed light on the complex dynamics surrounding the respondents' awareness and perception of risks associated with improper waste disposal.

**Results:** While a fair level of knowledge exists concerning the general risks, there are notable gaps in understanding specific aspects of human health risks related to improper waste disposal. Furthermore, the study findings highlight a critical disparity in awareness regarding specific human health risks associated with improper waste disposal.

**Discussion:** This study has shed light on the complex dynamics surrounding the respondents' awareness and perception of risks associated with improper waste disposal. This underscores the importance of enhancing public education and outreach programs to ensure a comprehensive understanding of the potential dangers to human health. The study municipality should explore sustainable waste management practices to mitigate the economic burden posed by increased waste generation.

KEYWORDS

**human health, impacts, improper waste disposal, environmental health, KwaZulu Natal**

## 1 Introduction and background

Improper waste disposal has always been a global concern (Selin, 2013; UN Environment, 2017; Sultanova et al., 2021). The rapid growth of industries, improved technologies, and standard of living are major factors that give rise to waste generation (Kurakalva et al., 2016; Sultanova et al., 2021). China, Mexico, and Brazil are among the countries with the problem of waste generation and the adverse impacts experienced in birth, death, and sickness in people (Getis et al., 2018; Kotze, 2020). In Japan, the World Bank has projected an increase of approximately 1.3 billion to 2.2 billion tonnes of waste generated yearly by 2025, meaning that the waste collection service rate will go far below 50%, leaving the area polluted and the rest of the uncollected waste discarded improperly (UN Environment, 2017).

Waste is classified in different forms including, municipal solid waste, industrial solid waste, and agricultural solid waste (Kwun Omang et al., 2021). However, improper waste disposal causes air, soil, and water pollution, indirectly contributing to the greenhouse gas effect, which affects human health, the environment, and the economy (Kwun Omang et al., 2021). African countries such as Nigeria, Kenya, and Sub-Saharan Africa are densely populated areas, leading to an adverse increase in resource consumption and waste generation, coupled with a massive decline in waste collection, treatment, and disposal (Selin, 2013; Kumar and Agrawal, 2020). The incidence of health issues related to poor waste management, such as diarrhea, was noticeable in younger children, such as diarrhea in Odukpani and Akamkpa (Kwun Omang et al., 2021). Ziraba et al. (2016) reported that approximately 70% of urban waste in developing countries has not been collected and disposed of appropriately, even though the implications of poorly managed waste on health are numerous. In Ghana, Amoah and Kosoe (2014) reported that 810 tonnes of solid waste is generated daily, out of which 216 tonnes are collected leaving a backlog of 594 tonnes uncollected posing serious environmental and public health hazards. Ferronato et al. (2017) also reported that waste management in developing countries represents a dangerous issue due to environmental impacts and human illnesses triggered by waste releases in water bodies.

Various studies of risk perceptions have demonstrated that women, in general, are more concerned about environmental hazards than men (Flynn et al., 1994; Greenberg and Schneider, 1995). Indeed, improper waste disposal health risks relating to gender have been reported by a lot of studies with contradicting findings (Mamady, 2016; Adewoyin, 2017; Kanhai et al., 2021a). For example, Mamady (2016) found that female individuals were independently associated with indiscriminate waste disposal as compared to their male counterparts in a study that looked at health and safety risks posed by improper disposal of household waste in Guinea. In a three-female focus group study in Ghana, participants in each group mentioned waste-related health hazards such as malaria, cholera, and diarrhea (Kanhai et al., 2021a). However, studies have also reported serious health risks of improper waste disposal to not be gender biased (Adeniyi and Oni, 2016; Adewoyin, 2017), reporting potential health risks of improper waste disposal for both males and females as respiratory problems such as asthma, bronchitis, and aggravated allergies due to inhalation of these pollutants.

In addition, water bodies can contaminate water sources and increase the risk of waterborne diseases such as cholera, typhoid fever, and diarrhea, affecting both males and females who consume contaminated water (Adeniyi and Oni, 2016). Also, improper waste management can lead to breeding grounds for disease-carrying vectors like mosquitoes, flies, and rodents. This increases the risk of diseases such as malaria, dengue fever, and leptospirosis, which can affect both genders (Adewoyin, 2017). The drivers of improper waste disposal in South Africa are exacerbated by poverty, rapid urbanization, and population explosion, leading to a decrease in waste management and in municipal failure to deliver services (Selin, 2013; Akmal and Jamil, 2021). Apart from health hazards and environmental degradation, poor waste management over the years has been responsible for causing several diseases and, in some cases, death, as mentioned by the United States of America's Public Health and the World Health Organisation (Alam and Ahmede, 2013; Letcher and Vallero, 2014; Kwun Omang et al., 2021). Environmentalists' concern about improper waste disposal's impact on human health and the environment has prompted studies in the United Kingdom. These studies reveal that a significant percentage of waste generated annually stems from a harmful practice (Giusti, 2009). Furthermore, Couth and Trois (2010) indicated that waste management, especially in rural areas of Africa, is non-existent. However, Kumar and Agrawal, 2020 indicated that in Africa, the issue of waste management has been initiated and expanded to lessen environmental harm and health risks. In addition, European countries' initiatives to curb the issue of poor waste management and progress have given positive results so far (Sultanova et al., 2021). As a means to mitigate waste problems, the UNEP hosted a global partnership on waste management in Japan, with waste experts to generate different ideas on strategies to be employed globally (UN Environment, 2017). This study is significant in that if waste management issues are not dealt with properly, the study municipality might lose its commercial functions (Asaduzzaman et al., 2014; Getis et al., 2018). In addition, the cities within the municipality might lose their prominence. The study conscientizes the city management about the health and environmental impacts of improper waste disposal as the conclusions derived from this study are to be shared with the management of the municipality. The impacts of improper waste disposal affect all aspects, such as social, environmental, and economic issues globally (Burcea, 2015; Khoso et al., 2018; Schenck et al., 2022). Therefore, this study added to the existing literature on the effects of improper waste disposal on health and the environment.

The rationale of the study lies in the urgent need for evidence-based policymaking to address the detrimental effects of improper waste disposal on both human health and the environment in KwaZulu Natal Province, South Africa. By investigating the specific impacts and patterns of improper waste disposal and giving answers, policymakers can better understand the scope of the problem and implement targeted interventions to mitigate its effects. This research aims to provide valuable insights that can inform policy decisions aimed at promoting sustainable waste management practices, safeguarding public health, and protecting the environment in the region. The study, therefore, aims to determine the impact of improper waste disposal on human health and the environment in uMgungundlovu District Municipality in the KwaZulu Natal Province of South Africa. The novelty of the work has been added to the manuscript, highlighted in green as R5C2 in the revised manuscript as follows" The novelty of this work lies in its localised focus, interdisciplinary approach, emphasis on community engagement, and provision of conclusions to mitigate the adverse effects of improper waste disposal on both human health and the environment in the Umgungundlovu District Municipality of South Africa.

# 2 Materials and methods

## 2.1 Description of the study area

This study was conducted at the Sobantu community in the Msunduzi local municipality within the uMgungundlovu District Municipality in the KwaZulu Natal Midlands in South Africa. According to Dlomo (2014), Sobantu Township had a serious challenge of environmental degradation and pollution since it is located within the proximity of 3 meters of a New England landfill site. The location makes it difficult for the residents to live a healthy life due to odor coming from the landfill site (Scott-Shaw, 2016). Poor management of catchment areas resulted in the degradation of wetlands within the municipality (Kudryavtseva, 2022). Furthermore, the lack of waste collection services exacerbated improper waste disposal in riparian zones across the Msunduzi municipality (Kudryavtseva, 2022).

## 2.2 Research design

This study adopted a mixed-method pragmatic research approach, encasing both open and close-ended questions on a semi-structured questionnaire, which was adopted for this study. The mixed method benefits the study by getting relevant information in response to questions asked by probing for more answers from the participants. The community members of Sobantu township were randomly selected to participate in the study. The minimum sample size was determined as 200 using published tables from the estimated population size of 7,448 of the study community Spencer et al. (2017). However, we got feedback from 100 respondents, and therefore, this study analysed primary data from 100 respondents for this study. Indeed, historical studies from statisticians have shown that a sample size of 100 is enough to make good statistical inferences (Barnard, 1949; Bonett and Price, 2002; Mascha and Vetter, 2018). An appropriate sample determination was done using a non-probability method to give participants an equal opportunity to participate (Alvi, 2016). However, the responses received and analysed from the semi-structured questionnaires used for this study were 100.

## 2.3 Data analysis

This study analysed data collected descriptively and inferentially using Statistical Package for Social Scientists (SPSS) software (version 29). A series of Pearson chi-square tests were applied to gauge the correlation between some demographic variables and some pertinent questions concerning knowledge of the general risks of improper waste disposal and aspects of human health risks related to improper waste disposal. Qualitative data, in the form of open-ended questions, was also analysed thematically and using descriptive statistics. Furthermore, the study applied an ordinal regression to assess the cost of clean-up for the municipality. The results are presented using tables and charts, and a brief explanation and discussion of the results are made. This study also reports results obtained from an ordinal regression run using SPSS software. Across all inferential statistics, the $p$ value was set at $p \leq 0.05$, and the results were also displayed using figures and tables outputs mainly for the SPSS software program.

## 2.4 Statistical analysis

All statistical analyses were done using Statistical Package for Social Scientists (SPSS version 29). Data was not normally distributed (Shapiro–Wilk test), so we used nonparametric statistical tests for the inferential statistics applied to this study. Statistical tests were two-tailed, and significance levels were set at $p \leq 0.05$. We first applied descriptive Statistics to analyse the demographic characteristics of the respondents. Secondly, we applied six chi-squared tests of independence to assess the risks of improper waste disposal by correlating the following variables:

- gender and the question of whether the respondents are aware of improper waste disposal in their community.
- age group and knowledge of the effects of improper waste disposal.
- the level of education and the knowledge of risk posed by improper waste disposal.
- marital status and knowledge of the factors that cause improper waste disposal in the community.
- the employment status of respondents and the most vulnerable to risks of improper waste disposal in their community.

Indeed, studies have reported the link between several demographic variables and the risk of improper waste disposal (Yoada et al., 2014; Addo et al., 2017; Fadhullah et al., 2022). The above analysis was done based on these studies. Furthermore, the 6$^{th}$ Chi-Squared test of independence was applied to assess the methods used by residents to dispose of waste and the importance of waste risk management. Two closed-ended questions were also analysed thematically to assess the risks of improper waste disposal.

### 2.4.1 Human health risk of improper waste disposal

To understand the human health risks posed by improper waste disposal, the study first asked the respondents if they knew of any human health risks caused by improper waste disposal. This study further prompted the respondent in an open-ended follow-up question to give the health risks the community is exposed to due to improper waste disposal. Secondly, the study asked the respondents if they had ever noticed any health hazards in and around their dumping area, and the responses were analysed descriptively. This study applied a chi-squared test of independence to assess the respondent's answers when asked about information available to communities about the impacts of improper waste disposal and the rate of concern of communities about the health impacts caused by improper waste disposal.

### 2.4.2 The economic cost of improper waste disposal

This section sought to understand the financial implications of improper waste disposal and asked the respondents ten Likert scale questions that were analysed using ordinal regression. To assess the cost implication, the study used the questions that asked whether waste generation increases the cost of clean-up and used it as a response variable for the other nine questions, which were set as independent variables. The Likert scale data was not normally distributed, therefore, the study applied ordinal regression to analyse the ten Likert scale questions, setting the first question mentioned

above as the dependent variable and the other nine questions as covariates. Indeed, finances are a serious issue in modern-day South Africa and hence the question of cost was chosen as the outcome variable as it will influence the responses.

# 3 Results

The demographic characteristics of respondents, including gender, religious affiliation, age group, education level, marital status, ethnic group, and employment status, are used for this study to correlate with other important critical questions underpinning this study. The study had 100 responses from Sobantu Township, where the majority of the respondents were females ($n = 56$), and of the 100 respondents, most were Christians ($n = 89$); the majority were divorced ($n = 45$); Black ($n = 97$); and were employed ($n = 47$).

## 3.1 The risks of improper waste disposal

This study gauged the knowledge associated with improper waste disposal by asking the respondents whether they were aware of improper waste disposal in their community, and the majority of the respondents ($n = 74$) reported knowing these risks. The Pearson chi-squared test reveals a statistically insignificant relationship between gender and the awareness of the respondents about improper waste disposal in their community ($\chi2 = 3.372$; df = 2; $p = 0.185$). However, most females reported being aware of improper waste disposal risks as compared to their male counterparts (Figure 1).

Respondents were further prompted to describe the improper waste disposal that they were aware of, and the majority ($n = 39$) of the respondents reported tins and plastics, and other improper waste disposals reported are tabulated in Table 1. Studies have reported that waste needs to be categorised appropriately to understand its effect thoroughly (Laurent et al., 2014; Ziraba et al., 2016). This study, therefore, applied the basic framework for categorising waste on the study questionnaire and asked the respondents questions about improperly disposed waste in their community that will fit into the frameworks as per the responses in the Table 1.

The chi-squared test results indicated no significant difference between age group and knowledge of the effects of improper waste disposal ($\chi2 = 8,893$; df = 12; $p = 0,712$). However, most of the respondents between the ages 36 and45 ($n = 25$) answered yes, when asked if they knew of the major effects of improper waste disposal (Figure 2).

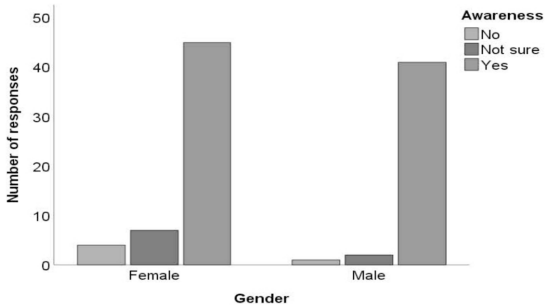


FIGURE 1
The relationship between gender and awareness of improper waste disposal in the community. Source: study data.

The chi-squared test results showed no correlation between the level of education and the knowledge of risk posed by improper waste disposal ($\chi2 = 13.996$; df = 8; $p = 0.821$). However, most of the respondents with a university degree indicated that they know about the risks posed by improper waste disposal (Figure 3).

Furthermore, the study prompted the respondents about the risks caused by improper waste disposal they are aware of in their community, and the majority of the respondents ($n = 27$) indicated diseases. The chi-square test results produced statistically insignificant results between the marital status and knowledge of the factors that cause improper waste disposal in the community ($\chi2 = 11.313$; df = 12; $p = 0.502$). The majority of the single people ($n = 25$) are the ones who knew the factors that cause improper waste disposal in the community (Table 2).

The study adopted mixed methods, therefore, qualitative data were collected using open-ended questions and were thematically analysed. The study further prompted the respondents to find out the factors that, according to the participants, caused or escalated improper waste disposal in the community. *"Municipality does not collect waste on time, industrial waste and pollution, lack of awareness and education on waste disposal, industrial strikes causing delay on waste disposal by the municipality, failure of the municipality to deliver services, lack of transportation trucks (Logistics), lack of trash bins to be used by the community to contain waste, lack of authorised designated areas to dispose of waste, the poor public attitude towards the environment, drainage blockage, lack of rules and regulations"* were the main themes that merged from the open-ended question answered by respondents. However, the majority of the respondents indicated that "*waste is not collected on time*" in some areas.

The chi-squared test indicated a statistically insignificant difference between the employment status and the most vulnerable to risks of improper waste disposal ($\chi2 = 26.\ 259$; df = 27; $p = 0.\ 504$). The respondents were expected to choose more than one response and most of the respondents employed ($n = 47$) answered 'All of them' when asked about the most vulnerable group at risks posed by improper waste disposal (Table 3).

The chi-squared test indicated a statistically insignificant difference between the methods used by residents to dispose of waste and the importance of waste risk management ($\chi2 = 33.849$; df = 36; $p = 0.571$). The majority of the respondents ($n = 74$) answered yes when asked if waste risk management is important. The question allowed the respondents to choose more than one response where the respondents were asked to mention the methods mostly used by the residents to dispose of waste and most respondents ($n = 20$) indicated illegally opened dumpsites; however, other methods, such as along the street, in the river and near the road were also frequently reported.

The respondents who answered 'yes' when asked if waste risk management is important were further asked to explain the reasons why waste risk management is an important issue. Thematic analyses were carried out since this was an open-ended question where respondents were expected to motivate their answers. The responses provided included *'risks associated with improper waste disposal on human health', 'impact of improper waste disposal on the environment', 'lack of education', 'impact of waste on water quality and ecosystem', 'impact of waste on climate', 'impact of waste on drainage systems' and Other.* Nevertheless, the theme *'risks associated with improper waste*

TABLE 1 Improperly waste disposed reported by the study respondents applied to a basic framework for categorizing waste.

| Waste categories | Potential risks | Number of responses |
|---|---|---|
| Organic Waste: Includes food scraps, yard waste, and other biodegradable materials and contamination | Improper disposal can lead to methane emissions and soil | 9 |
| Inorganic Waste: Non-biodegradable materials like plastics, glass, metals, and ceramics | These can persist in the environment for long periods, causing pollution and harming wildlife | 39 |
| Hazardous Waste: Includes chemicals, batteries, electronic waste (e-waste), and medical waste | These substances can pose serious health risks if not disposed of properly, contaminating soil and water sources | 6 |
| Toxic Waste: Waste containing toxic substances such as heavy metals, pesticides, and radioactive materials | Improper disposal can lead to poisoning, environmental degradation, and long-term health issues | 1 |
| Electronic Waste (e-waste): Discarded electronic devices like computers, TVs, and smartphones | Improper disposal can release harmful chemicals and heavy metals into the environment, posing health risks and polluting soil and water | 12 |
| Construction and Demolition Waste: Includes debris from building materials like concrete, wood, bricks, and insulation | Improper disposal can lead to land degradation, habitat destruction, and pollution of water sources | 4 |
| Biomedical Waste: Waste generated from healthcare facilities, such as used needles, syringes, and expired medicines | Improper disposal can spread diseases and contaminate the environment | 6 |
| Radioactive Waste: Waste containing radioactive materials, often generated from nuclear power plants, medical facilities, and research institutions | Improper disposal can result in radiation exposure, contaminating soil, water, and air | 0 |
| Liquid Waste: Includes wastewater from households, industries, and agricultural activities | Improper disposal can lead to water pollution, harming aquatic ecosystems and human health | 5 |
| Solid Waste: General household and commercial waste that does not fit into other categories. This can include paper, cardboard, textiles, and rubber | Improper disposal can lead to littering, pollution, and habitat destruction | 19 |

Source: Study data.

*disposal on human health*', as a reason why waste risk management importance emerged a lot as compared to other themes.

## 3.2 Human health risks of improper waste disposal

The majority of the respondents ($n = 85$) answered yes when asked if they knew of any human health risks caused by improper waste disposal. Several health issues, including the spread of diseases, skin or eye irritation, and nausea, were reported when respondents were asked about the health risks the community is exposed to due to improper waste disposal. However, the majority of the respondents ($n = 71$) reported respiratory problems. The results were expected because the literature reveals that greater exposure to an unhygienic environment has led to several diseases, including respiratory problems and the spread of diseases (Sultana, 2020; Fadhullah et al., 2022). In addition, a study by Etea et al. (2021) indicated that in Ethiopia, one of the residents shared a bad experience with respiratory problems due to exposure to the open dumpsite in an open-ended interview. The majority of the respondents (n = 89) reported mosquitoes and flies. However, other health hazards reported were limited to dark water flowing, domestic animals, scavengers, and bad smells.

Respondents also reported other common diseases that they think are caused by improper waste disposal in their community, such as cholera, respiratory infection, skin irritation, and diarrhea. However, the most reported disease was cholera ($n = 53$). The results were not surprising in an African context as two studies in Malaysia reported improper waste disposal as a challenge, and some people had experienced cholera and skin irritation, malaria, and diarrhea caused by improper waste disposal (Sultana et al., 2021; Fadhullah et al., 2022).

The chi-squared test results showed a statistically insignificant relationship when respondents were asked about information available to communities about the impacts of improper waste disposal and the rate of concern of communities about the health impacts caused by improper waste disposal ($\chi^2 = 6{,}401$; df = 4; $p = 0{,}171$). However, most of the respondents ($n = 72$) indicated that they are concerned about the health impacts caused by improper waste disposal. Regardless of how concerned the community reported to be, most of the reports from respondents further indicated that there is still a lack of information available to communities about the impacts improper waste disposal has on human health (Figure 4).

## 3.3 Economic cost of improper waste disposal

The ordinal regression results showed a statistically significant relationship when the question of whether waste generation increases the cost of clean-up ($\chi^2 = 276{,}84$; df = 33; $p < 0.001$; $R^2 = 65\%$). Moreover, significant differences were also found for the dependent variable and for the question of whether the respondents were willing to pay for the waste collection fee (Table 4). The significant parameters are shown in bold in Table 4.

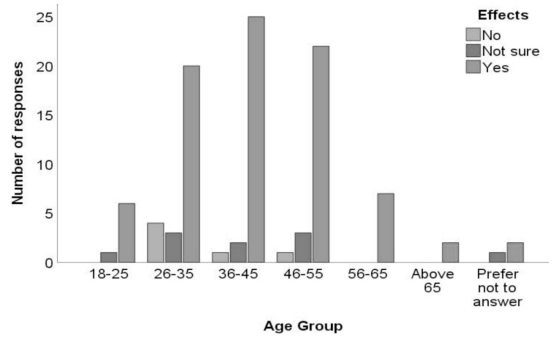


FIGURE 2
The relationship between age group and knowledge of the major effects of improper waste disposal. Source: study data.

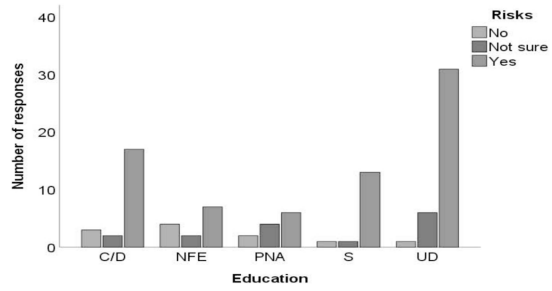


FIGURE 3
The relationship between the level of education and knowledge about the risks of improper waste disposal. C/D, Certificate/Diploma; NFE, No Formal Education; PNA, Prefer Not to Answer; S, Secondary; UD, University Degree. Source: study data.

TABLE 2 The relationship between marital status and knowledge of the factors that cause improper waste disposal in the community.

| Knowledge of the factors | | | |
|---|---|---|---|
| Marital Status | No | Not sure | Yes |
| Divorced | 0 | 0 | 1 |
| Living with Partner | 3 | 3 | 4 |
| Married | 3 | 8 | 24 |
| Prefer not to answer | 2 | 0 | 5 |
| Separated | 1 | 1 | 0 |
| Single | 8 | 10 | 25 |
| Widowed | 0 | 0 | 2 |
| Total | 17 | 22 | 61 |

Source: Study data.

The study further asked the respondents to suggest what the Msunduzi local authorities should do to resolve the issue of improper waste disposal. The responses were analysed thematically since the respondents were given a chance to voice their opinions. The main themes that merged from the open-ended question received from respondents were as follows: *"To provide trash bins to contain waste, to collect waste on time, to provide awareness and education, to provide transportation trucks, ensure that authorised areas to dispose waste provided, impose fines to polluters, employ more workers, encourage clean-up projects, municipality to allocate more funds for waste management, encourage recycling, municipality to monitor employees, put camera and signs onsite, pay for waste collection."* However, within the themes, "*to collect waste on time*" emerged as the main suggestion to the authority.

## 4 Discussion

We investigated the effects of improper waste disposal on the Sobantu community in the Mduduzi district municipality in the KwaZulu Natal Province and found that, indeed, there is a negative effect of the waste disposed improperly to this community. The results of the five chi-squared tests applied showed insignificant relationships when gender, age group, marital status, and employment status of respondents were correlated with several variables that were surprising. Studies around the world have reported correlations between several demographic variables and the risk of improper waste disposal (Yoada et al., 2014; Addo et al., 2017; Femi et al., 2017; Fadhullah et al., 2022). For example, in Akungba-Akoko, Nigeria, respondents' level of education and age of respondents influenced the responses to the risk of improper waste disposal (Femi et al., 2017).

This study is written in the Disaster risk reduction context; therefore, the long-term prospects include positive impacts on policy, public awareness, technological innovation, health outcomes, economic development, and environmental conservation. By addressing this critical multifaceted issue, the study has the potential to bring about lasting positive changes for both human health and the environment. The results of most females being aware of improper waste disposal as compared to their male counterparts were expected. Literature indicates that most of the time females are the ones who stay at home and are responsible for managing the household's waste, which makes them more concerned and aware of improper waste disposal happening in their households and their environment (Kanhai et al., 2021b; Yumna et al., 2019). Consistent with the study results, Tatlonghari and Jamias (2010) reported that women, as compared to their male counterparts, are more aware and knowledgeable of proper waste management. The results of the majority of the respondents reporting tins and plastics are consistent with the results of Dasgupta et al. (2022), who reported excessive and improper plastic waste that affected marine species in West Africa. It was reported that some marine species died due to ingesting and being entangled by plastic debris due to waste pollution, causing a loss of livelihoods to the communities relying on the fishery in West Africa (Dasgupta et al., 2022). In addition, Ncube et al. (2021) reported that mismanagement of plastic waste by developed and developing countries is declining. These results should be a call of concern to the residents of Sobantu, as the growing accumulation of plastic waste in the environment might cause the community to suffer the consequences.

The results of the age group 36–45 knowing more of the major effects of improper waste disposal as compared to any other age group was expected as this age group is referred to as mid to late adults in the South African context (Statistics South Africa, 2011) and naturally, adults will be more aware and knowledgeable about issues of major effects of improper waste disposal as compared to other age groups.

TABLE 3 The relationship between employment status and knowledge of the most vulnerable to risk(s) caused by improper waste disposal in the community.

| Knowledge of the most vulnerable | Employed | Prefer not to say | Self-employed | Unemployed |
|---|---|---|---|---|
| All of them | 20 | 1 | 16 | 16 |
| Older people | 4 | 0 | 0 | 0 |
| Pupils and students | 0 | 0 | 1 | 0 |
| Pre School children | 0 | 8 | 0 | 12 |
| Pensioners | 0 | 1 | 3 | 9 |
| waste pickers | 7 | 0 | 1 | 1 |
| Total | 31 | 10 | 21 | 38 |

Source: Study data.

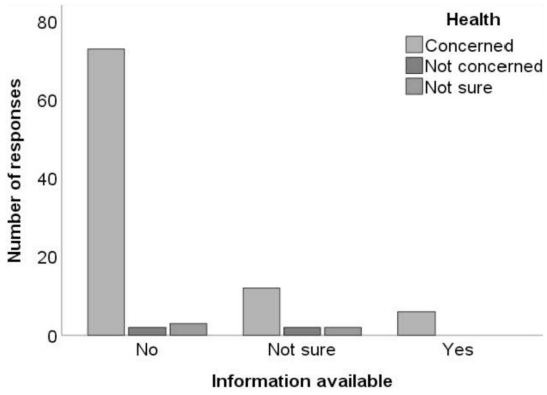


FIGURE 4
The relationship between health concerns caused by improper waste disposal and information availability. Source: study data.

Literature also reported that improper waste disposal is on the rise nowadays and has severe consequences on human health and the environment, making these mid to late adults very alert as they are normally of childbearing age, and they have to be more vigilant of issues that might affect the health and the environment their children are exposed to Olufayo and Omotosho (2007) and Damilola, (2023). Indeed, adults naturally, as compared to any other age group, will take more interest in things that will affect their communities' health, and otherwise they will be thinking more about the effects this will have on their offspring.

The results were not surprising when most of the respondents with a university Degree answered yes when asked if they knew about the risks posed by improper waste disposal. People with university Degrees have been reported by studies to be knowledgeable about a lot of serious issues that can impact their lives as compared to those with certificates, no formal education, and those with diplomas as degree qualifications teach theory and practice in most South African Universities (Seymour, 2007; Fink, 2013). Indeed, a university degree can set apart the level of thinking and awareness of people to some degree because of the knowledge gained throughout university studies (Eraut, 2000).

The results of diseases been the most risk associated with improper waste disposal were consistent with Amato and Togo (2021), who indicated that in Masvingo City, Zimbabwe, improper waste disposal polluted air, water, and land, and the repercussions turned out to harm the environment and cause health hazards such as respiratory problems, the spread of diseases due to influx of rodent infestation and odor to people residing near these polluted environments.

The results of the majority of the single people knowing the factors that cause improper waste disposal in the community as compared to other marital status groups were not expected because Mohamad and Masngut (2023) reported that the majority of married individuals have the best approach practices and are vigilant towards proper waste management than single individuals and therefore more knowledge of factors to support the theory of vigilance. In the South African context, the results that waste is not collected as the factor that the respondents thought of as causing improper waste disposal was not surprising at all. Recently, in 2023, the Tshwane Metropolitan Municipality's (one of the largest municipalities in the world) waste management employees were on a protest action for several months, and waste was not collected at all. This was televised in most South African Broadcasting channels for months on end.

The results were not surprising when the majority of the employed respondents answered, 'all of them' when asked who they think is most vulnerable to risks caused by improper waste disposal. Nuripuoh et al. (2022), reported that even though waste workers and waste pickers are responsible for sustainable waste management, due to exposure to the unhygienic environment, the dirt spread all over, creating diseases that end up affecting everyone in the area. Consequently, Giusti (2009) also reported that community members and everybody who works in waste management institutions are at risk of contracting diseases due to dirt being inhaled or touched, as some people do not use protective clothing when dealing with waste. A study by Orlins and Guan (2016) reported that in China, informal workers dealing with the dismantling and burning of e-waste and trying to make a living were reported to be sick due to inhaling toxins.

The results where the majority of the respondents reported the methods mostly used by the residents to dispose of waste as illegally opened dumpsites were expected because the literature has shown that the lack of proper and adequate solid waste management facilities leads communities to resort to throwing waste everywhere including riverbanks, roadside, and some practiced open burning (Haider and Kang, 2015; Etea et al., 2021). The results of health concerns caused by improper waste disposal were expected because reports that showed measures of informing the public regarding proper waste management

TABLE 4 Output of regression analysis for the Likert scale questions to assess the economic cost of improper waste disposal.

| Parameters | Estimates | SE | Wald | *p*-values |
|---|---|---|---|---|
| Waste generation increases the cost of clean-up | −38.412 | 10.418 | | <0.001 |
| Are you willing to pay for the waste collection fee? | **−44.123** | **16.516** | **7.137** | **0.008** |
| New form of waste collection and treatment needed | 1.887E−15 | 5.536 | 0.000 | 1.000 |
| Too much waste causes climate change, which results in global warming | -1.599E-14 | 15.237 | 0.000 | 1.000 |
| Waste creates job opportunities for employed and unemployed | 7.772E-16 | 9.871 | 0.000 | 1.000 |
| Waste blocks drainage systems, resulting in flooding and increases costs to repair damaged infrastructure | 2.914E-15 | 11.938 | 0.000 | 1.000 |
| Improper waste disposal chases away investors and tourists | −1.0.30E-14 | 9.066 | 0.000 | 1.000 |
| Waste surrounding households decreases property value | 8.327E-15 | 18.610 | 0.000 | 1.000 |
| Municipality will have to invest more money in waste management | −3.469E-15 | 12.639 | 0.000 | 1.000 |
| Community involvement and awareness campaigns will help reduce the load on the government | 7.855E-15 | 7.903 | 0.000 | 1.000 |

Source: Study data. Bold value represent significant parameters.

are still lacking, hence most respondents reported their concern (Zand and Heir, 2020; Mohamad and Masngut, 2023).

The regression results have shed light on how people believe that finance and paying the collection fee can somehow assist in dealing with the issue of improper waste disposal across the municipality. According to Matheson (2022), for the communities to lead a healthy quality life and to conserve the environment calls for proper solid waste management, which in turn requires additional funding, including increased collection rates, incineration, composting, sorting, and treatment before waste is discarded to a landfill site. In Sweden and Thailand, studies reported that various instruments for solid waste management, namely incineration, on top of the agenda, which made solid waste management in the area reported a success (Finnveden et al., 2013; Vassanadumrongdee and Kittipongvises, 2018). Similarly, Haider and Kang (2015) revealed that positive turnout to willingness to pay for waste collection was notable after people were made aware of the importance of waste reduction and economic opportunities associated with waste collection. Kaza et al. (2018) indicated that solid waste management tends to compromise the municipal budget as it requires more budget allocation.

The theme "*to collect waste on time*" emerged as the main suggestion to the authority when respondents were asked to suggest what the Msunduzi local authorities should do to resolve the issue of improper waste disposal was not surprising. Recently, the Tshwane Municipality had protest actions that lasted for a few months leading to improper waste disposal that led to all the other issues and health impacts raised by this study.

## 5 Conclusion

In conclusion, the findings of this study share some information that there are some repercussions associated with improper waste disposal, including the impact on human health, the environment, and the cost implications associated with the costs of cleaning up and maintaining damaged infrastructure. The study also revealed that improper waste disposal has short- and long-term results that both hinder developments in the communities. These results showed that waste management is important as not only does it offer a cleaner, healthier environment, but it also assists in managing improperly discarded waste, some of which is hazardous and non-hazardous.

South Africa is a developing country, and the lack of resources for responding to issues exacerbated by improper waste management can and should be avoided to reduce the potential costs of improper waste disposal. Based on the sampled population, the results from this study indicated that most of the people in Sobantu Township are educated. As a result, the conclusion can be made that somehow poor attitude and negligence of residents add to improper waste disposal witnessed within the study community. Indeed, Fobil et al. (2010) indicated that insufficient funds on the side of most governments allocated for waste management, such as waste collection services, ageing or not maintained infrastructure, and inefficient sanitation facilities, are among the factors that escalate improper waste disposal. The relationships between the demographic variables and the risk questions were, in most cases, insignificantly different statistically. The discussion justifies this insignificance. Indeed, studies have reported that statistically insignificant relationships do not necessarily mean socially and ecologically insignificant (Johnson and Ma, 1999; Dienes, 2014).

Improper waste disposal can have serious ecological consequences, especially in sensitive ecosystems like those found in South Africa (Eijsackers et al., 2020). The serious possible ecological consequences of improper waste disposal include but are not limited to water

contamination, soil and air pollution, habitat destruction, the spread of some invasive species, and health risks to wildlife (Singh and Singh, 2017). Addressing these ecological consequences requires proper waste management practices, education, and awareness campaigns to promote responsible waste disposal behaviors among individuals and communities (Ajibade et al., 2021). Additionally, enforcement of environmental regulations and policies is essential to prevent illegal dumping and hold polluters accountable for their actions (D'Amato et al., 2018).

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by University of the Free State General Human Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

TR: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Methodology, Formal analysis, Data curation, Conceptualization. NM: Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. ME: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsus.2024.1386047/full#supplementary-material

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