International Journal of Community Medicine and Public Health
Katole A et al. Int J Community Med Public Health. 2026 Feb;13(2):800-805
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20260309

Original Research Article

From awareness to action: e-waste handling practices among medical students in Puducherry

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Received: 20 November 2025
Revised: 01 January 2026
Accepted: 09 January 2026

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ABSTRACT

Background: Given the global concern over e-waste, which means discarded electrical or electronic devices, it makes sense that many families would be interested in recycling their old appliances. Today, India is one of the largest producers, but we still have a huge gap in safe recycling and disposal. This study aimed to evaluate the awareness and practices of e-waste management among medical students in Pondicherry with changing national policies and global trends.
Methods: A cross-sectional study was carried out for three months, among the students from the second year to final year (n=401) of two randomly selected medical colleges in Pondicherry. Data regarding awareness and practice were collected by a pre-designed semi-structured questionnaire, and data were analyzed using Microsoft EXCEL and Epi Info.
Results: The study defined the respondents of our findings as being 85.8% aware of the term "e-waste" and 91.0% acknowledging the e-waste's environmental hazards. In addition, only 12.2% had ever heard of the Indian laws concerning e-waste protection and its management. Less than 10% of the respondents reported always setting aside e-waste for recycling. Males were better informed of the amount of waste and what could be separated, such as guidelines classification, while females better acknowledged the consequences associated.
Conclusions: University students' knowledge of medical schools on e-waste policy is limited, and safe disposal practice may not reflect their awareness of the risk. Medical school inquiry-triggered education, directly connected to formal recycling systems, could bridge the gap between perceived risk and action.

Keywords: Awareness, Disposal, Electronics, E-waste, Medical students, Practice

INTRODUCTION

Part of the fastest-growing waste stream in the world, electronic waste (e-waste) encompasses "anything with a battery or a cord," including discarded equipment ranging from smartphones and laptops to diagnostic instruments for healthcare and medical electronics. The Global E-Waste Monitor 2024 estimates that nearly 62 million tons of e-waste will be generated annually worldwide, and this is expected to increase by a further 30% by 2030.[1]

India is currently the third-largest generator of e-waste globally, producing an estimated 3.2-3.8 million metric tons per year as of 2024.[1,2] This growth is fueled by rapid economic expansion, rising disposable incomes, increasing penetration of consumer electronics, and shorter replacement cycles for devices such as

smartphones, laptops, and televisions.[3,4] The composition of India's e-waste stream is dominated by large household appliances, information and communication technology (ICT) equipment, and consumer electronics, but there is also a growing contribution from healthcare equipment, particularly after the COVID-19 pandemic.[5] The regulatory landscape has evolved. The E-Waste (Management) Rules, 2022, went into effect on April 1, 2023, imposing greater Extended Producer Responsibility (EPR). Producers must fulfil recycling targets of 60% by 2023-24 and 80% by 2027-28. The Central Pollution Control Board (CPCB) has established a centralized online system for registering producers, recyclers, and refurbishes, while states like Telangana and Delhi are developing processing infrastructure.[6]

Even among highly educated populations, public and consumer knowledge of policy is still low in spite of these advancements. In spite of dumping old electronic goods with new ones, for various reasons, the majority of people are not aware of segregation, recycling and proper disposal of e-wastes.[7] Medical students, as future health professionals, have a unique opportunity to shape public views towards environmentally responsible e-waste disposal. In order to find the awareness and practices of e-waste among medical students, this study was conducted in one of the medical colleges. This is the apt age to impart knowledge and inculcate the habit of safe recycling and disposal. This study evaluates their awareness and practices in Pondicherry, showing the discrepancy between regulatory advances and actual behavioural patterns.

METHODS

This is a cross-sectional study conducted in the Union Territory of Puducherry, India, which comprises 9 medical colleges, including two government institutions (one central and one state-run) and seven private colleges affiliated with various universities under the National Medical Commission (NMC). A stratified random sampling technique was applied to ensure representation from both sectors. The colleges were stratified into government (n=2) and private (n=7) groups, and one college from each stratum was selected by simple random sampling (lottery method), resulting in two study sites (one government and one private). This approach ensured balanced representation and enhanced the generalizability of the findings across different institutional settings. The selected institutes were approached, and permission was obtained from the respective authorities. Complete enumeration of all the students from the medical college was done after getting oral consent from them. This included students from the second to final year from both colleges. After including all the students who had consented to participate, we were able to achieve a sample size of 401 medical students. We used a pre-designed semi-structured questionnaire, which contained 15 questions to find the knowledge and awareness on e-waste and 8 questions to find their practice regarding e-waste disposal. The students were expected to fill out the questionnaire and return it the same day.

RESULTS

In the present study, a total of 401 medical students participated, of which 228 (56.9%) were females and 173 (43.1%) were males. This indicates a higher representation of female students compared to males in the study population. The majority of medical students in this study acknowledged the dangers that electronic waste poses to human health and the environment, but they knew very little about the official management procedures, comprehensive recommendations, and current legislation. Although there were notable gender disparities in several areas, overall awareness was strong, and students regularly used a variety of electronic devices at home.

Table 1: Knowledge on e-waste among medical students.

Medical students	Female, N (%)	Male, N (%)	Chi square	P value
Knowledge of e-waste among students				
Yes	190 (83.3)	154 (89.0)	0.264	0.607
No	38 (16.7)	19 (11.0)		
Electronic gadgets use most frequently by students				
Computers/Laptops /TV/MP3	24 (5.99)	19 (4.74)	0.026	0.87
Cell phones	204 (50.87)	154 (38.41)		
Electronic products/appliances used in the household of students				
<2 E Product	88 (38.6)	69 (39.9)	0.098	0.952
2- 5 and >5	140 (61.4)	104 (60.1)		
Awareness of the volume of electronic waste generated by students				
Yes	89 (39.0)	86 (49.7)	4.558	0.033
No	139 (61.0)	87 (50.3)		
Awareness of any health risk associated with electronic waste among students				
Yes	183 (80.3)	129 (74.6)	1.849	0.174
No	45 (19.7)	44 (25.4)		

Continued.

Medical students	Female, N (%)	Male, N (%)	Chi square	P value
Awareness of electronic waste poses a serious threat to the environment among students				
Yes	215 (94.3)	150 (86.7)	6.940	0.008
No	13 (5.7)	23 (13.3)		
Awareness of some hazardous fractions in electronic waste needs special treatment in order to ensure safe disposal among students				
Yes	180 (78.9)	131 (75.7)	0.588	0.443
No	48 (21.1)	42 (24.3)		
Awareness of the hazardous or risks to the growing amount of e-waste in India among students				
No	54 (23.7)	36 (20.8)	14.728	0.012
Yes- but no specific information	57 (25.0)	61 (35.3)		
Yes- (toxicity in safety hazard)	10 (4.4)	18 (10.4)		
Yes- (Environmental problems)	39 (17.1)	26 (15.0)		
Recognition of both health and environmental hazard	67 (29.4)	32 (18.5)		
Knowledge of any E-waste management policies currently implemented in India				
Yes	26 (11.4)	23 (13.3)	0.328	0.567
No	202 (88.6)	150 (86.7)		
Knowledge of guidelines for the classification of the use electronic equipment among students				
Yes	37 (16.2)	43 (24.9)	4.585	0.032
No	191 (83.8)	130 (75.1)		
Awareness of recycling fair for electronic waste among students				
Yes	129 (56.6)	96 (55.5)	0.047	0.828
No	99 (43.4)	77 (44.5)		
Awareness of what happen to the discarded equipment among students				
Yes	74 (32.5)	72 (41.6)	3.567	0.059
No	154 (67.5)	101 (58.4)		
Awareness of E waste collection at door step among students				
Yes	96 (42.1)	76 (43.9)	0.134	0.715
No	132 (57.9)	97 (56.1)		
Willingness of students to pay for equipment collection and treatment				
Yes	110 (48.2)	90 (52.0)	0.561	0.454
No	118 (51.8)	83 (48.0)		

Regarding knowledge (Table 1), there was no significant difference (p=0.607) between the 83.3% of females and the 89.0% of males who claimed knowing about e-waste. Both sexes 7frequently used computers, laptops, televisions, and cell phones (p=0.87). There was no gender difference in the majority of students who reported owning more than two electronic devices in their homes (p=0.952). Males were substantially more aware of the amount of e-waste produced (49.7%) than females (39.0%) (p=0.033). Females (94.3%) were more likely than males (86.7%) to recognise e-waste as a significant environmental problem (p=0.008). The type of hazard knowledge also showed gender differences (p=0.012), with females more likely to recognise environmental and health threats (29.4% vs. 18.5%). Males were more aware of the rules for classifying used electronic equipment (24.9%) than females (16.2%) (p=0.032). However, there was no significant gender difference in the following areas: awareness of e-waste health concerns (p=0.174), hazardous fractions that require special treatment (p=0.443), awareness of recycling fairs (p=0.828), e-waste collection methods (p=0.715), and readiness to pay for disposal (p=0.454). Both sexes continued to have low levels of knowledge regarding India's e-waste management regulations (females 11.4%, males 13.3%; p=0.567).

As shown in Table 2, there was no significant gender variance (p=0.967) in the percentage of students who claimed always recycling electronic goods compared to nearly half who reported never recycling. Waste segregation was not regularly practised; over 40% of respondents reported never following correct segregation, and less than 10% always did (p = 0.699). When it came to purchasing behaviour, there was a statistically significant gender difference: 18.5% of men and 7.5% of women reported always buying new devices, even when their previous ones were still functional (p=0.001). For durability, the majority of students favoured purchasing devices from reputable companies; however, this did not

differ substantially by gender (p=0.582). Purchasing reassembled or used devices was comparatively rare, but men reported doing so more frequently (5.2% vs. 1.3%; p=0.058).

The majority of respondents, both males (53.2%) and females (59.2%), stated that they never traded or sold used devices, indicating that this practice was not common (p=0.159). Gender differences in the reasons for buying new devices were substantial (p=0.023). Males were more likely to mention wanting the newest technology (34.1%) than females were to mention functional loss or damage (39.0%). Most students (59.2% of females and 61.8% of males) kept their older devices at home before donating them to close friends and family. There was no discernible gender difference in the prevalence of disposal through trash or the unofficial system (p=0.910).

Table 2: Practice of e-waste among medical students.

Medical students	Female, N (%)	Male, N (%)	Chi square	P value
Material/products/gadget recycle by students				
Always	22 (9.6)	18 (10.4)		
Sometimes	103 (45.2)	78 (45.1)	0.066	0.967
Never	103 (45.2)	77 (44.5)		
Students observe proper segregation practice				
Always	17 (7.5)	17 (9.8)		
Sometimes	117 (51.3)	86 (49.7)	0.716	0.699
Never	94 (41.2)	70 (40.5)		
Students buy new electronic gadgets even if the older one still working				
Always	17 (7.5)	32 (18.5)		
Sometimes	106 (46.5)	84 (48.6)	14.083	0.001
Never	105 (46.1)	57 (32.9)		
Students buy gadgets with brands that are reputed for durability and longer life				
Always	146 (64.0)	102 (59.0)		
Sometimes	63 (27.6)	55 (31.8)	1.083	0.582
Never	19 (8.3)	16 (9.2)		
I buy second hand gadgets and or reassembled gadgets				
Always	3 (1.3)	9 (5.2)		
Sometimes	82 (36.0)	66 (38.2)	5.696	0.058
Never	143 (62.7)	98 (56.6)		
Student's trade or sell used electronic gadgets				
Always	9 (3.9)	14 (8.1)		
Sometimes	84 (36.8)	67 (38.7)	3.672	0.159
Never	135 (59.2)	92 (53.2)		
Reason for parching new cell phones / computers by students				
Physical damage	27 (11.8)	12 (6.9)		
Loss of function	89 (39.0)	47 (27.2)		
Need for better functionality	44 (19.3)	36 (20.8)	14.689	0.023
Desire for newest technology	54 (23.7)	59 (34.1)		
Other	12 (5.3)	17 (9.8)		
Practice done with the electronic gadgets that longer use by students				
Kept at home	135 (59.2)	107 (61.8)		
Given to close contact	42 (18.4)	30 (17.3)		
Sold to informal system	9 (3.9)	5 (2.9)	2.714	0.910
Sold to informal system	18 (7.9)	14 (8.1)		
Trash	22 (9.6)	15 (8.7)		

DISCUSSION

The findings of the research show that while most medical students showed a general understanding of electronic waste and the threats it poses to human health and the environment, there are still significant gaps in their understanding of current e-waste management regulations and recommendations. This pattern is consistent with earlier research from India that found that medical and other student populations had a high level of

awareness regarding the occurrence of e-waste but a low level of comprehension regarding safe disposal procedures and legal frameworks.[7,8] In Delhi, a study of medical undergraduates revealed that while 77% of them understood the idea of e-waste, just half were sufficiently informed about the types of equipment that contribute to it and the regulations in place.[7]

In line with our results, which showed that males were more likely than females to report awareness of e-waste volume and guidelines, previous research has also found that male students and those from urban backgrounds demonstrated significantly better knowledge.[9]

The need for focused educational initiatives that address particular informational demands is suggested by the notable gender variations in awareness of the volume of e-waste and environmental hazards. According to Subhaprada and Kalyani's Kurnool study, medical students' knowledge improved following health education initiatives, indicating knowledge gaps before such interventions.[8]

The tendency to keep outdated gadgets at home and poor e-waste management techniques, such as low recycling and poor segregation rates, highlight the difficulties in converting awareness into responsible behaviour. Studies of workers in the informal sector and larger metropolitan populations have also raised similar concerns, pointing out that improper handling and disposal of e-waste pose dangers to occupational and environmental health due to a lack of awareness about health risks and government regulations. Consumerist inclinations that influence the development of e-waste must be addressed in awareness campaigns, as seen by the gender-based disparities in purchasing behaviour, with men more likely to purchase new devices despite functional older devices and motivated by the need for the newest technology.[10,11]

It is crucial to improve medical education curriculum material and encourage behaviour change through customised interventions since inappropriate e-waste handling poses public health hazards, including exposure to dangerous compounds like heavy metals and flame retardants. Through these initiatives, aspiring medical professionals can be better prepared to advocate for and model efficient e-waste management, promoting environmental sustainability and protecting public health.[12]

Strengths of this study include a large sample of medical students, assessment of both knowledge and practice, and examination of gender differences. It offers a comprehensive perspective of where assistance is required and where awareness is high.

This study has few limitations. Social desirability and recall biases may exist because the data are self-reported and cross-sectional. The mentioned practices might exaggerate "good behaviour." Additionally, the study's generalisability to all medical students may be limited because it was conducted at one of the medical colleges. Furthermore, while gender disparities were investigated, this study did not thoroughly analyse other sociodemographic aspects, such as study year and urban/rural background, which may also have an impact on knowledge and practice.

CONCLUSION

This study reveals that although medical students show a high level of general awareness regarding electronic trash and the health and environmental hazards it poses, there are still significant gaps in their knowledge of official e-waste management regulations, guidelines, and safe disposal procedures. Low recycling and segregation rates, along with the propensity to keep old electronics at home, highlight the difficulties in converting knowledge into responsible behaviour. The necessity for specialised educational programs is further highlighted by gender disparities in consumer behaviour and knowledge. Empowering future health professionals with both awareness *and* practical ability to act is essential to reducing the burden of e-waste in India.

Recommendations

Based on the findings, medical colleges should incorporate e-waste management into their curricula through modules on environmental health and sustainability, supplemented by workshops, seminars, and student-led awareness initiatives. Collaborations with authorised recyclers should be formed to provide hands-on experience and official recycling possibilities, while incentives such as e-waste collection drives and buy-back programs can encourage responsible disposal. Leveraging technology, such as mobile applications and digital reporting systems, in conjunction with behaviour change communication via peer education and social media campaigns, can help to boost responsible practices even further. Regular monitoring, periodic surveys, and expanding comparable research to different student populations will aid in tracking progress and broadening the influence of these activities.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Katole A, Jha A, Giri P, Karpaga PP, Shukla AK. From awareness to action: e-waste handling practices among medical students in Puducherry. Int J Community Med Public Health 2026;13:800-5.