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HEALTHCARE AND THE E-WASTE TSUNAMI: THE SPECIFIC ISSUE OF E-MEDICAL EQUIPMENT

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Abstract: *The healthcare sector contributes significantly to the e-waste tsunami. It is estimated that healthcare uses and discards millions of electronic devices annually. This paper focuses on the e-waste generated by the healthcare sector and, more specifically, on the potential of the extended producer responsibility (EPR) approach to decrease the waste problems generated by electronic medical equipment (e-medical equipment). The central premise of the paper is that EPR represents a worthwhile alternative to the piecemeal and end-of-pipe approach advocated by many methods and current legislation.*

With no uniform and systematic federal legislation, the manufacturers of e-medical equipment based in the U.S. and Canada step forward with voluntary environmentally friendly initiatives. This paper attempts to analyze the efforts made by these manufacturers to green their products and to assess the benefits they derive from their proactive initiatives.

Keywords: sustainable development, e-waste, extended producer responsibility, healthcare, medical e-equipment.

Fields: *Environment and healthcare*

1. INTRODUCTION

Electronic products (e-products) are omnipresent in households and businesses, in developed countries and, increasingly, in developing countries. They cover a very wide range of products, ranging from mainframe computers to personal computers such as desktops, laptops and personal digital assistants, to computer peripherals such as printers, copiers, speakers, or CD-ROM drives. They also include a multitude of common consumer products such as telephones, cell phones, TVs, VCRs, DVD players, video cameras or stereo systems. E-waste refers to these e-products when they become obsolete or unwanted. The volume of e-waste is staggering. For instance, it is estimated that some 400 million of units are discarded each year in the US but the recycling rate is only 13.6% (EPA, 2010). Worse, a large proportion of electronic products are stockpiled at the end of their useful life. For instance, 75% of unwanted computers in the US remain in storage (EPA, 2010) waiting to be disposed of (EPA, 2010).

This paper focuses on the e-waste generated by the healthcare sector and, more specifically, on the potential of the extended producer responsibility (EPR) approach to

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decrease the waste problems generated by electronic medical equipment (e-medical equipment). The central premise of the paper is that EPR represents a worthwhile alternative to the piecemeal and end-of-pipe approach advocated by many methods and current legislation. Moreover, with no uniform and systematic federal legislation, the fragmented state policies in the U.S., which was termed as a "regulatory disorder" (Abela and Campbell, 2010), is not really inductive to proactive environmentally friendly initiatives from the private sector. The Canadian E-waste legal landscape, where different provincial laws prevail, is rather similar. Hence, manufacturers of e-products (including medical e-equipment) based in the U.S. and Canada step forward with voluntary environmentally friendly initiatives. This paper attempts to analyze the efforts made by these manufacturers to green their products and to assess the benefits they derive from their proactive initiatives.

The paper is structured as follows. The next section examines the overall trends associated with the e-waste generation while section 3 briefly outlines the research context and the methodology. Preliminary results based on the empirical evidence gathered from 59 manufacturers of medical e-equipment located in the U.S. and Canada are presented and discussed in section 4. The paper concludes with the contributions and implications that can be derived from the empirical results.

2. THE E-WASTE TSUNAMI AND OVERALL TRENDS IN THE GENERATION OF E-WASTE

The metaphor of a tsunami to describe the e-waste phenomenon has been already used by a few authors (see for instance: Johnson, 2008) and seems quite appropriate. Offshore, a tsunami is barely noticeable since its wavelength is very long, as much as a few hundred kilometres, while the wave amplitude is very small, sometimes only twelve inches (Haugen et al., 2005). However, a tsunami travels fast at 800km/hr, speeding at 950 km/hr in certain cases. When it reaches the shore, its impact is tremendous. Like a tsunami, the e-waste phenomenon remains relatively unnoticed for the last few decades but it has been growing at a fast pace and its future impacts raise serious health and environmental concerns.

2.1 The Main Causes behind the E-waste Tsunami and the overall Trends in the Generation of E-waste Generation

Three main interrelated factors contribute to the expected e-waste tsunami:

(1) Surging worldwide sales of e-products with shorter life-span

Rapid technological developments, sophisticated and demanding customers who view these products as part of their life style, and endless upgrades largely explain the increased sales of new e-products that become obsolete in shorter periods of time. Due to their shrinking lifespan, the number of unwanted e-products tends to be disproportionately high. In certain cases, the sales of e-products are induced by governments as it is the case in telecommunications. For instance, the U.S. Congress mandated June 13, 2009 as the first day for full-power television stations in to broadcast in digital only (FCC, 2009). As a result, some 35.5 million digital TVs were sold in the U.S. in 2009 (CEA, 2009). Surging sales of e-products with shorter life-span contribute to the fact that e-waste represents the fastest growing category of wastes in the U.S. (EPA, 2006) and in many industrialized countries (Robinson, 2009). The current worldwide production of e-waste is assessed to be between 20 and 50 million tonnes per year and is generated mainly by the U.S., Western Europe, China, Japan, and Australia (Davis and Herat, 2010; Robinson, 2009; Cobbing, 2008).

Sales of e-products in developing and newly industrialized countries are also expected to surge for next decade (United Nations University, 2010), resulting in a sharp rise of e-waste in the next 10 years. For example, some 1.21 billion mobile phones were bought worldwide in 2009 (Gartner, 2010) and the sales of these e-products grew 17% in first quarter 2010. During the same period, the sales of smart phones have increased by 45% worldwide (Gartner, 2010). E-waste generated from unwanted mobiles is projected to increase from 2007 to 2020 by seven times in China and by eighteen times in India (United Nations University, 2010). E-waste from computer products will follow a similar upward trend and is expected to double for China and to quintuple for India (United Nations University, 2010). Coping with these huge volumes of e-waste may prove to be a daunting task for the next decade.

(2) Stockpiling a Large Proportion of Unwanted e-products

Households, small businesses and small organizations store large volumes of unwanted electronics in stockrooms, basements, garages, etc. The total number of e-products that were stockpiled in the U.S. in 2007 was estimated to reach 234.6 million units (EPA, 2008, p.25). This figure includes TVs (99.1 million), desktop computers (65.7 million), desktop monitors (42.4 million), notebook computers (2.1 million) and hard copy peripherals such as printers, copiers, faxes and multi-functions (25.2 million). In addition, some 500 million cell-phones are left unused in American households (EPA, 2008). Stockpiling of old electronics seem to be common in industrialized countries and in developing economies (Ongondo et al., 2011). Eventually, these stockpiled e-products will become e-waste.

(3) Recycling a Very Small Portion of E-waste

According to the EPA, only 18% to 15% of e-waste is collected in the U.S. for recycling or for reuse (EPA, 2008) while the remaining e-waste is either incinerated or disposed in landfills. As much as 50% to 80% of the e-waste collected in industrialized countries for recycling or for reuse actually ends up in developing or newly industrialized countries. Although illegal under the Basel Convention, this is however a current practice (UNEP, 2009). For example, 70% of e-waste in recycling units in New Delhi (India) originates from developed countries (UNEP, 2009; Basu, 2006).

E-waste in emerging economies is simply dumped in open landfills, incinerated using primitive methods, even in open fires, or recycled with few health and safety protections and with low standards or no standard at all (LaDou and Lovegroove, 2008). "Primitive" recycling of e-waste take place in counties such as China (Huo *et al.*, 2007; Wong *et al.*, 2007), India (Chatterjee, 2008); Ha *et al.*, 2009), Nigeria (Osibanjo and Nnorom, 2007; Schmidt, 2006) or Vietnam (Tue *et al.*, 2010). "Informal" recycling or small scale recycling is very present in Brazil, Colombia, Kenya, Mexico, Morocco, Peru, Senegal, South Africa, and Uganda (UNEP, 2009).

With skyrocketing sales of e-products, developing and newly industrialized countries already generate high volumes of domestic e-waste. When their domestic e-waste is combined with the large volumes of imported e-waste from industrialized countries, the rate of e-waste accumulation is increasing at a fast pace but the existing collection and recycling capabilities in emerging economies are simply inadequate (United Nations report, "Recycling - from E-Waste to Resources"). Year after year, the environmental and health problems generated by e-waste build up. Like a looming tsunami, e-waste appears as a disaster waiting to happen.

2.2 Impacts of the E-waste: from Localised Contamination to Worldwide Migration

"*Electronic waste (e-waste) has emerged as a critical global environmental health issue because of its massive production volume and insufficient management policy in many countries*" (Chen *et al.*, 2010, p. 1). In fact, as displayed in table 1, e-waste contains many toxic materials such as lead, mercury, cadmium, beryllium, brominated flame retardants (BFRs) and **polyvinyl chloride** plastics (PVCs) that have demonstrated adverse health effects (Ogunseitan *et al.*, 2009).

Table 1
Adverse Effects of E-waste on Human Health

Toxic Materials	*Found in*	*Effects on human health*
Lead	CRT screens, batteries, printed wiring boards, etc.	Brain damage in children
Mercury	Older computers, fluorescent tubes, tilt switches, batteries, etc.	Brain and kidney damage
Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, printer drums for photocopying-machines, etc.	Kidney damage and human carcinogen
Beryllium	Motherboards, connectors, etc.	Human carcinogen
BFR's	Casings for computers, printers and TVs, printed circuit boards, etc	Adverse effects on the neurological and endocrine systems
Plastics and PVC's	Circuit boards, connectors, plastic covers, PVCs for cable insulation, etc.	Adverse effect on the immune and reproductive systems, and human carcinogen in the case of PVCs

In the U.S., more than 80% of e-waste is either disposed of in landfills or incinerated. E-waste in landfills may leak toxic chemicals into ground waters, even when modern techniques such as secure landfills using impervious liner are used. The main concerns rise from the leaching behaviour of certain metals such as lead, mercury and cadmium. Incineration with a controlled and complete combustion process is rather expensive and represents a heavy financial burden on municipal waste management plants. Inappropriate incineration of e-waste may release furans, dioxins, polycyclic aromatic hydrocarbons, polyhalogenated aromatic hydrocarbons, and hydrogen chloride. For instance, the incineration of plastics containing brominated flame-retardants generates polybrominated dibenzodioxins and dibenzofurans (Lenoir and Kampke-Thiel, 1995; Wäger *et al.*, 2010) that are highly toxic in small concentrations and very persistent in the environment. These chemicals are now omnipresent in the environment, even in remote areas such as the Arctic and deep in the oceans, and are found in increasing levels in sediments, marine animals and humans (Hischier, R. *et al.*, 2005; Karlsson, M. *et al.*, 2005; Koss, 2006).

"Primitive" and "small-scale" recycling is considered by most observers as the worst environmental problem and the most serious health issue arising from e-waste (Chen *et al.*, 2010; Caravanos, *et al.*, 2011). "Primitive" and "small-scale" recycling include crude techniques such as the use of highly corrosive acids to liberate precious metals such as gold from microchips or the use of open fires to burn wires and other plastics to extract copper. The local contamination on these recycling sites exceeds by far the European and North American safety levels. When in contact with these materials, either through skin contact or from inhalation, the e-waste workers experience serious adverse health effects, especially in low-income countries. The exposure risk of e-waste workers in the poorest regions where recycling is done bare hands, often by children, (Greenpeace International, 2009; Caravanos *et al.*, 2011), is inacceptable. The communities near these "primitive" and "small-scale" recycling sites are also in contact with these toxic contaminants that are present in the smoke, the dust, the water and the food.

The adverse impacts of e-waste on the environment and human health are the most acute in developing and newly industrialized countries. They also represent a serious worldwide problem (EPA, 2010). For instance, persistent organic pollutants can travel very long distances by wind or water, are known to persist in the environment for very long periods of time, "bio-accumulate" in human and animal tissue, and "bio-magnify" in food chains (Ritter *et al.*, 2011).

2.3 Solutions to Address the Problem of E-waste

T*he magnitude of the e-waste problem is worrisome and its scope* constitutes also a key concern for government, industries and citizens. Three main solutions can be undertaken in order to lessen this problem:

(1) Environmentally Friendly Valorisation Activities: Recuperation, Product Recovering and Recycling

Giving a value to the obsolete or unwanted electronic equipment permits to decrease the amount of e-waste to be eliminated and to reduce the negative impacts on human health and environment. E-waste valorization includes three different methods: recuperation, product recovery and recycling. Recuperation refers to extend the useful life of product by regular and preventive maintenance, updates, reparation and appropriate use of electronic equipment. Recycling aims at recovering materials that can be reusable or recyclable, such as copper, lead, and precious metals (silver, gold, platinum, and palladium) (Kang and Schoenung, 2005). Product recovery refers to give another use, different from the initial intended use, to the electronic equipment such as donating obsolete computers to poor population sectors or reusing them for pieces of art. Dijkema and al. (2000) indicated that wastes are resources that are not exploited to their full capacity. However, effective reprocessing methods and technologies, which recover the valuable materials with minimal environmental impact, are expensive. Indeed, these valorization methods are not fully used in industrialized countries. Moreover, re-use, recovering, and recycling, even if they are environmentally friendly, only represent only "stopgap" and "end of the pipe" measures that cannot cope with the increasing volumes of e-waste.

(2) Increased Public Awareness and more Stringent Legislation

Increasing public awareness of the e-waste problems represents an important starting point (Khetriwal *et al.*, 2009) that may change consumers' behaviour (Olla and Toth, 2010). Better informed consumers may require greener e-products for their next purchase, act more responsible when they dispose of their unwanted electronics, and pressure legislators and e-product producers to undertake more environmentally friendly actions.

More stringent regulations may constitute the most compelling option. Several legislations have been implemented in order to reduce the environmental and health impacts of e-waste. Since 2003, the EU Directive on *Waste Electrical and Electronic Equipment* (WEEE) controls the final disposal methods for unwanted electronics. Since July 1, 2006, the EU directive on the *Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment* (RoHS) bans new electrical and electronic equipment containing more than established levels of certain hazardous substances. In United States, California went ahead with several legislations that impose an e-waste recycling fee to consumers and restrict the use of heavy metals and hazardous substances in the production of electronic devices. Following the California efforts, other American states have developed regulations to ban mercury and flame retardants.

The above-mentioned legislations have generated long debates and are less stringent than originally intended. For instance, the first goals set by the European parliament were to process 85% of e-waste in EU countries by 2016 but the new requirements put forward in March 2011 now only concern 45 % of e-waste (UPI, 2011). This is considered by environmentalists as too modest and cannot "keep up with mounting e-trash" (Greenemeier, 2007, p.1).

(3) Extended Producer Responsibility (ERP)

The EPR may be defined as "an environmental protection strategy that makes the manufacturer of the product responsible for the entire life cycle of the product and especially for the take back, recycling and final disposal of the product" (Khetriwal *et al.*, 2009, p. 155). As an environmental policy approach, it implies first and foremost that the responsibility for a product at the end of its useful life is shifted from the municipalities and the consumers to the producers. Furthermore, the producers are also (1) liable for the environmental impacts generated by their products, (2) responsible to provide information on the environmental characteristics of their products (informative responsibility), (3) responsible (at least partially) for the costs for the collection, the recycling, or the final disposal of their products (economic or financial responsibility), and (4) responsible for the logistics or physical management of their products at the post-consumer phase (physical responsibility).

Electronics are complex products. Their final safe and environmentally sound disposition is particularly difficult and expensive. Ultimately, final consumers will probably bear the costs of an EPR approach. However, the EPR tackles the e-waste problems at their roots as it promotes a green vision through the whole cycle of the life of e- products, namely design, manufacturing, marketing, distribution, use and final disposal. Electronics manufacturers must therefore modify their competences, strategies and procedures in order to fulfill their extend responsibility.

The ERP approach has been recently encouraged in several countries. For instance, Switzerland, Netherlands, Norway, Belgium, Japan, Sweden and Germany have opted for imposing this approach to manufacturers (Khetriwal *et al.*, 2009). With the exception of California and Utah that collect an e-waste recycling fee from consumers, twenty-five U.S. states have adopted, between 2010 and 2011, some producer responsibility laws. These state laws that are mainly directed towards take-back and recycling programs that now financed by and fall under the responsibility of the manufacturers vary significantly with respect to the producers' financial and physical responsibility (Electronics Take Back Coalition, 2011).

3. RESEARCH CONTEXT AND METHODOLOGY

3.1 E-waste in Healthcare Sector

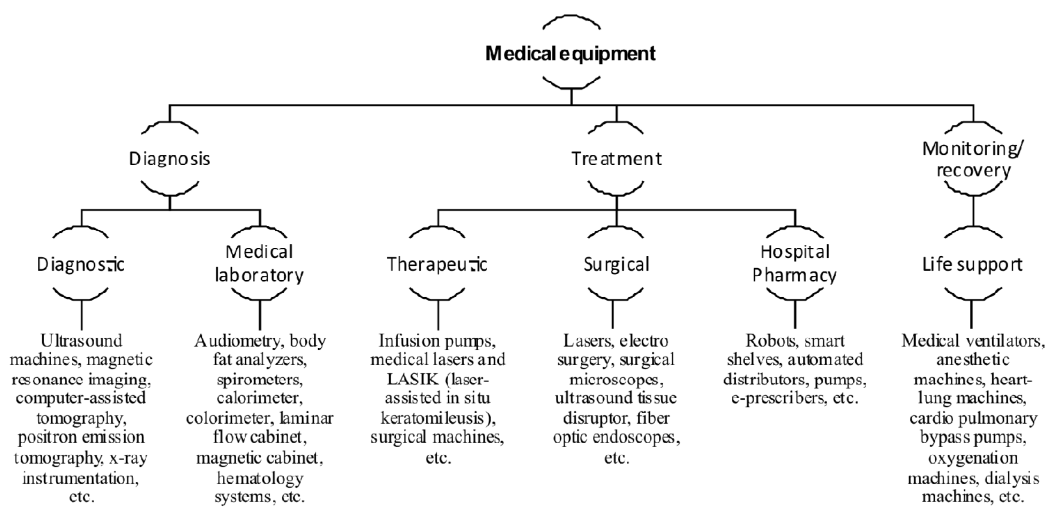
The health sector generates high volumes of e-waste that mainly falls under two main categories:

(1) *"Regular" e-waste.* The healthcare is information intensive as it relies on accurate and timely information for administrative and clinical applications. Moreover, it is also transactions intensive as it manages an estimated thirty billion transactions annually (Wager *et al.*, 2009). Information technologies including computers, printers, and other peripherals are therefore very present in healthcare organizations and the resulting high volumes of e-waste are inevitable. The end-of-life plan for e-products must include tight data security measures for the sensitive patient information stored on the discarded computers and other electronic equipment, as it is required by the Health Insurance Portability and Accountability Act.

(2) *Medical e-waste*. Lefebvre and co-authors (2011a) suggested that the incremental e-waste generated by obsolete or unwanted e-medical equipment is becoming a critical issue. E-medical equipment is omnipresent in the healthcare service, ranging from small, basic and inexpensive devices, such as thermometers or stethoscopes, to expensive and complex equipment such as surgical machines, robots or dialysis machines. Healthcare givers and support staff (pharmacists, nurse's assistants, technicians, orderlies and clerks) rely on e-medical equipment during all the phases of healthcare services, namely diagnosis, treatment and monitoring/recovery (Figure 1).

Several studies have demonstrated that the introduction of more sophisticated e-medical equipment is directly linked to the improvement of the medical services (Menachemi *et al.*, 2008). Giving the pressures for improving the quality of healthcare services, healthcare organizations tend to opt for the continuous modernization of their medical equipment. As a result, they contribute to the rising problem of medical e-waste that present the same adverse health and environmental impacts discussed in section 2.2. Medical e-waste poses an additional threat as in some cases e-medical equipment can be easily infected or contaminated with human body and fluids or with dangerous medical substances (Lefebvre, *et al.*, 2011).

Figure 1: Classification the E-medical Equipment



3.2 Methodology

The ERP (OECD, 2001; Yoshida and Yoshida, 2010; Zoeteman *et al.*, 2010) points to the critical role that producers play in minimizing the environmental impacts of their own products. A survey was therefore conducted among the manufacturers of e-medical equipment located in the U.S. and Canada. A thoroughly pre-tested questionnaire was sent to three respondents in each firm: the CEO (chief executive officer) because of his/

her overall knowledge of the strategic orientation of the firm, the head of operations/ manufacturing, and the marketing director. Multiple respondents seem to be highly appropriate for two main reasons: first, the data are more reliable than they would have been with a single informant (Bowman and Ambrosini, 1997) and second, an effective environmental strategy requires a functional integration (Lefebvre *et al.*, 1995).

The goodness of fit tests indicate that non-responding firms do not differ significantly from responding firms with respect to both firm size and the type of e-medical equipment. Due to the presence of multiple respondents, inter-rater reliability tests (Shrout and Fleiss, 1979) were also conducted in order to assess the existence of particular biases among the different types of respondents (CEOs, heads of operations/ manufacturing, marketing directors). Based on the inter-rater reliability tests, the information given by the respondents ranges from very reliable (r =0.97) to reliable (r = 0.59), with only the exception of one firm which is removed from the data base. In total, 59 manufacturers of e-medical equipment participated in our study.

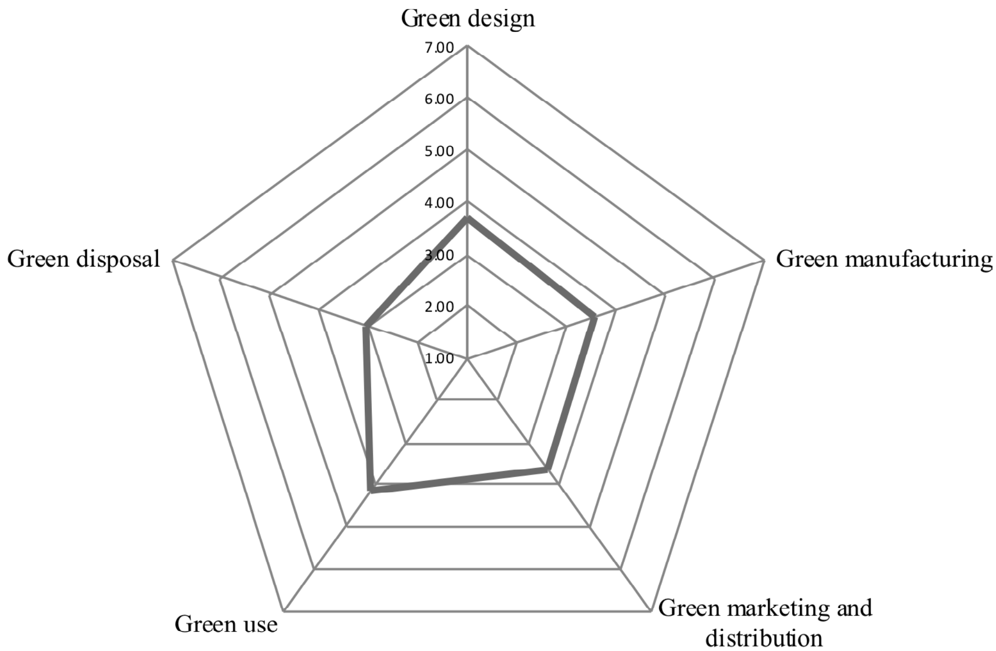
All the responding firms manufacture their products in North America but they are highly internationalized since they import raw materials and export their final products. They employ in average 156 full-time employees. The average life span of their products is about eleven years. They considered their clients- i.e. - healthcare organizations- as sophisticated and demanding. This may explain why most participating firms have implemented a TQM program (58%) and many are ISO 9000 certified (39%). However, very few manufacturers (3%) have implemented ISO 14000, an environmental program quality. This last result reflects the trend observed worldwide: ISO 14000 has been slower to take off in North-American and is far behind some European countries (in particular, United Kingdom and Sweden) and Japan.

4. RESULTS AND DISCUSSION

The ERP approach aims to minimize the negative environmental impacts of e-medical equipment at every stage of the product's lifecycle, namely design, manufacturing, marketing and distribution, use, and disposal. Figure 2 indicates the relative importance of the initiatives undertaken by e-medical equipment manufacturers to green their products at each of the above mentioned stage. Overall, these initiatives appear to be quite modest, ranging from 2.72 to 4.40 on 7 point-Likert scale.

As displayed in Figure 2, green use (4.40) receives the highest score: This represents a customer-oriented initiative and a sound business strategy. Green manufacturing (3.76) represents the second highest score. With the rising costs of energy and increasingly more expensive raw materials, green manufacturing allows reducing the overall manufacturing costs, which in turn entails a higher profit margin or lower prices for e-medical equipment. In either case, this is a winning situation. Surprisingly, green design (3.64) is only in third position although it is anticipated by most experts that the ERP approach leads to upstream changes in design. The very complexity of e-medical equipment may explain this rather low score for green design. Efforts are also made by the manufacturers to raise the customers' awareness of the environmental characteristics

Figure 2: The Relative Importance of Environmental Initiatives Undertaken by the Producers of E-medical Equipment at Each Stage of the Products' Life Cycle (1)



(1) Means based on Likert scales where 1 = no effort, 7 = considerable efforts

of their products. However, green procurement and green purchasing is not yet a generalized practice in healthcare organizations. This may explain partially the fourth position obtained for green marketing and distribution (3.47). Finally, green disposal (2.72) receives by far the lowest score, which is quite indicative of the mounting e-waste problems, the absence of uniform federal regulations regarding e-waste and the presence of fragmented and widely different state policies. Manufacturers tend to privilege a wait and see attitude until a clearer message is sent by legislators.

Appendix 1 sheds some light on the results presented in Figure 2 as it shows the relative importance of 15 specific initiatives undertaken by manufacturers for the five stages of the products' life cycle. "Increasing the product durability" (4.58 under green use) is the most important initiative among the 15 initiatives while ensuring the presence of recycling infrastructures (2.69 under green disposal), which is indeed a very expensive undertaking, scores the lowest.

Do manufacturers gain any competitive advantages from their green initiatives? The answer based on the results presented in Table 2 seems to be positive, but not overly positive. "Improving firm's green reputation" (rank 1, 3.66) ranks first. This rather intangible benefit does not necessarily translate to an "increase of profit margin" (last rank, 2.97) or an "increase market share" (rank 18, 3.01). On a more positive side, the environmentally friendly initiatives seem to "create new opportunities for new products" (rank 2, 3.51) that may eventually generate positive impacts on the bottom line. Cost reductions (reduction of energy, liability risk, transport, manufacturing and stocking costs, respectively ranks 3, 7, 9, 10 and 13) represent tangible and positive impacts for the manufacturers. Gaining a better knowledge of the environmental requirements from different markets, the environmental technologies and equipment, and the customers' needs (respectively, ranks 4, 5 and 6) may constitute a long-term sustainable advantage.

Table 2
The Impacts of the Environmental Initiatives Undertaken by the Producers of E-medical Equipment

Impacts of environmental activities undertaken by producers	*Mean[1]*	*Rank*
Improve firm's green reputation	3.66	1
Create new opportunities for new products	3.51	2
Reduce energy consumption	3.51	3
Have a better knowledge of environmental requirements from different markets	3.43	4
Have a better knowledge of environmental technologies and equipment	3.39	5
Have a better knowledge of customers needs	3.34	6
Reduce liability risk	3.31	7
Adopt more efficient manufacturing technologies	3.22	8
Reduce transport costs	3.20	9
Reduce manufacturing costs	3.18	10
Introduce new management system	3.16	11
Develop new products	3.16	12
Reduce stocking costs	3.09	13
Improve product quality	3.09	14
Acquire new competencies in marketing	3.08	15
Acquire new competencies in production	3.08	16
Reduce raw materials	3.02	17
Increase market share	3.01	18
Improve product design	3.01	19
Improve safety and workers conditions	3.00	20
Acquire new competencies in R&D	2.99	21
Increase profit margin	2.97	22

1. Means based on Likert scales where 1 = no benefit, 7 = considerable benefits;

5. CONCLUSION

The healthcare sector contributes significantly to the e-waste tsunami. *It is estimated that healthcare uses and discards millions of electronic devices annually.* With a heavy reliance on information technologies for day-to-day administrative operations and care services, healthcare is confronted with large volumes of normal e-waste, mainly in the form of discarded or obsolete computers and related peripherals. In addition to normal e-waste, hospitals and other healthcare organizations use a multitude of electronic devices and e-medical equipment for the diagnosis, treatment, and monitoring/recovery of patients. The resulting volumes of medical e-waste and their adverse impacts on health and the environment are significant but this issue remains under-investigated in the literature. The paper attempts to gain a better understanding of this specific issue.

While policy instruments and regulations seem to target end-of-life solutions to the e-waste problems, it seems more appropriate to tackle the problems at their source: producers can make the required changes so that the environmental impacts of their products are minimized throughout their life cycle, from design, manufacturing, marketing/distribution, and final disposal. This approach known as EPR is therefore much wider that the take-back systems. Following the EPR approach, the paper seeks to answer the following questions: Are producers of e-medical equipment proactive with respect to greening their products? Do they gain competitive advantages from greening their products?

The analysis of preliminary results demonstrates that there is room for improvements. The environmental initiatives undertaken by the American and Canadian manufacturers of e-medical equipment, that are strictly voluntary, remain rather modest and are mainly directed towards green use. Efforts towards green disposal appear to be minimal. The competitive advantages derived from these initiatives are mainly intangibles, do not affect the bottom line and are directed towards costs reductions.

For the top management and professionals of the manufacturers of e-medical equipment, the above initiatives seem to fall under the social responsibility of firms. However, EPR implies much more that being a responsible corporate citizen. The feedback loop from the downstream (disposal or end-of-life management) to the upstream (design of products) is not only central to the EPR approach but it is the key to the long term sustainable competiveness of these manufacturing firms. For public policy makers, implications are far reaching. The fragmented state and provincial e-waste policies in the U.S. and Canada represent stumbling blocks to manufacturers that do invest, at least to some extent as demonstrated by the empirical evidence, in environmental initiatives but are waiting to get a clear, unified and strong message from their legislators. Because e-waste represents a worldwide issue, a more coherent international approach to remove disparities between nations and continents. Stop-gap measures may not be sufficient to face the e-waste tsunami.

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Appendix 1
The Relative Intensity of Environmental Initiatives Undertaken by the Producers of E-medical Equipment

Stages	*Initiatives*	*Mean*[1]
Green design	Design product packaging to be easier to recycle	3.80
	Design the product in order to be easier to disassemble	3.50
	Design the product in order to be easier to recycle	3.20
	Design product for multiple uses	4.51
	Design product to be easier to repair	3.40
	Use more materials that are recycled or less toxic for the environment	3.20
Green manufacturing	Eliminate the wastes generated by product manufacturing and assembly	3.79
	Treat the wastes generated by product manufacturing and assembly	3.82
	Minimize the wastes generated by product manufacturing and assembly	3.90
	Reduce the amount of raw materials	3.72
	Reduce the energy needed for product manufacturing and assembly	3.59
Green marketing and distribution	Publicize the environmental characteristics of the product	3.56
	Inform customers of environmental characteristics of the product	3.44
	Minimize product packaging and make product packaging recyclable	3.40
Green use	Reduce the energy needed to use the product	4.27
	Increase the product durability	4.58
Green disposal	Establish recycling procedures and ensure appropriate procedures for dangerous or contaminated materials at the end of the product's life	2.74
	Ensure the presence of recycling infrastructures	2.69

1. Means based on Likert scales where 1 = no effort, 7 = considerable efforts.