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Health Impacts Of Environmental Waste In The Three Districts In The Free State

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Abstract
Developing countries, including South Africa, continue to face significant challenges in achieving effective and sustainable waste management despite progressive legislation. This study assessed the environmental and public health impacts of waste exposure among residents living near landfill sites in the province. The research adopted quantitative cross-sectional design. Primary data were collected by convenience from residents living near selected landfill sites using structured questionnaires, observational checklists, and field mapping supported by Global Positioning System (GPS) devices. Study sites were purposively selected based on prior evidence of operational deficiencies and exposure risks. Due to inadequate fencing and limited monitoring, school-age children and domestic animals were frequently observed scavenging at landfills for food or reusable items. Residential dwellings were found on seven landfill sites (38.9%), and three sites (16.7%) were located within 2 km of water bodies, the closest being approximately 140 m away posing a substantial risk of water contamination. While 62.8% of respondents had never been hospitalised, 21.5% reported admissions due to illnesses related to poor air quality, pathogen exposure, and environmental stressors primarily respiratory ulcers, bronchitis, diarrheal infections, and tuberculosis. The association between healthcare visits and disease prevalence ($p = 0.004 < 0.05$) reinforces the environmental health burden faced by communities near landfill sites. The study suggests enforcing segregation, treatment, and safe disposal of hazardous waste, revising landfill classifications and strengthening compliance monitoring systems and promoting waste diversion in alignment with the waste management hierarchy and Sustainable Development Goals (SDGs).
Keyword*: solid waste, environmental exposure, impacts, public health, animal health, landfills*

1. INTRODUCTION

Waste is a global concern that reflects deep-rooted environmental, socioeconomic and governance challenges; yet its definition remains fluid across regulatory, disciplinary and institutional contexts. Waste is commonly categorised by source (e.g. household, industrial, healthcare), type (e.g. plastic, organic, electronic), physical state (solid, liquid, gaseous), and characterisation (general, hazardous, or mixed) (Olaoke & Popoola, 2017; WHO, 2024a). According to NEMA (2008), waste is primarily divided into general and hazardous categories. General waste includes domestic, business, construction, demolition and inert waste that does not pose an immediate threat to human health or the environment. In contrast, hazardous waste contains organic or inorganic compounds that, due to their chemical, physical, or toxicological properties, present significant environmental and health risks (RSA, 2013a; Olaoke et al., 2017; EPA, 2019). The Hazardous Substances Act 15 of 1973 further enforces the precautionary principle by presuming waste to be hazardous until proven otherwise (RSA, 1973). Solid waste, although primarily composed of tangible materials, may also include sludge from wastewater treatment and certain chemical waste – though interpretations vary across jurisdictions (Hoornweg & Bhada-Tata, 2012; EPA, 2019). This study focuses specifically on solid waste. As Jansen et al. (2017) caution, definitional inconsistencies, fragmented legislation, and differing waste classifications can complicate waste management practices, escalate operational costs, and undermine coherent environmental governance.

A solid waste is classified as hazardous if it is specifically listed as a known hazardous waste or exhibits one or more characteristics of hazardous waste (EPA, 2024). Hazardous waste is considered more dangerous than general waste, as it often contains potent biological constituents, contaminants and toxic chemicals resulting

from the processing and conversion of raw materials into finished products (Olaoke & Popoola, 2017; Roy et al., 2022). It is categorised under hazardous waste according to Annexure 1(2)(b)(iii) of the Draft Waste Classification and Management Regulations. This category may include disinfectants, pesticides, bleach, battery acids and thinners. Wastes exhibiting ignitability include liquids with flash points below 60 °C, non-liquids capable of spontaneous ignition, flammable compressed gases, and oxidising agents. Corrosive wastes are typically aqueous with a pH ≤ 2 or ≥ 12.5 or have the ability to corrode steel. Wastes showing reactivity are unstable under normal conditions, may react with water, release toxic gases, or detonate when exposed to heat or pressure. Toxic waste poses significant health and environmental risks when ingested or absorbed, as they can leach contaminants into groundwater sources (EPA, 2024). A report by the DEA suggests that South Africa produces and disposes of slightly higher amounts of hazardous than general waste as out of the estimated 12.9 million tons of waste generated in 2017, approximately 57.5% was considered hazardous and 42.6% was classified as general waste (DEA, 2018; Nyika et al., 2021). The environmental and health impacts of MSW may vary according to its composition and management procedures followed (Chen et al., 2020). The quantity and special distribution of mismanaged waste data are also crucial for the development of more effective National Waste Management Plans.

The generation, composition, and management of waste is not purely statutory but deeply influenced by the socio-demographic issues of the source. MSW is the major component of solid waste managed by local municipalities (DEA; 2012). Globally, MSW generation has increased substantially in recent decades, accompanied by an increasing presence of hazardous waste streams originating from households (Gutberlet & Uddin, 2018). Some of the key factors influencing the effectiveness of solid waste include the household size, cumulative income range, urbanisation of the areas, population density, and location of the region (Zibara et al., 2016; Fadhullah et al., 2022). Even in contexts where direct measurement tools and consistent records of waste generation are lacking, estimates are typically derived from demographic trends and economic activity at municipal level. Industrial waste, in contrast, is frequently approximated based on production data – especially in cases where waste-related figures are sensitive, confidential, or inaccessible due to permit restrictions (DEA, 2012). Sadan and De Kock (2021) highlight that South Africa's waste data remain largely unreliable, due to inconsistent reporting by municipalities and waste operators through the South African Waste Information System (SAWIS). Nonetheless, during a parliamentary portfolio committee briefing held on 15 February 2022, the Department of Forestry, Fisheries, and the Environment (DFFE) estimated that South Africa generates approximately 107.7 million tons of waste annually. Alarmingly, about 92.7% of hazardous waste and 65% of general waste are still disposed of in landfills (Parliamentary Monitoring Group [PMG], 2022. Since the last century, shifts in consumption patterns and rapid urbanisation have led to notable changes in the waste stream and environmental pressures (Alabi et al.,2023). The number, capacity and design of existing disposal facilities are unlikely to evolve rapidly due to the prolonged and contested processes associated with securing new regional landfill sites. Yet, as consumption and industrialisation continue to rise, the volume of waste requiring disposal is expected to increase, placing additional strain on an already overburdened system (Vani et al., 2017; Ndukwe et al., 2019). Waste management is among the most critical public service responsibilities in developing countries, where municipalities allocate between 20% and 50% of their budgets to waste-related activities. Of this, approximately 80–95% is spent on collection and transportation alone (World Bank, 2021). However, inefficiencies persist. It is estimated that around 70% of urban waste in developing countries is either not collected or improperly disposed of (Zibara et al., 2016). The situation is more severe in low-income contexts, where over 90% of waste is dumped in open, unregulated sites, or incinerated in open practices that have devastating health and environmental consequences (Abubakar et al., 2022).

In South Africa, the legislative framework guiding waste governance is anchored in the Waste Act (RSA, 2008), which mandates DFFE to establish national norms and standards, while provincial departments are responsible for licensing waste facilities. Municipalities, in turn, are tasked with delivering waste collection and disposal services (Kalina & Schenck, 2024; Polasi et al., 2020). However, municipalities face significant challenges, including limited financial resources, equipment failure, political instability, corruption, labour unrest and institutional inefficiencies (Godfrey & Oelofse, 2008; DEA, 2012; Polasi et al., 2020; Kalina et al., 2024). Although major strides have been made since 1994 to expand waste services to underserved

communities, current systems remain inadequate to meet the demands of South Africa's growing and urbanising population (Kalina et al., 2024). Waste collection and final disposal are two key stages in the solid waste management hierarchy and continue to present major obstacles. Nearly 90% of all collected waste in South Africa is disposed of via landfilling, which is the least-preferred option in the waste hierarchy (Local Government Bulletin, 2023; Rodseth et al., 2020). In Sub-Saharan Africa, over 75% of waste are openly burned or deposited in unlicensed landfills. These dumping sites carry immense public health and socioeconomic costs – costs that remain largely unquantified by governments, industries, and affected households (Salam, 2010; Madaleno, 2018; Farah, 2019).

Despite the development of technologies that enable recovery and reuse, approximately 70–80% of MSW in Africa is technically recyclable. Yet only around 10% is recovered in practice, with South Africa reflecting similarly low recycling rates (AUDA, 2021; Local Government Bulletin, 2023). A staggering 87% of municipalities lack the financial capacity or infrastructure to implement waste minimisation strategies, including source separation and resource recovery (DEA, 2019). The absence of clear, enforceable guidelines on household waste segregation has led to indiscriminate disposal, including the mixing of hazardous and general waste streams (Du Toit & Bodenstein, 2014; Jansen et al., 2017). Recyclable materials are often landfilled or dumped, including an estimated 10 million tonnes of food waste annually, despite the prevalence of food insecurity in the country (WWF, 2017).

This improper handling of waste not only exacerbates pressure on limited landfill space, but also contributes to significant environmental and health risks, particularly for those living close to disposal sites, informal waste pickers and municipal workers. In response, the DEA (2018) published draft guidelines for the separation of waste at source, urging that such measures be aligned with municipal Integrated Waste Management Plans (IWMPs) and local waste by-laws. These guidelines aim to slow the depletion of landfill airspace and reduce pollution and environmental degradation. Jansen et al. (2017) further recommend that healthcare risk waste (HCRW) be integrated into broader waste systems rather than treated as a separate stream to ensure comprehensive and efficient management.

Environmental degradation resulting from poor waste management practices poses one of the most pressing sustainability issues of our time. The environment comprises both biotic (living organisms) and abiotic (soil, air and water) components, and landfill sites interact with these elements through processes such as leachate percolation, which can contaminate groundwater and surface water sources (Manisalidis et al., 2020; The Green Guardian, 2023). Landfills also emit significant quantities of greenhouse gases, including methane and carbon dioxide, which contribute to global warming and climate change (Ziraba et al., 2016; WHO, 2024a). These environmental impacts are linked to declines in biodiversity, ecological health, and the quality of human life (Ogundele et al., 2018; Gwibi et al., 2020; Krecl et al., 2020).

Populations residing near landfill sites are especially vulnerable to health risks, including poor sanitation, exposure to contaminated water and food, respiratory illnesses, rodent infestations, and vector-borne diseases (Salam, 2010; Alam & Ahmade, 2013; Ziraba et al., 2016; Scarponi et al., 2019). Children are particularly at risk due to their underdeveloped immune and metabolic systems, which limit their ability to eliminate environmental toxins (Cointreau, 2006). According to the World Health Organisation (2024b), an estimated 13.7 million deaths, approximately 24% of global mortality, can be attributed to modifiable environmental risk factors, with noncommunicable diseases such as cardiovascular illnesses, chronic respiratory conditions, and cancers being the most prevalent outcomes. These statistics underscore the urgent need for targeted interventions that prioritise environmental justice and protect the health of the most vulnerable communities.

The drivers of improper waste disposal in the Free State are exacerbated by poverty, rapid urbanisation, and population explosion. The Free State municipalities, such as the Mangaung Metro Municipality, Lejweleputswa, Xhariep, Fezile Dabi and Maluti-a-Phofung, have experienced rapid urbanisation and population pressure, exacerbating the increase in waste generation (Matjhabeng Local Municipality, 2024; Mangaung Metropolitan Municipality, 2022; Center of Scientific and Industrial Research [CSIR], 2024; Fezile Dabi Municipality, 2022; Cooperative Governance & Traditional Affairs [COGTA], 2020). The Free State province is the third-largest province in South Africa, located on the high central plains, and represents 10.6% of the total land area of the country, but is one of the least economically active provinces in South

Africa (OECD, n.d; Toerien, 2015). According to the Department of Statistics South Africa (2020), the largest employment decrease of 29 000 was recorded in the Free State province in the year 2020, and it remains the second province with the highest unemployment rate in the country after North West.

The high unemployment rate in South Africa is one factor leading to interprovincial migration and a rise in the proliferation of informal sector activities such as waste picking, driven by poverty (Uhunamure et al.,2021; AUDA, 2021). Despite the existing human settlement allocation disparities, these are the populations that usually settle informally in environmentally insecure places such as landfills without basic amenities such as water, toilets, and electricity, accounting for about 5 million in South Africa (International Budget Partnership, 2021; Schenck et al., 2022). This further influences the reliance of residents on social grants and free services. Health insurance coverage in the Free State is estimated at 17.8%, which leaves over 2.2 million of the uninsured population to be fully or partially dependent on the public health service, which is already overburdened due to insufficient human resources undermining undermines the quality of healthcare services provided in the province (Department of Health [Free State], 2016; Ritshidze, 2021). Vulnerability reduction would require an understanding of the underlying social, economic and political context, and then addressing the factors that increase risk and vulnerability (Dintwa et al., 2018).

The Free State has 73 landfill sites, whose capacities are already stretched and are operated like dumpsites (Roberts 2013; AfriForum, 2021; The Green Guardian, 2023). Even though MSW services are mostly underpriced, residents and businesses fail to pay, which has a direct impact on a municipality's budget and ability to render services or improve infrastructure (DEA, 2010; DEA, 2012; Polasi et al., 2021). Due to the lack of a hazardous landfill site in the Free State, e-waste and healthcare risk waste are disposed of at general waste landfill sites (Mangaung Metropolitan Municipality [MMM], 2016). There is a paucity in the scientific literature investigating the impacts on health and the environment of municipal landfill sites in the Free State and on sustainable solutions relevant and appropriate for all South African communities, including the marginalised groups. The available studies focus on respiratory health in those living near illegal dumpsites (Maluleka et al., 2025) and water quality, soil quality, and food security (Ololade et al., 2019; Mokhadi et al., 2020), and waste pickers' socioeconomic context (Schenck et al., 2016). Most studies were based on the Mangaung Metropolitan Municipality, however this study aims to assess the environmental risks linked to waste exposure and the impact of the environmental waste on the health of residents living in proximity to the landfill sites in the Free State province.

2. METHODOLOGY

2.1. Description of the study areas and selection criteria

The Free State Province is South Africa's third largest by land area, covering approximately 129,480 km^2, with a population of about 2.8 million distributed across four district municipalities, namely, Xhariep, Lejweleputswa, Fezile Dabi, Thabo Mofutsanyana, and the Mangaung Metropolitan Municipality (CSIR, 2024). The study is located in three district municipalities, namely Lejweleputswa, Fezile Dabi, Thabo Mofutsanyana.

A descriptive cross-sectional design was used for this study. Cross-sectional design permits an assessment of factors and outcomes of interest simultaneously in a representative sample of the target population (Udofia et al., 2017). Due to the frequent changes that happen at landfill sites influenced by municipal implementation, politics, and sometimes disasters, several other authors who conducted their studies at landfill sites, with residents and/ or waste pickers, also opted for the cross-sectional method in their studies (Kistan et al., 2020; Nambuli, 2021; Oghuehi et al., 2022).

2.2. Selection criteria of the study areas

Eighteen hotspot landfills in sixteen towns were observed and documented during fieldwork conducted for two waste studies in the Free State, supported by existing literature on landfill sites in the Region. Every Free State town has at least one landfill, but some have two or more, such as Virginia and Phuthaditjhaba towns. The selection of the landfill sites for this study was based on proximity to human settlements and environmental resources and operational status, and activity level. Landfills and residential areas in the vicinity, namely, Parys, Vredefort, and Heilbron in Ngwathe local municipality, Sasolburg in Metsimaholo local municipality, Viljoenskroon in Moqhaka local municipality, Virginia and Odendaalsrus in Matjhabeng

local municipality, Wesselsbron, and Bothaville in Nala local municipality, Theunissen and Winburg in Masilonyana local municipality, Phuthaditjhaba and Harrismith in Maluti-a-phofung local municipality, Paul Roux in Dihlabeng local municipality, and Frankfort in Mafube local municipality.

2.3. **Study population**

The inclusion criteria encompassed adults eighteen years and above who work or reside within a 2km radius of the landfill sites at the time of data collection, which places them at heightened risk of waste exposure. This age category did not require assent from parents to respond and was used because it is believed that individuals are mature enough to provide information on the impact of landfills on their immediate environment and health, and they can make informed decisions (Suleman et al., 2015; De & Debnath, 2016; Ampofo, 2020). The immediate groups that were potential participants for the study in these areas varied from residents living in both formal and informal settlements, waste pickers, recyclers, and municipal site employees.

2.4. **Sampling techniques and size**

In instances where the inclusion of the entire population is impractical or where not all members of the target population can be identified, sampling techniques are utilised to collect data that are considered to accurately reflect the characteristics of the broader population (Wang & Cheng, 2020; Stratton, 2021). Given the exploratory and descriptive nature of the study, a non-probability convenience sampling method was utilised to select participants from the identified population (Udofia et al., 2017). A convenient sample was selected based on availability and willingness to participate. Residents living on and/ or in the vicinity of the landfill will be selected. The frequent visits to the landfill sites during fieldwork, which form the experience of the researcher, revealed that this method will be viable due to the daily fluidity of the research population. The number of participants approached and asked to participate in the study was 185, while the actual number of participants who were willing to participate in the study was 121.

2.5. **Data collection tools and techniques**

2.5.1. Mapping using a Global Positioning System (GPS) device

This technique involves taking field trips to the selected landfill sites. Landfill site locations were mapped with the help of a Garmin Global Positioning System (GPS) (mobile Etrex 10 model). The device was calibrated for 10 minutes, and a waypoint was created for 90 minutes as recommended for good results in the guideline pamphlet. Then, the GPS coordinates indicating locations are saved on the device with the town names or distinctive locations where there was more than one landfill in the area. This medium-power device uses alkaline batteries; therefore, it is convenient to use for outdoor activities, especially in remote areas without the need to recharge.

2.5.2. Questionnaires

Structured questionnaires were used to assess the knowledge and perceptions of residents. Due to the diversity of ethnic groups at the dumpsite, the questionnaires were distributed to the participants in their preferred language, which was either Sesotho, English, or Afrikaans common in the Free State. Parameters of the questionnaire were sectioned A, B, and C. Section A included demographic data and socio-economic, Section B inquired about their environment and livelihood (access to water and ablution amenities and Section C gathered information on the wellbeing and health aspects of the participants. The questionnaire was a combination of closed-ended and open-ended questions with nominal, ordinal, and Likert-scale options like (Strongly Agree, Agree, Disagree, Strongly Disagree) (Ampofo, 2020).

2.5.3. Checklists

Observations were documented using a checklist during site walkthroughs, and photographs were taken. Direct observation refers to data collection where the researcher notes participants' actions without altering their environment (Busetto et al., 2020). The checklist was adapted from the one developed by AfriForum and the Minimum Requirements for Waste Disposal by Landfill guidelines and modified to suit the objective (DWAF,1998). Checklists were used during or after the observations, depending on feasibility and acceptability, as people tend to change behaviour and practices when they know that they are observed (Hawthorne effect) (Busetto et al.,2020; Cassim & Du Plessis, 2021).

2.5.4. Validity and Reliability

A research instrument is considered valid when it accurately measures the specific concept or construct it is intended to assess (Ampofo, 2020). Face validity is in relation to the misunderstanding and misinterpretation of the question, and this is where the researcher or a content domain expert simply looks at the contents of the instrument and decides whether it looks like it will measure what it is supposed to measure (Robertson, 2017). For this study, the researcher gave five potential participants a pretest and asked them to rate out of 10 if the instrument (questionnaire) looked like it measured what it was supposed to measure, and the responses were between 8 and 10, which was a high score. Another form of validity test is the content validity, which is the extent to which the instrument adequately captures or represents all relevant aspects of the topic or construct being studied (Ampofo, 2020). To ensure the content validity of the data to be collected, the questionnaires were peer reviewed by the study promoters and qualified field experts, and adjustments were made based on the responses to improve clarity and suitability. Additionally, questionnaires that were translated into other languages (Sesotho and Afrikaans) were back-translated into the developmental language (English) to ensure that they gave the same meaning.

Reliability refers to the consistency of a research instrument, indicating its ability to produce the same results under consistent conditions each time it is used (Udofia et al., 2017; Ampofo, 2020). The questionnaires were tested on residents in five towns of the Free State to validate the contents and check for ambiguity, and then adjustments were made where required. After incorporating feedback from pre-testing and making changes, the researcher wrote to the ethical committee to seek approval before directly administering it to study participants. This pilot was conducted to ensure the research instrument meets a suitable level of quality in terms of credibility and dependability (Fashina et al., 2020, 2021). Only questionnaires with 95% or more completion were included for analysis.

2.5.5. Data analysis

Numerical and nominal data collected by the questionnaire and checklist were coded and captured by the researcher in a Mentimeter application. A biostatistician conducted any further analysis. Descriptive statistics, namely frequencies and percentages, were calculated for categorical data, and means, standard deviations, medians, and percentiles were calculated for numerical data. Inferential analysis was carried out using IBM SPSS Version 29. Cross-tabulations were applied to investigate the interactions and patterns between the variables. The Chi-Square Test table then assesses whether the observed differences in these distributions are statistically significant. A significance value (p-value) of 0.05 or below indicates a statistically significant relationship between the variables, whereas a value greater than 0.05 suggests that any observed differences may be attributable to chance (Kwak, 2023; McLeod, 2025).

2.5.6. Ethical considerations

Ethical clearance was sought through an application to the Health Sciences Research Ethics Committee at the University of the Free State (UFS-HSREC), and approval was subsequently granted. The ethical clearance reference number is UFS-HSD2023/1726/0110. Permission to conduct the study in the selected areas in the Free State was also obtained via the National Health Databases application system of the Free State Department of Health, with the approval reference number FS2023/12/006.

3. RESULTS AND DISCUSSION

3.1 Sociodemographic determinants and environmental factors in residential areas

Table 1: Description of socio-demographic information of residents living in the vicinity of landfill sites

Characteristics	**Class**	**Frequency and Percentages**
Gender distribution	Male	64 (52.9%)
	Female	57 (47.1%)
Age category	School age (18 – 21)	7 (5.8%)
	Young adult age (22- 35)	37 (30.6%)
	Mid-age (36 - 59)	68 (56.2%)
	Pension age (60+)	9 (7.4%)

Nationality	South Africa	113 (93.4%)
	Lesotho	8 (6.6%)
Birthplace by province	Non-citizen	8 (6.6%)
	Gauteng	2 (1.7%)
	Free State	(88.4%)
	KwaZulu Natal	(3.3%)
Participation per district	Fezile Dabi	37 (30.6%)
	Lejweleputswa	44 (35.6%)
	Thabo Mofutsanyana	41 (33.9%)
Educational profile	None	1 (0.8%)
	Primary	64 (52.9%)
	Junior secondary	32 (26.4%)
	High school	22 (18.2%)
	Tertiary	2 (1.7%)
Employment status	Employed	39 (32.2%)
	Unemployed	70 (57.9%)
	A grant/ pension recipient	12 (9.9%)
Occupational categories	Grant/ pension recipient	12 (9.9%)
	Unemployed	70 (57.9%)
	Job not specified	3 (2.5%)
	Animal caretaker	1 (0.8%)
	Firm operations manager	1 (0.8%)
	Recycling cashier	1 (0.8%)
	Printing works	1 (0.8%)
	Expanded Public Works Programme (EPWP)	1 (0.8%)
	Security	3 (2.5%)
	General worker	1 (0.8%)
	Site contractor	1 (0.8%)
	Waste picker	24 (19.8%)
	Recycling operator	2 (1.7%)
Waste picking status	Yes	(30.6%)
	No	(67.8%)
	Unspecified	2 (1.7%)
Type of housing occupied	Shack house	47 (38.8%)
	Backroom of main house	23 (19%)
	Reconstruction and Development Programme (RDP) houses	36 (29.8%)
	Multi-storeyed apartment (complex)	3 (3.3%)
	Private single house	1 (9.1%)
Minors below 18 years	Yes	75 (62%)
	No	46 (38%)
Household size	Small family (1 to 3 members)	48 (39.7%)
	Medium size family (4 to 6 members)	44 (36.4%)
	Big or extended family (7+ members)	29 (24%)
Duration of residence	Less than 1 year	10 (8.3%)

	1 to 5 years	26 (21.5%)
	6 to 10 years	13 (10.7%)
	11 to 15 years	9 (7.4%)
	Above 15 years	63 (52.1%)

Table 2: Number of children per household unit

N	Mean	Std. Deviation
121	1,56	1,760

Table 3: Cumulative monthly income

N	Mean	Std. Deviation
121	1877,85	1688,961

Table 4: Relationship between housing type and combined monthly income

Ranks			
Housing type		N	Mean Rank
Combined monthly income (R)	Private single house	11	76,86
	Multi-storied apartment (complex)	4	51,38
	The Reconstruction and Development Programme (RDP) houses	36	54,49
	Backroom of the main house	23	63,52
	Shack house	47	61,86
	Total	121	

Table 5: Kruskal-Wallis H for monthly income

Test Statistics[a,b]	
	Combined monthly income (R)
Kruskal-Wallis H	3,946
Df	4
Asymp. Sig.	0,413
a. Kruskal Wallis Test	
b. Grouping Variable: Housing type	

Table 6: Relationship between respondents' access to municipal water and usage of wood for heating purposes

Crosstab					
			Wood		Total
			Yes	No	
Tap water provided by the municipality	Yes	Count	72	26	98
		% in tap water provided by the municipality	73,5%	26,5%	100,0%
		% in wood	77,4%	96,3%	81,7%
		% of total	60,0%	21,7%	81,7%
	No	Count	21	1	22

		% in tap water provided by the municipality	95,5%	4,5%	100,0%
		% in wood	22,6%	3,7%	18,3%
		% of total	17,5%	0,8%	18,3%
Total		Count	93	27	120
		% in tap water provided by the municipality	77,5%	22,5%	100,0%
		% in wood	100,0%	100,0%	100,0%
		% of total	77,5%	22,5%	100,0%

Table 7: Chi-Square results

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,980[a]	1	0,026		
Continuity Correction[b]	3,799	1	0,051		
Likelihood Ratio	6,431	1	0,011		
Fisher's Exact Test				0,025	0,018
Linear-by-Linear Association	4,939	1	0,026		
N of Valid Cases	120				
a. 1 cells (25,0%) have expected count less than 5. The minimum expected count is 4,95.					
b. Computed only for a 2x2 table					

Table 8: Cramer's V results

Symmetric Measures			
		Value	Approximate Significance
Nominal by Nominal	Phi	-0,204	0,026
	Cramer's V	0,204	0,026
N of Valid Cases		120	

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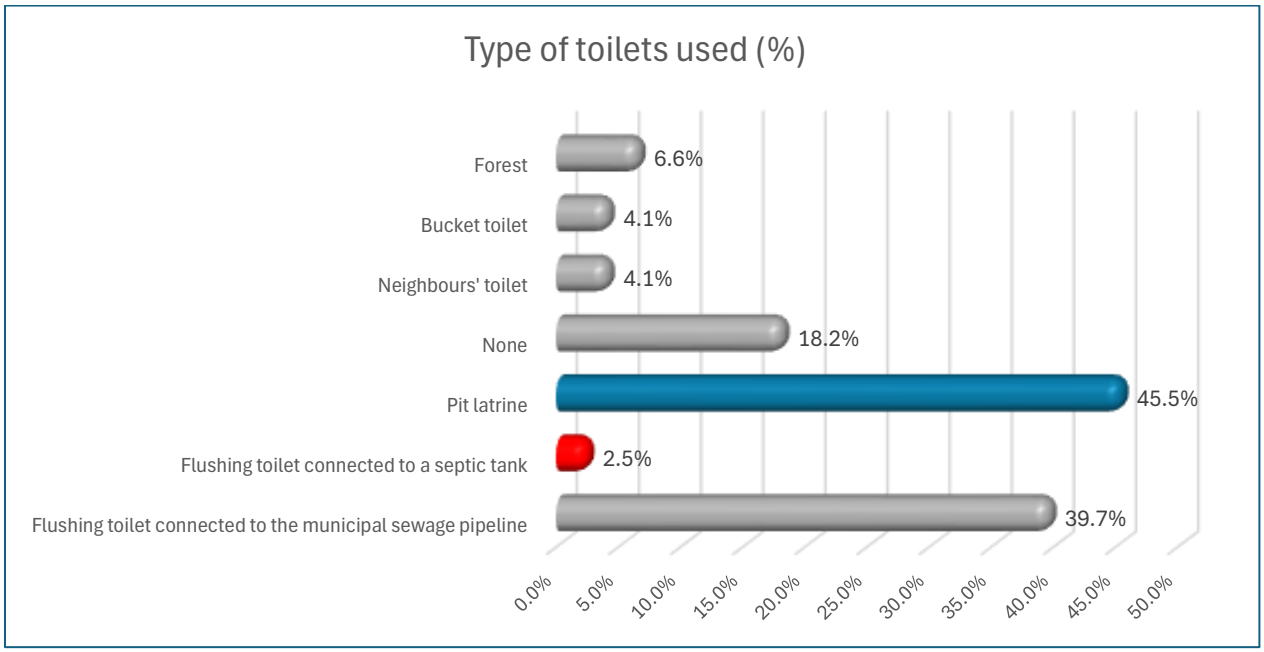

Figure 1: Types of sanitary facilities in participants' households

Table 1 summaries the demographic information or residents. The population of respondents was 52.9% male and 47.1% female, indicating a relatively balanced gender distribution, with a slight predominance of males. The findings are consistent with the provincial demographic trends of the Community Survey conducted in 2016, which reported that 58,3% of the population in the Free State province are male and 41,7% are female (Statistics South Africa, 2016). While the recent 2022 Census results provided an updated population total of 2.9 million in the Free State, specific gender percentages have not been highlighted in the initial report release (Statistics South Africa, 2023a). The national population trends for 2025, however, indicate that females account for 51% of the population, which is approximately 32 million out of the 63 million current population, and men only account for 49% (Statistics South Africa, 2025a). The higher female participation may also suggest that most households near the landfill site were female headed. Over half of the respondents (56.2%) were middle-aged (between 36 and 59 years), followed by young adults (30.6%) aged 22–35 years and pensioners (7.4%). The findings are slightly similar to the national trends that indicate that children under the age of 15 make up about 26,2% of South Africa's population, an estimated 16,5 million people. Adults between the ages of 35 to 59 are 19.2 million (30.4%). Meanwhile, around 10,5% of the population, or 6,6 million people, are aged 60 and older (Statistics South Africa, 2025a). Most of the respondents have stayed in these areas for over fifteen years, which can mean that they know the dynamics of the places better and have been exposed to environmental waste for a longer period of their lives.

A smaller proportion of the migrants (6.6%) in the study were from Lesotho. To the east, it has an international boundary with Lesotho; therefore, cross-border movement is common due to geographical proximity (Free State Online, n.d.). International migration trends, however, show that Gauteng is the number one preferred destination, followed by the Western Cape province. These provinces have a higher economic affluence, which can be a pull factor (Statistics South Africa, 2025b). The demographic data of a study conducted on female waste pickers in Mashaeng, Free State, revealed that they originally came from Lesotho and their ages ranged from 35 to 45 years (Ramolelle & Xweso, 2022). This shows that waste picking is one of the informal jobs that can attract international migration or sustain migrants who have moved into South Africa for greener pastures but found waste picking as the most viable source of income. Most respondents in this study are 35 to 45 years old, i.e. are within the middle adulthood group of 35–59 years. The middle-aged adult group generally demonstrate high labour force participation in the formal sector, often occupying mid-to-late-career positions. However, those with lower educational attainment and limited access to formal employment may resort to waste picking as an informal means of livelihood, especially after

COVID-19 layoffs and failure in business ventures (Yu et al., 2020; Schenck et al., 2016). Even in most European countries, poverty rates among older people remain higher for women than for men. In more than half of the countries with available data, this gender gap widens among one-person households compared to all households, reflecting women's heightened economic vulnerability when living alone (UN, 2017).

Most respondents (88.4%) were born in the Free State, followed by 3.3% in KwaZulu-Natal, while the smallest proportion (1.7%) originated from Gauteng. This high proportion of respondents born in the Free State is unsurprising, as the province, located on the vast, flat plains in the centre of South Africa, shares borders with most of the country's provinces, except Limpopo and the Western Cape (Free State Online, n.d.). A total of 35.5% of respondents resided in the Lejweleputswa District, followed closely by 33.9% in the Thabo Mofutsanyane District and 30.6% in the Fezile Dabi District. This relatively even distribution across the three districts suggests that the study achieved balanced geographical coverage within the Free State province. The slightly higher representation from Lejweleputswa may be attributed to the greater number of landfill sites included in this district (seven in total) or the closer proximity of residential areas to participating landfill sites, given that participants were selected through convenience sampling. The majority of respondents (52.9%) had attained only a primary level of education (Grades 1–7), followed by 26.4% who had completed junior secondary education (Grades 8–10) and 18.2% who had completed high school (Grades 11–12). Approximately 34% of respondents reported secondary schooling as their highest level of education, indicating relatively high dropout rates and limited progression to tertiary education (Statistics South Africa, 2023b). Nationally, the proportion of individuals attending educational institutions between the prime ages of 5 and 24 years increased by nearly 4%, from 73.1% in 2011 to 76.8% in 2016, reflecting gradual improvements in educational access (Statistics South Africa, 2023b). However, the concentration of respondents with only primary and incomplete secondary education in this study suggests that national achievements may not be evenly distributed across provinces, particularly in communities situated near landfill sites where socioeconomic constraints remain distinct.

Most respondents (57.9%) were unemployed, 32.2% were employed, and only 9.9% were grant or pension recipients. The high unemployment rate reflects a broader national challenge, as unemployment in South Africa, including in the Free State province, has remained persistently high and was further exacerbated by the socioeconomic disruptions of the COVID-19 pandemic ([DESTEA, 2022). The province's dependency ratio, which measures the burden placed on the working-age population to support dependents, declined from 66 in 2011 to 60 persons per 100 in Census 2022, indicating a modest demographic improvement (Lejweleputswa District Municipality, 2022). However, given the high proportion of unemployed respondents, economic dependency remains a significant concern in many communities within the province. Approximately 19.8% of respondents reported working as waste pickers, while 9.9% relied on social grants or pensions. Smaller proportions were engaged in informal economic activities such as animal caretaking, recycling, cashier work and small-scale printing. In total, 67.8% indicated that they had participated in waste picking activities at some point during their stay near the landfill sites. Waste pickers are often highly mobile, and the nature of their work tends to fluctuate seasonally. Their limited engagement with researchers may also stem from concerns that information provided could be relayed to authorities, potentially affecting their livelihoods. Globally, waste picking represents a small, but critical segment of informal labour; for example, in India, waste pickers account for only about 1% of the total of 2.2 million workers employed (WIEGO, n.d.).

Most respondents (38.8%) live in shacks, reflecting the continued growth of informal settlements around landfill sites, often attributed to delays in the delivery of Reconstruction and Development Programme (RDP) housing, which accounts for only 29.8% and backyard dwelling (19% of the respondents) (Aydamo et al., 2020; Ojo-Aromokudu et al., 2020; Parikh et al., 2020). Respondents residing in private, single houses recorded the highest mean rank (76.86), suggesting that this group generally reported higher combined monthly household incomes. They were followed by those living in backrooms (63.52), shack houses (61.86), and RDP houses (54.49) as indicated in Table 4. However, the difference in combined monthly income across the five housing types was not statistically significant ($p = 0.413 > 0.05$) as shown in Table 5, implying that the observed variation is likely due to random variation rather than a true association between housing type and household income. According to Statistics South Africa, the proportion of households living in backyard

dwellings, either in formal or informal settlements, increased from 7.3% in 2011 to 12.5% in 2016, with such dwellings being particularly common in urban areas (Statistics South Africa, 2023c). These types of dwellings typically provide affordable accommodation for families who cannot afford regular rent, are awaiting RDP allocation, or do not qualify for government housing. Nationally, the share of formal dwellings rose to 83.5%, followed by 12.2% informal and 3.9% traditional dwellings (Statistics South Africa, 2023). The finding that 9.1% of respondents resided in private or traditional dwellings was therefore noticeably higher than the national average, suggesting distinct local housing dynamics in communities near landfill sites. Around the world, one's home is a key asset for stored wealth (UN, 2017).

Respondents reported an average combined monthly income of R1 877,85 as shown I Table 3, which is approximately nine times lower than the national average combined monthly income of about R17 000, and four times lower than the median monthly household income of around R8 000, as reported in the 2022/2023 Income and Expenditure Survey (Statistics South Africa, 2025b). The majority of households (62%) had children under the age of 18, the typical school-going age, while 38% consisted solely of adults, and the respondents had an average of 1,56 (approximately two) children living in their households as indicated in Table 2. There are similarities in the findings nationally, with an average of 2.21 (approximately two) children. The relatively young population structure in communities around landfill sites also shows that there is additional pressure on household resources, especially where unemployment and people are living in poverty. Literature has also shown that children living near landfill sites are at a greater risk of environmental hazards (Gumede, 2015; Alabi et al., 2023).

The majority of respondents (78.3%) reported using wood as their primary household energy source for heating. Slightly more than half (53.3%) used electricity, 40% relied on paraffin, and 15.8% used methane gas. Only 0.8% of respondents had solar panels installed, while 3.3% reported burning solid waste, and 0.8% used dried cow dung as additional sources of heat. Despite the notable national progress of expanding electricity access, from just over 36% of households in 1994 to more than 94% by 2024, representing over 8.4 million new household connections, many South Africans continue to experience energy poverty. Approximately 1.6 million households remain unelectrified, particularly in informal settlements, peri-urban areas, deep rural regions, and newly developed housing projects (ESI Africa, 2025). Residents of informal and low-income formal settlements often have a high energy demand, which sometimes leads to illegal electricity connections (Monyai et al., 2023), often following repeated delays and unfulfilled service delivery promises by local authorities. However, due to the unreliability of electricity caused by frequent load shedding, especially in these areas, cheaper and more accessible energy sources such as wood are often preferred (Mocwagae et al., 2024). Previous studies have shown that dependence on wood fuel contributes to indoor air pollution, which is associated with severe health impacts, particularly among women and children (Alabi et al., 2023; WHO, 2024b). These risks are further exacerbated in households where cow dung and solid waste are used as substitute biofuels. The chi-square test indicates that the association of limited access to municipal water connections and the reliance on wood as their primary energy source were statistically significant ($p = 0.026 < 0.05$) as shown in Tables 6, 7 and 8. This relationship is largely driven by intersecting factors such as poverty, time poverty, and inadequate infrastructure. Households without municipal water access are typically low-income and face significant economic constraints. Consequently, wood becomes a preferred energy source, because it is freely available or low-cost, unlike municipal services such as water and electricity, which require regular payment (Netshipise & Semenya, 2022). Globally, access to clean fuels and technologies for cooking increased from 50% in 2000 to 57% in 2014. Nevertheless, over 3 billion people, primarily in Asia and sub-Saharan Africa, remain without access to clean cooking fuels and technologies, exposing them to high levels of household air pollution (UN, 2017).

Almost half of the respondents reported using pit latrine toilets (shown in Figure 1), a pattern similar to that observed in Limpopo province, where the predominant sanitation facility is the ventilated improved pit (VIP) latrine (NEWS24WIRE, 2023). The proportion of respondents with access to flush toilets connected to sewerage systems was 39.7%, considerably lower than the provincial average of 76.0% recorded for the Free State (Statistics South Africa, 2023). Additionally, the proportion of households relying on bucket toilets and practising open defecation was slightly higher than the national figures of 3.5% and 4%, respectively (Statistics South Africa, 2016; NEWS24WIRE, 2023). The continued lack of adequate sanitation facilities and the need

for residents to share toilets even after 1994 reflect not only a shortfall in post-apartheid reparation efforts to restore dignity to previously marginalised citizens, as envisioned in the Bill of Rights, but also contribute to ongoing public health challenges, environmental contamination, and social and psychological distress. These conditions particularly affect women and children, who may be more vulnerable to health risks and sexual exploitation (Saleem et al., 2019; NEWS24WIRE, 2023). In some informal areas where no sanitation facilities exist, the use of pit latrines has been recommended as a temporary measure (Netshipise & Semenya, 2022).

3.2 Association between waste landfill proximity and environmental exposure

Table 9: Location of the disposal sites and the distance from land use (agricultural or commercial), water sources, and waterways

Locations	**Land use (km)**	**Water bodies (km)**	**Waterways (km)**
1. Virginia 1	8.71	5.82	1.83
2.Odendaalsrus	6.38	7.23	2.10
3. Bothaville	6.73	6.28	13.34
4.Wesselsbron	1.60	4.61	17.26
5. Paul Roux	5.09	2.24	4.67
6. Bethlehem	7.29	3.35	10.16
7.Viljoenskroon	2.94	3.01	30.97
8. Maqhekung-Phuthaditjhaba	0.75	0.14	10.35
9.Pereng-Phuthaditjhaba	14.70	1.99	1.68
10. Vredefort	4.95	2.79	2.38
11.Heilbron	8.75	3.09	1.14
12.Sasolburg	1.42	1.20	20.84
13. Frankfort	2.68	9.42	4.42
14. Harrismith	10.42	4.13	8.57
15. Virginia 2	3.05	2.09	16.71
16. Theunissen	11.09	11.75	2.91
17. Winburg	12.21	11.69	11.18
18. Parys	2.10	2.04	20.59

Table 10: Distance of landfills from residential areas (km)

N	**Mean**	**Std. Deviation**
121	1,11	0,776

Figure 2: Informal settlements (shacks) on the landfill in Odendaalsrus

Figure 3: Informal settlement situated on the Sasolburg landfill site

Table 9 shows spatial distance between landfills and land use, waterbodies and waterways. More than half of the landfill sites were located within a distance of 5 km from areas of land use, with four sites (22%) situated within 2 km and one site located less than 1 km away, approximately 750m from land use. Land use is defined as the manner in which land may be used lawfully in terms of a land-use scheme or in terms of any other authorisation, which includes residential, agricultural, commercial, industrial and conservation areas (RSA, 2013b; TownPlanner, 2025). The geospatial findings of this study corroborate previous South African research showing a continuous reduction in the average distance between landfill sites and human settlements over time, from 68.5 km in 2008 to 8.5 km in 2015 (Tomita & Slotow, 2020). In the present study, nine landfill sites were found to be situated less than 5 km from land use zones, with an average distance of 1.11 km from human settlements in 2025 as shown in Table 10 and some were located on the landfill sites as shown in Figures 2 and 3. These results align with earlier observations that disposal sites, once located at acceptable distances from residential areas, now lie adjacent to predominantly low-income suburban housing (Du Preez et al., 2016). The situation is further exacerbated in informal settlements and slum areas, where increased population influx, rapid urbanisation, and expanding developments intensify land demand and lead to the encroachment of residential areas towards landfill zones (Akinrogunde et al., 2019). Studies have shown the possibility of contamination and significant health impacts on residents' living and water contamination where the buffer zone is 5 km or less from landfill sites (Gumede, 2015; Mokhadi et al., 2020; Phan et al., 2021; Maluleka et al., 2025).

Over the past decades, and continuing to the present, research on the effective management of landfill buffer zones in South Africa has remained limited, accompanied by inconclusive legislation and fragmented implementation. This has resulted in a lack of practical experience and the absence of well-established tools or conceptual models to guide best practices and promote the sustainable long-term management of these areas (Moodley et al., 2012; Macfarlane et al., 2014). The establishment and maintenance of buffer zones are enforceable under the Health Act, 2003 (Act 61 of 2003), which provides for measures necessary to prevent nuisances, unhygienic or offensive conditions, and any circumstance deemed harmful to public health, as outlined in the Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998). The landfill buffer distance from airports is explicitly prescribed as 3 km; however, the required distances from water bodies and land-use areas remain subject to the landfill's operational plans, as well as administrative and physical acceptance criteria determined at departmental discretion (DWAF, 1998; DFFE, 2021). In 2017, the Gauteng

Pollution Buffer Zones Guideline was introduced, recommending a best-case buffer of 400 m (or, in the worst case, 200 m) for general landfills, and a best-case buffer of 2 km (or, in the worst case, 1 km) for hazardous landfills. Despite these provisions, South Africa, particularly the Free State province, continues to experience challenges in distinguishing landfill classifications due to operational inconsistencies and the acceptance of mixed-waste streams containing both general and hazardous materials (Roberts, 2013; Machete & Shale, 2015). The findings of this study revealed that residential dwellings were present on seven landfill sites (38.9%). Three sites (16.7%) were located less than 2 km from water bodies, with the closest situated approximately 140 m away. The waterbodies in this context are inland water sources that include groundwater systems, wetlands, lakes, pans, dams and reservoirs (South African National Biodiversity Institute [SANBI], 2019). The inland waterways in the Free State comprise specific types of water bodies or channels acting as transportation routes, i.e. major river systems such as the Orange River, Vaal River, Klip River and Caledon River, including the artificial lakes and dams that are largely used for crop irrigation (Free State Provincial Spatial Development Framework [FSPSDF], 2024).

3.3 Perceived and lived health outcomes among residents living proximate to landfill sites

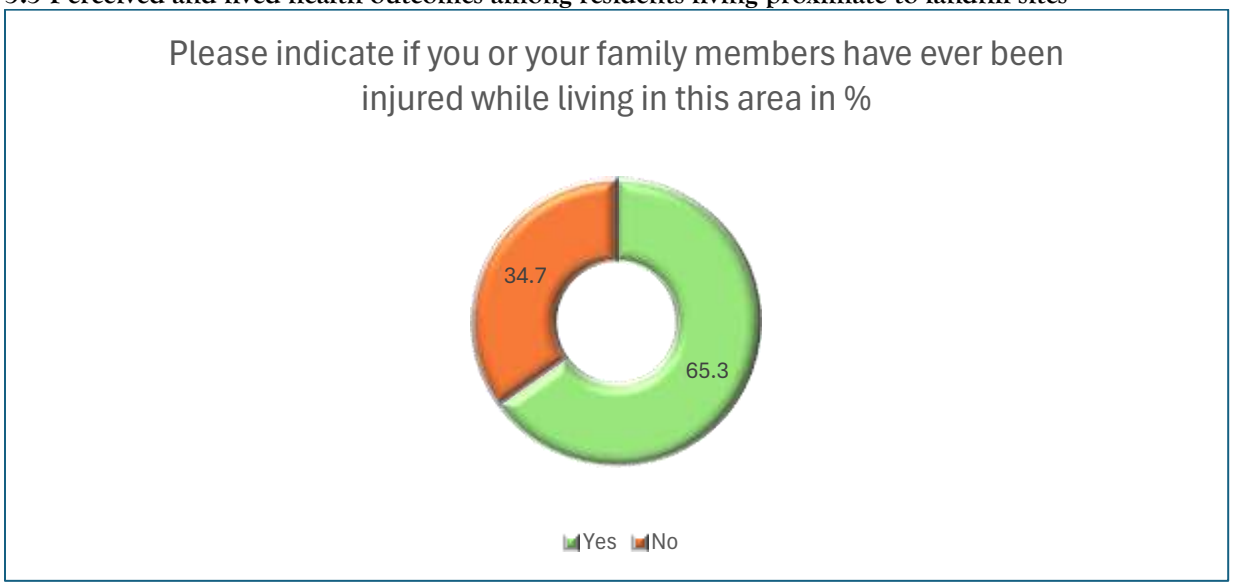

Figure 4: Injury incidences of residents

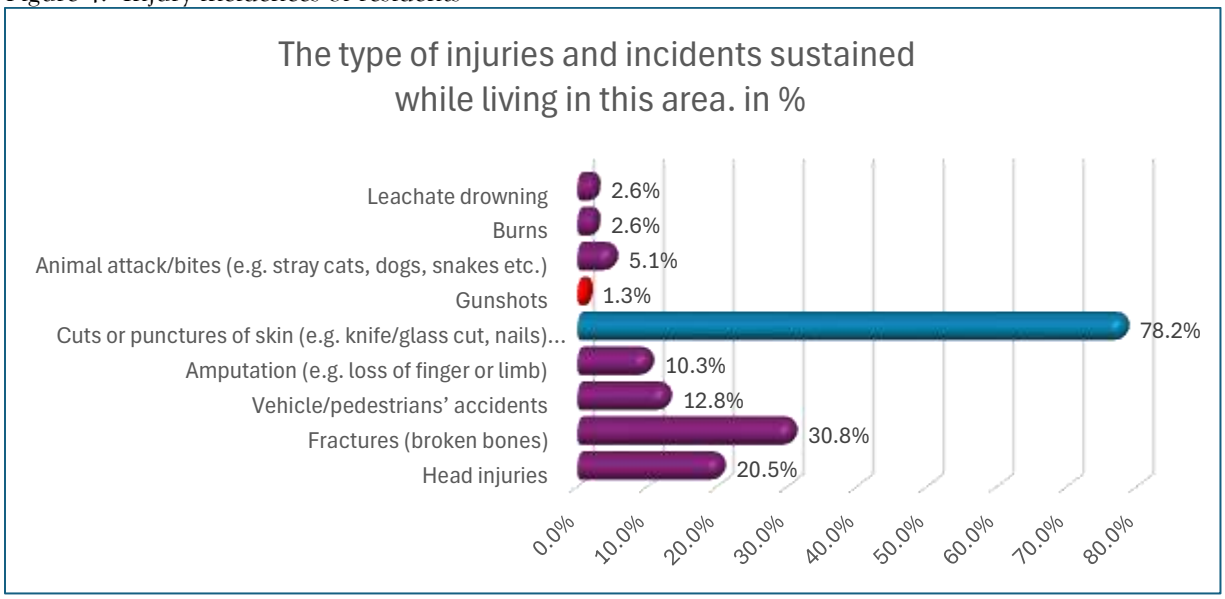

Figure.5: Percentage of participants who sustained injuries and incidents near the landfill site

Figure 4 shows that the majority of respondents (65.3%) reported that they or a family member had sustained an injury while residing near a landfill site, whereas 34.7% indicated no history of injury. Among those who were injured, the most commonly reported incidents were cuts or puncture wounds (78.2%), followed by fractures (30.8%), head injuries (20.5%), vehicle-related accidents (12.8%), and amputations (10.3%). A smaller proportion reported animal attacks (5.1%), leachate-related drowning or burns (2.6%), and injuries resulting from gun violence (1.3%) as shown in Figure 5. The largest proportion of respondents sustained injuries such as puncture wounds, cuts and fractures, which are usually associated with handling waste manually without appropriate personal protective equipment (Made et al., 2020; Tshivhase et al., 2022). Amputations and accidents can be associated with encounters with operational machinery and jumping on and off incoming traffic at landfill sites (Uhunamure et al., 2021). The incidences of animal attacks and children drowning in leachate further reflect the poor site management, inadequate fencing and free access of sites (Njoku et al., 2019; Tabloid Newspapers, 2023). Gun-related violence may suggest escalated conflicts at the landfill site amongst waste pickers, or broader socioeconomic problems in relation to waste picking in adjacent communities. One male respondent, aged 29, was reportedly shot and killed at the scene, while 17 other individuals sustained gunshot wounds and were transported to nearby hospitals for medical treatment after an altercation at Buffelsdraai landfill site in Durban (Tabloid Newspapers, 2023).

Table 11: Prevalence of disease or condition symptoms

	Frequency	**Valid Percent**
Respiratory problems – difficulty breathing, chest pain, nasal irritation, continuous coughing, and sputum		
Never	32	26.4
Once every 2 years	5	4.1
Yearly	7	5.8
Monthly	20	16.5
Weekly	11	9.1
Daily	46	38
Total	121	100
Reproductive problems – miscarriages, difficulty in falling pregnant, fibroids in women, children born with physical deformities or disability		
Never	102	84.3
Once every 2 years	12	9.9
Yearly	1	0.8
Monthly	1	0.8
Weekly	2	1.7
Daily	3	2.5
Total	121	100
Gastrointestinal symptoms – nausea, vomiting, watery or bloody faeces, stomach pain		
Never	26	21.5
Once every 2 years	6	5
Yearly	13	10.7
Monthly	18	14.9
Weekly	26	21.5
Daily	32	26.4
Total	121	100
Skin problems – allergies, bites, rashes, sores, blisters		

Never	50	41.3
Once every 2 years	16	13,2
Yearly	7	5.8
Monthly	10	8.3
Weekly	9	7.4
Daily	29	24
Total	121	100
Musculoskeletal problems – muscle aches, painful joints and back, arthritis		
Never	45	37.2
Once every 2 years	4	33
Yearly	4	3.3
Monthly	14	11.6
Weekly	10	8.3
Daily	44	36.4
Total	121	100
Vision problems – poor sight, partial blindness, cataracts, allergies (itchiness and redness)		
Never	51	42,1
Once every 2 years	2	1,7
Yearly	1	0,8
Monthly	7	5,8
Weekly	7	5,8
Daily	53	43.8
Total	121	100
Hearing problems – partially/impaired hearing – not hearing clearly)		
Never	93	76.9
Once every 2 years	1	0.8
Yearly	2	1.7
Monthly	3	2.5
Weekly	4	3.3
Daily	18	14.9
Total	121	100
Dental problems – tooth decay, bleeding gums, change of teeth colour)		
Never	63	52.1
Once every 2 years	14	11.6
Yearly	4	3.3
Monthly	8	6.6
Weekly	6	5
Daily	26	21.5
Total	121	100
Depression – prolonged stress and tiredness, anxiety (feeling unsettled)		
Never	53	43.8
Once every 2 years	8	6.6
Yearly	5	4.1

Monthly	12	9.9
Weekly	7	5.8
Daily	36	29.8
Total	121	100
Other mental health disorders or symptoms in adults – schizophrenia (having false images or scenarios), forgetfulness, being easily angered, acting out of character		
Never	96	79.3
Once every 2 years	3	2.5
Yearly	3	2.5
Monthly	2	1.7
Weekly	2	1.7
Daily	15	12.4
Total	121	100
Mental health disorder or symptoms in children (e.g. extreme hyperactivity/hypoactivity, slow development, speech problems, and cognitive abilities)		
Never	115	95
Once every 2 years	1	0.8
Weekly	1	0.8
Daily	4	3.3
Total	121	100
Sudden falling and/or seizures – falling followed by jerking movements of arms and legs, loss of consciousness		
Never	110	90,9
Once every 2 years	2	1.7
Yearly	2	1.7
Monthly	1	0.8
Daily	6	5
Total	121	100
Cardiovascular symptoms – heart attack, low/high blood pressure)		
Never	94	77.1
Once every 2 years	1	0.8
Daily	26	21.5
Total		
Blood sugar level disorder – dryness in the mouth, increased thirst, frequent urination, changes in appetite)		
Never	107	88.4
Once every 2 years	2	1.7
Daily	12	9.9
Total	121	100
Cancer-related symptoms – lumps in body parts, degeneration of tissue (parts of the body looking older than their age/losing shape); change of skin colour and texture		
Never	118	95.9
Once every 2 years	1	0.8

Monthly	1	0.8
Daily	1	0.8
Total	121	100
Stroke – numbness in the face, arm, and legs; loss of balance or coordination		
Never	116	95.9
Once every 2 years	1	0.8
Yearly	1	0.8
Monthly	1	0.8
Daily	2	1.7
Total	121	100
Weight loss in a short period		
Never	59	48.8
Once every 2 years	5	4.1
Yearly	9	7.4
Monthly	15	12.4
Weekly	5	4.1
Daily	28	23.1
Total	121	100
Fatigue (extreme tiredness/weakness)		
Never	54	44.6
Once every 2 years	3	2.5
Yearly	3	2.5
Monthly	9	7.4
Weekly	12	9.9
Daily	40	33.1
Total	121	100
Jaundice – (yellowing of eyes, skin, and mucous membrane; dark urine and pale stools)		
Never	112	92.6
Once every 2 years	2	1.7
Yearly	3	2.5
Monthly	2	1.7
Weekly	1	0.8
Daily	1	0.8
Total	121	100
Fever – (high body temperatures and heavy sweats, chills and shivering, breathing faster)		
Never	52	43
Once every 2 years	3	2.5
Yearly	5	4.1
Monthly	9	7.4
Weekly	8	6.6
Daily	44	36.4
Total	121	100
Headache or migraines		

Never	61	50.4
Once every 2 years	5	4.1
Yearly	7	5.8
Monthly	7	5.8
Weekly	12	9.9
Daily	29	24
Total	121	100
Acute sickness and death without being sick for a long time		
Never	116	95.9
Once every 2 years	2	1.7
Yearly	1	0.8
Daily	2	1.7
Total	121	100

Figure 6: Participants' smoking practices

Table 11 shows that about 38% of respondents reported respiratory problems, 26.4% indicated daily gastrointestinal symptoms, musculoskeletal problems (36.6%) and 43.8% of respondents indicated daily experiences of eye problems. Several community health surveys have identified a range of health problems among residents, including respiratory symptoms, skin, nose and eye irritation, gastrointestinal issues, psychological disorders and allergies (Nor et al., 2019). Previous studies reported a higher risk of adverse reproductive problems due to exposure to landfill sites, due to exposure to heavy metals, volatile organic compounds and endocrine disrupters (Njoku et al., 2019; Singh et al., 2018). In contrast, the majority (84.3%) reported never experiencing reproductive health issues such as miscarriages, infertility, fibroids in women, or children born with physical deformities or disabilities. The prevalence percentage is slightly lower, but it is noteworthy that a larger sample size was used, compared to this study.

High percentages of respondents had never experienced the following diseases or symptoms: cancer-related symptoms (97.5%), stroke (95.9%), childhood mental health problems (95%), jaundice 92.6%, sudden falls or epilepsy (90.9%), blood sugar-related symptoms (88.4%), and cardiovascular diseases (77.7%). Similarly, a study conducted in Johannesburg, South Africa, also revealed that 36.57% of waste pickers were at risk of mental health problems; chronic diseases were reported in 25.56% of the participants; while the majority (83.93%) reported having suffered from infectious diseases (Made et al., 2020). Chronic diseases or noncommunicable diseases (NCDs) typically develop in middle age after prolonged exposure to unhealthy

lifestyles such as tobacco use which can also be attributed to 79.2% of residents who agreed they smoke as shown in Figure 6, physical inactivity, and environmental pollution. Since the 1980s, an exponential increase in childhood diseases such as autism, asthma, attention-deficit hyperactivity disorder (ADHD), obesity, diabetes and various congenital disabilities have been observed worldwide, including Africa (AUDA, 2021). Despite their growing prevalence, these conditions are often underestimated in Sub-Saharan Africa, where the disease burden is largely associated with infectious diseases (Steyn & Damasceno, 2006; Stacherl & Sauzet, 2023).

The findings reveal that a considerable proportion of respondents had limited engagement with formal healthcare services, with only 30.6% reporting a visit to a healthcare facility within the previous month and 14% within two to three months prior. The fact that over a quarter (26.4%) last sought medical attention several years ago suggests that access to healthcare among landfill-adjacent communities remains sporadic and often reactive rather than preventive. This irregular utilisation pattern is consistent with previous studies highlighting that waste pickers and residents near dumpsites tend to delay medical consultations due to financial constraints, lack of healthcare infrastructure, and the normalisation of occupational hazards (Made et al., 2020). Over time, such populations may develop adaptive behaviours, relying on self-treatment or traditional medicine to cope with injuries and chronic conditions commonly associated with prolonged exposure to waste environments.

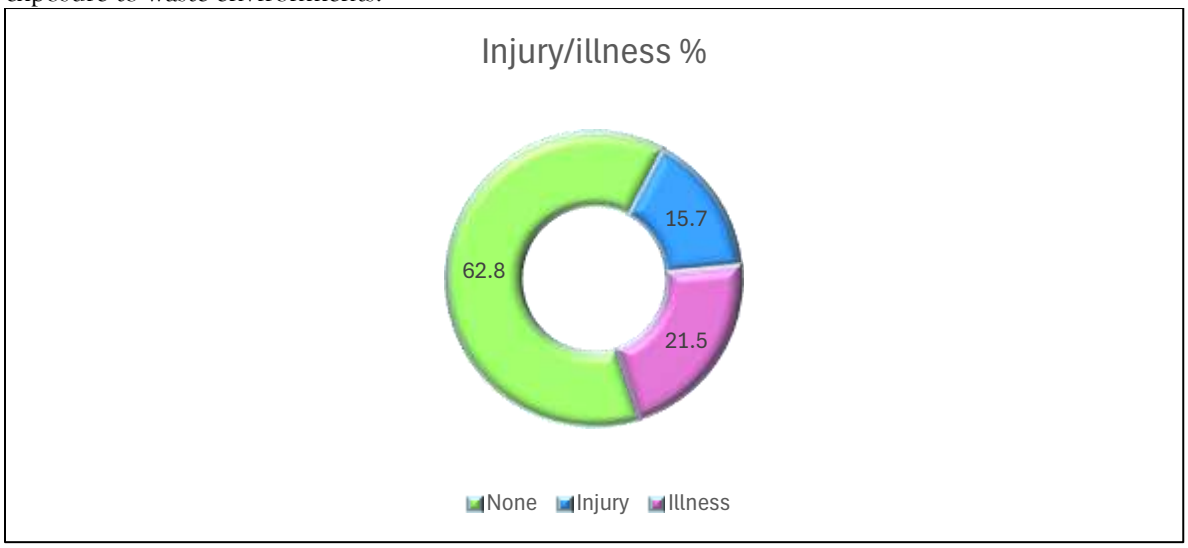

Figure 7: Hospitalisation record of participants

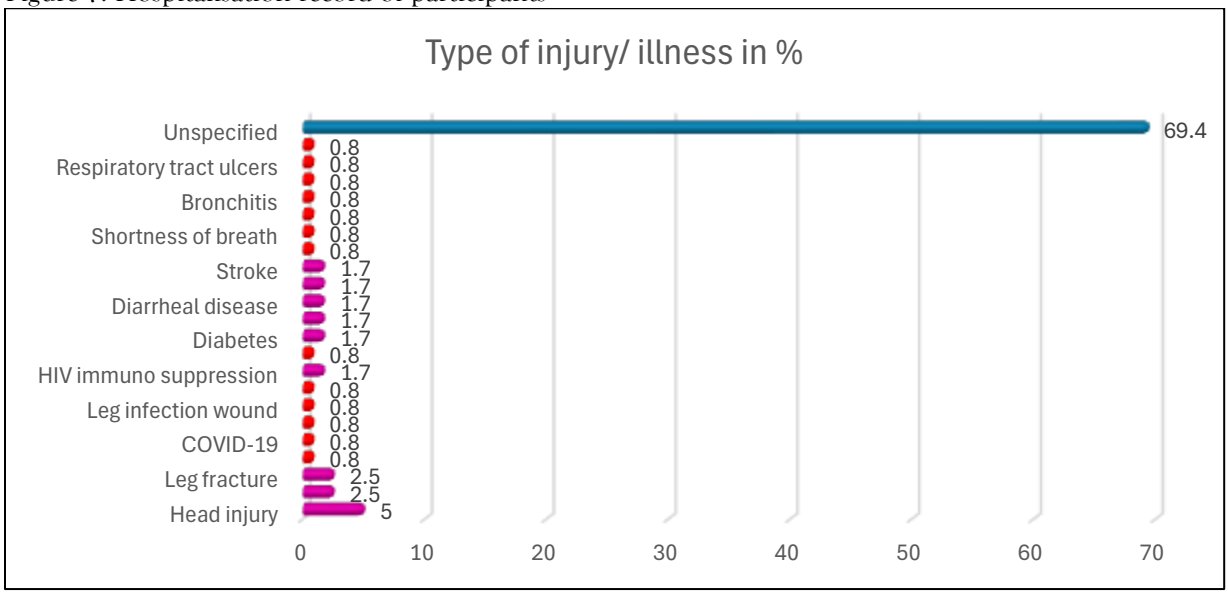

Figure 8: Type of injury or illness leading to hospitalisation

Table 12: The relationship between healthcare visits and the reported diseases/conditions/ symptoms

Ranks			
Please indicate when last you or your family visit healthcare facilities.		N	Mean Rank
Disease/ Conditions Symptoms	A few days before	3	53,67
	A week before	4	85,00
	Two weeks before	5	62,40
	A month before	37	75,32
	2–3 months before	17	65,88
	4-6 months before	12	64,96
	Between +1 year to 2 years	11	56,95
	+2 years	32	39,22
	Total	121	

Table 13: Kruskal-Wallis H test

Test Statistics[a,b]	
	Disease/ Conditions Symptoms
Kruskal-Wallis H	21,187
Df	7
Asymp. Sig.	0,004
a. Kruskal Wallis Test	
b. Grouping Variable: Please indicate when last you or your family visit healthcare facilities.	

Hospitalisation trends further underscore the vulnerability of these communities to both physical and infectious diseases. Figure 7 and 8 show that while 62.8% of respondents had never been hospitalised, 21.5% reported hospital admissions due to illnesses predominantly linked to poor air quality, direct exposure to pathogens, and general environmental stressors such as respiratory ulcers, bronchitis, diarrhoeal infections and tuberculosis. These findings mirror the pattern observed in other low-income waste environments, where exposure to landfill sites and poor sanitation contributes to high rates of respiratory and gastrointestinal diseases (Udofia et al., 2017; Akinrogunde et al., 2019; Uhunamure et al., 2021; Maluleka et al., 2025). Additionally, 15.7% of hospitalisations were injury related, encompassing fractures, burns and wounds acquired through daily waste-handling activities, further confirming the occupational risks associated with informal waste work.

The significant association between healthcare visits and the prevalence of reported diseases ($p = 0.004 < 0.05$) with highest mean ranks being a visit a week ago as shown in Table 12 and 13 reinforces the link between environmental exposure and adverse health outcomes. This suggests that those most affected by landfill-related illnesses are more likely to seek medical care, albeit under constrained circumstances. However, the large proportion (69.4%) of respondents who chose not to disclose their hospitalisation causes issues in Figure 8 may indicate underlying such fear of stigma, distrust of healthcare systems, or limited understanding of disease causation. Overall, these findings point to systemic health inequities and the absence of structured healthcare support for communities residing near landfill sites. The low frequency of healthcare utilisation, coupled with the high burden of illness, highlights the urgent need for targeted interventions such as mobile health clinics, occupational health awareness campaigns, and formal inclusion of waste pickers in municipal health monitoring programmes. Such strategies would not only enhance disease prevention and

treatment but also strengthen the overall resilience and well-being of vulnerable landfill-dependent populations.

4. CONCLUSION

The study highlights how socioeconomic disadvantage, historical spatial inequalities, and limited municipal capacity converge to produce disproportionate exposure to environmental risks for communities residing in proximity to landfill sites. Residents living adjacent to these waste facilities are particularly vulnerable to respiratory, dermatological, and gastrointestinal health outcomes associated with environmental pollution, odour nuisance, leachate infiltration and open burning. Despite these challenges, the study recognises the resilience and adaptive strategies of affected populations, particularly in informal settlements. However, their vulnerability remains compounded by low health literacy, poor access to health services, and minimal participation in local waste-governance processes. The lack of integrated waste-management planning, encompassing environmental monitoring, community education, and public-health surveillance, further exacerbates the risk of cumulative exposure. While the results cannot be generalised to all landfill sites in the Free State due to the study's limited sample size (18 sites), they provide a critical empirical reference point for understanding sub-provincial, waste-health linkages.

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