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KNOWLEDGE, ATTITUDES, AND PRACTICES ON ELECTRONIC WASTE MANAGEMENT AMONG MAKERERE UNIVERSITY STUDENTS, KAMPALA, UGANDA: A CROSS-SECTIONAL STUDY.

Phillam Jabim*, David Musoke
Department of Disease Control and Environmental Health, Makerere University School of Public Health, P. O. Box 7072, Kampala, Uganda.

Abstract

Background

The need for electronics such as laptops and phones are on the rise, especially in academic institutions including universities. These electronics are required for day-to-day activities such as lectures and communication. As time goes by, these electronics may no longer be required by the original user hence resulting in high volumes of electronic waste (e-waste). This generation of e-waste requires proper management to protect human health and the environment. This study therefore assessed the knowledge, attitudes, and practices on e-waste management among Makerere University students in Kampala, Uganda.

Methods

A cross-sectional descriptive study using a structured questionnaire to collect quantitative data was conducted among 336 Makerere University students. Collected data was analysed at a univariate level in STATA 14 software to assess knowledge, attitudes, and practices on e-waste management among the students.

Results

The majority of participants 267 (79.5%) were aged between 20-25 years, and more than half 179 (53.3%) were males. Most participants 153 (45.5%) had low knowledge levels on e-waste management, though the majority 180 (53.6%) knew what e-waste is. The majority of participants 275 (81.8%) had positive attitudes toward e-waste management, and nearly all 319 (94.9%) agreed that e-waste should not be disposed of with general waste. Mobile phones 223 (42.6%) were the most disposed of e-waste. Many students 125 (35.3%) discarded e-waste by selling as second-hand.

Conclusion

There was low knowledge, positive attitudes, and poor practices towards e-waste management among the university students.

Recommendation

There is a need for various stakeholders to enhance knowledge among students regarding the effects of poor e-waste management on humans and the environment to improve management practices. For example, university administrations can organise campaigns, webinars, and seminars that focus on proper e-waste management including disposal practices and effects on human health and the environment.

Keywords: *Knowledge, Attitudes, Practices, Electronic waste, Students, Uganda*
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Corresponding Author
Phillam Jabim
Email address: *jabimphilliam@gmail.com*
Department of Disease Control and Environmental Health
Makerere University School of Public Health
P. O. Box 7072, Kampala, Uganda
Tel: +256 78698 4342 / +256 70454 9262

Introduction

With the world transforming exponentially from a traditional to a technological nature over the last two decades, waste of electrical and electronic equipment (WEEE), also known as electronic waste (e-waste) is on the rise (Asiimwe and Åke, 2012, Uhunamure et al., 2021). WEEE therefore includes items such as computers, televisions, digital video disks, mobile phones, and many other components from electronics that are useless to their original users (Baldé et al., 2017, Nuwematsiko et al., 2021). High volumes of WEEE have been generated and consumed globally at a high rate since the 1980s (Lucier and Gareau, 2019). This rise is further promoted by the ever-increasing urbanization, industrialization, economic development, and population increase (Awasthi et al., 2018). As of 2019, the global e-waste monitor had approximated global e-waste generation at 54 million tons (Mt), with a projected increase rate of 30% (74 Mt) by 2030. Of these, only 17.4 Mt of the 54 Mt (9.3 Mt) were collected and recycled (Forti et al., 2020, Tiseo, 2021).

E-waste management includes reuse, regulated recycling, material recovery, incineration, and landfilling (Almulhim, 2022, Azodo et al., 2017)—the lack of an effective and well-planned e-waste management agenda results in several health effects on mankind. Examples of the health effects include cardiovascular diseases, asthma, pneumonia issues, brain damage, bone diseases, and kidney diseases (Bhutta et al., 2011, Needhidasan et

al., 2014). These effects majorly result because most of the discarded electronic gadgets contain toxic materials, hazardous, and non-biodegradable components. These components include more than one thousand (1,000) different substances such as cadmium, lead, mercury, arsenic, selenium, and flame retardants which create dioxin emissions when burnt (Almulhim, 2022). These end up polluting the environment, degrading the soil, depleting resources, and contaminating both surface and groundwater.

University students require information and communication technology (ICT) equipment such as laptops, mobile phones, and many other electronics for their academic, social, economic, and entertainment needs. This urgent need is backed up by university policies such as those that require each student to report for the first semester of their first year with a laptop to facilitate online studies using Zoom and Makerere University Electronic Learning (MUELE) applications. This therefore exerts pressure on caretakers and students to purchase, and or inherit these electronics from various sources hence contributing to the e-waste streams in their areas of residence and consequently in the country. Furthermore, some students possess multiple devices that perform similar tasks for example a laptop, mobile phone, smartwatch, and a tablet. With time, these various electronics contribute to the e-waste stream. It is therefore fundamental that students' knowledge, attitudes, and e-waste management practices are understood to design appropriate interventions and messages to curb the likely e-waste surge. This information will then be used to mitigate the effects of poor e-waste management on human health and the environment. This study therefore assessed the knowledge, attitudes, and practices on e-waste management among Makerere University students in Kampala, Uganda.

Methodology

Study setting

This study was conducted at Makerere University, the oldest and largest public institution in Uganda located on Makerere hill in Kawempe Division, one of the five administrative divisions of Kampala, Uganda'scapital. Makerere University was founded in 1922, and its main campus is about 5 km to the north of the city center, covering an area of 300 acres (Ahumuza, 2019). The co-ordinates of the university are 00°20′06″N 32°34′03″E. The university offers both arts and science courses. The university has thirty-one (31) schools and ten (10) colleges (Bisaso, 2017). The university offers programs for about 36,000 undergraduates and 4,000 postgraduates. In recent years, the university has adopted a blended approach of teaching that necessitates students to own electronics such as laptops and mobile phones to access most services, hence predisposing this particular category of electronic consumers to increased e-waste generation levels. This study was conducted between September 2023 and April 2024.

Study design and population

This was a cross-sectional descriptive study employing quantitative data collection methods. A structured questionnaire was used to collect quantitative data from undergraduate students within the ten colleges and thirty-one schools at Makerere University.

Sample size and sampling

The sample size for the study was determined using the formula by Kish Leslie (Kish, 1965), with a desired 95% level of confidence, a degree of precision of 5%, and a prevalence value of 32.3% as from a study conducted by Nuwematsiko et al. (2021) in Uganda. The computation resulted in a sample size of 336 participants. Simple random sampling involving the use of random identifier numbers that were run in an Excel random number generator was used to select five colleges, one school, and three programs. Schools that had three or fewer undergraduate programs had all the programs participating in the study. Within selected programs, students from all the years (I to V) were included in the study population. Within the study population, students from various years were randomly selected by using lists across all the years from each program. Using the student list sampling frame obtained from the school academic registrars, those to participate in the study were then randomly selected by using a random name generator on an Excel worksheet till the required number of participants per college was obtained. The number of participants from each college was therefore dependent upon the proportions of students within the programs hence sampling proportionate to size.

Eligibility criteria

Inclusion criteria

All undergraduate students studying at Makerere University.

Exclusion criteria

Undergraduate students who had spent less than 3 months at the university.

Data collection

An online structured questionnaire was designed using the KoboCollect application and the deployed link was shared with the study participants through either e-mails or via online platforms such as WhatsApp. The numbers were accessed by the school administration. Online data collection was used because many of the university sessions are run online hence the study participants were

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rarely physically present at their colleges. The questionnaire was used to assess knowledge, attitudes, and practices on e-waste management among the students at Makerere University. The questionnaire had closed-ended questions capturing socio-demographics such as age, gender, marital status, and religion. It also captured university factors such as the college of study, course of study, year of study, and finally residence during the time of study. The questionnaire also captured the source of information on e-waste such as from friends, school, family, social media, mass media, or others.

Data management and analysis

Knowledge was a composite variable measured using fifteen (15) questions requiring participants to identify what e-waste is, examples of sources of e-waste, effects of e-waste on human health and the environment, and e-waste management options. Each correct answer was scored as 1 and a wrong response scored as 0. Total scores were obtained and a cut-off of 80% was used to rate the participants to either have had good or poor knowledge of e-waste. This cut-off was selected based on Bloom's cut-off points for the assessment of knowledge (Nahida, 2007). Attitudes were assessed using a 5-point Likert scale (strongly agree, agree, neutral, disagree, and strongly disagree) using ten (10) questions. Each question was scored depending on the response given, with 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree, and 1 for strongly disagree. Total scores were obtained and a cut-off of 80% was also used based on Bloom's cut-off points and these were used to rate participants to either have had positive or negative attitudes towards e-waste management. The responses were collapsed into two categories "agree" for strongly agree and agree responses and "disagree" for neutral, disagree, and strongly disagree. Five (5) questions to assess practices were also assessed. The responses were then summarised into proportions, and percentages, and presented in graphical form.

Socio-demographic characteristics were measured by asking the participants for their age in years lived, their gender, their marital status, and the religion to which they belonged. University factors were measured by asking for one's college within the university, year of study, course being studied at the university, and residence during school times related to whether they were in halls or residence, hostel, or commuting from home. Source of information means regarding where the student heard about e-waste from, its management, and legislation. The sources of information were measured by asking for the places where the student normally received information on e-waste management such as school, social media, friends, family, and mass media. Data from the filled questionnaires were collected electronically using the KoboCollect application. From KoboCollect, the data was then exported to STATA 14 for cleaning and analysis. The data was analyzed at a univariate level, and results were presented in the form of frequencies, percentages, tables, and graphs.

Ethical considerations

Permission to conduct the study was obtained from Makerere University School of Public Health as part of the Bachelor of Environmental Health Sciences program. Study participants provided online informed consent after being explained to the details of the study before accessing the questionnaire. This was done by having an introductory page that informed participants about the study and requested their consent. All collected information was handled confidentially and accessed by only the principal investigator.

Results

Socio-demographic characteristics

A total of 336 participants took part in the study. More than three-quarters of the participants 267 (79.5%) were aged between 20-25 years, with more than half 179 (53.3%) being male. Most participants 225 (75.9%) were not employed, with the majority 156 (46.4%) residing in halls, and more than half had ever heard of e-waste 186 (55.4%) (Table 1).

Table 1: Socio-demographic characteristics of participants

Socio-demographics	Frequency (N = 336)	Percentage (%)
Age (years)		
20-25	267	79.5
26-45	69	20.5
	Mean = 24.2	S.D = ± 4.8
Gender		
Male	179	53.3
Female	157	46.7
Marital status		
Single	309	92.0
Married	27	8.0

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Employment status		
Employed	81	24.1
Not employed	255	75.9
College of study		
Agricultural and Environmental Sciences	48	14.3
Engineering, Design, Art, and Technology	48	14.3
Natural Sciences	76	22.6
Education and External Studies	97	28.9
Health Sciences	67	19.9
Year of study		
1	40	11.9
2	95	28.3
3	163	48.5
4	36	10.7
5	2	0.6
Residence		
Hall	156	46.4
Hostel/rental	135	40.2
Home	45	13.4
Had ever heard of e-waste		
Yes	186	55.4
No	150	44.6
Where they heard of e-waste		
Mass media	75	22.3
School	139	41.4
Social media	76	22.6
Family	7	2.1
Friends	39	11.6

Knowledge of students on e-waste management

The majority of participants had low knowledge on e-waste management 153 (45.5%), followed by moderate knowledge 138 (41.1%), and the least had high knowledge levels 45 (13.4%). More than half of the participants knew what e-waste is and were able to correctly define it 180 (53.6%), while most participants 204 (60.7%) identified e-waste as hazardous. More than half of the participants knew the effects of e-waste on humans 171 (50.9%), while 180 (53.6%) knew the effects of e-waste on the environment. More than three-quarters of the participants never knew any e-waste legislation in the country 282 (83.9%). Children were identified as the category of people most at risk of being affected by poor e-waste management 210 (55.4%). The majority of participants 279 (33.1%) chose education and sensitization on proper e-waste disposal as the most efficient way to prevent the effects of poor e-waste disposal (Table 2).

Table 2: Knowledge of students on e-waste management

Variable	Category	Frequency (N = 336)	Percentage (%)
Knew what e-waste is	Yes	180	53.6
	No	156	46.4
Correctly defined e-waste (N = 180)	Yes	180	100
	No	0	0
Sources of e-waste*	Phones	327	17.0
	Radios	308	16.0
	Televisions	330	17.1
	Computers	336	17.5
	Fridges	303	15.7
	Microwaves	305	15.8

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	Others	18	0.9
E-waste is hazardous	Yes	204	60.7
	No	132	39.3
Knew the effects of e-waste on humans	Yes	171	50.9
	No	165	49.1
Effects of e-waste on humans *	Cancer	168	44.4
	Heart damage	39	10.3
	Brain damage	87	23.0
	Kidney disease	45	12.0
	Asthma	27	7.1
	Others	12	3.2
Knew the effects of e-waste on the environment	Yes	180	53.6
	No	156	46.4
Effects of e-waste on the environment *	Pollutes the air	144	29.5
	Soil degradation	141	28.8
	Resource depletion	60	12.2
	Contaminates surface and groundwater	144	29.5
Ever heard of e-waste management (N = 171)	Yes	171	50.9
	No	165	49.1
From where they heard of e-waste management*	Social media	78	25.1
	School	135	43.3
	Mass media	51	16.4
	Friends	27	8.7
	Family	12	3.6
	Others	9	2.9
Best ways to dispose of e-waste*	Recycle	302	50.2
	Reuse	213	35.3
	Sale	78	13.0
	Others	9	1.5
Aware that some hazardous elements in e-waste needed special treatment	Yes	177	52.7
	No	159	47.3
Knew about the e-waste legislations in the country	Yes	54	16.1
	No	282	83.9
Most at risk of being affected by poor e-waste management*	Children	210	55.4
	Pregnant women	169	44.6
Knew how to prevent the effects of poor electronic waste disposal*	Establish electronic waste collection points	281	33.3
	Encourage recycling and reuse	274	32.5
	Education and sensitization on proper electronic waste disposal	279	33.1
	Others	9	1.1

*** Multi-response variable**

Attitudes of students toward e-waste management

Generally, the participants had positive attitudes towards e-waste management 275 (81.8%), followed by 44 (13.1%) with moderate attitudes, and the least had negative attitudes 17 (5.1%). Most of the participants 251 (74.7%) agreed that e-waste is different from other wastes, and almost all agreed that e-waste should not be disposed of with general waste 319 (94.9%). More than three-quarters of the participants also agreed that storage of e-waste at home is harmful 266 (79.2%). In addition, most participants agreed that e-waste has effects on human health 331 (98.5%), while all 336 (100%) agreed that e-waste has negative effects on the environment.

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The majority of participants 298 (88.7%) were also willing to take part in programmes that enhance and upgrade e-waste management knowledge (Table 3).

E-waste management practices of students

The majority of participants were able to identify mobile phones as the source of e-waste most possessed by students 330 (24.6%) followed by computers 321 (23.9%) (Figure 1).

The majority of participants had ever disposed of mobile phones 223 (42.6%). More than half of the participants considered segregating e-waste before disposal 186 (55.4%). The majority of participants 125 (35.3%) had disposed of the e-waste by selling as second-hand, and 178 (31.9%) reported having kept the e-waste at home (Table 4)

Table 3: Attitudes of students on e-waste management

Variable	Frequency N = 336 (%)	
	Agree	Disagree
E-waste is not different from other waste	85 (25.3)	251 (74.7)
E-waste should be disposed of in the general waste	17 (5.1)	319 (94.9)
Storage of e-waste at home is harmful	266 (79.2)	70 (20.8)
E-waste stored at home should be reused, recycled, or donated	308 (91.7)	28 (8.3)
Recycling e-waste makes a difference in protecting human health and the environment	325 (96.7)	11 (3.3)
E-waste has effects on human health	331 (98.5)	5 (1.5)
E-waste has effects on the environment	336 (100)	0 (0)
It is the government's responsibility to ensure proper e-waste management	230 (68.5)	106 (31.5)
It is the responsibility of the consumer to properly manage e-waste	320 (95.2)	16 (4.8)
Would like to voluntarily attend programmes that enhance and upgrade e-waste management knowledge	298 (88.7)	38 (11.3)

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Figure 1: Sources of e-waste possessed by students

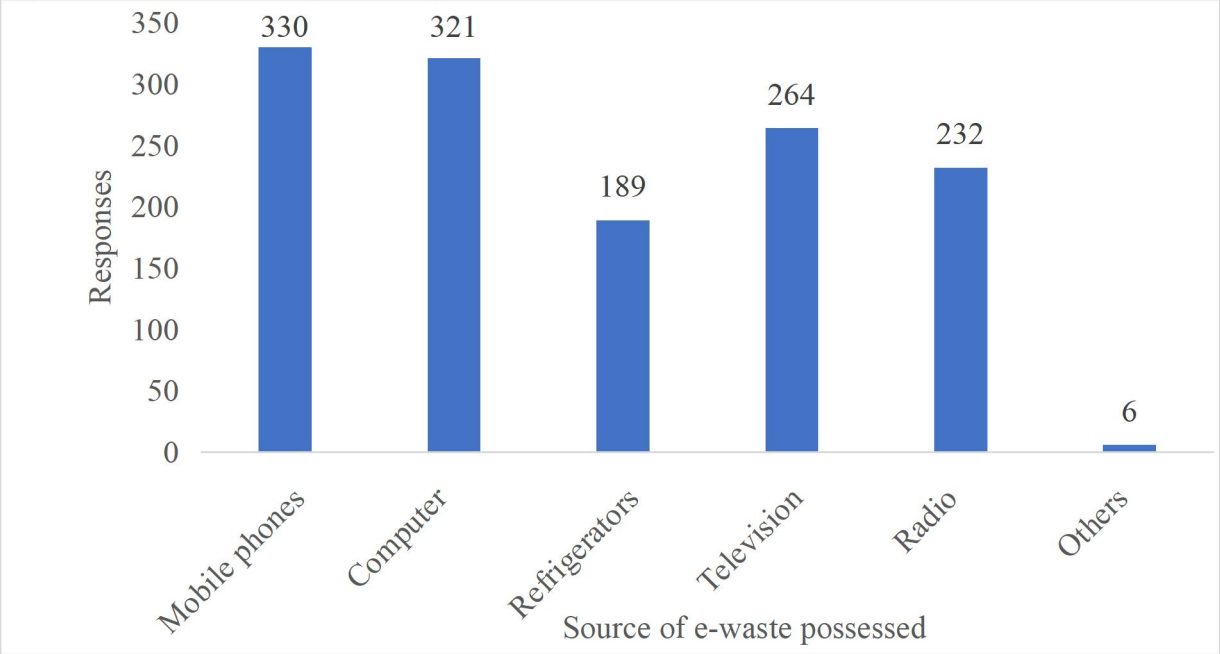

Table 4: Practices of students regarding e-waste

Variable	Category	Frequency (N = 336)	Percentage (%)
Considered segregating e-waste before disposal	Yes	186	55.4
	No	150	44.6
E-waste ever disposed of? *	Mobile phones	223	42.6
	Computer	89	17.0
	Refrigerators	35	6.7
	Television	58	11.1
	None	108	20.7
	Others	10	1.9
Disposal means of the e-waste*	Give to a friend	96	27.1
	Sell as second hand	125	35.3
	Take it to the local recycling centre	62	17.5
	Burn it	25	7.1
	Dispose of household waste	46	13.0
Other e-waste practices if wastes were not disposed of*	Keep at home	178	31.9
	Store at the repair shop	170	30.5
	Give to the children to play with	86	15.4
	Breakdown to remove spare parts	121	21.7
	Others	3	0.5

*** Multi-response variable**

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Discussion

Most students 153 (45.5%) in the study had poor knowledge regarding e-waste management though the majority 180 (53.6%) knew what e-waste was. This, therefore, implies that these students have the electronics and can identify them as e-waste when they become obsolete or of no more use to the owner. This finding is similar to that of a study among business students in a Zimbabwean public university where the majority of participants displayed low levels of e-waste management but they knew what e-waste was (Azlan et al., 2021). The study also found that the majority of participants 135 (43.3%) who had heard about e-waste had done so from school. This indicates the role of schools in sensitizing students through various platforms such as lectures on proper e-waste management. Awareness of proper e-waste management is very important as knowledge influences practices (Fabrigar et al., 2006). This could be explained in a way that, as a result of a lack of knowledge on e-waste management, some students treat e-waste as general waste and dispose of it poorly by mixing it with general waste, burning, or open dumping. These practices then have negative effects on human health and the environment.

The study found that most participants 282 (83.9%) were not aware of the e-waste legislation in Uganda. This finding is similar to a study conducted in universities in Zimbabwe, Nigeria, and Malaysia by Maphosa (2021), Azodo et al. (2017) and Azlan et al. (2021) respectively which found that the majority of the participants did not know the e-waste legislation within their countries. The lack of participants' awareness of local e-waste legislation could be due to weaker e-waste laws and poor implementation of the existing ones. With this, students are left to think that e-waste is not of serious concern hence the majority of them may treat the e-waste in ways convenient to them.

The majority of participants were aware of the effects of e-waste on human health 171 (50.9%) and the environment 180 (53.6%). The major effects on human health mentioned included cancer, heart damage, brain damage, kidney disease, and asthma. Major effects on the environment provided by participants included air pollution, soil degradation, and contamination of surface and groundwater. Similar findings were reported in a study among students at a Zimbabwean University (MAPHOSA et al., 2022) and among nursing students in India (Mane et al., 2019) where the majority of participants were aware that e-waste has negative effects on human health and the environment and were able to identify some of the effects.

The majority of participants 275 (81.8%) had positive attitudes regarding e-waste management. This could imply that the participants were willing to get to know more about e-waste management if presented with the opportunity. This finding is similar to studies conducted among students in the Philippines (Cruz et al., 2020) and Malaysia (Azlan et al., 2021) where the majority of participants had positive attitudes towards e-waste management. The majority of participants 325 (96.7%) in our study also had positive attitudes towards recycling e-waste as a means of protecting human health and the environment. This is a good observation as recycling e-waste ensures that it is used for other purposes such as resource recovery rather than disposing or poorly handling them. This finding is similar to that carried out in Brazil (Echegaray and Hansstein, 2017) and among California Berkeley students (Wright, 2011) where they had positive attitudes towards recycling e-waste and were therefore willing to engage in recycling activities.

The majority of students 298 (88.7%) in our study were also willing to voluntarily attend programmes that enhance and upgrade their e-waste management knowledge. This finding concurs with a study carried out in South Africa among university students where the majority were willing to voluntarily attend to and participate in programmes that enhance and upgrade e-waste management knowledge and practices (Olufemi et al., 2019). Furthermore, many participants in our study displayed negative attitudes toward e-waste management. This was majorly displayed when the majority of participants 230 (68.5%) mentioned that it was the government's responsibility to ensure proper e-waste management. This finding is similar to that of a study conducted in India among a student community which found that proper e-waste management among students was considered to be the role of the government (Iyer, 2018). Therefore, increased sensitization among the students regarding their role in e-waste management by various stakeholders such as university management is needed. This sensitization can positively influence how the students handle e-waste as they will no longer consider it as any other stakeholder's responsibility but their own hence improved health.

Mobile phones 330 (24.6%) and computers 321 (23.9%) were the most identified e-waste ever disposed of by the participants. This finding is similar to a study carried out in Nigeria among students which established that mobile phones and computers were the most frequently used electronics among them (Azodo et al., 2017). This may be because students require phones and computers for day-to-day academic activities such as attending lectures, doing exams, and communicating with friends and family. Most participants 125 (35.3%) in our study disposed of e-waste by selling as second-hand. These findings are similar to studies carried out in Nigeria (Azodo et al., 2017), Zimbabwe (Maphosa, 2021), and Uganda (Nuwematsiko et al., 2021) whereby most of the e-waste was disposed of by selling as second-hand to either individuals or e-waste recycling companies. Concerning undisposed e-waste, the participants in our study reported having kept the e-waste at home 178 (31.9%) or broken the e-waste down to remove spare parts 121 (21.7%) or given children to play with the e-waste 86 (15.4%). These findings are similar to a study conducted in India (Needhidasan et al., 2014) that found

that the majority of participants kept e-waste at home. More than half of the participants 186 (55.4%) in our study considered segregating e-waste before disposal. This finding is similar to a study carried out among a student community in Bangalore (India) that found that the majority of the students were willing to segregate e-waste before disposal (Iyer, 2018). Therefore, policymakers ought to design, enforce, and disseminate waste segregation policies so that the students can segregate generated e-waste hence enabling proper e-waste management which then leads to improved human health and environmental sustainability.

Conclusion

There was low knowledge, positive attitudes, and poor practices towards e-waste management among the university students.

Study Limitations and strength

The study only enrolled students offering programmes at the Makerere University main campus hence knowledge of those in annex compasses such as in Jinja, Arua, Mbale, and Mbarara were not included hence a study limitation. This could have created a selection bias but this was handled by use of simple random sampling and selecting a representative number of colleges within the university. Another limitation is that the study required students to possess electronic devices such as phones, laptops, or tablets that could access the internet to participate yet there may have been some students not having them. Nevertheless, a key strength of the study is that the study explored knowledge, attitudes, and practices of university students on e-waste management, a subject that has hardly been explored hence contributing substantial evidence to the existing body of literature to inform policy, practice, and future research.

Recommendations

There is a need for various stakeholders to enhance knowledge among students regarding the effects of poor e-waste management on humans and the environment to improve practices. For example, university administrations can promote proper e-waste management awareness among students by organising campaigns, webinars, and seminars that focus on proper e-waste management including disposal practices and effects on human health and the environment.

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Abbreviations and acronyms

E-waste Electronic waste
ICT Information and Communication Technology
WEEE Waste electrical and electronic equipment

Grant information

No funding was received to support this work.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

Philliam Jabim designed the study, conducted the data analysis, cleaned and analysed the data, and wrote the manuscript. David Musoke supervised all stages of the study from conceptualisation, proposal writing, data collection, and analysis, as well as manuscript writing.

Author biography

Philliam Jabim holds a bachelor's degree in Environmental Health Sciences from Makerere University School of Public Health in Kampala, Uganda. He is a member of Elevate Research and Health Services where he served as the Grants and Capacity Building secretary. At Elevate Research and Health Services, he also served as the course coordinator for a short course in scientific writing and publication. Philliam has engaged and supported several research works both within and away from Kampala in various capacities such as co-principal investigator, research assistant, and oversight of research works. This paper arises from his undergraduate research in partial fulfilment for the award of a Bachelor of Environmental Health Science at Makerere University where he emerged as the overall best student in his class with a Cumulative Grade Point Average (CGPA) of 4.78 out of 5.0

ORCID ID: Philliam Jabim: 0009-0001-9932-4042

David Musoke is a Senior Lecturer in the Department of Disease Control and Environmental Health at Makerere University School of Public Health (MakSPH), Kampala, Uganda. He holds a Bachelor of Environmental Health Sciences from Makerere University, Uganda, an MSc in International Primary Health Care from the University of London, UK, and a PhD in Public Health from Cardiff Metropolitan University, UK. He is the Chair of the Grants and Research Capacity Building Committee, and Coordinator of the short course in Water, Sanitation and Hygiene (WASH) at MakSPH and was instrumental in its development. He is also an Affiliate Member of the African Academy of Sciences. His research is on environmental health (including WASH), health systems/services (such as maternal health, mental health,

health-seeking behaviour, and human resources for health), and diseases (such as malaria, non-communicable diseases, and COVID-19). He is a member of many professional associations including Health Systems Global (HSG). Currently, he is Co-Chair of the Community Health Workers (CHWs) Thematic Working Group of HSG, as well as President-Elect of the International Federation of Environmental Health. He is an Academic Editor for the following journals: PLOS Global Public Health; BMC Public Health; and BMC Health Services Research. He is also a Senior Visiting Fellow at Nottingham Trent University (UK).

ORCID ID: David Musoke: 0000-0003-3262-3918

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