Original Article

DOI: 10.7860/JCDR/2026/82595.24113

Knowledge, Attitude and Practice of Electronic Waste among Medical Undergraduates in Belagavi, Karnataka, India: A Cross-sectional Study

Public Health Section

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ABSTRACT

Introduction: India is currently at a rapid pace of technological advancement and increasing electronic device consumption, thereby increasing e-waste, especially after the Coronavirus Disease -2019 (COVID-19) pandemic. E-wastes contain a multitude of hazardous materials having a detrimental effect on both environmental and human health.

Aim: To evaluate the knowledge, attitude and practice of e-waste management among medical students, the future healthcare professionals who will influence public health and environmental sustainability initiatives.

Materials and Methods: The present cross-sectional study was conducted among 522 undergraduate medical students of Jawaharlal Nehru Medical College Hospital in Belagavi, Karnataka, India, from 1st September to 30th September 2024. Data was collected with a pre-designed, pretested, structured questionnaire. All enrolled students were included. Mann-Whitney U test and Kruskal-Wallis H test were used for statistical analysis.

Results: The majority of participants 341 (65.3%) were aged between 18 and 20 years. Around 83 (54.2%) were female. Most were in their second year of medical college 179 (34.3%). Around 477 (91.4%) of students were familiar with the concept of e-waste. Most 466 (89.2%) were aware of the harmful effects of e-waste; 477 (91.4%) recognised its negative impact on environment. Only 277 (53.1%) has the knowledge of existing government policies, rules, or regulations concerning e-waste management. Mobile phones were the frequently used devices 496 (95%). Most of them 375 (71.8%) had purchased less than two new devices in the past five years. The most common reason for purchasing new electronics was loss of function 233 (44.6%). Around 231 (44.3%) reported keeping unused electronics at home.

Conclusion: According to the results of the present study medical students demonstrate good knowledge of e-waste hazards. However, significant gaps remain in policy knowledge. Proper disposal practices were not followed, most of the students kept the unused devices at home.

Keywords: Digital waste, Environmental health, Pollution, Public health

INTRODUCTION

India is currently at a rapid pace of technological advancement and increasing electronic device consumption. India is the world's second-largest manufacturer of mobile phones and the fifth-largest producer of electronic waste (e-waste) globally [1,2]. It is inevitable that as electronic gadgets keep increasing, a corresponding surge in e-waste generation occurs. E-waste includes discarded electronics such as mobile phones, computers, televisions, and home appliances. They contain a multitude of hazardous materials having a detrimental effect on both environmental and human health [3].

E-waste is known to harbor heavy metals such as lead, mercury, and cadmium, along with toxic organic compounds like Polycyclic Aromatic Hydrocarbons (PAHs) and Brominated Flame Retardants (BFRs) [4]. Lead, commonly found in Cathode Ray Tubes (CRTs) and solder, is a potent neurotoxin especially harmful to children. Mercury, often present in batteries and fluorescent lighting, can impair brain function and damage the kidneys and immune system. Cadmium, another e-waste constituent, is carcinogenic and linked to kidney and bone disorders [5,6]. Similarly, BFRs and PAHs are known endocrine disruptors that may interfere with thyroid function and increase cancer risk [7].

If disposed improperly, particularly via informal or unregulated recycling methods, these substances enter into the ecosystem, leading to contamination of soil, groundwater, and air. Such contamination has been associated with severe health consequences, including neurological, renal, immunological, and endocrine dysfunction [8].

Especially after the COVID-19 pandemic there has been a spike in e-waste generation, particularly in the education sector, including those in medical colleges [9]. While remote learning was essential for continuing medical education during the pandemic, it also contributed to environmental degradation by increasing electronic waste generation. This emphasises the urgency of raising awareness about responsible e-waste management, especially among future healthcare professionals who will influence public health and environmental sustainability initiatives. The present study aimed to evaluate the knowledge, attitude and practice of e-waste management among medical students, with a particular focus on their knowledge of health hazards related to improper disposal and awareness of environmentally safe handling techniques.

MATERIALS AND METHODS

The present cross-sectional study was conducted among 522 undergraduate medical students of Jawaharlal Nehru Medical College Hospital in Belagavi, Karnataka, India, over the course of one month, from 1st September to 30th September 2024. Ethical clearance was obtained from the Institutional Ethics Committee (Ref. No. MDC/JNMCIEC/481).

A universal sampling method was adopted-the total number of medical students enrolled: were 800 students. Out of the 800 enrolled students, a total of 522 participated in the study, while 278 were excluded due to non-consent or absence during data collection.

Inclusion criteria: All students who consented to the study were included.

Exclusion criteria: Students who did not consent to participate in the study and absent for three data collection periods were excluded.

Study Procedure

A pre-designed, pretested, structured questionnaire which contained 20 questions, multiple choice ones, was used to assess the knowledge about e-waste management. It was developed using literature review and expert input, validity established through peer review by subject experts, reliability: Cronbach alpha 0.729, indicating good internal consistency. The language of the questionnaire was English. The questionnaire covered various aspects such as knowledge about the hazardous components of e-waste, knowledge of health risks associated with improper disposal, familiarity with proper e-waste management practices, and general attitudes toward e-waste disposal and sustainability.

Knowledge was scored as follows: a score of upto 3 indicated poor knowledge, scores of 4-5 indicated moderate knowledge, and scores of 6-7 indicated good knowledge.

STATISTICAL ANALYSIS

The data was entered into Microsoft Excel and analysed using SPSS software. The qualitative data was summarised as percentages and proportions. Statistical methods were applied to assess the level of awareness among the students. The Mann-Whitney U test was used to compare awareness scores between males and females. The Kruskal-Wallis H test was used to assess differences in awareness scores across age groups and year of study. Bonferroni Correction was used for pairwise comparison of knowledge scores between different academic years.

RESULTS

The present study assessed the knowledge, attitude and practice related to e-waste management among 522 undergraduate medical students of a tertiary medical college hospital in Belagavi.

The majority of participants 341 (65.3%) were aged between 18 and 20 years. Around 239 (45.8%) were male and 283 (54.2%) were female. Most of the study participants were in their second year of medical college 179 (34.3%) [Table/Fig-1].

Variable	Category	n (%)
Age (Years)	18-20	341 (65.3)
	21-25	178 (34.1)
	>26	3 (0.6)
Sex	Male	239 (45.8)
	Female	283 (54.2)
Year of study	1st Year	173 (33.1)
	2nd Year	179 (34.3)
	3rd Year	131 (25.1)
	4th Year	39 (7.5)
Religion	Hindu	451 (86.4)
	Muslim	37 (7.1)
	Christian	8 (1.5)
	Jain	23 (4.4)
	Others	3 (0.6)

[Table/Fig-1]: Sociodemographic details of the participants (N=522).

Regarding knowledge, 477 (91.4%) of students were familiar with the concept of e-waste. Most of them 466 (89.2%) were aware of the harmful effects of e-waste on human health, while 477 (91.4%) recognised its negative impact on the environment. Additionally, 468 (89.6%) of students knew that toxic elements in e-waste require special treatment for environmentally sound disposal. Most of the students know disposal of e-waste is necessary (91.2%). However, only 277 (53.1%) have the knowledge of existing government policies, rules, or regulations concerning e-waste management [Table/Fig-2].

Variable	Response	n (%)
Knowledge about concept of e-waste	Yes	477 (91.4)
	No	45 (8.6)
Knowledge of disposal of e-waste is necessary	Yes	476 (91.2)
	No	46 (8.8)
Knowledge regarding harmful effect of e-waste to health	Yes	466 (89.2)
	No	56 (10.8)
Knowledge regarding harmful effect of e-waste to environment	Yes	477 (91.4)
	No	45 (8.6)
Knowledge about toxic/hazardous elements requiring special treatment for environmentally sound disposal	Yes	468 (89.6)
	No	54 (10.4)
Knowledge about any Government policies, rules, or regulations regarding e-waste	Yes	277 (53.1)
	No	245 (46.9)
Knowledge of collection schemes, recycling programs, or campaigns regarding e-waste	Yes	317 (60.7)
	No	205 (39.3)

[Table/Fig-2]: Knowledge regarding e-waste among the participants (N=522).

The main sources of information about e-waste included educational institutes 238 (45.6%), the internet 218 (41.8%), friends and family 59 (11.3%), and television 7 (1.3%) [Table/Fig-3].

Variable	Response	n (%)
Source of information	Educational institutes	238 (45.6)
	Internet	218 (41.8)
	Friends and family	59 (11.3)
	Television	7 (1.3)

[Table/Fig-3]: Source of information regarding e-waste.

In terms of electronic device usage, mobile phones were the most frequently used devices by 496 (95%) of students. Most of them 356 (68.2%) had purchased less than two new mobile devices in the past five years. Regarding PC/laptops, 375 (71.8%) had purchased only one device in the past five years. Most of them 375 (71.8%) had purchased less than two new devices in the past five years. The most common reason for purchasing new electronics was loss of function 233 (44.6%). Around 374 (71.6%) of students recognised that unused electronics constitute e-waste, whereas 148 (28.4%) did not [Table/Fig-4].

Variables	Response	n (%)
Mobile phones purchased/ replaced in last 5 years	<2	356 (68.2)
	2	152 (29.1)
	3-4	14 (2.7)
PC/laptop purchased/replaced in last 5 years	>1	147 (28.2)
	1	375 (71.8)
How often have you replaced your old device with a new one in the past five years?	More than five times	14 (2.7)
	Two to five times	133 (25.5)
	Less than twice	375 (71.8)
What is the reason for replacing your existing device?	Loss of function	233 (44.6)
	Desire for new technology	150 (28.7)
	Physical damage	128 (24.5)
	Lost/misplaced	11 (2.1)
Do you think unused electronic devices constitute e-waste?	Yes	374 (71.6)
	No	148 (28.4)

[Table/Fig-4]: Attitude regarding e-waste among the participants (N=522).
PC: Personal computer

In the present study, mobile phones were the most frequently used electronic device among participants, particularly in the 18-20 years age group (62.1%), with slightly higher usage among females (55.2%). Usage was highest among 1st (32.1%) and 2nd year students (34.1%). In contrast, laptops, tablets, and smart watches were reported by only a small proportion of students, mainly within the younger age group.

Regarding disposal practices, the majority answered keeping old electronics at home (64.5% in 18-20 years), followed by giving or selling them to friends or acquaintances (61.4%). Smaller proportions reported selling devices elsewhere or disposing of them through informal collectors. Importantly, a notable percentage discarded electronics in the trash (63.0% in 18-20 years; 69.1% females), reflecting inadequate and environmentally unsafe e-waste disposal practices among the study population [Table/Fig-5].

Variable	Response	n (%)
Most frequently used device	Mobile phone	496 (95)
	Tablet	17 (3.3)
	Laptop	7 (1.34)
	Smartwatch	2 (0.4)
	Total	522 (100)
How do you dispose of your electronic device?	Keep at home	231 (44.3)
	Gave or sold to friends/ acquaintances	153 (29.3)
	Sold elsewhere	81 (15.5)
	Disposed of to informal collectors	35 (6.7)
	Disposed of in the trash	22 (4.2)
	Total	522 (100)

[Table/Fig-5]: Practice regarding electronic devices usage and disposal.

Present study shows a significant association between e-waste knowledge and year of study [Table/Fig-6]. Knowledge score was not normally distributed. A statistically significant association was observed between e-waste knowledge and year of study, with 2nd-year students having the highest median score 7.00 (5.00-7.00) (Kruskal–Wallis test, H=33.05, p=0.001). No significant association was found with age (H=0.903, p=0.637) or sex (Mann-Whitney U test, U=32569.5, p=0.442).

Variable		Median (Q1-Q3)	Test applied (p-value)
Age group (years)	18-20	6.00 (5.00-7.00)	Kruskal-Wallis H test (0.637) H value=0.903
	21-25	6.00 (5.00-7.00)	
	>25	5.00 (5.00-7.00)	
Sex	Male	6.00 (5.00-7.00)	Mann-Whitney U test (0.442) U Value= 32569.5
	Female	5.00 (5.00-7.00)	
Year of study	1st Year	5.00 (5.00-7.00)	Kruskal-Wallis H test (0.001)* H value= 33.05
	2nd year	7.00 (5.00-7.00)	
	3rd year	6.00 (5.00-7.00)	
	4th year	5.00 (4.00-7.00)	

[Table/Fig-6]: Association between sociodemographic variables and knowledge about e-waste among study participants.
*Significant
(The Mann-Whitney U test was used to compare knowledge scores between males and females. The Kruskal-Wallis H test was used to assess differences in knowledge scores across age groups and year of study).

Pairwise comparison of knowledge scores was performed using the Mann-Whitney U test with Bonferroni correction, and a p-value<0.0083 was considered statistically significant. Significant differences were observed between 1st and 2nd year (p=0.001), 1st and 3rd year (p=0.005), and 2nd and 4th year students (p=0.001). No significant differences were found between the remaining groups [Table/Fig-7].

Pair	p-value
Ist year -2nd year	0.001*
1st year -3rd year	0.005*
1st year -4rd year	0.0786
2nd year-3rd year	0.039
2nd year-4rd year	0.001*
3rd year -4th year	0.054

[Table/Fig-7]: Pairwise comparison using Mann-Whitney U Test.
* Statistically significant after Bonferroni's correction

DISCUSSION

Among the 522 medical students who participated in the present study, 91.4% understood the concept of e-waste, 89.2% were aware of its harmful health impacts, and 91.4% acknowledged its environmental dangers. These rates are much higher than the studies conducted in elsewhere in India, who has reported knowledge levels in the range of 50-77% [10]. The reason for such wide difference might be that those studies have also included allied-health-science students along with medical students, reinforcing the need for better formal education in terms of e-waste, environmental and human health.

In contrast, community-level studies reported alarmingly low knowledge-only around 6.7% of community respondents recognised the term "e-waste," and proper disposal knowledge hovered below 20% [11,12]. This discrepancy highlights the persistent urban-rural and education-driven divide in environmental knowledge. This is in line with the previous results where most students (45.6%) got their information from educational institutes.

In the present study, 89.6% were aware that e-waste contains toxic/hazardous elements, whereas only 53.1% knew about governmental policies and less than 61% were aware of collection/ recycling schemes. These results are similar to the findings of a study in Tamil Nadu, which reports around 76% good knowledge and 70% positive perception [13].

However, substantial gaps in policy and program knowledge remain, mirroring trends in community and student populations across India [14]. The relatively lower policy-awareness (53%) suggests that while environmental and health messages are reaching these groups, institutional frameworks are not being communicated as effectively in academic settings.

Most of them (71.8%) had purchased less than two new devices in the past five years. This is in line with other studies that report most users replaced devices 1-3 times [10]. Physical damage and loss of function are leading causes. Most (71.6%) thought that unused electronic devices constituted as e-waste.

Around 44.3% reported keeping unused electronics at home. This was similar to other studies that reported storing devices or passing them along to acquaintances is far more common than informal dumps or trashing [15].

The present study found a highly significant association between knowledge and year of study (p<0.001), with second-year students scoring the highest. This pattern might reflect curriculum timing-knowledge peaks after specific modules and declines with absent reinforcement in the higher years. A major strength of the present study is the comprehensive assessment across multiple knowledge dimensions with a large sample (N=522).

Limitation(s)

The main limitation lies in the focus on students-limiting generalisability to the general population. Also, since the students themselves filled the questionnaire there is a chance of self-reported bias. Placement of e-waste education and disposal methods early in academic curricula and reinforcement through public and institutional initiatives

may improve long-term knowledge. Moreover, adopting community and occupational health strategies used in other states can enhance broader societal outcomes.

CONCLUSION(S)

From the findings of the present study, The authors conclude that medical students demonstrate good knowledge of e-waste. Most thought that unused electronic devices constituted as e-waste. Regarding practice, mobile phones were the commonly used device; no proper disposal methods were followed-most kept the unused devices in their homes. Significant gaps remain in policy knowledge.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 31, 2025
- Manual Googling: May 11, 2026
- iThenticate Software: May 13, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 10

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 07, 2025**
Date of Peer Review: **Nov 17, 2025**
Date of Acceptance: **May 15, 2026**
Date of Publishing: **Aug 01, 2026**