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Side Effects of the Electronic Health Care Revolution: Toxic E-waste

Oladele A. Ogunseitan

ELECTRONIC REVOLUTION IN HEALTHCARE

The scope of the global market for medical electronic products is estimated be worth more than $100 billion in 2022. Having increased steadily at an annual growth rate of nearly 12%, the market is projected to reach $248.43 billion by the year 2030.[1] The electronic revolution in health care spans a wide range of equipment and procedures including, at the low end, the replacement of formerly ubiquitous ∼$20 mercury thermometers (which fell into disrepute because of mercury toxicity) with digital and infrared thermometers, which typically cost less than $50 and are even more ubiquitous in the age of fever-inducing infections during the COVID-19 pandemic. At the high end of the electronic revolution is perhaps the most expensive equipment, the magnetic resonance imaging scanners, which can cost more than $200 million. Between these extremes are mobile phones and desktop computers that have enabled the revolution in electronic health records and, of course, numerous diagnostic tools including polymerase chain reaction machines, computed tomography scanners, and robots for surgical procedures. At the core of all electronic medical equipment is the printed circuit board (PCB) with various electronic circuitry connecting electronic components, which facilitate specific functions, speed, and reliability of the equipment (**Figure 1**). PCBs and many electronic components are made with toxic metals, organic compounds, rare elements, and precious materials. For nearly 3 decades, concern has been raised in various sectors about the increase in accumulation of electronic waste (e-waste) and the potential and documented adverse impacts of such toxic waste on people and the environment.[2-5]

CULTIVATING ENVIRONMENTAL STEWARDSHIP IN HEALTH CARE

Recent interests in "greening" the health care industry have focused on the energy consumption or carbon footprint of medical facilities and procedures, particularly in the context of the replacement of paper records with electronic or digital health records, and the replacement of incandescent lighting systems with fluorescent tubes and light-emitting diodes.[6] The urgency of progressing toward reduction of the environmental impacts of the health care system is anchored on the imminent threat of abrupt climate change. However, the response of the health care system to the COVID-19 pandemic has expanded the focus of environmental footprint researchers to include materials use and waste management, particularly because of the rapid demand for personal protective equipment and the challenges of managing personal protective equipment waste.[7] A recent study of 200 adult neurosurgical cases at a hospital during a 1-year period indicated that a typical neurosurgeon's activity generated an average 1782.2 kg/year in solid waste.[8] This is an underestimate in part because of the exclusion of waste generation from complex spinal instrumentation used for fixations, emissions from the manufactory of shunt components, and titanium cranial implants. Also, most, if not all, waste electronic equipment was not counted within the scope of the research.

CURTAILING THE RISKS OF ELECTRONIC WASTE

Medical waste is often considered hazardous largely because of the potential for infectious contaminants, which rightfully warrants special handling and careful management in comparison with domestic municipal waste. However, electronic waste generated from hospital systems is hazardous because it contains toxic chemicals. In general, best practices for the management of e-waste is different for various categories of waste that are typically managed by different handlers. Local, national, and international regulatory policies that govern the management of medical waste generally do not include e-waste, and the policies for e-waste management vary widely across geopolitical domains. The demand for high levels of reliability and, in some cases, sterility or resistant to frequent disinfection also separate medical electronics from general consumer electronics. For example, the transition from lead-containing solder to lead-free solder in consumer electronics likely took longer for medical electronic equipment because the long-term reliability of tin-lead solders was well documented, whereas the supposedly "greener" alternative solders did not have a track record to assure medical device manufacturers and regulatory agencies such as the Food and Drug Administration.[9] The need for high reliability, patient safety, sanitation, and compactness demand that the PCBs in medical devices are typically high-density interconnecting. They drive equipment for imaging systems, ultrasonic scanners, video-enhanced monitors for heart pumping rate, blood pressure, blood glucose monitors; infusion pumps, and analgesia pumps. In addition, implantable electronic devices such as pulse generators require highly sensitive materials and may have more precious metals than domestic consumer electronics. Therefore the e-waste stream from hospital systems

Abbreviations
PCB: Printed Circuit Board

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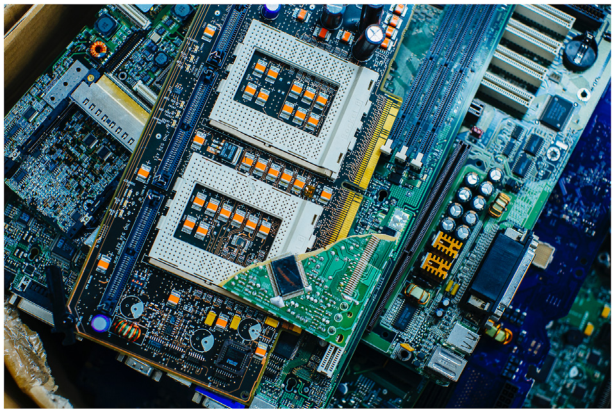

Figure 1. Printed circuit boards (PCBs) with their installed electronic components are common to all medical electronic devices. PCBs typically contain a mixture of precious metals, toxic metals, and organic compounds including flame retardants, which render them attractive for artisanal miners, but they are also toxic and exert adverse impacts on human health and environmental quality. Photograph of PCB is from the author's collection.

may be qualitatively and materially different from the e-waste stream from the general population, but there is no reliable evidence that these streams are managed differently, posing risks to people and the environment. In 2021, the World Health Organization estimated that more than 12 million women and 18 million children work in the e-waste management sector, trying to recover small amounts of gold, copper, and other semi-precious metals, often in unsupervised conditions and under the constant risk of exposure to toxic chemicals known to cause cancers, reproductive health issues, and cognitive impairment.[10]

CROSS-SECTOR SOLUTIONS

Solutions to the e-waste problem demand the collaboration of all sectors of society that have been revolutionized by electronic products, and the health care professions have a major role, beginning with manufacturers of electronic medical devices. For example, the top 10 medical device companies in the world, in terms of sales (Medtronic, Johnson & Johnson, Abbott, Philips, Fresenius, GE, Becton-Dickinson, Siemens, Cardinal Health, and Stryker)[11] can invest more vigorously in repairing and refurbishing devices and collecting defunct products from hospitals. In so doing, they would reduce the amount of e-waste that must be discarded and commit to using recycled components and materials in manufacturing. Health care facility administrators and staff need to be educated about the global risks associated with e-waste such that the stewardship of best environmental practices, conservation, and systems view of preventive health care is integrated into continuing professional development. Building a circular economy for electronics requires both technical innovation and alignment of regulatory policies across all countries to avoid the inequity issues associated with international movement of hazardous waste.[12-14]

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