

HOUSEHOLD HAZARDOUS WASTE: GAUGING KNOWLEDGE LEVEL AND ITS IMPLICATION FOR DOMESTIC WASTE HANDLING AND DISPOSAL PRACTICES

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ABSTRACT

Household hazardous waste (HHW) refers to waste generated at the household level that can pose a danger to public and environmental health if not managed properly. The amount of waste, including HHW, has been increasing due to urbanisation, rising income levels, and changes in lifestyles. Unfortunately, most households are not aware of the potential risks associated with this waste, despite the serious health and environmental hazards it can pose. This creates a conundrum which this study seeks to unpack. A mixed-method approach addressed this gap, including a policy dialogue and a survey of 1,245 Greater Accra Metropolitan Area respondents. From the findings, most respondents disposed of aerosol cans, disposable sharps, unused or expired medication/drugs, fluorescent tubes and bulbs, and electronic waste as part of their household waste. Significantly, it was concerning that 68% of participants were unaware of the potential health hazards associated with improper disposal of HHW. Based on empirical evidence, the awareness levels were affected by gender, education level, and occupation. To address the issue of HHW and reduce its harmful impact on the environment and public health, it is essential to implement policies that encourage waste segregation, establish product stewardship programs, and conduct targeted education campaigns. These actions will help raise awareness about the significance of proper HHW disposal. Additionally, it is vital to have a strong political will to effectively enforce legislation that supports the shift towards more sustainable waste management practices, thus promoting sustainable development.

1. INTRODUCTION

Waste is a by-product of human activities. In the past, people conveniently and unobtrusively disposed of it in large open land spaces, as the population density was low. However, with rapid urbanisation, population increase, developing living standards, and lifestyle changes, the volume and content of waste have significantly changed, respectively (Kaza et al., 2018). It has been estimated that around 2 billion tonnes of solid waste are generated globally every year, and this number is expected to rise up to 3.4 billion by 2050, given the current trend. Additionally, there has been a significant increase in the demand for and usage of packaged products and electronics in the last few decades (Kaza et al., 2018). These dynamics in municipal solid waste (MSW) composition have been typified by an emerging waste stream, household hazardous waste, which is of critical public and ecological health concern.

Household Hazardous Waste (HHW) has been a matter of concern in developed countries since the 1980s, but there is no universally accepted definition or list of waste products considered as HHW. In fact, even within a single country like the United States, the list of HHW may vary from region to region (Wallace et al., 2018). Nevertheless, it is generally agreed that HHW has some common characteristics, including being toxic, corrosive, flammable, and reactive. HHW is generated from domestic consumption and includes unused, expired, or leftover consumer products like batteries, motor oil, brake fluid, etc. It also includes home improvement products like paint, caulk, and air fresheners, health and beauty products like hair dye, nail polish, and bath salts, as well as household cleaning products like stain removers, disinfectants, bleaches, shoe polish, and furniture polish (Wessel, 2004). Other examples of HHW are pesticides, insecticides, weedicides, fabric dyes, fluorescent tubes, light bulbs, and ink cartridges (Al-Tamimi et



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al., 2018). Other examples of HHW are pesticides, insecticides, weedicides, fabric dyes, fluorescent tubes, light bulbs, and ink cartridges (Delgado et al., 2007; Edokpayi et al., 2017; Inglezakis & Moustakas, 2015; Kontogianni et al., 2014).

Due to the increasing amount of waste and the emergence of hazardous waste streams including HHW, the waste management industry has become more crucial. It is necessary to properly manage and treat MSW coming from households, public and private areas, buildings, and commercial establishments to prevent significant environmental and public health hazards (Edokpayi et al., 2017). Despite the inherent substantial threats, landfilling remains the most preferred, used, and cheapest household waste management. Indeed, almost 70% of MSW is disposed of internationally in landfills (Delgado et al., 2007; Edokpayi et al., 2017; Inglezakis & Moustakas, 2015). Also, unlike the advanced nations, many emerging economies grapple with inadequate infrastructure and capacity to effectively handle the increasing MSW quantities and composition dynamics. For example, only 44% of sub-Saharan Africa's population can access proper MSW management services (Oteng-Ababio, 2023).

Although HHW constitutes a relatively small fraction (up to 3%) of MSW (UN-HABITAT, 2010), prior studies have indicated that its mismanagement poses severe environmental and public health risks. At home, expired pharmaceuticals, disposable sharps, home improvement products, etc., may cause poisoning, burning and injuries to both humans and domestic animals (Ansong et al., 2016; Gutberlet & Uddin, 2017; Roggof & Biderman, 2015). Beyond the point of generation, waste workers face HHW-related hazards, including fires and explosions caused by chemical reactions in waste compaction trucks, transfer stations, shredders, or landfills (Gutberlet & Uddin, 2017; Roggof & Biderman, 2015). HHW also poses soil, water, and air contamination risks when improperly disposed of. Therefore, it is essential to correctly identify and assess all potential hazards to protect against possible environmental impact (Kontogianni et al., 2014).

Effective HHW management is a function of public awareness, efficient collection, availability of the necessary infrastructure, and the existence and enforcement of the relevant laws. Table 1 presents various approaches implemented in different regions worldwide, which may be tailored to the context of other countries to proper HHW management. In the USA, some states have specific HHW laws. However, this is not the general case in Europe. Rather, the European Hazardous Waste Directive (no. 91/689/EDC) directs member countries to manage HHW along with other industrial hazardous waste (Inglezakis & Moustakas, 2015; Mudiyansele & Herat, 2022). South Africa's Waste Act of 2008 stands out as an illustration of a comprehensive legislation that offered the necessary legal structure guiding the development of the national strategy for HHW management. Adequate public awareness of what constitute HHW, relevant laws, and collection programmes promote HHW avoidance, reduction, and source separation (Fuller et al., 2018). Investment in collection programmes and treatment infrastructure is also crucial. Mobile or fixed

collection approaches, or a combination of both have been adopted. In regions that have made significant strides in HHW management, like the USA and Europe, product stewardship schemes, such as Extended Producer Responsibility (EPR), have been used to finance HHW management programmes (Cassel, 2018).

Unlike hazardous waste streams from industrial sources, HHW is not strictly regulated under any law in Ghana, including the National Environmental Sanitation Policy (NESP). This is largely because the amount of HHW generated in Ghana and the significance of their disposal practices are poorly understood. Generally, the amount of HHW generated is believed to be small, so disposal risks are negligible. However, there is a lack of reliable and clear information on their generation rates and disposal practices. With changes in legislation, for example, in 2016, when the Environmental Protection Agency (EPA) achieved the passage of the Hazardous and Electronic Waste Control and Management Act (Act 917) (Republic of Ghana, 2016) and the Legislative Instrument on Hazardous and Electronic Waste Control and Management Regulations (LI 2250), it has become important to acknowledge the hazardous elements contained in MSW and shift towards regulated, specialised and safe storage and handling processes throughout the entire value chain. As concerns about chemicals in household products increase, the potential environmental consequences from their disposal are also becoming more apparent, thus, giving a *raison d'être* for the current study.

Furthermore, existing studies on HHW in the global South highlight the need for data (Edokpayi et al., 2017) and more awareness regarding HHW management (Edokpayi et al., 2017; Mmereki et al., 2017; Ubachukwu et al., 2014). For instance, Ubachukwu et al. (2014) found low public awareness of HHW dangers in Nigeria's Enugu metropolis. Edokpayi et al. (2017) reported limited HHW awareness among tertiary students in Nigeria, Kenya, and South Africa, while Decharat et al. (2020) observed low to moderate HHW awareness in Thailand's Phatthalung province. The issues with HHW management, like the quantities, qualities, and the public's awareness levels, only worsen the already existing setbacks such as policy and legislation, limited financial resources, inadequate infrastructure and logistics, and insufficient institutional capacity (Edokpayi et al., 2017).

In Ghana, academic research and policy attention have primarily focused on specific HHW streams, such as electronic (see Daum et al., 2017; Oteng-Ababio, 2010; Grant and Oteng-Ababio, 2012; Owusu-Sekyere et al., 2022; Owusu-Twum et al., 2022) and household medical waste (Sasu et al., 2012; Udofia et al., 2017). Despite the fact that households generate a diverse range of household hazardous waste (HHW) items, no study has been carried out to investigate HHW in a broader sense. This knowledge gap is the reason behind the current work. The study aims to address concerns related to managing HHW generated in typical urban scenarios, using Metropolitan Accra as a laboratory. The primary objective of this study was to identify and quantify the predominant hazardous pollutants in MSW and develop specific profiles. To achieve this, we conducted a mixed-method study to assess common HHW in

TABLE 1: Key approaches to effective HHW management.

Intervention	Country	Advantages	Limitations	Reference
Legislation and enforcement				
1. Comprehensive Waste Management Act	Austria South Africa	Covers the management of all existing waste streams and those that may emerge in the future.	The process of formulating and enacting the comprehensive Act may take long or may be stifled by low political interest.	
2. HHW Specific legislation	USA	HHW is clearly defined or items that constitute HHW are explicitly indicated.	List or definition may vary geographically and may also be inexhaustive as new products emerge.	Wallace et al. (2018); Inglezakis and Moustakas (2015)
Collection approaches				
1. Collection events	USA, Austria, Germany, Sweden, Denmark	Special days dedicated or events for community-based HHW collection.	Limited number of collection times per year.	Fuller et al. (2018)
2. HHW collection facilities	USA, France, Hungary, Italy, UK, Spain	- Collection throughout the year. - May be co-located with MSW facilities, municipal parks, or fire stations.	- May require significant infrastructural investment. - Long distances to drop-off points may discourage public patronage of services.	Nightingale and Lewry (2018); Mudiyansele and Herat (2022)
3. Kerbside and door-to-door (DTD) collection		- Higher service patronage due to convenience to the public. - DTD offers equitable service access, especially for the disabled and homebound customers.	- Relatively higher per-unit cost. - Unreliable pick-up services will disincentivise the public from participating.	Quinn and Brunning (2018)
4. Retail collection	USA, Japan, Germany, Switzerland	HHW are retrieved from consumers through the same channel the products were purchased.	Both retailers and consumers may require financial incentives to participate.	Mudiyansele and Herat (2022)
Financing mechanisms				
1. Extended Producer Responsibility	USA, Europe	Effective EPR programmes shape product design and also finance separate HHW collection and treatment.	Requires strong coordination and collaboration between government agencies and industry stakeholders.	Fuller et al. (2018); Cassel (2018)
2. Taxation		Excise tax on household hazardous products to minimise consumption.		
Social marketing				
Public education and sensitisation	USA, Europe	- Foster change in consumer behaviour and motivate source segregation and participation in HHW collections. - May be combined with collection programs.	May not yield the intended outcome if the relevant laws are not enforced and collection programmes are not well implemented.	Fuller et al. (2018)

and around the study area and investigate domestic management practices. Firstly, a policy dialogue was used to understand the current state of HHW management from key stakeholders' viewpoint in Ghana. Subsequently, a concise review of the relevant policies and legislation was undertaken. Following this, we conducted a survey to assess the public's understanding and perspective on the matter. The findings were then triangulated and discussed. The findings of this study could be useful in deciding appropriate waste disposal methods and modifying existing ones. We will explore the research methodology and residents' understanding of HHW. Ultimately, our aim is to provide recommendations for a smoother transition towards sustainable environmental management.

2. MATERIALS AND METHODS

2.1 Context of the study area

Accra, Ghana's capital, has expanded spatially since its inception in the late 1870s. The city is located within the Greater Accra Metropolitan Area (GAMA), among the fast-growing urban conurbations in Sub-Saharan Africa (UN-HABITAT, 2009). The region comprises 29 self-governing districts (GSS, 2021) and covers 1,079 km² (see Figure 1). While immigration to the city area certainly contributes to its growth and expansion, residential mobility from more central locations to the urban fringes and natural population growth are equally important. According to recent estimates from the Ghana Statistical Service, GAMA contained

a population of approximately 4.6 million (2016) (Akubia & Bruns, 2019).

The GAMA region, with a population of almost 4.9 million, has become a functional area. It has strong territorial connections with surrounding communities and is a significant socio-political and economic hub, with territorial solid waste linkages with adjoining areas. The region is divided into three residential classes based on income, namely low, medium, and high-income zones reflecting varying levels of neighbourhood planning, densification, and infrastructural development (Songsore et al., 2009; Songsore & McGranahan, 1993). These areas have unique waste management systems that can be classified as formal or informal. The formal sector typically uses advanced vehicles, while informal players commonly rely on motorized tricycles, which can easily navigate through communities with poor road access. However, studies indicate that even in well-planned neighbourhoods, the services provided by waste management companies may be perceived as unreliable, leading to the growth of the informal sector in recent years. (Deku, 2017; Sarfo-Mensah et al., 2019). GAMA is estimated to produce 1.3 million tonnes of MSW annually, with a per capita production rate of 0.74 kg (Miezah et al., 2015) and a current waste collection rate of about 70% (Oteng-Ababio, 2023).

2.2 Data collection and analysis

To gain a better understanding of HHW awareness and management, we took an exploratory, sequential, mixed-method approach described by Creswell and Clark (2017). This method employs qualitative research to explore a topic and utilises the results to develop an instrument for subsequent quantitative research. As shown in Figure 2,

our first step was to hold a policy dialogue with various stakeholders. Nineteen participants, including five officials from waste management (collection, processing, and disposal) companies, three representatives from the informal waste sector (including the president of the main informal waste collectors association and two e-waste workers), three waste sector academics (from the University of Ghana and Kwame Nkrumah University of Science and Technology), two environmental legal professionals, one waste management consultant, and three public officials in the industry (two waste management directors (WMDs) and a representative from the Ministry of Sanitation and Water Resources). WMDs are responsible for city (metropolitan) waste management. After a brief introduction of HHW by the authors, a cross-section of the participants presented on pre-selected topics, including contemporary concerns regarding MSW streams, the existing legislative frameworks governing HHW globally and locally, current (local) governments' arrangements to manage HHW, and how the private and informal sectors were handling such waste stream along the waste management value chain. After the presentations and deliberations, the participants were divided into groups for a breakout session to discuss the topic further. They summarised the current state of knowledge and challenges associated with HHW management and proffered some policy recommendations. The policy dialogue highlighted the lack of knowledge on HHW, generating intense public discussions and commentary on the subject.

Based on the workshop findings, a structured questionnaire was designed and administered through a public survey to gather additional information on the management practices of HHW in the region. The questionnaire includ-

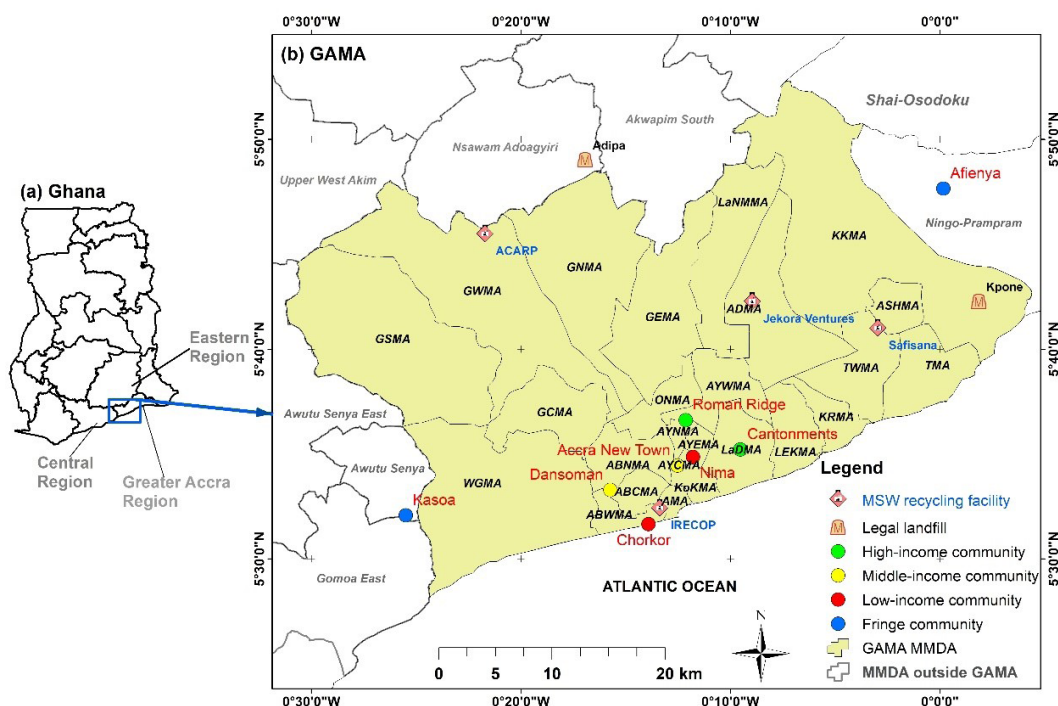


FIGURE 1: Map of the study area.

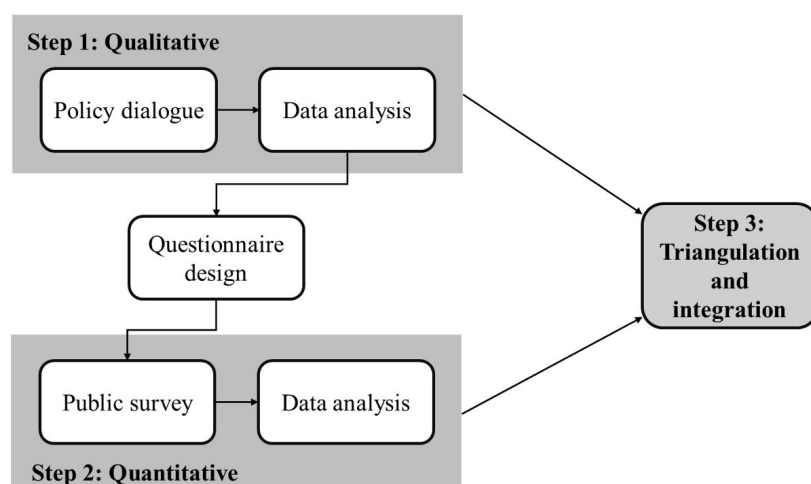


FIGURE 2: Process flow of sequential mixed-method approach used study.

ed questions related to the socio-demographic details of the respondents, the HHW streams that they manage, and their knowledge about the handling, disposal, and potential hazards of HHW. Proxy questions were also used to assess the level of awareness and understanding of the topic among the respondents. The study was conducted in eight communities, namely Chorkor, Nima, Dansoman, Accra New Town, Cantonments, Roman Ridge, Kasoa, and Afienya. These communities were selected purposively to reflect the geographical and socioeconomic diversity of the region and to account for some spillover dormitory communities, as shown in Figure 1. Entry into the communities, except for Cantonments, was facilitated by an Assemblymember of the area, who also provided guidance in identifying the community boundaries.

The required sample size was estimated at 1,230 using the Yamane's formula (Equation 1), based on the current population of the GAMA (GSS, 2021), Kasoa and Afienya, at a 2.85% margin error. The sample sizes for each community were determined using the proportional quota technique based on the 2010 population and housing census (PHC), which had community-level data available at the time of the study. The sample sizes for Cantonments and Afienya were slightly adjusted to reflect field conditions, including empty houses and significant community expansion compared to 2010, respectively. Respondents (household heads or their representatives, 18 years or older) were selected using a multi-stage sampling technique similar to the one described by Frimpong (2019). The study involved a total of 1,245 participants who were administered questionnaires in their local dialect by trained field officers.

$$n = N / (1 + N * e^2) \quad (1)$$

where n is the sample size, N is the population size, and e is the margin error.

We analysed the transcribed audio recording of the workshop and notes taken thematically using ATLAS.ti. This was also complemented by a mini review of the HHW-related laws in Ghana. Moreover, we used descriptive and inferential statistics in IBM SPSS (version 24) to examine the survey data. We evaluated the knowledge levels of the

respondents by using a scoring system where "0" represented an incorrect response, "1" was assigned to "I don't know", and "2" indicated a correct answer. We used the median scores of the respondents for the questions measuring HHW handling, disposal, and environmental impact as the aggregated scores. Median scores of less than one, equal to one, and more than one were interpreted as "low," "neutral," and "basic" knowledge levels, respectively. The term "basic" was used instead of "high" to describe the level of knowledge required for correct responses since the study questionnaire only included typical examples of HHW.

To determine if respondents' socioeconomic characteristics affected their likelihood of hearing about HHW, we used logistic regression. We inputted all variables into the equation using variable codes displayed in Table A.1. Beforehand, we assessed multicollinearity among predictor variables using variance inflation factor (VIF) and tolerance values, as outlined in Field (2013).

Finally, we discussed the study results by integrating and triangulating information gathered from both the qualitative and quantitative sources.

3. RESULTS

3.1 Respondents' sociodemographic profile

Table 2 displays that most participants (58.2%) were females, which is consistent with the recent census data indicating a higher proportion of females (about 51%) in the study area (GSS, 2021). Also, many females were at home during the survey period, particularly in low and middle-income communities. Additionally, about 51.8% of the respondents were young adults aged between 21 and 40 years, 34% were middle-aged adults aged between 41 and 60 years, and 11.4% were senior citizens above 60 years.

Out of all the respondents, only 9.6% had no formal education. Basic and secondary education was completed by 28.3% and 31.8% of the participants, respectively. Around 20% were government or private employees, while 31.8% were traders. The majority of the participants (51.4%) were married, followed by single (31.3%), widowed (6.6%),

TABLE 2: Sociodemographic characteristics of the respondents.

Sociodemographic characteristic		Frequency	%	Sociodemographic characteristic		Frequency	%
Gender	Male	725	58.2	Age	Up to 20	35	2.8
	Female	520	41.8		21 - 40	645	51.8
					41 - 60	423	34.0
					More than 60	142	11.4
Highest education level	None	119	9.6	Average monthly income (GHC)	0 - 500	463	37.2
	Primary	115	9.2		501 - 1000	358	28.8
	Basic	352	28.3		1001 - 1500	174	14.0
	Secondary	396	31.8		1501 - 2000	109	8.8
	Tertiary	263	21.1		Above 2000	141	11.3
Major occupation	Unemployed	183	14.7	Type of dwelling unit	Separate	290	23.3
	Government worker	90	7.2		Semi-detached	122	9.8
	Private company employee	159	12.8		Apartment/flat	135	10.8
	Artisan/craftsman	163	13.1		Compound house	657	52.8
	Trader	396	31.8		Improvised home	29	2.3
	Student	73	5.9		Other	12	1.0
	Other	181	14.5				

co-habiting (6.3%), and divorced (4.4%). Two-thirds of the participants earned a monthly income of GHC 1,000 (USD 105) or less, while only 11.3% earned more than GHC 2,000 (USD 210). The most prevalent dwelling unit was a compound house (52.8%), followed by separate houses (23.3%), apartments and flats (10.8%), and semi-detached houses (9.8%). A small percentage of individuals lived in improvised homes such as kiosks or containers.

3.2 Household solid waste management practices

Based on Table 3, the majority of the participants (54.7%) used authorised waste bins to store their waste, while others utilized improvised containers like old sacks and plastic bags. Figure 3 displays some of the various receptacles employed for waste storage. The type of storage container used varied depending on the economic status of the community. High-income households primarily used authorised waste bins (96.0%), while middle-income settlements used waste bins for about 50.2% of waste storage, with improvised containers and sacks accounting for 18.9% and 11.7%, respectively. Less than half of the respondents (37.9%) in low-income communities had authorized waste bins. It's ironic that the prevalence of authorized waste bins was slightly higher at 47.0% in fringe communities. This isn't surprising since most of the emerging middle-income families settle in the peri-urban neighbourhoods where land is relatively affordable.

From the data analysis, it was found that only 36.2% of the respondents practised waste separation at home. The most commonly separated materials were plastics, cardboard, and metals. Out of this percentage, 61.3% sold parts of their waste to itinerant buyers, which was more common in low and middle-income neighbourhoods. This indicates that monetary incentives may significantly drive household

waste segregation in the study area. Additionally, a significant proportion (23.1%) of people disposed of their waste through open burning. This method was more prevalent in dormitory communities on the outskirts (49.4%), which are currently underserved with official waste collection services in most cases.

The study found that 46.8% of participants reported that informal waste collection was the official arrangement in their neighbourhoods. These waste collectors typically use smaller vehicles like motorised tricycles to access areas with poor road accessibility. Also, 45% of respondents were served by waste management companies that use compaction trucks, while 7% had communal container systems. The remaining 4.8% had no official waste collection arrangement.

The study also provided insights into the availability of waste collection services in different neighbourhoods. In high-income areas, most households (86.7%) were served by waste management companies providing door-to-door services. In contrast, approximately 50 to 60% of households depend on informal operators for door-to-door collection in low-income, middle-income, and fringe communities. Communal waste disposal systems were primarily found in low-income neighbourhoods, serving about 16.7% of households. In communities located along the coast, residents often resorted to dumping their waste at the sea-side. In contrast, others would dispose of their waste in drains and bushes or burn it in open areas where there was no official waste collection arrangement.

3.3 Gauging respondents' awareness and knowledge levels

This section focuses on the inventory of household hazardous waste (HHW) as reported by our respondents.

TABLE 3: Household waste management practices.

MSWM practice		Frequency	% Low-income	% in community type			
				Middle-income	High-income	Fringe	
Primary storage	Waste bin	681	54.7	37.9	50.2	96.0	47.0
	Plastic bag	131	10.5	27.1	18.9	1.8	16.1
	Used sack	213	17.1	13.2	11.7	1.8	12.9
	Improvised container	216	17.4	21.8	18.9	0.4	22.9
	Others	4	0.3	0.0	0.2	0.0	1.2
	Total	1245	100.0	100.0	100.0	100.0	100.0
Official waste collection arrangement	Waste management company	516	41.4	26.8	36.6	86.7	28.1
	Private informal ('aboboyaa')	582	46.7	51.1	54.8	9.8	59.8
	Communal container	87	7.0	16.7	6.2	0.9	1.6
	Other (none)	60	4.8	5.4	2.4	2.7	10.4
	Total	1245	100.0	100.0	100.0	100.0	100.0
Waste management practices	Burying	13	1.0	1.6	0.4	0.9	1.6
	Open burning	288	23.1	12.6	18.5	18.2	49.4
	Separation	451	36.2	37.5	44.5	29.8	25.3
	Sell to itinerant buyers	279	22.4	38.5	23.6	6.2	14.5
	Reuse	123	9.9	18.6	10.6	1.8	4.8

**FIGURE 3:** Types of receptacles for waste storage. (a) waste bin, (b) sacks, (c) improvised containers, and (d) plastic bags.

It explores their awareness and knowledge regarding HHW and the management practices they adopt to deal with it. The aim is to understand better the types of hazardous waste found in households, respondents' awareness and knowledge levels, and their practices for managing such waste. The study examines the prevalence of HHW in households, respondents' familiarity with this waste, and their management strategies.

According to Figure 4, 41.3% of the respondents reported generating unused or expired medications/drugs, while 40.5% generated used or broken light bulbs. Most participants who generated these HHW fractions did so over one month or more, as depicted in Figure 5. Additionally, 23.0% of the participants generated various types of battery waste, such as dry cells, vehicle batteries, and power banks. These wastes were produced after more than three months (44.1%), monthly (17.8%), or quarterly (31.8%). Fur-

thermore, 16.7% of the participants reported generating expired paints and solvents, while 70.1% produced such waste generally after over three months.

More than half of the respondents (56.6%) confirmed that they dispose of sharps like used razor blades, needles, and lancets in their homes. These disposable sharps were generated mostly every month (33.6%), but also frequently over a week (24.0%), quarterly (18.6%), or beyond three months (19.7%). Most respondents (86.7%) generated compressed cans, such as body spray, spray starch, air freshener, and insecticide spray, every month (56.4%). About one-third of the respondents (32.5%) produced unused or expired pest control chemicals or e-waste (32.8%). Two-thirds of those who generated e-waste (66.4%) indicated it took over three months to produce them. However, a considerable proportion of the respondents produced expired or unused pest control chemicals on a weekly

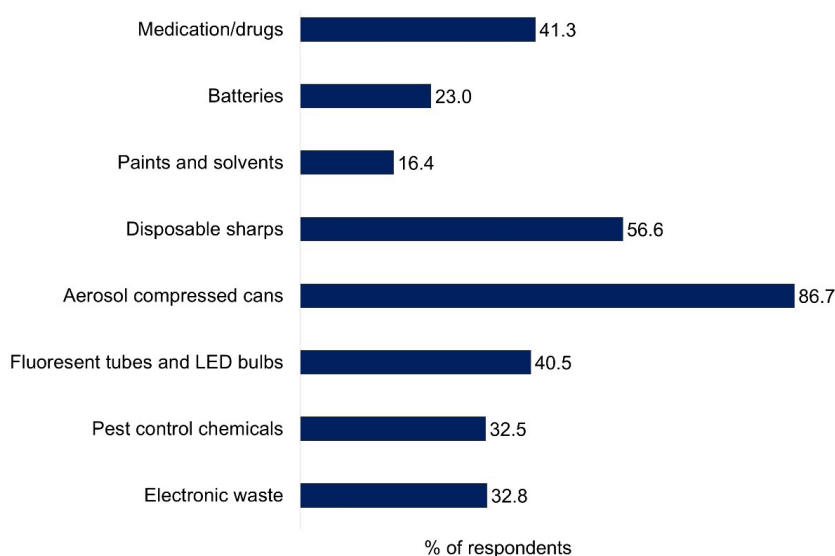


FIGURE 4: Percentage of respondents who generated various streams of household hazardous waste.

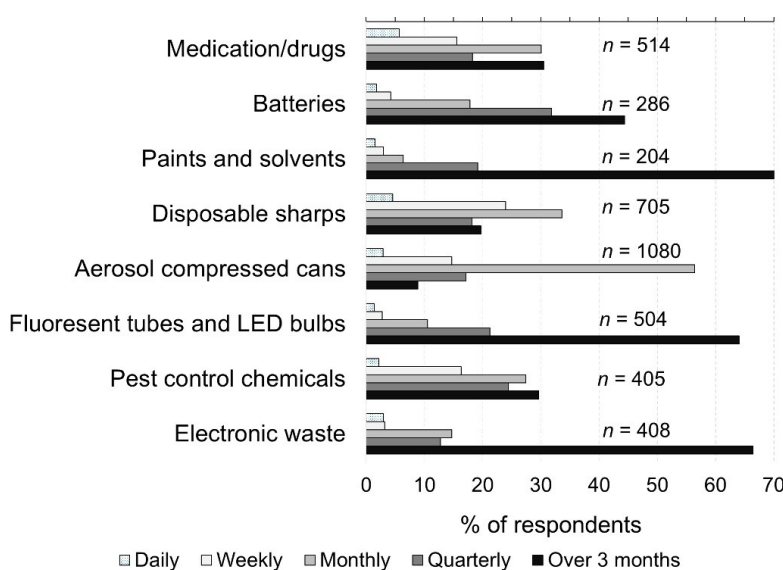


FIGURE 5: Frequency of generation of household hazardous waste streams.

(16.3%), monthly (27.4%), quarterly (24.4%), or over three months (29.6%) basis.

According to Figure 6, over 71% of the respondents disposed of hazardous household waste (HHW) by adding it to regular waste bins. This included medication, batteries, diapers, sanitary products, sharps, aerosol cans, bulbs, and pesticides. Paints and other hazardous solvents were also often added to waste bins, stored in backyards, or disposed of by other means. As for e-waste, 35.3% of the respondents added it to waste bins, 40.9% stored it in their backyards, and 23.0% disposed of it through other methods. Backyard storage was commonly used for battery products (15%), sharps (10.8%), and pesticides (13.1%).

Though the survey results appear interesting, they somehow parallel the qualitative data. For example, revelations from the policy dialogue confirmed the generation of these HHW fractions and their co-disposal with mainstream waste. To support this, an operator of an MSW treatment facility observed as follows:

"...The kind of waste coming to the processing plant is very abhorrent and negatively impacts our operations...I cannot mention the number of chemicals we receive in the form of liquids, powders, etc. These chemicals are negatively affecting the quality of the products that we are producing. Not only the quality, but the maturation period is also adversely affected." – Composting & Recycling Plant Operator 1

This observation highlights the challenges material recovery facilities face treating MSW contaminated with HHW, including extended compost production cycles and compromised compost quality.

The survey results indicate that there is a lack of awareness among the public regarding the proper handling of HHW. As per the findings of Figure 7, 67.6% of people had not even heard of HHW, and 75.7% were not aware of its treatment options. Even though more than half (56.6%) of the respondents believed that household waste should not be handled the same way, 52.6% were unsure or had low knowledge of the appropriate HHW handling methods. Upon further analysis of the data, it was discovered that individuals familiar with HHW, aware of its treatment methods, or read product labels were more likely to be from high-income neighbourhoods. This is likely due to the higher levels of education in these communities, which were later confirmed by the regression analysis findings.

According to the study, it was found that most participants (85.8%) had a basic understanding of the correct methods for disposing of Household Hazardous Waste (HHW) which is shown in Figure 8. Additionally, the majority (79.9%) were aware of the environmental harm that could result from improperly managed HHW. The level of knowledge varied depending on the type of HHW, with over 80% of the participants exhibiting a basic understanding of handling and disposing of aerosol cans, e-waste, and pest control chemicals. Approximately 75% of the participants had a similar level of knowledge regarding disposing of expired or unused medicines, while two-thirds were familiar with handling batteries, paints, and solvents. However, only about 50% had comparable knowledge regarding the disposal of disposable sharps. Furthermore, less than half of the participants (48.9%) admitted to reading product labels before discarding them.

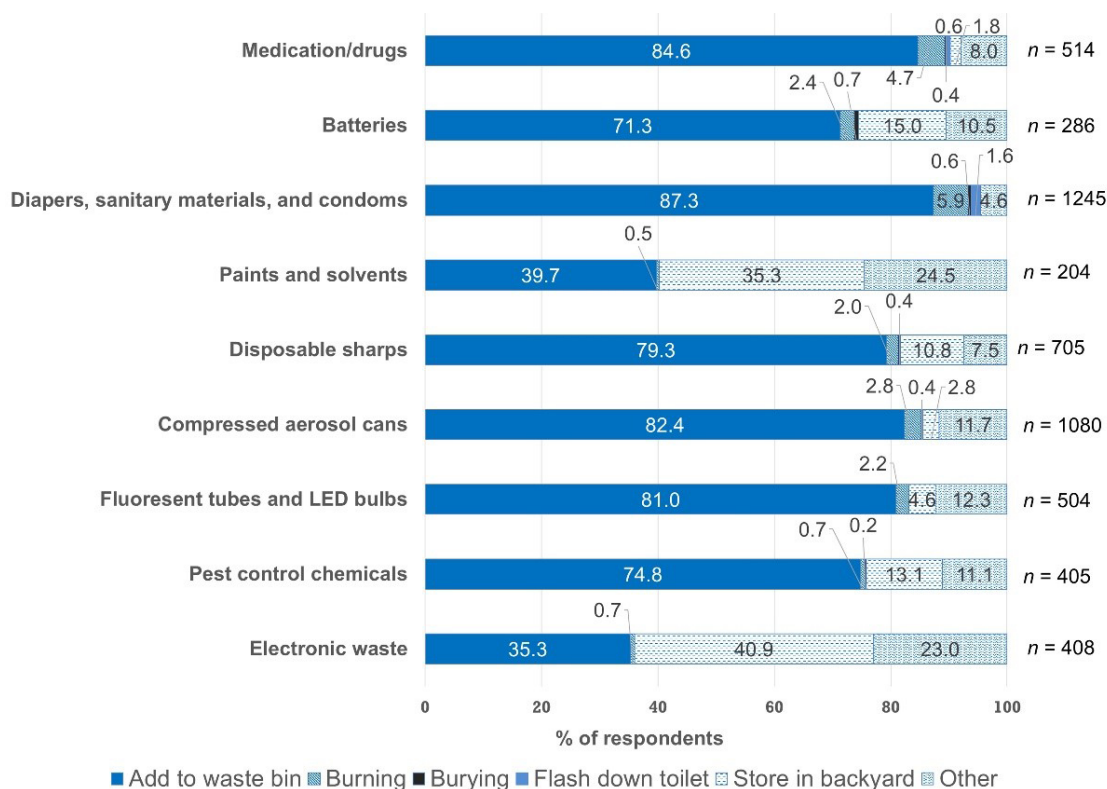


FIGURE 6: Distribution of household hazardous waste disposal methods.

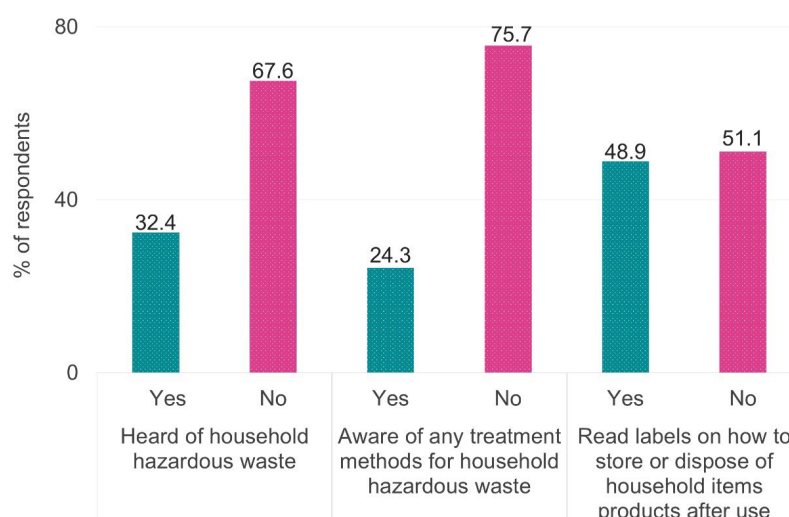


FIGURE 7: Household hazardous waste awareness rates the among respondents.

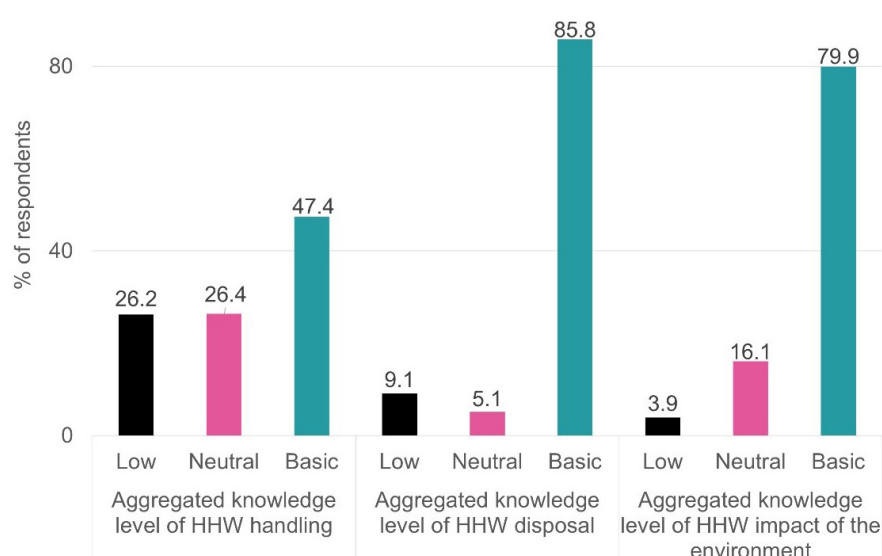


FIGURE 8: Respondents' knowledge levels regarding household hazardous waste handling, disposal, and environmental impact.

The study employed logistic regression analysis to investigate if awareness of HHW varied between different sociodemographic groups. The binary regression model accurately predicted whether a respondent had heard of HHW, with a model accuracy of 71.0%, a Chi-square (χ^2) value of 115.21 and a p-value of $<.0001$. The -2LogLikelihood value was 1452.6, R^2_{CS} was .09, while R^2_N was .12. Furthermore, the predictors had an acceptable level of multicollinearity, as the VIF was < 5 and the Tolerance was > 0.2 .

Based on the results presented in Table 4, the gender, education level, and major occupation of respondents were significant predictors of their awareness of HHW. However, age, income, and dwelling unit type did not significantly impact. The data indicates that being male increased the likelihood of hearing of HHW by 1.4 times (or 40%) compared to females (Exp (β) = 1.447, $p < 0.01$). Furthermore, higher levels of education increase the chances of hearing about HHW (Exp (β) = 1.217, $p < 0.01$). Among the different occupational groups, there was significant difference

in HHW awareness (Wald $\chi^2 = 16.25$, $df = 6$, $p < 0.01$). Specifically, government workers (Exp (β) = 2.741, $p \leq 0.001$) and students (Exp (β) = 1.886, $p < 0.05$) were 2.7 and 1.9 times, respectively, more likely to have heard of HHW than the unemployed.

During the policy dialogue, it was noted that there is a general lack of awareness and knowledge regarding HHW among both practitioners and the public. Although participants were familiar with some common HHW, such as car batteries, pesticides, and motor oil, they did not recognise other hazardous items, such as empty aerosol cans, fluorescent tubes, nail polishes, and creams. Here are some observations made during the workshop:

"It's surprising how little people know about household hazardous waste, even those who work in related fields. The main issue is that we don't always realize which home items can be hazardous. Many everyday household items pose a threat to our health and the environment, but we

TABLE 4: Relationship between sociodemographic profile and the likelihood of hearing of HHW.

Variable	β	Wald	df	Sig.	Exp (β)
Gender (ref: female)	0.369 **	7.286	1	0.007	1.447
Age	-0.011	0.014	1	0.906	0.989
Education	0.217 **	9.636	1	0.002	1.242
Average monthly income	0.104	2.995	1	0.084	1.109
Occupation (ref: unemployed)		18.096	6	0.006	
Artisan/craftsman	0.399	2.456	1	0.117	1.490
Government employee	1.008 ***	10.126	1	0.001	2.741
Private company employee	0.405	2.371	1	0.124	1.500
Trader	0.196	0.764	1	0.382	1.217
Student	0.634 *	4.134	1	0.042	1.886
Other	-0.092	0.127	1	0.721	0.912
Type of dwelling unit (ref: separate house)		3.142	5	0.678	
Apartment/flat	0.283	1.522	1	0.217	1.327
Compound house	-0.083	0.259	1	0.611	0.921
Improvised home	-0.248	0.252	1	0.616	0.781
Other	-20.453	0.000	1	0.999	0.000
Semi-detached	0.126	0.293	1	0.588	1.134
Constant	-1.934 ***	23.846	1	0.000	0.145

Note: ref means reference group; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; $N = 1245$; β = coefficient; Exp (β) = odds ratio

don't always recognize them as such." – Breakout Session Group 1

"Throughout today's discussions, a recurring theme has been the lack of knowledge or awareness around certain topics. As a group of well-educated, well-read and well-exposed individuals who grasp the complexities of various issues, it is both concerning and intriguing to note this trend. However, we also need to consider ordinary people who live in households with an average education level of junior high school or even lower. It is a cause for concern that they may not be aware of important topics. For instance, there seems to be a lack of awareness about the waste category we are currently discussing." – Academia Participant 1

During the workshop, it was revealed that informal workers handle and process 93-97% of Ghana's e-waste. The participants in the policy dialogue expressed concern that most workers in the e-waste industry have limited knowledge of the hazardous nature of the materials they handle. A consultant in the e-waste sector aptly described the consequences of leaving the handling of this waste stream to be managed by the informal players:

"Many workers in the informal sector do not wear personal protective equipment, such as gloves or boots, and are often exposed to unknown hazards. Although many of these workers are aware of the potential health risks associated with their work, their knowledge of these risks is often limited. Studies suggest that only 1-10% of workers have a comprehensive understanding of the risks they face, and even this level of knowledge may not be sufficient to change their behaviour." – MSW Management Consultant.

During the policy dialogue, three crucial factors were identified to address the issues surrounding the management of household hazardous waste (HHW) in Ghana. Several important points were raised, including raising awareness and intensifying public education on HHW. It was also emphasised that promoting and enforcing the segregation of household waste is necessary. The lack of specific laws regarding HHW makes it necessary to enact appropriate policies and legislation to govern its management and promote household waste separation. Additionally, it is critical to have enforcement mechanisms in place to ensure compliance. This would require adequately resourcing environmental health offices (in the districts and municipalities) and waste management departments (in the metropolises) to carry out their mandate. Furthermore, it was suggested that the country establish special courts to address environmental sanitation-related issues. Finally, it was necessary to establish special collection systems or arrangements with reliable services to sustain the public's interest in separating HHW. These insights were gathered from workshop participants:

"To summarise our position regarding household hazardous waste, although there are environmental laws in place in Ghana, no specific law or act currently addresses HHW from households. We believe that there should be a law created that clearly defines the term "household hazardous waste" and establishes penalties for those who violate it. This legislation would allow us to take legal action against offenders and protect our rights." – Legal Practitioner.

"...There is an urgent need to develop and enforce sanitation policies and legislation. Special courts should also be established to address sanitation-related issues." – Breakout Session Group 1

4. DISCUSSION

This study confirms that automotive products (e.g., vehicle batteries and motor oils, etc.), light bulbs, pesticides, home improvement products (e.g., paints, air fresheners, etc.), and household cleaners (e.g., disinfectants, bleaches, etc.) are familiar sources of HHW in urban sub-Saharan Africa (Edokpayi et al., 2017). The study highlights the everyday use of aerosol cans, such as insecticide sprays, body sprays, air fresheners, hair sprays, and others, as well as disposal sharps like razor blades, lancets, and injection needles, as well as expired and unused medications, fluorescent tubes, and e-waste among residents in the study area. This emphasises the need to pay attention to properly dispose of and manage these items. The prevalence of aerosol cans is attributed to the shift from traditional practices of using lime and lemon to control body odour to using containerised deodorants and the increased adoption of insecticide sprays in Ghana over the past few decades.

Additionally, the number of cases of non-communicable diseases, such as diabetes, heart disease, and cancer, has increased in the recent past (Ministry of Health, 2022). Managing diabetes at home may require frequent blood sugar level monitoring with glucometer kits, where the patient's finger is pricked with lancets for blood samples. In certain instances, patients self-administer insulin injections to regulate their glucose levels at home. These contribute to the widespread use of disposable sharps. The proportion of respondents who generated medication/drugs HHW in this study was 41.3%, less than the over 50% reported by Sasu et al. (2012).

4.1 HHW awareness and knowledge levels in GAMA

The results of this study show that around two-thirds of those surveyed were not familiar with HHW, and three-quarters did not know of any HHW treatment methods. Additionally, more than 50% of the respondents had insufficient knowledge of the proper handling of HHW or were uncertain about the correct procedures. These findings are similar to previous reports from Sub-Saharan Africa (Edokpayi et al., 2017; Ubachukwu et al., 2014) and Thailand (Decharat et al., 2020). These pieces of evidence underscore the necessity for heightened awareness and education in developing countries regarding HHW and its detrimental ecological and public health effects. Enhanced awareness can also drive public demand for government intervention, urging the development of policies and legal frameworks and the provision of logistical support for effective HHW management.

During a policy dialogue, it was discovered that even those working in the MSW management sector, who are expected to possess adequate knowledge about HHW, did not consider specific HHW fractions hazardous. Items such as vehicle batteries, pesticides, paints, thinners, and partially empty gas cylinders were quickly recognised as hazardous. However, other household hazardous items such as nail polishes, lipsticks, creams, and unused medication or drugs were not considered. It was also revealed that the management of HHW is entirely missing from Ghana's

waste management architecture and that no politician or sector minister has ever mentioned it. Although the country has hazardous waste legislation that targets industrial and commercial activities, there is no regulatory framework for HHW. This suggests that policymakers are unaware of the prevalence and risks of HHW. Therefore, raising more awareness among the public and key stakeholders about the risks associated with HHW is crucial. It should be noted that many countries in the sub-region, such as South Africa, Nigeria, and Kenya, do not have a legislative framework for Hazardous Household Waste (HHW). As a result, there is no specific definition of HHW for these countries (Mmereki et al., 2017). This lack of or variation in the HHW definition can affect the public's perception of what is hazardous and make it difficult to quantify and monitor HHW. This issue has been rightly pointed out as a cause of concern.

4.2 Implications of HHW knowledge level for HHW handling and disposal

As mentioned earlier, most of the participants were not familiar with HHW. More than half of the respondents needed guidance on how to handle HHW. Despite this, nearly 80% of the participants understood the proper disposal methods and the harmful effects of HHW on the environment. However, it is concerning that even with this knowledge, many respondents still disposed of HHW along with MSW. Our research aligns with previous studies (Sasu et al., 2012; Udofia et al., 2017), indicating that three out of four participants dispose of pharmaceutical waste with Municipal Solid Waste (MSW). Furthermore, the report highlights that over 80% of the study population disposes of sharp waste in household bins. However, our research contrasts with the situation in developed countries where safe receptacles are commercially available in pharmacies for individual use to store used needles safely. In Ghana, such safe containers are primarily found in medical facilities and are rarely available at the household level.

The study revealed that open burning of municipal solid waste was very common (23%) in the study area. However, we found that the deliberate burning of household hazardous waste was limited (0.5-4.7%). This result was not surprising since the study participants had basic knowledge about the harmful effects of HHW on the environment and public health. The study also found that in 2020, the Ghana Food and Drugs Authority (FDA) initiated the 'Take Back Unwanted Medicines from Consumers' (TBUM) Project to retrieve unused and expired medicines from households, starting from Accra (FDA, 2020). However, as rightly noted by Amoabeng et al. (2022), the lack of awareness of such programmes has limited their impact.

Regarding how to get rid of household hazardous products, there are usually instructions on the labels provided by the manufacturers. However, according to earlier studies Edokpayi et al. (2017), people in sub-Saharan Africa tend to ignore these instructions. Even those who read the labels do not follow the proper disposal instructions. Our study found that almost half of the respondents claimed to read the product labels before disposal, a claim which coincided with the number of our respondents who had

received at least a secondary education. This finding suggests that even those who claim to read the instructions still require help disposing of certain products due to a lack of separate disposal containers. Our observation was consistent, with over half of the respondents stating that certain household waste streams should be handled differently. These respondents also understood the consequences of improper hazardous waste management on public and environmental health. The irony is that despite this awareness among some respondents, many admitted to disposing of hazardous waste with regular municipal waste.

It appears that the handling and disposal practices of HHW in GAMA are influenced by several factors beyond the population's level of awareness and knowledge about the subject. Logistical, infrastructural, legal, and institutional gaps need attention. For example, the study found that 45% of respondents did not have approved waste bins and instead used sacks, crude containers, and other unapproved waste storage methods. This discourages the source separation of household waste. Additionally, previous studies (Deku, 2017; Sarfo-Mensah et al., 2019) have shown that waste collection services in the area are generally unreliable, raising concerns about whether the existing waste collection regime can support separate HHW collection. The unreliable waste collection services have created opportunities and economic niches for the growth of informal waste collectors, who serve a significant proportion (41.5%) of the residents in the area. Unfortunately, these informal waste collectors may not have enough knowledge and expertise in managing HHW, which poses a risk to themselves and the environment.

4.3 Policy implications and recommendations

The recent study highlights the urgent need to reassess the country's institutional and policy frameworks for managing MSW. Currently, there is no specific policy for the management of HHW. Therefore, it is crucial to have specific legislation that defines HHW and outlines a streamlined management process, from storage to disposal. Our study advocates adopting a comprehensive MSW legal framework similar to South Africa's Wastes Act and Austria's Waste Management Act. This framework should encompass handling various forms of waste, such as liquid, gas, solid, and particulate waste, recycling operations, and all parties' responsibilities throughout the waste management process. The policy must also highlight the obligations of governmental bodies, economic and financial mechanisms, EPR, and the movement of waste across borders as integral components.

Given that the country has numerous laws regarding environmental sanitation, yet their impact is limited, having specific legislation for HHW will not be enough to guarantee positive results. Previous studies have identified significant challenges in policy enforcement due to factors such as lack of political will, funding deficiencies, limited capacity and commitment of enforcement institutions, corruption, and poor sanitation culture. To overcome these obstacles, it is crucial to develop enforcement mechanisms. Environmental health officers must be appropriately recruited and adequately resourced to enforce the law at the community

level. Additionally, sanitation courts should be established to expedite offenders' prosecution and deter others from breaking the law.

We suggest implementing EPR programmes as part of the reform. The EPR system would hold producers accountable for managing their products at the end of their life cycle. Producers can finance HHW collection and disposal programmes through the EPR system to ensure proper disposal of hazardous household waste. The EPR financing scheme could also integrate the provision of appropriate storage receptacles for such programmes to encourage HHW separation at source. Currently, EPR programmes are limited to collecting plastic waste and e-waste; only a few such programmes exist in Ghana. These programmes are incentivised. In 2017, the Ghana Recycling Initiative by Private Enterprises (GRIPE) was established to promote recycling efforts among plastic producers worldwide. However, despite the good intentions, the initiative has not fulfilled its commitments and is often used as a marketing ploy to deflect blame for plastic pollution (Chellé & Dontoh, 2022).

The success of EPR in managing HHW depends on specific policies and regulations, as well as the active participation of producers in EPR initiatives. However, EPR schemes often struggle to succeed in developing countries due to poor waste management infrastructure, lack of transparency, and neglect of the informal sector (Talbot et al., 2022). Ghana faces the same challenges in integrating the informal sector into its waste management system. Therefore, policymakers should find ways to involve the informal sector to improve MSW management and build capacity. The government needs to expedite efforts to integrate the informal sector formally, as outlined in the 2020 National Waste Management Strategy (NWMS). The NWMS aims to address the integration issue by acknowledging, registering, and offering training to informal workers. However, progress in implementation has been slow. The NWMS could provide informal waste workers with necessary occupational health and safety training if successfully implemented.

Additionally, policymakers could combine EPR programs with economic instruments like packaging taxes and landfill fees to enhance their effectiveness (Vink, 2020). However, caution should be exercised as funds from such measures may only be allocated with a dedicated fund secretariat. This was seen with the 10% Environmental Excise Tax on plastic products in 2013 (Keesman, 2019). Therefore, the government should establish the necessary structures to ensure the timely release of funds accrued from financial instruments to sustain any EPR regime.

Effective waste management is crucial for Ghana, and this includes managing HHW. To achieve this, Ghana needs a comprehensive approach considering all forms of waste. The Integrated Sustainable Waste Management (ISWM) framework is a suitable basis for relevant policies because it incorporates the physical and governance structures necessary to manage all waste types (Letcher & Slack, 2019). The waste management hierarchy has proven to be a practical approach for managing HHW. However, the success of HHW management programmes depends on inclusivity - the involvement of the public, private and local government

institutions, national government, and producer responsibility organisations (Wilson et al., 2013). Therefore, Ghana's HHW management policies must prioritise educating and encouraging the public to reduce their consumption of HHW products. Strategies such as buying only the necessary quantities, opting for less hazardous alternatives, and fully utilising the products can help minimise HHW.

This study found that females, individuals with low formal education, and non-government workers were less likely to be aware of HHW. Therefore, policymakers must implement public awareness campaigns that are more targeted and inclusive to ensure that all sections of the public are informed about HHW. Additionally, research has shown that women are vital in managing household waste and are more likely to exhibit pro-environmental behaviours. (Lee et al., 2011; Odonkor & Sallar, 2021), which further emphasises their significant role in effective HHW management. Hence, failure to adequately raise awareness among women will hinder the success of HHW management efforts. In addition, it has been observed that Tuesdays are the best day for HHW education programmes in coastal communities, as most people do not go fishing on that day.

Efficient waste separation is crucial in reducing the depletion of natural resources, promoting recycling, and prolonging the lifespan of landfills by diverting waste. Households may practice waste separation for various reasons, such as financial incentives. Our research found that while 35-40% of respondents disposed of e-waste, paints, and solvents with regular waste, a similar percentage stored them in their backyards. Although paints and solvents can be stored for future use, e-waste is commonly hoarded for economic reasons. Our study also confirms that people from low- and middle-income communities are likelier to practice household waste separation and sell them for financial gain. However, recent studies suggest that personal ethical values also significantly shape people's intention to separate household waste (Oduro-Appiah et al., 2022). These internal normative pressures include separating waste as a show of respect for the environment and feeling guilty for not separating their waste to help protect the environment (Schwartz & Howard, 1981), which is deeply entrenched in the beliefs of the three major religions in the country. Therefore, campaign messages promoting HWS should reinforce moral obligations. Additionally, legislation and enforcement are necessary to encourage HHW segregation at the household level.

5. CONCLUSIONS

Our study aimed to assess participants' level of awareness and knowledge regarding Household Hazardous Waste (HHW). The results showed that HHW accounts for only a small percentage of Municipal Solid Waste (MSW) and is not widely known among the general public. However, some citizens have become more aware of HHW through local education and information initiatives. They can now identify hazardous materials in the waste generated in their daily lives. Despite its low volume, HHW should be collected separately and treated effectively. The current practice of disposing of HHW in conventional landfills can

lead to the release of potentially harmful materials into the environment, making it crucial to handle it with care.

Residents' knowledge level regarding hazardous waste disposal and its impact on the environment varied depending on the type of waste. This raises concerns about the health and safety risks associated with how some households in Ghana handle certain types of hazardous waste. Although many residents have basic knowledge about the adverse impact of hazardous waste on the environment and how to dispose of it properly, they still dispose of it with regular waste. Proper handling and disposal of hazardous household waste can be challenging due to various reasons such as lack of awareness, insufficient laws, poor enforcement, and logistical and infrastructural obstacles. Our study recommends educating the public about hazardous household waste and raising awareness through targeted campaigns to address this issue. It is crucial to enact hazardous household waste and household waste segregation regulations and appropriate enforcement regimes to combat this problem.

Effectively managing household hazardous waste involves addressing several essential aspects. Local authorities should promote and implement separate collection schemes designed for different groups of HHW items. These schemes should be reinforced where preliminary initiatives have already been taken. The government, producers, and retailers should collaborate to develop integrated take-back systems to ensure ease of use. It is crucial to support the existing legislative framework and use consistent terminology across different countries. This will enable reliable statistics to be collected. Reducing the amount of HHW generated should be a top priority. This can be accomplished by using less hazardous materials in manufacturing and making conscious daily decisions. These efforts will also positively impact the management of HHW, as prevention is key. It is important to note that there is a lack of accurate data regarding the amounts of HHW generated. Therefore, future research should examine the quantities of HHW fractions produced within the GAMA, starting with the most commonly encountered types.

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