Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(4), 1479-1498 | ISSN:2251-6727

An Exploratory Analysis of Awareness of E-waste Management

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(Received: 02 September 2023 Revised: 14 October Accepted: 07 November)

KEYWORDS

e-waste management awareness, e-waste management, health impact, e-waste policies, Corporate & Government initiatives

Abstract

The inventiveness of this article is to assess awareness of different segments of users and handlers of e-waste with respect to four dimensions of e-waste management. These dimensions are government policies (extended producer responsibility (EPR), subsidies of setting up dismantling & recycling units, e-waste rule 2016 and 2018, etc.), government and corporate e-waste management initiatives, impact on health and environment, and awareness among households. To achieve the objective, a survey by structured questionnaire asking users and handlers was conducted. In all, valid data of 89 respondents were analysed. This data was collected using the convenience sampling technique. The collected data was subjected to descriptive analysis, chi-square test, factor analysis and its associated parameters and measures. Findings indicate higher than average level of awareness among users and handlers of different demographic. Gender and education have a significant association with purchase decisions and age and education level with the upgradation of electronic items. The study also suggests there is a need to increase the level of awareness of e-waste management among users and handlers.

Introduction

In the present era, no evidence is needed to adage that there is an exponential increase in the use of electronic goods, be it household or industry. Increased focus and application of automation technologies has made life of humans easy and comfortable. On the other hand, dependency of humans on the electronic machines has increased and resulted in an immense amount of electronic waste (e-waste). In addition, the casual approach of recycling of e-waste has become a serious concern in developing countries. In summary, the management of electronic trash (e-waste) should be a current concern, since poor e-waste disposal has detrimental effects on the environment and public health.

Furthermore, in the last decade, human life has changed drastically in every area, especially with regard to increased usage and dependency of electronic goods in households or industry, like smartphones, laptops, computers & its monitors. Smartphones, refrigerators, printers, LCD, LED, air conditioner, washing machines etc. These electronic items are developed, manufactured and used due to the utility of these items in making life easier and comfortable in many ways. Reports indicate one of the largest and fastest-growing sectors in the world today is the electronics sector, which has seen spectacular growth over the past 25 years in turn, it has resulted in a sharp rise in electronic waste, but the sector lacks in its disposal infrastructure. To mention, in the fiscal year 2021-22, India generated an estimated 16.01 lakh tonnes of e-waste (with an additional 50,000 tons imported from other countries every year) (Bhowmick, 2011)**.** However, only 5.27 lakh tonnes of e-waste were collected and

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JCHR (2023) 13(4), 1479-1498 | ISSN:2251-6727

recycled (representing just 32% of total e-waste) (Prakash, 2023).

Due to its large population, it is anticipated that by 2025, it will be one of the world's biggest buyers of electronic goods and will move up to the fifth rank from twelve (Ojha, 2020). There are currently 562 authorized e-waste recyclers, collectively having a capacity of approximately 1790348.27 metric tonnes per annum. Nevertheless, the official recycling capacity is not fully utilized due to the dominance of the informal sector, which still manages over 90% of e-waste. The informal sector employs nearly a million individuals engaged in manual recycling activities. Since these workers are not registered, it becomes challenging to monitor employment-related issues like labour rights, compensation, and safety measures. The lack of Dismantlers and recyclers, which is mainly concentrated in metropolitan areas, is a significant concern, leading to inadequate disposal of e-waste (Jadhav, 2022).

The world's electronic waste volume has hit 52.2 million tons or 6.8 kg per human by 2021 and will be 63.7 million tons by 2025. This creates a serious concern for the human population as it will be polluting materials in the environment. These pollutants can evaporate into the air from polluted ground and harm water and soil. It will be augmented by plastics and other burning metals. It will further add air pollutants which will condense as residues on crops, market goods specialty food items, and other surfaces. Toxic substances released by discarded e-waste find their way into aquifers and drinking water systems. Human health may be impacted by harmful substances and metals such as polychlorinated biphenyls (PCBs), cadmium, lead, mercury, and cadmium, which cause major health issues for both men and women (Xu et al, 2015).

The existing situation is concerning, and necessitates a comprehensive approach to address the waste challenges and e-waste in particular. Although India has implemented an e-waste management policy (e-waste rule 2016, 2018) aimed at ensuring safe disposal of waste and promoting proper practices, a considerable portion of the population remains unaware of these regulations. Hence, it is crucial to increase consumer awareness among Indians regarding the proper disposal of electrical devices and the potential consequences of mishandling e-waste (Goel et al, 2021). Taking action to enhance public awareness about the significance of reducing e-waste is of utmost importance. And developing novel approaches or models is essential for the efficient treatment of e-waste (Bhat et al, 2012). There should be a greater focus on using materials that are less hazardous, readily recoverable and recyclable. The purpose of this study was to evaluate users and handlers' awareness of government & corporate e-waste management policies and initiatives, the impact of health and household level awareness also. In addition, the study attempts to analyse the influence of demographics of the respondents on the purchase of electronic items and upgradation of electronic items. The impact of government initiative is substantial as evident from the increase in number of dismantling and recycling units in India from 312 in 2020 to 562 in 2022 (Singh et al, (2023).

Literature Review

After sorting the overabundance of relevant studies, this section present review of select studies on e-waste including (i) awareness of government policies and initiatives among the users and handlers, (ii) awareness of health impact of e-waste, (iii) awareness of facets of e-waste at household level, and (iv) awareness of e-waste management policies of the government among users and handlers. The review is not limited to the studies from India.

Awareness of Government & Corporate initiatives among the handlers/users of e-waste

Electronic waste, commonly known as e-waste, has become a global concern due to its environmental and health impacts. As the consumption of electronic devices continues to rise, there is a growing need for effective e-waste management strategies. Governments and corporations play a crucial role in addressing this issue through various initiatives aimed at raising awareness and promoting responsible e-waste disposal. This literature review

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JCHR (2023) 13(4), 1479-1498 | ISSN:2251-6727

examines the existing research and literature related to the awareness of government and corporate initiatives in e-waste management. Gumbo and Kalegele (2015) believed that the users and handlers must be informed of the steps taken by the government to address e-waste issues. On the subject, their findings reveal that only 2.9% of respondents were aware of government initiatives on e-waste in Tanzania, whereas 97.1% of respondents were unaware of these policies & programmes.

Gu et al, (2019) finds out the primary components of the bacterial method for metal extraction are the inorganic acids and oxidising compounds produced by bacteria, which can react with E-waste. The metals included in E-waste are then removed as a last step. These processes make use of both indirect and direct methods. Because fungi may produce organic acids to react with E-waste and can extract metals from E-waste as a final step, their mechanism for removing metals from E-waste differs from that of bacteria. In addition to their reactivity to E-waste, fungi also absorb things. According to laboratory circumstances, both bacteria and fungi can generally extract base metals and precious metals from e-waste. Researchers can choose whichever approach to extract metals. Mor et al, (2021) throws light on the significance of e-waste management techniques for environmental sustainability. A well-structured questionnaire that was given to engineering students in India was used for the research's empirical investigation. Six fundamental levels of understanding about the management, creation, and first treatment processes for e-waste were examined in educational institutions. The results of this study revealed that, despite the notion of extended producer responsibility gaining popularity, still there is a scarcity of knowledge regarding the methods used to create and handle e-waste. They concluded that despite the efforts of capable authorities, very few people are aware of e-waste management.

At the international level, The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal treaty are signed by 192 countries that aims to minimize the generation and transboundary movement of hazardous wastes, including e-waste. Still, awareness level is very low which is evident from the available research with respect to e-waste management policies.

Awareness of health impact of e-waste on users/handlers

There has been a growing interest in the health and environmental impacts of e-waste around the world. This interest is largely due to the realization of the harmful effects of e-waste on the environment and health of the population. E-waste is a collective name for electronic devices dumped as waste. It consists of materials such as plastics, lead, aluminium and silica that can impact health negatively if not properly handled. Mensah and Ababio (2012) explore the perception of health and environmental concerns of workers and residents living close to e-waste recycling sites in Ghana using both qualitative and quantitative research techniques. They find that workers' environment and health perceptions were seriously downplayed and do not match those of epidemiological studies, revealing a lack of convergence between lay and expert knowledge. Kiddee et al, (2013) gives a general overview of the harmful materials included in e-waste, their possible effects on the environment and human health, and the current management approaches being employed in some nations. Gives a general overview of the harmful materials included in e-waste their possible effects on the environment and human health, and the current management approaches being employed in some nations. In nations like India, the way that e-waste is currently stored, processed, recycled, and disposed of has the potential to seriously affect both the environment and human health. (Borthakur (2015)).

Heacock et al, (2016), Grant et al, (2013) highlighted that e-waste exposure is a complex process because there are many routes and sources, different exposure time periods, and possible inhibitory, synergistic, or additive effects of chemicals. Exposure variability may come from the type and quantity of e-waste, length of processing history at sites, and methods and locations of processing activities and physiological

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vulnerability, especially in pregnant women leading to stillbirths, premature births, reduced birthweights and children. Fleischer (2018) states that Ghana currently absorbs 40,000 tons of electronic waste annually and has the largest recycling industry on the continent. The flood of waste & e-waste has led to the eviction of some residents in the receiving region, raising serious health issues. With little information and the indifferent attitude of authorities, communities like Agbogbloshie in the capital city are coping with technological waste and potentially radioactive rubbish. They are the sufferers by the unfavourable consequences brought on by the expansion of the electrical sector.

Sahu (2019) made an effort to gather data on the current level of e-waste generation, information on the parts and hazardous materials that are contaminating the environment and exposing people to these chemicals, and information on the drawbacks of e-waste recycling, incineration, and landfill disposal. India's current e-waste management procedures were found to have a number of flaws, including inadequate rules, inventory issues, health dangers from shady recycling, ignorance, and corporate reluctance to address important issues. Rautela et al, (2021) examined the effects of e-waste management on the atmosphere and the health of humans. The study offers a full analysis of programs to deal with the problem of insufficient e-waste reprocessing procedures and their harmful consequences on the environment and human health. They came to the conclusion that creating an ecologically friendly regulatory structure for recycling would enable them to create an inventory of end-of-life electronic products, which would be necessary for effective management of e-waste.

Ali and Akalu (2022) draws a cross-sectional study to assess the awareness and management of 345 purposely selected e-waste workers including all those who are actively engaged in e-waste buying, selling, dismantling, storing, and transferring. A questionnaire was used to obtain the required information. The findings show that about 92% of the Dismantlers, 70% of the sellers, and 55% of the repair and maintenance workers have poor awareness about the impact of e-waste on health. The awareness level of the respondents is very poor and influenced by several complex factors. During the study period, no study groups were practicing any of the proper e-waste management at all. It is evident from these studies that awareness level of e-waste on health is very low and secondly literature available on awareness is also in scarcity.

Awareness at household level users

Attia et al, (2021) found gaps among households' awareness and disposal behavior of e-waste. It is a result of low level of e-waste recycling rates. Based on these differences, strategies were proposed for an effective e-waste management system in the context of Dubai, and were supported by the proposal of an e-waste legislation framework in the UAE. Tarawneh and Saidan (2013) findings also indicated that a sizable portion of the sample who responded had inadequate awareness of and knowledge of e-waste.

Nuwematsiko et al, (2021) found that consumers of electronics in Kampala lacked understanding about how to handle e-waste, current laws, and final disposal, with some advising burning and others disposing in regular trash.

Abundance and Souza (2019) developed and applied Waste from Electrical and Electronic Equipment (WEEE) estimation method in a Brazilian city. The study is based on primary data that reflects the differences in WEEE generation among the various household or social and economic profiles. They suggested that lifespan distributions are more desirable factors in WEEE estimation studies than discrete averages. They found a significant variation of lifespan profiles for different types of WEEE among the different Zones of the city which are having different social and economic background.

Sivathanu (2016) in his study mentioned that 58.5% of the 600 customers in Pune who participated in the survey were aware of e-waste. Among the informed customers, 88.03 percent are from the high-income category and 94.87 percent are postgraduates or professionals. The findings demonstrate a substantial correlation between consumer knowledge of e-waste and income and education

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JCHR (2023) 13(4), 1479-1498 | ISSN:2251-6727

levels. Additionally, 91.45% of consumers who are knowledgeable favour appropriate e-waste management and disposal.

Effective and responsible management of E-waste is a global concern today. Mella et al, (2015) looks at consumer awareness and attitudes regarding recycling and reuse of mobile phones. The results were evaluated using a theoretical framework based on the theories of planned behaviour (TPB) and value-belief-norm (VBN) and are based on a survey that was performed in the Finnish city of Oulu. The results show that consumers are highly aware of the value and presence of trash recovery systems, but this awareness has not been translated into recycling behaviour.

Almulhim (2022) evaluate household awareness of e-waste, environmental problems associated with improper disposal, and willingness to engage in managing e-waste management in Saudi Arabia. Using a snowball sampling method, an online questionnaire was administered to 523 respondents to gather data on household knowledge of waste management. The collected data indicates that 65.0% of study participants ($n = 340$) were aware of e-waste. However, 69.8% of the study participants ($n = 365$) claimed that they had not been educated on how e-waste poses a serious environmental problem.

Awareness of e-waste management policies among the handlers/Users

Attia Saritha et al, (2014) try to comprehend the public's opinion of e-waste management as well as the many origins and causes of e-waste generation. The purpose of this study is to raise awareness of sustainable practises and difficulties in the handling of electronic trash, particularly waste from personal computers (PCs) and cell phones. We deduced from the study's findings that the majority (90%) of the population is unaware of e-waste and its problems, necessitating the urgent need to raise awareness of this expanding danger. Needhidasan et al, (2014) indicated the current technological challenges, such as e-waste, are becoming more prevalent globally due to technological breakthroughs, industrial development, population growth, and economic expansion. Also, study focuses on the policies framed by the organisations related to e-waste. Borthakur and Govind (2017) highlights the complexity in India's e-waste management system, namely how these complexities are brought about by the e-waste's complex socioeconomic, cultural, and other connected implications that affect consumer disposal behaviour and knowledge. Findings suggest that a given nation's efforts to develop inclusive E-waste management policies for effectively addressing its current E-waste challenge may benefit from learning from experiences around the world regarding consumers' disposal behaviours and knowledge. Perera et al, (2022) focuses on the reusing and recycling of e-waste because it helps restore precious metal components, which are quickly running out. It has been carefully investigated how the general public views recycling electronic garbage as well as its difficulties and restrictions as a new business model. The study's finding shows how successfully investigate consumer perceptions, which may be used to develop a sustainable business model to assess managing e-waste.

In addition, there are studies with respect to perception and awareness among youth in different part of the world. To mention, Ramzan et al, (2019) made an exploratory effort to look into young consumers' participation, awareness, and knowledge of sustainable e-waste management techniques. The study also examines China's e-waste recycling practises, legislative framework, and current state of the field. The poll found that while respondents had strong environmental awareness, they knew little about the rules and laws governing e-waste, recycling programmes, and the formal and informal recycling industries. In order to encourage environmental awareness and sustainable e-waste management practises among young customers in China, the findings offer practitioners insightful information. Goel et al, (2021) examines the various ways that customers' attitudes towards e-waste can be changed, assisting the society in handling e-waste better and putting a focus on effective and efficient e-waste disposal. The findings indicate that there are five crucial aspects that influence client decision-making during e-waste disposal. This is preceded by

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many stakeholders in the management of e-waste being aware of the poisonous adverse effects on human health, environmental awareness threats, awareness of e-waste disposals, and understanding of the value and convenience of recycling. Islam et al, (2021) studied using a questionnaire survey in Sydney, Australia to gauge young consumers' awareness of, perceptions of, and disposal patterns for waste electrical and electronic equipment (WEEE). The results offer insightful information for legislators creating sustainable e-waste management plans among young Australian consumers.

Motivation for this study

Based on the review and analysis of past studies, it has been observed that there are certain gaps in the context of awareness of e-waste policies, initiatives of government and corporates among the users and handler at an individual and household level in Indian context. Though this study is exploratory in nature, but it fills some gaps in the existing literature as evident from the research objectives given in the following.

Objectives of the Study

After identifying the research gap, following objectives were framed in the study: -

1. To study the general awareness level of respondents on the electronic waste management & variation among different segments of respondents.
2. To identify the awareness of government & corporate initiatives among the handlers/users of e-waste.
3. To evaluate the awareness of users/handlers about the e-waste management policies.
4. To ascertain the users' and handlers' awareness of the health effects of e-waste.
5. To study the association or dependency of electronic items purchase decisions with the demographics of sample units.
6. To study the association or dependency of upgradation of electronic items with the demographics of sample units.
7. To identify major factors/ dimensions based on data collected on 13 statements.

Research Methodology

The context

The data is collected from the users and handlers of e-waste. A person who uses an electronic device in any way is called as a user in this study. On the other hand, E-waste handlers are individuals or entities engaged in the collection, dismantling, and recycling of discarded electronic products to recover valuable materials and minimize environmental impacts.

A comprehensive literature search was performed in order to identify the current state of the art as regards consumer awareness related to e-waste management and also what are their perception regarding e-waste and its management. The analysis is conducted on the basis of the database collected through primary data via questionnaire and secondary data via reports, articles, etc. This descriptive research study aims to comprehend how households in Delhi NCR perceive and are aware of e-waste. Both primary and secondary data were gathered for this study. A structured questionnaire with closed-ended questions utilizing a five-point Likert scale was used for the main survey.

Sampling Units

Sample of study consisted of users and handlers. The convenience sampling approach was used to choose the sample of respondents in order to conduct the study and determine the awareness and other aspects of e-waste management. Our definition of convenience sampling includes only one dimension that is easy access to the sample units otherwise it was a random selection of individuals from the population. A sample of 89 users and handlers from Delhi NCR is selected to collect primary data using a structured questionnaire.

Questionnaires were handed over to the respondents with a request for filling at the spot. Due care has been taken to reduce possible biases in selecting the respondents who are not many in handler category. Further into it, an in-depth examination was done for each filled-in questionnaire to check the consistency of data. The incomplete questionnaires were rejected for the further analysis. The questionnaire had the following dimensions:

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(i) Demographics of the respondent such as gender, age, educational qualification, marital status, occupation, status in e-waste domain.
(ii) Association or dependency of electronic items purchase decisions with demographics of sample units.
(iii) Association or dependency of upgradation of electronic items with demographics of sample units.
(iv) Comparisons of awareness of policies of e-waste management, government & corporate initiatives, impact on health, and awareness of e-waste management at household level.

Sample size

It is an exploratory study, a sample size of 180 to 200 thought to be an adequate one. Accordingly, 200 respondents from the target population were approached to fill in the questionnaire. Out of 200, only 120 respondents agreed to fill the questionnaire. After thorough examination of the filled in data, 89 questionnaire data was considered for analysis.

Selection of respondents

NCR region consists of Capital city Delhi, parts of the Indian states of Uttar Pradesh and Haryana. As per the latest statistics available, Haryana and Uttar Pradesh together constitute approximately 44% capacity for dismantling and recycling of e-waste in India (Singh et al, (2023). The employee (designated as handlers) of these units were contacted for the purpose of collection of data with little success. Therefore, approximately equal number of respondents were identified in the category of users.

Data Analysis Methods

Data were subject to statistical analysis such as descriptive statistical analysis and frequency distribution. This analysis was applied to mainly categorized data. To Likert scale data, reliability analysis is applied before subjecting the data for testing mean different using t-test, F-test for carrying out factor analysis. The reliability analysis was done with a view to identify inconsistencies in the data set. Chi-square test statistic is applied to test the association of electronic items purchase decisions and upgradation of electronic items with demographics. Though, this exploratory study does not consist of a large number of statements/variables but still data were subjected to factor analysis as one of the most used tools for exploratory data analysis. It explains the association occurring between Likert scale level responses of the respondents.

Results & Discussion

This section presents the descriptive statistics of demographics of respondents, results of testing of various hypotheses of statements/questions asked to respondents in relation to various categories of respondent demographics. As mentioned in research methodology, the study includes Likert scale data on construct identified in relation to e-waste management. Likert scale data is subjected to data reduction technique, i.e., factor analysis, reliability tests (Cronbach Alpha), analysed data is collected along with factor analysis, validity and reliability are presented in this section.

Demographic Profile of the Respondents

The demographic profile of the respondents on the basis of age, gender, marital status, qualification, Occupation and role in E-waste management are presented in Table 1 and 2. It is evident from Table 1 that the majority of the respondents are male (69.7%) as compared to female respondents (30.3%). The respondents' age distribution shows a higher representation of individuals aged 30 to 45 years (47.2%), followed by those less than 30 years old (28.1%), and a 24.8% of respondents in the age groups of more than 45 years. Regarding marital status, the majority of the respondents were married (76.4%), while a smaller portion reported being unmarried (23.6%). The detail data of marital status is not included due to paucity of space and lack of variation in the average awareness score.

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Table 1 Frequency distribution & awareness score of respondents as per their gender & age

Items/ Statements	**Average Awareness Score**				
	Gender		**Age**		
	Male	**Female**	**<30**	**30-45**	**>45**
	62 (69.7)	27 (30.3)	25 (28.1)	42 (47.2)	22 (24.8)
E-waste policies of government in managing e-waste.	4.5± 0.01	3.2± 0.03	4.0± 0.02	4.0± 0.03	4.4± 0.02
Extended Producer Responsibility (EPR) policy of E-waste in India	4.2± 0.01	3.5± 0.04	3.8± 0.01	4.2± 0.02	3.8± 0.01
E-waste impact on environment	4.8± 0.02	3.8± 0.05	4.1± 0.03	4.6± 0.03	4.8± 0.02
Guidelines issued by government and corporates	4.0± 0.03	3.3± 0.06	2.3± 0.03	4.3± 0.03	4.5± 0.04
Training E-waste Handling	4.3± 0.03	3.3± 0.04	4.2± 0.03	4.1± 0.01	3.6± 0.03
E-waste rule 2016 and its amendments	3.0± 0.02	3.0± 0.06	2.0± 0.03	3.3+ 0.01	3.6± 0.02
E-waste 2018	2.9± 0.04	3.6± 0.05	1.3± 0.01	3.7± 0.02	3.9± 0.06
Policies regarding subsidies for creating e-waste management facilities	4.4± 0.02	3.4± 0.06	3.3± 0.02	4.3± 0.03	4.6± 0.03
Adequate network & management of e-waste recycling	3.0± 0.01	4.0± 0.02	3.5± 0.03	3.2± 0.03	3.3± 0.01
Framework of E-waste management	3.4± 0.01	4.0± 0.01	4.0± 0.03	3.3± 0.02	3.0± 0.00
Handling E-waste among households	3.5± 0.03	3.5± 0.03	2.7± 0.03	3.7± 0.03	4.0± 0.03
General awareness E-waste among households	3.9± 0.01	3.0± 0.01	2.8± 0.02	3.8± 0.02	4.1± 0.07
E-waste impact of health on citizens	4.5± 0.02	3.9± 0.03	3.6± 0.03	4.5± 0.03	4.7± 0.04
Source: Author(s)					

The average score of awareness of these statements is also calculated with respect to demographics of the respondents. Based on the average score for different categories of the demographics it is inferred that awareness is more among male respondents in comparison to female respondents except for (i) e-waste policy 2018, (ii) adequate network & management of e-waste recycling, and (iii) framework of e-waste management. For the majority of the statements, awareness level is more in the age group of 30-45 years except for the statement (i) e-waste policies of government in managing e-waste, (ii) training on e-waste handling, (iii) e-waste policy 2018, (iv) adequate network & management of e-waste recycling, and (v) framework of e-waste management (table 1).

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Table 2 Frequency distribution & awareness score of the respondent as per their academic qualification, occupation and role in e-waste

Items/ Statements	**Average Awareness Score**							
	Academic qualification			**Occupation**			**Role in e-waste**	
	Graduate	**PG**	**PQ**	**Business**	**Service**	**Professional**	**Users**	**Handlers**
	34 (38.2)	47 (52.8)	8 (9.0)	28 (31.5)	45 (50.6)	15 (16.9)	40 (44.9)	49 (55.1)
The policies of government in managing e-waste	3.8± 0.01	4.3± 0.03	4.1± 0.02	4.7± 0.04	3.7± 0.04	4.4± 0.03	3.4± 0.03	4.7± 0.02
EPR policy of E-Waste in India	4.0± 0.02	4.0± 0.02	3.8± 0.02	4.6± 0.01	3.6± 0.05	4.3± 0.03	3.6± 0.04	4.3± 0.03
E-waste impact on environment	4.0± 0.03	4.9± 0.02	4.6± 0.02	4.9± 0.10	4.3± 0.04	4.7± 0.02	4.9± 0.03	4.2± 0.04
Guidelines issued by government and corporates	3.0± 0.04	4.3± 0.01	4.1± 0.03	4.3± 0.04	3.5± 0.05	4.1± 0.03	3.4± 0.03	4.1± 0.02
Training E-waste Handling	3.4± 0.02	4.4± 0.02	4.2± 0.03	4.0± 0.05	4.0± 0.05	4.3± 0.02	4.0± 0.04	4.0± 0.04
E-waste Rule 2016 and amendments	3.2± 0.02	2.8± 0.02	3.5± 0.04	2.8± 0.03	3.1± 0.04	3.0± 0.04	2.4± 0.03	3.5± 0.03
E-waste Rule 2018	3.1± 0.04	3.1± 0.01	3.3± 0.03	3.5± 0.02	2.9± 0.03	3.3± 0.03	4.0± 0.04	2.7± 0.03
Subsidies policies creating e-waste Mgt facilities	3.5± 0.03	4.5± 0.02	4.3± 0.04	3.9± 0.01	4.2± 0.04	4.3± 0.03	3.9± 0.03	4.3± 0.03
Adequate network & management of recycling	3.7± 0.03	3.0± 0.03	3.5± 0.01	3.3± 0.05	3.3± 0.03	3.4± 0.05	3.5± 0.04	3.1± 0.04
Framework of E-waste Mgt	2.7± 0.02	3.9± 0.02	3.6± 0.01	3.9± 0.02	3.1± 0.05	3.6± 0.02	3.9± 0.04	3.0± 0.03

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Handling E-waste among households	3.1± 0.01	3.8± 0.04	3.5± 0.02	3.2± 0.02	3.8± 0.04	3.4± 0.02	3.1± 0.03	3.8± 0.02
General awareness E-waste among households	2.8± 0.04	4.1± 0.02	3.9± 0.03	4.0± 0.03	3.3± 0.03	3.9± 0.03	3.4± 0.03	3.8± 0.05
E-waste impact of health of citizens	3.6± 0.02	4.8± 0.01	4.5± 0.04	4.8± 0.01	4.0± 0.05	4.5± 0.02	4.1± 0.04	4.5± 0.02
Source: Author(s)								

The results presented in Table 2 divulges that the respondents' educational qualification is relatively high as the number of respondents with post-graduate qualifications are 52.8% compared to 38.2% with graduate qualifications. A smaller percentage of respondents held professional qualifications (9.0%). Regarding occupation, the sample has a relatively balanced representation, with a slightly higher percentage of respondents in service occupations (50.6%) compared to those in business (31.5%). Representation of respondents with professional occupations was 16.9%. Only one respondent fell into the "Others" category for occupation (1.1%). In terms of roles related to e-waste domain, the study has a higher proportion of "Handlers" (55.05%) as compared to "Users (Creator of e-waste)" (44.9%).

Analysis of average awareness score reveals that the awareness level among post graduate (PG) degree holders is higher except for three statements / parameters, i.e., (i) e-waste rule 2016 an its amendments, (ii) e-waste rule 2018, and (iii) adequate network & management of e-waste recycling. The comparative analysis of average awareness scores for three categories of occupation reveals that awareness level is higher among business category of respondents for 8 statements except for (i) training of e-waste handling (higher among professionals), (ii) e-waste rule 2016 and its amendments (higher among respondents who are in service), (iii) subsidies policies (higher among professionals), (iv) adequate network & management of recycling (higher among professionals), and (v) handling of e-waste among households (higher among respondents with services background). Analysis of average awareness score for two categories of respondents based on role in e-waste reveals that awareness levels are higher among handlers except for four statements, i.e., (i) e-waste impact on environment, (ii) e-waste rule 2018, (iii) adequate network & management of recycling, and (iv) framework for e-waste management (Table 2).

Association of demographics and purchase decision of electronic items

This section presents the analysis of dependency of purchase decision of electronic items and upgradation of electronic items with the demographic background of the respondents. To analyse the statistical significance of the association, the Chi-square test for independence was conducted for each demographic and presented in table 3 and 4. The purchase decision is measured as influenced by necessity, status symbol & increase in income, added features, and advertisement The computation of the chi- square test is done to test the following hypotheses.

i. For gender

H_0: There is no association between gender and influence on the purchase of electronic items.

H_1: There is an association between gender and influence on the purchase of electronic items.

ii. For age

H_0: There is no association between age and influence on the purchase of electronic items.

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H_1: There is an association between age and influence on the purchase of electronic items.

iii. For educational qualification

H_0: There is no association between educational qualification and influence on the purchase of electronic items.

H_1: There is an association between educational qualification and influence on the purchase of electronic items.

iv. For occupation

H_0: There is no association between occupation and influence on the purchase of electronic items.

H_1: There is an association between occupation and influence on the purchase of electronic items.

v. For Marital Status

H_0: There is no association between Marital Status and influence on the purchase of electronic items.

H_1: There is an association between Marital Status and influence on the purchase of electronic items.

vi. For Users' and handlers' awareness of the health effects of e-waste

H_0: There is no association between the awareness level of Users' and handlers' towards the health effects of e-waste and influence on the purchase of electronic items.

H_1: There is an association between awareness level of Users' and handlers' towards the health effects of e-waste and influence on the purchase of electronic items.

As presented in Table 3, the Chi-square tests did not find any statistically significant associations between the age, gender, & marital status in influencing the purchase of electronic items as the p-values are greater than the significance level of 0.05. It implies that the influencing factors such as necessity, new added advanced features, status symbol and increase in income, and advertisement on electronic item purchases have a similar impact across different demographic categories, and variations in electronic item purchases are not primarily attributed to gender, age, or marital status differences among the respondents.

Table 3 Analysis of influence of respondents on the basis of gender, age & marital status for purchase of electronic items

Electronic Items purchase Influenced by	**Male (%)**	**Female (%)**	**< 30 years (%)**	**> 30 years (%)**	**Married (%)**	**Unmarried (%)**	**Total (%)**
Necessity	26 (22.99)	7 (10.01)	5 (9.27)	28 (23.73)	27 (25.21)	6 (7.79)	33 (37.07)
New added advanced features	15 (16.02)	8 (6.98)	7 (6.46)	16 (16.54)	18 (17.57)	5 (5.43)	23 (25.84)
Status symbol and increase in income	9 (9.75)	5 (4.25)	5 (3.93)	9 (10.07)	9 (10.70)	5 (3.30)	14 (15.73)
Advertisement	12 (13.24)	7 (5.76)	8 (5.34)	11 (13.66)	14 (14.52)	5 (4.48)	19 (21.34)
Total	62 (69.66)	27 (30.33)	25 (28.08)	64 (71.91)	68 (76.40)	21 (23.59)	89 (100)
	The chi-square statistic is 2.0872. The p-value is 0.554502. The result is not significant at p < .05.		**The chi-square statistic is 5.048. The p-value is 0.168314. The result is not significant at p < .05.**		**The chi-square statistic is 1.7989. The p-value is .0615166. The result is not significant at p < .05.**		
Source: Author(s)							

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Table 4 Analysis of influence on respondents on the basis of qualification, occupation & awareness of e-waste for purchase of electronic items

Electronic Items purchase Influenced by	**Graduate (%)**	**Post graduate & professional (%)**	**Business & professional (%)**	**Service (%)**	**Users (%)**	**Handlers (%)**	**Total (%)**
Necessity	11 (12.61)	22 (20.39)	9 (16.31)	24 (16.69)	5 (14.83)	28 (18.17)	33 (37.07)
New added advanced features	9 (8.79)	14 (14.21)	14 (11.37)	9 (11.63)	14 (10.34)	9 (12.66)	23 (25.84)
Status symbol and increase in income	7 (5.35)	7 (8.65)	9 (6.92)	5 (7.08)	9 (6.29)	5 (7.71)	14 (15.73)
Advertisement	7 (7.26)	12 (11.74)	12 (9.39)	7 (9.61)	12 (8.54)	7 (10.46)	19 (21.34)
Total	34 (38.20)	55 (61.79)	44 (49.43)	45 (50.56)	40 (44.94)	49 (55.05)	89 (100)
	The chi-square statistic is 1.1801. The p-value is 0.757792.		**The chi-square statistic is 10.3539. The p-value is 0.015786.**		**The chi-square statistic is 18.8586. The p-value is 0.000292.**		
Source: Author(s)							

The table 4 indicates that there is a significant association between the factors influencing the purchase of electronic items and the occupation of respondents (business & professional or service) as well as the respondents' role in e-waste (users or handlers) as the p-values are less than the significance level of 0.05. However, there was no significant association between the factors influencing purchase and respondents' educational qualifications. This suggests that the occupation of respondents and status as users & handlers of e-waste plays a significant role in influencing the electronic item purchase behaviour.

Frequency of upgradation of Electronic Items

Table 5 and 6 shows thirst for the dependence of the frequency of upgradation of electronic items with respect to same six demographics. To analyse the statistical significance of the association/dependency, the data was subjected to Chi-square test for independence to test the following hypotheses. The frequency of upgradation is categorised as frequently, regularly, occasionally, and rarely on a time horizon of 1 year to more than 8 years.

i. For gender

H_0: There is no association between gender and frequency of upgradation of electronic items**.**

H_1: There is an association between gender and frequency of upgradation of electronic items**.**

ii. For age

H_0: There is no association between age and frequency of upgradation of electronic items**.**

H_1: There is an association between age and frequency of upgradation of electronic items**.**

iii. For educational qualification

H_0: There is no association between educational qualification and frequency of upgradation of electronic items**.**

H_1: There is an association between educational qualification and frequency of upgradation of electronic items**.**

iv. For occupation

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H_0: There is no association between occupation and frequency of upgradation of electronic items**.**

H_1: There is an association between occupation and frequency of upgradation of electronic items**.**

v. For Marital Status

H_0: There is no association between Marital Status and frequency of upgradation of electronic items**.**

H_1: There is an association between Marital Status and frequency of upgradation of electronic items**.**

vi. For Users' and handlers' awareness of the health effects of e-waste

H_0: There is no association between the awareness level of Users' and handlers towards the health effects of e-waste and frequency of upgradation of electronic items**.**

H_1: There is an association between awareness level of Users' and handlers towards the health effects of e-waste and frequency of upgradation of electronic items**.**

As presented in Table 5, the chi-square statistic value as 17.01 with the p-value as 0.0007 is less than 0.05 only for age, indicating that there is a significant association between age group and the frequency of upgrading electronic items. The gender and marital status demographics do not show strong evidence of a significant association.

Table 5 Analysis of frequency of upgradation of electronic items on the basis of gender, age & marital status

Upgradation of electronic items	**Male (%)**	**Female (%)**	**< 30 years (%)**	**30-60 years & above (%)**	**Married (%)**	**Unmarried (%)**	**Total (%)**
Frequently (Within 1-2 years)	10 (10.45)	5 (4.55)	9 (4.21)	6 (10.79)	10 (11.46)	5 (3.54)	15 (16.85)
Regular basis (2-5 years)	33 (29.26)	9 (12.74)	5 (11.80)	37 (30.20)	37 (32.09)	5 (9.91)	42 (47.19)
Occasionally (5-8 years)	13 (14.63)	8 (6.37)	5 (5.90)	16 (15.10)	15 (16.04)	6 (4.96)	21 (23.59)
Rarely (8 years & more)	6 (7.66)	5 (3.34)	6 (3.09)	5 (7.91)	6 (8.40)	5 (2.60)	11 (12.35)
Total	62 (69.66)	27 (30.33)	25 (28.08)	64 (71.91)	68 (76.40)	21 (23.59)	89 (100)
	The chi-square statistic is 3.4285. The p-value is 0.330152.		**The chi-square statistic is 17.0102. The p-value is 0.0007.**		**The chi-square statistic is 7.1769. The p-value is 0.066467.**		
Source: Author(s)							

Table 6 Analysis of frequency of upgradation of electronic items on the basis of qualification, occupation & awareness of e-waste

Frequency to upgrade your electronic items	**Graduate (%)**	**Post graduate & professional (%)**	**Business & professional (%)**	**Service (%)**	**Users (%)**	**Handlers (%)**	**Total (%)**
Frequently (Within 1-2 years)	9 (5.73)	6 (9.27)	10 (7.42)	5 (7.58)	5 (6.74)	10 (8.26)	15 (16.85)

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Regular basis (2-5 years)	9 (16.04)	33 (25.96)	17 (20.76)	25 (21.24)	20 (18.88)	22 (23.12)	42 (47.19)
Occasionally (5-8 years)	10 (8.02)	11 (12.98)	12 (10.38)	9 (10.62)	10 (9.44)	11 (11.56)	21 (23.59)
Rarely (8 years & more)	6 (4.20)	5 (6.80)	5 (5.44)	6 (5.56)	5 (4.94)	6 (6.06)	11 (12.35)
Total	34 (38.20)	55 (61.79)	44 (49.43)	45 (50.56)	40 (44.94)	49 (55.05)	89 (100)
	The chi-square statistic is 10.0577. The p-value is 0.018082.		**The chi-square statistic is 3.6992. The p-value is 0.295832.**		**The chi-square statistic is 1.0006. The p-value is 0.801118.**		
Source: Author(s)							

The table 6 indicates that there is a significant association between educational background and the frequency of upgrading electronic items as the p-value is less than the significance level of 0.05 or 5%. However, there was no significant association between the remaining two demographics, i.e., roles & occupation with the frequency of upgrading. This suggests that the education level of respondents plays a significant role in influencing their frequency of upgrading electronic items. To conclude education background and occupation plays a significant role in upgradation of electronic items.

In all there were 13 statements presented to respondents to rate these statements at 5-point Likert scale. These statements are about various facets of awareness of e-waste management in India. These statements were chosen after a thorough literature analysis, discussions with specialists. The collected data of 13 statements are subjected to factor analysis/data reduction with a view to find out inherent dimensions or factors. The objective is to have a smaller number of variables or dimensions or factors so that it is easy to understand and make decision with key factors. The result of factor analysis with rotated component matrix is given in Table 7.

Factor Analysis

Table 7: Factor analysis–Rotated Component Matrix

Items/ Statements	**Component**				**Average Awareness Scores**
	1	2	3	4	
E-waste policies of government in managing e-waste	0.535				4.1 ±0.02
Extended Producer Responsibility (EPR) policy of E-Waste in India	0.678				4.0 ±0.01
E-waste impact on environment				0.663	4.5 ±0.02
Guidelines issued by government and corporates		0.883			3.8 ±0.04
Training E-waste Handling		0.673			4.0 ±0.03
E-waste rule 2016 and its amendments	0.902				3.0 ±0.02

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E-waste rule 2018	0.872				3.1 ±0.06
Policies regarding subsidies for creating e-waste management facilities	0.592				4.1 ±0.03
Adequate network & management of e-waste recycling	0.784				3.3 ±0.01
Framework of E-waste management		0.727			3.4 ±0.00
Handling E-waste among households			0.856		3.5 ±0.03
General awareness E-Waste among households			0.817		3.6 ±0.07
E-waste impact of health of citizens				0.653	4.3 ±0.04
The variance explained (%)	37.511	11.585	09.779	08.132	
Cumulative Variance Explained (%)	37.511	49.096	58.875	67.007	
Extraction Method: PCA					
Rotation Method: Varimax Using K Normalization					
Source: Author(s)					

Based on the results of this study, it can be inferred based on average awareness score given in table 7. that health and environment related awareness level of users and handlers of the electronic waste management is maximum in comparison to other three dimensions, i.e., awareness of government policies, awareness at households' level, and awareness of government and corporate initiatives.

To know the awareness of government policies, the respondents were asked to rate their awareness on six statements about government policies, i.e., (i) e-waste policies of government in managing e-waste, (ii) regulatory policy such as extended producer responsibility (EPR). (iii) E-waste rule 2016 and its amendments, (iv) e-waste rule 2018, (v) policies regarding subsidies for creating e-waste management facilities, (vi) adequate network & management of e-waste recycling. As is evident from the average score of awareness, respondents' awareness is more about general statements such as government policies (4.1). Policies of subsidies (4.1) and EPR (4.0). However, their awareness is low about specific laws enacted by government, i.e., e-waste rule 2016 (3.0), e-waste rule 2018 (3.1), adequate network & management of recycling (3.3). People believe that government always extends financial help for activities related to health and environment to the industry, therefore, their score about the awareness of the subsidiaries is higher in comparison to adequate network and management for recycling.

The respondents were presented three statements about government & corporate initiatives, i.e., (i) guidelines issued by government and corporates, (ii) training on E-waste handling, and (iii) framework for E-waste management and respondents were requested to rate these statements. It can be seen that respondents are more aware about training on e-waste handling (4.0) in comparison with guidelines issued by government and corporate (3.8) and the framework of e-waste management (3.4). It is based on the average score of awareness (table 7).

The criteria for identifying factors or dimensions are based on eigenvalues >1. As a consequence, only four components or factors or dimensions having more than one eigenvalue were identified for making use of the finding of the study by policy makers. More than 67 % of the original value's variability was explained by these 4 factors or dimensions of latent variables which is adequate as per the norms (Goyal & Singh (2007)). The nomenclature of four identified factors along with factor loading is listed in table 8. The values of factor loading are within norms of variability explained by new identified factors or dimensions.

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Table 8 Nomenclature of the factors along with factor loading

Factor	Items/ Statements	Factor Loading	Factor Name
1 (6)	E-waste policies of government in managing e-waste	0.672	Awareness of Policies of e-waste management
	Regulatory policy such as Extended Producers Responsibility (EPR)	0.711	
	E-waste rule 2016 and its amendments	0.706	
	E-waste rule 2018	0.745	
	Policies regarding subsidies for creating e-waste management facilities	0.606	
	Adequate network & management of e-waste recycling	0.784	
2 (3)	Guidelines issued by government and corporates	0.769	Awareness of Government & Corporate Initiatives
	Training of E-waste Handling	0.729	
	Framework of E-waste management	0.817	
3 (2)	E-waste impact on environment	0.700	Awareness of health impact
	E-waste impact of health of citizens	0.811	
4 (2)	Handling E-waste among households	0.710	Awareness e-waste at household level
	Awareness E-Waste among households	0.875	
Factors extracted from Factor Analysis			
Source: Author(s)			

It is evident from table 8 that policy makers may pay attention to the awareness about four dimensions, i.e., (i) Policies of e-waste management, (ii) Government & Corporate Initiatives, (iii) health and environmental impact, and (iv) e-waste at household level.

Validity and Reliability Test

Factor analysis is preceded with validity and reliability test for checking the adequacy of data for factor analysis. The validity and reliability of the data were checked through Kaiser-Meyer-Olkin (KMO), Bartlett's Test of sphericity and Cronbach's Alpha (Table 9). The Kaiser-Meyer-Olkin (KMO) Test is used to determine adequacy of sampled data for factor analysis. The test measures sampling adequacy for each variable in the model and for the complete model. The KMO is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited your data is to Factor Analysis. If its value is more 0.8 that also in this case indicate adequacy of sampling. Additionally, the significance value from Bartlett's Test of Sphericity was found to be less than 0.05, confirming that the scale is acceptable and that there are significant correlations between the variables. It means the sample is not taken from the population wherein the correlation matrix of statements is unit matrix. Thus, both tests affirm that the data is appropriate for factor analysis, as there are strong inter-connections among the variables. The Cronbach's alpha score obtained was 0.821, which is deemed to be a good level of reliability.

Table 9 Reliability Co-efficient, KMO and Bartlett test

Reliability coefficient – Cronbach's alpha	KMO- Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Test
0.821	0.802	Chi-Square- 458.814, Degree of freedom- 78, P-value = 0.000.
Source: Author(s)		

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Conclusion

In the present-day context, the electronic items are purchased due to necessity in daily life instead of leisure purpose. Mobile is becoming like cloths. People want to be connected while at work at home or during travel. The life of mobile phones may be 20 years, but users replace the mobile phone early due to new features. Similarly, other electronic items are replaced earlier than their useful life. This trend is bound to result in more e-waste in the days to come. Based on the analysed data & its interpretation presented in earlier sections, following is concluded.

The general awareness level of respondents on the electronic waste management is more than average as evident from average scores presented in table 1, 2, and 6. Variation in average awareness scores with respect to demographics of the respondents indicates that awareness is more among male respondents in comparison to female respondents. The awareness is higher among the respondent of age between 30 -45 years in comparison to other age categories. Respondents with post graduate qualification are more aware of e-waste management. In addition, awareness is more among the respondents with business background and are handled of e-waste. The respondent's awareness in general more about the policies of e-waste management and impact of health and environment in comparison to government and corporate initiatives for managing e-waste.

Result of association or dependency of frequency of purchase of electronic items reveals that gender and education have a significant association with purchase decisions. The majority of respondents reported that they purchase electronic items due to necessity followed by newly added advanced features. On the other hand, age and education level have a significant association with frequency of upgradation. The majority of respondents upgrade their electronic tolls within 2-5 years. Based on the results of factor analysis, four dimes/ factors emerged in the context of e-waste management. These emerged dimensions are aware of the policies of e-waste management, awareness of government and corporate initiatives, awareness of impact on health, and awareness of e-waste at household level.

Suggestions

Results indicate good awareness about e-waste management among respondents. However, there is a need enhance it. Government agencies may take initiatives to increase the awareness by running campaign time to time towards e-waste management at household levels. The public has to be made aware of the proper methods for disposing of e-waste, the negative impacts of e-waste, the necessity for segregation at collection locations, consumer protection regulations regarding e-waste, and the construction of disposal sites.

In addition, government may initiate programs to encourage producers to reduce the hazardous level of future electronic waste by investing in research & development. Regulation in place should be monitored for the efficient enforcement of the provision of 2016 and 2018 e-waste management acts. Infrastructure needs to be developed for recycling of ever-increasing e-wastes. Government & corporates should sign the MOU with foreign nations and can collectively work towards tackling e-waste. Informal sector of e-waste recycling too needs to be taken care of along with organized sectors of e-waste recycling.

Implications of study

Results of studies with respect to understanding & awareness of e-Easte among the stakeholders of the ecosystem of e-waste and e-waste management, will impact the success of government policies and initiatives, and reduce the impact of unscented handling of e-waste on health and environment. Study also reveals that in emerging economy like India, the appropriate authorities, set up for standard operating procedures for managing and processing e-waste in a sustainable way, need to be strengthened further.

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