Consumer awareness and perceptions about e-waste management in semi-urban area of northern Tamil Nadu: A mixed-method approach

Boopathy Nisha, Shikha Shajil, Ruma Dutta, Timsi Jain

Abstract:

BACKGROUND: The increased use of electronic devices has caused a rise in the generation of e-waste, which is detrimental to the environment and human health. This study aimed to assess consumer awareness, perception, and disposal methods of e-waste management and its determinants in a semi-urban area of northern Tamil Nadu.

MATERIALS AND METHODS: It was a mixed-method approach using a sequential explanatory technique with both quantitative and qualitative methods in adult e-consumers. Quantitative data were collected from 350 participants selected via simple random sampling using score-based semi-structured questionnaire. Qualitative data were obtained purposely from eight selected consumers such as recyclers, local leaders, and importers of electronics using key informant interviews. Sociodemographic details and disposal practices were summarized as frequencies and percentages. The independent *t*-test and linear regression analysis were used to obtain the determinants. Qualitative data were analyzed thematically.

RESULTS: Of the 350 participants (208 males and 142 females), the majority (76%), had good knowledge of e-waste management. Consumers (70%) predominantly had a positive perception. Selling e-wastes to scrap dealers (35%) and disposing of household wastes (21%) were common disposal methods. Male gender, higher education ($\geq 10^{th}$ grade), and skilled and professional workers were significant determining factors of good knowledge and positive perception toward e-waste management.

CONCLUSION: There is a need for those in authority to pay special attention to sensitizing the public to the disposal of e-waste practices, ill effects of e-wastes, segregation at collection sites, legislations and laws on e-waste to consumers, and the establishment of disposal sites.

Keywords:

E-consumers, e-waste management, perceptions, unsafe disposal

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Introduction

The electronics industry has become one of the world's largest and fastest-growing industries. Over the last 25 years, it has experienced phenomenal growth, which has led to a rapid increase in obsolete electronics, which, in turn, has significantly caused a hike in the generation of electronic waste in industrialized countries.[1] In 2019, the worldwide production of e-waste was 53.6 million tonnes with an upsurge of 21% over past 5 years. By 2030, e-waste generation is anticipated to grow to 74.7 million tonnes.[2] India, one of the largest consumers of electronic products in the world, is expected to rise to the fifth place from 12th place by 2025.[3] Approximately 800,000 tons of e-waste is produced in India, with

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an additional 50,000 tons imported from other countries every year.[1]

Improper dumping of e-waste such as used televisions, cell phones, computers, and fax machines can cause lead and other substances to seep into the soil.[4] These substances pollute water and soil, and can vaporize into the air from contaminated ground. Air pollutants from plastics, burning metals, and contaminants settle as residues on crops, market products, and other surfaces. In cities with organized waste management systems, e-waste is discarded along with solid wastes in landfills. Discarded e-waste releases toxicants that enter aquifers and drinking water supplies.[2]

Harmful materials and metals such as mercury, cadmium, lead, brominated flame retardant plastics, and polychlorinated biphenyls (PCB) can affect human health.[1] Elevated levels of lead have been found in the blood of those who burnt e-waste.[5] Human exposure to toxic chemicals can cause pulmonary and cardiovascular disease, hormonal imbalance, immune system suppression, birth defects, genitourinary diseases, old age dementia, and learning disabilities. Women exposed to heavy metals and PCB suffer from anemia, hormonal problems, menstrual cycle irregularities, endometriosis, autoimmune disorders, and cancer of the reproductive system. Neurobehavioral developmental problems, low birth weight or spontaneous abortion, and birth defects are related to exposure to lead and mercury in the first trimester of pregnancy. The burning of e-waste in open air pits is associated with infertility.[6,7]

Although India developed the dedicated e-waste management policy to ensure, guide, and promote safe e-waste management,[8] many of its citizens are unaware of the rules.[1] The level of awareness of the Indian public of the disposal and harmful effects of electronic products is, therefore, most inadequate.[1,9] The best way to combat the huge increase in the amount of e-waste in landfills and its threat to the environment and human health arising from the growing demand for electronic devices is the promotion of awareness of the general public to the importance of reducing e-waste. More emphasis should be placed on use of less toxic, easily recoverable, and recyclable materials.[4]

This study aimed to assess the consumer awareness, perception of e-waste management, and its determinants in a semi-urban area of Tamil Nadu. It was also to gain an insight into the disposal and recycling methods of e-wastes.

Materials and Methods

This study employed a mixed-method approach using a sequential explanatory technique with both quantitative and qualitative methods for data collection from adult electronic consumers residing in the urban field practice area of the tertiary care medical college hospital in Thiruvallur district of Tamil Nadu. Qualitative data were collected to complement the findings of quantitative data and get an insight into the results. The urban area of this district is the eastern extension of metropolitan city and, therefore, exhibits urban electronic possession characteristics. Ethical approval was obtained from the Institutional Review Board vide Letter No. SMC/IEC/2021/03/183 dated 30/03/2021, and informed written consent was taken from all participants.

Adult "Electronic consumers" above 18 years of age residing in the study area for at least 6 months prior to the study were included. For the purpose of the study, we defined "e-consumer" as any person using, repairing, or selling electrical and electronic equipment such as mobile phones, televisions, computers, laptops, refrigerators, air-conditioners, and other kitchen home appliances. We excluded individuals who had no electronic device at the time of data collection.

We used Kish Leslie (1964) formula for cross-sectional studies to calculate the sample size following assumptions such as prevalence (p) as 72.7% (based on the study on e-waste awareness of different sections of the population in India, there is a prevalence (p) of poor knowledge of e-waste management[4]) and with 5% precision and 10% nonresponse rate. The total sample required was 343 e-consumers for quantitative data. We used multistage random sampling technique with the first stage, i.e., the selection of administration division of the city (5 out of 15 wards), probability proportional to size. The second was the selection of study participants using a family survey register in the selected wards. Qualitative data were obtained purposely from selected consumers such as recyclers, local leaders, and importers of electronics using key informant interviews (KIIs). Data saturation was attained by the end of 8th KII.

We used a pretested semi-structured interview form in quantitative component for data collection on awareness, perceptions, and disposal and management practices of e-waste. The study comprised four sections: (i) sociodemographic details of the e-consumer such as age, gender, occupation, socio-economic status, and education; (ii) awareness of e-waste and its management including knowledge of e-waste, its effects on health, regulations (law), and usage/disposal choices; (iii) perceptions on problems associated with e-waste recycling, handling, and disposal of electronics; and (iv) e-waste management practices of common disposal options used in the community. The face and content validation of the questionnaire was done by individual experts, and internal consistency and reliability were

found by using Cronbach's alpha (0.82), and a pilot study was done using 10% of the study population but not included in the final analysis. Research assistants were trained for face-to-face interviews of participants, which were conducted using the Epicollect5 Toolkit after written informed consent was obtained from all the participants.

For the qualitative component, KIIs were conducted from purposely selected representatives in a suitable location at their workplaces using interview guides. The interview guide included questions on the perception of e-waste and its management and disposal practices in the community. Modulation of KIIs was done by experienced research assistants trained in conducting qualitative interviews.

Pretesting of the data collecting tool (Epicollect5)[10] was done with 10% of the respondents, whose data were not included in the final analysis. Quality check of collected data was done to confirm the consistency, comprehensiveness, and ensure the proper daily collection of data. Data were exported to SPSS 21 software (IBM Corp., Armonk, N.Y., USA)[11] from Epicollect5 for cleaning and analysis. Participants' sociodemographic details and disposal practices were summarized as frequencies and percentages because of the diversity of the responses. Level of awareness was assessed using six questions and scored as either "1" for correct or "0" for incorrect responses, giving an overall range of 0-6. However, perception was determined using 6 questions on "5-point Likert scale" (strongly agree, agree, neutral, disagree, and strongly disagree). The responses were collapsed for the purpose of analysis into two categories with "agree" (strongly agree, agree) with "1" score and "disagree" (neutral, disagree, and strongly disagree) with "0" score, with an overall range of 0–6. Based on the mean score on "Knowledge" subscale, the scores ≥4 and ≤3 were considered "Good Knowledge" and "Poor Knowledge," respectively. Similarly, based on the mean score of "Perception" subscale, the scores ≥5 and ≤4 were considered "Good Perception" and "Poor Perception," respectively. The independent variables were age, gender, education, occupation of head of household, and total annual income. After checking for normality of the data, we applied independent *t*-test for association of knowledge; perception scores with demographic independent variables and determinants were obtained using linear regression analysis.

Qualitative data were retrieved from audio tape recordings, transcribed verbatim, and translated into English from the local language in which they were conducted. Transcripts were read thoroughly before coding by the two independent researchers.

Intercoder agreement was obtained from researchers for discrepancies and resolution by comparing each other's raw data until consensus was reached. Coded transcripts were uploaded in NVivo software[12] for thematic analysis using deductive and inductive approaches. Selected quotes represented the main themes in the study. The inter-researcher agreement was obtained before analysis by personal interaction to minimize the biased interpretations.

Operational definitions[8] were as follows: (1) "E-waste" is defined as electrical and electronic equipment discarded as waste by the consumer or bulk consumer, or rejected from manufacturing, refurbishment, or repair processes and (2) "e-waste exchange" meant an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e-waste generated from end-of-life electrical and electronic equipment between agencies or organizations authorized under these rules.

Results

Of the 350 participants, 59.5% were males and 40.5% were females with the mean age of 35 ± 12.2 years. Less than half (43%) of the participants were <35 years of age. A major proportion of the consumers (95%) 10th grade education. Eighty-seven percent of the participants were unskilled workers, students, or homemakers, while the remaining 13% were skilled workers and professionals. Of the respondents, 37% had an annual income above 2.5 lakh (Indian currency).

On assessing consumer awareness of e-waste, the following results shown in Table 1 were observed. More than half of them (59.4%) were unaware of the term "e-waste or e-waste handling" and the majority (79.4%) were unaware of e-waste legislation in our country.

The majority of e-consumers (84%) strongly believed that "E-waste handling and disposal should be improved in India." The level of perception toward e-waste handling and management of consumers is shown in Table 2. The distribution of disposal methods used by e-waste handlers is shown in Figure 1. The scoring of the questions based on awareness revealed that 76% participants had high awareness. The scores of the perception subscale showed that 70% respondents had good perception.

The association of independent variables with knowledge and perception scores is tabulated in Table 3. Education subgrouped as less or more than 10th grade and occupation had significant associations with good knowledge and perception scores. Education ≥10th grade was an independent predictor for both good knowledge and

perception. Further, the predictors of good knowledge and perception of e-waste were male gender and skilled workers. The determinants of poor knowledge and perceptions of e-waste management were drawn using linear regression which is shown in Table 4.

Qualitative findings on perceptions of recycling of e-waste of KIIs were responses to follow-up questions
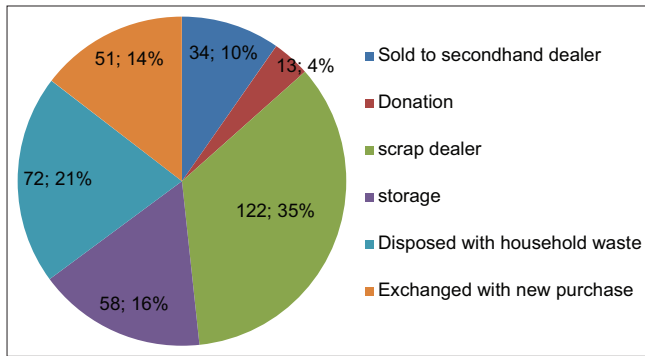
on the effects of e-wastes on human health and environment and the storage of e-waste at home as a symbol of remembrance or ignorance. Some key informants perceived e-waste recycling as doing more harm than good because many were recycling illegally by dismantling and removing parts they wanted and disposing of the rest indiscriminately as specified below:

E-waste recycling in our country is informal. Recycled devices stop working after a few weeks. Actually, in a workshop, different parts of spoilt electronics are removed until it is no longer fit for use. Eventually, disposal of e-waste is indiscriminate. Like, you find the shell of a television dumped near a large water body.(Key Informant 4, 6, 8).

Indiscriminate disposal of e-wastes was perceived as harmful to the environment and consumers' health. Common ill effects perceived were injuries from explosions, harmful radiation, contaminating water sources, and depletion of the ozone layer. Electronic devices repair consumers' perceptions on ill effects are stated below:

Figure 1: Distribution of disposal methods used by e-waste handlers

Table 1: Level of knowledge of e-waste handling among consumers

Knowledge on e-waste handling	Good knowledge N (%)	Poor knowledge N (%)
Aware of the term "e-waste or e-waste handling"	139 (40.5)	204 (59.4)
Aware of ill effects of e-waste on health and environment	280 (81.7)	63 (18.3)
Aware of e-waste handling before disposal (reuse or donate)	297 (86.6)	46 (13.4)
Aware of available options for disposal of e-wastes	220 (64)	123 (36.1)
Aware of e-waste segregation at household level	327 (95.4)	16 (4.6)
Aware of e-waste legislation available in our country	71 (20.6)	272 (79.4)

Table 2: Description of the perceptions about e-waste handling among consumers

Perceptions on e-waste handling	Good perception N (%)	Poor perception N (%)
E-waste handling and disposal should be improved in India	288 (84.0)	55 (16.0)
Storing e-wastes in homes is harmful	269 (78.3)	74 (21.7)
E-wastes have a harmful effect on environment and human health	340 (99.1)	3 (0.86)
Increasing global demand on electronic devices is a serious problem	269 (78.3)	74 (21.7)
Important to recycle e-waste before disposal	221 (64.6)	122 (35.4)
Electronic devices not working are considered waste	43 (12.6)	300 (87.4)

Table 3: Association of independent variables with knowledge and perception of e-consumers

Independent variable	Subcategory	Awareness Mean±SD	*t*	Perceptions Mean±SD	*t*
Age (years)	<35	4.01±0.94	1.256	4.89±1.22	−0.667
	>35	3.88±0.89		4.98±1.09	
Gender	Males	3.86±0.84	−2.679*	4.92±1.18	−0.151
	Females	4.13±1.01		4.91±1.18	
Education	<10th grade	3.83±0.97	−2.668*	4.47±1.40	−6.877*
	≥10th grade	4.09±0.86		5.29±0.78	
Occupation	Unskilled, students and homemakers	3.95±0.91	−2.830*	4.84±1.18	−2.321*
	Skilled and professional	4.56±1.91		5.18±1.12	
Average income	Annual income <2.5 lakhs	3.94±0.92	−0.963	4.82±1.19	−2.644*
	Annual income >2.5 lakhs	4.06±0.94		5.21±1.11	

*P<0.05 is statistically significant by independent *t*-test. SD=Standard deviation

Table 4: Multiple regression analysis results: Factors related to awareness and perceptions of e-consumers

Independent variable	Awareness		Perceptions	
	β co-efficient	F	β co-efficient	F
Age >35 years	−0.171	2.336	−0.111	0.649
Male: Gender	−0.246	5.411*	−0.023	0.031
Education: ≥10th grade	0.276	6.373*	0.852	40.04*
Occupation: Skilled and professional	−0.201	0.320	−0.758	4.337*
Average annual income: >2.5 lakhs	0.220	0.172	0.702	1.155

*$P<0.05$ is statistically significant

Definitely!! Let's talk about a mobile phone while it is being charged at a plug point. The device suddenly explodes like a bomb resulting in burns, hearing loss and sometimes death. Also the high voltage used by electronic devices is very dangerous. Secondly, we dump laptops, TVs, computers in lakes or ponds resulting in deadly contaminated the drinking water!! Also, they remain in the soil making it unfertile for plant growth. Lastly, refrigerators have ozone depleting substances in them and cause many problems!!! (Key Informant 2, 5).

E-wastes stored at home and not being disposed of owing to personal attachment or ignorance of disposal methods is an important negative perception of disposal of e-wastes. This perception is stated by many key informants as follows:

Yes. My grandfather gifted me an old age big fat TV when I got married. Even though, I don't watch it, I won't dispose of it. So we have the mentality of keeping e-waste because of sentimental attachment. It is hard to let go. We also give some e-waste like used mobiles, laptops etc., to children to play with. Some store them because they do not know what to do with them.(Key Informant 1, 3, 7).

Discussion

The study was carried out in Chennai, one of the largest urban cities in India. We intended to study the awareness, perceptions, and behavior of consumers in e-waste handling.

A major proportion of participants, 79.4% (242), were not aware of the e-waste legislation and rules in our country. This figure is slightly lower than the 89% found in the study conducted by Anuj Shah in Gujarat, India. These large numbers in the population lack awareness of the laws,[1] which is the result of the failure of the concerned authorities to disseminate and enforce the rules. These findings show that responsible organizations and authorities should endeavor to raise awareness and strictly enforce the rules governing proper e-waste management.

This study showed that the majority of participants were aware of the ill effects of e-waste on health and environment (280 [81.71]). In contrast, a study by Tarawneh in Jordan reported only 31% awareness of the ill effects of e-wastes.[13] This might be due to the growing awareness of toxic materials such as leaded paints and plastics, promoted through sensitization programs to increase consciousness of the risk factors to health.

About 38% (98) of participants, which is much lower than the 69.4% indicated in the study by Mahat[14] in Malaysia, were aware of various options for e-waste disposal such as selling to secondhand dealer, exchanging for a new item or and giving it away. This shows that the message has not adequately reached the general public. This study showed that 35% of the consumers sold their e-wastes to scrap dealers, which is in accord with the study in Jordan 46.1%. Conventionally, people are likely to sell their e-wastes to scrap dealers.[13]

The majority, 84% (256) of respondents in contrast to the 18% found by a study conducted in Andhra Pradesh,[15] felt that there should be an improvement in the handling and disposal e-waste in India. Our results are similar to the study by Delcea *et al.*,[16] in which most respondents, 74.1% (406), stated that e-waste recycling was an important aspect of a responsible citizen's life. This may be due to the lack of proper e-waste drop-off facilities in their area and also because of poor management of e-waste in India where most e-waste ends up in landfills. Targeted interventions to consumers in educational institutions and the informal sector industries would do much to improve e-waste management in India.

A large proportion of people, 78.3% (239), felt that storing e-waste in homes was harmful, which agrees with the study by Borthakur[17] of 64%. In this study, 17% (58) stored their e-waste at home which concurs with the 27% found in the study in Malaysia on awareness of the handling of household e-waste.[18] The various reasons for the storage of undisposed e-wastes at home were that children's toys were attractive and expensive, there was personal attachment to the items and therefore most were unwilling to dispose of them, also knowledge of disposal was limited. These findings resulted from qualitative approach which is an indication for further quantitative research. Similar reasons have been adduced in many studies.[18,19]

Most of the participants, 87.4% (266), considered electronic devices that are not working as waste, which is in contrast to the study by Borthakur in New Delhi in which only 47.8% considered nonfunctional devices as waste.[17] This could be due to a lack of awareness of the valuable materials found in e-waste which can be utilized to create new products. Nearly 35% (122) of participants gave their e-wastes to scrap dealers, just as was found in other Indian studies.[17,20,21] Most of the participants followed this approach owing to the dearth of proper e-waste drop-off points and the lack of awareness of formal e-waste collection systems in the country. About 21% (72), similar to Akhtar's findings of 30%, disposed of their e-waste with household waste.[18] Therefore, it is crucial that the government of India speeds up the process of establishing disposal sites in all cities and promotes sensitization programs for its consumers.

Our study stands out as we used different data collection methods for triangulation of information to gain a better insight into the e-waste management by consumers and the qualitative findings increase the validity of the results. However, our study has limitations with regard to generalizability as it focused on a small semi-urban area, and did not include such consumers as scrap dealers, recyclers, civil society organizers, and responsible government authorities for a more precise result in e-waste management process. This requires further study.

Conclusion

Our findings show that awareness on e-waste disposal methods has to be improved. Although people's perception was good, most followed unsafe disposal methods that resulted in a toxic environment for humans. Thus, more studies should be conducted on finding newer eco-friendly recycling methods, improving the performance of old devices to limit unsafe disposal of outdated products. Disposal sites should be established by the authorities, who should also direct awareness campaigns at consumers on the ill effects of e-wastes and enforce segregation at collection sites and legislation and laws on e-wastes.

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Conflicts of interest
There are no conflicts of interest.

References

1. Shah A. An Assessment of Public Awareness Regarding E-Waste Hazards and Management. Independent Study Project Collection. Available from: https://digitalcollections.sit.edu/isp_collection/1820/. [Last accessed on 2021 Aug 14].

2. World Health Organization. Children and Digital Dumpsites: E-Waste Exposure and Child Health. Available from: https://www.who.int/publications-detail-redirect/9789240023901. [Last accessed on 2021 Aug 14].

3. Sivathanu B. User's perspective: Knowledge and attitude towards e-waste. Int J Appl Environ Sci 2016;11:413-23.

4. Tyagi N, Naseem Y, Atif M. A study of public awareness about e-waste. Res J Soc Sci Manage 2013;3:185-94.

5. Orisakwe OE, Frazzoli C, Ilo CE, Oritsemuelebi B. Public health burden of e-waste in Africa. J Health Pollut 2019;9:190610.

6. McAllister L, Magee A, Hale B. Women, e-waste, and technological solutions to climate change. Health Hum Rights 2014;16:166-78.

7. McAllister L. The Human and environmental effects of e-waste. In: Population Reference Bureau. Washington. Population Environment Research Network. Populationenvironmentresearch.org; 2013.

8. Ministry of Environment, Forest and Climate Change; 2021. Available from: https://greene.gov.in/wp-content/uploads/2018/01/EWM-Rules-2016-english-230.03.2016.pdf. [Last accessed on 2016 Mar 23].

9. Needhidasan S, Samuel M, Chidambaram R. Electronic waste – An emerging threat to the environment of urban India. J Environ Health Sci Eng 2014;12:36.

10. Gupta S, Sharma S, Gohil R, Sachdeva S. Epicollect5: A Free, Fully Customizable Mobile-based Application for Data Collection in Clinical Research. J Postgrad Med Educ Res 2020;54:248-21.

11. IBM Corp. IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp; 2017. Available from: https://hadoop.apache.org. [Last accessed on 2021 Aug 15].

12. QSR International. NVivo 12 Qualitative Data Analysis Software; 2020. Available from: https://www.qsrinternational.com/nvivoqualitative-data-analysis-software/support-services. [Last accessed on 2021 Aug 15].

13. Tarawneh A, Saidan M. Households awareness, behaviors, and willingness to participate in E-waste management in Jordan. Int J Ecosyst 2013;3:124-31.

14. Mahat H, Hashim M, Nayan N, Saleh Y, Norkhaidi SB. E-waste disposal awareness among the Malaysian community. Knowl Manage E Learn Int J 2019;11:393-408.

15. Saritha V, Sunil Kumar KA, Srikanth Vuppala NV. Consumer attitudes and perceptions on electronic waste: An assessment. Pollution 2015;1:31-43.

16. Delcea C, Crăciun L, Ioanăș C, Ferruzzi G, Cotfas LA. Determinants of individuals' e-waste recycling decision: A case study from Romania. Sustainability 2020;12:2753.

17. Borthakur A, Singh P. The journey from products to waste: A pilot study on perception and discarding of electronic waste in contemporary urban India. Environ Sci Pollut Res Int 2021;28:24511-20.

18. Akhtar R, Masud MM, Afroz R. Household perception and recycling behaviour on electronic waste management: A case study of Kuala-Lumpur, Malaysia. Malays J Sci 2014;33:32-41.

19. Nuwematsiko R, Oporia F, Nabirye J, Halage A, Musoke D, Buregyeya E. Knowledge, Perceptions, and Practices of Electronic Waste Management among Consumers in Kampala, Uganda. J Environ Public Health. 2021;2021:1-11. Available from: https://www. hindawi.com/journals/jeph/2021/3846428/. [Last accessed on 2021 Aug 14]

20. Shilpa Shetty S. Youth perception towards e-waste: A study with reference to Udipi district. Asia Pac J Res 2020;1:43-8.

21. Nijamudeen S, Nisha B, Dutta R, Jain T. Awareness of climate change and its impact on public health among medical and paramedical students in a teaching hospital of Tamil Nadu. Ann Trop Med Public Health 2021;23(23)SP2323111.