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Electronic Waste – A Growing Concern for the Health Sector

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INTRODUCTION

Electrical and electronic equipment (EEE) continues to revolutionize the world in several sectors including business, entertainment, development, and health (with the application of Information and Communications Technology (ICT) in the health sector - known as e-health).

The broad arena of ICT application constitutes perhaps the fastest growing activity in the world. Extraordinary technological progress and consumer demand have led to a huge increase in the production of new electronic goods. This, together with continuous and astonishingly rapid replacement by consumers, has resulted in the new and widespread dilemma of disposal of large amounts of "old" technology, or electronic-waste ('e-waste', also known as waste electrical and electronic equipment (WEEE) generated when EEE is discarded[1].

e-Health is just one area of application of ICTs. However, as e-health is promoted and new technology solutions are devised, the health and healthcare sectors are unwittingly contributing to damage to both the environment and human health. Recent work in this new field of research known as 'environmental e-health' has concluded there are three primary areas of environmental impact (resource depletion, energy use, and accumulation of e-waste). Of these, perhaps the latter is of most concern, particularly given the associated trans-boundary movement of this around the globe, mostly from developed countries to developing ones. Compounding this setting is planned obsolescence[2,3] and 'evergreening' of equipment (consumer desire to have the latest technology), which has dramatically reduced the useful life of handheld devices (now about 18 months) and computers (now about 3 years), maximizing turnover and rapidly increasing the volume of e-waste.

E-waste contains many potential environmental contaminants as well as valuable components. For example, in the US about 21.3 million TVs were discarded which contained approximately 35,000 tonnes of lead but also over $420 million in precious metals[4]. Regrettably, most e-waste is discarded or mishandled in uncontrolled and inappropriate ways. Due to its hazardous material content (e.g. , metals such as Lead, Cadmium, Mercury, and plastics including polyvinylchlorides (PVC)) e-waste may have a negative impact on the environment contaminating the air, ground, and water. As a consequence, e-waste represents a human health risk when not properly managed and discarded[5]. The disposal of e-waste thus needs to be managed in an environmentally sound fashion to minimize environmental damage and health hazard. Additional benefits exist: Proper management of e-waste not only contributes to reduced environmental damage and better health outcomes, but also to growing economies and to narrowing the digital divide[6,7].

This chapter briefly reviews the current e-health and environmental e-health setting, then explains and expands on the e-waste issue, and concludes by considering the relevance of e-health related e-waste to Latin America.

A MODEL OF THE ENVIRONMENTAL IMPACT OF ICTs

In 2003 the relationship between e-health and environmental impact ('Environmental e-Health') was first presented[8]. Continued work in this new area of research by a group at the University of Calgary led to a preliminary model published in 2010[9], with an enhanced model shown to also have relevance to Knowledge Translation, another ICT intensive field[10]. Although focussed on e-health, the authors believe this model has value as a simple and generic framework with which to examine the environmental impacts of any application of ICT, and is described below.

e-Health has been used as an exemplar because it is heavily supported by use of ICTs, is now a focus of activity and significant investment worldwide, is growing rapidly and globally, is anticipated to become pervasive in developed and developing countries alike in the immediate future, and should be enhancing not harming health. Growth of e-health is partially sparked by global policy initiatives; e.g. the World Health Organisation's 2005 e-Health Resolution encouraging all member states to develop e-health strategies to utilise e-health as a means to address their health and healthcare needs[11], or the Pan American Health Organisation's (PAHOs) Regional e-Health Strategy approach announced at their 51st Directing Council meeting last year[12]. According to Terry[13] other factors leading to rapid growth include: increased exposure to hundreds of thousands of 'apps' (inexpensive, small pieces of software for smart devices that typically perform a specific practical or entertaining function – some health related); increased Internet access (wireless connectivity; access to personal health resources such as Microsoft's Health Vault or Google Health); corporate wellness (monitoring behaviour and health of employees to change behaviour); and the emerging consumer-centric model (uncontrolled by government).

The potential for exponential growth is huge. Yet nowhere is there a requirement for considering the environmental impact of these e-health solutions. Given the growing concern for our environment, and growing implementation of e-health solutions, this is no longer acceptable. Because the connection between e-health and the environment is new, the spectrum of potential benefits and harms associated with e-health are essentially unknown at this time. To bring awareness and focus to this issue, recent research at the University of Calgary sought to better understand the environmental benefits and costs of e-health, and to summarise these in a simple model that would inform and encourage discourse within the health and healthcare sectors.

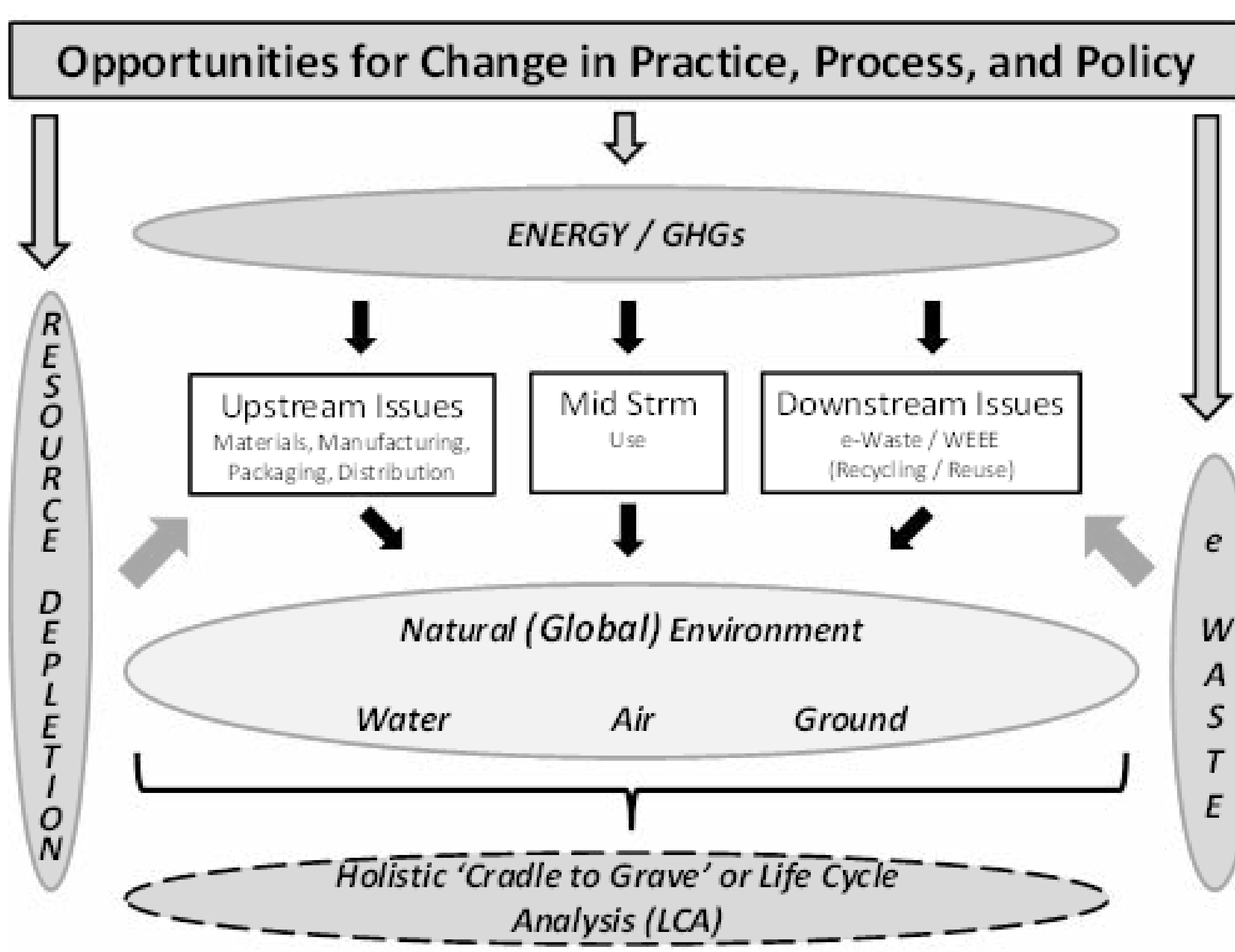

Figure 1. Diagram summarising the Environmental e-Health Model

Sufficient evidence exists of environmental impact from the available ICT literature to extrapolate to e-health. Potential environmental impact of e-health, both harms and benefits, can be considered at three stages in the 'life-cycle' of any specific e-health solution or component (see Figure 1). These can be 'upstream impacts' (applying to the extraction, processing, or synthesis of raw materials, the manufacture of the e-health components, and the packaging and distribution of these components), 'mid-stream impacts' (referring to design, implementation, and the period of actual use of the e-health solution), and 'down-stream impacts' (considering the 'end-of-life' (EOL) aspects of disposal or recycling). These components are presented in the generic model seen in Figure 1, together with the final aspect that completes the model – the need for Life Cycle Assessment / Analysis (LCA, see below). Although convenient for description, there is considerable overlap across these categories; indeed, energy use and associated greenhouse gas and particulate emission is common to all three stages. For example, ~81% of a desktop computer's energy consumption occurs when making the computer, not using it or disposing of it[1].

There is universal recognition among industry, government and other stakeholders that environmental issues and impacts should be analyzed from a life cycle perspective to truly gauge the overall impact of any proposed ICT application (including e-Health solutions). LCA has been widely used by researchers to assess solid-waste management; however, the optimum material flow from one management option to another has not been researched to date, and empirical evidence of environmental impact and estimation of risk perceived by the public is lacking[14]. Furthermore, application of LCA to specific e-health applications is completely lacking.

For this chapter, focus is directed towards only one component of the model - the end of the e-health application life-cycle which results in creation and accumulation of e-waste.

WHAT CONSTITUTES e-WASTE?

'e-Waste', the term used to refer to the solid-waste stream of unwanted or obsolete electrical and electronic equipment[15,6], includes a broad variety of products that may range from large household appliances such as refrigerators and air conditioning equipment, to smaller devices such as television sets, personal computers, and cell phones, among many others. e-Waste is broadly classified into three categories; white goods, brown goods, and ICT Scrap[16]. The white group includes mainly large household appliances with a high metal content; the brown group includes household electrical entertainment appliances; and the third group is simply composed of ICT Scrap. These devices are discarded by individuals and small businesses, large businesses, institutions and governments, and original manufacturers[17].

In the context of the healthcare industry a host of EEE has traditionally been used (e.g. diagnostic, monitoring, and laboratory equipment), however this is now being exacerbated by rapid development of new e-health solutions that are no longer confined to hospitals, but include the home and, through m-health (mobile health), anywhere in between. The ultimate vision of e-health in terms of connecting people with health and healthcare systems is – anyone, anytime, anywhere.

WHY IS e-WASTE SUCH AN ISSUE?

Seven areas of concern can be described: Volume, Complexity, Toxic potential, Informal recycling, and regulatory aspects such as Transborder, Ethical, and Policy issues, each of which is outlined below, and summarised in Table 1.

Growth – Volume and Rate

Among the main concerns regarding e-waste is the alarming quantity being generated each year. There is a fundamental and growing dependence on ICT by society. This, coupled with rapid technological advances and response to consumer demand, have led to dramatic increases in the production of new electronic goods. Robinson[5] estimated the global production of e-waste to be 20-25 million tonnes per year. In contrast the UNEP[18] estimated the global production to be closer to 40 million tonnes per year. Growing contributors are mobile telephones, computers, and television sets which Cobbing[19] estimated would contribute 5.5 million tonnes in 2010, rising to 9.8 million tonnes in 2015. Computers and mobile telephones are considered to be disproportionately abundant because of their short lifespan[5], and these are the most common technologies used in e-health.

Table 1. Summary of Areas of Concern Associated with e-Waste

Issue	Summary
Growth – Volume and Rate	The volume of e-waste is growing rapidly in both developed and developing countries, and the rate of growth is increasing also
Complexity	Modern e-health and other electronics equipment are complex in terms of material content, with many metals and plastic materials
Toxic potential	Some component materials are toxic elements or may create toxic elements when burnt during poor recycling practices
Informal recycling	Poor environmental practice during 'informal recycling' places both individuals and the environment in jeopardy

Regulatory Aspects:	
Transborder issues	Although illegal, ‘dumping’ of WEEE takes place often from developed to developing countries.
Ethical issues	Health care practitioners follow the tenet of ‘first, do no harm’, yet they contribute to harming the environment and human health through thoughtless adoption of technology
Policy issues	Desire to manage e-waste has led to examination of policy solutions to minimise obsolescence, and encourage recycling solutions

Perhaps more disturbing is the expected *rate of growth* in e-waste production across the globe. The UNEP[18] has predicted that by 2020 e-waste from old computers will rise dramatically; 2-*fold* in South Africa, 4-*fold* in China, and 5-*fold* in India, from 2007 levels. e-Waste from discarded mobile phones alone will be about seven times higher than 2007 levels in China, and 18 times higher in India.

Contributing to this growth in e-waste production is the rapid obsolescence (mentioned above) and poor recycling of still functioning older equipment. Usable electronic equipment is often discarded by users who simply desire to replace them for new technology available in the market[20]. According to Nordbrand[21] recycling is minimal, with only about 3% of individuals recycling their phones, and with a major increase in discarded computer and TV monitors expected as those currently in use are replaced by smaller, better, and flatter screens (e.g. , LCD screens)[17]. Sometimes, consumers are mandated to change technology! Here, the requirement to convert analog to digital television reception is a prime example. In the US this resulted in ~ 27 million televisions being discarded in 2007 of which only about 18% were recycled[4]. Globally, very little e-waste is responsibly recycled, and evidence suggests the current quantities of WEE are grossly underestimated[22].

Complexity

e-Waste is one of the most complex solid-waste streams because of the extensive variety of products, their rapidly changing design, and their composition (typically composed of a wide selection of metal, plastic, and ceramic materials). A single mobile phone may contain more than 200 chemical compounds, some of poorly understood human health and environmental impact[21]. These include both hazardous materials and elements, as well as some valuable elements, which complicates both toxic potential and recycling options.

Hazardous materials in e-waste include batteries, cathode ray tubes (CRTs), switches, liquid crystal displays (LCDs), asbestos waste, toner cartridges (liquid and pasty as well as colour toner), printed circuit boards, polychlorinated biphenyl (PCB) containing capacitors, flat screens, plastics containing halogenated flame retardants, equipment containing CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons), or HFCs (hydrofluorocarbons), and gas discharge lamps[23]. Hazardous elements found in e-waste include Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), hexavalent Chromium (Cr), Copper (Cu), as well as valuable elements such as gold (Au) and silver (Ag)[4,1].

CRTs are currently the largest component in the e-waste stream followed by personal computers (PCs) which contain the largest proportion of printed circuit boards among electronic products[24]. CRTs and printed circuit boards contain various hazardous materials which must be separated and disposed of properly, making recycling difficult[25]. CRTs may contain barium, cadmium, chromium, copper, lead, zinc, and various rare earth metals; while printed circuit boards may contain arsenic, cadmium, chromium, lead, and mercury[26]. Of these toxic elements lead has been of most concern, and a major reason for increasing efforts to reduce the number of CRTs in the waste stream as well as generate policy around its handling and processing[27].

Toxic Potential

As the environment is contaminated the potential for harm to living organisms (including humans) increases, with harm to humans being indirect and direct; e.g. Br flame retardants are toxic to aquatic life and enter the human food chain by that route (indirect), and can create dioxins and furans when burnt which can be inhaled during informal recycling (direct).

What makes something 'toxic'? Toxicity is the degree to which any substance can damage a living organism. A sixteenth-century Swiss chemist, known as Paracelsus and viewed by some as the father of toxicology, is said to have stated (paraphrasing) - 'the dose makes the poison'. In other words, 'toxic' substances may be harmless in small doses, while ordinarily harmless substances (table salt, vitamin C, water) can lead to intoxication and death when taken in large enough doses. However, it is now accepted there are some very toxic substances for which only a small dose is necessary to cause a toxic insult, and others for which it is not certain if there is such a thing as a minimum 'safe' dose below which no harm is seen.

But to be harmful to humans a substance must be more than simply innately toxic. It must be present in sufficient quantity (harmful dose), be present in an appropriate form (solid, liquid, gas, or aerosol), and exist in a setting where there is opportunity for human exposure (acute or chronic; single, multiple, or continuous) via a suitable route of ingestion (oral, respiratory, dermal). Furthermore, many toxic materials derived from e-waste are not biodegradable and 'bio-accumulate' in living organisms (with cumulative effects on up the food chain, ultimately humans), and the toxicity of chemical mixtures or multiple toxic exposures is not always simple to predict due to uncertain synergistic effects.

Given this, various occupational safety and hygiene standards have been established to minimise human exposure. These are generally sufficient in developed countries, however, throughout the world irresponsible disposal of e-waste in unlined landfills or 'roadside dumping', or informal recycling, can lead to release of toxic substances into soil, surface and groundwater, and the air, even contamination of food supplies[5,26,28,29]. Illegal inter-jurisdictional export of hazardous e-waste to developing countries also occurs, where an unregulated industry has grown leading to individual, local, and regional exposures to toxic material[17].

Informal Recycling

Beyond environmental considerations, there are business incentives to recycling. One metric ton (t) of electronic scrap from personal computers (PC's) contains more gold than that recovered from 17 t of gold ore (1). But in countries where poverty is rife and environmental controls are weak or absent, simply recovering copper for resale (by burning the plastic of sheathed wire) is incentive enough. Recycling is conducted in both formal and informal ways. In general Formal recycling of e-waste runs at a net cost in developed countries, and Informal recycling runs a net profit in developing countries (primarily due to low wages and poor environmental guidance and oversight); for example recycling a computer costs about EUR 10 in Sweden, but only EUR 1.50 in India[21].

The process of *Formal* recycling has been described as occurring in three major steps: Disassembly, Upgrading, and Refining[15,16,24]. 'Disassembly', or dismantling of WEEE in a manner that singles out select hazardous or valuable components, is an indispensable first step. Thereafter various mechanical or metallurgical processes 'upgrade' the recycled waste by concentrating the content of valuable components, and discarding hazardous materials. Finally, the material is 'refined' and the recovered materials are reused.

However, the reality is that *Informal* recycling of e-waste in developing countries predominates, and the process is far from ideal, exposing workers - and neighbourhoods - to hazardous chemicals, materials, and by-products as e-waste is broken, acid etched, and burnt to extract valuable components and metals. There is a growing body of scientific evidence confirming the adverse health effects resulting from emissions and contamination associated with informal e-waste recycling practices, which constitutes a serious problem particularly in developing countries[6,20].

A recent video has value in visualising the issue[30]. The movie shows informal e-waste recycling in a slum called Agbogbloshie just outside of Accra, Ghana in West Africa. There e-waste, exported illegally as 'second hand goods' from the developed world, is crudely broken down and burned in an effort to reclaim some raw materials (e.g. copper wire) that can then be sold. Just change the name and location, because the same is happening elsewhere in African, Asian, and Latin American and Caribbean countries. According to Fedele, the legacy is "illness and sickness, pollution, and environmental destruction".

Regulatory Aspects

Increased exportation of e-waste from developed to developing nations is taking place despite existence of legislation making it unlawful. This raises additional concerns around ethical issues and policy issues.

i) Transborder Issues

Two primary drivers for 'export' of e-waste include *re-use* (ICT being sent to developing countries as 'donations' of secondhand equipment since they cannot afford the latest technology), and *recycling* (being fueled by low wages, high demand for raw materials, and poor environmental controls in the developing world).

Although estimates of worldwide e-waste volumes exist, accurate information regarding e-waste volumes is lacking. How much e-waste is generated, and how it is circulating are difficult to assess mainly due to the current system of data gathering, in which secondary and waste products are said to be "large invisible" to national statistics[24]. This presents a barrier to effective e-waste management since knowledge regarding the volumes of e-waste and when and where it will be generated is critical to develop adequate infrastructure to respond to the management needs. To address this problem, Kang and Shoenung [31] developed a time-series Materials Flow Analysis Model (MFAM) to estimate future quantities of e-waste (focusing on computer systems) by modeling the stages of production, usage and disposal as a function of time. Despite some methodological limitations, this study provides a good example of scientific efforts that are being made to gather empirical evidence that may inform decision makers in the search for best practices regarding e-waste management.

ii) Ethical Issues

Primary ethical issues include 'who is responsible for e-waste and its management', and 'can hazardous components be eliminated'? Here activities within the EU exemplify current thinking. New EC legislation (the WEEE Directive) requires producers of the e-waste to bear the cost of proper disposal (although this is of course simply passed along to consumers), and also requires producers to phase out use of some of the most hazardous substances – e.g. lead, mercury, Cd, hexavalent Cr, and Br flame retardants (the Restriction of Hazardous Substances Directive (RoHS) Directive). Ironically, as these environmental directives take full effect, some experts fear they will simply stimulate the illegal export of e-waste from the EU to developing countries [21], posing a further ethical dilemma.

iii) Policy Issues

To address the issues and concerns of e-waste management many countries have drafted or examined policy to encourage the reuse, recycling, and other forms of recovery as a way to reduce disposal [32,33,16,6] and to discourage obsolescence[34]. Policy efforts to address e-waste management largely focus on three approaches; recycling systems, limiting toxic content of EEE, and trade bans. Williams et al.[6] studied these three main policy approaches being applied in the electronics sector, illustrated each of them with practical examples from the literature, and provided insight regarding the environmental, social and economic benefits and costs each of them; they used personal computers as the unit of analysis. The first approach, Legislating Takeback/Recycling systems, attempts to ensure that e-waste is collected and recycled within legislative borders. As noted, a good example of this is the Waste Electronic and Electronical Equipment (WEEE) Directive within the EU, which mandates take-back/recycling systems for all the countries in the European Union. Williams et al. concluded that the benefits of this approach are currently poorly understood. The second approach, regulating content of toxics, attempts to find alternative materials to replace those of concern in EEE. Again, a good example of this approach is the RoHS Directive which has the role to control or ban certain materials in EEE for products sold in the European Community. Here Williams et al. concluded that the domestic environmental benefits regarding heavy metals are not clear. The third approach, Trade Bans, attempts to manage the environmental impacts associated with the informal recycling of e-waste mainly by cutting the provision of e-waste through import and export bans. At the international level the Basel Convention serves as the central framework for controlling international movements of hazardous materials. Williams et al. concluded that given successful enforcement of these bans, reducing the provision of e-waste to informal recycling activities would mitigate the environmental impact overseas. However, from a social standpoint, these bans reduce availability of used equipments to consumers in developing countries, and from an economic standpoint they eliminate jobs in the fields of recycling and reuse.

Nnorom and Osibanjo[15] reviewed Extended Producer Responsibility (EPR) legislation which exists in most developed countries (mandating manufacturers and importers to take-back used electronic products at their end-of-life), and proffer an adapted form of EPR for developing countries.

Despite these examples, policy regarding e-waste management is much needed to address the important negative consequences of poor management of this solid-waste stream. In addition, compliance and enforcement are issues even once policy is promulgated. Unfortunately, compliance with and enforcement of e-waste policy is resource intensive as it requires adequate technical infrastructure, human resources, and public awareness which are not always present, particularly in developing countries. For example, despite having banned e-waste imports, China remains a major e-waste dumping ground for exports from developed countries (UNEP, 2009). Other challenges arise with the implementation of steps such as trade bans; companies will send non-functional equipment along with ones that can be resold to developing countries. This loop-hole makes it difficult to control the quantity and quality of the electronics which can be sent for reuse[5]. Research is required to provide the evidence that needs to be in place to guide the generation of sound policy at both the national and international levels.

e-WASTE MANAGEMENT

Poor policy, together with the limited knowledge of the real hazardous potential of e-waste, inaccurate estimation of its quantity, and the questionable cost-benefit of reuse and recycling, make it difficult to design proper management processes for this solid-waste stream. A thorough understanding of the environmental, social, and economic implications of the increasing amounts of e-waste being generated globally, and the problems associated with its management locally, is crucial to create effective policy to address its impact on the environment and human health.

Such insight is limited for e-waste in general, and effectively absent for the e-health setting in particular, requiring consideration of first principles. A widely accepted universal guideline for waste management is the hierarchy of 'reduce, reuse, recycle' and subsequent disposal of residual waste. Ahluwaloa & Nema [14] represented a waste management hierarchy by an inverted triangle divided in three layers. We have revised this to include 7 layers, and termed this the Responsible Response hierarchy, with the relative width of each layer representing preference for that particular option. The 'Reduce, Re-use, Recycle' principles are well established, therefore greater description is given to the new components.

1. Respect. It is necessary to have a fundamental respect for the environment in order to encourage and comply with outputs, findings, and further principles derived from the remaining levels of the hierarchy. This may be reflected in the growing concept of 'social responsibility'. In essence every person or business whose action might impact the environment has an obligation to 'first, do no harm', and therefore to act in a manner that maintains a balance between the economy and the ecosystem, and that benefits society at large.

2. Rethink. All stakeholders (consumers, vendors, public and private agencies) are charged with the deliberate responsibility to rethink the entire arena of e-waste (from generation to disposal) and develop new ways of thinking about and responding to the e-waste dilemma. Manufacturers must look towards managed and moderate growth, discarding planned obsolescence and evergreening to maximize sales and profits. The public also must raise their understanding of 'risk', which influences recycling preferences and practices, and in turn impacts compliance with regulations regarding handling of e-waste. The public's propensity to replace old equipment simply driven by the desire to have a newer, better model must also change. No matter how difficult, such a change in attitude has been identified as a fundamental requirement to achieve sustainable waste management[33].

3. Redesign. Focus here is given to vendors examining aspects associated with design and manufacture of e-products; e.g. simpler disassembly (self-disassembly; Active Disassembly using Smart Materials, ADSM), or use of shape memory polymer (SMP) technology. Manufacturers should be encouraged to change the design phase rather than focussing on EOL recovery and recycling.

4. Reduce. This layer represents an interim mode of responsible response –

to ‘reduce’ environmental impact based upon current practice (the EU’s WEEE and RoHS Directives might exemplify this).

5. Reuse. This includes refurbishment of old technology to ensure it meets appropriate performance criteria; however, this is not to be used as a means of illegal dumping of e-waste.

6. Recycling. For the small amount of e-waste remaining, formal recycling programs and facilities must be available in each country.

7. The final layer represents disposal (i.e. landfilling) and is the least desirable response of all, but will be required for the small quantity of benign residual components left after response from each prior step has been maximised.

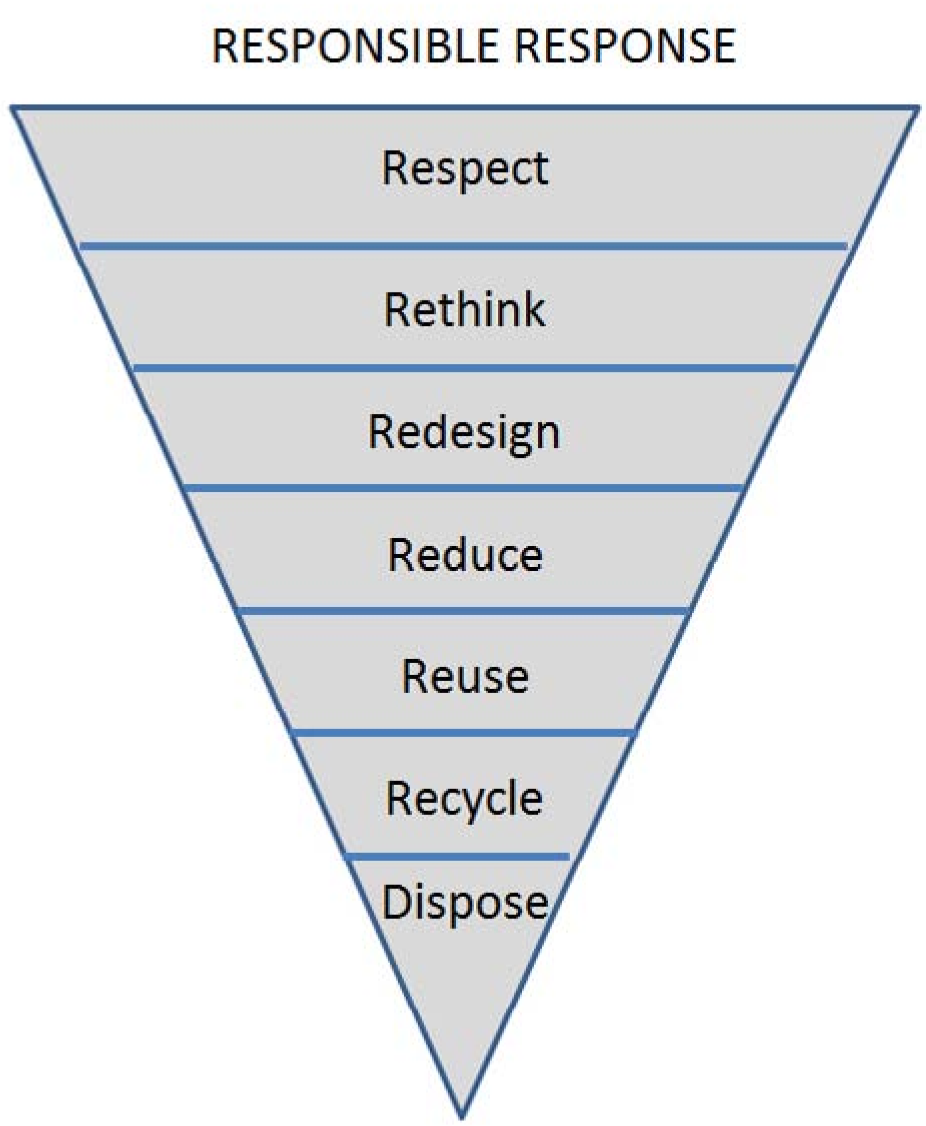

Figure 2 – The Environmental e-Health Responsible Response Hierarchy

The above hierarchy is broadly applicable, but here we are considering e-health. All phases of the life-cycle of an e-health technology have potential to influence e-waste. During the up-stream phase, improved approaches to manufacturing could reduce material consumption and modular construction could extend useful life. During the use phase, extending the useful life of e-health solutions could also be achieved through reducing 'evergreening'. Finally, during the EOL phase, the most important phase of solid-waste management, enhanced re-use and recycling processes would allow proper handling of e-waste. There are different options available for management of e-waste and several factors should be considered before choosing the most appropriate e-waste management option. Among them are cost, environmental impact, health impact, and risk perceived by the public[14].

Reality check - Cost-benefit ratio

Williams et al.[6] asked the question "Is recycling actually environmentally preferable to putting e-waste in sanitary landfills"? They conducted a literature review and could not find empirical data to respond to this question, and argued that it is conceivable that recycling could emit more toxic heavy metals over the lifecycle than those emitted when putting e-waste in sanitary landfills. However, as opposed to landfills, recycling has special value in that it addresses resource depletion (replacing production of virgin materials with recycled substitutes)[6] and creates jobs.

These authors further highlight the rapid and continued increase in international 'forward supply chains' (FSC), but also the globalization of the less known and studied 'reverse supply chains' (RSC). They defined a reverse supply chain as "the network of activities involved in the reuse, recycling, and final disposal of products and their associated components and materials". They can be a significant source of employment and revenue, and have the potential to bridge the digital divide. Leigh et al[32] demonstrated the potential economic benefits from redirecting electronic wastes within a region in Atlanta (USA), and concluded that material recycling accompanied by whole product resale and reuse produces positive impacts on a region's economy (including new revenue and new employment). In addition, Kahhat and Williams[20] indicated reusing computers both generates employment and reduces the digital divide (increasing accessibility of low income families and small businesses to affordable computers.).

Current policy targets manufacturers as the main entity responsible for e-waste management, although the producers of e-waste are in fact the end-users. This creates concerns. The WEEE Directive for example, effectively makes the manufacturers responsible for products they no longer own. Therefore, legally, they have the right not to participate in recovery efforts[33]. Ownership is an important concept in the field of e-waste management. In the context of waste management, ownership was defined as "a right and a responsibility to act upon something, that is, to manipulate its properties: purpose, structure and state"[35].

Despite the extensive support of EEE resale and reuse, there has been great concern among certain non-governmental organizations (NGOs) about the international flow of e-waste[17]. The main route of clearance of e-waste from developed countries is through export to developing countries, with the digital divide being used as an excuse for e-waste trade[34]. Rather than closing the digital divide, these actions are opening a "digital dump"[21].

e-Health and e-Waste in Latin America

e-Health and e-waste are globally pervasive [36,22,18]. Latin America* (LA) is poised for marked growth in both. With greater adoption of e-health solutions within the Region comes growth in e-waste, and the need to raise awareness of the issue, perform research to thoroughly understand the extent of the

* Latin America includes countries in Central and South America as well as the Caribbean.

problem and means to mitigate it, and a responsive policy setting that ensures appropriate management of the problem. Some LA countries including Brazil, Mexico, and Colombia, have been identified as hosts to informal recycling practices[37], and the literature shows that countries that lack proper systems for e-waste management (primarily recycling and disposal) will experience increasing e-waste related problems.

e-Health in Latin America

A recent report[38] describes many e-health initiatives taking place within the Latin American and Caribbean regions. In Latin America 11 countries were noted to be actively engaged in e-health; these countries were Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Panama, Peru, Uruguay, and Venezuela. Within Colombia alone 43 distinct telehealth activities have been identified[39]. In the Caribbean region 8 countries were identified; Trinidad and Tobago, Dominican Republic, Grenada, Belize, British Virgin Islands, Saint Lucia, Jamaica, and Cayman Islands[38]. In addition, a Pan American Health Organization (PAHO) survey of 19 countries found 68% considered e-health to be a priority on their national agendas and 47% have adopted policies or strategies that incorporate the use of ICTs in the health sector. Clearly e-health is already embedded within this region. Such adoption is only likely to increase with approval last year of PAHOs Resolution CD51/13 through which PAHO will support countries in the hemisphere in developing public policies for e--Health[12].

e-Waste in Latin America

Just how significant is the issue of e-waste for the LA region? The current volume of e-waste in LA is unknown, which makes management of this solid--waste stream difficult to address. To date, the only countries to have baseline studies looking at e-waste are Mexico, Costa Rica, Colombia, Peru, Argentina and Chile[40]. Even though the amount and quality of recycling activities varies in the different LACs, it is generally characterized by its informality. To makes things worse, most LACs don't have specific e-waste policy in place. According to Boeni et al.[40] specific e-waste legislation is only being developed in Costa-Rica, while all other LA countries are lagging behind in drafting policy for e-waste management. The reality in LA in regards to solid-waste disposal is not very promising. Open-air dumps and poorly located landfills (e.g. close to waterways) are still prevalent; many countries don't count with regular municipal waste collection options; and most of them don't have the financial resources to improve the solid waste collection system anytime soon.

At this point in time, most e-waste is generated in developed countries and exported to developing countries (external sources). However, research suggests this will change very shortly with increased consumption of ICT solutions within developing countries (internal sources). As a consequence rapid growth in e-waste can be expected.

External Sources:

Nnorom and Osibanjo[15] describe the scope, significance, and concern that exists around the illegal export of e-waste to developing countries, in contravention of the Basel Convention. The recent UNEP report has warned that developing countries face serious environmental and health problems from the alarming increase in hazardous waste from electronic devices, much due to dumping in the wake of aggressive marketing of electronic technology equipment.

Boeni[40] identifies several studies in Latin America that have assessed the increasing e-waste quantities and confirmed the importance of sustainable e-waste management for the Region, however LA specific insight is limited [20,22,40,41]. Experience from India shows computer scrap is managed through several low-end management activities including reuse, open burning, backyard recycling, and disposal in sanitary fills. All of these methods of disposal are very rudimentary and represent serious risk of environmental and health hazards[14]. Achim Steiner, UNEP executive director, has been quoted as saying "Developing countries will face rising environmental damage and health problems if e-waste recycling is left to the vagaries of the informal sector, unless action is stepped up to properly collect and recycle materials"[42].

Internal Sources:

One study forecasts the volume of just obsolete personal computers (PCs) that are generated in developing regions will exceed that of developed regions in only 4-6 years, and that by 2030 the number of obsolete PCs from developing regions will reach 400–700 million units compared to 200–300 million units from developed regions[43]. The problem of e-waste is of immediate relevance to LA countries. Robinson[5] suggests LA will become a major e-waste producer before 2019.

Other factors suggest LA may face a greater threat from e-waste. LA has higher Internet penetration rates than the world average (4 times that of Africa, and 1.5 times that of Asia), creating a ripe setting for generation of e-waste [40]. In addition, urbanization rates in LA (75%) are much higher than the ones observed in Asia (40%) and Africa (38%) [44], and just as any other place in the globe, LA is experiencing a rapid increase in technology adoption in several fields including e-health. As new technologies rapidly develop, older technologies become obsolete or unwanted and as a consequence, large amounts of e-waste are generated. A review conducted by Boeni et al.[40] provided alarming data predicting a fast increase in e-waste streams in several LA countries, and suggested the 120,000 tonnes of computer waste generated each year in LA will triple by 2015. Public awareness of this phenomenon is growing and with it, there is increasing concern from governments and the general public of LA countries in regards to the potential environmental damage and health risks that this phenomenon may cause.

Although quasi-internal, contributions from other sectors will also impact the overall e-waste situation. For example, the Inter-American Development Bank's 'One-to-One Laptop Programs in Latin America and the Caribbean' are anticipated to place nearly 7 Million laptops in LA countries, which will naturally require replacement over time, and contribute to the e-waste dilemma [45].

CONCLUSION

The e-waste problem is not coming, it is here. And ironically the healthcare sector as an avoracious adopter of ICT solutions is a prime contributor. Adoption and application of ICTs is not going to change – they have become embedded within fundamental human activities, including health and healthcare. However, social responsibility and healthcare ethics require the contribution of e-health (including telehealth, e-learning, knowledge translation, health data storage, cloud computing, and other application areas) to environmental damage be clearly understood, and our innovative skills be turned to finding ways to mitigate the negative impacts of environmental e-health, in particular e-waste generated through facilitating health and healthcare.

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