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THE UPTAKE OF SUSTAINABLE WASTES MANAGEMENT: THE CASE OF ELECTRONIC MEDICAL EQUIPMENT

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THE UPTAKE OF SUSTAINABLE WASTES MANAGEMENT: THE CASE OF ELECTRONIC MEDICAL EQUIPMENT

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«If a man empties his purse into his head no man can take it from him. An investment in knowledge pays the best interest.»

Benjamin Franklin, 1706-1790

Écrivain, scientifique et homme d'État américain

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RÉSUMÉ

Le système de santé est un secteur hautement réglementé jouant un rôle important au sein de l'économie canadienne. En 2007, la santé représentait environ 11% du produit national brut, pour une somme s'élevant à près de 160 milliards $. Les hôpitaux occupent une place stratégique au sein du système de santé. Ils génèrent donc une quantité de déchets qui est proportionnelle à leur importance. Le taux de génération de déchets des hôpitaux nord-américains varie entre 1,5 et 3,9 kg par lit par jour. La littérature indique qu'environ 80% de ces déchets sont de nature domestique, le 20% restant est constitué de déchets cliniques. Lorsque certains déchets infectés, hasardeux ou radioactifs sont manipulés inadéquatement, mis au rebut ou éliminés incorrectement, ils peuvent représenter un danger direct pour les travailleurs oeuvrant en santé et pour le grand public.

Dans un rapport datant de 2002, l'Organisation Mondiale de la Santé recommande aux autorités sanitaires d'élaborer un plan de gestion des déchets de la santé afin d'assurer, des pratiques sécuritaires, efficaces et environnementales. Dans la lancée de ce rapport, cette initiative de recherche propose d'identifier un produit clé qui soit particulièrement significatif pour la gestion durable des déchets de la santé : les équipements et machines électroniques utilisés par les hôpitaux pour les divers soins de santé, depuis le diagnostic jusqu'au traitement des patients. Ces équipements et machines électroniques comme par exemple les systèmes d'imagerie médicale, les pompes à infusion, les défibrillateurs, les sphygmomanomètres ou les thermomètres numériques sont de plus en plus présents dans les hôpitaux et autres institutions. La problématique de ces déchets électroniques a

été peu étudiée dans la littérature existante, même si elle comporte beaucoup d'impacts et peut poser une menace directe à la santé publique et à l'environnement. En effet, les déchets électroniques contiennent plusieurs éléments dangereux comme les métaux lourds, comme le plomb, le cadmium ou le mercure, les plastiques chlorés ou les matériaux ininflammables à base de brome des plaques de circuit, etc. Ces polluants libérés dans l'environnement sont la cause de nombreux cancers, défauts de naissance et de disruption hormonale.

Cette initiative de recherche propose un large éventail d'activités qui ont pour but de valoriser et minimiser les déchets électroniques. Ces opportunités sont offertes par un continuum d'organisations qui œuvrent ensemble pour atteindre une gestion des déchets durable. Ce réseau inter organisationnel est composé des fabricants de produits cliniques, des hôpitaux, de organisations qui transportent et traitent les déchets cliniques. Ce projet de recherche se propose d'être le point de départ pour des études futures. Premièrement, il propose une perspective qui permet d'évaluer les impacts environnementaux de chacun des acteurs clés. Deuxièmement, cette étude permet d'établir une liste de variables de recherche qui pourront être validées, raffinées et testées. Par exemple, un point de départ qui pourrait être intéressant pour une recherche empirique future serait d'évaluer les avantages réalisés grâce aux différentes initiatives environnementales. Troisièmement, cette recherche démontre que la gestion du cycle de vie de produit n'est pas un concept cantonné à la théorie mais qu'il peut constituer une approche ayant des effets concrets sur l'environnement et sur les organisations.

ABSTRACT

The healthcare is a highly regulated sector and an important economic actor. According to the latest statistics, close to 10,6% of Canada's GDP is devoted to healthcare and the healthcare system is the third largest employer in the country with 1,9 million employees Hospitals play a strategic and central role in the healthcare sector, are complex systems and, generate huge amounts of wastes that have adverse effect on human health and on the environment. It seems therefore rather pertinent to propose a framework for sustainable wastes management in the healthcare sector, and more specifically for the wastes generated by hospitals.

A sustainable wastes management framework implies that healthcare wastes are minimized, even eliminated. It also requires strong product stewardship and adequate options at the end of product life cycle. It therefore points to a network of organizations that provides or arranges to provide a coordinated continuum of wastes management activities. A field study was conducted in order to obtain some preliminary empirical evidence on such network and gain insights into hospital wastes management. The main results from the field study are as follows. First, entities of the inter-organizational network for wastes could be identified and their respective roles could be outlined. The five broad groups of entities may be retained, namely the suppliers that provide the necessary inputs for hospitals' activities, the hospitals themselves which "consume" these inputs and transform them into waste, the waste treatment and disposal organizations that handle, treat, recycle and dispose of wastes.

From on-site observations and interviews conducted during the field study, it also became evident that the typology of healthcare wastes as proposed in the literature should also include an important type of waste, namely electronic medical equipment. In fact, not only electronic medical equipment is omnipresent in hospitals but it is highly sophisticated and present severe environmental problems that do not seem to be covered by the actual regulatory framework. Finally, the coordinated continuum of wastes management activities that are under the responsibilities of the suppliers of electronic medical equipment could be validated. Such an approach builds on the product stewardship concept and avoids that environmental burdens are shifted from one stage of the product lifecycle to the next stage.

The results from the field research serve as valuable inputs to the survey design. The questionnaire was sent to North-American firms responsible for manufacturing electronic medical equipment. The total number of responding firms was 59 firms and the response rate was 6,7%. As the survey was conducted for exploratory purposes, this critical mass of firms although rather small is sufficient enough to carry univariate and bivariate statistical analyses. Results from the survey indicate that, with 156 full-time employees in average, the responding firms are highly internationalized. Their customers (i.e. hospitals) are sophisticated and demanding. Their products life cycle is approximately eleven years in average. More than half of these firms have implemented TQM programs but very few (3 %) are certified ISO 14 000. The environmental initiatives undertaken by the suppliers of electronic medical equipment directly affect their own organizations, the hospitals, the wastes treatment and disposal organizations, and all the organizations previously mentioned. These initiatives are rather modest. The main drivers of the environmental initiatives are the customers' requirements (i.e. hospitals) and market opportunities while actual and projected regulations seem to play a moderate role. The impacts of these environmental initiatives for the suppliers of medical electronic equipment are mostly market driven opportunities and building environmental capabilities.

Relationships between firms' characteristics and environmental initiatives are weak but proactive environmental initiatives are significantly and positively related to an aggressive technology strategy, to demanding and sophisticated customers, and to alleged benefits, in particular some market driven and cost reduction opportunities. The strong and positive relationships between environmental initiatives and new knowledge and new competencies acquisition may indicate a self reinforcing phenomenon where the first environmental initiatives among suppliers of medical electronic equipment allow to build some environmental capabilities that will eventually translate into more proactive environmental initiatives, thereby generating a positive impact on the waste management activities of the organizations downstream (hospitals, wastes treatment and disposal organizations). The uptake of a sustainable healthcare wastes management is largely dependent on the actions of organizations located upstream.

CONDENSÉ EN FRANÇAIS

Le système de santé est un secteur hautement réglementé qui détient un rôle important au sein de l'économie canadienne. En 2007, la santé accaparait presque 11% du produit national brut, pour une somme s'élevant à près de 160 milliards $. Le système de santé est également le troisième plus grand employeur au Canada avec 1,9 millions d'employés. Au Québec, les services de santé emploient 255 062 personnes incluant 22 631 professionnels.

Actuellement, les hôpitaux jouent un rôle stratégique dans le secteur de la santé. En 2006, les hôpitaux ont reçu 44 milliards $ en 2006, représentant ainsi 30% de toutes les dépenses en santé. Le taux de génération des déchets dans les hôpitaux nord-américains s'élève à environ 6,1 kg/capita. On estime qu'en 2005, les hôpitaux américains ont généré deux millions de tonnes de déchets cliniques (Health Care Without Harm, 2008; U.S Census Bureau, 2008). La littérature indique qu'environ 80% de ces déchets sont de nature domestique. Le 20% restant est constitué de déchets cliniques qui peuvent être classifiés comme 1) infectés (par exemple les seringues ou les scalpels souillés, ou les déchets pathologiques), 2) dangereux (ce qui inclut les produits pharmaceutiques primés ou les déchets génotoxiques), et 3) radioactifs. Lorsque certains déchets cliniques sont manipulés inadéquatement, mis au rebut ou éliminés incorrectement, ils peuvent représenter un danger direct pour les travailleurs œuvrant en santé et pour le grand public. Cette situation est pour le moins paradoxale pour des institutions qui ont pour mission de veiller à la santé du public.

L'OMS recommande donc aux autorités sanitaires d'élaborer un plan de gestion des déchets de la santé détaillé, tant au niveau national que régional, afin d'assurer, des pratiques sécuritaires, efficaces et environnementales. Celui-ci doit contenir des directives adressées aux gestionnaires des hôpitaux visant à prévenir et à réduire la production de déchets.

La gestion des déchets de la santé fait face actuellement à plusieurs défis comme l'inquiétude croissante de l'opinion publique face aux questions environnementales, une réglementation de plus en plus sévère ainsi qu'un coût de traitement de décontamination de plus en plus élevé. Un cadre de gestion des déchets qui vise de devenir durable doit nécessairement minimiser voire éliminer les matières résiduelles. Pour atteindre cet objectif, les impacts environnementaux de chaque phase du cycle de vie du produit doivent être réduits drastiquement. De plus, il doit exister un large éventail d'options de minimisant les impacts environnementaux lors de la fin de vie du produit.

Cette initiative de recherche propose que les opportunités de valorisation et minimisation des déchets de la santé doivent être étudiées. Ces opportunités sont offertes par un continuum d'organisations qui doivent œuvrer ensemble pour atteindre une gestion des déchets durables. Ce réseau inter organisationnel est composé des fabricants de produits cliniques, des hôpitaux, des transporteurs et des firmes de traitement des déchets cliniques.

Les solutions technologiques de fin de vie de produits domestiques ont été largement étudiées dans le passé. Cependant, ce n'est pas le cas pour leur contrepartie clinique. Le cadre actuel de gestion des déchets de la santé est limité parce que les différents intervenants ne considèrent pas la totalité des opportunités de valorisation des matières résiduelles. La nature «sale» de ces matières résiduelles a grandement limité les possibilités de recyclage des produits cliniques.

Cette initiative de recherche retient un type de déchets cliniques, soit les équipements et machines électroniques utilisés pour les soins de santé comme par exemple svp mettre 5 exemples et démontre que ce type de déchets est particulièrement significatif pour la gestion durable des déchets de la santé. Elle propose également un continuum des activités de gestion des déchets liés aux équipements et machines électroniques utilisés pour les soins de santé. De plus, notre recherche tente d'évaluer l'intensité de ces activités, d'analyser les incitatifs pour conduire ces activités et d'évaluer les impacts de ces activités. Finalement, elle propose d'analyser les différentes opportunités de valorisation des déchets.

Les données ont été recueillies à partir de plusieurs sources d'information:

Information disponible dans la littérature et dans les différentes banques de données gouvernementales comme Recyc-Québec, ICRIQ (Fabricants et distributeurs du Québec) et Strategis (Industrie Canada).

Contacts directs avec plusieurs entreprises: Veolia es Canada Services Industriels, Services Matrec Inc., Sani-Eco Inc, BFI Environnement, Chem-Environnement, Enviroplast Inc. et le Groupe Lavergne.

Contacts directs avec des gestionnaires d'un hôpital, incluant le responsable de la gestion des déchets, afin d'identifier les pratiques de gestion des déchets des hôpitaux.

Envoi d'un questionnaire destiné à des entreprises manufacturières d'équipements médicaux destinés au secteur de la santé.

Les entrevues effectuées avec les gestionnaires de la santé et les responsables de la gestion des déchets d'un hôpital ont permis de retenir les déchets électroniques comme étant une importante source d'inquiétude au sein du secteur de la santé. Les produits électroniques comme par exemple les systèmes d'imagerie médicale, les pompes à infusion, les défibrillateurs, les sphygmomanomètres ou les thermomètres numériques, sont en effet de plus en plus utilisés et permettent d'apporter des soins hautement sophistiqués aux patients. Les déchets générés par ces équipements et machines électroniques contiennent plusieurs éléments dangereux pour la santé et l'environnement : par exemple, les métaux lourds tels que le plomb, le cadmium ou le mercure présents dans les moniteurs cathodique, les plastiques chlorés des câbles, les matériaux ininflammables à base de brome des plaques de circuit, etc. Uniquement aux États-Unis, plus de 70% des métaux lourds des sites d'enfouissement proviennent de déchets électroniques. Les polluants libérés par ce type de déchets dans l'environnement peuvent être la cause de nombreux cancers, défauts de naissance et de disruption hormonale. Cette situation suggère que des efforts additionnels, non seulement de la part des manufacturiers mais également de la part de tous les acteurs clés, doivent être entrepris pour réduire les impacts environnementaux. Une élimination des déchets ne respectant pas les règles de l'art, comme leur incinération ou leur enfouissement, entraîne une menace directe à la santé publique comme à l'environnement.

Un questionnaire a été envoyé aux cadres des entreprises manufacturières nord-américaines responsables de la production des équipements et machines électroniques destinés au secteur de la santé. Cinquante-neuf (59) entreprises ont participé à cette enquête avec un taux de réponse de 6,7%. Les gestionnaires des entreprises devaient répondre à des questions concernant le profil de l'entreprise, la commercialisation du dernier produit, les caractéristiques des clients et des produits, aux initiatives environnementales concernant leurs produits, les incitatifs pour de telles initiatives et les impacts de ces initiatives.

La taille moyenne des entreprises répondantes est de 156 employés, avec une médiane de 75 employés. Ces entreprises concentrent leurs ventes et achats en Amérique du Nord. Leurs clients sont exigeants et demandent de nombreux changements aux produits fabriqués. La durée moyenne de ces produits est de onze ans. Plus de la moitié des entreprises répondantes possède un programme de qualité. Cependant, un nombre marginal (3%) d'entre elles sont certifiées ISO 14000.

Les initiatives environnementales entreprises affectent tous les acteurs du réseau inter organisationnel : premièrement, les manufacturiers eux-mêmes, deuxièmement, les hôpitaux qui « consomment » ces produits, et, finalement, les organisations qui transportent et traitent ces produits à fin de leur vie utile, ou tout au moins quand les hôpitaux désirent les mettre au rebut. Les initiatives environnementales des manufacturiers des équipements et machines électroniques destinés aux soins de santé sont toutefois modestes. Les entreprises répondantes semblent s'être tout d'abord souciées de satisfaire les besoins de leurs clients. En effet, les activités de gestion de déchets ayant un impact direct sur les hôpitaux sont beaucoup plus intenses que les autres. D'autre part, les entreprises répondantes ont également profité de l'argument environnemental pour réduire leurs coûts de fabrication. En effet, les initiatives environnementales ont permis aux manufacturiers de réduire la quantité de matières premières et d'énergie impliquées lors de la fabrication.

Les résultats montrent que des initiatives environnementales plus agressives sont reliées à une stratégie technologique agressive et à la satisfaction de clients exigeants. Une stratégie environnementale agressive permet également aux manufacturiers de réduire leur coût de production et acquérir de nouvelles parts de marché en commercialisant leur produit comme «vert». La relation positive et significative entre l'intensité des initiatives environnementales et l'acquisition de nouvelles connaissances et de nouvelles compétences peut indiquer un comportement innovateur qui s'appuie sur des capacités organisationnelles. Une organisation qui a mis en place certaines initiatives environnementales aura tendance à entreprendre d'autres initiatives encore plus audacieuses. Conséquemment, cette situation peut engendrer un effet positif sur tout l'ensemble du réseau inter organisationnel.

En dépit de certaines limites dues principalement à la nature exploratoire de cette recherche et à la taille restreinte de l'échantillon, ce projet de recherche permet de poser certaines bases sur lesquelles pourraient s'appuyer les études futures. Ce projet de recherche se propose d'être le point de départ pour des études futures. Premièrement, il propose une perspective qui permet d'évaluer les impacts environnementaux de chacun des acteurs clés. Deuxièmement, cette étude permet d'établir une liste de variables de recherche qui pourront être validées, raffinées et testées. Par exemple, un point de départ qui pourrait être intéressant pour une recherche empirique future serait d'évaluer les avantages réalisés grâce aux différentes initiatives environnementales.

Troisièmement, cette recherche démontre que la gestion du cycle de vie de produit n'est pas un concept cantonné à la théorie mais qu'il peut constituer une approche ayant des effets concrets sur l'environnement et sur les organisations.

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INTRODUCTION

Canadians are deeply attached to their healthcare system which account for close to 10,6% of GDP. Main concerns regarding the Canadian universal health care system are directed towards increasingly rising healthcare costs, long waiting times for some healthcare services, and shortage of medical practitioners to name a few. Healthcare wastes management problems are far less known by the general public, the medical professionals, the healthcare managers and the academic researchers. However, the healthcare sector generates huge amounts of wastes, basically corresponding to its economic weight, that have documented adverse effect on human health and the environment (Health Care Without Harm, 2008; Da Silva, & al., 2004).

This research project focuses on the wastes induced by hospitals that face many challenges such as proper decontamination of infected wastes, high cost of wastes treatment or inappropriate wastes management practices. The primary intent here is to propose a sustainable wastes management framework for the healthcare sector, and more specifically for hospitals. Such a framework implies that 1) healthcare wastes are minimized, or, even eliminated, 2) strong product stewardship is required and adequate options at the end of product life cycle are available and 3) a network of organizations provides or arranges to provide a coordinated continuum of wastes management activities.

This document is structured as follows. The first chapter briefly examines the general context of our research project, namely the actual context of the Canadian and provincial healthcare sector, proposes a typology of healthcare wastes, exposes the issues and concerns arising from these wastes and describe how these wastes could be treated. The second chapter represents a literature review that allows us to framework for the uptake of sustainable healthcare wastes management. The overall research strategy and the main results from the field study are presented in the third chapter whereas the results from the survey conducted among the suppliers of medical equipment are presented and discussed in the fourth chapter. Finally, the conclusion summarizes the most important results, examines some methodological issues and limitations, discusses the theoretical and practical contributions and offer some potential avenues for future research initiatives.

CHAPTER 1: THE CONTEXT

This first chapter outlines the general context of our research project- i.e. the organization of healthcare in Canada and in Québec and its relative economic importance (sections 1.1 and 1.2). It also covers the specific context of hospitals (section 1.2) before tackling one area of concerns, namely healthcare wastes generated by hospitals (section 1.3).

1.1 Healthcare in Canada

1.1.1 The organization of healthcare in Canada

The Canadian healthcare system was first regulated by the Canadian Healthcare Act under the British North American Act of 1867 and later by the Canadian Constitution of 1982. The Canadian Healthcare Act establishes the norms at the national level but stipulates that healthcare is under provincial jurisdiction.

The Canadian healthcare system encompasses the ten provincial and the three territorial healthcare systems. Healthcare services are managed and offered by the different provincial and territorial administrations. Those administrations pay for hospitals, healthcare services, equipments and personnel. For low-income citizens, most of provincial administrations offer supplemental health services such as dental, optometrist, and ambulance services as well as drugs insurance. Under the Canadian Healthcare Act, provincial administrations must comply with the following principles: all citizens must have free access to the public health system and the health system must be under public supervision. Provincial and federal administrations share responsibilities in delivering health services to the First Nations peoples as well as ensuring public hygiene, disease control, and food and drug control while the federal health agency coordinates the effort of the different provincial administrations. Finally, federal and provincial health authorities align their efforts in emergency situations such as facing the threat of a highly virulent disease.

1.1.2 The economic importance of healthcare in Canada

Healthcare expenses followed in Canada an upward trend during the last three decades: in 1975, healthcare costs represented about 7% of GNP (Gross National Product) while, in 2005, that percentage reached 10.3%. According to Canadian Institute on Healthcare Information (2007), the public health sector represented $104 billion, accounting for 70% of total spending on healthcare. The other 30% came from private health sector mostly covering supplemental health services such as drugs, dental services, optometrist services and ambulance insurance.

Cost structure significantly changed over the last three decades. First, the total expenses for healthcare staff and hospitals decreased while the expenses for drugs prescription and medical equipment increased. According to the Canadian Institute on Healthcare Information (2005), the relative importance of the costs of drugs almost doubled within the last three decades: in fact, drugs represented 9% of total healthcare costs in 1975 and reached, in 2005, 18% of the total health spending. The relative importance of costs for the healthcare labour force slightly decreased in the last three decades, from 15% of total healthcare costs in 1975 (second rank among the total healthcare costs) to 13% in 2005 (third rank).

According to the latest statistics, the healthcare sector holds an important part in the Canadian economy: close to 10,6% of Canada's GDP is devoted to healthcare, total expenditures in 2007 approached $160 billion and the healthcare system is the third largest employer in the country with 1,9 million employees (Canadian Institute for Health Information, 2007).

1.2 Healthcare in the province of Québec

1.2.1 The organization of healthcare in Québec

The Québec Ministry of Health and Social Services was created on June 20th, 1985 with the enactment Ministry of Health and Social Services Act. The Ministry main mission is to maintain, improve and restore Quebecers' health and ensure their well-being while at the same time improving the accessibility to better healthcare and social services. The Ministry also oversees the operations of Quebec healthcare system and social services. Finally, it determines priorities, objectives, policies and orientations of healthcare and supervises its application. The Ministry dispatched its responsibilities to each of the eighteen regional health authorities: the agencies. They have the overall responsibility to manage and provide healthcare and social services in a specific territory. Their specific responsibilities are illustrated in Table 1.1.

Table 1.1- Responsibilities of Regional Health Agencies

Services coordination	• Insure the coordination of health services: physicians and nurses activities to facility installations, local groups' action, both public and private eldercare activities. • Enable cooperation between each stakeholder in a specific region. • Promote activities that improve health and well-being • Determine access parameters to each facility. • Maintain and improve the coordination of services on a specific territory.
Physical and human resources management	• Determine regional needs in terms of personal and medical supply • Elaborate regional planning according to theses needs • Perform the supply activities for all the regional facilities
Resources distribution	• Allocate budget to health facilities • Give subsidies to local groups • Control budgets allocated to health facilities and local groups
Public health	• Implement public health measures • Organize services and allocate resources according to provincial standards
Service organization	• Plan and monitor the health services on a specific territory • Enable the development and the management of local health network • Support the local facilities and intervene, if needed, to enable partnership between health professionals and health managers.
Health and well-being priority	• Monitor the health facilities according to provincial standards • Monitor eldercare practices • Partnership with the First nations in of healthcare system management

With the draft bill 25 adopted in December 2003, the Government of Quebec initiated a major reconfiguration of its health and social services. The initial regional boards were replaced with new entities called "Agencies for the Development of Health and Social Services Networks" (Ministère de la Santé et des Services Sociaux du Québec, 1998). The new entities aim at bringing health social services closer to the population in their territory based on the concept of integrated network.

1.2.2 The economic importance of healthcare in Québec

Undoubtedly, the health and social services system plays an important economic role. For instance, it employs more than 7% of the Québec labour force. In 2007, Quebec healthcare system regroups a workforce of 255 062 persons, including 22 631 professionals. Close to $ 8,3 billion was attributed in salaries and marginal benefits (Ministère de la Santé et des Services Sociaux du Québec, 2008). Quebec healthcare system is actually composed of 294 establishments where citizens can receive health and social services.

If the proportion of health expenditures over GDP remains rather stable in Québec over the last 20 years, public health care costs still represents the single most important governmental budget heading with 43% of total budget. For year 2008-2009, healthcare will amount to 25.5 $ billion, a 5.5% increase or an additional $ 1,3 billion over the last year (Ministère des Finances du Québec, 2008).

1.3 The specific context of hospitals

1.3.1 The importance of hospitals in the Canadian healthcare system

Hospitals play a strategic role in the Canadian healthcare system from the financial, operational and social perspectives.

First, hospitals actually remain the single largest spending category in healthcare, reaching $44 billion in 2006 and accounting for almost 30% of total spending (CIHR, 2007). However, the relative importance of hospitals spending significantly decreased over the last three decades since in hospitals spending in 1975 accounted 43% of total healthcare expenses. The decrease is chiefly due to drastic cuts of federal funding mainly due to efforts towards deficit reduction in the early to mid 1990s. As Canadian hospitals are financed by both federal and provincial governments, the weight of hospitals spending shifted towards provincial administrations.

Second, hospitals offer a wide-range of health services from specialized services, such as intensive care to general health services. At the operational level, hospitals offer crucial services within a geographical area. For example, in Quebec, every small health organizations can refer patients to a hospital in order to receive more specialized services.

Third, hospitals have a tremendous impact within small communities. For example, Brome-Missisquoi Perkins (BMP) hospital located in Cowansville gives to Eastern Township population a strong community incentive. Both the community and the BMP hospital staff are committed in improving their health institution performance and environment. For instance, the BMP Hospital has a foundation that helps the hospital to acquire high-cost equipment and formation tools. In addition, residents of Cowansville area massively demonstrated their support for BMP hospital when Quebec healthcare ministry wanted to closed this institution (PC, 1999). According to James (1999), residents in rural areas perceived that the impact of their local hospital closure would include the loss of local jobs, a further decline in the economy, the suffering of elderly and children, the rise of transportation problems, and the out-migration of some residents.

1.3.2 Hospitals as complex systems

Considered as professional bureaucracies (Mintzberg, 1983), health care organizations, and especially hospitals are viewed as very complex systems (Glouberman and Mintzberg, 2001). Professional bureaucracies rely on duly trained specialists or "professionals" and on standards that arise mainly from outside its own structure (as opposed to the machine bureaucracy that develops from inside its own standards). Professional bureaucracies are characterized by the search "for standardization of procedures and products through the so called pigeonholing process: the organization seeks to match predetermined contingency to a standardized program, and so organize itself around the skills and knowledge of its professionals who are in charge of categorizing or "diagnosing" the client's (patient) need and apply, or execute, the matching program or procedure" (Lega and DiPietro, 2005). Moreover, the presence of a double power structure between the healthcare providers on one hand and the administrators or managers on the other hand causes major difficulties in managing healthcare organization (Glouberman and Mintzberg, 2001).

The broad model that have emerged in the Anglo-American context is characterized "by the role of physicians as consultants paid of a fee-for-services basis, by the management of hospital resources (beds, operating rooms, nurses, technologies, etc.) in the hands of nurses and administrators, by the sharing of such resources among specialty units and departments, by devolved responsibility to departments chairs, by a financially oriented culture quite spread in the organization" (Lega and DiPietro, 2005). Authors argue that optimal resources utilization is not totally achieved but scale economies and efficient resource allocation are actively pursued. Anglo-Saxons countries which operate public-fund healthcare system, such as United Kingdom, Australia and Canada, are strongly committed to the development of clinical governance tools to orient and influence physicians' behaviors (Nauert, 1995; Charns, 1986; Godlee, 1990; Heyssel, 1989 & Duckett, 1994).

Hospitals could be considered as a manufacturing plant: receiving inputs, transforming them, and producing outputs, such as improved health. However, this may be too simplified since healthcare organizations do not deliver standardized manufactured products to customers. Moreover, each human being is unique and, therefore, reacts differently to a treatment. Hospitals can also be viewed as a living organism. Such analogy is "conveyed by the science of complex adaptive systems, which reformulates systems theory in a way that produces a "model of the organization more closely related to reality" (Begun, Zimmerman & Dooley, 2003). Complex systems, such as healthcare organizations, are "concerned with explaining how "living" systems work" (Begun, Zimmerman & Dooley, 2003). Furthermore, strong financial constraints, increasing public expectations and rapid evolution of the medical sciences increase the pressures on hospitals which have to implement clinical governance. Such governance requires a hospital to integrate financial control, service performance and clinical quality (Freedman, 2002; Scally & Donaldson, 1998). Both hospitals administrators and physicians must feel accountable for its outcomes.

Although there is a consensus that changes are required, professional barriers are inducing a high degree of rigidity in healthcare organizations. In fact, provincial medical licensure authorities have established statutory rights on certain tasks. For example, nursing is struggling for more recognition among medical profession and whishes to perform some tasks that are now performed by physicians.

1.4 Healthcare wastes

The health sector generates huge amounts of wastes corresponding to its economic weight (see sections 1.1.2 and 1.2.2). Since there is no data available on the waste generation rate in the Canadian healthcare sector, we have to assume that hospitals in Canada behave similarly to hospitals in industrialized countries. For instance, American hospitals generated 2 million tons of waste in 2005. (Health Care Without Harm, 2008; U.S Census Bureau, 2008).

Current healthcare waste management may be improved: most of the wastes generated by healthcare are either buried at the sanitary landfill after being properly decontaminated (Health Care Without Harm, 2001) or burned in local incinerators without being properly disinfected, thus, loosing great opportunities of material recovery and recycling.

The aging population causes an increasing demand on the healthcare system, thereby increasing the number of medical procedures and, consequently, the waste generation rate. Actually, the wastes generation rate within North America varies between 1,5 and 3,9 kg/bed/day and with in Western Europe between 3,3 and 4,4 kg/bed/day (Alhumoud

& Alhumoud, 2007). We therefore can expect that an increasing volume of medical wastes such as soiled syringes, needles, or used electronic devices will continue to flow throughout the waste management chain.

1.4.1 Type of wastes generated by the healthcare sector and their impacts

Healthcare activities generate a wide range of wastes (Figure 1.1). Theses wastes are thereby divided in two classes: domestic wastes and clinical wastes.

According (Health Care Without Harm, 2008), "as much as 80% of the waste produced in healthcare centres is not hazardous but ordinary waste like that from homes and offices". These ordinary wastes also called domestic wastes include residual material from offices such as obsolete computers, paper and cartons or from kitchens as, for instance discarded food. This class of waste is therefore similar to waste produce by a hotel. The remaining wastes are clinical wastes (Raman et al., 2006) and include " laboratory waste consisting of discarded cultures and stocks of infectious agents and associated microbiological, pathological wastes, selected isolation wastes, used and unused discarded sharps, animal waste, human blood, and blood products" (Vijayan and Kumar, 2006, p.94). According to Tudor & al. (2004), the British Environmental Protection Act of 1990 (Office of Public Sector Information, 2008) and the Controlled Waste Regulations of 1992 (Office of Public Sector Information, 2000), clinical wastes may be defined as any waste which consists of wholly or partly of human or animal tissue, blood or body fluid, excretion, drugs or other pharmaceutical products, swabs or dressings or syringes, needles, or other sharp instruments and may be classified as infected, hazardous and radioactive (Figure 1.1). According to Vijayan and Kumar (2006, p.94), 80% are non infectuous.

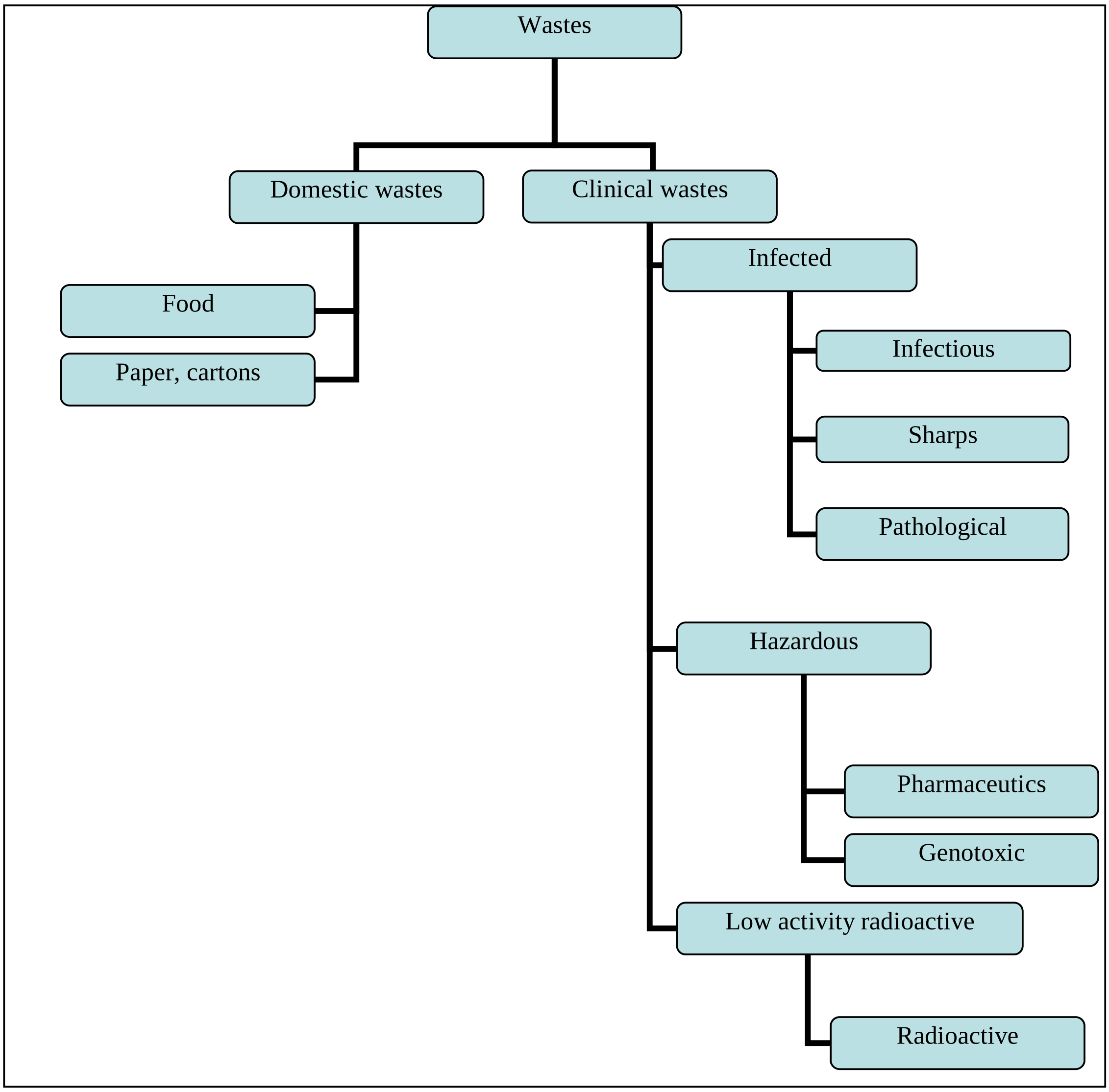

Figure 1.1 - Classification of waste generated by the health care system (adapted from Raman & al., 2006; Qdais & al,2006.; Tudor & al., 2004; Da Silva & al., 2004, Diaz & al., 2007, Alvim-Ferraz & al., 2005)

Domestic wastes

Domestic wastes except for electric and electronic materials (also called e-waste) do not constitute a direct threat to public health (Table 1.2) but represent however a burden on the environment. The potential health problems related to e-waste arise mainly from the heavy metals found in products such as computers. E –waste represents 40 % of lead and 75% of the heavy metals found in landfills that could potentially infiltrate and contaminate the groundwater supply, leading to serious health problems.

Table 1.2- Domestic wastes generated by an hospital; description, source and impact (Tudor & al.; 2004)

Type	**Source**	**Hazard for health**
Electric and electronic materials	Electric and electronic devices	Contamination of groundwater supply by heavy metals, leading to health problems such as cancer, birth defects, or hormone disruption
Food	Kitchens	None
Paper, cartons	Offices	None

Clinical wastes

In addition to their ecological burden, clinical wastes constitute a direct threat to human health (Table 1.3). This class of wastes needs to be handled with extreme care in oder to minimize contamination risks and other health hazards.

Table 1.3 – Clinical wastes generated by an hospital: description, source and impact (Tudor & al.; 2004)

Class	Type	Source	Hazard for health
Infected	Infectious	Wastes from surgeries and autopsies on patients with infectious diseases	Gastro enteric infections, respiratory infections, ocular infection, skin infection, genital infection, anthrax, AIDS, hemorrhagic fevers, septicaemia, bacteriaemia,, candidaemia, viral hepatitis A, B and C
	Sharps	Disposables needles, syringes, saws, blades, broken glasses, nails or any other item that could cause a cut	
	Pathological	Tissues, organs, body parts, human flesh, fetuses, blood, and body fluids	
Hazardous	Pharmaceutics	Drugs and chemicals that are returned from the wards , spilled, outdated, contaminated, or no longer required	Intoxication, either by acute or chronic exposure, and injuries, including burns, to skin, eyes, or the mucous membranes caused by contact with flammable, corrosive or reactive materials
	Genotoxic	Highly hazardous, mutagenic, teratogenic or carcinogenic, such as cytotoxic drugs used in cancer treatment and the metabolites	Extreme irritants which have harmful local effects after direct contact with skin or eyes, and cause dizziness, nausea, headache or dermatitis
Low activity	Radioactive	Solids, liquids and gaseous wastes contaminated with radioactive substances used in diagnosis and treatment of diseases like toxic goiter	Headache, dizziness, and vomiting, affect genetic material and destruction of tissue

Many hospitals across the world still have primitive waste management such as incinerating all waste streams, from reception-area trash to operating-room wastes. Health Care without Harm (2008), a pressure group promoting environmental sound healthcare practices around the world, indicates that waste incineration by the healthcare sector is a leading source of highly toxic dioxin, mercury, lead and other hazardous air pollutants. Furthermore, according to Da Silva, Hoppe, Ravanello & Mello (2004), clinical wastes present a risk to the public health and the environment due the presence of biological agents and of the physical, chemical, or radioactive characteristics of certain types of waste. Unless rendered safe, clinical wastes represent hazardous, pharmacological and/or physical (e.g. sharps) dangers to any person coming into contact with it.

As illustrated in Table 1.3, clinical wastes represent a direct threat to human health. Infected wastes, such as infectious, sharps and pathological wastes can transmit gastro enteric infections, respiratory infections as ocular infection. They can even transmit mortal disease as AIDS. Pharmaceutics and genotoxic wastes can cause great irritation to mucus membranes. People that enter direct contact with these substances need urgent medical help. Direct contact with radioactive wastes may cause headache and vomiting, and can even affect genetic material.

1.4.2 Treatment of wastes generated by the healthcare sector

These two wastes classes need specific treatment because domestic and clinical wastes are different in nature (Tables 1.2 and table 1.3). Tables 1.4 and 1.5 respectively summarize treatment procedures for domestic and clinical wastes.

Domestic wastes

Table 1.4 illustrates opportunities of materials recovery existing domestic wastes. Wastes from offices such as electric and electronic and materials can be recovered and then be recycled. Nevertheless, environmental awareness level among healthcare organizations is low and electronic product as well as paper and cartons are buried in landfills (Tudor et al., 2004).

Table 1.4– Existing treatment for each type of domestic wastes (Tudor & al.; 2004)

Type	Source	Treatment
Electric and electronic materials	Electric and electronic devices	Recycling Landfill
Kitchens	Kitchens	Landfill
Offices	Offices	Recycling Landfill

Clinical wastes

Many incidents during the 1980's and 1990's involving clinical waste alarmed the public opinion and, thus, forced the government to adopt stricter regulations regarding these kind of wastes. In 1988, clinical waste including used syringes, needles and blood flask and latex gloves were washed up on the Long Island and New Jersey beaches causing great concerns among the population and the public health authorities. According to AFP (1988), clinical wastes were mysteriously unloaded in high sea in Long Island. Similar incidents also happened in Canada throughout the 1980s and the 1990s. After these major incidents, both American and Canadian federal governments amended their Solid Waste Disposal Act with the Medical Waste Tracking Act. In addition, contamination of workers among the disposing organizations still occurred frequently.Even though clinical wastes in industrialized countries are no further found in public places, healthcare system still continues to have a significant impact upon the environment.

There are different treatment processes for clinical wastes (Table 1.5), namely incineration, autoclaving, dielectric heating, and microwaving.

Actual provincial regulations are strict regarding the treatment of clinical wastes. Quebec provincial regulations indicate that cytotoxic drugs, pathological and other pharmaceuticals wastes must be incinerated. ***Incineration*** is a process that transforms wastes into ashes using combustion reaction. Generally, combustion takes place in a combustion chamber where wastes are burned to ashes. Ignition takes place at a temperature surrounding 250^{o}C and wastes are transformed into ashes, vapour and, ideally, only carbon dioxide (Health Care Without Harm, 2001). Nevertheless, combustion reactions are never complete and other gas are emitted trough the incineration process. For example, sharps wastes cannot be incinerated because it will generate too much too much persistent pollution such as dioxins and other hazardous particles generated by plastic incineration. In addition, particles from incinerators actually involve air pollution thus increasing risk of polluting surrounding fields and ground water (Alvim-Ferraz & Afonso, 2004).

Under Quebec regulation on clinical wastes, both sharps and infectious wastes must be decontaminated using the autoclave process. ***Autoclaving*** is a simple process that uses steam to neutralize potential infectious agents, prior to their land burying (Health Care Without Harm, 2006). Wastes are heated up at a temperature of 134^{o}C and are subject to a pressure of 207 kPa. The autoclave process significantly change wastes aspect and wastes are not recognizable after treatment.

Dielectric heating is a process that employs a dielectric oven in order to destroy potentials infectious agents. It employs a dielectric oven where low frequency radio waves are used to generate a high strength electrical field. First, wastes are compacted and sprayed with wastes using in a size reduction facility. Afterward, wastes are subjected to a high-voltage electric field (LF radio waves, 50 kV/meter, 10 MHz) resulting in a dielectric heating at about 95^{o}C. The advantages of this technology remain in low particle emission and wastes reduction volume (Health Care Without Harm, 2001).

Microwaving is a steam-based process that use moist present in wastes in order to decontaminate wastes. Steam generated by microwave energy destroys infectious agents. What make microwaving an effective quick cooking device also makes it as a useful disinfection system (Health Care Without Harm, 2001). Therefore, in order to improve microwaving process water must be added in the microwaving chambers.

Table 1.5– Existing treatment for each type of clinical wastes (Raman & al., 2006, Tudor & al.; 2004)

Type	Source	Treatment
Infectious	Wastes from surgeries and autopsies on patients with infectious diseases	Incinerator, dielectric heating,
Sharps	Disposables needles, syringes, saws, blades, broken glasses, nails or any other item that could cause a cut	Autoclaving, dielectric heating, microwaving
Pathological	Tissues, organs, body parts, human flesh, fetuses, blood, and body fluids	Landfills, dielectric heating, microwaving
Pharmaceutics	Drugs and chemicals that are returned from the wards , spilled, outdated, contaminated, or no longer required	Dielectric heating
Genotoxic	Highly hazardous, mutagenic, teratogenic or carcinogenic, such as cytotoxic drugs used in cancer treatment and the metabolites	Dielectric heating
Radioactive	Solids, liquids and gaseous wastes contaminated with radioactive substances used in diagnosis and treatment of diseases like toxic goiter	Dielectric heating

1.5 Concluding remarks

From this first chapter, we can make the following conclusions:

1) The healthcare is an highly regulated sector and an important economic actor

and

2) Hospitals play a strategic and central role in the healthcare sector, are complex systems and, generate huge amounts of wastes that have adverse effect on human health and on the environment.

It seems rather pertinent to propose a framework for sustainable wastes management in the healthcare sector, and more specifically for the wastes generated by hospitals. This will be explored in the next chapter.

CHAPTER 2: TOWARD A SUSTAINABLE WASTES MANAGEMENT FRAMEWORK FOR THE HEALTHCARE SECTOR

This second chapter examines the current wastes management practices in the healthcare sector (section 2.1), outlines some issues and challenges related to these practices (section 2.2) and analyses some concepts associated to a sustainable wastes management (section 2.3).

2.1 Wastes management guidelines for the healthcare sector

The World Health Organization offers since 1999 comprehensive guidelines for healthcare wastes management. We will briefly summarize the recommended activities related to wastes management (section 2.1.1) and will outline the responsibilities of main stakeholders (section 2.1.2).

2.1.1 Wastes management activities

Wastes management refers to the following activities: planning, handling and collection, storing, transporting, sorting, and treating. These operations apply to both domestic and clinical wastes whether they are hazardous or non-hazardous.

Activity 1: Planning

The World Health Organization (1999) recommend to public health authorities to elaborate a plan, at the national or regional level in order to insure efficient, safe and environmentally sound wastes management practices. Under WHO recommendations, the main goal of a national wastes program is to prevent and minimize wastes production. Healthcare organizations must put the emphasis on treating wastes by safe and environmentally sound methods, reuse and recycle wastes to the extent possible and bury of the final residues in confined and carefully chosen landfill sites. Conducting a national survey is also important in order to assess the healthcare wastes generation patterns.

The wastes management plan must help healthcare organizations to comply with legislation. Once the guidelines are completed, public health authorities should initiate a training programme for medical personal and wastes management officers. Finally, public health authorities must review the national wastes management programme in order to insure programme efficiency. This review also permits to make some adjustments. It is increasingly required that wastes producer is responsible for the environmentally sound treatment and final disposal of its own wastes.

Wastes management plan is also essential at healthcare organization level. The plan should clearly define duties and responsibilities of all members of personal, clinical and non-clinical, with respect to the handling of healthcare waste.

Activity 2: Handling and collecting

Healthcare wastes, either they are clinical and domestic, are collected by the hospitals attendants. Their responsibilities are to collect wastes from the wastes generation location and to transport them to the wastes storage unit, where wastes will then be collected by the wastes disposal organizations.

Medical staff, physicians and nurses have also great responsibilities in wastes collection. Their primary responsibilities are to sort wastes by sources. Wastes are segregated by nature: either they are chemicals, with high metals contents, radioactive, aerosol, infectious, sharps, catatonic or non-hazardous (domestic). During the wastes collection phase, rigid containers must be used and be collected on a daily basis in order to prevent contamination and leakage risks. Each waste container is identified by colors and marked with the substance symbol for infectious substances.

Wastes containing a high level of heavy metals (e.g. cadmium, mercury and lead) should be collected separately. Aerosol containers are not destined for autoclaving or incineration and therefore, must be collected with general healthcare waste once they are completely empty. Low-level radioactive infectious wastes, for example swabs, syringes for diagnostic or therapeutic use, may be collected in a separate bags or containers.

Sharps wastes are collected together, regardless of their contamination level. Containers should be rigid and impermeable, usually made of metal or high-density plastic, in order to safely retain sharps and any residual liquids from syringes. Containers must be difficult to open and needles and syringes need to be broken in order to be unusable. Cytotoxic wastes are collected in strong leak-proof containers labeled “Cytotoxic wastes”. For large quantities of chemical wastes, it is recommended to use containers resistant to chemicals that are clearly identified. Specialized treatment facilities for chemicals wastes are required. The identity of the chemicals should be clearly marked on the containers in order to prevent the mixing of different types that should never be mixed.

Anatomical wastes are subjected to special care due to their special nature. Therefore, disposal processes must respect religious and culture customs. Special burial may be applied for this type of wastes.

Activity 3: Storing

Clinical wastes must be stored in rigid, sealed and waterproof recipients and the storage area must be refrigerated under a temperature of 4^{o}C. The World Health Organization recommends that the storage area to be easy to clean and disinfect. Therefore, it must have an impermeable, hard-standing floor with a water supply and good drainage. In addition, the supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area. The storage area should afford easy access for staff in charge of handling the wastes and it should be possible to lock the area in order to prevent access by unauthorized persons and undesirable animals.

Storage units must have good lighting and ventilation but sun ray must be prevented. Easy access for waste-collection vehicles is also essential. Finally, the storage area should not be situated in the proximity of fresh food stores or food preparation areas. Both cytotoxic and radioactive wastes should be stored separately from other healthcare wastes in a designated secure location. Special care must be undertaken regarding radioactive wastes. They should be stored in containers that prevent dispersion behind lead shielding. Information such as storage conditions and date of storage is required for proper storage. Wastes storage during radioactive decay must be labeled according to the type of radionuclide.

Activity 4: Transporting

Wastes are being shipped at the waste treatment unit by the waste disposal organization. They must maintain a daily register transported wastes. According to Quebec biomedical wastes management regulations, all clinical wastes must be labeled properly and refrigerated at a temperature of $4^{o}C$ during transport.

Disposal operations must meet both packaging and vehicle requirements. No compliance of one of these requirements greatly increases contamination risks. The packaging requirements include an inner packaging, a primary receptacle of metal or plastics with leak-proof seal and a watertight secondary packaging. In addition, an absorbent material must be present to absorb the entire contents placed between the primary receptacle and the secondary packaging.

Packaging standards also include an outer packaging of adequate strength in order to meet its capacity and mass requirements with a minimum external dimension of 4 inches. The outer packaging should be appropriately labeled. Rigid and leak-proof packaging made of plastic or metals shall be used for healthcare wastes transport. Packaging containers intended to contain sharps wastes objects must be resistant to puncture in order to ensure workers health and safety.

Wastes transporting vehicle must be of a suitable size suitable to the design of the vehicle, with an internal body height of 7.2 feet. If the vehicle is involved in a collision, a bulkhead placed between the driver's cabin and the vehicle body should prevent wastes to enter in direct contact with the driver. The transporting vehicle requires an authorization certificate emitted by the health authorities, a refrigeration system, a retention bowl and a non porous cell. In order to facilitate vehicle cleaning, it must be decontaminated on a daily basis; the internal finish of the vehicle must be designed in order to be steam-cleaned. The vehicle should be marked with the name and address of the wastes carrier and the international hazard sign should be displayed on the vehicle box.

Sharps wastes for healthcare facilities producing under than 50 kg monthly may be transported without respecting to all hygiene constraints. Healthcare facilities producing more than 50 kg must respect to all hygiene requirements.

Activity 5: Treatment

Quebec provincial regulations indicate that cytotoxic drugs, pathological and other pharmaceuticals wastes must be incinerated. Both sharps and infectious wastes must be decontaminated using the autoclave process, a simple process that uses steam to neutralize potential infectious agents, prior to their land burying.

Activity 6: Disposing

More severe regulations and growing of public awareness force both healthcare and wastes managers to stop the incineration of medicals syringes. There is here a material recovery opportunity because, once properly treated, the syringes are no more contaminated. The materials chosen in the design phase of the syringes play an important role facilitating material recuperation.

After autoclave processing, infectious and sharp wastes can be buried in a local sanitary landfill. However, pathological, pharmaceutics and genotoxic wastes must be incinerated. Clinical wastes are unloaded in a special trench. In order to decrease contamination threat, sharps wastes are buried in priority, therefore they are rapidly compacted.

2.1.2 The main stakeholders in wastes management in a hospital

The principal stakeholders involved in wastes management are namely hospital chairman, waste management officer, heads of hospital departments, infection control officer, chief pharmacist, radiation officer, senior nursing officer, hospital managers, hospital engineers, financial controller and waste management officers(Diaz & al., 2007).

Hospital chairman as the head of hospital is responsible to form a waste management team and to elaborate a written waste management plan for the hospital. The chairperson allocates financial and personnel resources in order to ensure efficient waste management operations. The waste management officer (WMO) is named by the hospital chairman and is, therefore, under direct responsibility of the chairman. He supervises, coordinates and monitors daily wastes management operations in accordance with national guidelines. He also keeps continuous links with the infection control officer, the chief pharmacist and the radiation officer in order to stay updated on both handling and disposing practices for pathological, pharmaceutical, chemical, and radioactive materials.

In the area of waste collection, the WMO controls the internal collection of waste containers and their transport to the central waste storage unit on a daily basis. The WMO ensures that appropriate bags, containers, protective clothing and collection trolleys are available. The WMO also oversees the proper usage of the storage facility unit for clinical wastes, which must be locked and only accessible to authorized hospital staff. He must also prevent all dumping of waste containers on inappropriate landfill sites.

As for staff training and information, the WMO should ensure that all medical personnel are aware of their own responsibilities for segregation and storage of healthcare wastes. He should be in contact with the senior nursing officer, the hospital manager and the department heads in order to do so. WMO must also ensure that hospital attendants are only responsible for the handling and the transport of containers and sealed bags to the storage unit.

WMO is responsible of incident management and control. The WMO ensure there is a written emergency procedure available in place and at all times, and that personnel know the action to be taken in the event of an emergency. He investigates any incident related to the handling of healthcare wastes.

The role of infection control officer (ICO) is to provide continuous advice concerning the control of infection and the standards of the waste disposal process. The ICO organizes and supervises staff training courses on safe waste management. The infection control officer has also the responsibility of chemical disinfection, sound management of chemical stores and chemical waste minimization.

The chief pharmacist has similar responsibilities with the ICO. He is responsible for the sound management of pharmaceutical stores and for pharmaceutical waste minimization. He performs the continuous monitoring of procedures for the disposal of pharmaceutical waste. These duties include adequate training of personnel involved in pharmaceutical wastes handling and the safe utilization of genotoxic products as the safe management of genotoxic wastes. The duties of the radiation officer are similar with the chief pharmacist but are related to radioactive wastes.

The supply officer (SO) link with the WMO to ensure a continuous supply required for proper clinical wastes management: plastic bags, containers of the right quality, spare parts for on-site waste transport. He ensures that they are always available. The SO also investigates the opportunities of purchasing environmentally friendly products.

The hospital engineer installs and maintains wastes storage facilities and handling equipment in compliance with the specification of the national guidelines. He is also accountable for proper on-site waste treatment operations and maintenance equipment.

The hospital engineer supervises staff training toward sound waste disposal and operating on-site waste treatment facilities.

2.2 Issues and challenges in existing healthcare wastes management practices

Although the guidelines set by WHO are rather comprehensive, we propose that opportunities of waste valorization and waste minimization should also be studied in order to reduce further the impact of healthcare.

Waste valorization activities represent activities such like recycling, recuperation and product recovery. Actually, the valorization level in hospitals is relatively low: at best, theses institutions get a recycling rate for their wastes of about 45% according to Health Care Without Harm. Solutions for recycling domestic wastes exist and were largely studied. For their clinical counterpart, solutions for materials recovery are marginal due to their “dirty” nature: clinical wastes must be treated prior to land burial and there remains a feeling that it can cause infection even after being properly treated. Syringes and needles manufacturers discourage sharps wastes recycling due the difficulty to recuperate materials from these products and to the lack of environmental considerations in the design process (Health Care Without Harm, 2001). Actual waste management frameworks are limited because supply does not seem to be aware of material recovery opportunities. Dijkema and al. (2000) indicated that wastes are only resources that are not exploited to their full capacity. Therefore, numerous precious resources could be extracted from wastes if the healthcare waste management framework enables it.

The management of wastes generated by the healthcare faces many challenges: growing public awareness about environmental and health issues, increasingly more severe regulations about medical wastes in both westerns and developing countries and higher wastes treatment costs. Each year, poor medical waste management exposes health care workers and wastes handlers to multiple infections and injuries (Health Care Without Harm, 2001 & 2007). According to Singh (2004), about 8 millions workers related to the healthcare industry worldwide are at risk of occupational exposure to blood borne pathogens such as HCV, HBV and HIV. In addition, between 600 and 800 thousand injuries related to needle stick and other percutaneous injuries occur annually among healthcare workers within the United States according to Centre for Disease Control and Prevention (CDC) and the Department of Health and Human Services, USA (Singh, 2004). Moreover, the Centre for Disease Control (2003) reported that 5.1%, i.e. 24 844 out of the adults with AIDS in the USA have been or are working in the healthcare sector.

The situation is even worse in the developing countries. In 2002, WHO assessed hospitals wastes management practices in 22 developing countries. Results showed that the proportion of hospitals that did not use proper clinical wastes disposal methods ranges from 18% to 64%. As a consequence, the WHO reported worldwide that 21 million of hepatitis B virus infections (HBV) (32% of all new infections), two million (HCV) infections (40% of all new infections) and at least 260 000 HIV infections (5% of all new infections) were caused from poor clinical wastes management in 2000

(WHO, 2002). Furthermore, millions of persons in the world get infections and the toxic effects of poor waste management (Health Care Without Harm, 2008).

Although regulations exist in most of Western countries (for instance, the Hazardous Wastes Regulations of 2006 in UK or the Medical Waste Tracking Act of 1989 in USA), many healthcare organizations seem to neglect basic hygiene and safety standards (Blenkharn, 2006). Clinical wastes management in some British National Health Services (NHS) hospitals continues to be largely inadequate: no respect of basic hygiene, safety standards, fire and hazardous wastes regulations and poor wastes segregation. According to Blenkharn (2006), many British hospitals do not comply with national standards. For instance, clinical wastes storage area is accessible to the general public whereas clinical wastes carts and area dedicated to their storage are in a poor state. Furthermore, waste segregation is inappropriate among hospitals: domestic wastes are mixed with clinical wastes, thus increasing treatment costs. In fact, proper separation of wastes has an important influence on the hospital budget: “while the price of the mixed communal waste disposal is now approximately 75 Euro per ton” compared to 260 Euro per ton for “the specific sanitary hospital waste treatment costs” (Bencko, 2003).

According to Tudor and al. (2007), only a small fraction of wastes generated by hospitals are being actually hazardous and thus requiring a special treatment. Ozbek and Sanin (2004) concluded that a high proportion of wastes from offices and clinics such as “empty amalgam capsules, masks and medicine containers is non-hazardous wastes, and pose no threat to human/animal health" and ,therefore, are recyclable. To insure wastes reduction, both recycling and segregation programs should be implement in healthcare organization. Many British hospitals do realize the potential benefits of wastes segregation and recycling. For example, some hospitals have begun to send back secondary packaging to suppliers. Some other sites started "to remove recyclables such as high density polyethylene (HDPE), polyethylene terephtalate (PET), cardboard, toner cartridge and office paper from the wastes stream and to use either reusable or biodegradable nappies" (Tudor, 2007).

Due to pressures from both public and environmental lobbies, the governments and international institutions try to move towards a cleaner medical wastes management. For example, the Stockholm Convention bans the production of persistent organic pollutants (POPs). These pollutants are "chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife. POPs circulate globally and can cause damage wherever they travel." (UNEP, 2007). According to Health Care Without Harm and the World Health Organization, healthcare is not only a major generator of POPs like dioxins or furans but also heavies metals such as mercury and cadmium. As a result, many governments are banning progressively the medicals incinerators because of the pollution they are generating.

2.3 Sustainable healthcare wastes management

The expression sustainable waste management framework may be defined according to Fiskel (2006) as an integrated approach toward managing material life cycles to achieve both economic and environmental viability. Material life cycle includes all activities related to material selection, exploration, extraction, transportation, processing, consumption, recycling and disposal. Other authors, for example Parlikad & al. (2005) and Kulkarni & al. (2005) will rather use the term product life cycle management (PLM). This expression is defined as an integrated and information driven approach related all aspects of a product's life: from its design inception, through its manufacture, deployment and maintenance phase. Product lifecycle is culminating in product removal from service to its final disposal. PLM encompasses numerous constituencies, including engineering, manufacturing, sales and marketing, and numerous processes, including design, supply chain, and customer support.

Although sustainable healthcare wastes management seems highly desirable, healthcare organizations are not totally embracing the concept. Most of the British National Health Services (NHS) have included the concept of sustainability in their policies but this concept has been greatly neglected within the practices of British healthcare, chiefly due to the increasing use of disposable products in hospitals (Bencko ,2003; Tudor, 2007).

2.3.1 Toward wastes minimization

Several opportunities of reducing environmental impacts of the public healthcare system exist. In a perfect world, all output, whether it is solid, gaseous or liquid, could be transformed into an input. As we may see, it is actually not the case. **Wastes minimization** refers to the reduction and the recovery of wastes while **detoxification** refers to prevention or reduction of adverse human or ecological effects associated with materials use. This later approach includes activities such as:

1) replacing toxic or hazardous components with less harmful ones (for instance replacing mercury-filled patient thermometers with digital or electronic thermometers; or replacing mercury-filled blood pressure measuring devices with aneroid units.)
2) reducing the toxic or hazardous properties of waste streams (for instance removing brominated flame retardants from medical electronic products by designing products that comply with fire standards without using flame retardants materials)
3) reducing greenhouse gas associated with the combustion of fossil fuel (decreasing the amount of pathological wastes needed to be incinerated by improving wastes sorting at the source)

While detoxification reduces the environmental pressures of material use, **dematerialization** can actually decouple material use from industrial growth, either by reducing material requirements or by substituting virgin raw resources for recycled materials.

2.3.2 Zero waste

Dijkema, Reuter & Verhoef (2000) indicated that wastes are not an inevitable end product of industrial activities and consumption and set a new paradigm for waste management: waste is a substance that one would like to dispose off and one is prepared to pay some fee for using it. Therefore, that substance is only a waste if it is labelled as waste. For example, a producer may consider unwanted by-product as “prompt scrap” or “production waste” while others regard these substances as a potential source of inputs. Therefore, wastes are defined as material that are not used to its full potential.

According to Health Care Without Harm (2008), the World Health Organization (2002) and Tudor (2007), healthcare facilities can reduce the environmental impact of their activities by relying on a cluster of organizations or industries. This situation means that the output of one can become the input of another. Therefore, integrated waste management will ultimately be the most efficient approach in terms of both economics and also environment benefits. In fact, Health Care Without Harm (2008) and Fiksel (2006) propose to analyse the opportunities of creation of economic value. Current wastes management represents an enormous loss of resources both in material and energy but it requires a major mind shift: One thinks of wastes as garbage, rubbish or even dangerous or toxic material but should think of wastes as potential inputs (Dijkema and al., 2008). By adopting a sustainable framework in the management of healthcare wastes, the “waste” label applied on the residual materials generated by can be changed for a “resource” label and, ultimately, there is zero waste.

Obviously, the above approach is close to zero emission which also aims to achieve increased efficiency of material use. Clusters of industries should use the output of one as the input of the other as much as possible. Three elements are identified to realize zero emission among these clusters according to Baumgartner & Zielowski (2007): total of material productivity, separation of output product and wastes and creation of bio systems to coordinate input and output.

1) ***Total material productivity (TMP)*** concentrates both on the systematic reduction of emissions and waste which means optimizing the output and favouring the efficient and effective use of resources - i.e. minimizing the required resources for a given desired output.

2) The problem of industrial output components is mainly due to its mixture. ***Material separation technologies (MST)*** aim to separate of products and follow-up for further use. Single components could be reused and integrated in other processes as precious inputs but the mixture of industrial output is usually treated as waste and cannot be used as a new materials processes. Treating wastes output for some industries as input process for other industries also leads to increased processing costs. Further developments in separation and sorting technologies will improve the recycling processes both in terms of costs and efficiency.

3) ***Integrated biosystems (IBS)*** aims the establishment of networks to use one’s output as another one’s input. Industrial and other societal actors develop a cooperative material recycling and energy cascading network. On the basis of separated and

specified output components, partners have to be detected for using these materials and energy as inputs. This network can be worldwide because an industry that is willing to use such outputs might not be next to the emitting industry and could be anywhere in the world as it is the case for instance of the Umicore Precious Metal for electronic scrap recycling.

Baumgartner & Zielowski (2007) state that there is a progressive path to attain the zero waste goal: TMP should be established first, MST second and IBS third.

2.3.3 End of product life cycle options

United States Environmental Protection Agency, Pichell (2005), Dijkema, Reuter & Verhoef (2000) and Fiksel (2006) agree on dematerialization and detoxification among the supply chain. However, the United States Environmental Protection Agency proposes a hierarchy of activities in order of preference: reducing the quantity and toxicity of wastes, reusing materials as a whole or components, recycling materials, composting, incineration with energy recovery, incineration without energy recovery and, finally, sanitary land filling

Much of obsolete and malfunctioning equipment can be reuse or remanufacture or recycle. However, this is not always the case. For example, malfunctioning electronics are not repaired due to the low cost of replacement and recycling of electronics does not seem to be popular. According to Pitchel (2005), only 11% of electronic wastes are recycled compared of 28% for municipal solid wastes (MSW). Nearly 75% of unwanted electronics are in storage because uncertainty as to how to manage them.

However, materials recovery could open opportunities of value creation because there are a number of recoverable materials presented in electronics devices: precious (gold, silver, platinum, etc.),, heavy metals (cadmium, lead, etc.), special metals (tellurium, selenium, antimony, etc.), glass and plastics. Major types of electronic equipment found within the MSW (IT equipment, CPUs, LCD and cathode monitors, etc.) possess a negative or zero value net value when recycled. The net value is defined as the value of recovered components or materials, minus the cost to recover the materials. This situation could change because of the rising value of precious metals and others engineered materials and with the implementation of a much more efficient processes of electronic materials.

2.3.4 Product stewardship

Product stewardship represents another interesting concept for achieving sustainable wastes management: Whoever designs, makes, sells, or uses a product takes responsibility for minimizing its environmental impact. This responsibility spans the product's life cycle from selection of raw materials to design and production processes to its uses and disposal. Several European and Asian nations have established product stewardship models that involve numerous types of products including electronics. European nations have been the vanguard in addressing the electronic wastes (or e-wastes) problem by proposing an ambitious system of "extended producer responsibilities". In 2001, European Parliament adopted a directive that requires producers of electronics to take responsibility, financial and otherwise, for the recovery and recycling of e-waste. A second directive requires manufacturers to phase out the use of hazardous materials in electronics products.

2.4 Concluding remarks

In a perfect world, all output, whether it is solid, gaseous or liquid, could be transformed into an input. As we have seen, it is actually not the case in the healthcare sector as this sector faces many challenges. A sustainable wastes management framework implies that healthcare wastes are minimized, even eliminated. It also requires strong product stewardship and adequate options at the end of product life cycle. It therefore points to a network of organizations that provides or arranges to provide a coordinated continuum of wastes management activities.

Our next steps will be to propose a research strategy in order to obtain some preliminary empirical evidence on a potential inter-organizational network for hospital wastes management.

Many American hospitals face non-compliance with federal and state hazardous waste laws towards disposal of electronic wastes. In addition, the Health Insurance Portability and Accountability Act (HIPAA) mandate end-of-life data security and privacy requirements for health care organizations.

CHAPTER 3: OVERALL RESEARCH STRATEGY AND RESULTS FROM THE FIELD STUDY

This third chapter presents the overall research strategy (section 3.1) and the main results from the field study (sections 3.2, 3.3, and 3.4).

3.1 Grounded theory and research objectives

Research initiatives on sustainable wastes management in the healthcare sector are lacking and our collective knowledge remains limited. Our research seems therefore appropriate for grounded theory.

According to Glaser and Strauss (1967), grounded theory is ideal for unfamiliar research environment. Stern (1995) acknowledges this by stating "the strongest case for the use of grounded theory is in investigation of uncharted waters, or to gain a fresh perspective in a familiar situation." While some authors define the grounded theory approach as "a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon" (Stauss and Corbin, 1990), others include the combination of qualitative and quantitative data using multiple data collection methods (Eisenhardt, 1989). Our research strategy is in line with the later definition.

The overall research objective is to gain a better understanding of sustainable wastes management approach for the healthcare sector. More specifically, we will attempt to:

1) Identify the key actors of the inter-organizational network responsible for hospital wastes management, establish the structure of such network and define their respective role;

2) Identify one product that is particularly relevant for sustainable healthcare wastes management approach in hospitals and provide appropriate justification for retaining this product;

3) Propose a coordinated continuum of wastes management activities related to the selected product and involving the key actors of the inter-organizational network;

4) Assess the relative intensity of these activities identified in 3), the main drivers of these activities and their impacts.

The field study allows us to meet objectives 1, 2 and 3 whereas the fourth objective corresponds to the explorative survey. In line with grounded theory, the literature review was ongoing during the field research, and the justification of different decision points (for instance, the selection of one product that is particularly relevant for sustainable healthcare wastes management approach in hospitals) was confronted with both empirical evidence and the literature.

In summary, we have opted for a grounded theory approach. Such an approach attempts to generate new theories and to elaborate original undertakings (Schreiber, 2001, p.57). Empirical data represent the starting point and the main purpose is to explore the field with no preconceived ideas (Starrin, Dahlgren, Larsson & Styrborn, 1997, p.31). As mentioned by Dey (1999, p.4), the researcher should discard his or her own theoretical preferences and be receptive to the empirical evidence (Glaser, 1998, p.68). There is therefore no initial conceptual model, no research hypothesis, and no theory verification or validation.

3.2 The inter-organizational network

In order to respond to our first objective, we relied on the following sources of information:

1) publically available information on Internet and several governmental lists such as *Recyc-Québec*, ICRIQ (*Fabricants et distributeurs du Québec*) and Strategis (Industry Canada).

2) direct contacts with several firms which transport, treat or dispose of the clinical wastes generated by hospitals, namely Services Matrec Inc.,Sani-Eco Inc., BFI Environnement, Chem-Environnement, Enviroplast Inc. and Le Groupe Lavergne.

3) direct contacts with managers including the waste management officer from the hospital of Tergooi in the Netherlands. This 847-bed hospital has a staff of approximately 3000 employees and employs about 180 medical specialists. It provides healthcare services to a community of approximately 247,000 residents.

From the information obtained from the above mentioned sources, it can be proposed that the upstream and downstream wastes management activities span across several keys players as illustrated in Figure 3.1 .In this highly simplified structure of a potential inter-organizational network for hospital wastes management, five broad groups of entities (in bold characters in Figure 3.1) may be retained, namely the suppliers that provide the necessary inputs for hospitals' activities, the hospitals themselves which "consume" these inputs and transform them into waste, the waste treatment and disposal organizations that handle, treat, recycle and dispose of wastes.

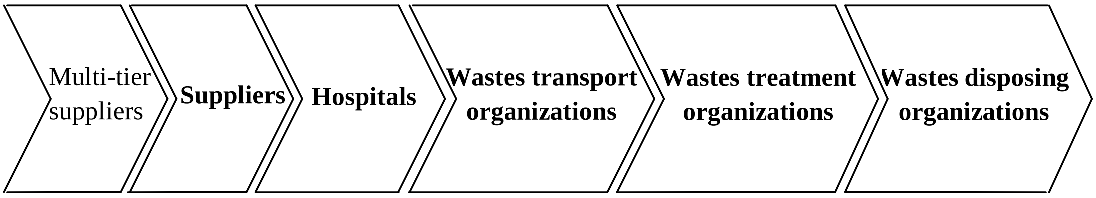

Figure 3.1 – Organizations involved in the upstream and downstream hospitals wastes management activities

Drawing the boundaries for LCA (Suh et al, 2004) is here rather arbitrary. Within the scope of our research efforts, the proposed network excludes multi-tier suppliers and raw material providers. However, suppliers may give information on the criteria for selecting their own suppliers based on their environmental performance (Klassen & Vachon, 2003; Rao, 2004) or for choosing raw materials that are less harmful to the environment (Carlson-Shalak et al, 2000).

Suppliers provide hospitals with a wide array of products such as 1) medical furniture (for instance, Médi-Sélect based in Québec City or Roxon Médi-Tech in Montreal), 2) pharmaceutical products (for example, Axcan Pharma Inc. based in Mont-Saint-Hillaire with its gastroenterology products and therapeutic treatments), 3) diagnostic instruments and accessories (for example, GE Healthcare located in Mississauga, Ontario or

Siemens Canada located in Dorval), 4) drug and medication management devices (for example, Baxter Corporation located in Sherbrook, with its wide range of infusion and syringe pumps) or 5) patient monitoring system (for instance, BLT Monitoring Co., Lucknow, Uttar Pradesh, in India with its variety of blood pressure devices and cardiac monitoring devices). The non-exclusive lists of the suppliers based in the province of Quebec and located elsewhere in the world are presented respectively in Appendices A.1 and A.2. Most of the suppliers manufacture their product in Asia but have a sales office in Québec.

Hospitals'primary specific goal is to provide healthcare services to a community. In province of Québec, there are 24 hospitals (*CH- Centres hospitaliers*) and 5 university hospitals (*CHU- Centres hospitaliers universitaires*) (see Appendice B). Hospitals do not place wastes management as the top priority and tent to ship wastes quickly in order to keep their own installations clean, thus reducing contamination risks. Hospitals can however perform source separation activities, i.e. they remove potentially recyclable materials, such as used electronic devices, from the waste stream. Wastes segregation activities play further on a crucial role upon the efficiency of wastes recycling operations.

Wastes treatment facilities can decontaminate, sterilize and destroy clinical wastes and meet all regulatory compliance of biohazardous materials at the local, provincial and federal levels (see Appendix C). Treating firms can either perform decontamination activities off-site or directly on hospital site. One firm detains the quasi monopole on decontamination in Quebec, namely Stericycle located at Ville-Ste-Catherine, on the south shore of Montréal. In addition, Stericycle owns a wastes treatment facilities located in Moncton (NB) servicing also all clinical wastes generated by the Atlantic Provinces (New Brunswick, Nova Scotia, Newfoundland-and-Labrador and Prince Edward Island).

They can also provide transportation services for both clinical and domestic wastes from hospitals to clinical wastes treatment facilities or recycling organizations (see Appendix C). For instance, Clean Harbors Canada from Corunna (Ontario) offers to hospitals specialized waste transport services for biomedical, hazardous and other special material. Transportation services consisted to carry wastes from hospitals to treatment sites while respecting both provincial and federal regulations, especially regulations on biomedical wastes transportation.

Wastes disposing organizations are be divided in two: the recycling facilities and the final disposal organizations. Final disposal organizations perform landfill operation for infected and sharps non-anatomical wastes. Recycling facilities actually perform the material recovery operations such as: product disassembling, material separation and segregation and, finally, material transformation. Most recycling organizations (for more details see appendix C) recuperate plastics, paper and cartons, glass and electronics products. The main goal of recycling facilities is to perform effective materials extraction from wastes. Common examples from recycling operations are found in everyday situation: newspapers are recycled into cardboard or new newspaper, plastic is shredded and manufacture into fabric or aluminum window frames are converted into new beverage containers. Recycling organizations require that material be homogeneous and free of contamination. Clinical wastes are carried in domestic wastes landfill where they are buried as domestic wastes. Landfill operators' extend special care to clinical wastes, especially to sharp waste. They bury a special entrenchment where sharp wastes are unloaded, crushed and compacted. The following table shows the main responsibilities of different organizations involved in the inter-organizational network illustrated in Figure 3.1.

Table 3.1- Responsibilities of organizations involved in the upstream and downstream hospitals wastes management activities

Key players	Responsibilities as identified from the field research
Suppliers (WMS)	• Provide to the healthcare sector the products they need to deliver efficient healthcare.
Hospitals (WMH)	• Plan and execute environmental sanitation programs within the guidelines for public health. • Determine sanitation standards and enforce sanitation regulations. • Collect and dispose solid waste generated by each department.
Wastes treatment and transport organizations (WMTD)	• Decontaminate or treat the medical wastes. • Perform the operation in which the physical or chemical properties of waste are changed to reduce size and/or volume to facilitate handling. • Transport the wastes from the hospitals to the waste treatment unit. • Secure and segregate from hospital to the waste treatment unit.
Wastes disposing organizations (WMTD)	• Recycle the wastes and valorise, i.e. give an added-value, the material recuperated. • Use standard equipment, such as conveyors, shredders, compactors, compaction containers, hauling equipment, and especially designed pulverizes necessary to receive, separate and dispose of wastes. • Perform safe disposal activities, incineration or bury in sanitary landfill, for materials that cannot be recovery

It may happen that a single firm is responsible for both wastes transport and treatment. For example, Biomed Recovery & Disposal performs transportation and disposal for healthcare wastes generated for the whole province of Saskatchewan.

3.3 Medical electronic equipment in hospitals

From the interviews carried out with the waste management officer and several managers in one hospitals and from the contacts made with managers from two of the firms previously mentioned in section 3.2, it became evident that electronic medical equipment is particularly relevant for studying sustainable healthcare wastes management approach for several reasons: it is omnipresent in hospitals, it is highly sophisticated, and it raises serious environmental concerns.

3.3.1 The omnipresence of medical electronic equipment

The medical electronics provide remarkable benefits to both patients and care givers. In fact, medical applications and healthcare increasingly require advanced electronic solutions. The following paragraphs briefly expose a few examples of medical electronic equipment typically found in hospitals, from expensive and complex imaging systems to everyday medical devices.

Imaging systems are electronic medical equipment that may be divided into two main segments, namely the diagnostic and therapeutic markets. The diagnostic imaging market represents the portion of medical equipment that produces images of a chosen area or organ of the human body. X-ray imaging still constitutes the first imaging method by medical imaging professionals: it holds more than the half of the diagnosis market while ultrasound, magnetic resonance imaging (MR), computed tomography (CT) and nuclear medicine represent the over half.

The X-ray technology is used for general radiography, radiography & fluoroscopy, angiography, cardiovascular mammography and dental diagnosis. It is a film-based system, in which an image is processed on special radiographic film. A series of X-ray, photon ray produced by electrons, hit the organ to be examined and are absorbed by matter. Radiographic film is after printed by absorbed x-ray. Therefore, physician can examined a single image or a series of individual images in order to reach a diagnosis.

Infusion pumps are widespread devices which deliver fluids, medication or nutrients into a patient's circulatory system. Infusion pumps are used for anaesthesia purposes and for both medication and nutrient management. Using electronic monitoring, they offer advanced functionalities such as the capacity to pre-program a set of production dispensing protocols, an automated dosing system, or a high dispensing accuracy (Drumea and Vasile, 2006), while by simplifying clinical treatment and saving valuable patient care time.

Defibrillators are used for the life-threatening cardiac arrhythmias, ventricular fibrillation and ventricular tachycardia. The defibrillation process consists of delivering a therapeutic dose of electrical energy to the affected heart. Depending on the type of device used, defibrillators can be external, transvenous, or implanted. Some external products, such as the well-known as automated external defibrillators (AEDs), automate the diagnosis of treatable cardiac rhythms. Earlier defibrillators relied on electronics based on a monophasic waveform but, nowadays, the biphasic waveform tends to be the dominant design (Cooke, 2002).

Sphygmomanometers are commonly known as blood pressure meters. The mercury sphygmomanometer has been for decades the standard for clinical measurement of blood pressure. In line with recent pressures to remove mercury in medical devices (Healthcare Without Harm, 2006), alternatives to the mercury sphygmomanometers were sought, in particular the electronic sphygmomanometers which combine electronic and auscultatory components. In the electronic sphygmomanometers, the mercury column is replaced by an electronic gauge and the stethoscope is used in the same way as with the mercury sphygmomanometers. Many concerns are raised about their accuracy and they require regular and rigorous calibration in order to avoid reading errors (Pickering, et al., 2005).

Pulse oximeters measure of the arterial oxygen saturation (SpO2) and indirectly the pulse rate. They are often attached to a medical monitor, also displaying heart rate, so health professional can see a patient's oxygenation at all times. Electronic pulse oxymeters may use advanced silicon photodiode to ensure highly reliable SpO2 readings.

Thermometers are found in every household and, of course, in hospitals. The traditional mercury-filled thermometers have been replaced with digital (electronic and infrared) thermometers. The digital thermometers offer high accuracy and the great speed for temperature measurements and are indeed very convivial.

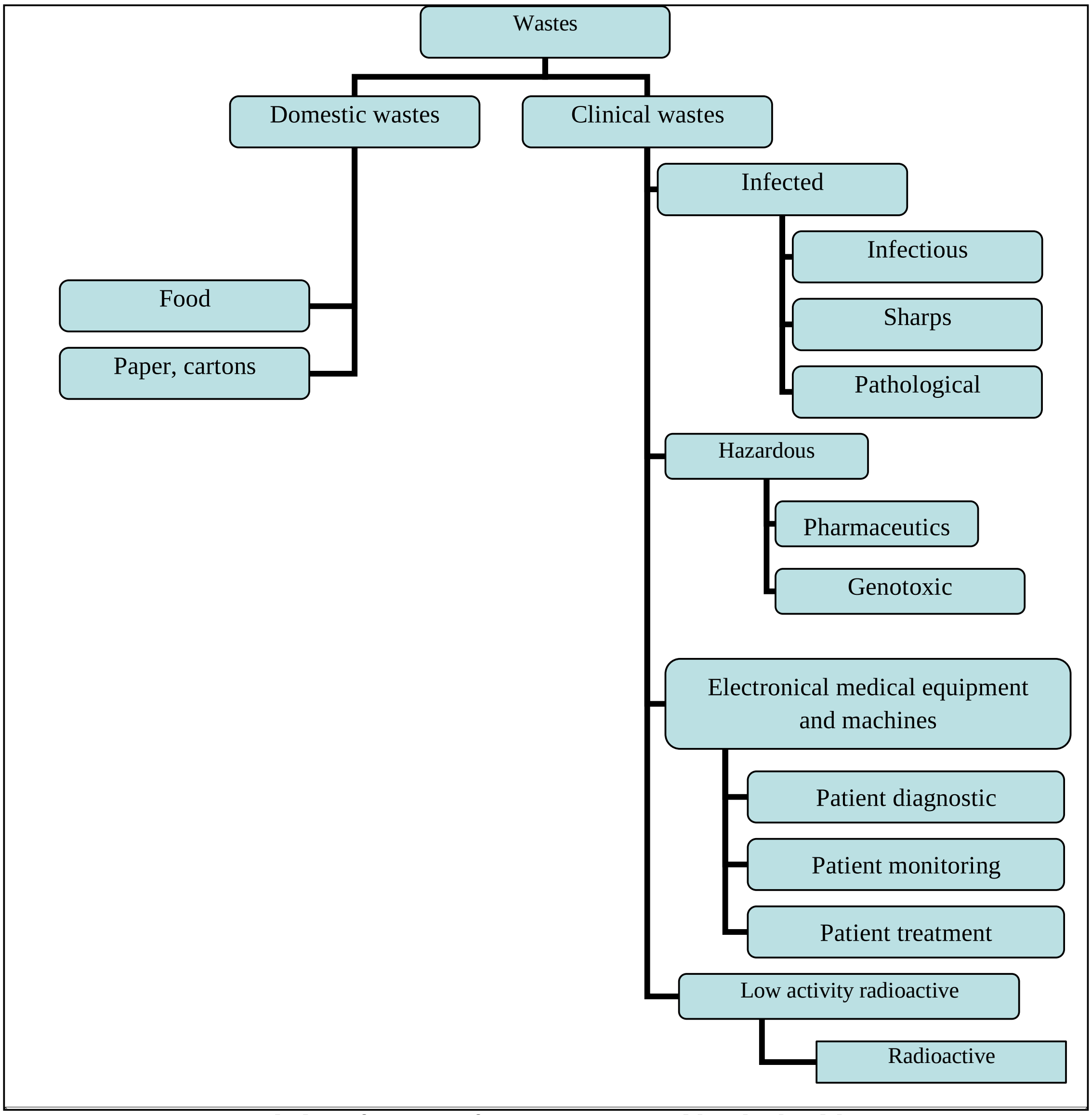

Figure 3.2 Proposed classification of wastes generated by the health care system (as initially adapted from Raman & al., 2006; Qdais & al,2006.; Tudor & al., 2004; Da Silva & al., 2004, Diaz & al., 2007, Alvim-Ferraz & al., 2005 and as modified based on the field study)

The omnipresence of electronic equipment and machines dedicated to healthcare services was demonstrated from the on site-observations in the Tergoii hospital. Interviews also suggested that this type of clinical wastes is important, is highly sophisticated (see section 3.3.2) and has deep environmental impacts (see section 3.3.3). We therefore propose to modify our former Figure1.1 (p.13) in order to integrate this additional type of clinical wastes (Figure 3.2).

3.3.2 High levels of technological sophistication

From the examples described in section 3.3.1, medical equipment and devices are increasingly sophisticated moving towards electronics, digitalization, remote access and emergent technologies such as magnetic resonance imaging magnetic, nanotechnologies or infrared technology.

Electronics, digitalization and remote access

The traditional X-ray technology presents major limitations. First, it is more suitable to examine static organs than dynamic ones. Second, the time delay between exposure and diagnosis is too long as the film must be developed and then delivered to the physician. Third, radiographic films are difficult to store, are relatively expensive and images cannot be easily duplicated. Hospitals are thus turning to digital imaging systems which allow obtaining real time data acquisition with advanced digital enhancement, thus, resulting in high quality image and high-resolution display. Furthermore, these systems are able to transmit the digital image to multiple parties, display it, archive it and retrieve it efficiently. Finally, the digital format image enables health professional to deliver it remotely via a networking infrastructure (via for instance, the Digital Imaging & Communication in Medicine (DICOM) protocol).

A similar digital trend is also occurring in the fluoroscopy, angiography and cardiology. Analog video cameras are being actually replaced by CCD cameras: images are processed, stored and displayed as digital videos. Dynamic imaging is acquired at a speed ranging from one at a time up to 30 images per second. Similar to the consumer photography market, the X-ray imaging market is transitioning from film and analog imaging methods to digital. To follow the introduction of digital imaging systems, electronic peripherals and accessories such as electronic flat panel detectors have been introduced in the recent years.

The trend towards electronics and digitalisation is also apparent in many medical devices as previously discussed in section 3.3.1. In addition, remote access via Internet or other networks and added intelligence in electronics devices open multiple possibilities for telemedicine applications. For instance, the new infusion pumps can allow long distance calibration while pulse oximetry when incorporating intelligence into both the sensor and the monitor, and thus allowing more flexibility into the managed care of outside patients.

Emerging technologies

Magnetic resonance imaging which has been in widespread use for less than 20 years is now most commonly used in radiology to visualize the structure and function of the human body. It provides much greater contrast between the different soft tissues of the body than does computed tomography (CT). This technique is therefore especially useful in neurological, cardiovascular and ontological imaging. It uses a powerful magnetic field to align the nuclear magnetization of hydrogen atoms present in water in the body. Radiofrequency fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by a scanner. In order to improve organ imaging, signal can be manipulated by additional magnetic fields.

Nanotechnologies are found in an increasing variety of devices. For example, sphygmomanometers may be implanted directly in the body. Infrared sensor technology represents another interesting and recent technological development: for example, infrared thermometers which measure heat emitted from the temporal artery in the forehead.

3.3.3 Environmental concerns regarding electronic medical equipment

The problems

As we have demonstrated previously, hospitals use a wide range of electronic medical equipments. These equipments contain many hazardous constituents, from lead in cathode ray tube monitors to chlorinated plastics in cable wiring, brominated flame retardants in circuit boards and plastic enclosures, and mercury in liquid crystal displays (Health Care Without Harm, 2004). These hazardous substances are linked to human health effects like cancer, birth defects, and hormone disruption. Improper disposal of electronic equipment, such as incineration or bury without precaution, poses a direct threat to public health and the environment.

Disposal of brominated flame retardants is a main concern. When incinerated, they are light enough to be transported long distances through the atmosphere. In addition, the chemical structures of brominated flame retardants are very stable, i.e. they do not break down easily in the environment. Brominated flame retardants attach to particles and, therefore, accumulate in media such as dust and sediments. These chemicals are now ubiquitous in the worldwide environment, including remote areas such as the Arctic and deep in the oceans. Research shows (Hischier, R. & al., 2005; Karlsson, M. & al.,2005; Koss, L., 2006) that increasing levels of these chemicals have been measured in sediments, marine animals and humans, which indicate a significant potential for damage to ecological and human health.

Concerns also exist around the export of electronic wastes to developing countries. These nations are less equipped to handle hazardous materials and, therefore, workers of recycling industries work in poor health and safety conditions. In fact, "recycling is done by hand in scrap yards, often by children" (Health Care Without Harm, 2004). In addition, the export of electronics wastes is frequently in violation of international law, as well as domestic laws in the importing countries.

Some initiatives

Some initiatives fall into the regulatory framework whereas some arise from public pressure groups, environmental agencies and healthcare workers. For instance, Environmental Protection Agency (EPA) is working "to foster environmentally friendly design; to increase purchasing and use of electronics products that are environmentally sustainable; and to increase the reuse and safe recycling of used electronics" (U.S Environmental Protection Agency, 2006)

The potential initiatives for hospitals

According to EPA, the healthcare industry, as a large volume buyer and through its purchasing choices, may be a powerful levee towards electronics manufacturing greener practices. In addition, hospitals may benefit to take into account all the life-cycle impacts of electronics in purchasing decisions since healthcare organizations are likely to be stuck with costs associated with disposal of these products at the end of their useful life. Furthermore, when purchasing electronics, hospitals and healthcare organizations can integrate a total cost of ownership approach that incorporates end-of-life disposal costs in the product and services costs. In addition, hospitals can negotiate contracts with suppliers that require products and practices to meet specific environmental criteria, namely: establishing manufacturer take back requirements for electronic equipment at the end-of-life, extending the life of electronic equipment through upgrades and reuse and recycling old electronics with a vendor who has integrated the stewardship approach regarding its own product.

Healthcare can save significantly by integrating end-of-life management into purchase analysis. Therefore, manufacturers are encouraged to institute take back programs for old electronic devices. As a consequence, take back programs create an incentive to design for recycling, increase the use of recycled content, and decrease the use of toxic materials. Without these incentives, the purchaser bears responsibility for managing increased volumes of electronic wastes. In addition, healthcare institutions using manufacturers take back programs will comply with environmental and public health standards, but also to guarantee data-security and complete data destruction.

The potential initiatives for medical electronic manufacturers

Medical electronic manufacturers are beginning to act in order to reduce the environmental and health impacts of their products. For example, Ethicon, a surgery products manufacturer affiliate to Johnson & Johnson, acknowledges the concerns about recycling medical device materials that have been in contact with blood or other body fluids during use and, therefore, identifies opportunities for safe recycling of many of products through decontamination. However, many manufacturers of medical electronic products under achieve upstream wastes management activities.

Legislative initiative and medical electronic equipment

Under the European Union directives, the California Electronic Waste Recycling Act of 2003 and other legislation, electronic must be collected separately from other wastes to prevent it from ending up in a landfill or being incinerated. All electronic wastes within the European Union sold after 13 August, 2005 must be labelled with a symbol in order facilitate recycling.

The State of California has enacted landmark legislation, California Electronic Waste Recycling Act of 2003, to establish a funding system for the collection and recycling of certain electronic wastes. Key elements of the Act Electronic Waste Recycling Act are namely: “reduction in hazardous substances used in certain electronic products sold in California, collection of an electronic waste recycling fee at the point of sale of certain products, distribution of recovery and recycling payments to qualified entities covering the cost of electronic waste collection and recycling and directive to recommend environmentally preferred purchasing criteria for state agency purchases of certain electronic equipment.” (Californian Integrated Board of Waste Management, 2008). Fees for recycling certain types of electronic wastes are displayed in Table 3-2.

Table 3.2- Electronic recycling fee by size of electronic scrap from the Californian Integrated Waste Management Board

Viewable Screen Size	**Recycling Fee**
Between 4 inches and 15 inches	$6
Between 15 inches and 35 inches	$8
35 inches and larger	$10

Recycling electronic medical equipment requires specialized facilities and technical personnel given the complexity of the equipment and presence of hazardous materials, for example X-Ray equipment and printed circuits present in electronic devices. Electronic wastes should be kept separate from other contaminated, infectious, biological, and hazardous wastes. Moreover, for collection and recycling purposes, electronic wastes must be separated and properly decontaminated. Emerging WEEE legislation does not change the management and disposal procedures of electronic products that may be infected. Therefore, electronic wastes from the healthcare continue to be handled as medical wastes and disposed according to the laws and regulation governing these types of wastes.

3.4 A coordinated continuum of wastes management activities

From the interviews conducted with key managers from the hospital and two suppliers, we were able to propose a continuum of activities that could reduce the wastes problems in each layer of the inter-organizational network displayed in Figure 3.1.

Observations made on the key players involved in the inter-organizational network allowed us to combine the activities conducted by the waste treatment organizations and the wastes disposal organizations since these organizations were the same in many occasions. As a result, only three entities (or levels) are presented in the first column of Table 3.3, namely the suppliers (WMS), the hospitals (WMH) and, the wastes treatment and disposal organizations (WMTD).

Table 3.3- A coordinated continuum of wastes management initiatives

Level	Wastes management initiatives	Theoretical justification
Suppliers (WMS)	Use more materials that are recycled or less toxic for the environment	Verhoef and al., 2004; Dijkema and al., 2000; Dalrymple and al., 2007
Suppliers (WMS)	Reduce the amount of raw materials	Fiskel, 2006; Baumgartner and al., 2006
Suppliers (WMS)	Reduce the energy needed for product manufacturing and assembly	Fiskel, 2006; Baumgartner and al., 2006
Suppliers (WMS)	Eliminate the wastes generated by product manufacturing and assembly	Pauli, 1997; Baumgartner and al., 2006
Suppliers (WMS)	Treat the wastes generated by product manufacturing and assembly	Pauli, 1997; Baumgartner and al., 2006
Suppliers (WMS)	Minimize the wastes generated by product manufacturing and assembly	Pauli, 1997; Baumgartner and al., 2006
Suppliers (WMS)	Establish mechanisms to dispose of the wastes generated by product manufacturing and assembly	Pauli, 1997; Baumgartner and al., 2006
Hospitals (WMH)	Reduce the energy needed to use the product	Fiskel, 2006; Throne-Holst and al., 2006
Hospitals (WMH)	Increase the product durability	Fiskel, 2006; Harrison and al., 2005; Knoth and al., 2004
Hospitals (WMH)	Design product for multiple uses	Fiskel, 2006; Harrison and al., 2005; Knoth and al., 2004
Hospitals (WMH)	Design product to be easier to repair	Parlikad and al, 2005; Kulkarni and al., 2005; Harrison and al., 2005; Knoth and al., 2004
Hospitals (WMH)	Minimize the materials for packaging the product	Fiskel, 2006; Lee and al., 2001
Hospitals (WMH)	Design product packaging to be easier to recycle	Lee and al., 2001
Waste treatment and disposal org. (WMTD)	Design the product in order to be easier to disassemble	Dalrymple and al., 2007
Waste treatment and disposal org. (WMTD)	Design the product in order to be easier to recycle	Verhoef and al., 2004; Dijkema and al., 2000; Dalrymple and al., 2007
Waste treatment and disposal org. (WMTD)	Establish recycling procedures	Verhoef and al., 2004; Dijkema and al., 2000; Moors and al., 2004
Waste treatment and disposal org. (WMTD)	Ensure the presence of recycling infrastructures	Verhoef and al., 2004; Dijkema and al., 2000; Hanoura and al., 2006; Moors and al., 2004; Dalrymple and al., 2007
Waste treatment and disposal org. (WMTD)	Establish the mechanisms for disposing the hazardous and infected materials	Verhoef and al., 2004; Dijkema and al., 2000; Pauli, 1997; Raman and al., 2006

From the results from the field research, we concluded that electronic medical equipment manufacturers (or suppliers) have a tremendous impact upon each player of the supply chain This last remark could also be traced in the literature: according to Health Care Without Harm (2008) and Dalrymple (2007), electronics manufacturers deeply influence the sustainability level among the supply chain as they performed product design, manufacturing and product packaging design.

Hospitals, treatment and disposal organizations must adapt to the initiatives made by the supplying organizations. Product functionality and characteristics and product packaging as designed by suppliers have a direct impact on hospital wastes management. For instance, wastes generated by product packaging are included in the hospital waste stream (Lee and al., 2001). Moreover, product sustainability is deeply influenced by the easiness to disassemble, to segregate material and to transform electronic wastes into usable materials, all of which is initially decided by the suppliers but has a tremendous impact on the wastes treatment and disposal organizations. It was therefore decided to take a product-centric approach and address environmental issues along all stages of the product life-cycle, i.e. from design phase, the production/ manufacturing /assembly, packaging phase, transport/ distribution phase, use/consumption phase, wastes treatment phase to final disposal phase. Such an integrated approach is also in line with the concept of product stewardship (Curran, 1996; Hannoura & al., 2006)

3.5 Concluding remarks

The field research allowed us to gain considerable insights into hospital wastes management. First, entities of the inter-organizational network for wastes could be identified and their respective roles could be outlined. The initial structure of such network was slightly modified as wastes transport activities are usually carried out by wastes treatment and disposal firms. From on-site observations and interviews, it became evident that the typology of healthcare wastes as proposed in the literature and as initially illustrated in Figure1.1 should also include an important type of waste, namely electronic medical equipment (Figure 3.2). In fact, not only electronic medical equipment is omnipresent in hospitals but it is highly sophisticated and present severe environmental problems that do not seem to be covered by the actual regulatory framework. As a result, medical electronic wastes are inadequately managed. Finally, the coordinated continuum of wastes management activities that are under the responsibilities of the suppliers of electronic medical equipment could be validated. Such an approach builds on the product stewardship concept and avoids that environmental burdens are shifted from one stage of the product life-cycle to the next stage.

The results from the field research serve as valuable inputs to the survey design (chapter 4).

CHAPTER 4: THE SURVEY DESIGN AND PRELIMINARY RESULTS

4.1 The survey design

Building on the results obtained from the field study (chapter 3), the questionnaire was elaborated and potential responding firms were identified.

4.1.1 The questionnaire

The questionnaire was designed in order to collect data related to five broad sets of variables, namely the firm's profile, the wastes management initiatives, the participation of key internal actors, the drivers and the impacts of such activities.

Firm's profile includes information on firm's size, level of exports and imports, the level of sophistication of their customers, actual and projected cost structure and the presence of total quality management program such as ISO 9000 or total environmental management program, such as ISO 14000. All these variables were identified as potential determinants of a proactive environmental strategy in general (Lefebvre & Lefebvre, 2003; Lefebvre, Lefebvre & Talbot, 2001).

Upstream and downstream wastes management activities are evaluated for the last product developed and marketed by the firm. This product centric approach is in line with the empirical and theoretical justification provided in chapter 3. In addition, the questionnaire allows us to gather related data on the product characteristics and the level of sophistication of the customers of that particular product (Lefebvre & Lefebvre, 2003).

Participation of key internal actors deals with the involvement of employees and managers in the wastes management activities, including the top managers, the shareholders, the R&D staff and the production line employees. According to Tudor and al. (2002) and Sayre (1996), such a broad involvement is crucial when implementing quality programs such as TQEM (Total Quality Environmental Management).

Drivers of change arise from actual and projected environmental regulations, from pressures from ecologist groups and coalitions such as Healthcare Without Harm or The Electronics Take Back Coalition, and from customers requirements.

Impacts of wastes management activities at the firm level may include improvements in product design and quality as well as costs reductions such as energy costs for instance (Curran, 1996; Lehman, 1983; Verhoef and al., 2004; Moors and al., 2004). According to Riegel (1983), environmental initiatives can improve the product position among rival products, thereby improving the overall competitive positioning of the firm (Lefebvre & Lefebvre, 2003).

4.1.2 Responding firms

In the province of Québec, most firms that we could identify are distributors (76 firms in appendix A.1) and the number of firms manufacturing medical equipment is too limited (23 firms in appendix A.2). We have therefore decided to send the questionnaire to North-American firms responsible for manufacturing electronic medical: the firms are located in all Canadian provinces and, in a large part, in the United States.

The questionnaire was sent using regular postal services and guaranteed complete confidentiality. The total number of responding firms was 59 firms and the response rate was 6,7%. As the survey was conducted for exploratory purposes, this critical mass of firms although rather small is sufficient enough to carry unvariate and bivariate statistical analyses (sections 4.2.1 and 4.2.2 respectively).

4.2 Results and discussion

4.2.1 Descriptive statistics

4.2.1.A Profile of responding firms

All 59 firms in our sample are manufacturers of medical electronic equipment that is sold to hospitals and include both SMEs (Small and medium-size enterprises) and large firms (Table 4.1). The average firm's size is 156 full-time employees, with a standard deviation of 80,00. Half of responding firms are SMEs with less than 75 full-time employees. The largest firm in our sample has 2 200 employees.

Table 4.1- Firms' size (n=59)

	Number of full time employees
Mean	156,06
Standard deviation	80.00
Median	75,00

These firms are highly internationalized: close to 80% of responding firms import the necessary inputs for manufacturing their products and export their products in the same proportion. Their customers are rather demanding and sophisticated but require radical changes to the medical equipment to a lesser extent (Figure 4.1). The high level of professionalism found in hospitals may explain the first two characteristics whereas the bureaucratic behavior of these institutions may lower the demand for radically improved products.

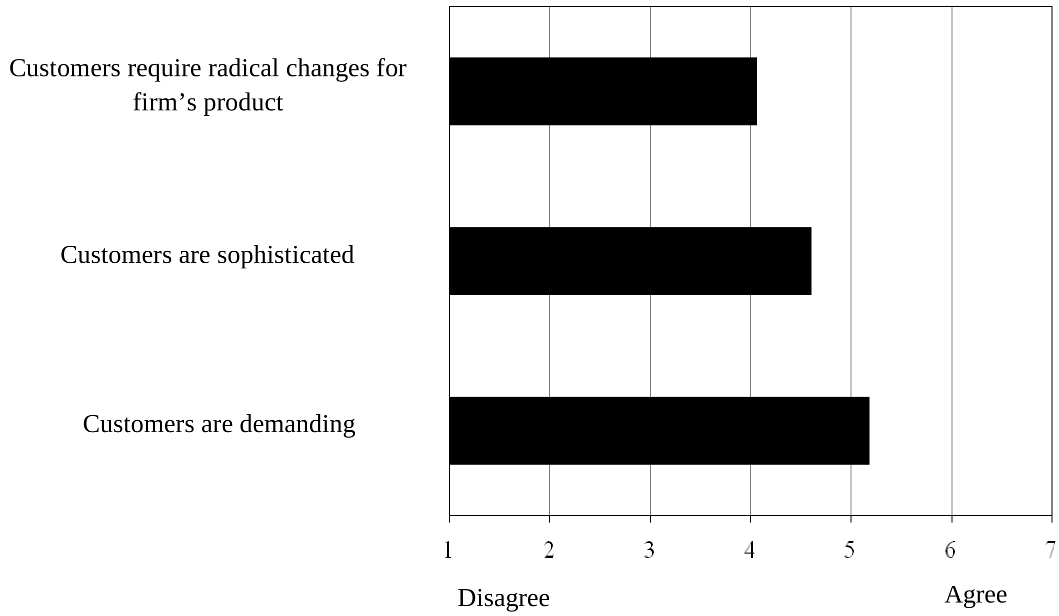

Figure 4.1 - Characteristics of customers (n=59)

Responding firms indicate that the average of their product life cycle length is about eleven years in average: maximum life cycle length is thirty years while the minimum is about some months. This is in line with the wide variety of medical electronic equipment described in chapter 3. The actual and projected costs structure for the 59 firms is displayed in Figure 4.2.

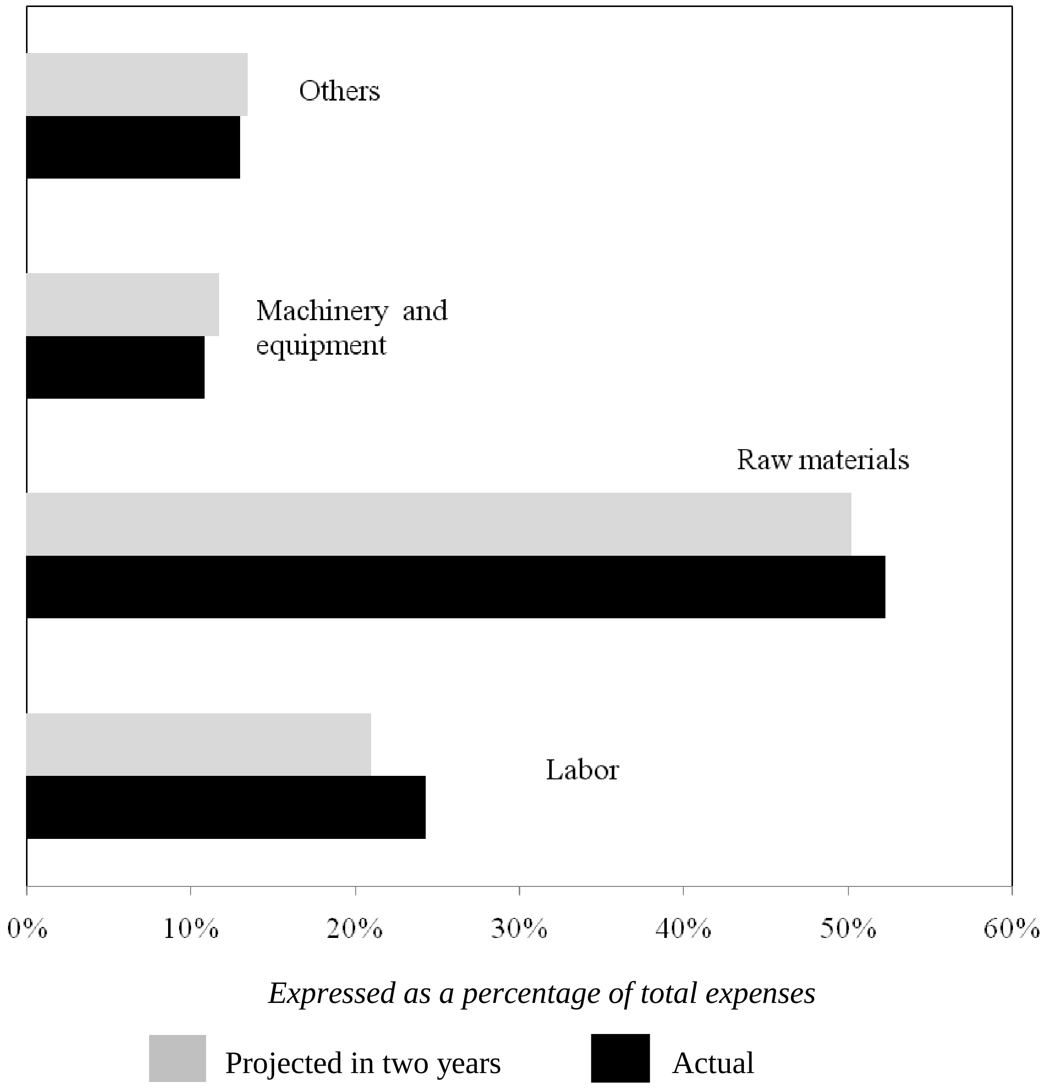

Figure 4.2 - Actual and projected cost structure (complete data are presented in appendix D)

Responding firms are expecting to lower labour and raw material costs within the next two years while at the same time increasing the investments in machineries and equipment (Figure 4.2). This is symptomatic of a strategic intent to increase productivity in manufacturing firms. Furthermore, greater investments in production processes may result in more efficient use of material and raw materials, thus, resulting to a decreasing wastes generation pattern.

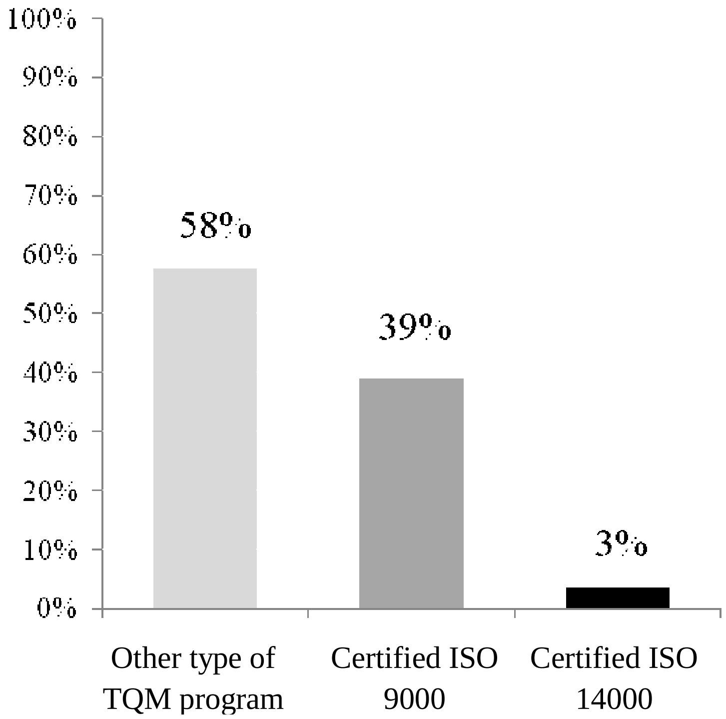

Figure 4.3- Quality management initiatives

Total quality program and environmental issues share similar concepts. There is in fact a striking analogy between the concepts of “zero defects” and “zero emission”. Both concepts impose a strict discipline upon manufacturers for continuous improvement and require functional integration. These goals are rather idealistic as firms cannot achieve total zero defect or zero emission. Hence, the implementation of a total quality program among an enterprise may represent a vector for achieving a comprehensive environmental management. Therefore, it is expected that the presence of a total quality management program will be associated to environmental performance. Most firms in our sample (58%) have implanted a TQM program while 39% are certified ISO 9000 (see Figure 4.3). The ISO 14000 program seems less popular with only 3% of firms being certified. ISO 14000 can describe as a total quality environmental management program (TQEM) because it imposes to care not only about product quality but also wastes generation caused by production process. TQEM programs are still marginal, especially in North-America but growing awareness about environmental issues may increased the popularity of ISO 14000.

4.2.1.B Wastes management initiatives

The environmental initiatives undertaken by the manufacturers of medical electronic equipment result into a decrease of wastes burden on all actors of the inter-organizational network as demonstrated previously in chapter 3. They allow better wastes management for the manufacturers, or suppliers, of medical equipment to hospitals (Figure 4.4), for the hospitals (Figure 4.5) and for the transport, treatment and disposal organizations (Figure 4.6).

The environmental initiatives that have a direct impact on the wastes management activities of manufacturers (or suppliers) receive an average score between three and four based on a 7 points Likert scale, which is rather low (see Figure 4.4; more detailed statistics on environmental activities are presented in appendix D). Three activities that receive the highest scores are cost oriented, namely *reduce the amount of raw materials, decrease the quantity of energy needed for product manufacturing and assembly* and *minimize the wastes generated by product manufacturing and assembly. Minimization, treatment and elimination of wastes generated by product manufacturing and assembly* follow closely behind.

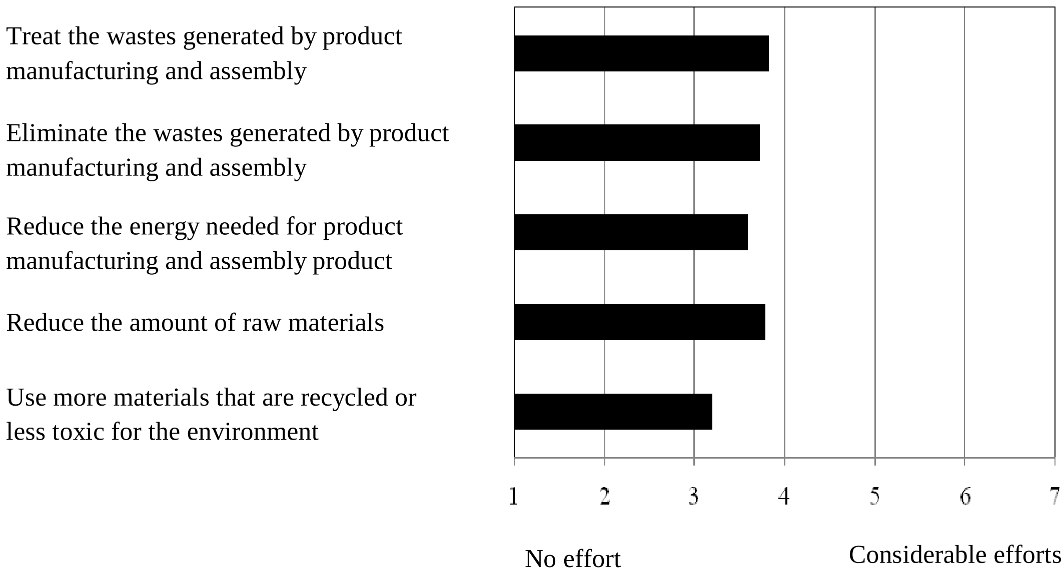

Figure 4.4- Environmental initiatives that affect wastes management activities for suppliers (WMS)

The *use of materials that are recycled or less toxic for the environment* obtains the lowest score (Figure 4.4), despite growing public awareness about environmental issues and stringer regulations. For instance, Health Care Without Harm, an environmentalist lobby promoting green procurement in healthcare system, shows that hazardous materials contain in electronic devices are not only harmful for the environment, but also for human health as they can cause cancers, increase birth defects and generate other significant health problems.

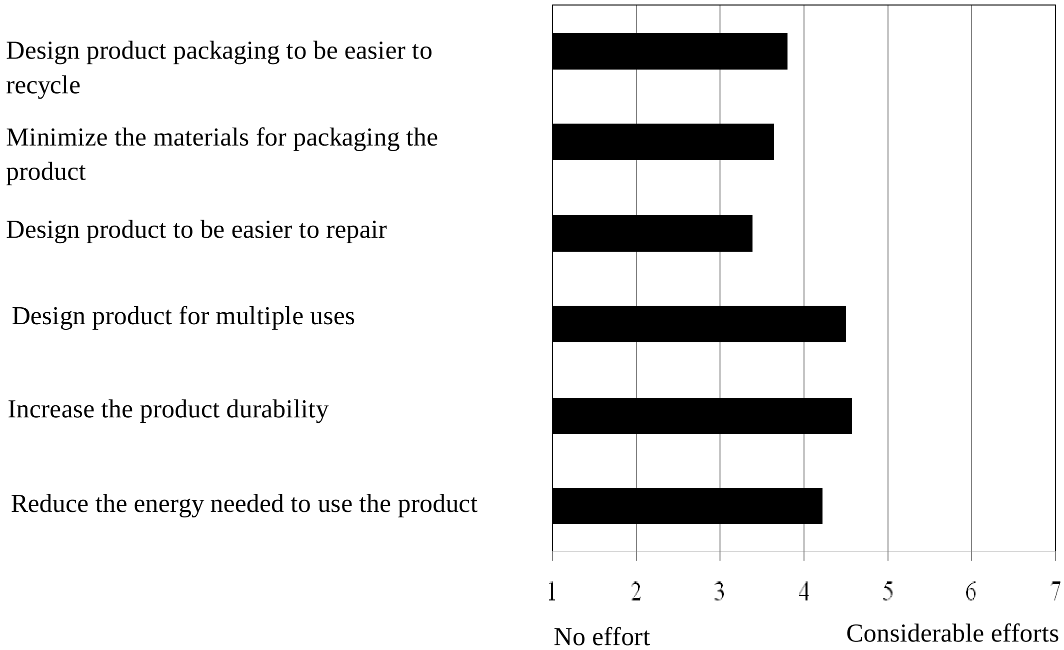

Figure 4.5- Environmental initiatives that affect wastes management activities for hospitals (WMH)

Some initiatives undertaken by manufacturers directly affect wastes management activities in hospitals (Figure 4.5). Green product design such as *design product for multiple uses*, *increase the product durability* and *reduce the energy needed to use the product* receive relatively high scores (above 4). However, the activity labelled *design the product in order to be easy to repair* obtains the lowest score: one can speculate that customers, in occurrence hospitals, are not interested in repairing themselves medical electronic equipments.

We can also observe from Figure 4.5 that the green design for packaging, namely *minimize the materials for packaging the product* and *design product packaging to be easier to recycle* do not seem as important as the green product design.

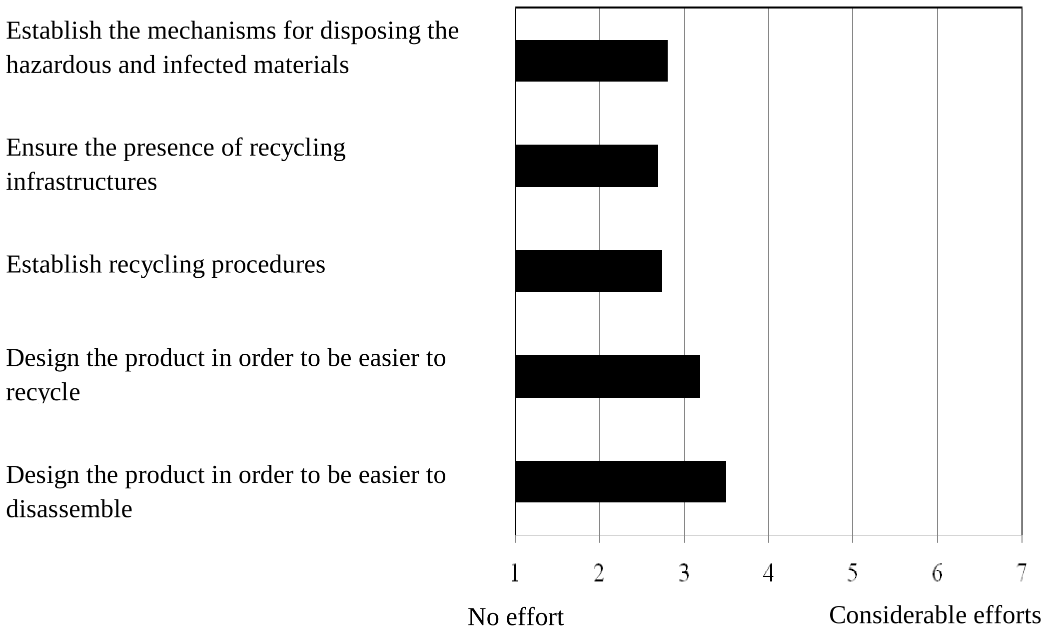

Figure 4.6 : Environmental initiatives that affect wastes management activities for the treatment and disposal organizations (WMTD)

At the end of the life cycle of medical electronic equipments, the initiatives to reduce the environmental burden of medical electronic equipments are low (Figure 4.6), with three activities (well under the middle point of the Likert scales), namely *ensure the presence of recycling infrastructures*, *establish recycling procedures* and *establish the mechanisms for disposing the hazardous and infected materials.* In fact, Cross (1990) claims that many hazardous materials are not still recuperated and many electronics devices are burned in incinerators.

4.2.1.C Drivers of proactive wastes management activities

Figure 4.7 presents the relative importance of several factors that influence the implementation of more proactive wastes management activities**.**

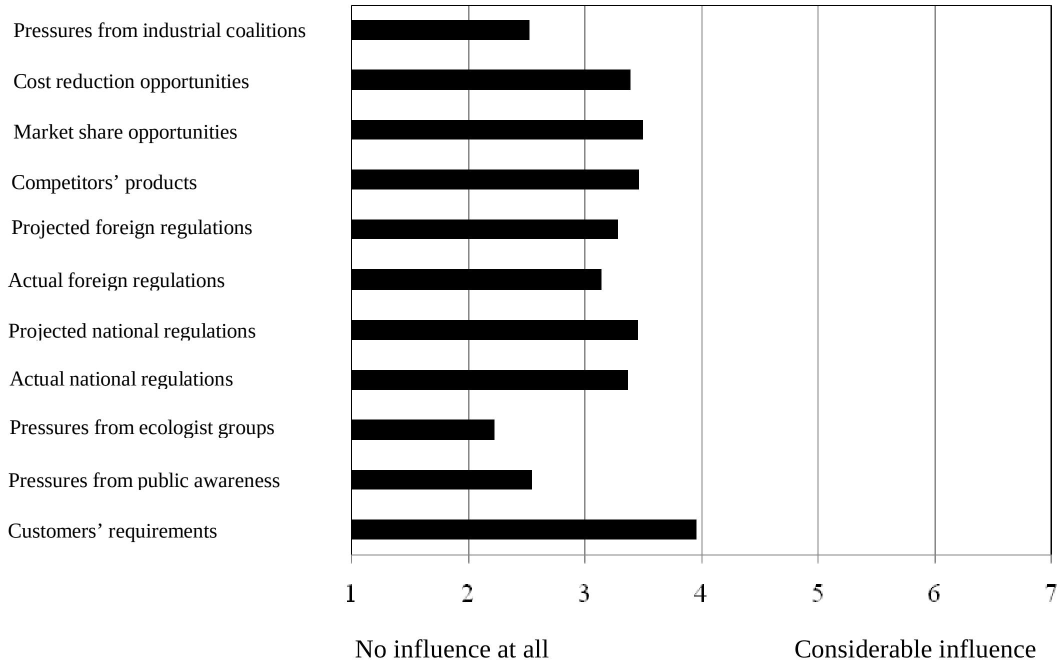

Figure 4.7- Drivers of wastes management activities

First, we observe that the most influent factors is customers’ requirements (3,97). Customers (here hospitals) thus hold an important role on their suppliers’ decisions to design and manufacture greener products. Market share opportunities comes in second rank closely followed in third rank by competitor’s products (respective scores of 3,50 and 3,47), suggesting that market driven influences represent strong drivers of a more proactive environmental strategy in manufacturing firms. Cost reduction opportunities with a mean of 3,40, rank in fourth position and basically represent a way to increase profit margin.

Responding firms stated to be mildly influenced by actual and projected regulations with average scores between 3,15 and 3,47 (see Figure 4.7). Pressures from industrial coalitions, from public awareness, and from ecologist groups are placed as the least influential factors. However, pressures from ecologist coalitions may play an important but indirect role as these coalitions have a strong influence on public opinion which in turn influences hospitals to undertake more sustainable wastes management practices. For instance, Health Care Without Harm played a strong role for the implementation of green procurement initiatives in hospitals, which obviously translates into more proactive environmental initiatives at the suppliers level (customers' requirements are indeed placed in first rank).

4.2.1.D Impacts of wastes management activities

Figure 4.8 illustrates the impacts of proactive wastes management activities among the responding firms. With a score between 3,00 and 4,00, responding firms state that environmental activities have rather mild impacts.

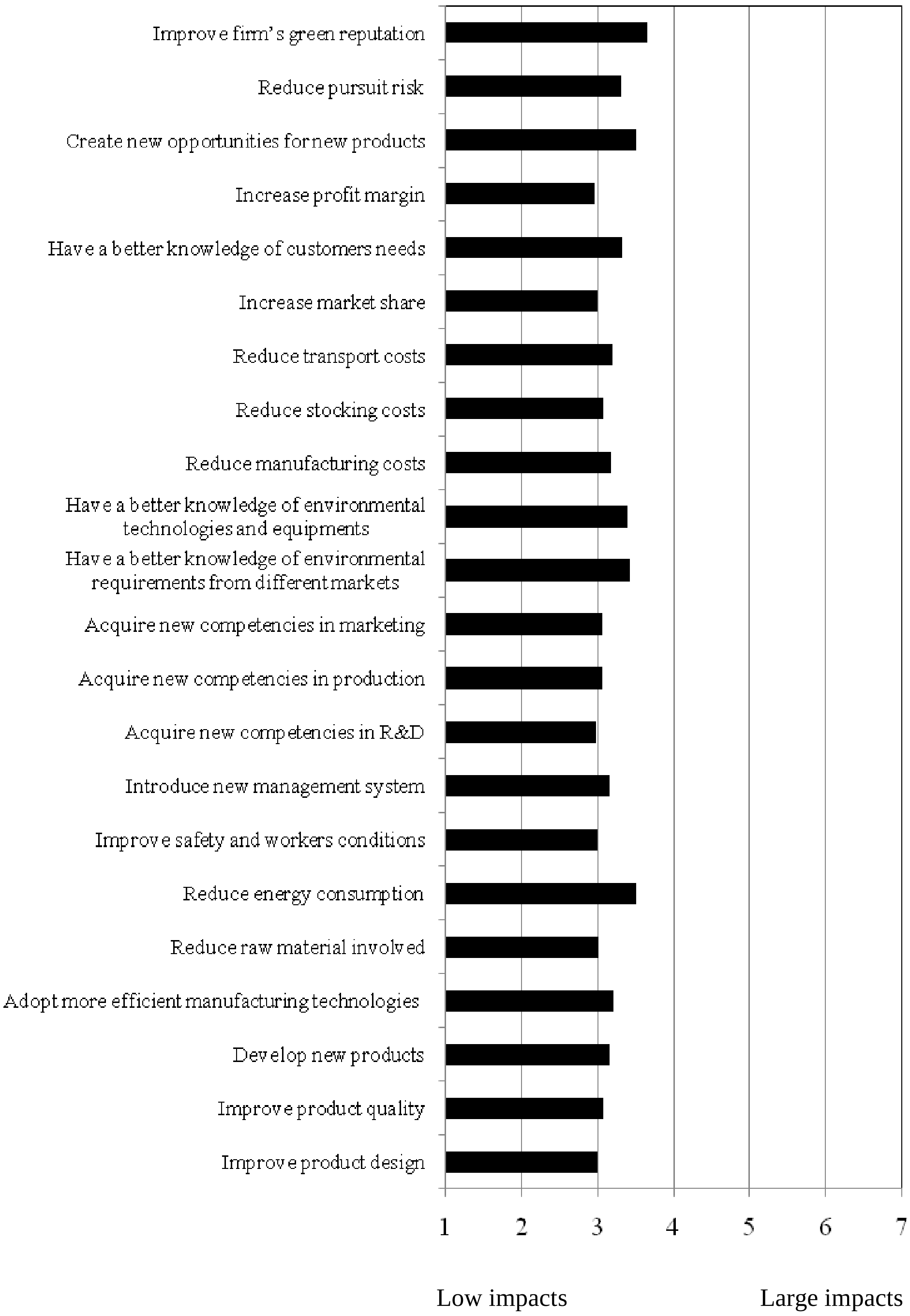

Figure 4.8: Impacts of proactive wastes management activities according to responding firms

The two largest impacts of proactive wastes management activities (Figure 4.8) are *improving firm's green reputation* and *creating new opportunities for new products* which is aligned with the importance of customers' requirements and firm reputation for the WMS (Figure 4.7). These two impacts are closely followed by *have a better knowledge of environmental technologies and of equipment and customer' needs* and *reduce pursuit risk* with an average score. Therefore, firms seem to pursue strategic market driven opportunities while building at the same time stronger environmental capabilities, at least with respect to environmental technologies and equipment.

Costs reductions such as *reducing energy consumption* combined with *increasing profit margin and market share*, which received also relatively high scores (Figure 4.8), have a direct and positive impact on financial results. This suggests that a proactive environmental strategy leads not only to intangible benefits such as a better reputation and an improved corporate image but also to tangible benefits that affect the bottom line figures. Nevertheless, responding firms stated that the impacts of their environmental activities are rather moderate.

4.2.2 Relationships between wastes management activities and the different sets of variables

4.2.2.A Relationships between waste management activities and firms' characteristics

Table 4.2 presents the Pearson correlation coefficients between some firms ' characteristics (size, R&D intensity, level of exports and level of imports) and the environmental initiatives that affect wastes management activities for the suppliers

(WMS), for the hospitals (WMH) and for the treatment and disposal organizations (WMTD). The overall wastes management activities that include WMS, WMH and WMTD is simply entitled WM (fifth column in Table 4.2.). Although all correlation coefficients displayed in Table 4.2 are positive, they are not very significant. Exports do not play any significant role whereas size, R&D and level of imports are barely significant.

Table 4.2: Pearson correlation coefficients (bilateral tests) between wastes management activities and firm's characteristics (n=59)

Firm's characteristics	**WMS**	**WMH**	**WMTD**	**WM**
Firm's size	0,116 p=0,380	0,048 p=0,720	0,102 p=0,450	0,094 p=0,488
R&D intensity	0,057 p=0,686	0,140 p=0,324	0,163 p=0,252	0,127 p=0,376
Level of exports	0,062 p=0,642	0,108 p=0,422	0,097 p=0,476	0,098 p=0,474
Level of imports	0,035 p=0,800	0,173 p=0,208	-0,129 p=0,354	0,063 p=0,650

4.2.2.B Relationships between wastes management activities and the different dimensions of technology strategy

The relationships between the different dimensions of technology strategy and wastes management activities (Table 4.3) are much stronger. All Pearson correlation coefficients are positive and significant. In particular, an aggressive technology strategy with respect to production technologies and production equipment (first two lines of Table 4.3) is strongly and significantly related to wastes management activities in all three levels (suppliers, hospitals, and, treatment and disposal organizations). Overall, an aggressive technology is more strongly related to wastes management activities in hospitals (WMH), which is not surprising as hospitals are the customers of our responding firms. The later are obviously more inclined to try to reduce the wastes problems for their customers than they will be further downstream i.e. for treatment and disposal organizations.

Table 4.3: Pearson correlation coefficients (bilateral tests) between wastes management activities and the different dimensions of technology strategy (n=59)

Firm's characteristics	WMS	WMH	WMTD	WM
Firm always seeks the latest production technologies	0,598 p=0,000	0,525 p=0,000	0,521 p=0,000	0,597 p=0,000
Firm go forward with production equipment evaluation projects	0,612 p=0,000	0,496 p=0,000	0,588 p=0,000	0,600 p=0,000
Firm has a strong innovation reputation among its production department	0,367 p=0,004	0,337 p=0,010	0,378 p=0,004	0,393 p=0,002
Firm seeks to increase R&D budgets within the next five years	0,142 p=0,286	0,445 p=0,000	0,133 p=0,326	0,298 p=0,024
Firm always spend more for new product development	0,197 p=0,138	0,465 p=0,000	0,181 p=0,176	0,333 p=0,012
Firm always seeks the best technical personal	0,167 p=0,212	0,478 p=0,000	0,107 p=0,428	0,293 p=0,028
Firm always perform technological forecast for the products	0,355 p=0,006	0,551 p=0,000	0,244 p=0,068	0,468 p=0,000
Firm always perform technological forecast for the processes	0,580 p=0,000	0,436 p=0,000	0,576 p=0,000	0,593 p=0,000

4.2.2.C Relationships between waste management activities and customers' characteristics

Table 4.4 examines the link between customers' characteristics (here hospitals and other healthcare institutions) and wastes management activities. The strongest correlation coefficients are observed for WMH indicating that the suppliers tend to align their environmental strategies with their customers requirements for wastes minimization, more than they do for themselves (WMS) or for members located further downstream

(WMTD). The wastes management initiatives thus seem to respond to a market-pull momentum.

Table 4.4 : Pearson correlation coefficients (bilateral tests) between wastes management activities and customers ‘characteristics (n=59)

	WMS	WMH	WMTD	WM
Actual customers are demanding	0,367 p=0,004	0,673 p=0,000	0,446 p=0,000	0,561 p=0,000
Actual customers are sophisticated	0,044 p=0,742	0,356 p=0,006	0,101 p=0,454	0,187 p=0,164
Actual customers require radical changes for firm’s product	0,104 p=0,434	0,400 p=0,002	0,18 p=0,182	0,235 p=0,080

4.2.2.D Relationships between waste management activities and the alleged drivers

All drivers are significantly and positively correlated with the three broad dimensions of wastes management activities, namely WMS, WMH and WMTD (Table 4.5). Internal consistency dictates that the strongest alleged drivers (Figure 4.7) should also be closely related to overall waste management activities (WM). This is indeed the case as the highest correlation coefficients occur between WM and market share opportunities (0,625), competitors’ products (0,554), cost reduction opportunities (0,550) and pressure from public awareness (0,567).

Table 4.5 – Pearson correlation coefficients (bilateral tests) between waste management activities and alleged drivers (n=59)

	WMS	WMH	WMTD	WM
Customers requirements	0,423 p=0,000	0,496 p=0,000	0,488 p=0,000	0,507 p=0,000
Pressure from Public awareness	0,488 p=0,000	0,585 p=0,000	0,508 p=0,000	0,567 p=0,000
Ecologist group pressure	0,407 p=0,002	0,552 p=0,000	0,431 p=0,000	0,503 p=0,000
Actual national environmental regulations	0,329 p=0,010	0,491 p=0,000	0,445 p=0,000	0,449 p=0,000
Projected national environmental regulations	0,38 p=0,002	0,499 p=0,000	0,457 p=0,000	0,476 p=0,000
Actual foreign environmental regulations	0,378 p=0,004	0,556 p=0,000	0,405 p=0,002	0,484 p=0,000
Projected foreign environmental regulations	0,343 p=0,008	0,518 p=0,000	0,416 p=0,002	0,46 p=0,000
Competitor products	0,429 p=0,000	0,565 p=0,000	0,565 p=0,000	0,554 p=0,000
Market opportunities	0,544 p=0,000	0,589 p=0,000	0,59 p=0,000	0,625 p=0,000
Costs reduction opportunities	0,453 p=0,000	0,542 p=0,000	0,533 p=0,000	0,550 p=0,000
Pressure from industrial association and coalitions	0,199 p=0,130	0,461 p=0,000	0,312 p=0,018	0,352 p=0,008

4.2.2.E Relationships between waste management activities and alleged impacts

With a rather moderate level of wastes management activities (Figures 4.4, 4.5 and 4.6), benefits derived from these activities are also rather moderate (Figure 4.8). However, the more intense are wastes management activities, the higher are the benefits (Table 4.6). In fact, we observe from Table 4.6 that wastes management activities and alleged benefits are highly correlated with correlation coefficients ranging between 0,598 and 0,704.

Table 4.6 - Pearson correlation coefficients (bilateral tests) between wastes management activities and alleged benefits (n=59)

Benefits	WMS	WMH	WMTD	WM
Improve product design	0,637 p=0,000	0,613 p=0,000	0,674 p=0,000	0,692 p=0,000
Improve product quality	0,651 p=0,000	0,591 p=0,000	0,726 p=0,000	0,704 p=0,000
Develop new products	0,528 p=0,000	0,583 p=0,000	0,56 p=0,000	0,604 p=0,000
Adopt more efficient manufacturing technologies	0,597 p=0,000	0,512 p=0,000	0,733 p=0,000	0,640 p=0,000
Reduce raw material involved	0,640 p=0,000	0,527 p=0,000	0,758 p=0,000	0,670 p=0,000
Reduce energy consumption	0,494 p=0,000	0,571 p=0,000	0,476 p=0,000	0,545 p=0,000
Improve safety and workers conditions	0,562 p=0,000	0,460 p=0,000	0,665 p=0,000	0,578 p=0,000
Introduce new management system	0,587 p=0,000	0,524 p=0,000	0,663 p=0,000	0,620 p=0,000
Acquire new competencies in R&D	0,555 p=0,000	0,54 p=0,000	0,658 p=0,000	0,625 p=0,000
Acquire new competencies in production	0,566 p=0,000	0,506 p=0,000	0,701 p=0,000	0,628 p=0,000
Acquire new competencies in marketing	0,562 p=0,000	0,531 p=0,000	0,725 p=0,000	0,641 p=0,000
Have a better knowledge of environmental requirements from different markets	0,551 p=0,000	0,488 p=0,000	0,673 p=0,000	0,598 p=0,000
Have a better knowledge of environmental technologies and equipments	0,596 p=0,000	0,539 p=0,000	0,743 p=0,000	0,658 p=0,000
Reduce manufacturing costs	0,527 p=0,000	0,491 p=0,000	0,647 p=0,000	0,584 p=0,000
Reduce stocking costs	0,514 p=0,000	0,468 p=0,000	0,664 p=0,000	0,57 p=0,000
Reduce transport costs	0,552 p=0,000	0,498 p=0,000	0,679 p=0,000	0,606 p=0,000
Increase market share	0,635 p=0,000	0,533 p=0,000	0,694 p=0,000	0,661 p=0,000
Have a better knowledge of customers needs	0,544 p=0,000	0,529 p=0,000	0,653 p=0,000	0,618 p=0,000
Increase profit margin	0,593 p=0,000	0,509 p=0,000	0,713 p=0,000	0,639 p=0,000
Create new opportunities for new products market share	0,54 p=0,000	0,563 p=0,000	0,564 p=0,000	0,607 p=0,000
Reduce environmental liability risk	0,706 p=0,000	0,592 p=0,000	0,615 p=0,000	0,684 p=0,000
Improve firm's green reputation	0,577 p=0,000	0,574 p=0,000	0,56 p=0,000	0,614 p=0,000

The strongest relationships (i.e. Pearson correlation coefficients superior to 0.70) between wastes management activities and the 22 benefits listed in Table 4.6 can be observed along three dimensions 1) improvements in product *quality, 2)* improvements in productivity such as *adopting more efficient manufacturing technologies* and *reducing raw materials in manufacturing processes,* 3) improvements in capabilities by *acquiring new competencies both in production and in marketing* and by gaining *new knowledge of environmental technologies and equipments.* Ultimately, some wastes management activities such as WMTD are also strongly related to *profit margin increases.*

4.3 Concluding remarks

With an average of 156 full-time employees, the responding firms are highly internationalized. Their customers (i.e. hospitals) are sophisticated and demanding. Their products life cycle is approximately eleven years in average. More than half of these firms have implemented TQM programs but very few (3 %) are certified ISO 14 000.The environmental initiatives undertaken by the suppliers of electronic medical equipment directly affect their own organizations (WMS), the hospitals (WMH) , the wastes treatment and disposal organizations (WMTD), and all the organizations previously mentioned (WM). These initiatives are rather modest. The main drivers of the environmental initiatives are the customers' requirements (i.e. hospitals) and market opportunities while actual and projected regulations seem to play a moderate role. The impacts of these environmental initiatives for the suppliers of medical electronic equipment are mostly market driven opportunities and building environmental capabilities.

Relationships between firms’ characteristics and WMS, WWMH, WMTD and WM are weak but proactive environmental initiatives .are significantly and positively related to an aggressive technology strategy, to demanding and sophisticated customers, and to alleged benefits, in particular some market driven and cost reduction opportunities. The strong and positive relationships between environmental initiatives and new knowledge and new competencies acquisition may indicate a self reinforcing phenomenon where the first environmental initiatives among suppliers of medical electronic equipment allow to build some environmental capabilities that will eventually translate into more proactive environmental initiatives, thereby generating a positive impact on the waste management activities of the organizations downstream (hospitals, wastes treatment and disposal organizations). The uptake of a sustainable healthcare wastes management is largely dependent on the actions of organizations located upstream.

CONCLUSION

This document presents some preliminary results of a larger research initiative. It is basically groundbreaking work as the main objective is to gain a better understanding of a complex phenomenon. The results presented here should be interpreted in the light of some limitations that we fully acknowledge. Once the organizations involved in hospitals wastes management were identified and their respective responsibilities described, we have limited our research efforts to one layer of the inter organizational network, namely the suppliers. Furthermore, we have retained one type of waste, namely what is called commonly called e-waste. Our focus is therefore very narrow and the empirical results from both the field study and the survey cannot grasp the full complexity induced by the proposed framework for the uptake of sustainable healthcare wastes management. Finally, the sample size for the survey is rather small (n=59) and limits generalization to North American suppliers of electronic medical equipment.

Despite these limitations, this research project makes several contributions as it sets the bases on which future research can build upon. First, it provides an overall approach and structure for similar investigations that could be undertaken 1) with suppliers that provide different inputs to hospitals, such as medication for instance or 2) at a different layer of the inter organizational network, such as the hospitals or the wastes treatment and disposal organizations. Second, it proposes a preliminary set of research variables that could be further validated, refined and tested. In particular, the list of environmental initiatives and alleged benefits represent an interesting starting point for future empirical research. Third, it demonstrates that product stewardship is not only a theoretical concept but also a practical approach since the environmental initiatives undertaken by the suppliers of medical equipment affect the wastes management activities of all organizations located upstream and downstream of the network.

Some practical contributions may arise from this project. Electronic wastes are indeed a growing problem across the world. According to Pitchell (2005), more than 70% of heavy metals founded in American land fill come from e-wastes. Empirical evidence from our research shows that environmental initiatives undertaken by the suppliers of one specific type of electronic products could reduce this problem while at the same time could improve the competitive positioning of these firms. This strongly suggests that additional efforts regarding environmental practices should be recommended or even that stricter environmental regulation is needed.

Further research could lead to a detailed investigation at each layer of the inter organizational network, namely the suppliers, the hospitals, the wastes treatment and disposal organizations in order to compare their environmental efforts and determine where is the weakest link in terms of environmental efforts. Collaboration activities and strategies within and between each layer of the inter organizational network would be also a worthwhile research undertaking. It would be also interesting to assess the most profitable end-of-life activities, namely reuse product as a whole, reuse some product components or recover materials from electronic scrap. Finally, healthcare wastes have documented negative impacts on the environment and human health and represent a risk factor that cannot be ignored. Risk analysis and assessment would thus be another compelling research undertaking.

Wastes management in the healthcare sector has been considered by some experts as “disappointing” (Tudor et al., 2007) and the uptake of a sustainable wastes management framework still needs considerable additional efforts from both practionners and researchers.

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APPENDIX A

Appendix A.1: Hospitals suppliers based in the province of Québec

Firm	Location (City, Country)	Type of firm
SIC: Équipement pour salle blanche et laboratoire	Bromont	Fabrication
Andromed	Montreal	Fabrication
Stellate Systems	Montreal	Fabrication
Adaptaide	Repentigny	Fabrication, Service
Stryker	L'Islet	Fabrication
AMD-RITMED	Granby	Fabrication
Institut national d'optique	Québec	Fabrication
Air Liquide	Montréal	Fabrication
Art Recherches et technologies avancées	Montréal	Fabrication
Avera	Bois-des-Fillion	Fabrication
Cryocath technologie	Kirkland	Fabrication
Edelstein	Montréal	Fabrication
Baxter	Sherbrooke	Fabrication
Stockeryale Canada	Dollard-des-Ormeaux	Fabrication
Technologie médicale internationale	Montréal	Fabrication
Web-Tex	Montréal	Fabrication
Galenica	St-Liboire	Fabrication
IBIOM Instruments	Sherbrooke	Fabrication
Industrie Allerair	Montréal	Fabrication
Médian Médical	Pointe-Claire	Fabrication
Medxl	Montréal	Fabrication
Produits médicaux oméga	St-Jérôme	Fabrication
Kreetech	Longueuil	Fabrication
Al Carrière extincteur	Montréal	Distribution
Almédic	Montréal	Distribution
AMG Médical	Mont-Royal	Distribution
Astro-Med	Longueuil	Distribution
Atlas Medic	Québec	Distribution
Auto Control	Pointe-Claire	Distribution
AVH technologies	Laval	Distribution
Belpro Medical	Montréal	Distribution
Biospace Med Canada	Montréal	Distribution
Cardiotronics	Côte-St-Luc	Distribution
Centre de Stomie du Québec	Québec	Distribution
Centre d'équipements orthopédique	St-Eustache	Distribution
Centre othopédique Joly	Joliette	Distribution
Chromabec	Waterloo	Distribution
Compagnie des Sciences chromatographiques	Montréal	Distribution
Distribution Praxair	Montréal	Distribution
Distribution SBC	Mont-Laurier	Distribution

Appendix A.1: Hospitals suppliers based in the province of Québec (suite)

DS Médical	Gaspé	Distribution
Dufort & Lavigne	Montréal-Est	Distribution
Dulong Medtech	Montréal	Distribution
Emrn Inc	Montréal	Distribution
Les Entreprises Michel Cullen Médical	Balinville	Distribution
Entreprise Solumed	Laval	Distribution
ERFA Canada	Montréal	Distribution
Getinge Canada	Montréal	Distribution
Groupe Christie	St-Eustache	Distribution
Groupe Uniplus Médical	Lévis	Distribution
Intelligence Artificielle & Applications	Val-David	Distribution
Invacare Canada	Kirkland	Distribution
Kodak Canada	Montréal	Distribution
Labbell	Shawinigan	Distribution
Laboratoire Bergeron	Montréal	Distribution
Liber-T Medtech	Québec	Distribution
Maranda Lauzon	Laval	Distribution
Médical Minogue	Montréal	Distribution
Medi-Plus	Montréal	Distribution
Médique fournitures médicales	Mont-Royal	Distribution
Médi-Sélect	Québec	Distribution
Mont-Pharma	Montréal	Distribution
Nicram enviro	Dorval	Distribution
Novacentre technologie	Boucherville	Distribution
Opti-Ressources	Lévis	Distribution
OSR Médical	Montréal	Distribution
Oxybec Santé confort	Sherbrooke	Distribution
Oxygène Granby	Granby	Distribution
Paramedic	Saguenay	Distribution
Pega Médical	Laval	Distribution
Physio-Trace	St-Hyacinthe	Distribution
Polymed Chirurgical	Montréal	Distribution
Produitsde réhabilitation	Montréal	Distribution
Quadromed	Montréal	Distribution
Québec médical	Québec	Distribution
Roche diagnostics	Laval	Distribution
Roxon Médi-Tech	Montréal	Distribution
Santé 3e âge	La Prairie	Distribution
Saerstedt	Montréal	Distribution
Services Healthmark	Montréal	Distribution
Siemens Canada	Dorval	Distribution
SM Canada	Ste-Marie	Distribution
Smith & Nephew	Montréal	Distribution
S.N. Bernier	Blainville	Distribution
SOS Oxygène	Montréal	Distribution
SOS Technologie Action Urgence	Longueuil	Distribution
Spécialité JP Arpin	Montréal	Distribution

Appendix A.1: Hospitals suppliers based in the province of Québec (suite et fin)

SPI Sécurité	Blainville	Distribution
SPME	Québec	Distribution
Stelmagel	Montréal	Distribution
Surgie-Pharm avancée	Dorval	Distribution
Systèmes médicaux Philips	Montréal	Distribution
Technologie mondiales Lifeguard	Montréal-Ouest	Distribution
Toshiba Canada	Kirkland	Distribution
Trudell Medical Marketing	Montréal	Distribution
TSO3	Québec	Distribution
Tyco Healthcare group	Pointe-Claire	Distribution
UXR	Dorval	Distribution

Appendix A.2 : Hospitals suppliers based elsewhere in the world

Firm	**Location (City, Country)**	**Type of firm**
Medical Products Manufacturers: Noida	Noida, India	Fabrication
Adage Medical Systems,	New Delhi, India	Fabrication
Universal Medical Instruments : Mumbai	Mumbai, , India	Fabrication
West World Enterprises	New Delhi, India	Distribution
Imagerie Meditech	Saint-Avertin, France	Fabrication
Relief Medical Systems	Delhi, India	Distribution and fabrication
Technocare Medisystems	Surat, India	Distribution and fabrication
Adonis Medical Equipments Pvt. Ltd	Mohali,	Distribution and fabrication
Nice Neotech Medical Systems Pvt. Ltd.,	Chennai, India	Distribution
RPPL	Ambala Cantt, India	Distribution
JMD Healthcare System	Delhi, India	Distribution and fabrication
Hospital Supply Company	Kolkata, India	Distribution and fabrication
Electrocare Systems And Services Private Limited	Chennai, India	Distribution and fabrication
Status Medical Equipments	Satara, India	Distribution and fabrication
Genesis Medical Systems Private Limited	Hyderabad, India	Distribution and fabrication
JDS Medison Private	New Delhi, India	Distribution and fabrication
Medica Enterprise,	Thane, India	Distribution
S. H. Pitkar Orthotools Private Limited	Pune, India	Distribution
BLT Monitoring Co	Lucknow, India	Fabrication
Balvindra Instruments Corporation	Ambala, India	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Tricor Systems, Inc.	Elgin, USA	Fabrication
Powermag, Inc	Newbury Park, USA	Fabrication
Intertech Engineering Associates, Inc.	Westwood, USA	Service
Medivative Technologies Inc.	Indianapolis, USA	Fabrication
Cal Quality Electronics, Inc.	Santa Ana, USA	Fabrication
KS Tooling, Inc.	York, USA	Fabrication
SMS Technologies, Inc.	San Diego, USA	Fabrication
GE Healthcare Canada	Mississauga, Canada	Fabrication
Inteprod LLC	Eagleville, USA	Fabrication
DataCon, Inc	Burlington, USA	Fabrication
Sibex Electronics	Safety Harbor, USA	Fabrication
SterlingTech Software	Rochelle Park, USA	Service
Brady Medical	Baldwin Park, USA	Service
Hitachi Computer Product	Norman, USA	Fabrication
Aubrey Group	Irvine, USA	Fabrication
Norfolk Medical Products Inc.	Skokie, USA	Fabrication
Newport Medical Instruments Inc.	Costa Mesa, USA	Fabrication
Medigroup, Inc.	Naperville, USA	Fabrication
Misonix Inc.	Farmingdale, USA	Fabrication
ISG Technologies	Columbia, USA	Fabrication
Toshiba	Tokyo, Japan	Fabrication
Holorad	Salt Lake City, USA	Fabrication
Canon Medical Systems	Amstelveen, Netherlands	Fabrication
Agilent Technologies	Santa Clara, USA	Fabrication
Leica Microsystems	Wetzlar, Germany	Fabrication
Thermo Fischer Scientific	Fitchburg, USA	Fabrication
Phonak	Stäfa, Switzerland	Fabrication
Medtronic, Inc	Fridley, USA	Fabrication
A.D.A.M.	Atlanta, USA	Fabrication
Philips Healthcare	Melbourne, USA	Fabrication
Cordis Corporation	Warren, USA	Fabrication
St. Jude Medical, Inc.	St. Paul, USA	Fabrication
Boston Scientific	Natick, USA	Fabrication
Axon Instruments, Inc.	Sunnydale, USA	Fabrication
Stryker Corporation	Hamilton, Canada	Fabrication
Genetix	New Milton, UK	Fabrication
Medrad	Warrendale, USA	Fabrication
Nonin Medical, Inc.	Plymouth, USA	Fabrication
Merge Healthcare	Milwaukee, USA	Fabrication and distribution
Edwards Lifesciences LLC	Irvine, California	Fabrication and distribution
Cytyc Corporation	Marlborough, USA	Fabrication and distribution
Analogic Corporation	Peabody, USA	Fabrication
3M Healthcare	St. Paul, USA	Fabrication

Fonar Corporation	Melville, USA	Fabrication and

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Medline Industries, Inc.	Illinois, USA	Fabrication
A1cNow	Tarrytown, USA	Fabrication
Hospira, Inc.	Lake Forest, USA	Fabrication
Mini Mitter Co., Inc.	Bend, USA	Fabrication and distribution
Datascope Corp.	Montvale, USA	Fabrication and distribution
Accellent -	Wilmington, USA	Service
Zevex International, Inc.	Salt Lake City, USA	Fabrication and distribution
ABAXIS, Inc.	Union City, USA	Fabrication and distribution
LeMaitre Vascular, Inc	Burlington, USA	Service
ABIOMED, Inc.	Danvers, USA	Fabrication
American Medical Systems, Inc.	Minnetonka, USA	Fabrication
Vasomedical, Inc.	Westbury, USA	Fabrication and distribution
Advanced Neuromodulation Systems, Inc.	Plano, USA	Fabrication and distribution
Sage Products Inc.	Cary, USA	Fabrication
Meridian Medical Technologies Inc	Bristol, USA	Fabrication
Cardiac Assist Technologies	Pittsburg, USA	Fabrication and distribution
DWL Elektronische Systeme GmbH	Singen, Germany	Fabrication
Aubrey Group, Inc.	Irvine, USA	Fabrication
Welch Allyn	Skaneateles, USA	Fabrication
Terumo Cardiovascular Products Manufacturer	Tokyo, Japan	Fabrication
Narang Enterprises	New Delhi, India	Fabrication and distribution
Aspect Medical Systems, Inc.	Norwood, USA	Fabrication
The Getinge Group	Getinge, Sweden	Service
Hillenbrand Industries, Inc.	Batesville, USA	Service
World Heart Corporation	Oakland, USA	Fabrication
Biomedica Gruppe	Eching, Germany	Fabrication and distribution
PARI Respiratory Equipment, Inc.		Fabrication
Jones Medical Instrument Company	Oakbrook, USA	Fabrication and distribution
Acorn Cardiovascular, Inc.	St. Paul, USA	Fabrication
Bioject Inc.	Tualatin, USA	Fabrication
Sunrise Medical	Longmont, USA	Fabrication
Inlet Medical, Inc.	Trumbull, USA	Fabrication
Advanced Brain Monitoring	Carlsbad, USA	Fabrication
OEM NIBP Modules	San Antonio, USA	Fabrication
Vital Signs, Inc.	Totowa, USA	Fabrication
CCC del Uruguay SA -	Montevideo, Uruguay	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Nihon Kohden America, Inc.	Foothill Ranch, USA	Fabrication
Xactix, Inc.	Pittsburgh, USA	Fabrication
Micro Medical	Kent, UK	Fabrication
Criticare Systems, Inc.	Waukesha, USA	Fabrication and distribution
ScanMed of Medic Inc	Omaha, USA	Fabrication
Biegler Medizin Elektronik	Mauerbach, Austria	Fabrication
Surgical Laser Technologies	Montgomeryville, USA	Service
Getinge Skärhamn AB	Sweden	Fabrication
A&D Medical	San Jose, USA	Fabrication
Utah Medical Products, Inc.	Midvale, USA	Fabrication
Creganna Medical Devices	Marlborough, USA	Fabrication
American Medical Alert Corp.	Oceanside, USA	Fabrication
NMT Medical Inc.	Boston, USA	Fabrication
Reed Shilling Healthcare	Didcot, UK	Fabrication
Gambro Renal Products USA	Lakewood,, USA	Fabrication
Angeion Corporation	Saint Paul, USA	Fabrication
BioMedix	Saint Paul, USA	Fabrication
Therus Corporation	Seattle, USA	Fabrication
Beijing Yuande Bio-Medical Engineering Co.,Ltd.	Bejing, China	Fabrication
Chattanooga Group	Hixson, USA	Fabrication
Atrium Medical Corporation	Hudson, USA	Fabrication and distribution
Sulzer Carbomedics	Austin, USA	Fabrication and distribution
Allied Healthcare Products, Inc.	St. Louis, USA	Fabrication and distribution
Sechrist Industries, Inc.	Anaheim, USA	Fabrication
WR Medical Electronics Co.	Stillwater, USA	Fabrication
Compex Technologies	St. Paul, USA	Fabrication
Millennium Technology Inc.	Richmond, Canada	Fabrication
Vax-D Medical Technologies LLC	Oldsmar, USA	Fabrication and distribution
Charter Medical, Ltd.	Winston-Salem, USA	Fabrication
Life-Tech, Inc.	USA	Fabrication
Erchonia Medical, Inc.	McKinney, USA	Fabrication and distribution
Ds Degradable Solutions	Schlieren, Switzerland	Fabrication
Cardinal Health	Dublin, Ireland	Fabrication
Medcomp	Harleysville,, USA	Fabrication
NESS Neuromuscular Electrical Stimulation Systems, Ltd.	Ra'anana, Israel	Fabrication
Mediplus	Cressex, UK	Fabrication
Micron Products, Inc.	Fitchburg, USA	Fabrication
GN Otometrics	Taastrup, Denmark	Fabrication
QRS Diagnostic, LLC	Plymouth, USA	Fabrication
Sygma Bio-Medical	La Farlede, France	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Ellman International	Oceanside, USA	Fabrication
Vascular Technology, Inc. (VTI)	Nashua, USA	Fabrication
Suru Group of Companies	Mumbai, India	Fabrication
Sensor Technology & Devices, Ltd	Belfast, UK	Fabrication
Tomed	Bensheim, Germany	Fabrication
The Daavlin Company	Bryan, USA	Fabrication
Medical Murray -	North Barrington, USA	Fabrication
RGB Medical Devices	Madrid, Spain	Fabrication and distribution
KMC Systems, Inc.	Merrimack, USA	Fabrication
Enpath Medical, Inc.	Minneapolis, USA	Fabrication
Theralase, Inc.	Toronto, Canada	Fabrication
PhotoTherapeutix	Hudson Falls, USA	Fabrication
Intego	Jacksonville, USA	Fabrication
PLC Medical Systems, Inc	Franklin, USA	Fabrication
DermaMed USA, Inc.	Lenni, USA	Fabrication and distribution
US Endoscopy Group	Mentor, USA	Fabrication
Jasan International, Ltd.	Hong Kong, China	Fabrication
HealthTronics, Inc.	Austin, USA	Fabrication
Propper Manufacturing	Long Island City, USA	Fabrication
Escalon Medical Corporation	New Berlin, USA	Fabrication and distribution
Baldwin Medical Australia	Knoxfield, Australia	Fabrication and distribution
Laboratory Technologies, Inc.	Maple Park, USA	Fabrication
Oceanic Medical Products	Atchison, USA	Fabrication
Cardiotech International, Inc	Wilmington, USA	Fabrication
Diabetes Technologies	Thomasville, USA	Fabrication
Alfa Scientific Designs, Inc	Poway, USA	Fabrication
Parker Medical	Highlands Ranch, USA	Fabrication
Tagg Industries	Laguna Hills, USA	Fabrication
Empire Medical Products	Albany, USA	Fabrication
Inrad	Kentwood, USA	Fabrication and distributor
Digital Imaging Equipment	Breda, Netherlands	Fabrication
I.E.M. GmbH	Stolberg, Germany	Fabrication
ZMI Electronics, Ltd.	Kaohsiung, Taiwan	Fabrication
Dent-Eq	Hermitage, USA	Fabrication and distributor
Tarsus Products AB	Örnsköldsvik, Sweden	Fabrication
Heartway Medical Products Co., Ltd	Taiwan	Fabrication
LIFE Corporation -	Milwaukee, USA	Fabrication
Thermo-Pad	Summerland, Canada	Fabrication
HakoMed	Honolulu, USA	Fabrication and distributor
CareFlex Ltd.,	United Kingdom	Fabrication and service
Affinity Medical Technologies	Irvine, USA	Fabrication
MedDetect	Rochester, USA	Fabrication

NOA Medical	Washington, MI, USA	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Heathcare Cable Systems	Richmond, USA	Fabrication
Axelgaard Manufacturing	Lystrup, Denmark	Fabrication
Stickman Peritoneal Dialysis Accessories	Kemptville, Canada	Fabrication
InnerVision Medical Technologies Inc	Calgary, Canada	Fabrication
MMI Medication Carts	Oakville, Canada	Fabrication
Phipps and Bird	Richmond, USA	Fabrication
Axiom Diagnostic Clinical Lab Products	Worms, Germany	Fabrication
Termo-Cont Ltd	Russia	Fabrication
Sol-Air Systems, Inc.	Kelowna, Canada	Fabrication
Beijing Meigaoyi Co., Ltd.	Beijing, China	Fabrication
Sklar Corp.	West Chester, USA	Fabrication
Primus Corp.	Kansas City, USA	Fabrication
FIM Medical	Lyon, France	Fabrication
Hart Enterprises, Inc.	Sparta, USA	Fabrication
Prepco	Colebrook, USA	Fabrication
STD Manufacturing	Stoughton, USA	Fabrication
Mpe-Inc	Milwaukee, USA	Fabrication
Harrison Insulating Systems	Lancashire, UK	Fabrication
Sterybox	Milan, Italy	Fabrication
Pan Medical Ltd.,	Gloucester, UK	Fabrication
Braintronics -	Almere, Netherlands	Fabrication
Toltec International, Incorporated	Lakewood, USA	Fabrication
Electromedical Resources, Inc	Miami, Florida	Fabrication
Forest Medical LLC	East Syracuse, USA	Fabrication
MDMI Manufacturing Canada Ltd	Richmond, US	Fabrication
Meditec Co., Ltd.	Sungnam City, Korea	Fabrication
Trident	Ontario, USA	Fabrication
Major Medical Products	Batavia, USA	Fabrication
Transtracheal Systems	Englewood, USA	Fabrication
WEM Electronic Equipment	Ribeirão Preto, Spain	Fabrication
Beta Star Corporation	Honey Brook, USA	Fabrication
Omega Laser Systems Ltd	United Kingdom	Fabrication
Bioland Technology Limited	Hong Kong, China	Fabrication
Narula Udyog	New Dehli, India	Fabrication
Ranfac	Avon, USA	Fabrication
Gottfried Medical, Inc.	Toledo, USA	Fabrication
PriMed Instruments, Inc.	Mississauga, Canada	Fabrication
MC Healthcare Products, Inc.	Beamsville, Canada	Fabrication
Meridian Medical	West Sussex, UK	Fabrication
Indian Instruments Manufacturing Co.	Calcutta, India	Fabrication
Stethron	Chenai, India	Fabrication
Worldwide Medical Technologies	Oxford, USA	Fabrication
Neotec Medical Industries	Jalan Bukit Merah, Singapore	Fabrication
MRI Medical -	Tucson, USA	Fabrication
Specialty Surgical Products, Inc.	Victor, USA	Fabrication
Chesapeake Medical	Baltimore, USA	Fabrication

Siam Intermagnate Co., Ltd.	Bangkok, Thailand	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Futura Medicals -	Kakkanad, India	Fabrication
TransVac Systems	Denver, USA	Fabrication
Laboratories Meditech Rousset	Rousset, France	Fabrication
Shanghai Viomed	Jiangsu, China	Fabrication
ISPG	New Milford, USA	Fabrication
Repro-Med Systems, Inc.	Chester, USA	Fabrication
Micro-Tech Enterprises	Lincoln, USA	Fabrication
Tarry Manufacturing, Inc.	Danbury, USA	Fabrication
SPC Petrolaser	St. Petersburg, Russia	Fabrication
Centron Technologies Corporation	Seoul, Korea	Fabrication
Bio-Medical Equipment Service Co. (BMESCO)	Louisville, USA	Fabrication
Merit Cables, Inc.	Santa Ana, USA	Fabrication
Yachroma-Med	Moscow, Russia	Fabrication
Medicare Equipment	Mumbai, India	Fabrication
Evercart	Carson City, USA	Fabrication
Expoimage	Redlands, USA	Fabrication
DiMed - Safe Needle Technology	Perth, Australia	Fabrication
Electrocare	Mylapore, India	Fabrication
MTM Medical	Dayton, USA	Fabrication
Ventrex	Clearwater, USA	Fabrication
GTS General Technology & Service Ltd.	Hong Kong, China	Fabrication
Morquip Body Handling System -	Cradley Heath, United Kingdom	Fabrication
Erie Medical	Pleasant Prairie, USA	Fabrication
IGR Enterprises	Beachwood, USA	Fabrication
Medi Cal Instruments, Inc.	Lewis Center, USA	Fabrication
Shailee	Vile Parle, India	Fabrication
Siemens Healthcare	Erlangen, Germany	Fabrication
Verity Medical, Ltd.		Fabrication
BioMed Diagnostics		Fabrication
Leeder Group, Inc.		Fabrication
Ortivus AB		Fabrication
Leisegang Medical, Inc.		Fabrication
Celon AG Medical Instruments	Teltow, Germany	Fabrication
Barco Medical Imaging Systems		Fabrication
Thermal Angel		Fabrication
Endocare, Inc.		Fabrication
Mindray Medical International Limited		Fabrication
EP MedSystems, Inc.		Fabrication
BTL Medical Technologies	Atlanta, USA	Fabrication

Cooper Surgical Inc.		Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Bedfont		Fabrication
Airgonomic Seating Systems		Fabrication
Tracoe		Fabrication
Odin Medical Technologies		Fabrication
Mechanized Business Applications		Fabrication
Datex-Ohmeda		Fabrication
Microlife		Fabrication
Izevsky Mekhanichesky Zavod	Russia	Fabrication
VBM Medizintechnik	Germany	Fabrication
L.e.West	UK	Distributor
Osmometer	Germany	Fabrication
Medical Calibration Service		Service
AR Custom Medical Products, Ltd		Fabrication
Acorn Cardiovascular, Inc.	St. Paul, USA	Fabrication
Advanced Brain Monitoring		Fabrication
Advanced Neuromodulation Systems, Inc.		Distribution Fabrication
Affinity Medical Technologies		Fabrication
Alfa Medical		Fabrication
Alfa Scientific Designs, Inc	Poway, USA	
Allied Healthcare Products, Inc.		Distribution Fabrication
Agilent Technologies		Distribution Fabrication
American Medical Alert Corp.		Distribution Fabrication Service
American Medical Systems, Inc		Fabrication
Analogic Corporation		Fabrication
AndroMed		Fabrication
Angeion Corporation	St. Paul, USA	Fabrication
Applied Imaging Corp		Distribution Fabrication
Aspect Medical Systems, Inc.		Fabrication
Associated Imaging Services, Inc.		Distribution Service
Atrium Medical Corporation		Distribution Fabrication
Axelgaard Manufacturing		Fabrication
Axiom Diagnostic Clinical Lab Products		Fabrication
Axon Instruments, Inc.		Fabrication
BTL Medical Technologies		Fabrication
Baldwin Medical Australia		Distribution Fabrication
Barco Medical Imaging Systems		Fabrication
Bedfont		Fabrication Service
Bio-Medical Equipment Service Co. (BMESCO)		Fabrication
BioMed Diagnostics		Fabrication Distribution
Biegler Medizin Elektronik		Fabrication Distribution
Beta Star Corporation		Fabrication
BioMedix	St. Paul, USA	Fabrication
Bioject Inc.		Fabrication
Biomedica Gruppe		Fabrication Distribution
Bradfern Ltd.		Fabrication

Braintronics	Netherlands	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Cardiotech International, Inc	Wilmington, USA	Fabrication Distribution
Care Development		Fabrication
Centron Technologies Corporation		Fabrication
Charter Medical, Ltd.		Fabrication
Chesapeake Medical		Fabrication
Compex Technologies		Fabrication Distribution
Cooper Surgical Inc.		Fabrication
Cordis Corporation		Fabrication
Cytyc Corporation		Fabrication Distribution
Currie Medical Specialties, Inc		Fabrication
Criticare Systems, Inc.		Fabrication
Creganna Medical Devices		Fabrication
D Medical		Fabrication
DWL Elektronische Systeme GmbH	Germany	Fabrication
Dallzell USA Medical Systems		Fabrication Distribution
Datascope Corp		Fabrication Distribution
Datex-Ohmeda		Fabrication
DermaMed USA, Inc.		Fabrication Distribution
Design Med		Fabrication
DiMed - Safe Needle Technology		Service
Diabetes Technologies		Fabrication Distribution
Diametrics Medical, Inc.		Fabrication Distribution
Dideco S.p.A.	Italy	Fabrication
Dr. Kohr Medical Technologies		Fabrication Distribution
Ds Degradable Solutions	Switzerland	Fabrication
Dynamed Biomedical	Canada	Distribution Service
EP MedSystems, Inc.		Fabrication
Eco Medics AG		Distribution Service
Edap Tms S.A.		Fabrication Distribution
Edwards Lifesciences LLC	Irvine, California	Fabrication Distribution
Electrocare		Fabrication
Electronic Diversities		Fabrication
Ellman International		Fabrication
Endocare, Inc.		Fabrication Distribution
Enpath Medical, Inc.		Fabrication
Erie Medical		Fabrication
Escalon Medical Corporation		Fabrication
Exacon Scientific A/S		Fabrication
Expoimage		Fabrication
FIM Medical		Fabrication
Famy Care, Ltd.		Fabrication
Fonar Corporation		Fabrication Distribution Service
Forest Medical LLC		Fabrication
Futura Medicals		Fabrication
GN Otometrics		Fabrication
Gambro Renal Products USA		Fabrication

Gottfried Medical, Inc.		Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Hart Enterprises, Inc.		Fabrication
HealthTronics, Inc.		Distribution Fabrication
Heartway Medical Products Co., Ltd.	Taiwan	Fabrication
Heathcare Cable Systems		Distribution Fabrication
Helena France S.A.	France	Fabrication Distribution Service
Hillenbrand Industries, Inc.		Fabrication Distribution Service
Hospira, Inc.		Fabrication
I.E.M. GmbH	Germany	Fabrication
IGR Enterprise		Fabrication
Indian Instruments Manufacturing Co.	India	Fabrication
Inflatable Cervical Stabilizing Device		Fabrication
Inlet Medical, Inc.		Fabrication
InnerVision Medical Technologies Inc		Fabrication
Inrad		Fabrication distribution
JSC Redox	Russia	Fabrication
J Sterling Industrie		Fabrication
Integrated Recovery Products, Inc.		Fabrication
Izevsky Mekhanichesky Zavod	Russia	Fabrication
Japan Lifeline		Fabrication
Jewett, Inc.		Fabrication
Jones Medical Instrument Company		Fabrication
KMC Systems, Inc.		Distribution
Kadavil Electro Mechanical Industries		Fabrication
Kahle Engineering	New Jersey, USA and Caravaggio, Italy	Fabrication
Kcup.com		Fabrication
LIFE Corporation		Fabrication
Laboratories Meditech Rousset		Fabrication
Laboratory Technologies, Inc.		Fabrication
LeMaitre Vascular, Inc		Fabrication
Life-Tech, Inc.		Fabrication
MC Healthcare Products, Inc		Fabrication
MDMI Manufacturing Canada Ltd	Canada	Fabrication
MRI Medical		Fabrication
MTM Medical		Distribution
MedDetect		Fabrication Distribution
MedCam Technology, Inc		Fabrication Distribution
Mechanized Business Applications		Fabrication
Major Medical Products		Distribution
MedPro Inc.		Fabrication
Medcomp		Fabrication
Medi Cal Instruments, Inc.		Fabrication
Medic Electronica		Fabrication
Medical Murray		Fabrication
Medical System		Distribution Service

		Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Mediplus	UK	Fabrication
Meditec Co., Ltd.		Fabrication
Medline Industries, Inc. Save		Fabrication
Medrad		Fabrication
Medwave, Inc.	Arden Hills, Minnesota	Fabrication
Meridian Medical Technologies Inc.		Fabrication
Merit Cables, Inc.		Fabrication
Micron Products, Inc.		Fabrication
Microlife		Distribution
Micro-Tech Enterprises		Fabrication
Micro Medical	UK	Fabrication
Millennium Technology Inc.	Canada	Fabrication
Mindray Medical International Limited	Shenzhen, China	Fabrication Distribution Service
Mini Mitter Co., Inc.		Fabrication Distribution
Morquip Body Handling System	UK	
Mpe-Inc		Fabrication
NESS Neuromuscular Electrical Stimulation Systems, Ltd.		Fabrication
NMT Medical Inc.		Fabrication Distribution
NOA Medical		Fabrication
Narang Enterprises	India	Fabrication
Neotec Medical Industries		Fabrication
Nihon Kohden America, Inc.	USA	Fabrication Distribution
Nonin Medical, Inc.		Fabrication
Northeastern Technologies Group		Distribution Service
Oceanic Medical Products		Fabrication
Odin Medical Technologies		Fabrication Distribution
Omega Laser Systems Ltd	UK	Fabrication
Optovent AB		Fabrication
PARI Respiratory Equipment, Inc.		Fabrication
Ortivus AB		Fabrication
P Payne	UK	Fabrication
Palomar Medical Technologies, Inc.		Fabrication
Pan Medical Ltd.,	UK	Fabrication
Pappas Surgical		Fabrication
Parker Medical		Fabrication
Philips Medical Systems		Fabrication
Phipps and Bird		Fabrication
Phonak		Fabrication
PhotoTherapeutix		Fabrication
Prepco-Finished Medical and Biotech Devices		Fabrication
PriMed Instruments, Inc	Canada	Fabrication
Primus Corp.		Fabrication
RGB Medical Devices		Fabrication Distribution
QRS Diagnostic, LLC		Fabrication

QQBMedical.com		Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite)

Rampa Enterprises		Fabrication
Ranfac		Fabrication
Repro-Med Systems, Inc.		Fabrication
Ridge Medical Products, Inc		Fabrication
SPC Petrolaser		Fabrication
Sage Products Inc.		Fabrication
ScanMed of Medic Inc		Fabrication
Scotmed On-Line		Fabrication
Sechrist Industries, Inc.	Anaheim, USA	Fabrication
Shailee		Fabrication
Shanghai Viomed	Shanghai, China	Fabrication
Siam Intermagnate Co., Ltd.		Fabrication Distribution
Sklar Corp.		Fabrication
Sol-Air Systems, Inc.	Canada	Fabrication
Specialty Surgical Products, Inc.		Fabrication
St. Jude Medical, Inc		Fabrication
Stethron		Fabrication
Sterybox		Fabrication
Stellate Systems		Fabrication
Star Medik Sdn Bhd	Malaysia	Fabrication
Sulzer Carbomedics		Fabrication Distribution
Sunrise Medical		Fabrication
Surgical Laser Technologies		Fabrication Distribution
Tagg Industries		Fabrication Distribution
Tarry Manufacturing, Inc.		Fabrication
Tarsus Products AB		Fabrication
Technofab		Fabrication Distribution
Tempest International		Fabrication
Terra Universal	Fullerton, USA	Fabrication
Terumo Cardiovascular Products Manufacturer		Fabrication
The Daavlin Company		Fabrication
The Getinge Group		Fabrication
Theralase, Inc.		Fabrication
TherapyShapes.com		Fabrication
Therus Corporation		Fabrication
Tomec/MRM		Fabrication
Toltec International, Incorporated		Fabrication
Ti-Ex		Fabrication
Thies Vacu-Tec	Germany	Fabrication
Tomed		Fabrication
Tracoe		Fabrication
TransVac Systems		Fabrication
Transtracheal Systems		Fabrication
Trident		Fabrication
US Endoscopy Group		Fabrication
Utah Medical Products, Inc.		Fabrication
VBM Medizintechnik	Germany	Fabrication

Appendix A.2 : Hospitals suppliers based elsewhere in the world (suite et fin)

Vascular Technology, Inc. (VTI)		Fabrication
Vasomedical, Inc.		Fabrication
Vax-D Medical Technologies LLC		Fabrication
Ventrex		Fabrication
Verity Medical, Ltd.	UK	Fabrication
Video Instruments		Service
World Heart Corporation		Fabrication
Wescom Products, Inc		Fabrication
WEM Electronic Equipment		Fabrication
Vital Signs, Inc.		Fabrication Distribution
Worldwide Medical Technologies		Fabrication
Xactix, Inc.		Fabrication
ZMI Electronics, Ltd.		Fabrication
Zevex International, Inc.		Fabrication

Appendix B : Hospitals presented within the province of Québec

Hospital name	**Location**	**Region**
CENTRE HOSPITALIER D'AMQUI	Amqui	Bas Saint-Laurent
HOPITAL DE MATANE	Matane	Bas Saint-Laurent
HOPITAL REGIONAL DE RIMOUSKI	Rimouski	Bas Saint-Laurent
CENTRE HOSPITALIER REGIONAL DU GRAND-PORTAGE	Rivière-du-Loup	Bas Saint-Laurent
CENTRE HOSPITALIER TROIS-PISTOLES	Trois-Pistoles	Bas Saint-Laurent
HOPITAL DE NOTRE-DAME-DU-LAC	Notre-Dame-du-Lac	Bas Saint-Laurent
HOPITAL D'ALMA	Alma	Saguenay Lac-St-Jean
HOPITAL DE CHICOUTIMI	Chicoutimi	Saguenay Lac-St-Jean
HOPITAL DE DOLBEAU-MISTASSINI	Dolbeau-Mistasini	Saguenay Lac-St-Jean
HOPITAL DE LA BAIE	La Baie	Saguenay Lac-St-Jean
HOPITAL ET CENTRE DE READAPTATION DE JONQUIERE	Jonquière	Saguenay Lac-St-Jean
HOPITAL, CLSC ET CENTRE D'HEBERGEMENT DE ROBERVAL	Roberval	Saguenay Lac-St-Jean
CENTRE HOSPITALIER NOTRE-DAME DU CHEMIN	Québec	Capitale-Nationale
CENTRE HOSPITALIER PORTNEUF	Saint-Raymond	Capitale-Nationale
CENTRE HOSPITALIER ROBERT-GIFFARD	Québec	Capitale-Nationale
CENTRE HOSPITALIER SAINT-FRANCOIS	Québec	Capitale-Nationale
HOPITAL CHAUVEAU	Québec	Capitale-Nationale
HOPITAL DE BAIE-SAINT-PAUL	Baie-Saint-Paul	Capitale-Nationale
HOPITAL DE LA MALBAIE	La Malbaie	Capitale-Nationale
HOPITAL DE L'ENFANT-JESUS	Québec	Capitale-Nationale
HOPITAL DE SAINTE-ANNE-DE-BEAUPRE	Beaupré	Capitale-Nationale
HOPITAL DU SAINT-SACREMENT	Québec	Capitale-Nationale
HOPITAL JEFFERY HALE	Québec	Capitale-Nationale
HOPITAL LAVAL	Québec	Capitale-Nationale
HOPITAL STE-MONIQUE	Québec	Capitale-Nationale
LA MAISON MICHEL SARRAZIN	Québec	Capitale-Nationale
CENTRE HOSPITALIER REGIONAL DE TROIS-RIVIERES	Trois-Rivières	Mauricie et Centre-du-Québec
HOPITAL DU CENTRE-DE-LA-MAURICIE	Shawinigan-Sud	Mauricie et Centre-du-Québec
HOPITAL SAINTE-CROIX	Drummondville	Mauricie et Centre-du-Québec
HOTEL-DIEU-D'ARTHABASKA	Victoriaville	Mauricie et Centre-du-Québec
CENTRE HOSPITALIER UNIVERSITAIRE DE SHERBROOKE – Hôpital Fleurimont et Hôtel-Dieu	Sherbrooke	Estrie

Appendix B : Hospitals presented within the province of Québec (suite)

HOPITAL ET CENTRE D'HEBERGEMENT D'YOUVILLE	Sherbrooke	Estrie
HOPITAL, CLSC ET CENTRE D'HEBERGEMENT D'ASBESTOS	Sherbrooke	Estrie
HOPITAL ET CENTRE D'HEBERGEMENT ARGYLL	Sherbrooke	Estrie
CENTRE HOSPITALIER DE L'UNIVERSITE DE MONTREAL	Montréal	Montréal
CENTRE HOSPITALIER DE ST. MARY	Montréal	Montréal
CENTRE HOSPITALIER UNIVERSITAIRE SAINTE-JUSTINE	Montréal	Montréal
CENTRE UNIVERSITAIRE DE SANTE MCGILL	Montréal	Montréal
HOP. MARIE-CLARAC DES SOEURS DE CHARITE DE STE-MARIE	Montréal	Montréal
HOPITAL CATHERINE BOOTH DE L'ARMEE DU SALUT	Montréal	Montréal
HOPITAL DE LACHINE	Montréal	Montréal
HOPITAL DE LASALLE	Montréal	Montréal
HOPITAL DE READAPTATION LINDSAY	Montréal	Montréal
HOPITAL DE VERDUN	Montréal	Montréal
HOPITAL DOUGLAS	Montréal	Montréal
HOPITAL DU SACRE-COEUR DE MONTREAL	Montréal	Montréal
HOPITAL FLEURY	Montréal	Montréal
HOPITAL GENERAL DE MONTREAL	Montréal	Montréal
HOPITHOPITAL GRACE DART (5122-3246) AL GENERAL DU LAKESHORE	Montréal	Montréal
HOPITAL JEAN-TALON	Montréal	Montréal
HOPITAL LOUIS-H. LAFONTAINE	Montréal	Montréal
HOPITAL MARIE CLARAC	Montréal	Montréal
HOPITAL MONT-SINAI	Montréal	Montréal
HOPITAL NEUROLOGIQUE DE MONTREAL	Montréal	Montréal
HOPITAL NOTRE-DAME DU CHUM	Montréal	Montréal
HOPITAL RICHARDSON	Montréal	Montréal
HOPITAL RIVIERE-DES-PRAIRIES	Montréal	Montréal
HOPITAL ROYAL VICTORIA	Montréal	Montréal
HOPITAL SAINTE-ANNE	Montréal	Montréal
HOPITAL SAINT-LUC DU CHUM	Montréal	Montréal
HOPITAL SANTA CABRINI	Montréal	Montréal
HOPITAL SHRINERS POUR ENFANTS	Montréal	Montréal
HOTEL-DIEU DU CHUM	Montréal	Montréal

Appendix B : Hospitals presented within the province of Québec (suite)

INST. DE READAPTATION GINGRAS-LINDSAY-DE-MONTREAL	Montréal	Montréal
INSTITUT DE CARDIOLOGIE DE MONTREAL	Montréal	Montréal
INSTITUT PHILIPPE-PINEL DE MONTREAL	Montréal	Montréal
INSTITUT UNIVERSITAIRE DE GERIATRIE DE MONTREAL	Montréal	Montréal
L'HOPITAL GENERAL JUIF SIR MORTIMER B. DAVIS	Montréal	Montréal
VILLA MEDICA INC.	Montréal	Montréal
CENTRE HOSPITALIER DU PONTIAC	Shawville	Outaouais
CENTRE HOSPITALIER GATINEAU MEMORIAL	Gatineau	Outaouais
CENTRE HOSPITALIER PIERRE-JANET	Gatineau	Outaouais
HOPITAL DE GATINEAU	Gatineau	Outaouais
HOPITAL DE HULL	Gatineau	Outaouais
HOPITAL DE MANIWAKI	Maniwaki	Outaouais
CENTRE HOSPITALIER HOTEL-DIEU D'AMOS	Amos	Abitibi-Témiscamingue
CENTRE HOSPITALIER LA SARRE	La Sarre	Abitibi-Témiscamingue
CENTRE HOSPITALIER ROUYN-NORANDA	Rouyn-Noranda	Abitibi-Témiscamingue
CENTRE HOSPITALIER SAINT-JEAN	Macamic	Abitibi-Témiscamingue
HOPITAL ET CLSC DE VAL-D'OR	Val-d'Or	Abitibi-Témiscamingue
HOPITAL ET CENTRE D'HEBERGEMENT DE SEPT-ILES	Sept-Îles	Côte-Nord
HOPITAL LE ROYER	Baie-Comeau	Côte-Nord
CENTRE DE SANTE DE CHIBOUGAMAU	Chibougameau	Nord-du-Québec
CENTRE DE SANTE ISLE-DIEU	Matagami	Nord-du-Québec
CENTRE DE SANTE LEBEL	Lebel-sur-Quévillon	Nord-du-Québec
CENTRE DE SANTE RENE-RICARD	Chapais	Nord-du-Québec
HOPITAL DE CHANDLER	Chandler	Gaspésie-îles-de-la-Madeleine
HOPITAL DE L'ARCHIPEL	Les Îles-de-la-Madeleine	Gaspésie-îles-de-la-Madeleine
HOPITAL DE MARIA	Maria	Gaspésie-îles-de-la-Madeleine
HOPITAL DE SAINTE-ANNE-DES-MONTS	Saint-Annes-des-Monts	Gaspésie-îles-de-la-Madeleine
HOPITAL HOTEL-DIEU	Gaspé	Gaspésie-IDLM
HOPITAL DE MONTMAGNY	Montmagny	Chaudière-Appalaches
HOPITAL DE SAINT-GEORGES	Saint-Georges-de-Beauce	Chaudière-Appalaches

Appendix B : Hospitals presented within the province of Québec (suite et fin)

HOPITAL DE THETFORD MINES	Thetford Mines	Chaudière-Appalaches
HOTEL-DIEU DE LEVIS	Lévis	Chaudière-Appalaches
HOPITAL CITE DE LA SANTE	Laval	Laval
HOPITAL JUIF DE READAPTATION	Laval	Laval
CENTRE HOSPITALIER REGIONAL DE LANAUDIERE	Saint-Charles-Borromée	Lanaudière
Hôpital Pierre-Le Gardeur	Terrebonne	Lanaudière
HOPITAL DE MONT-LAURIER	Mont-Laurier	Laurentides
HOPITAL DE SAINT-EUSTACHE	Saint-Eustache	Laurentides
HOPITAL LAURENTIEN	Sainte-Agathe-des-Monts	Laurentides
HOPITAL REGIONAL DE SAINT-JEROME	Saint-Jérôme	Laurentides
CENTRE HOSP. KATERI MEMORIAL - TEHSAKOTITSEN : THA	Kahnawake	Montérégie
CENTRE HOSPITALIER ANNA-LABERGE	Châteauguay	Montérégie
CENTRE HOSPITALIER DE GRANBY	Granby	Montérégie
HOPITAL BARRIE MEMORIAL	Ormstown	Montérégie
HOPITAL BROME-MISSISQUOI-PERKINS	Cowansville	Montérégie
HOPITAL CHARLES LEMOYNE	Longueuil	Montérégie
HOPITAL DU HAUT-RICHELIEU	St-Jean-sur-Richelieu	Montérégie
HOPITAL DU SUROIT	Salaberry-de-Valleyfield	Montérégie
HOPITAL HONORE-MERCIER	Saint-Hyacinthe	Montérégie
HOPITAL PIERRE-BOUCHER	Longueuil	Montérégie
HOTEL-DIEU DE SOREL	Sorel-Tracy	Montérégie

APPENDIX C: CLINICAL WASTES TREATMENT FACILITIES AND RECYCLING ORGANIZATIONS

Table C.1: Clinical wastes treatment facilities

Firm	Location (City, Province)
Stericycle	St. Catherine, Québec Moncton, New Brunswick
Newalta Corporation	Dartmouth, Nova Scotia Brossard, Québec Burlington, Ontario Calgary, Alberta
Clean Harbors Canada Inc.	Corunna, Ontario
Scaletta Sand and Gravel Ltd.	Trenton, Ontario
Energy Sustaining Technologies	Winnipeg, Manitoba
Environmental waste international Inc.	Ajax, Ontario
Biomed recovery and disposal Limited	Aberdeen, Saskatchewan
Sorinco	Chambly, Québec

Table C.2 : Recycling organizations of ferrous materials

Firm	Location (City, Province)
Nova Pb inc.	Sainte-Catherine, Québec
Rouville Station inc.	Richelieu, Québec
Norcast	Mont-Joli, Québec
Fonderie Laroche ltée	Pont-Rouge, Québec
Fonderie Grand-Mère	Grand-Mère, Québec
Magotteaux Ltée	Magog, Québec
Fonderie Laperle	Saint-Ours, Québec
Fonderie Poitras	L'Islet, Québec
Fonderies Sainte-Croix inc.	Sainte-Croix, Québec
Fonderie Waterloo	Waterloo, Québec
J. Fagen & Fils inc.	Saint-Joseph-de-Sorel, Québec
Fonderie Benoit Marcoux inc.	Laurierville, Québec
Fonderie Bergeron & fils inc	Laurierville, Québec
Fonderie Ouellet inc.	Saint-Léonard-d'Aston, Québec

Table C.3 : Recycling organizations of non-ferrous materials

Firm	Location (City, Province)
Métafix inc.	Lachine, Québec
Métaux Champetier ltée	Montréal, Québec
Fonderie générale du Canada	Lachine, Québec
Alliages Noral Alloys inc.	Laval, Québec
Fonderie Cormier inc.	Saint-Thomas, Québec
FCM & Co	Lavaltrie, Québec
Noranda inc	Rouyn-Noranda, Québec

Table C.4 : Recycling organizations of glass materials

Firm name	Location (City, Province)
Potters Canada	La Prairie, Québec
AFG Industries Ltée	St-Augustin-de-Desmaures, Québec
Unical inc.	Longueuil, Québec
Gaudreau Environnement inc.	Victoriaville, Québec

Table C.5: Recycling organizations of paper and cartons

Firm name	Location (City, Province)
Smurfit-Stone Matane	Matane, Québec
Abitibi-Consolidated inc. (Alma)	Alma, Québec
Cascades Jonquière inc.	Jonquière, Québec
Glassine Canada inc.	Québec, Québec
Papiers White Birch Division Stadacona S E C	Stadacona, Québec
Abitibi-Consolidated inc. (Shawinigan)	Shawinigan, Québec
Cascades Carton Plat inc. Cartonnerie East Angus	East Angus, Québec
Cascades East Angus inc.	East Angus, Québec
Kruger inc. (Usine de Brompton)	Brompton, Québec
Kruger inc.	Montréal, Québec
Sonoco Montréal Corporation	Montréal, Québec
Bowater Produits forestiers du Canada inc.	Gatineau, Québec
Domtar Inc.	Gatineau, Québec
Abitibi-Consolidated inc. (Baie-Comeau)	Baie-Comeau, Québec
Cascades Groupe Papiers Fins inc.(div. Fibres Breakey)	Breakeyville, Québec
Papiers Scott ltée (Crabtree)	Crabtree, Québec
Cascades Groupe Papiers Fins inc. (div. Rolland)	Saint-Jérôme, Québec
Cascades Groupe Tissu inc. (Lachute)	Lachute, Québec
Benolec ltée	Sainte-Julie, Québec
Papiers Perkins ltée	Candiac, Québec
Cascades Groupe Tissu inc. Kingsey Falls	Kingsey Falls, Québec
Cascades inc. (Division papier)	Kingsey Falls, Québec
Les Papiers Marlboro inc.	Drummondville, Québec
Norampac inc. (div. Kingsey-Falls)	Kingsey Falls, Québec
Papier Kingsey Falls (Div. Cascades inc.)	Kingsey Falls, Québec

Table C.6 : Recycling organizations of plastics materials

Firm	Location (City, Province)
Enviroplast Inc.	Montréal, Québec
Genfoot Inc.	Lachine, Québec
Le Groupe Lavergne (div. Petco)	Montréal, Québec
SolPlast inc	Montréal, Québec
Transit Plastiques inc.	Montréal, Québec
Atelier de tri des matières plastiques recyclables du Québec ATMPRQ	Laval, Québec
Les Produits Polychem ltée	Saint-Jean-sur-Richelieu, Québec
Plastiques D.C. inc.	Granby, Québec
Supérieur Plastiques inc.	Salaberry-de-Valleyfield, Québec
PFG Polymers inc.	Mascouche, Québec
Plastrec inc.	Joliette, Québec
Sac Vrac Gentilly inc.	Bécancour, Québec
Recyc RPM. inc.	Saint-Damien-de-Buckland, Québec
S.L.M. Plastiques inc	Saint-Damien-de-Buckland, Québec

Table C.8: Recycling organizations of electronic wastes

Firm	Location (City, Province or State)
FCM & Co	Lavaltrie, Québec
Planiconcept Viel	Rimouski, Québec
Entreprise-école Recypro d'argenteuil	Lachute. Québec
Kadisal	Montréal, Québec
Allied Computer Brokers	Amsbery, Massachusetts
ARS Computer Disposal and Recycling Solutions	North Oxford, Massachusetts
LifeSpan Technology Recycling	Wellesley, Massachusetts
Recycling Donation Center	Stoughton, Massachusetts
World Computer Exchange-USA	Hull, Massachusetts
Advanced Recovery Inc.	Newark, New York
DK Recycling	New Berlin, New York
e-Scrap Destruction	Islandia, New York
E-Solutions USA, LLC	Hauppauge, New York
Eastern Environmental	Port Chester, New York
Eco International	Vestel, New York
Maven Technologies ,LLC	Rochester, New York
Northeast Surplus & Materials. LLC	Syracuse, New York
PC Recycler, Inc	Watervliet, New York
RECYCLEPLACE.COM	Fairport, New York
WeRecycle!, Inc.	Mount Vernon, New York
Waste Management & Recycling Products (WMRP)	Schotia, New York
e-End USA	Frederick, Maryland
E-Structors, Inc.	Elkridge, Maryland
TBS Industries	Philadelphia, Pennsylvania
Umicore	Brussels, Belgium

APPENDIX D: TABLES OF RESULTS

Table D.1: Actual and forecasted cost structure

Cost structure	Actual	Projected in two years
Labor	24,29% (1,44%)	20,97% (1,40%)
Raw material	52.23% (1,71%)	50.19% (2,06%)
Equipment	10.84% (1,03%)	11.76% (1,10%)
Other	12.98% (1,57%)	13.45% (1,66%)

Table D.2: Total quality program existing in responding firms

Other type of TQM program	Certified ISO 9000	Certified ISO 14000
57,57%	38,98%	3,45%

Table D.3 Intensity of activities having an impact upon the suppliers

	Use more recycled or less toxic materials	Decrease the quantity of raw materials involved	Decrease the quantity of energy needed to manufacture the product	Eliminate polluting refuse	Treat or catch polluting refuse	Decrease wastes generation	Find mechanism to dispose wastes or production refuses
Mean	3,20	3,79	3,59	3,72	3,82	3,90	3,53
Std errors of mean	0,25	0,23	0,24	0,28	0,29	0,27	0,27
Median	3,00	4,00	3,00	3,00	4,00	4,00	4,00
Minimum	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Maximum	7,00	7,00	7,00	7,00	7,00	7,00	7,00

Table D.4 Intensity of activities having an impact upon the hospitals

	Decrease the quantity of energy needed to use the product	**Increase product life cycle length**	**Design the product for future multiple functions**	**Design the product in order to be easy to fix**	**Decrease product packaging**	**Design the packaging in order to be easy to recycle**
Mean	4,27	4,577	4,507	3,40	3,65	3,80
Std errors of mean	0,27	0,27	0,27	0,23	0,24	0,28
Median	4,00	4,00	5,00	3,00	4,00	4,00
Minimum	1,00	1,00	1,00	1,00	1,00	1,00
Maximum	7,00	7,00	7,00	7,00	7,00	7,00

Table D.5 Intensity of activities having an impact upon the treatment and disposal organizations

	Design the product in order to be easy to disassemble	**Design the packaging in order to be easy to recycle**	**Establish recycling procedures**	**Insure the presence of recycling facilities**	**Establish hazardous wastes disposal processes**
Mean	3,50	3,20	2,74	2,69	2,80
Std errors of mean	0,27	0,25	0,25	0,25	0,27
Median	4,00	2,50	2,00	2,00	2,00
Minimum	1,00	1,00	1,00	1,00	1,00
Maximum	7,00	7,00	7,00	7,00	7

Table D.6- Internal coherence between specific and broad waste management activities: part 1

	WMS	WMH	WMTD	WM
Actual customers require minor changes for firm's product	0,264 0,022	0,53 0,000	0,371 0,002	0,438 0,000
Comparison between latest developed product and the ones developed before	0,010 0,471	0,091 0,248	-0,126 0,175	-0,016 0,453
Comparison between latest developed process and the ones developed before	0,084 0,263	0,191 0,075	0,049 0,358	0,110 0,208
Use more materials that are recycled or less toxic for the environment	0,794 0,000	0,591 0,000	0,704 0,000	0,755 0,000
Reduce the amount of raw materials	0,776 0,000	0,790 0,000	0,602 0,000	0,811 0,000
Reduce the energy needed to use the product	0,626 0,000	0,780 0,000	0,450 0,000	0,703 0,000
Increase the product durability	0,606 0,000	0,851 0,000	0,564 0,000	0,746 0,000
Design product for multiple uses	0,485 0,000	0,839 0,000	0,494 0,000	0,672 0,000
Design product to be easier to repair	0,589 0,000	0,748 0,000	0,454 0,000	0,671 0,000
Design the product in order to be easier to disassemble	0,66 0,000	0,738 0,000	0,522 0,000	0,712 0,000
Design product packaging to be easier to recycle	0,622 0,000	0,657 0,000	0,673 0,000	0,702 0,000
Choose supplier who has less polluting activities	0,766 0,000	0,682 0,000	0,426 0,000	0,706 0,000
Reduce the energy needed for product manufacturing and assembly	0,837 0,000	0,713 0,000	0,562 0,000	0,787 0,000
Eliminate the wastes generated by product manufacturing and assembly	0,845 0,000	0,646 0,000	0,533 0,000	0,749 0,000
Treat the wastes generated by product manufacturing and assembly	0,912 0,000	0,627 0,000	0,693 0,000	0,816 0,000

Table D.7- Internal coherence between specific and broad waste management activities: part 2

	WMS	WMH	WMTD	WM
Minimize the wastes generated by product manufacturing and assembly	0,94 0,000	0,691 0,000	0,774 0,000	0,879 0,000
Establish mechanisms to dispose of the wastes generated by product manufacturing and assembly	0,894 0,000	0,641 0,000	0,751 0,000	0,827 0,000
Put the emphasis on the product green aspect while performing the marketing	0,537 0,000	0,635 0,000	0,438 0,000	0,602 0,000
Inform customers about the product green aspect	0,523 0,000	0,62 0,000	0,484 0,000	0,603 0,000
Minimize the materials for packaging the product	0,726 0,000	0,806 0,000	0,729 0,000	0,83 0,000
Design product packaging to be easier to recycle	0,769 0,000	0,866 0,000	0,67 0,000	0,861 0,000
Optimize the distribution network	0,577 0,000	0,85 0,000	0,542 0,000	0,754 0,000
Establish recycling procedures	0,56 0,000	0,435 0,000	0,843 0,000	0,616 0,000
Ensure the presence of recycling infrastructures	0,559 0,000	0,412 0,001	0,866 0,000	0,611 0,000
Establish the mechanisms for disposing the hazardous and infected materials	0,513 0,000	0,335 0,005	0,816 0,000	0,571 0,000