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The INDUSEM position paper on the emerging electronic waste management emergency.

Authors: Nayer Jamshed, Praveen Aggarwal, Sagar Galwankar and Sanjeev Bhoi

Date: Jan-March 2020

From: Journal of Emergencies, Trauma, and Shock(Vol. 13, Issue 1)

Publisher: Medknow Publications and Media Pvt. Ltd.

Document Type: Article

Length: 3,167 words

Lexile Measure: 1860L

Full Text:

Byline: Nayer. Jamshed, Praveen. Aggarwal, Sagar. Galwankar, Sanjeev. Bhoi

Electronic waste or e-waste is a serious and concerning issue globally. Exponential increase in the production of these instrument have created a man-made problem of e-waste; United Nations has called it as 'tsunami of e-waste.' Informal management and unsafe disposals have compounded the problem further. The hazardous chemicals, metals, and organic pollutants released from e-waste can lead to serious health consequences such as organ damage, genetic defects, neuropsychiatric illness, and cancer. Problem of e-waste is colossal and should be seen as major public health emergency. In India, use of electronic instrument has increased considerably with less focus on formal waste management and safe disposal. This has created a major health hazard. International health agencies, Indian Council of Medical Research, e-waste regulating bodies, academic institutes, and various government and non-government organizations should join hands together to effectively manage the problems of e-waste. Swacch Bharat Abhiyan started by the honorable Prime Minster should consider e-waste as the top most priority in terms of its safe management and disposal.

Introduction

Across the globe, the electronic and electric devices are being used in staggering quantity.[1] These include numerous products such as computers and laptops, household appliances, batteries, medical devices including cardiac monitors, toys, mother board, mobile phones, and cathode ray tubes.[2] The list is endless; it is just to enumerate few of them. Exponential increase in their utility has created a new man-made problem of electronic waste or e-waste. E-waste contains potentially hazardous substances produced due to unsafe and inappropriate management practices related to dismantling, recycling and disposal of end-of-life electrical and electronic equipment. As new electronic and electric gadgets are continually introduced into the market, consumers get enticed to change their existing products that are either damaged or outdated. The resulting mass of electronic products discarded has become the fastest-growing waste in the world.[3] Improper electronic waste management, may lead to contaminations in terms of air, soil, water pollution, which may adversely affect human health and environment. Large amount of electronic waste may also cause global warming and climate change which is one of the major challenges faced by both developing as well as developed countries.

Magnitude of the Problem

Globally, 50 million metric tons of e-waste was estimated to be generated in 2018.[4] If it remains unchecked, this could reach up to 120 million tonnes by the year 2050; that is why United Nations has called it as 'tsunami of e-waste.'[5] According to 2014 estimates, the top e-waste producer was the United States, which generated 7.1 million tonnes (Mt), followed by China, which generated nearly 6.0 Mt. When the amount of e-waste produced was considered per person, the countries within Europe generated an average of 15.6 kg of e-waste, closely followed by Oceania 15.2 kg and American 12.2 kg.[4],[6] About 80% of the e-waste generated globally is recycled in informal settings, mainly in developing countries such as Nigeria, Ghana, China, India, Vietnam, Thailand, and Philippines.[7] World Economic Forum and the World Business Council for Sustainable Development have released a joint report, which estimated the material value of our spent devices; globally, this amount is \$62.5 billion/year. More than 120 countries have an annual GDP lower than the value of our growing pile of global e-waste.[8]

E-Waste in India

India is the fifth largest electronic waste producer in the world, with an estimate of approximately 2 million tons of e-waste generation annually. Undisclosed amount of e-waste, imported from other countries has further compounded the problem.[9] According to

Manufacturer's Association for Information Technology, India, in 2007 an estimated, 50,000 tons of e-waste was imported from developed countries as 'charity for reuse.' [10] This imported e-waste mostly ends up in informal recycling facilities either immediately or after the reused product is discarded.

Metropolitan cities produce the major chunk of these e-waste with 24% of the estimated e-waste produced from Mumbai, while Delhi, Bengaluru and Chennai production of e-waste were 21.2%, 10.1% and 9.1%, respectively. [11] Majority of e-waste in India is generated from computer devices which account for nearly 70% of the e-waste, while 12% comes from the telecom sector, 8% from medical equipment and 7% from electric equipment. The government, public sector companies, and private sector companies generate nearly 75% of electronic waste, with the contribution of individual household being only 16%. [12] In India, use of mobile phones, tablets, and laptops are on the exponential rise. According to estimates, 1.012 billion active mobile connections were present in January 2018. [13] With changing consumer behavior and rapid economic growth, it is estimated that India will generate 5.2 million tonnes of e-waste by 2020. [14]

Recycling of Electronic Waste

E-waste is often used for possible refurbishment, remanufacture and reuse various parts for repair. It is estimated that only 25% of valuable metals are recovered during informal e-waste recycling while 75% of this waste are junks. [15] Formal recycling of e-waste which does not compromise the health of workers and the environment, is resource intensive, and is rarely practiced. Instead, informal recycling is often practiced to retrieve valuable elements such as gold, platinum, silver, palladium, and copper without the use of technology required to minimize exposure or protective equipment. This dismantling process leads to the release of dangerous chemicals, carcinogen, heavy metals, and gases which can adversely affect human health and environment. [16], [17]

Constituents of E-Waste

E-waste is extremely hazardous compared to many of the municipal wastes because they contain thousands of components made of deadly chemicals. Types of pollutants and their source of origin from various sources of e-waste is shown in [Table 1]. [18], [19], [20] [Table 1]

E-Waste Exposure and Health Risk

Adverse health effects depend on route, source and duration of e-waste exposure. Pregnant women, children, elderly people and people with disability or preceding illness may face additional risk. [21] Children are extremely vulnerable because of increased chances of transmission through placenta, breast feed, hand to mouth activities in early years, increased uptake in terms of their body surface area, and inefficient excretion of these toxins. [22] Studies conducted in China, Delhi, Bengaluru and Ghana indicate that hazardous substances from e-waste can extend beyond processing sites and into the ecosystem. [23] Significant amount of e-waste pollutants and toxins were found in drinking water and their foodstuffs, which can be a major health concern. [23], [24] A systematic review based on 23 epidemiological studies revealed associations between exposure to e-waste and physical health outcomes. [21] These include lower forced vital capacity, increase in spontaneous abortions, stillbirths, premature births, and reduced birth weights and birth lengths. People working in e-waste recycling units or living in the vicinity of e-waste recycling towns had evidence of DNA damage with increased frequencies of micronucleated or binucleated cells in peripheral blood. [25] E-waste also affects the reproductive system leading to decreased sperm count, libido, delayed puberty, and infertility in both males and females. [26], [27] E-waste pollutants such as polychlorinated biphenyls, polybrominated diphenyl ethers, metallic nickel, chromium, cadmium and some polycyclic aromatic hydrocarbons are possibly carcinogenic and may cause cancer. [28] Significant association has been reported between changes in mental health and e-waste pollutants. It includes behavioral disturbances, attention deficit hyperactivity disorder, aggressive behavior, and violent crimes. [29]

Various health effects caused by e-waste pollutants are summarized in [Table 2]. [Table 2]

Biogeochemical Effect of E-Waste

Soil microbes act as crucial moderators of geochemical cycling processes and pollutant remediation. Microbes are extremely crucial to the functioning of all the ecosystems and follow the hypothesis of 'everything is everywhere,' hence can diffuse easily at a global scale. [30] Microbial community diversity has a definite role in stress adaptation and functional stability of the ecosystem. These microbes may be severely affected by the e-waste contaminants. E-waste chemicals and metals inhibit microbial enzyme and their metabolic activities. It also weakens the resistance of soil microbial community, decreases microbial community diversity and their community structure. [31], [32] Ecotoxicological effect of e-waste has been shown in Guiyu region of South China where significant decrease in microbial biomass, nutrient cycling and basal respiration had been noted. [33] Significant damage of the microbes by e-waste will affect the balance of the ecosystem, and it will not be limited to the contaminated area alone but will spread to a large area posing significant health issues.

E-Waste Control in India

Ministry of Environment and Forest has placed legal liability for reducing and recycling electronic waste with producers for the first time under the E-waste (Management and Handling) Rules 2011. [34] The rule is effective from May 1, 2012. According to this regulation, producers will have to issue consumers with information on disposing of equipment after use to prevent e-waste from being dropped in domestic waste, and must make the public aware of the hazardous components present. Commercial consumers and government departments are now responsible for recycling the e-waste they generate. In 2018, government has amended the e-waste (management) rules in a move to facilitate and effectively implement the environmentally sound management of e-waste in India. Major objective of the amendment was to channelize the e-waste generated in the country towards authorized dismantlers and

recyclers in order to formalize the e-waste recycling sector. Ministry of Environment has also directed the industrial sector to collect 10% of e-wastes through Extended Producer Responsibility Plan. Plan 'Karo Sambhav' was started by integrating many non-government organizations and agencies, with an aim to enable people and institution to ethically recycle the e-wastes carefully while fortifying sustainable livelihoods for waste pickers.[35] Swachh Bharat Abhiyan initiated by the honorable Prime Minister of India, also emphasized strongly on awareness to adverse effect of e-waste and aims to ensure 100% collection, scientific processing, recycling and safe disposal of these e-waste. In 2018, another rule was drafted by the Ministry to ban the import of second hand electronic equipment for charity and possible reuse, unfortunately ministry removed this clause from the final regulation of 2018. Despite the rules, they are openly flouted either deliberately or due to ignorance.

E-Waste: What Is the Way Forward

E-waste is a serious and concerning issue globally. It should be considered as a major public health emergency. It affects almost every organ, with increased genetic defect, neuropsychiatric illnesses and malignancies. Collaborative efforts must be made to counteract the dangerous effect of e-waste on human health and environment. International health agencies, Indian Council of Medical Research, e-waste regulating bodies, academic institutes, and nongovernment organizations should join hands together with the national government to effectively manage the problems of e-waste. To reduce the health and environmental hazards of e-waste, following steps are recommended:

*Create an E-Waste task force under the Indian Council of Medical Research involving experts from the Ministry of Electronic and Information Technology, Ministry of Environment and Forest, Ministry of Health, Public Health, Toxicology, Electronic industries, Judiciary, etc. It should have specific agenda to counter the danger posed by e-waste. It will create a health interface, to design, implement, and regulate policies and processes related to e-waste management. The task force should review the existing interventions and their effectiveness in protecting the health of e-waste workers and their families, and then try to find the knowledge gaps and technological shortcomings. It would formulate effective policies on requisite infrastructure and technical assistance to the industries for safe disposal of e-waste. It would recommend how to make the legislation to curb the unlawful import and recycling of the e-wastes effective. It would also suggest possible ways to minimize e-waste like redesigning of electric and electronic instruments to increase product life. Another objective of the task force would be to frame guidelines to improve diagnosis and management of persons exposed to e-waste

*One of the objectives of the task force will be to formulate research questions so as to increase the body of evidence of the health effects of e-waste exposure *Increase funding to carry forward the research on e-waste and their adverse effect on living being and environment *Develop affordable technologies to recycle e-wastes and their safe disposal *Increase the number of e-waste recycling centers in India. Even though 178 registered e-waste recyclers accredited by the government exist, but for a population of 1.3 billion, it is grossly inadequate *E-waste management centers should be governed with strict regulation under expert supervision. Experts should also include toxicologist to supervise the effects of e-waste *E-waste management should be given top priority under the Swachh Bharat Abhiyan for the effective management and safe disposal.

Conclusion

Staggering production and use of electronic equipment has created the problem of e-waste. Contamination of the environment, persistence and bioaccumulation of these chemical pollutants warrant consideration to perceive it as global public threat to health. E-waste is a major health hazard for children and vulnerable population like pregnant women, old age and people with co-morbid illnesses. Serious knowledge gaps exist between e-waste exposure and health outcomes which justify investment in research. Improved waste recovery methods, formal cycling and compliance to international norms will help in reducing the menace of e-waste.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Source Citation (MLA 8th Edition)

Jamshed, Nayer, et al. "The INDUSEM position paper on the emerging electronic waste management emergency." *Journal of Emergencies, Trauma, and Shock*, vol. 13, no. 1, 2020, p. 25. *Gale Academic OneFile*, <https://link-gale-com.libraryresources.columbiasouthern.edu/apps/doc/A618551796/AONE?u=oran95108&sid=AONE&xid=60eec289>. Accessed 27 Apr. 2020.

Gale Document Number: GALE|A618551796