

Original Article

Perceptions and practices related to e-waste management among medical students

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ABSTRACT

Objectives: Every year, less than 25% of electronic and electrical waste or “e-waste”, generated globally is being managed through appropriate channels. Unregulated e-waste disposal practices release hazardous chemicals posing significant risks to human and environmental health. This study was planned to assess perceptions and practices related to e-waste management among medical students in Tamil Nadu.

Material and Methods: A descriptive, cross-sectional study was conducted in June 2024 among undergraduate medical students in a medical college in Tamil Nadu to assess their perceptions and practices towards e-waste, using a pre-tested, semi-structured questionnaire administered through Google survey forms.

Results: Among the 189 students who participated, about 85% were aware of e-waste-associated hazards; 8% knew about e-waste management legislation. The majority opined that the Government and individuals had a major role in e-waste generation and minimization. Weak legislation (62.4%) and lack of awareness (58.7%) were the most common reasons identified for poor e-waste disposal practices; about one-fourth favoured a tax-payer funded financing model for e-waste management; 65.6% were willing to use recycling containers if available. 56.1% participants replaced their personal gadgets within 5 years or less and the reasons for replacement were equally distributed between physical (36%) or functional damage (46.6%) and preference for newer technology (32.3%). Non-reusable gadgets were either retained at home (40.7%) or exchanged for new ones (30.7%). Domestic appliances were replaced less frequently than personal gadgets, and the most common reasons for replacement were disuse or damage.

Conclusion: Despite satisfactory awareness about e-waste-related hazards, e-waste management practices remained inadequate among the study population. However, self-reported lack of awareness about disposal methods and sense of individual responsibility and willingness in e-waste mitigation among the participants offer scope in planning targeted health education and advocacy efforts.

Keywords: Disposal practices, Electronic and electrical waste, e-waste, e-waste management, Perceptions, Recycling

INTRODUCTION

With the usage of electrical and electronic equipment (EEE) on the rise, the quantity of EEE waste generation has increased enormously.^[1] Electronic and electrical waste, also referred to as “waste electrical and electronic equipment” or “e-waste,” is defined as “any end-of-life equipment that is dependent on electrical currents or electromagnetic field in order to work properly.”^[2] Out of approximately 62 million tonnes of e-waste generated in 2022, merely 22.3% was collected and recycled through appropriate channels.^[3] The scenario is no different in India. E-waste contains components of high economic value, which has contributed to the increasing role of the informal sector in the recycling process.^[3] But a lack of modern industrial technology and protective mechanisms in the informal sector

results in the release of potentially hazardous substances, posing a significant threat to workers and the environment.^[3]

E-waste-related health risks may result from direct contact with harmful materials such as lead, cadmium, chromium, brominated flame retardants, or polychlorinated biphenyls; from inhalation of toxic fumes, and indirectly from accumulation of chemicals in soil, water, and food. Furthermore, their toxic by-products are likely to affect human health.^[1-3] Reported adverse effects are manifold and include fetal loss, prematurity, low birth weight, congenital malformations, abnormal thyroid function, neuro-behavioral disturbances, and genotoxicity.^[2]

The 4 R's of waste management, namely, reduce, reuse, recycle, and recovery, are the need of the hour to tackle the

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growing burden of e-waste.^[4] Despite owning one or more EEEs, the majority of the general population lacks awareness about the hazardous nature of e-waste.^[1] Raising awareness and communicating the health impacts is one of the main strategies to implement the 4 R's pertaining to e-waste.^[1,4]

This study was planned to assess the perceptions and practices related to e-waste among medical students to encourage them to review their waste management behavior and adopt responsible practices and empower them with knowledge to address the impact and health risks of e-waste as medical professionals in the future.

MATERIAL AND METHODS

A descriptive, cross-sectional study was conducted among undergraduate medical students of our Institution to assess their perceptions and practices toward e-waste during the month of June 2024. The required sample size was estimated using the formula $4pq/d^2$, based on the awareness about e-waste collection facilities (35.42%) among medical students in Subhaprada *et al.* study ($p=35.42\%$; $q=100-p$, d =absolute precision 7%).^[5] The estimated sample size of 186 was approximated to 200, considering a probable non-response of 10%.

Random sampling method was used to recruit participants from each batch. Considering the sample size of 200, an equal number of students (50) were chosen randomly from 4 batches (first, second, third, and final year). Fifty students from each batch were selected by computer-generated random numbers.

After approval from the Institutional Ethics Committee, the date and time of the study were selected without interrupting the academic schedule of the participants. A pre-tested, semi-structured questionnaire consisting of the following sections- sociodemographic characteristics, awareness about e-waste, perceptions about e-waste management, and practices related to e-waste was used. The questionnaire was administered using Google survey forms. Information about the study was explained to students, and the same was included along with the consent form as part of the Google survey form, and participants were given the choice to withdraw at any stage of the study till the final submission of their responses. The participants were assured utmost privacy and confidentiality of their responses.

The data collected was downloaded in Microsoft Office Excel 2007 and coded. Descriptive analysis was performed using SPSS version 23.0.

RESULTS

Among the 200 invited participants, 189 completed the questionnaire, with a response rate of 94.5%. Amongst them, 87 (46%) were males and 102 (54%) were females; 172 (91%) and 17 (9%) belonged to nuclear and joint families respectively.

The students were asked if they were aware of the term e-waste and their source of information in the first section of the questionnaire. Among the 189 participants, 88.4% (167) were aware about the term e-waste; and as reported by them, school textbooks were the primary source of information (45.5%), followed by internet or social media (38.9%), print media (10.8%) and informal talk (4.8%). The next section of

Table 1: Distribution of awareness about e-waste among participants (N=189)

Variable	Frequency (N=189)	Percentage (%)
Which of the following electrical or electronic equipment can end up as e-waste? *		
Mobile phones	187	98.9
Batteries	179	94.7
Telephones	179	94.7
Televisions	179	94.7
Air-conditioners	176	93.1
Refrigerators	174	92.1
Washing machines	176	93.1
Computers or laptops	174	92.1
What is your idea about disposal methods of e-waste? *		
Taken to landfills	68	36
Disposed separately from other waste	82	43.4
They are burnt	33	17.5
They are sent abroad	35	18.5
No idea	40	21.2
What do you think are the hazards associated with e-waste? *		
Endocrine dysfunction	86	45.5
Respiratory disorders	117	61.9
Negative birth outcomes	91	48.1
Impaired childhood growth	76	40.2
Impaired cognitive development	88	46.6
Genetic disorders	102	54
Environmental damage	23	12.2
No idea	29	15.3
Have you heard of any electronic waste management policy or legislation in India?		
Yes	15	8
Are you aware of any e-waste collection or management agency in your area?		
Yes	24	12.7
Have you come across recycling containers for e-waste?		
Yes	39	20.6
Have you noticed a warning/ symbol on electrical or electronic products that warns about not disposing e-waste in trash?		
Yes	152	80.4

*Multiple responses obtained

Table 2: Perceptions related to e-waste and its management among participants (N=189)		
Variable	Frequency (N=189)	Percentage (%)
What do you think are the causes for increasing volume of e-waste? *		
More gadgets	109	57.7
More consumers	120	63.5
Increased choices*	53	28
Imports	48	25.4
What do you think are the reasons for improper and illegal dumping of e-waste? *		
Lack of awareness	111	58.7
Lack of incentives	34	18
Inadequate disposal options	44	23.3
Weak governance and lax enforcement	118	62.4
Who is responsible for the growing amount of e-waste in India? *		
Individual consumers	125	66.1
Community	74	39.1
Government	100	52.9
Producers or Manufacturers	70	37
Among the above whom do you think can play a major role in minimization of e-waste in India? *		
Individual consumers	94	49.7
Community	24	12.7
Government	106	56.1
Producers or Manufacturers	22	11.6
Which of the following do you think is the best model for financing of e-waste management system?		
Taxpayer-funded	49	25.9
Polluter-pays	131	69.3
Both	9	4.8
Would you use a recycling equipment if or container if available in your area?		
Yes	124	65.6
No	30	15.9
May be	35	18.5
*Multiple responses obtained; * Increased choices included options such as increased availability on e-commerce sites, flexible buying options, festival offers etc.		

the Google form had a short note on e-waste followed by a question with list of possible items that may end up as e-waste and other questions open to everyone. Table 1 displays the distribution of awareness about e-waste among participants.

Eight percent were aware of the e-waste management policy, but none of them could specify the policy. Table 2 shows the perceptions related to e-waste management among participants.

Table 3: Practices related to e-waste among participants (N=189)		
Variable	Frequency	Percentage (%)
How frequently do you replace your personal electrical or electronic equipments, such as mobile phones, laptops or tablets?		
Once in 5 years or less	106	56.1
6 to 10 years	9	4.8
Rarely/ till it works	74	39.1
In the past, what were your commonest reasons for purchasing new personal devices? *		
Physical damage	68	36
Loss of function	88	46.6
Need for greater functionality	61	32.3
Desire for newer technology	61	32.3
What do you do with electrical or electronic equipments that are physically or functionally damaged and cannot be reused?*		
Keep them at home not knowing what to do	77	40.7
Exchange them for a new one	58	30.7
Give them to junkyard	28	14.8
Dispose them along with general waste	19	10
Return them to store for recycling	28	14.8
Give them to dealers who recycle them	23	12.2
How frequently do you renew domestic appliances such as refrigerator, mixer-grinders, washing machines etc. in your households?		
3 to 5 years	38	20
5 to 10 years	83	44
10 to 15 years	68	36
What were the commonest reasons for renewing domestic appliances? *		
Availability of more functional products in the market	46	24.3
The current products become unusable	91	48.1
Buying new one economic than servicing repaired one	86	45.5
*Multiple responses obtained		

Among the participants, 177 (93.6%) personally owned mobile phones, 93 (49.2%) had Bluetooth headsets or earphones, 94 (49.7%) had computers or laptops, and 45 (23.8%) personally owned other appliances such as hair dryers, electric shavers, and kettles. Table 3 describes the common e-waste-related individual and household practices among the participants.

DISCUSSION

A total of 189 students participated in our study. School textbooks were the key source of information followed by the internet or social media and print media among our respondents, whereas the Internet or media was the primary source of information in studies by Subhprada *et al.* (30.2%) and Azodo *et al.* (32.4%).^[5,6]

About one-fifth of our participants (21.2%) lacked any idea about e-waste disposal practices. While the majority believed that they are treated separately from general waste, few thought e-waste was dumped in landfills or burnt, or sent abroad. In Deniz *et al.* study, 31.2% had no idea about disposal practices, while 34.4% supposed that they are dumped in landfills.^[7] In a community-based study among a relatively younger population in Uttarakhand, 77% of respondents reported a lack of awareness about disposal methods.^[8]

More than four-fifths (84.7%) of our participants were aware of e-waste-related hazards. Similar high proportions were reported from medical college-based studies in India by Subhprada *et al.* (84.37%) and Arpitha *et al.* (81.18%).^[5,9] Azodo *et al.* study among Nigerian college students of other streams demonstrated that their awareness of e-waste, its hazardous contents, and health risks were known to less than one-third participants.^[6] Except for Shah A study from Ahmedabad, awareness about e-waste hazards was uniformly low in community-based studies by Kariwala *et al.* in Lucknow (37%), Duraisamy *et al.* from Bangalore (12.5%), and Meem *et al.* from parts of Bangladesh (46%).^[10-13] The comparison shows that the sources of knowledge available to students have not percolated to the communities and also highlights the scope of using medical students as ambassadors for imparting scientific knowledge on e-waste and its safe disposal to communities.

The reported knowledge about the existence of a Government policy related to E-waste was similar and low in most student-based studies (<10%). The low awareness (3-12%) was also reflected in community-based studies from Ahmedabad, Bangalore, Lucknow, and Dhaka.^[10-13] The consistent lack of awareness in most Indian studies points to the need for utilizing various channels of information to sensitise the population to the policy regulations available. Despite a relative lack of knowledge about other aspects of e-waste, Azodo *et al.* (22.8%) and Deniz *et al.* (17%) reported marginally higher awareness about national and international e-waste legislation among college students in Nigeria and Turkey, respectively.^[6,7]

Approximately half of our participants were aware of e-waste recycling, which was comparatively lesser than in Azodo *et al.*'s study;^[6] 20.6% reported seeing recycling containers,

and 12.7% were aware of e-waste collection or management agencies in their areas. A relatively encouraging trend was reported among the general population of Ahmedabad, where 37% and 25% were aware of formal and informal systems of e-waste collection and management, respectively, in their neighborhood.^[10] Most other available student-based or community-based studies reported substantially low (<10%) awareness about recycling hotspots or recollection centres.^[5,9,11]

There was a noticeable link between awareness and attitude related to the recycling of e-waste; 54.5% were aware of the benefits of recycling e-waste, and 65.6% were willing to use recycling containers if available in their area. A similar positive trend was reported by Deniz *et al.* among Turkish students, where 70% were aware that recycling conserves natural resources, and 96.8% were willing to use recycling containers if available.^[7] This gives a clue to focus any policy decisions or advocacy efforts towards improving the knowledge of the public in responsible use and disposal of EEE to encourage positive attitudes and behaviours.

The majority of respondents opined that consumers and Government agencies are responsible for e-waste production or reduction in India, followed by producers or communities. The sense of self-responsibility among respondents is an encouraging trend that should be utilized for instilling judicious gadget use and disposal practices. The majority of our participants felt that the responsibility of dealing with e-waste lies with the Government (58.2%), followed by consumers and manufacturers. The important role of Governments and manufacturers was also stressed by respondents in Saritha *et al.*, Kariwala *et al.*, and Meem *et al.* studies.^[11,13,14]

Weak governance and enforcement, lack of awareness or incentives, and absence of options or facilities for disposal were identified as chief reasons for improper and illegal dumping of e-waste by our respondents. Similar views were reported by respondents in Saritha *et al.* study.^[14]

While more than two-thirds of participants preferred the polluter-pays principle for financing of e-waste management system, 25.9% were also encouraging of the tax-payer funded model, implying consumer responsibility in e-waste management. A comparable motivating trend was revealed by Saritha *et al.* among the general population, with more than three-fourths agreeing to pay in excess to enable the recycling of e-waste.^[14]

The felt need and desire for new technology and access to updated versions combined with innovative advertising and marketing strategies have resulted in a never-seen-before increase in buying behavior. The availability and competitive offers on e-sale platforms add to the trend and together

contribute to reduced usage span of electrical and electronic gadgets and consequent increase in e-waste generation. Loss of function and physical damage were reported to be the most common reasons for buying new devices in our study, though 32.3% cited the need for higher functionality or technology. The most common reasons were comparable to community-based studies from New Delhi, Lucknow, and Uttarakhand, where more than 70% reported need-based buying because of physical damage or technological problems.^[8,11,15] But the shifting patterns of consumerism with predilection toward newer technology or greater functionality are evident from studies by Subhaprada *et al.* (45.83%), Shah A (61%), and Saritha *et al.* (81.6%).^[5,10,14]

The longevity of ownership or the frequency of disposal differed for personal gadgets and household domestic appliances. More than half the respondents replaced their personal gadgets at least once in 5 years or less (56.1%). While about one-fifth of our study participants (20%) reported renewing their domestic appliances by 3 to 5 years, more than one-third (36%) used them for about 10 to 15 years.

Larger gadgets such as home appliances are exchanged for new ones at the household level, but smaller gadgets such as mobile phones, calculators, batteries, chargers, and circuits end up being stored at homes due to limited knowledge about their disposal or lack of options or incentives for their recycling and disposal. The longer the duration of storage, the higher the chances of it being disposed along with general waste and entering the informal sector with severe health and environmental consequences.

On enquiry of treatment of e-waste after physical or functional damage of gadgets, 40.7% of our respondents reported retaining e-waste at home due to lack of awareness on what to do with them, followed by exchange for new one (30.7%). Disposal along with general waste and selling to scrap dealers were other choices reported. Arpitha *et al.* reported similar disposal options by medical students.^[9] The options differed based on the products. Exchange policies with discounts on new products for home appliances and electronic gadgets allow for the return of e-waste to producers for possible recycling and reuse of their constituents. Though indecisiveness about disposal mechanisms is the main reason for retaining the products at home, sharing with personal contact or family members for second-hand use, along with exchange patterns as seen in most studies, reveals a popular belief about the inherent value of the products for later use.^[15] In Shah A study from Ahmedabad, the majority of the respondents reported giving to personal contact (35%) or keeping them at home (26%); while 18% returned them to formal system, the rest of them disposed them with informal system (9%) or trash (13%).^[10] With a minimal change in the

proportions, the pattern of disposal was similar in the Azodo *et al.* study among Nigerian students and the Saritha *et al.* study from Vishakapatnam.^[6,14] Deniz *et al.*'s study among Turkish college students, despite a comparative picture of disposal practices, also revealed an encouraging trend with return to sellers (9.7%) or formal recyclers (11%).^[7] In Duraisamy *et al.*'s study from urban Bangalore, despite adequate awareness about disposal options with the formal sector, disposal with the informal sector, and general waste was followed by 80% and 20% of participants at the consumer level, respectively.^[12] Exchange for new products and disposal with general waste was also reported by Kariwala *et al.* and Nath *et al.* in Lucknow and Uttarakhand, respectively.^[8,11] Regardless of willingness for safe disposal of e-waste, most of the above studies reveal disposal with general waste or with informal systems, emphasizing the necessity of improving awareness among different stakeholders and increasing the availability of recycling options and formalizing the unorganized sector involved in collecting scrap e-waste.

The study has its limitations. The use of Google survey forms, despite a controlled environment, could have introduced bias in the distribution of perceived knowledge of participants. The analysis was restricted to descriptive statistics, and with the lack of inferential statistics, the study does not delve into the factors influencing e-waste-related perceptions and practices. The findings observed among medical students cannot be generalized to geographically or educationally different population settings. However, this research provides important insights into the gadget buying and disposal practices of the study population, and the attitudes expressed with regard to e-waste generation and management offer possible solutions in planning health education and advocacy actions. The findings of the study also offer scope for future qualitative research to explore the reasons behind the identified behaviours and thereby strengthen advocacy strategies.

CONCLUSION

Though the majority of participants had adequate knowledge about e-waste and its hazards, the disposal practices are poor due to a lack of accessible and available options. Advocacy strategies and policy measures should be targeted towards recognizing and bridging this gap with appropriate actions focusing on responsible e-waste management.

Ethical approval: The research/study approved by the Institutional Review Board at Karpaga Vinayaga Institute of Medical Sciences and Research Centre, number KIMS/SUG/2018/6, dated 10th May 2018.

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REFERENCES

1. World Health Organization (WHO). Children's environmental health. Available from: <https://www.who.int/ceh/risks/ewaste/en/> [Last accessed 2024 Nov 16].
2. Grant K, Goldizen FC, Sly PD, Brune M-N, Neira M, van den Berg M, *et al.* Health consequences of exposure to e-waste: A systematic review. *The Lancet Global Health* 2013;1:e350-61.
3. World Health Organization (WHO). Raising awareness on e-waste and children's health. Webpage. Available from: <https://www.who.int/activities/raising-awareness-on-e-waste-and-children's-health> [Last accessed 2024 Nov 17].
4. IISD's Business and Sustainable Development: A Global Guide. The 4Rs-reduction, reuse, recycling and recovery. Available from: https://www.iisd.org/business/tools/bt_4r.aspx [Last accessed 2024 Nov 18].
5. Subhaprada CS, P. K. Study on awareness of e-waste management among medical students. *Int J Community Med Public Health* 2017;4:506.
6. Azodo AP, Ogban PU, Okpor J. Knowledge and awareness implication on e-waste management among Nigerian collegiate. *J Appl Sci Environ Manage* 2017;21:1035.
7. Deniz PÖ, Aydın ÇY, Kiraz ED. Electronic waste awareness among students of engineering department. *Cukurova Medical Journal* 2019;44:101-9.
8. Nath B, Kumari R, Gupta V, Vaswani ND, Lekhwani S. A community based study on e-waste disposal in srinagar, uttarakhand: Assessment of awareness and practices. *Int J Community Med Public Health* 2018;5:3429.
9. Arpitha VS, Patil PS. Knowledge, attitude, and practice of e-waste among medical students, Dharwad. *Int J Med Sci Public Health* 2020;9:488-91.
10. Shah A. An assessment of public awareness regarding e-waste hazards and management strategies. Independent Study Project (ISP) collection 1820; 2014. Available from: https://digitalcollections.sit.edu/isp_collection/1820 [Last accessed 2024 Jan 26].
11. Kariwala P, Kandpal SD, Dixit S, Singh AK, Pathak A, Singh S. Knowledge, attitude and practices regarding electronic waste management among users of electronic equipments living in Lucknow city. *Indian J Community Health* 2023;35:38-45.
12. Duraisamy S, Narayanappa RR, Sobagiah RT. Self reported practice of e-waste disposal and awareness about its health hazards among people at various levels in selected urban slums of bangalore: A cross sectional study. *Int J Community Med Public Health* 2017;4:2146.
13. Meem RA, Majumder AK, Bahauddin KM. Assessment of knowledge, attitude and practice of electronic waste management among consumers in Dhaka city, Bangladesh. *J Adv Res* 2021;8:126-35.
14. Saritha V, Sunilkumar KA, Srikanth VN. Consumer attitudes and perceptions on electronic waste: An assessment. *Pollution* 2015;1:31-43.
15. Borthakur A, Singh P. Understanding consumers' perspectives of electronic waste in an emerging economy: A case study of new delhi, India. *Energ Ecol Environ* 2022;7:199-212.

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