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RESEARCH ARTICLE

Household Hazardous Waste Management Practices in Nairobi Kenya

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ABSTRACT

This study investigated the awareness and practices of household hazardous waste (HHW) handling in sampled households in Nairobi, Kenya. Household hazardous waste, which includes products such as batteries, pesticides, and cleaning agents, poses significant environmental and health risks if not managed properly. This study aimed to assess the knowledge, attitudes, and behaviors of household heads regarding the identification, segregation, and disposal of HHW. A structured questionnaire was administered to a sample of household heads to collect data on their awareness of various HHW management methods, including open dumping, incineration, reuse, landfill/burying, reducing usage, and recycling. The findings indicate that level of education is associated with the ability to read and understand labels on hazardous products ($\chi 2 = 183.376$, df $=1$, $p < 0.05$). The data indicate that households with post-secondary education are more likely to read labels than are those with lower levels of education. Furthermore, the study highlights that 85% of participants are aware of open dumping, and 58.3% were aware of incineration/burning, while awareness of reuse (15.3%), landfill/burying (2.7%), reducing usage (1.3%), and recycling (1.3%) is notably low. The study concludes that there is a critical need for enhanced educational campaigns and interventions to promote safer HHW management practices. By increasing the awareness and understanding of proper disposal methods, it is possible to mitigate the adverse environmental and health impacts associated with improper HHW disposal. The insights from this research will inform policy makers and stakeholders in developing strategies to improve HHW management in counties and similar settings.

Keywords: Hazardous, household, Kenya, Wastes.

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1. Introduction and Background

1.1. Background of the Study

The phrase household hazardous waste (HHW) includes waste from households that has certain characteristics including the ability to ignite, react, corrode and toxicify. This waste can lead to physical injury or harm to people handling wastes in household if they are not handled properly and managed well (Vidanaarachchi *et al*., 2006; Wagner *et al*., 2013).

Household hazardous waste can cause chemical poisoning in humans and animals. In addition, they can have deleterious effects on humans and the environment if not handled well, coupled with poor disposal (Amouei, 2014).

Various household items have become dangerous wastes owing to their characteristics, necessitating specialized handling, treatment and disposal to safeguard environment, water, and humans (Bandunee *et al*., 2015). Immense health threats are posed to households, people handling wastes and salvagers of useable items by hazardous wastes because they emit many pollutants including mercury and other volatile organic compounds leading to cumulative adverse effects to people as well as the environment (Fleisted & Christensen, 2007).

Inadequate segregation of HHW contribute to poor management planning. Furthermore, a low level of public awareness of hazardous household waste products contributes to deficient storage, handling and safe disposal in households (Gu *et al*., 2014; Driedger, 2001).

The advent of hazardous waste poses a significant environmental problem and is a perpetual occurrence. Moreover, hazardous waste is perceived by the public and the media as astonishing environmental and human health risk exposures. Despite the problem of hazardous waste and accruing pollution effective actions are not evident in many households. Accumulating heaps of wastes is a prevalent problem in many parts of Nairobi, especially, in low and middle-income areas, that do not have working waste management structures and systems. On the other hand residents in high-income estates, have private waste collection efficient systems by paying considerably, although unfortunately they do not follow up to ensure proper end disposal (Gumo, 2018).

This study investigated hazardous wastes types produced by residents of Nairobi where scant or inadequate information is documented regarding the issue. Additionally, there is a need to document accidents and injuries resulting from hazardous substances. Despite the existence of policies in Kenya focusing on wastes, their implementation is still in demand. Thus, this study can contribute to the implementation of policies of household hazardous wastes in Nairobi by authorities as well as the national government.

The broad objective was to substantially assess the activities for hazardous waste management systems in residential holdings-types of waste types, and characteristics. Moreover, assessing the potential environmental impacts of garbage sites is critical. The findings provide insights into waste handling, storage and disposal. In addition, segregating waste materials, is essential for effective management.

1.2. Objectives

The following specific objectives guided the study: 1) to examine the activities involved in general of more hazardous waste, 2) to examine the environmental impacts of generation, 3) to determine the type of household hazardous waste mostly disposed, and 4) To assess the time taken to dispose of solid waste.

2. Methods

A descriptive cross-sectional design which entailed the use of qualitative and quantitative data collection methods. The design was appropriate because it allowed the use qualitative and quantitative analytic methods.

2.1. Variables of Study

The independent study variables included socio-demographic factors, household hazardous wastes production, and awareness of handling and disposal of hazardous waste in households whereas the dependent variable was household hazardous waste handling practices.

2.2. Study Site

This study was conducted in Starehe Sub-county which was purposely selected to represent Nairobi County, which covers an area of 2,793.10 square kilometers. It is one of the 17 sub counties in Nairobi County, Kenya. The study area population is estimated to be 210,423 people (Kenya National Bureau of Statistics (KNBS), 2019). The sub-county has six wards-Nairobi Central, Ngara, Pangani, Landi-mawe, South B and Ziwan/Kariokor. Primary socioeconomic activities include casual employment, limited farming and minor trading, among others. Nairobi which has a semi-tropical climate, is near to the eastern end of the East Africa Rift Valley approximately 1800 m above sea level, thus influencing the climate conditions in the area. Additionally, the area receives more than 610 mm of rainfall.

According to Kenya National Bureau of Statistics (KNBS) (2019), this study site had 69,389 households with a combined population of 194,726 people were about 69,389 household heads in 6 wards of the sub-county.

2.3. Inclusion Criteria

Heads of household (both male and female), were included in the study and in their absence a household member who was above 18 years of age was included, if he/she had lived in the area for more than six months. The six-month duration of stay in the sub-county, was considered an adequate time for awareness of waste management information in the study area. The selection of household heads was based on the consideration that they were accountable for wastes management in their households.

2.4. Exclusion Criteria

Household heads or if an adult member was unavailable in the household, the household was excluded from the study, and respondents who refused to give consent were excluded. Additionally, household heads and adults who were not in sound mind or were ill were excluded.

2.5. Study Population

Households constituted the study population, and the key participants were household heads. The heads of households were the respondents during data collection. This study targeted a population of 69,389 household heads. In addition, people who had stake in waste management in the area were included as key informants. Key informants of various professions were considered to have adequate knowledge of HHW because they worked in the sanitation sub-sector in government departments. There were a total of 17 key informants.

2.6. Sampling Technique

The multistage sampling method was employed in this study. In the first stage simple random sampling was used; in the second stage systematic sampling and purposive sampling was adopted. Simple random sampling was used to select two of the six wards, namely, Nairobi Central and Landi Mawe out of five wards in the sub-county. A table of random numbers was used to select the wards. two areas from each of the two wards, simple random sampling was used to sect two areas from each ward. The assistants of the researcher moved to the middle of the area and tossed a pencil to get the direction of movement to identify the household heads to be interviewed. The closest household to which the pen pointed was visited and the head of household was interviewed. Thereafter systematic sampling was used to interview every 2nd house and so on. Key informants were purposively selected from relevant government departments and other stakeholders involved in sanitation activities in the study area.

2.7. Sample Size Determination

The sample size was determined using the formula used by Fisher *et al*. (2003). Thus, the formula n = Z2 pq/d2 yielded a sample size of 377 households in which the target population was > 10,000. In addition, 10% was added to the sample size to cater to non-response. Therefore, the required sample size 415.

2.8. Construction of Research Instruments

The questionnaires were used to collect primary data. These questionnaires included structured and unstructured research questions to obtain information from household heads. A key informant interview guide was used to collect qualitative data. The informant interview guides collected information from 17 informants who were key to the study.

2.9. Pre-Testing

Pre-testing of Questionnaires were done prior to administering them to the participants. This was performed to ensure that the questions were relevant and clear. The pretesting was performed on 15 household heads comprising 10% of size of sample, and was conducted in a ward that was not part of the study area.

2.10. Validity

Instruments meticulously designed to ensure that the collected data reflected the objectives of this study. In addition, the validity of the instruments was enhanced by seeking expert opinions, and improving accuracy of the inferences. An adequate sample size also enhanced the validity of the study.

2.11. Reliability

Reliability aims to ensure that instruments yield the same results repeatedly and minimize random errors. This was realized by quality questionnaires aligned with specific objectives, proper coding and training of enumerators prior to the data collection. The reliability of the questionnaire's internal consistency was determined using Cronbach's alpha method, ranging from 0 to 1. It reliability increases with an increase in value (Cooper & Schindler, 2006). Coefficient values of above 0.7 was obtained in this study which indicate good reliability.

2.12. Data Management and Analysis

Entailed removing questionnaires incomplete questionnaires with inconsistent responses. Data editing was performed to correct illegible, incomplete, inconsistent and ambiguous responses. Thereafter

quantitative data were coded using a codebook consisting of various variables following the structure of the questionnaires. Additionally, the data were cleaned and consistencies were rectified.

Content analysis was thematically used to analyze the data gathered qualitatively, and related literature was presented in the respective themes. The collected quantitative data was entered into the Statistical Package for Social Scientists (SPSS version 21) after coding and then analyzed. Descriptive statistics were used to summarize the quantitative data. After data analysis, it was then presented in frequency tables, and the chi-square test was used for inferential statistics to assess association among variables.

3. Results/Findings

3.1. Socio Demographic Information of Participants

According to this study, 50.9 per cent of the respondents were female and 49.1per cent were male. Majority of the respondents (47%) were 17 to 34 years, while 28% were 35 to 54 years. Additionally, 11% were over 64 years while 14% were 55 to 64 years. Ten (10)% had no formal education, 21% had primary education, 48% had secondary education and 22% had tertiary education.

The study also revealed that 47% of respondents had two to three people living in households, 12.5% had more than three, and 41 per cent had less than two. Thus, the majority of the households had 2–3 people.

3.2. Categorization of Household Hazardous Wastes

Hazardous waste in households was classified into eight categories. These include drugs/pharmaceuticals, sharps, pesticides, used electronics, and automotive products such as oils, adhesives, paints, solvents and disinfectants. A Typical household can generate all or many of these hazardous wastes; however, this is dependent on economic activities. Categorization is crucial for household hazardous waste management (Ojeda-Benítez *et al.*, 2013; Slack *et al.*, 2005).

Hazardous household waste came from numerous sources. These included cleaning products such detergents and disinfectants, pesticides and herbicides, leftover paints as well as solvents from home activities. Others include automotive products, such as motor oil and brake fluids, and electronic waste containing hazardous materials such as lead and mercury. The other sources included batteries, expired/ unused medications, personal care items like nail polish and hair dye, aerosol cans. Additionally, there are fluorescent bulbs and tubes containing toxic substances. These wastes are, reactive, ignitable or toxic and require specialized handling from storage, segregation and disposal. Hence proper management and disposal are essential in order to prevent pollution and human risks.

3.3. Generation of Household Hazardous Waste

The results indicated that 81% of households were discarding batteries as well as electronics such as cell phones, Televisions and radios, 69% were discarding of used drugs/pharmaceuticals, 81.5% were producing pesticides remains, fungicides/rodenticides and 41% discarded used needles and syringes for resulting from treatment of pets. Moreover, 49% generated automobile products including oils, kerosene and petrol gas. Furthermore, 61.7% of households produced glues and adhesives, and 94.1% produced disinfecting agents, laundry items and cosmetic products. The others included polythene materials. The results are presented in Table I below.

3.4. Procurement of Hazardous Commodities in Households

The study enquired from respondents where they bought household hazardous items which after use become hazardous waste requiring meticulous handling management. Arising from results, 25.7% of respondents said they purchased hazardous items in shop, 14.4% hawkers/peddlers, 15.65 said from

TABLE I: Types of HHW Generated in Households

	Yes (%)	No (%)	Total (%)
Disused drugs/pharmaceuticals for human or animal	69	31	100
Used needles and syringes	40	60	100
pesticides, insecticides, fungicides/rodenticides	81.5	18.5	100
Used batteries and electronics, cell phones, radio, and television	81	20	100
Automotive products-oils, paraffin and petrol	49	51	100
Glues and adhesives	62.7	37.3	100
Paints and solvents	61.7	38.3	100
Disinfectants, laundry products and cosmetics	94.1	5.9	100

TABLE II: Purchase of Household Hazardous Goods

Where they are bought	Frequency	Percentage
Shop	109	25.7
Supermarket	111	27.75
Open markets	142	15.6
Chemists	80	14.2
Hawkers/peddlers	57	14.4
Total	400	100

markets, 14.2% said in chemists and 0.5% from supermarkets. The results are presented in Table II below.

3.5. Incidence Associated with Hazardous Waste in Households

Respondents were asked to state the occurrences and incidences of accidents associated with hazardous waste in households among occupants in houses. This is explained by the fact that accidents/injuries from improperly managed hazardous wastes could be prevalent in humans as well as pets in households, some of which could be deadly to young people as well as adults unless carefully, promptly and properly managed (Senzige, 2014). Thus, respondents were asked to report whether any household members had suffered hazardous waste related accidents.

The results showed that 61 per cent of the household members reported no household accidents associated with hazardous waste. However, 39% said that at least one household member in household was a casualty of accidents related to hazardous waste. This means that the majority of households did not report incidents related to hazardous waste. As for household Member's age involved in accidents, 65.7% of respondents said that members who experienced accident were of 0 to 5 years of age, 28.4% were above 18 years, and 5.8% were aged 6 to 11 years. The results are presented in Table III below.

3.6. Household Hazardous Wastes Implicated in Accidents

Victims associated with hazardous waste in households, were further required to state the types of hazardous waste in households that led to accidents. Ten (10) per cent of indicated accidents were caused by acaricides/pesticides/ poisons, 52 per cent indicated that they were caused by paraffin and cooking gas, 19 per cent indicated that they were caused by drugs while 20 was caused by sharps. Table IV below presents the results.

3.7. Management of Health Problems Associated with Accidental Occurrences

Respondents were asked about the health problems associated with accidental incidents. Results indicated that 36.3% indicated unconsciousness which was attributed to accidents, followed by diarrhea/vomiting (28.3%), irritation of eye (18.6%), respiratory disorder (10.9%) and skin condition was (5.9%). Key informants such as health workers, stated that frequently reported accident incidences due to hazardous waste in households included injuries related to sharps like needles, cuts, fire outbreaks, food and drug poisoning, and skin and respiratory conditions attributed to pesticides. Further when respondents were required state whether household victims were given treatment following mishap,

TABLE III: Household Members Who Were Involved in Accidents

Age in years	Frequency	Percentage
0-5	23	65.7
6-11	2	5.8
18 +	9	28.4
Total	34	100

TABLE IV: Household Hazardous Wastes Implicated in Accidents

Accident	Type of Household HW	Frequency	Percentage
Skin irritation and burns	Pesticides and poisons	4	10%
Cuts and bruises	Sharps	8	20%
Adverse drug reactions	Drugs and medications	8	19%
Fire accidents	L.P.G. (liquefied petroleum gas) and Paraffin e.g., candle, kerosine	21	51%
Total		40	100

TABLE V: Health Conditions Attributed to Accidents Treatment Place and Outcome

Health conditions attributed to Accidents	Frequency	Percent
Diarrhea/vomiting	9	28.3
Infection of skin	2	5.9
Irritation of eye	7	18.6
Respiratory infection/condition	3	10.9
Unconsciousness	13	36.3
Total	34	100
Treatment Place		
Hospital/facility	26	76.5
Members of Household	4	11.8
Traditional healers	2	4.9
Total	34	100
Outcome/result		
Survived accident	32	93.1
Did not survive	2	5.9
Total	34	100

40.2% said that the household members were treated by other members in households immediately following the injury, 36.3% received treatment in a hospital and 24.0% received treatment from herbalists/traditional healers. The respondents were asked about the accident outcomes. The results are presented in Table V below.

The results above revealed that 93.1% household respondents said that people affected/injured by accidents from hazardous waste survived while 5.9 reported that the victims did not.

3.8. Knowledge on Hazardous Waste in Households

The level of knowledge about household hazardous waste management practices was assessed using knowledge scores. This was determined by the questions of whether they obtained accurate responses. A score of 0-3 indicated low knowledge, 4–7 indicated fair knowledge, 8–11 indicated good knowledge and 12–13 indicated excellent knowledge. The score measurement method was derived from Hebbal *et al*. (2011). The results indicate that 47.1 per cent were between 4 and 7, 33.7 per cent 8 to 11 and 18.3 per cent scored below 3 while 0.8 per cent garnered scores of 12 to 13. The results demonstrate that many respondents were moderately aware of hazardous household waste handling.

Regarding disposal methods, respondents were provided with different management disposal methods, where a dichotomous scale assessed awareness of disposal methods. Results indicated that 84% of the stated open dumps, 59.3% stated incineration or burning, 15.4% cited reuse, while 2.6% mentioned landfill/burying, 1.3% pointed out reducing usage and similar proportion stated recycling. This demonstrated that the majority of households were aware of the methods of open dumping/incineration. As for hazardous wastes identification in households, this study revealed that 91.8% of respondents said that they are able to identify hazardous waste whereas 8.2% said that they were unable to identify hazardous waste in household. The identification of HHW is vital as this type of waste requires special care (Massawe *et al.*, 2014; Malandrakis, 2008).

3.9. Information on Household Hazardous Waste

Study source of information for the identification of household hazardous waste indicate that 41.7% said that they received information from radio and television, 39.8% said from health workers, while 5.3% said they got information from neighbors and 5.8% from veterinary practitioners. Many household heads received information from radio, television and health workers.

3.10. Household Hazardous Waste Management Practices

Majority of respondents (81.5%) reported that adhesives/glues should be buried, which was considered appropriate way of disposing adhesives and glues that have been used. Additionally, 91.2% of respondents, said that pesticides, insecticides, fungicides, as well as other chemicals should be buried or taken to landfills. This was also considered an appropriate method for disposal of wastes. Results also revealed that 96.6% were of the opinion of reusing oil/flammable containers, which is quite risky. Besides, 87.7% said that needles/syringes should be reused in treatment of animals, a dangerous view/action. Furthermore 86.5 per cent of respondents pointed out that unused drugs should be disposed of by burning, which may lead to environmental pollution. Moreover, 40.7 per cent correctly felt that there is no need to incinerate aerosol-compressed cans, which may lead to explosions.

TABLE VI: Knowledge and Management of Disposal of Household Hazardous Waste Practices and Association

Knowledge	Frequency	%
Pesticides remains, insecticides, fungicides and other farm chemicals disposal by burying/landfill	365	91.2
Disposal by burning of unused drugs	345	86.4
Discarded batteries and electronics (phones, radio, television) not be disposed of by burning	118	29.7
Not used adhesives/glues disposed by landfill/burying	324	81.5
Needles/syringes used in treating animals should be reused	300	75
Oil/flammable containers should be reused	347	86.5
Aerosol/ compressed containers should be incinerated	163	40.9

Note: Association ($\chi 2$ test = 184.276, df =1, $p < 0.05$).

Nonetheless, 28.6% stated that old batteries and used electronics such as cell-phones, radio, and torches shouldn't be disposed of by burning. Table VI below presents the result.

3.11. Household Hazardous Waste segregation

When **r**espondents were asked about segregation of hazardous waste from the main household waste prior to being disposed of, 87.7% said they didn't segregate prior to disposal while 12.3% said that they did. The respondents who said they segregated hazardous waste from the general household waste prior to disposal, 87% segregated used needles and syringes, 85 per cent segregated expired or unused animal /human drugs and the same proportion segregated poisons, insecticides, fungicides and pesticides. A further, 15.4% segregated adhesives/glues, 12.6% segregated containers of used oils, kerosene, petrol and discarded aerosol containers, 7.9% segregated batteries as well and used electronics such as cell phones, radio, torches etc.

3.12. Household Hazardous Waste Storage Prior to Disposal

It is important that hazardous waste storage be done properly to prevent contamination or poisoning effects on humans (Mbeng *et al*., 2012). Length of storage is determined by the types of waste generated (Taboada-Gonzalez *et al*., 2010).

Results indicate that 84% of the households store their waste according to households and make weekly payments for collection services. However, the collected waste is disposed of in crude dump sites prior to being trucked to the end disposal point. In most cases waste collection trucks transport waste to a transfer stations, where they are re-loaded into larger trucks and taken to landfill or alternative waste disposal facilities. Moreover, 9% of residents, prefer burning their waste in the open ground. This poses considerable environmental and human risks due to the emission of toxic fumes and pollutants. Furthermore, 7% of residents simply throw their wastes into the environment, thereby leading to health hazards.

3.13. Labelling of Household Hazardous Commodities

Virtually all hazardous household goods or commodities have labels with instructions on how they should be handled, stored and dispose of. This helps users to utilize and manage them safely. From results of the study, 66% said they didn't' read the label or follow instructions on label hazardous commodities purchased whereas 34% indicated that they read the labels and followed instructions. This indicates that many households hardly read the labels and follow instructions hazardous goods procured. The capacity of household members to read labels and follow instructions is important for managing hazardous household waste (Udofia *et al.*, 2017).

Level of education is also crucial in understanding the reading of labels as well as following instructions on the same. The results of this study showed a significant correlation between education level and reading of labels and instructions on hazardous commodities/items ($\chi 2 = 183.276$, df = 1, $p < 0.05$). The findings further revealed that household members with post-secondary education were more likely to read labels and follow instructions on hazardous goods than those with secondary and primary education.

Respondents gave various reasons for reading and following instructions in the labels. According to the results, 80.1% said that they were not able to read, 11.7% said didn't see the label, 5.8% said that many goods did not have labels, a paltry 0.7% said did not look at the labels. There is no doubt that labels/instructions have guiding information disposal methods as well as the storage of hazardous goods/commodities in households.

3.14. Management of Various Categories of Hazardous Wastes in Households

3.14.1. Cosmetic and Laundry Products

When respondents were asked how they dealt with discarded cosmetic and laundry products in their households, 75% reported that they managed them through open dumps, and 25% said by reducing their use. This was an indication that many households managed cosmetic and laundry products in their household through open dumps.

3.14.2. Human and Animal Unused Drugs

Some households kept pets such as dogs and cats, and some also had cattle and poultry. The results indicate that 51.6% of respondents managed unused drugs (human and animal) in their households through crude disposal, 39.9% said through incineration/burning, and 8.4% said through burying. Thus, findings showed that crude disposal was the most commonly used method to manage unused drugs in the households.

3.14.3. Pesticides, Insecticides, Fungicides and Other Chemicals

The results of this study further revealed that 48.9% of respondents said that they disposed pesticides, insecticides, fungicides as well as other farm chemicals in their household in landfills or disused pits, 36.9% mentioned they adopted open dumps, 13.5 per cent used incineration/ burning while 0.8% reduced usage. According to Amouei (2014), pesticides, insecticides, fungicides and chemicals from farms should be stored in double polythene bags for proper disposal.

3.14.4. Old Batteries and Used Electronic Items

Old batteries and electronic devices pose considerable challenges to both the environment and health. This is fuelled by increased urbanization and technological advances that have resulted in increased electronic waste (e-waste), including items such as mobile gadgets, computers and household appliances. Approximately 51% of e-waste is disposed of through open dumping, while approximately 19% is burned openly, thereby emitting harmful toxic substances into the environment. The 29% remaining is recycled through informal sectors or improperly disposed of.

3.14.5. Used Oils, Kerosene, petrol and empty aerosol Containers

Many households in this study use paraffin in cooking using stoves, burn waste, or light candles especially when there is interruption in power supply. Empty containers are sometimes reused to carry various products, in addition to their initial purpose. The findings of this study showed that 83.2 per cent of respondents indicated that they reused containers, 9.2% said they incinerated/burnt them, while 4.1% indicated they disposed them off in land fill or buried them while 3.4% t indicated they did open dumping.

4. Discussion

The high rates of hazardous waste types-electronics, pharmaceuticals, pesticides, chemicals, and plastics-discarded by households underscore an urgent need for systemic interventions. Without improved waste management infrastructure, regulation, and public participation, the potential for environmental degradation, public health harms, and antimicrobial resistance is significant.

Similar studies have found that in many low- and middle-income countries (LMICs), households lack reliable systems for disposing of pharmaceuticals, electronics, and chemical waste. For example, Insani *et al*. (2020) found widespread improper disposal of unused and expired medicines. Parvez *et al*. (2021) systematically reviewed health consequences of e-waste exposure and documented effects on children's physical growth, respiratory functions, and developmental outcomes linked to heavy metals and other contaminants. Jain (2023) reviews management practices of e-waste and emphasizes that many hazards stem from lack of awareness, regulation enforcement, and infrastructure for safe disposal.

This study of Nairobi households highlights that household hazardous waste (HHW) including leftover paints/solvents, pesticides, batteries, cleaners, used oils, pharmaceuticals, and e-waste enters mixed municipal streams with limited source separation and ad-hoc disposal. These patterns mirror broader findings in low- and middle-income countries (LMICs), where awareness is growing but practice lags and formal HHW collection services are sparse (Manggali & Susanna, 2019; Kumar *et al*., 2023).

The prominence of e-waste in this sample is consistent with recent regional and global assessments reporting rapid growth of discarded electronics and persistently low recycling rates in Africa (≈1%), driven by short product life cycles, informal markets, and limited infrastructure (AP News, 2024). In

such contexts, households often store obsolete devices or dispose of them with general refuse both noted in Nairobi, exacerbating risks the from heavy metals and brominated flame retardants.

The findings on the incidence of hazardous waste-related accidents in households highlight significant public health and safety concerns. Although the majority (61%) of households reported no accidents linked to hazardous waste, a substantial proportion (39%) indicated that at least one household member had suffered an accident due to exposure or improper handling of such waste. This indicates that while many households may be practicing relatively safe waste management, the burden of hazardous waste-related injuries remains considerable in a sizable fraction of homes. Similar findings have been reported in other contexts where household hazardous waste (HHW) management practices were inadequate, leading to increased risk of injury, poisoning, or contamination (Senzige, 2014; Johannessen *et al*., 2020). Adults above 18 years constituted 28.4% of the accident cases. This group is likely to be exposed during waste handling activities such as cleaning, discarding pharmaceuticals, or disposing of electronic and chemical waste. Adults may also underestimate the risks of handling hazardous waste without protective measures, increasing the likelihood of injury (Al-Khatib & Sato, 2009). Additionally, 5.8% of incidents involved children aged 6–11 years, who, although more aware than toddlers, still lack the maturity to identify and avoid hazardous materials.

The health and environmental risk pathways identified by respondents (skin/eye irritation, indoor air quality concerns, and drain contamination) align with authoritative guidance: improper HHW disposal can injure sanitation workers, contaminate wastewater systems, and expose children and pets (U.S. Environmental Protection Agency, 2025). Nairobi's occasional open burning—documented in prior local assessments, further elevates the exposure to dioxins and furans, particularly where mixed waste includes chlorinated plastics or residual chemicals (IPEN, 2005; Gumo, 2018).

The policy-practice gap that emerged in our findings is unsurprising. Kenya's Sustainable Waste Management Act, 2022 mandates segregation at the source and prescribes specialized handling of hazardous waste, while Nairobi County's Solid Waste Management Act, 2015 establishes obligations for proper containers and handling. However, implementation and enforcement remain uneven, and household-level HHW streams are not systematically serviced, leaving residents to improvise disposal or rely on informal buyers (Kenya, 2022; Nairobi City County, 2015; National Environment Management Authority (NEMA), 2017). Recent circular-economy diagnostics for Nairobi also acknowledge progress in policy coupled with persistent operational gaps (Climate-KIC & Wasafiri, 2024).

Our analysis further indicates that more correct HHW practices among households with greater education/income parallels LMIC evidence that knowledge and socioeconomic status predict safer management (Manggali & Susanna, 2019; Kumar *et al*., 2023). In dense informal settlements, where storage space is constrained and service coverage is inconsistent, households face structural barriers to segregation and safe temporary storage. Therefore, tailored risk communication and neighborhood-level collection points are critical equity interventions.

The study revealed mixed practices in the management of household hazardous waste. A large proportion of respondents reported that adhesives/glues (81.5%) and pesticides, insecticides, and fungicides (91.2%) should be buried or taken to landfills, which are considered safer disposal methods that help prevent environmental contamination (United States Environmental Protection Agency (USEPA), 2022; World Health Organization (WHO), 2021). However, some practices were unsafe. For example, 96.6% of respondents believed oil and flammable containers could be reused, which poses risks of accidental fires and contamination. Similarly, 87.7% suggested reusing syringes and needles in animal treatment, an unsafe practice that increases the risk of infections and injuries (Kadam *et al*., 2019).

In addition, 86.5% of respondents indicated that unused drugs should be burned, which may reduce accumulation but also contributes to toxic emissions (Daughton, 2020). While 40.7% correctly noted that aerosol cans should not be incinerated to avoid explosions, only 28.6% recognized that batteries and electronics should not be burned—an unsafe practice since it releases heavy metals and toxic pollutants. These findings indicate that while some households are aware of correct disposal methods, unsafe practices remain widespread, highlighting the need for community education and stricter enforcement of safe waste management strategies (World Health Organization (WHO), 2021).

For implications for policy and practice, these results suggest key complementary tracks, namely, 1) Service design: Pilot periodic HHW drop-off days and fixed community collection points for paints/solvents, batteries, bulbs, pesticides, oils, and small e-waste, integrated with licensed downstream treatment (as envisaged under EMCA and 2022 Act regulations). Clear guidance is needed to prevent the disposal of chemicals and toilet flushing of pharmaceuticals (U.S. Environmental Protection Agency, 2025; Kenya, 2022). 2) Extended producer responsibility (EPR): Leverage existing national EPR frameworks to operationalize take-back schemes (e.g., batteries, electronics, paint containers) and formalize partnerships with refurbishers to divert reusable electronics—an approach flagged in Nairobi's circular-economy baseline (Climate-KIC & Wasafiri, 2024). 3) Behavioral interventions:

Evidence-based social marketing (salience cues on product labels; point-of-sale information, and ward-level campaigns) can shift storage and disposal norms, but works best when paired with convenient options. Nairobi's by-laws and national regulations provide a legal backbone, and consistent enforcement and citizen reporting mechanisms can close the loop (Nairobi City County, 2015; National Environment Management Authority (NEMA), 2017).

This has substantial public health significance. By reducing open burning and mixed disposal of HHW, Nairobi can limit the releases of persistent organic pollutants and heavy metals implicated in respiratory, neurological, and carcinogenic outcomes, concerns repeatedly highlighted in global reviews of hazardous waste and health (Fazzo *et al*., 2017). The benefits will disproportionately accrue in neighborhoods currently bearing the highest exposure burden.

The strengths and limitations that highlight a key strength is the study's focus on household-level practices in an African megacity undergoing regulatory transition, offering timely decision support to county and national actors. Limitations include reliance on self-reported behaviors that may under- or over-state risky practices, and the absence (if applicable) of direct environmental measurements (e.g., drain effluent testing, ambient dioxin sampling). Future work should triangulate behavioral data with environmental and biomonitoring indicators and evaluate cost-effectiveness of HHW collection models in Nairobi's diverse settlement types.

5. Conclusion

Most of the households in Nairobi, according to this study, used batteries and electronic items including unused drugs and pharmaceuticals for human or animal use, pesticide remnants, fungicides and accaricides as well as used needles and syringes. Day-to-day activities resulting in the use of hazardous commodities including electronic devices, and medical equipment have increasingly led to hazardous waste generation.

Another notable conclusion from this study is that, despite of considerable awareness, about 6% t of households experienced hazardous waste related accidents in their households. Moreover, most households in Nairobi do not segregate their household hazardous waste from the general household waste prior to storage and disposal. Furthermore, it was evident that most households hardly read the labels or follow instructions on the hazardous goods they purchase in households. Additionally, open dumping and burning are prevalent methods of hazardous waste disposal in households in Nairobi.

Finally, this study has demonstrated that Nairobi households generate meaningful volumes of HHW and currently lack seamless, affordable pathways for safe segregation, management and disposal, thus exposing people to significant levels of risk.

6. Recommendations

Aligning community-level services with Kenya's 2022 national framework and Nairobi County by-laws, backed by producer responsibility and targeted behavior change, offers a practical route to protect health, workers, and ecosystems while advancing the city's circular economic goals. Additionally, various measures can be undertaken by the government to improve hazardous wastes management including 1) increasing public awareness and education by launching comprehensive awareness campaigns to educate residents on the importance of proper HHW segregation, storage, and disposal, as well as implementing HHW segregation programs by encouraging and facilitating the segregation of HHW from general waste by providing clear guidelines and necessary resources, such as labeled bins and collection bags, 2) improving the infrastructure for HHW collection by establishing designated collection points and increasing the frequency of waste collection services and providing guidelines on safe storage methods and the duration of storage for different types of HHW, enforcing regulations, and encouraging residents to read and follow the labels and instructions on HHW products.

There is a need for a study on the long-term environmental impact of HHW disposal methods, such as open dumping and burning, on soil, water, and air quality.

Conflict of Interest

The authors have no conflicts of interest and have not received any funding for the study.

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