A GENERAL MODEL TO COMPUTE WASTE DISPOSAL COSTS FOR HEALTH CARE PRODUCTS

by

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*This thesis is dedicated to my parents, **Akbar** and **Maryam***

my only reason to live, laugh and succeed

and

*to my beloved sisters, **Somayeh** and **Zohreh***

my forever friends.

*This is also in debt to my angles, **Faezeh** and **Mohammad***

I could never have this without you

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ABSTRACT

Hospitals are large producers of solid waste. The cost of segregating and discarding products in these waste streams is high. Studies have shown there is a considerable potential to reduce these costs while simultaneously decreasing environmental impacts, employing a variety of methods and techniques. In this thesis a costing method is developed that assigns waste discarding costs proportionally to each product. By providing discarding cost information at this level of disaggregation it is possible to directly influence purchasing decisions, identify priority products for focused interventions and determine the ratio of a product's purchasing cost to discarding cost. The approach demonstrated in this study is aimed to be a significant first step in connecting environmental concerns to hospital budgets, purchasing decisions and staff compliance with waste management strategies. The model is sufficiently general for other industries including health care providers, and in particular those which outsource waste removal from their property.

LIST OF ABBREVIATIONS USED

AHP	Analytic Hierarchy Process
Bio-Waste	Biological Waste
CBA	Cost-Benefit Analysis
EHF	Environmental Handling Fee
EPP	Environmentally Preferable Purchasing
ER	Evidential Reasoning
E-waste	Electronic Waste
GAIA	Geometrical Analysis for Interactive Aid
GIS	Geographical Information System
HCW	Health Care Waste
HCWM	Health Care Waste Management
IWK	IWK Health Centre
LAWRRD	Local Authority Waste Recycling Recovery and Disposal
LCA	Lifecycle Assessment
LCC	Lifecycle Costing
MCDM	Multi-Criteria Decision Making
MSWM	Municipal Solid Waste Management
ORWARE	Organic Waste Research
PIDAC	Provincial Infectious Diseases Advisory Committee
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluation
RBMCA	Risk-Based Multi-Criteria Assessment
RMW	Regulated Medical Waste
SKU	Stock Keeping Unit
SSADM	Structured Systems Analysis Design Method
SWAP	Strategic Waste Achievement Program
TDABCS	Time-Driven Activity-Based Costing System
UCM	Unit Cost Method

B_j	Total Number of Bins of Stream j Picked Up within t
C_j	Compress Rate for Stream j Compactor
DC_i	Discarding Cost of Product i
DV_j	Disposed Volume Of Container For Stream j per Each Pick-up
D_j	Number of Stream j Containers being Dumped within t
FC_j	Stream j Average Fuel Cost per Pick-up
F_j	Stream j static Cost
HC_j	Stream j Haul or Pick-up Cost per Container or Bin
L_j	Stream j Container Load Coefficient
PC_i	Purchase Cost of Product i
$P_{k,j}$	Portion of Component *k*s being Disposed in Stream j
Q_i	Order Quantity of Product i within period t
RC_j	Stream j Container Rental Cost within t
TC_i	Total Cost of Product i within period t
TDC_i	Total Discarding Cost of Product i within period t
TDV_j	Total Disposed Volume Within Period t For Stream j Container
TF_j	Stream j Tipping Fees per Kg
TPC_i	Total Purchase Cost of Product i within period t
VS_j	Stream j Container Capacity
V_k	Volume of Component k
$WF_{j,c,k}$	The Cost of Factor c in Stream j for Component k
W_k	Weight of Component k
$n_{i,k}$	Number of Component k of Product i
m	Number of Times Stream j is Charged for F_j within t
t	Time Period

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Chapter 1: Introduction

Hospitals consume a large amount of renewable and non-renewable resources in providing health care services, and produce a wide variety of wastes in return. Waste is defined as using more resources than necessary to achieve a system's objective. This could include using too much energy, doing extra and unnecessary work, and maintaining excessive inventory levels. Solid wastes compose a large percentage of the overall hospital-based wastes and range from non-hazardous outputs such as glass, cardboard, and food wastes to extremely hazardous cytotoxic drugs and biological wastes (bio-waste) [1]. The increase in the volume of hospital-based wastes in both the United States and Canada has been significant in the past few decades with the quantity in the United States more than doubling since 1955 [2]. This increase is primarily due to increased use of plastics/disposables, unnecessary red-bag disposal, inefficient waste management and lack of waste storage space in hospitals [2].

The majority of health care solid wastes either end up in a landfill or are incinerated [1], [2]. In the Unites States, 75-100% of solid medical wastes are incinerated when in fact only 10-15% of hospital waste is infectious and 1-2% of medical wastes actually establish enough risk to the public to require incineration [2]. According to a fact sheet produced by the Toronto Environmental Alliance in 2000, Ontario hospitals were estimated to produce 150,000 tons of solid waste annually. Of this, 10% was handled as bio-waste, despite only 6.1% being bio-waste [2]. Health care institutions can realize significant cost savings and reduce their output of solid waste by designing process improvement initiatives to reduce waste expenditures, detection of cost recovery opportunities and controlling over-consumption. For example, the IWK hospital has reduced amounts of its discarded hazardous waste recently by deposing of the used diapers in the general garbage instead of bio-waste.

In the past decade, Canadian federal and provincial governments have realized that there is considerable room for improvements in solid waste management. They have established initiatives to minimize excess product purchasing, inessential resource usages, encouraged material reuse and recycling, facilitated solid waste segregation, and audited waste streams to identify potential problem areas [1], [2], [3], [4]. Researchers are aiming to refine health care solid waste reduction strategies to expand beyond the "3Rs" of reduce, reuse, and recycle to include repair [2], rethink, and research [5]. In the past decade, various hospitals have adopted strategies to reduce waste streams and achieve cost containment [6]. Over a five year period, the Brookdale University Hospital and Medical Center in New York implemented a waste management initiative that reduced regular medical wastes by 2,404,680lbs, which equated to an 84.9% cost reduction [6]. Chandra [7] studies in the U.S. show that the significant waste generated through the entire medical supply process can be prevented by proper process improvement actions. This has the potential to save billions of dollars annually in U.S. hospitals.

Material disposal in hospitals is complicated as there are typically multiple waste streams and selecting the correct stream depends on the product and also on its use. For example, latex gloves are typically disposed of as bio-waste; however, if not soiled with blood or blood products they can be disposed of safely as general waste. Other products are not as easily categorized. Intravenous solutions should be disposed of in two streams: the liquid down the drain and the plastic bag through the plastic recycling stream. Soiled diapers, despite containing human waste, should be disposed of in the garbage, not as bio-waste.

The motivation for this study is founded in the operations of the IWK Health Centre (IWK), a women's and children's hospital in Nova Scotia, Canada. The IWK is an ideal environment for developing and testing solid waste disposal strategies. It offers a large range of services but to a specialized population. This means that the wastes and challenges are similar to other larger hospitals in the province but on a smaller and more manageable scale. Although the IWK will act as a canvas for this study, the results will have broader application. Other hospitals (or institutions) can follow the framework when designing their own initiatives and can refer to the IWK study as a case-in-point. Furthermore, Nova Scotia is an ideal region to undertake this study as it is a world leader in diverting solid waste [8] and has some of the most restrictive rules governing solid waste disposal.

In this study a framework for measuring and evaluating waste disposal activities in hospitals is provided. Specifically, the following four topics are presented: 1) defining the major hospital waste streams; 2) providing a method to compute the costs associated with using each stream. The costs per stream are defined in sufficient detail such that for a given Stock Keeping Unit (SKU) it is possible to compute its complete discarding cost; 3) Demonstrating the framework and computing the discarding costs for a variety of products using data and typical practices at the IWK; 4) Finally, applying this information to decrease hospital costs and compliance with proper disposal policies are discussed.

The thesis is organized as follows. Chapter 2 develops problem identification and reviews background information collected from the IWK to define the major waste streams. Chapter 3 reviews literature focusing on waste management and particularly health care waste management problems. Chapter 4 defines the general model and details the data collection and parameter estimation in addition to the IWK specific model concepts. Chapter 5 provides a proof of concept results and discuss general conclusions drawn from specific products. In Chapter 6, the conclusion is driven by discussing comparisons, implementation efforts and limitations of the model.

Chapter 2: Problem Statement

2.1. General statement

Waste management has become a significant universal challenge and health care systems are one of the most important contributions to this universal problem. Waste discarded from hospitals can be contaminated and hazardous for both people and the environment. Health Care Waste (HCW), which includes all the waste and by-products generated by health care centers, can be categorized into different waste streams, each of which requires its own treatment and disposal to be safe for patients, residents and the environment.

Taking the best and the most cost effective course of action is important in Health Care Waste Management (HCWM). Based on a report by Kaplan [9], 85% of waste generated from hospitals is discarded as hazardous. This results in higher discarding costs as hazardous waste disposal can cost almost 20 times more than general waste [9]. Furthermore, it increases environmental pollution as disposal treatment is required for this type of waste. Kaplan [9] also concluded that the majority of waste disposed of as hazardous is actually nonhazardous.

Chandra's [7] study in the US showed that waste which is generated through the medical supply process can be entirely prevented by proper process improvement actions. This has the potential to save billions of dollars annually in US hospitals [7]. At the IWK (and other similar Canadian health systems) these processes have been established in order to comply with municipal regulations, health requirements, facility restrictions, available resources, management priorities and budget limitations.

In order to be able to direct and improve HCWM processes, it is essential to measure HCW cost. If waste costs are not measured, they are more difficult to be reduced. HCW costs paid by hospitals can be divided into two categories, internal and external. Internal costs include separate collection, on-site handling, internal storage, equipment and staff costs. External costs include off-site transport and disposal costs which are typically performed by a third-party. Having these different types of costs, of which many are measured in different units (e.g. weight, volume, etc.) makes it difficult to directly isolate the discarding cost for any one product. This leads to difficulties in defining and implementing HCW cost reduction strategies.

More accurately defining waste cost, as is done in this thesis, makes quantifying HCW cost reductions possible. This will provide the essential information for HCWM to make the most effective and productive decisions and to determine the best course of action for different types of waste. As described in the “Alternatives for Treatment and Disposal Cost Reduction of Regulated Medical Wastes” [10], the basic reason for the continuously increasing discarding costs of hospitals’ medical waste is the misclassification and the improper disposal of wastes. If the most cost-effective treatment and disposal method for each properly-classified waste type is applied, this would result in considerable cost savings. Defining discarding cost of different treatments for the hospital products will facilitate a clear understanding and classification of HCW.

2.2. Health Care Waste Streams

In this section different types of HCW are described. Additionally their characterizations in the IWK and the way they are treated are discussed to provide background information needed to understand the model proposed in this study. The details are specific to the IWK, but are generally valid for other health care organizations. In this section the specification of each waste stream in the IWK is structured as follows;

- Definition
- Source segregation
- Central storage (within the hospital)
- External transport and disposal
- Charges

According to practices provided by Provincial Infectious Diseases Advisory Committee (PIDAC) [11] and other provincial, municipal and health regulations, HCW and by-products can be categorized in different streams as follows;

2.2.1. General Waste

Definition

General waste is non-medical. This type of waste does not cause any contamination risk. It is very similar to household trash. According to PIDAC [11], some examples of hospital general waste are provided in Table 1. General waste generally ends up in landfills when discarded.

Source Segregation

Specific bins with white or clear bags are designated for general waste. The waste is removed from different areas on a daily basis and is kept in intermediate soiled rooms to be removed to central storage. A sample of general waste buckets in the IWK is shown in Appendix A.

Central Storage

At the IWK, general waste is divided in two different parts, large general garbage and small general garbage. It is separated using two different containers to simplify hauling and disposing procedures.

Large general garbage typically consists of furniture, and construction, demolition and renovation debris which take up extensive space. As the main focus of this study is on products which are coming into the hospital through the SAP system (Systems, Applications & Products in Data Processing) which will be discussed in detail later, large general garbage has been excluded from this study. The framework approach defined for the other streams could also be used for large general garbage. The IWK tries to reuse, rehome or resell the components of these large general waste items as much as possible. Large general garbage is stored in the permanent open top container in the IWK which is a separate container from the small general garbage.

In this thesis general waste therefore refers to small general garbage. General waste is disposed of in the dual recycling container unit. This unit is designated for both the general waste and the clean cardboard streams. This type of container is used due to hauling and pick-up restrictions. The receiving bay in the IWK does not allow two separate containers to be located, picked up and hauled. This dual container is occupying one space while covering two major waste streams at the same time. This container is equipped with a flexible divider which facilitates two variable capacities for general waste and cardboard [12]. The IWK dual compactor unit is shown in Appendix B.

External Transport and Disposal

Royal Environmental (Regroup) is one of the major waste management suppliers in Halifax, NS., which is operating waste collection and disposal for five different waste streams in the IWK: general waste, clean cardboard, recyclables, large general garbage and electronic waste. General waste is picked up on average three times a week.

Charges

The dual container unit is rented by the IWK. Fees associated with this unit include monthly rental cost, haul cost, applicable disposal and transportation fees. ervicing and maintenance fees are also included.

2.2.2. Recyclables

Definition

Recyclables are non-medical by-products of the hospitals. Recycling is the act of reprocessing post-industrial or post-consumer residuals into new products [13] . In the IWK, recyclables are divided in two different streams for the purpose of better disposal. Clean Cardboard goes to a separate stream, which will be discussed later. In this thesis recyclables follow the municipal definitions by Halifax. Some examples of recyclables are provided in Table 1. Recyclables generally end up in recycling facilities to be recovered and reused.

Source Segregation

In the IWK, special blue bins with clear bags are designated for recyclables. They are located throughout the hospital for ease of access from clinical to non-patient areas. Recyclables are generally known as a good potential revenue resource. However due to the limited storage space and available resources hospitals typically cannot separate refundable items from other recyclables to use this opportunity. In some departments, income from selling segregated bottles and cans is used by staff for educational purposes. Samples of recyclable blue bins in the IWK are shown in Appendix A.

Central Storage

A modified closed top container is used to store clear bags of paper and recyclables blue bag debris in the IWK. A picture of this unit is shown in Appendix B.

External Transport and Disposal

Regroup is in charge of the modified closed top container contents in the IWK. Blue bag recyclables are picked up at least once, every two weeks or as required. The contents are dumped at the Halifax Regional Municipality's recycling facility. Loose paper and blue bag recyclables are processed separately within these facilities.

Charges

A closed top container is rented by the IWK. Charges associated with this unit include monthly rental cost, haul cost and transportation fees. Right now there is no disposal fee or commodity processing fee for the blue bag recyclables but this may be imposed in the future by the recycling facility. The supply of equipment, servicing and maintenance are also included.

2.2.3. Cardboard

Definition

In health care systems, disposing of cardboard is a challenge as most of the medical and non-medical products come into the hospital in cardboard packaging. This includes small low volume items as well as large biomedical equipment. The cardboard can be reused and recycled. Cardboard can also be a potential revenue opportunity like some recyclables. In Halifax, there are some organizations seeking to pay less for used clean cardboard. In the IWK, simple collection and storage of cardboard is facilitated by a separate stream from other recyclables.

Source Segregation

In the IWK, Cardboard is separated as the most common packaging in all departments. Some departments like biomedical engineering also try to reuse the high quality cardboard instead of disposing of it. In addition to the opportunity to create revenue through cardboard as with other recyclables, it also can be reused or exchanged with other organizations.

Central Storage

A dual container is designated for both general waste and cardboard. This unit provides two variable capacities for both streams by a steel wall between the two components. This container is also utilized to compress cardboard. This feature simplifies cardboard segregation and disposal. Cardboard is bulky and large and therefore it has to be flattened prior to disposal. The compression ability of this dual container allows dumping cardboard as is, without folding or flattening them.

External Transport and Disposal

Regroup provides handling of cardboard in the IWK. The dual container's contents are picked up three times a week on average. General waste and cardboard are then transported to two separate waste handling facilities.

Charges

As described before, the container is rented by the IWK. Charges include monthly rental cost, haul cost and transportation fees. Supply of equipment, servicing and maintenance fees are also included.

2.2.4. Organics

Definition

Organics or biodegradables can be recovered through composting processes, and can thus be reused for agricultural or landscaping purposes [13]. Based on Nova Scotia Waste-Resource Management Strategy [14], resources which can be composted are no longer accepted to be disposed of as general waste in landfills in Nova Scotia. Subsequently, the IWK has organics as a separate stream. Examples of the items included in this stream are provided in Table 1.

Source Segregation

In the IWK, special green bins are designated for organics in food related areas. Special bins with green or organics color-coding are also provided all across the hospital for patients and staff use. A picture of these bins is provided in Appendix A.

Central Storage

In the IWK, there is a space designated for organic bins to be stored. This area is provided outside the hospital building for cleaning and health purposes. The bins are steam cleaned and deodorized upon each use [15].

External Transport and Disposal

Regroup provides hauling services for the organics in the IWK. The bins are picked up four times a week but this may differ based on different factors like season or increased volume periods. The supplier provides the cart-swap exchange service [15], so they will take the full bins and return the empty bins at each pick-up.

Charges

As the organic bins are not rented, there is no rental cost for this stream. Compostable fees include pick-up charges, organics monthly static costs and transportation costs.

2.2.5. Bio-Waste

Definition

Bio-waste comprises biological and medical waste generated from health centers which is contaminated and infectious. Therefore it is potentially hazardous for human health and the environment and needs special treatment to be disposed of [11]. Based on PIDAC practices, bio-waste includes the following types of waste:

- Human anatomical waste
- Human and animal cultures or specimens (excluding urine and feces)
- Human liquid blood and blood products
- Items contaminated with blood or blood products
- Body fluids visibly contaminated with blood

- Body fluids removed in the course of surgery, treatment or for diagnosis (excluding urine and feces)

Detailed examples of bio-waste are provided in Table 1. Bio-waste ends in incineration or autoclave facilities to become safe prior to landfill disposal.

Source Segregation

Bio-waste source segregation is vital for health centers as it is infectious and hazardous. For this purpose special bins with color coding and yellow bags are provided in all clinical areas including patients' rooms. A picture of the mentioned equipment is shown in Appendix A. The containers designated for bio-waste have to be resistant enough to withstand waste weight without being torn, cracked or broken. The waterproof yellow bags should be thick enough to resist leaking and breaking. Each bag should be closed when is three-quarters full [11]. It is important for cost-saving purposes to make sure other types of waste are not mixed with bio-waste. This will be analyzed by detail in future sections.

Central Storage

Based on PIDAC practices [11], bio-waste has to be stored in appropriate containers and kept in a special designated room which is only accessible by authorized staff. In the IWK, there is a separate room for bio-waste storage with limited access. Bio-waste is stored there in leak-proof bins which are disinfected before reuse. IWK uses special grey bins for this purpose as shown in Appendix B. Bio-waste is transferred from clinical areas to designated soiled rooms several times a day and then is moved to central storage room using leak-proof and cleaned carts.

External Transport and Disposal

Stericycle Company provides services for collection, treatment and disposal of medical and bio-waste in Canada [16].This supplier runs waste collection and disposal for bio-waste, cytotoxic waste, pharmaceutical waste and sharps in the IWK. They supply special grey bins, pick bio-waste up six times a week and safely treat and discard it [16]. The supplier also provides the cart-swap exchange service, so full bins are taken and the clean and dis-infected empty ones are returned per each pick-up.

Charges

As the grey bins are not rented, there is no rental cost for this stream. Bio-waste fees include hauling charges and final disposal costs.

2.2.6. Sharps

Definition

Any clinical material which contains needles, syringes, blades or glass and can cause punctures, is included in this stream [11]. As sharps can cause hazardous, like accidental injections, they require special handling with caution [17]. Sharps generally are autoclaved and occasionally are incinerated [13].

Source Segregation

Regardless of being infectious or not, sharps are considered as highly hazardous hospital waste [18], therefore their segregation is critical and important. Sharps containers have to be strong to avoid any puncture or cuts. They have to be distinguishable with color coding, specifically code yellow with a biohazard symbol for waste sharps container as shown in Appendix A. Sharps which are contaminated with cytotoxic material have to be placed in special sharps containers with cytotoxic hazard label as shown in Appendix A [19] since they require a different treatment. The containers also have tight secured lids. They are sealed permanently when three-quarters full [17].

Central Storage

Sharps containers are picked from generation points and moved to the hospital central storage. Like bio-waste, sharps have to be stored in a separate room which is accessible just by authorized staff and is clearly defined by biohazard symbols.

External Transport and Disposal

Stericycle Company has the responsibility of handling the transportation, treatment and disposal of IWK sharps [16].

Charges

IWK is only charged for waste sharps disposal. Stericyle Company does not supply the equipment for sharps. IWK owns sharps containers, therefore their supply cost is not counted as an external cost and consequently is excluded from the proposed cost model.

2.2.7. Cytotoxic Waste

Definition

Cytotoxic drugs are used to treat cancer as a part of chemotherapy. Cytotoxic waste is any material in contact with these drugs. The toxicity of cytotoxic drugs has made them dangerous to be handled and therefore more caution is required [20], [21]. Cytotoxic waste cannot be treated by autoclaving and therefore is separated from other bio-wastes in the IWK and similarly in other health care facilities.

Source Segregation

With regard to cytotoxic toxicity and special treatment requirements, source segregation is essential for this stream. All cytotoxic waste should be placed in special red containers with the cytotoxic hazard symbol on it as shown in Appendix A.

Central Storage

After cytotoxic waste is collected from generation areas, it is kept in special storage rooms which are separate from food preparation or supply and distribution departments. Like bio-waste, this storage has to be clearly identified using appropriate biohazards symbols and has to be restricted just for authorized staff [19].

External Transport and Disposal

Cytotoxic waste is transported to incineration or medical deactivation facilities to be discarded. Transportation for cytotoxic waste is done according to the requirements of Transportation of Dangerous Goods Act and Regulations [19]. In IWK, this is operated by Stericyle Company.

Charges

Stericycle takes cytotoxic containers and charges the IWK just for disposal of the waste.

2.2.8. Pharmaceutical Waste

Definition

Based on the Food & Drugs Act [22], pharmaceuticals include prescription and non-prescription drugs, while excluding radionuclides, radiopharmaceuticals and biologics such as blood and vaccines [23]. In the IWK, according to the Pharmacy Policy and Procedure, "All discontinued patient drugs, outdated drugs, contaminated drugs, improperly stored drugs and containers with worn, illegible or missing labels are considered as pharmaceutical waste" [24]. Pharmaceuticals end up in incineration facilities to be discarded.

Source Segregation

Pharmaceutical waste is collected in separate white containers in the IWK as shown in Appendix A.

Central Storage

In the IWK, medications that are to be discarded are placed in a designated area in the pharmacy department to be removed by housekeepers [24]. Then they are kept in a separate bio-waste room. The containers have to be handled with caution based on the Transportation of Dangerous Goods Policy [25].

External Transport and Disposal

The Stericyle Company picks up all pharmaceutical containers and load them on pallets which are shipped for incineration [24]. Stericycle provides the replacement of the approved shipping containers and facilitate tracking of the waste [16].

Charges

The IWK is charged for the pharmaceutical waste based only on the final disposal cost provided by Stericycle Company.

2.2.9. Confidential Papers

Definition

Based on the IWK Confidentiality Policy and Procedure [26] , anything which is normally not available for the public, including any information about patients or staff, is considered as confidential waste. Confidential information requires appropriate disposal. Tapes, discs and information on electronic devices must be cleared and paper must be shredded. Confidential documents are shredded on site and stored separately to be disposed according to confidential waste rules and regulations.

Source Segregation

Special small gray bins designated for confidential paper are located in all clinical and office areas of the hospital. The small office bins are then transferred to the central storage.

Central Storage

As shown in Appendix B, in IWK, confidential documents are kept in locked grey bins prior to disposal.

External Transport and Disposal

The Iron Mountain Company is in charge of on-site document destruction for IWK. Within the storage time, the confidential papers are stored in locked grey bins.

Charges

The Iron Mountain Company charges IWK based on the number of bins to be shredded regardless of being full or not.

2.2.10. Electronic Waste (E-Waste)

Definition

The province of Nova Scotia is trying hard to keep electronics out of landfills, as throwing out electronics would increase environmental and human hazard [27]. As a result the IWK does not dump electronics with general garbage.

Source Segregation

The IWK separates electronics from general garbage. Initially they try to reuse, rehome, sell or donate the unrepairable electronics which can be reused according to health care obligations and restrictions. Finally those which cannot be repurposed are recycled as e-waste.

Central Storage

In the IWK, e-waste is stored in a designated cage for electronics disposal.

External Transport and Disposal

E-waste is taken to recycling facilities by Regroup. Electronics are picked up on call and are commonly hauled once a month or more frequently for special circumstances.

Charges

Regroup does not charge IWK by electronics weight or for disposal. The only charge is for trucking time and transportation.

2.2.11. Chemicals

This stream is one of minor waste streams in IWK. Chemical waste is mainly the by-product of laboratory work including expired chemicals and any solids, liquids or gases containing or contaminated with hazardous chemicals like flammable solvents, leachate toxic materials, corrosives, reactive and toxic materials [28]. As required by the Workplace Hazardous Materials Information System Regulations under the Nova Scotia Occupational Health and Safety Act [29], the health center has to assure safe handling and storage of chemical waste prior to disposal. Chemicals are finally disposed of differentially based on their type and may be stabilized and solidified to be disposed of in landfills or may be recycled.

2.2.12. Batteries

This stream is also another minor waste stream in the IWK. Batteries contain heavy metals and toxic chemicals and therefore have to be disposed of in a safe manner. In IWK and other hospitals, different types of batteries are used, ranging from small alkaline batteries to large lead-acid batteries [13]. Batteries finally end up in special facilities to be recycled.

2.2.13. Paints

Different types of paints are used for various purposes like facility repair and maintenance in hospitals. In Nova Scotia, paints are recycled into new paints. For this purpose IWK has a separate stream for paint disposal [14].

2.2.14. Pressurized Containers

This minor stream in IWK includes compressed gas cylinders which cannot be recharged or returned as these cylinders are not accepted at local landfills for potential hazards [30]. They have to become safe prior to disposal.

Table 1*-Sample Hospital Waste and their Disposal Streams*

Waste Category	Examples
General Waste	• Dressings, sponges, diapers, incontinent pads, PPE, disposable drapes, dialysis tubing and filters, empty IV bags and tubing, catheters, empty specimen containers, lab coats and aprons and pads that will not release liquid or semi-liquid blood if compressed • Waste from offices, kitchens, washrooms, public areas • etc.
Recyclables	• Paper recyclables (Non-confidential) • Blue bag recyclables including plastic containers, tubes and lids, plastic bags, paper or plastic wraps, Steele and aluminum cans, boxboard • etc.
Organics	• Food waste • Food napkins, soiled paper and boxboard • Paper towel • etc.
Bio-waste	• Human anatomical waste • Blood and blood products, items contaminated with blood or blood products • Drainage collection units and suction container soiled contents • etc.

2.3. Problem Identification

The problem is to define the real cost of any product purchased and discarded in the hospital. Typically, when making purchasing decisions, hospitals only consider a product's purchasing cost and ignore handling and reuse, recycling and discarding costs. However, as will be shown, the discarding cost for certain classes of products can be substantial. Ignoring these costs of products may lead to increased HCWM costs.

Attaching the real cost to products provides incentives to those purchasing products and also for everyone else, to cooperate in waste cost reduction strategies. If the real cost of a product can be defined, improvements or failures can also be determined. Knowing the real cost of the products will also affect both disposal and purchasing strategies.

This thesis provides a methodology which facilitate a assigning a unique cost to each product so that HCW authorities can clearly see the cost of each product discarded in the hospital while considering different disposal scenarios. As Kaplan et al. [31] mentioned in a report published by Harvard Business School, the impacts of process improvement and cost reduction actions can be validated and compared by having a proper costing system. This study proposes such a system by determining the real cost for a product which accounts for the Purchasing Costs and the External HCWM Costs.

Chapter 3: Literature Review

Over the past decades, reducing operating costs has been an area of a great focus in health care systems while management and disposal of Regulated Medical Waste (RMW) is still a considerable expenditure for health care facilities, which could be reduced [6]. Based on results of Hosny et al. [32], most HCW problems relate to poor waste management, lack of awareness, insufficient resources, and poor control of waste disposal.

Through conducted studies, literature, observations and records, almost 80% of waste generated from hospitals is similar to domestic waste and only 20% is considered as hazardous waste [32]. This makes HCWM, to some extent, similar to municipal waste management. As such, literature related to municipal waste management will also be reviewed in this chapter.

The literature review is organized as follows. First, studies which focus on Municipal Solid Waste Management (MSWM) are reviewed in Sections 1- 4. Section 1 goes over optimization models and some examples of their application in MSWM. Section 2 investigates decision support models applied in MSWM which are employed to assist waste management authorities to evaluate a system's alternatives using techniques such as Cost-Benefit Analysis (CBA), Lifecycle Assessment (LCA) and Multi-Criteria Decision Making (MCDM). Section 3 reviews other models or methods to solve MSWM problems. Section 4 reviews MSWM costing models. Section 5 focuses solely on health care models related to HCWM. This includes costing models and general models for waste management.

3.1. Municipal Solid Waste Management Optimization Models

Different MSWM models have been proposed within the last few decades to solve problems associated with waste management. Early models were optimization models which focused on optimizing specific aspects of the problem [33]. Figure 1 summarizes main optimization models in the area of MSWM. Many models have focused on facility location problems. Esmaili [34] presented a dynamic optimization model which was able to find the optimal processing or disposal facilities which minimized haul, processing and disposal costs. Haddix [35] proposed two facility location-allocation models to solve solid waste management problems. In more recent studies, Huang et al. [36] developed an integrated fuzzy stochastic linear programming model to find the optimal types, times and sites of solid waste management facilities which minimized system costs. In a case study, the optimal collection stations in Port Said (Egypt), were defined. Badran et al. [37] implemented a mixed integer programing model to minimize the total cost of the entire MSWM system. Chang et al. [38] developed a minimax regret optimization analysis to determine where to construct facilities which results in the smallest measurable regret.

Waste flow allocation problems considered fixed location and strive to optimize the flow and amount of material to each facility. Ilhan et al. [39] developed a mixed integer programming model to optimize the total solid waste collection and transportation costs by considering various transfer and disposal sites in addition to transportation options. The model could also define waste flows to each site. This model was implemented as a case study in a city in Turkey.

Cheng et al. [40] used a two stage inexact mixed integer linear programming model to select the optimal landfill site and waste flows which could minimize the total waste system cost. Moreover, Yeomans et al. [41] presented a model which was a combination of a genetic algorithm with simulation. The model highlighted optimal solutions for the waste flow allocation plan under uncertainty. In another study for facility expansion and waste flow allocation, Maqsood et al. [42] employed mixed integer programming to minimize the cost of the system. Another case was conducted in a city in Northern China to find the optimal distribution of waste flows which could minimize the waste management system cost in the planned period. Li et al. [43] used a fuzzy stochastic interval linear programming model to solve this problem.

Other similar optimization models focusing on waste management problems after waste is discarded from different generating points, including the transportation flows and disposal facilities, have been conducted recently. In 2011, Zhang et al. [44] proposed an inexact reverse logistics model which could find the optimal transportation flows as well as disposal and inventory capacity of all facilities to minimize the total system cost including inventory, transportation and disposal costs.

A model to determine the optimal amounts of waste sent out of the facility and the specifications of treatment plants has been developed by Antmann et al. [45] in 2013. The paper proposed a simulation-based decision optimization framework for solid waste management which represented the whole lifecycle of different types of waste and found optimal or near-optimal plans. The objective of the model was maximizing environmental and social benefits and minimizing costs. The model was able to define the flows of waste and the optimal number, kinds and the location of the facilities.

Routing problems are also studied extensively in waste management related literature. Chiplunkar et al. [46] developed an optimization model to solve the vehicle routing problem for refuse collection in large cities and applied the model as a case study in a part of Bombay. In another level of optimization, Chang et al. [47] developed a nonlinear program followed by an integer program to define the optimal allocation of resources and costs. The model could find optimal routes and amounts of waste to recycling and disposal facilities at minimum cost and to allocate waste collection duties between existing collection vehicles and labor. The model was demonstrated as a case study in a region of Taiwan.

In a recent study by [48] 2014, a Geographical Information System (GIS) was used to direct the facility selection and route optimization with the aim of reducing the overall cost. This article presented different optimization tools coupled with GIS to solve MSWM problems.

Reviewing examples of proposed solid waste management optimization models demonstrates that procedures employed by these models can deal with well-structured problems while the nature of the waste management data make some of the complex problems ill-structured and uncertain [41]. An improved optimization method reflecting uncertainty was presented by Huang et al. [36]. Huang et al. [36] developed an integrated fuzzy stochastic linear programming model to find the optimal types, times and sites of solid waste management practices, while minimizing system costs.

Yeomans et al. [41] also presented a model which was a combination of a genetic algorithm with simulation. The model could find the optimal solutions for the waste flow allocation planning under uncertainty. Furthermore this model was applied as a case study in a municipality of Ontario, Canada. Maqsood et al. [42] minimized the expected value for the cost of facility expansion and waste flow allocation using a mixed integer programming under uncertainty.

Li et al. [49] proposed a two-staged stochastic programming model to solve the problem of timing, sizing, placement and expansion of a facility under uncertainty and implement it as a case study in the City of Regina (Canada). Another optimization model was developed by Xu et al. [50] in 2010, to facilitate generating waste management alternatives and identifying desired policies. Xu et al. [50] used a stochastic robust interval linear programming model to solve MSWM problems under uncertainty.

Waste management problems can include capacity planning aspects too. Capacity planning problems deal with a series of interrelated decisions in which dynamic programming is capable of solving them by dividing the problem into a series of sub problems [51]. Baetz [52] presented a dynamic programming model to assist in capacity planning decisions associated with MSWM. His model facilitated determining the optimal capacity expansions. As mentioned earlier, Esmaili [34] also presented a dynamic optimization model which was able to find the optimal processing or disposal facilities.

During recent decades, research efforts have been more focused on the development of economic-based optimization models for MSWM problems [53]. Trends in the literature in this area suggest that models are mostly directed toward waste management problems after waste is discarded from the generation points. There are few studies examining points in time before waste is removed from the generating systems including residential, business, commercial or health care systems.

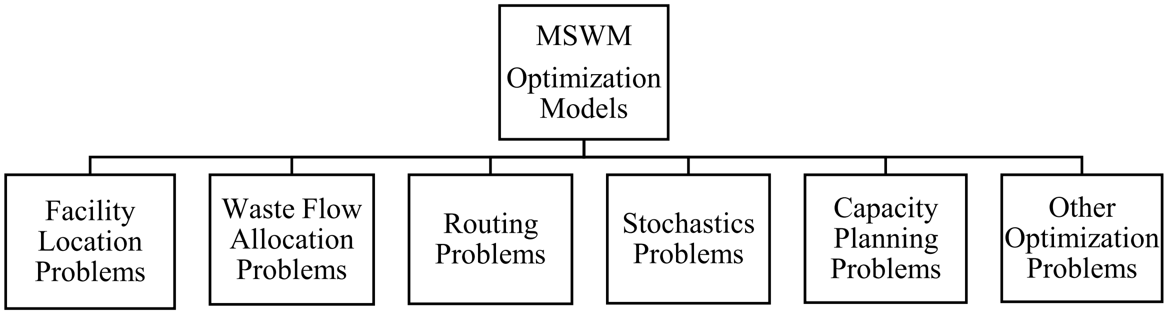


Figure 1 : MSWM Main Optimization Models

3.2. Municipal Solid Waste Management Decision Support Models

As discussed before, early studies considered optimization models. Next we review models focused on integrated waste management, considering environmental, economic and social aspects to achieve sustainable waste management models and strategies [33]. As Morrissey et al. [33] described, these models can be divided into three categories:

- Decision support models based on cost-benefit analysis
- Decision support models based on lifecycle assessment
- Decision support models based on multi-criteria decision making

Decision Support Models can help support the evaluation of different options using appropriate tools and techniques [54]. Figure 2 summarizes MSWM decision support models.

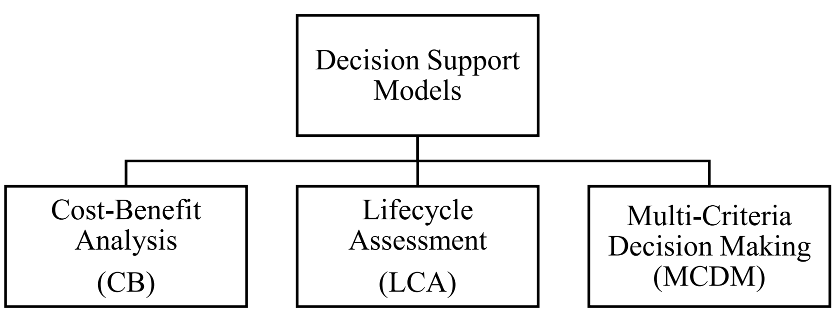


Figure 2 : MSWM Decision Support Models

3.2.1. Cost-Benefit Analysis (CBA)

CBA is an analytical method to assess total costs and benefits of implementing a planned project [55]. CBA can be used to compare different waste treatment options in a waste management system [56]. Based on the definitions provided by Karmperis et al. [57], CBA can be applied in the following steps:

- Objectives discussion
- Project identification
- Feasibility and alternatives study
- Financial analysis
- Economic analysis
- Risk assessment

The basic advantage of CBA is choosing the best final waste disposal treatment by comparing all costs and benefits involved [58]. As stated by Morrissey et al. [33], CBA analysis assists in selecting a proper waste management scenario as well as other decisions related to waste management, for example evaluating recycling and reuse procedures. CBA examines projects case-by-case using investment evaluation techniques to analyze the feasibility of the projects through their environmental and financial benefits and costs [54].

Weng et al. [59] studied how effective an MSWM system is by developing an integrated CBA framework. This framework facilitates evaluation of the financial cost-effectiveness of MSWM systems.

In a study conducted by Bogert et al. [60], costs and benefits of residential recycling were analyzed versus disposal systems in four Washington State cities. Costs and benefits of replacing virgin materials in manufacturing with recycled materials were also compared in this case study. In the area of recycling, another CBA analysis was used by Folz [61] to compare the costs and benefits of two solid waste recycling scenarios and compare them with traditional disposal analysis. Using CBA facilitates selecting the scenario or treatment with the greatest net benefit.

In Norway, CBA analysis was employed by Ibenholt et al. [56] to assess the cost-effectiveness of Norwegian recycling policy for liquid board containers. Results found that the presented recycling system had a higher net social cost than traditional disposal systems. Another case was performed in Indonesia to compare the available treatments for traditional markets waste disposal [62]. The Deposit–refund law for beverage containers in Israel was also analyzed using CBA by Lavee [63]. Lavee measured storage, collection, and treatment costs of empty containers as cost factors and alternative treatment costs savings, cleaner public spaces, landfill disposal reduction, energy savings and new workplace advantages as potential benefits of the program. In 2013, Karmperis et al. [57] proposed a risk-based multi-criteria assessment method to select the best of the available waste management alternatives.

3.2.2. Lifecycle Assessment (LCA)

LCA is a method used to assess the environmental impacts and resources used throughout the waste management service [55]. It is a management tool used to assess the environmentally and economic sustainability of the waste management systems [64]. As Rebitzer et al. [65] stated, the LCA can be applied in 4 steps:

- Goal and scope definition
- Lifecycle inventory analysis
- Lifecycle impact assessment
- Lifecycle improvement assessment

With regard to waste management system inquiries, the lifecycle of waste is different from the lifecycle of a product. It starts with discarding the material to waste streams and ends with final disposal or recovery of the waste, while the product lifecycle starts when it is extracted from the raw material and finishes when it is discarded [66]. LCA describes the system of the examined product, identifies all inputs and outputs of the examined product, evaluates the scores of different impacts, reports the results and discusses the possibility of minimizing impacts of the examined product on the environment [54].

Björklund et al. [67], Reich [68] and Eriksson et al. [69] posed an LCA based model, named ORWARE (Organic Waste Research) which was a simulation model based on

LCA, used to calculate waste management costs as well as flows and environmental impacts. ORWARE was applicable for both organics and inorganics. The model included activities when waste was collected at the generation source, such as households, business or industries.

Harrison et al. [70] developed a computer-based model decision support tool which proposed an LCA methodology to assist decision makers to find strategies that best satisfy MSWM system goals.

LCA is also used by Ulukan et al. [71] to assess the environmental issues. Ulukan et al. used a fuzzy TOPSIS method to compare collection methods by considering the social, financial, and also environmental aspects.

Similar studies have been conducted based on LCA in waste management including [72] in 1996, [67] in 1999, [73] in 1999, [74] in 2000, [75] in 2000, [70] in 2001, [76] in 2004, [65] in 2004, [77] in 2006, [62] in 2006, [78] in 2007 and [64] in 2008.

Lifecycle Costing (LCC) is an analytical method to assess different types of costs of a product or a service using the LCA approach [55]. LCC is used to determine cost-effectiveness of the alternatives. Activities causing direct costs or benefits in a defined time horizon are considered in LCC [79].

LCA is an appropriate tool to analyze environmental issues in waste management, however as decision makers need to consider environmental and economic aspects together, LCC is used to account for all costs of a product and this combination can be used as a tool to evaluate the waste management system [80].

In 2014, Veronica et al. [81] proposed a cost model for LCC which followed a unit cost method (UCM). Based on UCM, first the waste system had to be broken down to different stages including separation, collection, transportation, treatment and disposal and then cost items related to each stage were identified [81]. This work had a similar objective as this thesis study but costs were computed based on consumed resources (e.g. bags, bins, labor, etc.), not stock keeping units (SKU) as processed in this study.

These studies presented models and tools for environmental and economic assessments and comparison of the available alternatives for waste disposal. LCA can facilitate environmental analysis and CBA can facilitate economic assessment.

3.2.3. Multi-Criteria Decision Making (MCDM)

Karmperiset et al. [54] argued that MCDM models can help to analyze and evaluate alternatives available for a problem by following specific steps. Their framework was as follows:

- Objectives definition
- Alternatives identification
- Decision making criteria definition
- Alternatives' scores calculation

The MCDM identifies all options satisfying project objectives and selects the most appropriate one based on decision making criteria and weight values [54].

Hokkanenet et al. [82] discussed the application of the ELECTRE (Elimination and Choice Expressing Reality) method which was based on the MCDM approach to solve environmental related problems. An actual application of this method was presented in their article to solve a MSWM System problem in the Oulu district in Northern Finland. Other similar studies in the MCDM area have been conducted by [83], [84] and [85].

As a sample of applicability of this method, Chenget et al. [40] presented a combination of MCDM and inexact mixed integer linear programming methods to find the optimal landfill site and allocation of waste flows with the objective of minimizing the total system cost. The city of Regina was used as a case study. In the coastal part of Croatia, Vegoet et al. [86] applied two MCDM methods, PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) and GAIA (Geometrical Analysis for Interactive Aid) to analyze and evaluate waste management alternatives. PROMETHEE is based on a non-parametric outranking method. PROMETHEE is applicable for a finite set of alternatives and GAIA is a visualization method following the PROMETHEE ranking method.

Through a case study in Dalian, China in 2011, a hybrid model of fuzzy comprehensive evaluation and AHP was used by Du et al. [87] to select the best alternative in waste management systems. Tarmudi et al. [88] also employed the AHP and fuzzy ideal solution method to decide how to dispose the MSW. Analytic hierarchy process (AHP) is one of the basic approaches of MCDM. In 2013, Kumar et al. [89] also used AHP to select a landfill site for MSWM.

In another case study applied in Iran in 2012, solid waste assessment analysis was conducted using a MCDM technique, the evidential reasoning (ER) approach [90].

Moreover, Karmperis et al. [57] proposed a risk-based multi-criteria assessment (RBMCA) model in waste management which was able to select the optimum alternative of a project. This could help decision makers studying feasibility and alternatives of the project while doing a CBA.

3.3. Other Municipal Solid Waste Management Models

Based on the literature reviewed, most models used to solve problems associated with waste management are optimization and decision support models. In this section other models, techniques and methods which evaluate different options in this area are discussed.

Estimating amounts of generated waste is also an area of concern for researchers as it can provide required information for planning as well as evaluating the system under study. As an example, Daskalopoulos et al. [91] developed a theoretical model which could find the optimal combination of technologies for the handling, treatment and disposal of solid waste. The model was able to consider solid waste rates, compositions and environmental impacts. Estimated quantity of the solid waste was used to evaluate the impacts of applying one or a combination of treatment and disposal methods. However, the model did not cover collection and transportation costs. A case study has also been conducted in Jordan using statistical analysis to propose a model to predict amounts of waste generated [92].

Different methods and techniques can be employed to assist decision makers in the process of making waste management-appropriate decisions. The Helsinki Metropolitan Area model is proposed by Tanskanen [93] to analyze recovery rates, costs and emissions for MSWM. This model could analyze and compare different separation strategies which could satisfy municipal targets. Identifying potential separation strategies, calculating amounts of recoverable materials and defining different strategies' effects on cost and emission were the contributions of this method.

The Strategic Waste Achievement Programme (SWAP) and Structured Systems Analysis Design Method (SSADM) were two methodologies proposed by Woolridge et al. [94] to help managers and policy makers developing a sustainable and rational waste management system. SWAP uses a structured graphical representation of the system to select the most appropriate waste management action and SSADM is a prescriptive method that can graphically document the system to find potential areas to be improved. In 2006, Brown et al. [95] developed the LAWRRD (Local Authority Waste Recycling Recovery and Disposal) method to model waste management decision making in order to find the total cost and facility requirements in a local authority level.

Alternatively, the above-mentioned techniques can be used together or combined with other techniques to solve waste management problems. Costi et al. [53] proposed a decision support system which could contribute to planning for the MSWM. Their method also employed optimization techniques to define the flows to be sent to different disposal facilities as well as the optimal number, kinds and location of the facilities. The proposed model was a constrained non-linear optimization problem with binary and continuous decision variables and the constraints reflected technical, normative, and environmental issues.

3.4. Municipal Solid Waste Management Cost Models

"The economics literature dealing with the cost structure of MSW disposal and recycling services is quite limited" [96]. Goddard [97] stated that based on the analysis presented in his paper, the solid waste problem can be solved only if it is clarified that the problem is not only technical but that fundamentally it is economic in nature, and recommends a number of economic instruments which could be used for a better MSWM. This gap in waste management research forms the fundamental structure of this study. The following is a review of studies regarding the cost of different factors in waste management.

Hirsch [98] proposed a residential refuse collection cost model including operating and capital cost for collection and disposal. He assumed that the total cost of annual residential refuse collected was determined by the average annual amount per pick-up and the number of pick-ups. Stevens [99] calculated waste collection cost. His focus was on analyzing the relation between the cost of waste removal service and the variety of factors impacting household refuse collection cost. Dubin et al. [100] also analyzed contributing factors of household waste collection costs. In 2001, Callan et al. [96] modelled the total cost of providing MSW services, including disposal and recycling costs and implemented them in US municipalities. In The Netherlands, Dijkgraaf et al. [101] estimated total municipal waste collection costs and analyzed potential savings which could be achieved by contracting out refuse collection.

Cost models can also assist in decision making processes. The US EPA's National Risk Management Research Laboratory developed a decision support tool for MCW to calculate life-cycle environmental tradeoffs and full costs of different waste management strategies. The computer software calculated environmental impacts and costs for collection, handling, transport, treatment, and disposal [102]. Furthermore, Gomes [103] developed a model to calculate the costs of collection and transport to compare the economic effects of alternative collection scenarios.

Moutavtchi et al. [104] developed a full-cost accounting methodology for waste management systems. This methodology acted as an information support tool to assist decision makers in MSW at regional and municipal levels. In a more recent study in 2010, solid waste service cost determinants were studied [105]. The study was conducted in a region of Galicia. Bel et al. [105] presented a general model to estimate determinants of the MSW cost, including collection, transport and treatment services.

More relevant to this research study, in 2012, Parthan et al. [106] stated that MSWM costs can be estimated using the Unit Cost Method (UCM), benchmarking techniques and developing cost models. Unit cost methods can be used for budget preparation, purchasing, and during facility design. As this method is straightforward, it is the most common cost estimation method in MSWM. Benchmarking estimates the cost based on the actual cost data from a similar organization and can be calculated per capita or volume [106].

Another study in the area of waste cost was completed by Greco et al. [107] in 2014. Greco et al. estimated the cost of different types of waste and for different municipalities in Italy. The model also considered indirect costs of the firms. Activity based costing was employed in a cost model proposed by Groot et al. [108] in 2014, for waste cost calculations. The model was used to calculate costs of collection within municipalities and predicted the impacts of different parameters of a municipality.

3.5. Health Care Waste Management

Attention has been given to waste management systems in health care employing a variety of different methods. Kaplan et al. [9] reported that 6,600 tons of waste is generated by U.S. health care facilities per day. According to the U.S. Environmental Protection Agency, 85% of these wastes are nonhazardous and are similar to domestic waste, though it is still discarded as hazardous waste. Therefore, conclusions derived from studies conducted on MSWM can be extended to HCWM with regard to health and safety requirements for patients, residents and the environment. In this section more recent research studies, particularly in the area of health care, are reviewed.

Liberti et al. [109] proposed a model which generated optimal operations for hospital waste management including characterization, collection, storage, transportation, and disposal of infectious hospital wastes and implemented it as a case study in Italy. In a later study, Sabour et al. [110] used mathematical models to predict amounts of waste generated at hospitals in Iran. If the infectious waste generation rate can be predicted, staff can be educated accordingly and the required facilities will be provided for appropriate collection methods. This will lead to cost reduction. In a similar study Jahandideh et al. [111] predicted the amount of hospital waste generated using two predictor models including artificial neural networks and multiple linear regression.

Knowing the amounts of generated waste can help in the development of a sustainable waste management program. Chaerul et al. [112] proposed a HCWM model based on system dynamics analysis which quantified the population and waste generation dynamics until 2030.

Decision Support Models are also commonly used in HCWM in order to choose among the available alternatives for each problem. In a case conducted in Istanbul the collection of wastes from internal storage at the hospital and then transportation to the final disposal facilities were investigated [113]. In addition, the existing and the proposed transportation routes were analyzed using CBA and the most efficient and cheapest routes were determined [113].

With regard to the MCDM techniques' applications which were discussed earlier, in 2011 Chung [114] proposed a fuzzy AHP which enabled health care authorities to choose appropriate infectious medical waste disposal firms. In a case study conducted in Shanghai, China, HCW treatment alternatives were evaluated using a new MCDM technique called VIKOR-based fuzzy MCDM [115]. Another case study in Turkey focused on finding the most appropriate treatment alternative by evaluating five different healthcare waste treatment alternatives using MCDM techniques including analytic network process and ELECTRE [116]. Applying MCDM, benefits, costs, and risks together can determine the best suited method [116].

HCW cost reduction is the main objective of this study; for this reason more recent literature regarding HCW costs are considered. In a report issued by the Harvard Business Review, the crisis of health care costs was discussed. "It is a well-known management axiom that what is not measured cannot be managed or improved" [31]. Kaplan et al. [31] argued that while there is not a clear understanding of how much it costs for a special service to be done, no improvement can be achieved to reduce that cost. The costing method developed in this thesis aims to take the first step in HCW cost reduction proceedings, which was to calculate and understand the cost spent for waste.

Kaplan et al. [31] proposed a Time-Driven Activity-Based Costing System (TDABCS) which could help measure health care costs accurately, given that an accurate costing system could help decision makers find areas to investigate, understand the cost, and identify cost saving opportunities. TDABCS was also utilized by French et al. [117] in 2013 to measure the value of process improvement actions considered to reduce cost while not impacting the quality of the service. This method enabled health care providers to be able to evaluate and assess the effects of any changes to a process prior to their implementation.

Based on Garcia, [6] the following framework was recommended for reducing the cost of the regulated medical waste process:

- Identify the current status of the system by conducting a survey and assessment of all areas
- Support process improvement with the help of an experienced person to implement and control the plan
- Review regulations and provide a new policy
- Select the proper waste hauler based on requirements
- Modify the collection system, which requires all the containers to be located and labeled properly
- Educate staff
- Monitor the process to achieve cost reduction goals
- Provide accurate data of quantities of solid waste and regulated waste and the related disposal expenditures
- Control and report results

Implementing these steps correctly will result in benefits for the hospital and be used as a cost reduction tool [6]. The fact that intervention costs are small but can result in great returns within a short time [9] motivates researchers to focus on proactive actions and provides health centers with strategies to reduce waste and costs associated with waste [118].

An article published in 2002 provided guidelines for Environmentally Preferable Purchasing (EPP), which is the process of purchasing products with less harmful impacts on the environment and human health [119]. As discussed in the article, this is very important given that preventing excess cost is easier and cheaper than implementing corrective actions. The steps to implement EPP as described in the article are as follows:

- Create the EPP team
- Identify goals, plans, determine goals achievable through purchasing improvements and prioritize products, services, contract and materials
- Provide alternatives to achieve the goals
- Evaluate and prioritize the alternatives
- Conduct a pilot study
- Implement the selected alternative
- Track and control improvements

In 2013, Della Vecchia [118] argued that health care providers can reduce waste and save on their supplies, resources and operations. Some suggested actions include:

- Supply Chain Leadership: EPP which invoke purchasing products with less environmental impacts, as what is purchased is going to be discarded as waste.
- Streamlining Supply Inventory: This implies reducing excess supplies which are finally discarded as waste in the form of expired or donated items.
- Suppliers Steps: opportunities to reduce waste that can be taken by suppliers, including less packaging and/or using reusable shipping pallets.
- Education: educating staff on how their behavior can affect the environment and financial status is a very important step to waste reduction. This requires an understanding of the current practice and fees, given that if something is not measured it cannot be managed.

Recycling is also demonstrated to be very effective in a sustainable waste management system. Guidelines to improve plastic recycling programs within health centers are provided through an analysis of the conclusions of a six-month pilot study in Stanford [120]. The article introduced environmental and financial benefits derived from clinical recycling. In the pilot study they conducted, the results illustrated that plastics comprise nearly 70% of the materials diverted from landfills. In addition, the program contributed to a 75% cost saving.

Ultimately, “Over the last decades, a traditional research topic in the waste management field has been focused on developing tools and methods to help decision makers with tactical decisions over waste management systems” [54]. Models at this aggregation level tend to be reactive, in that they accept what is coming into the hospital as fixed, and develop waste management strategies reactive. This research study begins at a lower aggregation level, specifically the product or SKU level. By providing metrics at this level, waste management strategies can be more proactive by discouraging the use or intake of products with high discarding costs.

Chapter 4: Costing Model

The purpose of this study is to define the cost of a product disposed of in a waste stream, including purchasing cost and external discarding cost. Consulting the purchase cost in this study is essential in order to understand the importance of a product. Products which are expensive to purchase are not necessarily effective on waste cost reduction. Cheap products with specific characterizations can be significantly effective on waste cost reduction. These products may also be overlooked in consumption or waste reduction policy making, because of their low purchase cost.

The challenge in calculating the external discarding cost is facilitating a proper understanding of different amounts paid through different invoices to calculate disposal cost in different streams. Translating invoices to a mathematical costing model will solve this problem.

The concepts described in this chapter are the same in all health centers in principle. The methodology can be used as a framework for all health care facilities by applying their own parameters and factors.

4.1. Definitions

Product:

Anything purchased in the hospital through the SAP system is defined as a product in this study. Products are not ordered individually, they are ordered in cases with different specifications. In this study, product refers to the stock keeping unit (SKU) of each product which is ordered. For example gloves are ordered in cases of 10 boxes and each box contains 50 gloves. Therefore discarding cost of product glove per each SKU consists of discarding cost of 1 case, 10 boxes, and 500 gloves.

Component:

Different parts of a product. For the glove example, the components of the product are two types of packaging and the gloves.

Stream:

Waste stream in which components of products and their contents are disposed, defined as follows:

- Major Non-infectious Streams:

  I. General Waste
  II. Recyclables
  III. Cardboard
  IV. Organics

- Major Infectious Streams:

  V. Bio-waste
  VI. Sharps
  VII. Cytotoxic
  VIII. Pharmaceuticals

- Other Significant Streams:

  IX. Confidential Paper
  X. E-Waste
  XI. Chemicals
  XII. Batteries

- Other Minor Streams:

  XIII. Paints
  XIV. Pressurized Containers

Cost Factor:

Different waste removal fees which are introduced and discussed in detail in the Section 4.3.2., including:

- Rental Cost
- Haul Cost
- Fuel Cost

- Static Cost
- Tipping Fees

4.2. Mathematical Cost Computation Model

The formulas are written for each product i, each stream j and each component k where:

- $Product\ i\ ;\ i \in \{1,2,3, \dots, I\}$
- $Stream\ j\ ;\ j \in \{1,2,3, \dots, S\}$
- $Component\ k\ ;\ k \in \{1,2,3, \dots, K\}$
- $Cost\ Factor\ c\ ;\ c \in \{1,2,3, \dots, C\}$

As discussed earlier, the real cost of each product is calculated as its total purchase cost in addition to its total discarding cost which is represented with the following notations;

- $TC_i = TPC_i + TDC_i$ (1)

Where:

- $TC_i = Total\ Cost\ of\ Product\ i\ within\ period\ t$
- $TPC_i = Total\ Purchase\ Cost\ of\ Product\ i\ within\ period\ t$
- $TDC_i = Total\ Discarding\ Cost\ of\ Product\ i\ within\ period\ t$
- $t = Time\ Period\ (In\ our\ case\ annually)$

And

- $TPC_i = Q_i * PC_i$ (2)

- $TDC_i = Q_i * DC_i$ (3)

Where:

- $Q_i = Order\ Quantity\ of\ Product\ i\ within\ period\ t$

- $PC_i = Purchase\ Cost\ of\ Product\ i\ (per\ SKU)$
- $DC_i = Discarding\ Cost\ of\ Product\ i\ (per\ SKU)$

Note that this formulation assumes the system is at steady state meaning approximately the same amount is purchased and disposed of in each period t.

Accordingly for each product i;

- $DC_i = \sum_{k=1}^{K} \sum_{j=1}^{S} \sum_{c=1}^{C} P_{i,k,j} * n_{i,k} * WF_{j,c,k}$ (4)

Where;

- $P_{i,k,j} = Portion\ of\ Component\ ks\ being\ Disposed\ in\ Stream\ j\ such\ that$:
- $\sum_{j=1}^{S} P_{i,k,j} = 1 \qquad \forall i, k$ (5)

- $n_{i,k} = Number\ of\ Component\ k\ of\ Product\ i$

For example, the product glove is ordered by cases of 10 boxes, and there are 50 gloves per each box in the case. Therefore this product is consisting of three components, cardboard packaging (k=1), gloves' boxes (k=2) and latex gloves (k=3) where $n_{i,1}$=1, $n_{i,2}$=10 and $n_{i,3}$=500.

- $WF_{j,c,k} = The\ Cost\ of\ Factor\ c\ in\ Stream\ j\ for\ component\ k$

$WF_{j,c,k}$ is defined and explained in the Cost Factors Calculation Section (Section 4.3.2).

4.3. Methodology

4.3.1. Notations

Product Parameters

Product parameters can be measured or retrieved from the manufacturer:

- $V_k = Volume\ of\ Component\ k$
- $W_k = Weight\ of\ Component\ k$

Stream Parameters

Stream parameters can be retrieved from waste management service suppliers' contracts and invoices:

- $VS_j = Stream\ j\ Container\ Capacity$
- $L_j = Stream\ j\ Container\ Load\ Coefficient$
  ($Load\ Coefficient$ is an indicator of how full the container is when hauled)
- $D_j = Number\ of\ Stream\ j\ Containers\ being\ Dumped\ within\ t$
  $(Number\ of\ Pick\ Ups\ within\ t)$
- $B_j = Total\ Number\ of\ Bins\ of\ Stream\ j\ Picked\ Up\ within\ t$
- $C_j = Compression\ Rate\ for\ Stream\ j\ Compactor(if\ applicable)$
- $RC_j = Stream\ j\ Container\ Rental\ Cost\ within\ t$
- $HC_j = Stream\ j\ Haul\ or\ Pick\ Up\ Cost\ per\ Container\ or\ Bin$
- $FC_j = Stream\ j\ Average\ Fuel\ Cost\ per\ Pick\ Up$
- $F_j = Stream\ j\ Fixed\ Cost$
- $m = Number\ of\ Times\ Stream\ j\ is\ Charged\ for\ F_j\ within\ t$
- $TF_j = Stream\ j\ Tipping\ Fees\ per\ kg$

4.3.2. Cost Factors Calculation

In order to be able to calculate the cost of desired cost factors for different waste streams ($WF_{j,c,k}$), characterizations of their containers have to be considered. Waste containers can be categorized as follows;

- Regular waste containers, with different sizes, capacities and specifications which are stored in appropriate locations in the health center and are dumped by the suppliers per each pick-up.
- Compactor containers, which can compress waste and are discharged per each pick-up. With regard to types of waste and their storage regulations and limitations, some of the containers are capable and allowed to compress waste. For such streams the volume of the component which is discarded is reduced by a

predefined compression rate. The compression rate is retrieved from the compressor specifications.

- Specialized bins, which are featured by having wheels for ease of removal. These containers are taken out by the supplier and replaced by empty, clean and, if required, disinfected ones upon each pick-up.

The cost of desired factors in different streams ($WF_{j,c,k}$) is defined as follows:

4.3.2.1. C=1; Rental Cost

The HCW is collected and stored within the hospital and is removed by designated suppliers. Each waste stream has its special designed containers. Some of them are owned by the health center and some are rented, with the latter having a rental cost associated with them.

For the components which are discarded in streams with a rental cost, the component rental cost is defined as follows:

$$WF_{j,1,k} = \begin{cases} \dfrac{V_k}{L_j * D_j * VS_j} * RC_j & Regular\ Waste\ Containers\ (In\ our\ case{:}\ j = 1{,}2) \\ \dfrac{C_j * V_k}{L_j * D_j * VS_j} * RC_j & Compactor\ Containers\ (In\ our\ case{:}\ j = 3) \\ \dfrac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * RC_j & Specialized\ Bins\ (Not\ Applicable\ in\ our\ case) \\ 0 & Otherwise (No\ Rental\ Cost) \end{cases} \tag{6}$$

In our case, the containers of the following streams are rented by the IWK:

- General waste, $j = 1$
- Recyclables, $j = 2$
- Cardboard, $j = 3$

A container's rental cost is a static cost within a predefined time period. The health center is charged for this cost regardless of the weight of the container at the time of pick-up. Therefore total volume is the only effective element to calculate rental cost factor. Furthermore since rental cost is independent from number of pick-ups, the ratio of the total rental cost within period t and the container's total disposed volume within period t (TDV_j) is used for this purpose. This is represented with the following equation:

$$\frac{V_k}{TDV_j} = \frac{WF_{j,1,k}}{RC_j} \tag{7}$$

For the compactor containers, the compressed volume has to replace the component's volume. This implies that $C_j * V_k$ has to be used instead of V_k in all calculations for streams with compactor containers.

Total disposed volume is calculated differently for each type of container. For all waste containers including regular and compactor containers, total disposed volume is the product of number of containers dumped within period t and the volume of the container.

With regard to health requirements, HCW is removed on a regular basis to avoid any contamination. Containers are supposed to be full when hauled. But as flow of waste differs based on different conditions in the health center, waste containers may be removed while not being full. In order not to miss any part of cost and also be able to see the cost of disposal with containers which are not full, the load coefficient factor (L_j) is used. This coefficient shows how full the container is. Where:

$$0 < L_j \leq 1 \qquad \forall j \tag{8}$$

Therefore the total disposed volume for regular and compactor containers within period t is calculated using the following equation:

$$TDV_j = L_j * D_j * VS_j \tag{9}$$

For streams with specialized bins, there is an assumption that a new bin will be used whenever the previous bins are completely full. Thus there is always one bin that may not be full when they are picked up. Therefore the load coefficient is applicable for just the last picked up bin.

With the above assumption and since B_j bins are removed within period t in D_j pick-ups for streams with specialized bins, $(B_j - D_j)$ bins are full when hauled and only D_j ones may be or not be full. Therefore the total disposed volume is calculated using the following equation;

$$TDV_j = VS_j * [(B_j - D_j) + L_j * D_j] \tag{10}$$

The rental factor cost for those streams which do not have rented containers is 0, $WF_{j,1,k} = 0$.

4.3.2.2. C=2; Haul Cost / Pick-up Cost

Upon collection and storage of HCW within the hospital, designated suppliers pick the containers up and haul them to respective waste facilities. Some of the suppliers charge the health center for waste pick-up and haul cost. Therefore there is a cost associated with those waste streams which are hauled by suppliers charging for waste removal from the hospital.

For the components which are disposed in streams with pick-up and haul cost, the component Haul Cost is defined as follows:

$$WF_{j,2,k} = \begin{cases} \frac{V_k}{L_j * VS_j} * HC_j & Regular\ Waste\ Containers\ (In\ our\ case: j = 1,2) \\ \frac{C_j * V_k}{L_j * VS_j} * HC_j & Compactor\ Containers\ (In\ our\ case: j = 3) \\ \frac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * B_j * HC_j & Specialized\ Bins\ (In\ our\ case: j = 4,5) \\ 0 & Otherwise (No\ Haul\ Cost) \end{cases} \tag{11}$$

In our case, the following waste streams have the pick-up or haul cost:

- General waste, $j = 1$

- Recyclables, $j = 2$
- Cardboard, $j = 3$
- Organics, $j = 4$
- Bio-waste, $j = 5$

Having the same situation as rental cost, the health center is charged for haul cost regardless of the weight of the container at the time of pick-up. Therefore volume is used again to calculate haul cost factor. But the haul cost is different from rental cost since it is dependent on the number of containers or bins picked up. Thus for the regular and compactor containers, the ratio of pick-up cost per container and the container disposed volume per each pick-up (DV_j) is used, as shown in the following equation;

$$\frac{V_k}{DV_j} = \frac{WF_{j,2,k}}{HC_j} \quad (12)$$

With regard to the load coefficient concept discussed earlier in this section, disposed volume is thus calculated using the following equation:

$$DV_j = L_j * VS_j \quad (13)$$

For streams with specialized bins, pick-up cost is charged per each bin being picked up. Therefore the ratio of total pick-up cost within period t and total disposed volume within the same period is used to define haul cost factor of a component in respective streams. Total pick-up cost is the product of total number of bins picked up and pick-up cost per bin. Consequently total disposed volume is calculated using equation (10).

The cost of pick-up or haul cost factor for those streams which do not charge for waste pick-up is 0, $WF_{j,2,k} = 0$.

4.3.2.3. C=3; Fuel Cost

Some of waste management suppliers charge the organization for waste removal services in more detail than just pick-up and/or haul cost. These detailed services may include variable or static costs. Therefore the cost of fuel is employed as a cost factor for those streams. Fuel cost is a representative type of variable costs associated with waste removal.

For the components which are disposed in streams charged for fuel cost, the component fuel cost is defined as follows:

$$WF_{j,3,k} = \begin{cases} \frac{V_k}{L_j * VS_j} * FC_j & Regular\ Waste\ Containers\ (In\ our\ case: j = 1,2) \\ \frac{C_j * V_k}{L_j * VS_j} * FC_j & Compactor\ Containers\ (In\ our\ case: j = 3) \\ \frac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * D_j * FC_j & Specialized\ Bins\ (In\ our\ case: j = 4) \\ 0 & Otherwise (No\ Fuel\ Cost) \end{cases} \quad (14)$$

In our case, the following waste streams have fuel cost:

- General waste, $j = 1$
- Recyclables, $j = 2$
- Cardboard, $j = 3$
- Organics, $j = 4$

Fuel cost varies based on different conditions like the daily fuel price or traffic on the truck's route to the disposal facility. Therefore an average amount of fuel cost for each pick-up over the period t and delivery is used to define the fuel cost factor, FCj.

Suppliers charge the health center for fuel cost regardless of the weight of the containers when hauled. Furthermore this cost is dependent on the number of dumps. For the regular and compactor containers, the ratio of fuel cost per dump and the container disposed volume per each dump is used, as shown in the following equation;

$$\frac{V_k}{DV_j} = \frac{WF_{j,3,k}}{FC_j} \quad (15)$$

Disposed volume for regular and compactor containers is similarly calculated using equation (13).

For streams with specialized bins, the ratio of total pick-up cost within period t and total disposed volume within the same period is used to define haul cost factor of a component in the respective streams. Total pick-up cost is the product of the total number of dumps and fuel cost per dump. Consequently total disposed volume is calculated using equation (10).

The cost of fuel factor for those streams which are not charged for fuel cost is 0, $WF_{j,3,k} = 0$.

4.3.2.4. C=4; Static Cost

Some streams have special costs which are static, such as maintenance or clean-up costs. In this group of cost factors, the behavior of static costs is used.

For the components which are disposed in streams charged for static cost, the component static cost is defined as follows:

$$WF_{j,4,k} = \begin{cases} \dfrac{V_k}{L_j * D_j * VS_j} * m * F_j & Regular\ Waste\ Containers\ (In\ our\ case: j = 1) \\ \dfrac{C_j * V_k}{L_j * D_j * VS_j} * m * F_j & Compactor\ Containers\ (In\ our\ case: j = 3) \\ \dfrac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * m * F_j & Specialized\ Bins\ (In\ our\ case: j = 4) \\ 0 & Otherwise (No\ Static\ Cost) \end{cases} \quad (16)$$

In our case, the following waste streams are charged for static costs:

- General waste, $j = 1$, Maintenance Cost
- Cardboard, $j = 3$, Maintenance Cost
- Organics, $j = 4$, Organics static Cost

Containers located in the health center require regular maintenance, similarly some containers or bins need cleaning, disinfecting and other services as required. These kinds of costs are not dependent on weight of the containers at the time of service and are just dependent on the number of services being done. Therefore volume is used to calculate static cost factor of the components. The ratio of total static cost within period t and the container's total disposed volume within period t is used for this purpose. This is represented with the following equation:

$$\frac{V_k}{TDV_j} = \frac{WF_{j,4,k}}{F_j} \tag{17}$$

Total disposed volume for regular, compactor containers and specialized bins are calculated using respectively equation (9) and (10). Total static cost is the product of total number of service and static cost per service.

The cost of static factor for those streams which do not have any static cost is 0, $WF_{j,4,k} = 0$.

4.3.2.5. C=5; Tipping Fees

Tipping fees are the amounts paid to waste removal suppliers for final waste disposal. As described before in the Health Care Waste Streams Section (2.2), different types of waste are disposed in different facilities using special disposal techniques and treatments. Those facilities charge the suppliers for waste disposal and the suppliers charge the health centers for the same reason. Accordingly there is a fee associated with those streams which are disposed in waste facilities. Waste streams which are recycled do not charge such fees.

For the components which are disposed in streams that are charged for final disposal cost as tipping fees, the component tipping fees are defined as follows:

$$WF_{j,5,k} = \begin{cases} W_k * TF_j & Any\ \ Container\ or\ Bin\ (In\ our\ case{:}\ j = 1{,}5{,}6{,}7{,}8) \\ 0 & Otherwise\ (No\ Tipping\ Fees) \end{cases} \tag{18}$$

In our case, the following waste streams are charged for tipping fees:

- General waste, $j = 1$

- Bio-waste, $j = 5$
- Sharps, $j = 6$
- Cytotoxic waste, $j = 7$
- Pharmaceutical waste, $j = 8$

Although waste is removed in containers or bins, waste disposal facilities fees are based on waste weight regardless of the number of containers or bins being used to store or haul it. Therefor tipping fees are simply product of weight of the component and final disposal cost for the stream in which that component is disposed.

Cost of tipping fees factor for those streams which do not have any final disposal cost is 0, $WF_{j,5,k} = 0$.

4.4. Implementation of the Model

4.4.1. IWK Specific Model

The IWK waste removal cost factors for major streams are summarized in Table 2. Different waste streams at the IWK have different cost factors as explained in the previous section. Table 2 presents the IWK specific cost factors for major waste streams.

Table 2-*Waste Removal Cost Factors in the IWK*

j	**Waste Streams** $j \in \{1, 2, \dots, S\}$	**Waste Removal Fees – Cost Factors** $c \in \{1, 2, \dots, C\}$				
		Rental Cost	Haul Cost	Fuel Cost	Static Cost	Tipping Fees
1	General	✓	✓	✓	✓	✓
2	Recyclables	✓	✓	✓	N/A	N/A
3	Cardboard	✓	✓	✓	✓	N/A
4	Organics	✓	✓	✓	✓	N/A
5	Bio-waste	N/A	✓	N/A	N/A	✓
6	Sharps	N/A	✓	N/A	N/A	✓
7	Cytotoxic	N/A	✓	N/A	N/A	✓
8	Pharmaceuticals	N/A	✓	N/A	N/A	✓

For general waste, a dual container is rented at the IWK. The supplier hauls general waste from the hospital to the landfill and also charges the IWK for fuel cost. The hospital has to pay for general waste final disposal in the landfill based on the disposed waste weight. As illustrated in Table 2, cost factors in the general waste stream include rental, haul, fuel and static costs as well as tipping fees.

Recyclables are stored in the closed-top container at the IWK. This container is rented by the IWK. The supplier hauls the contents to designated recycling facilities and also charges the health center for the truck's fuel cost. Recyclables do not have Tipping fees as they are recycled. Table 2 summarizes that cost factors for the recyclables are rental, haul and fuel costs.

The cardboard stream has the same container as general waste at the IWK. Like the general waste, cost factors in the cardboard stream include rental, haul, fuel and static costs. Cardboard is counted as a byproduct which can be reused or recycled. For this reason the cardboard stream does not have the tipping fees factor.

Organic waste is kept in green bins which are rented by the IWK. The supplier charges the health center based on the number of bins being picked up. Organics are then transferred to the final composting facility. The hospital pays for the truck's fuel cost. The supplier takes the full bins, discharges, cleans and returns them to the hospital. The IWK is charged for a fixed amount for the services provided by the supplier for the bins. Therefore cost factors for the organics are rental, haul, fuel and static costs.

At the IWK hospital, health care hazardous waste including bio-waste, sharps, pharmaceuticals and cytotoxic waste, is under one supplier's responsibility. They are stored in their special bins which are owned by the IWK. The supplier takes the bins on a regular basis and hauls them to special facilities which keep them safe prior to disposal in landfills. The hospital is charged for this process based on the disposed hazardous waste weight. Therefore the cost factors for the mentioned streams include haul cost and tipping fees.

Based on the proposed methodology to calculate products' cost, the cost of each product purchased through the IWK SAP system and discarded in a waste stream can be computed using the following model;

$$TC_i = TPC_i + TDC_i$$

$$where$$

$$TPC_i = Q_i * PC_i$$

$$TDC_i = Q_i * DC_i$$

$$DC_i = \sum_{k=1}^{K} \sum_{j=1}^{S} \sum_{c=1}^{C} P_{i,k,j} * n_{i,k} * WF_{j,c,k}$$

$$WF_{j,1,k} = \begin{cases} \frac{V_k}{L_j * D_j * VS_j} * RC_j & j = 1,2 \\ \frac{C_j * V_k}{L_j * D_j * VS_j} * RC_j & j = 3 \\ \frac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * RC_j & N/A \\ 0 & Otherwise \end{cases}$$

$$WF_{j,2,k} = \begin{cases} \frac{V_k}{L_j * VS_j} * HC_j & j = 1,2 \\ \frac{C_j * V_k}{L_j * VS_j} * HC_j & j = 3 \\ \frac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * B_j * HC_j & j = 4,5 \\ 0 & Otherwise \end{cases}$$

$$WF_{j,3,k} = \begin{cases} \frac{V_k}{L_j * VS_j} * FC_j & j = 1,2 \\ \frac{C_j * V_k}{L_j * VS_j} * FC_j & j = 3 \\ \frac{V_k}{VS_j * [(B_j - D_j) + L_j * D_j]} * D_j * FC_j & j = 4 \\ 0 & Otherwise \end{cases}$$

$$WF_{j,4,k} = \begin{cases} \frac{V_k}{L_j * D_j * VS_j} * m * F_j & j = 1 \\ \frac{C_j * V_k}{L_j * D_j * VS_j} * m * F_j & j = 3 \\ \frac{V_k}{VS_j * \left[\left(B_j - D_j\right) + L_j * D_j\right]} * m * F_j & j = 4 \\ 0 & Otherwise \end{cases}$$

$$WF_{j,5,k} = \begin{cases} W_k * TF_j & j = 1,5,6,7,8 \\ 0 & Otherwise \end{cases}$$

The model has been programmed using Python 2.7 with a user interface designed in Microsoft Excel. Sample products from the IWK SAP have been chosen to evaluate the model, which will be discussed in the following chapters.

4.4.2. Data Preparation

In order to validate the proposed methodology and demonstrate its performance, a variety of products are required to test the methodology. There are more than 10,000 different types of products used at the IWK. A subset of products which are used frequently or have special characteristics were picked.

Products with special characteristics can be a representative way to test the robustness of the proposed model. These characteristics are as follows (to be discussed in detail in a future chapter):

1. Large and hard
2. Heavy
3. Highly used
4. Recyclable
5. Specialized package
6. Non-hazardous
7. Cheap to purchase while expensive to discard

Since the above mentioned information was not available in SAP, we relied on experts to choose which of the highly ordered products have these characteristics. Thus products with certain characteristics from the subset of the most frequent products were used to test the boundaries of the model. The final selected list of products at the IWK and their characteristics are presented in Table 3. The numbers labelling the column headers correspond to the number of the special characteristics above. The selection was limited to 30 products since collecting the information was a very labor-intensive process which will be discussed in future sections. The products discussed in this section are typically made up of the following components:

- Case
- Box
- Protector wrap
- Product

***Table 3**-Sample Products Characterizations and Order Frequency*

		Characteristic							**Order Frequency Per Year**	
ID	**Product Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Per SKU**	**Units Per SKU**
0	Glove Exam Single			✓					88	400
1	Syringe Sampling			✓					206	100
2	Container Specimen	✓	✓	✓			✓	✓	193	100
3	Tubing Suction Non Conduct			✓				✓	486	40
4	Set Blood Collection Safety								154	50
5	Glove Exam			✓				✓	1191	1000
6	Tubing Oxygen Supply			✓			✓		238	50
7	Gel Ultrasound				✓		✓		219	24
8	Set Enteral Feed Pump						✓		173	30
9	Bag Patient Belonging			✓	✓		✓		20	500
10	Glove Surgical Neolon			✓				✓	94	400
11	Glove Surgical Neolon			✓					59	400
12	Wipe Wet Dispenser	✓	✓		✓		✓		382	12
13	Enteral Delivery Pump						✓		70	30

		Characteristic							Order Frequency Per Year	
ID	**Product Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Per SKU**	**Units Per SKU**
16	Surgical Glove Neolon			✓					45	400
17	Sterile Delivery Pack					✓			263	15
18	Glove Exam Nitrile			✓				✓	303	500
19	Catheter IV Auto guard								18	200
20	Bath Sitz with Graduated Bag	✓					✓	✓	255	10
21	IV Lac Ringers			✓			✓	✓	2532	12
22	Toothbrush						✓		12	144
23	Liner Suction System Flex	✓		✓	✓		✓	✓	213	50
24	Catheter IV Auto guard Safety								12	200
25	Needle Blunt Fill Safety			✓					178	1000
26	Kit Arterial Blood Sample								9	200
27	Device Bag Access Blood								20	25
28	Glove Exam Nitrile			✓				✓	197	500
29	Cleanser CRM	✓			✓		✓		371	12

4.4.3. Data Collection

The parameters of the model are categorized as follows;

- Items' specifications
- Contractual factors
- Fluctuating factors

4.4.3.1. Item Specifications

The following information is required for each product to run the model.

- Product description: product name, description and SKU number which are retrieved from SAP software.

- Order quantity of the product (Q_i): number of products ordered within time period t which is retrieved from SAP software.
- Purchase cost of the product (PC_i): can be retrieved from product available information through SAP software.
- Packaging information: including types of packaging and number of products per each case, unit or box of packaging which can be retrieved from the product specification on purchase orders.
- Components information ($n_{i,k}$): Including type and quantity of each Component. Component is defined in this study as each part of the product which is discarded separately. This can be retrieved from the product specification on purchase orders.
- Component weight and volume (V_k, W_k): can be found by manual measurement.

The health center could not provide weight and volume information for each of the components of the products. For this reason these factors had to be measured manually.

Manually measuring the volume and weight of every single component of a product (including external packaging, wraps and all internal parts) is time consuming. For this thesis, the required information for measurement including products' catalogs, pictures and locations was collected through meetings with related staff. For each product, first the product was found on the shelves, then it was broken down into its components and each part of the product including packaging, wraps and all components were measured and weighted. The list of all 30 sample products were broken down into their components with their weight and volume (V_k, W_k) (Appendix C).

For future implementation, the health center can request this information from the vendors since it is onerous to collect this information manually.

4.4.3.2. Contractual Factors

Contractual factors which are defined based on suppliers' contracts and invoices include the following information;

- Cost factor parameters (RC_j, HC_j, FC_j, F_j and TF_j): including rental cost, haul or pick-up cost, fuel cost, static costs and final disposal cost for different streams which are retrieved from contracts.
- Stream parameters (D_j, B_j, TDV_j): including number of dumps, number of bins or containers hauled and total disposed volume or weight which are retrieved from invoices.
- Container information (VS_j): including type of the container, specification and capacity which are retrieved from contracts.

4.4.3.3. ***Fluctuating Factors***

Some products (and components) can be discarded in different streams under different circumstances, for example gloves or Specimen Containers. This is summarized in Figure 3.

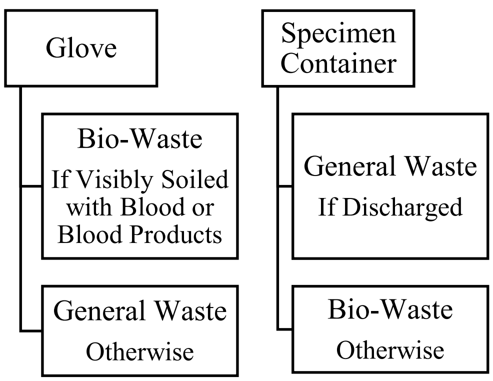


Figure 3: Disposal Fluctuating Factor

Uncertain behavior of these kinds of components is considered in the model by $P_{i,k,j}$. $P_{i,k,j}$ defines the portion of component ks being disposed in stream j and values are obtained from expert opinion. For future studies, the health center can conduct an observation to calculate the exact value of $P_{i,k,j}$.

Chapter 5: Results

5.1. Empirical Results

In this section a summary of collected data is provided. In order to be able to control waste removal costs, information available through contracts and invoices should be translated into a unique mathematical language. In addition to the mathematical costing model, there should be a clear recognition of products specification, usage and disposal treatments. These elements can be made possible by collecting and documenting relevant information which is currently held in distinct sources. In this section the results from the observations and data collections are provided in a categorized order to highlight the current state for the reader.

5.1.1 Information from Contracts for Main Waste Streams

The following information is retrieved from the IWK contracts with different suppliers who are in charge of the waste removal process. Since some data and information from the contracts and invoices are confidential, including prices, only non-confidential information is provided in this document. This information is used to demonstrate the proportion of waste disposed of in each stream.

Dual Container:

Specifications:

- Capacity = 30 Cubic Yards (22.9 m^3)
- Average pick-up time = 3 Times/Week
- Average pick-up weight = 2 Tonnes (2000 Kg)

Approximate annual statistics:

- This container is picked up at least 144 times within a year.
- If we assume the container is full when hauled ;
    - 3,302.9 m^3 of general waste and cardboard is hauled in a year.
    - As the container is split 60% for general waste and 40% for cardboard, 1,981.7 m^3 of general waste and 1,321.2 m^3 of compressed cardboard are removed from the health center within a year.

    - In terms of weight 288,000 Kg of general waste and cardboard is hauled annually.

Closed Top Container:

Specifications:

- Capacity = 30 Cubic Yard (22.9 m^3)
- Average pick-up time = 0.5 Times/Week
- Average pick-up weight = 1 Tonnes (1000 Kg)

Approximate annual statistics:

- This container is picked up at least 24 times within a year.
- If assumed the container is full when hauled ;
    - 550.5 m^3 recyclables are hauled in a year.
    - In terms of weight 24,000 Kg recyclables are hauled annually.

Green Bins:

Specifications:

- Capacity = 64 Gallons (0.2 m^3)
- Average pick-up time = 4 Times/Week

Approximate annual statistics:

- Organics are picked up 192 times in a year.
- On average 452 bins are removed in a year.
- If assumed the bins are full when hauled, 109.5 m^3 of organics are removed in a year.

Bio-Waste Grey Bins

Specifications:

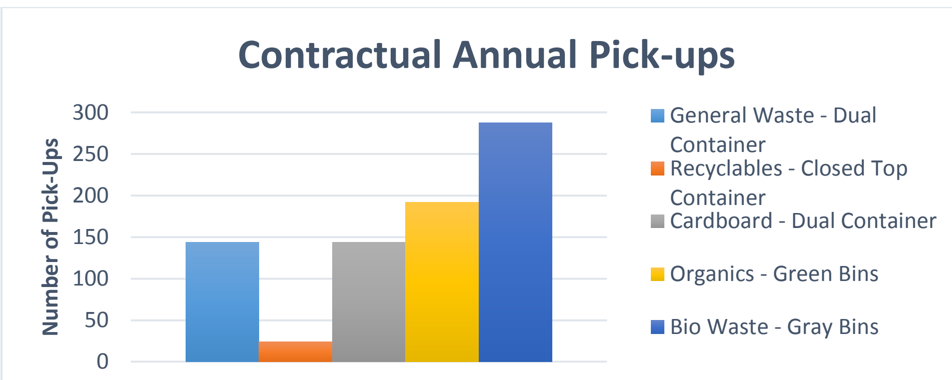
- Capacity = 96 Gallons (0.4 m^3)
- Average pick-up time = 6 Times/Week
- Average pick-up weight = 20 Kg

Approximate annual statistics:

- Grey bins are picked up 288 times in a year.
- On average, 6471 bins have been removed in a year.
- If assumed the bins are full when hauled;
  - 2,318.8 m^3 of bio-waste is discarded in 2013.
  - In terms of weight 127,620 Kg of bio-waste is discarded in 2013.

Pick-up frequency based on contractual information is provided in Chart 1. As illustrated, bio-waste has the highest pick-up rate, which is reasonable since it is hazardous and cannot be kept longer than a predefined safe time to get removed from temporary storage. Organics are the next most frequently picked up waste as the contents will biodegrade rapidly.

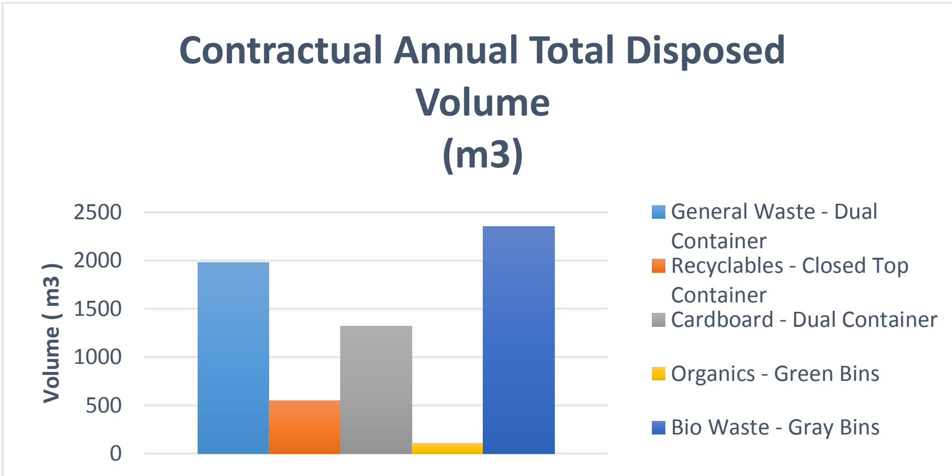
Figure 4-*Contractual Annual Pick-ups*



Disposed volume for the IWK main waste streams based on contractual information is provided in Chart 2. The amounts are provided with the assumption that the containers get hauled when they are full.

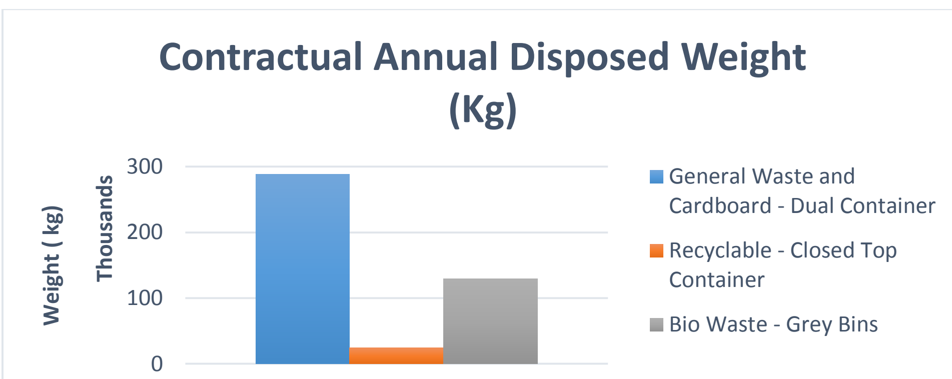
Bio-waste, general waste and cardboard are the top three disposed waste streams in the IWK. As the facility in the study is a hospital, bio-waste is frequently produced and since most of the products can be discarded in general waste including office areas, clinical areas, food services and public areas, this stream is also generated widely throughout the institution. Cardboard is another great waste stream since most of the products are brought to the hospital in cardboard packaging.

Figure 5-Contractual Annual Total Disposed Volume



The disposed weight for main waste containers based on contractual information is provided in Chart 3. The amounts are provided with the assumption that the containers get hauled when they are full. As illustrated in the graph, the dual container's total disposed weight is the highest as it is determined by two great waste streams in the IWK. Recyclables are the lightest as they are mostly large but not heavy like bottles or boxes.

Figure 6-Contractual Annual Disposed Weight



5.1.2 Information from Invoices for Main Waste Streams

The following data are retrieved from 2013 invoices indicating the amount of waste actually disposed of in 2013. Non confidential amounts are provided as follows;

General Waste / Cardboard – Dual Container

- Number of pick-ups = 157 Times

- Total disposed waste = 358,140 Kilograms

Recyclables – Closed Top Container

- Number of pick-ups = 26 Times

Organics – Green Bins

- Number of pick-ups = 182 Times
- Number of bins = 452 Bins

Bio-Waste – Grey Bins

- Number of pick-ups = 320 Times
- Number of bins = 6,381 Bins
- Total disposed waste = 138,115.9 Kg

Cytotoxic Waste – Red Buckets

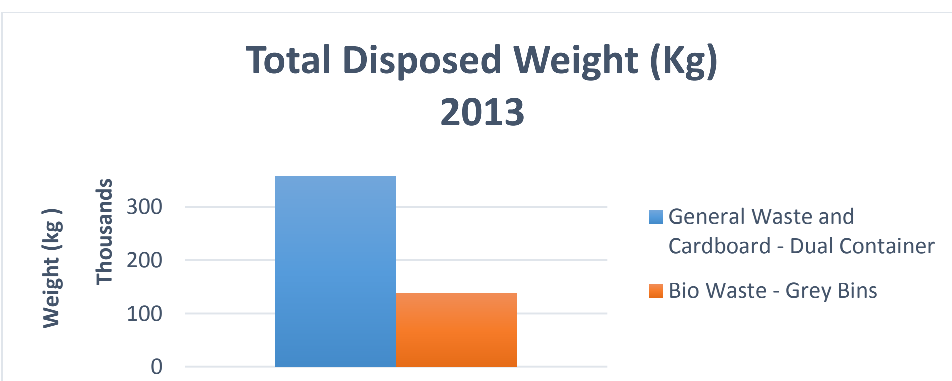
- Number of BINS = 1,440 Bins
- Total disposed waste = 4,544.6 Kg

Pharmaceuticals – White Buckets

- Number of bins = 585 Bins
- Total disposed waste = 4,010.8 Kg

Total disposed weight for general waste, cardboard and bio-waste is provided in Chart 4. As illustrated in the graph, although the facility under study is a hospital, the majority of its waste is not infectious.

***Figure** 7-2013 Total Disposed Weight*



5.2 Model Outputs

In this section the model results are highlighted for each chosen product. The purpose is to determine the annual discarding cost for each product. We determine this cost under three scenarios. An optimistic scenario which sees the majority of products disposed of correctly; a pessimistic scenario takes into account common disposal mistakes; and a "most likely" scenario which best reflects the current situation. As such, the "most likely" scenario is referred to as the "current" scenario for simplicity.

Studying discarding cost of each product in the optimistic, current and pessimistic disposal scenarios can illustrate potential improvement areas. Scenario descriptions, differences, and results are reviewed and discussed in this section.

The different scenarios are accounted for in the model using different values in the $P_{i,k,j}$ matrix. As described earlier, the components of this matrix for each product show the portion of component ks get discarded in stream j. The behavior of people throwing products out makes the components of this matrix.

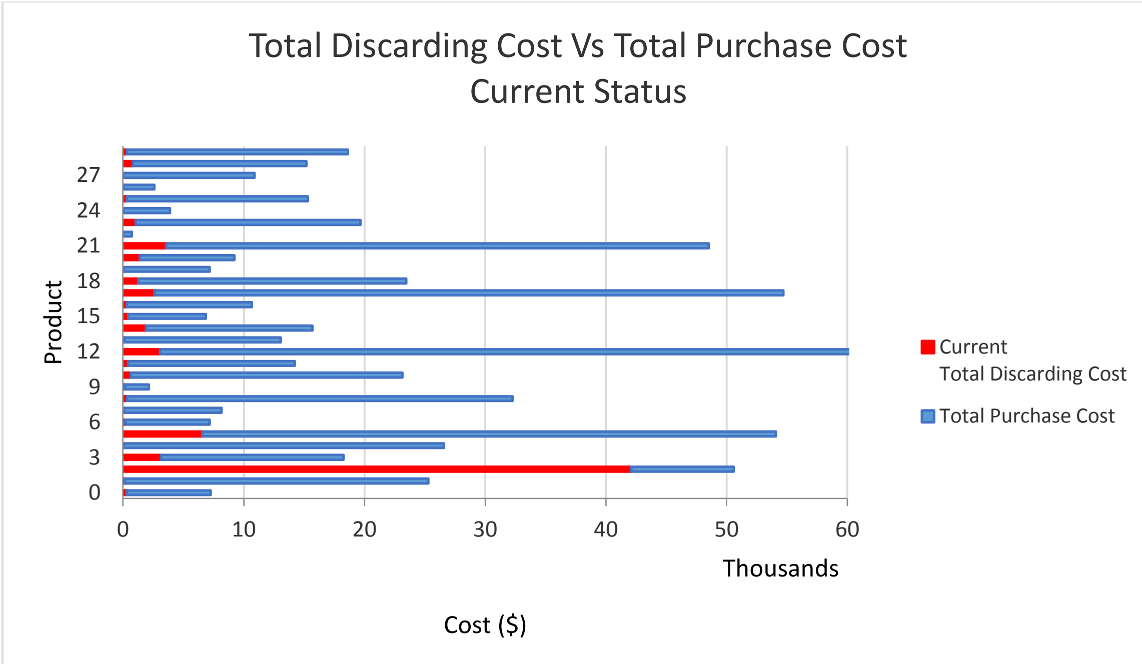
5.2.1 Current Status Scenario

The current status scenario expresses the ongoing disposal process for each product in the IWK. The current portion of components that gets discarded in different streams is used as the model fluctuating factors ($P_{i,k,j}$ matrix) for this scenario. Data are collected based on conducted observations and expert opinion. The results illustrate the total cost of each product with the current purchasing and disposal strategies. The current scenario results are shown in Chart 5 and Table 4.

__Table 4__-Current Scenario Results

Product ID	SAP No.	Current Scenario			
i		Total Discarding Cost ($) TDC_i	Total Purchase Cost ($) TPC_i	Total Cost ($) TC_i	% Total Discarding Cost to Total Cost
0	100341	317.84	6,948.82	7,266.66	4.37
1	104016	161.44	25,140.24	25,301.68	0.64
2	103163	42,093.21	8,510.67	50,603.88	83.18
3	103144	3,134.24	15,139.55	18,273.79	17.15
4	102778	54.35	26,531.72	26,586.07	0.2
5	104315	6,570.15	47,528.27	54,098.42	12.14
6	104105	192.02	6,991.36	7,183.38	2.67
7	103883	85.30	8,066.58	8,151.88	1.05
8	104069	325.24	31,940.22	32,265.46	1.01
9	103496	181.15	1,948.46	2,129.61	8.51
10	104174	642.18	22,487.76	23,129.94	2.78
11	105499	403.07	13,836.70	14,239.77	2.83
12	104318	3,060.30	59,231.19	62,291.49	4.91
13	103965	138.78	12,921.30	13,060.08	1.06
14	104316	1,903.19	13,777.74	15,680.93	12.14
15	104688	431.76	6,424.54	6,856.30	6.3
16	104179	306.75	10,364.29	10,671.04	2.87
17	105326	2,602.30	52,107.30	54,709.60	4.76
18	104220	1,259.18	22,194.45	23,453.63	5.37
19	104039	56.10	7,129.62	7,185.72	0.78
20	103165	1,383.81	7,845.11	9,228.92	14.99
21	119993	3,556.05	44,957.10	48,513.15	7.33
22	103481	15.75	707.34	723.09	2.18
23	104698	1,043.74	18,621.24	19,664.98	5.31
24	104037	37.40	3,851.28	3,888.68	0.96
25	103621	303.65	15,004.10	15,307.75	1.98
26	103765	39.93	2,538.12	2,578.05	1.55
27	103566	6.88	10,889.78	10,896.66	0.06
28	104215	818.67	14,378.16	15,196.83	5.39
29	108989	331.84	18,296.38	18,628.22	1.78
	Total	71,456.27	536,309.39	607,765.66	

Figure 8-Current TDC Vs TPC



Current Status Outstanding Points

1. *i=2; SAP No.103163; Container Specimen 800ML*

According to the current status, empty specimen containers and their wraps are discarded in general waste and bio-waste with an equal probability. Discarding cost of this product is 83% of its total cost. This is because it is large and cannot be compressed when discarded. Currently the hospital is spending 5 times more than purchasing cost to have it discarded.

2. *i=3, SAP No.103144; Tubing Suction Non Conduct STER 7MM 6FT*

According to the current status, this product is discarded in bio-waste which is a proper disposal method. But it is an outstanding product, since its discarding cost is 17% of the total cost which is significant. The reason is that this product is a heavy bio-waste.

3. *i=20, SAP No.103165; Bath Sitz with Graduated Bag*

According to the current status, this product is discarded in bio-waste for 50% of the cases and as it is large and cannot be compressed, its discarding cost is significant. The hospital spends 15% of the total cost to have it discarded.

4. i=5, SAP No.104315; Glove Exam and i=14, SAP No.104316; Glove Exam

According to the current status, these gloves are discarded in bio-waste in 50% of the cases. As gloves are highly used in the hospital, 12% of the total cost is spent for having them discarded which is significant for a light and small product.

5.2.2 Other Scenarios

In order to be able to find products which are effective for waste cost reduction, the optimistic and pessimistic discarding scenarios are studied. This will facilitate detection of products which have a considerable gap between their optimistic and pessimistic discarding cots and accordingly can make potential saving opportunities. Thus through analyzing these scenarios, it is possible to find how far the current discarding strategies are from the proper strategies.

In this section the optimistic and pessimistic discarding scenarios are studied, but the model is capable of investigating any other desired scenarios. As explained earlier, the matrix of fluctuating factors $P_{i,k,j}$ is changes for different scenarios which arises from disposal behaviors.

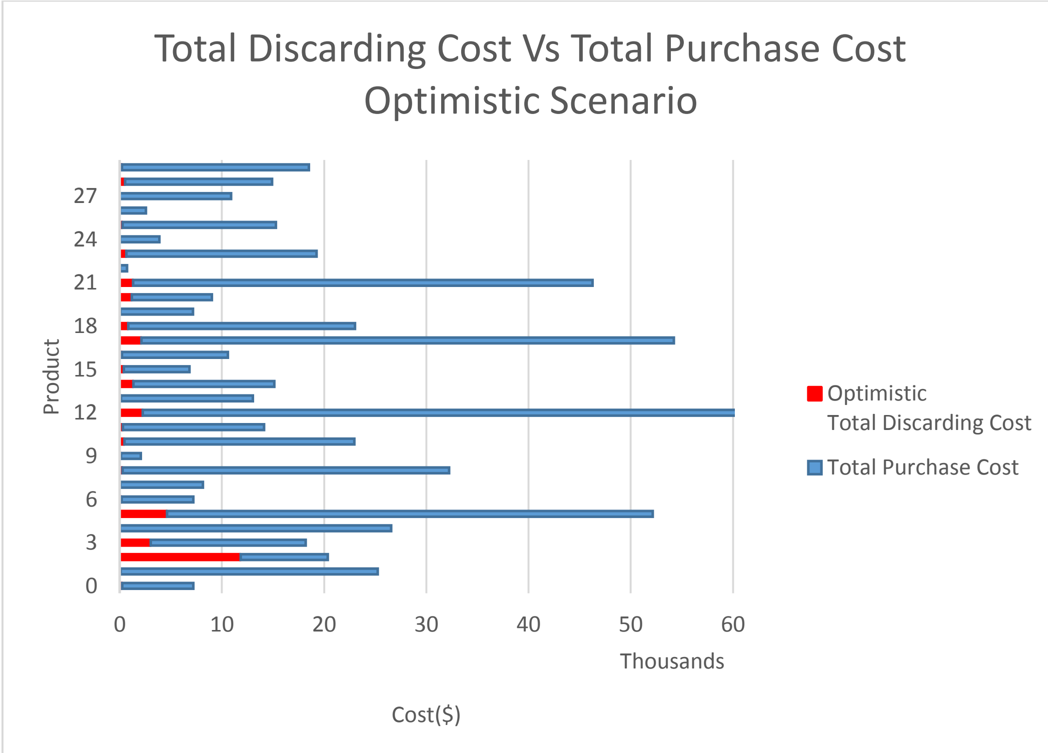
5.2.2.1 Optimistic Discarding Scenario

In this scenario, it is assumed that all components of the products are discarded in proper streams. Fluctuating factors values are defined based on conducted observations and expert opinion. The model is run with the optimistic values and the results are shown in Table 5 and Chart 6.

Table 5-Optimistic Scenario Results

Product ID	SAP No.	Optimistic Scenario			
i		Total Discarding Cost ($)	Total Purchase Cost ($)	Total Cost ($)	% Total Discarding Cost to Total Cost
0	100341	243.16	6,948.82	7,191.98	3.38
1	104016	97.26	25,140.24	25,237.50	0.38
2	103163	11,833.09	8,510.67	20,343.76	58.16
3	103144	3,039.31	15,139.55	18,178.86	16.72
4	102778	34.19	26,531.72	26,565.91	0.13
5	104315	4,631.30	47,528.27	52,159.57	8.88
6	104105	189.80	6,991.36	7,181.16	2.64
7	103883	61.02	8,066.58	8,127.60	0.75
8	104069	275.19	31,940.22	32,215.41	0.85
9	103496	122.36	1,948.46	2,070.82	5.91
10	104174	468.55	22,487.76	22,956.31	2.04
11	105499	294.09	13,836.70	14,130.79	2.08
12	104318	2,253.03	59,231.19	61,484.22	3.66
13	103965	116.55	12,921.30	13,037.85	0.89
14	104316	1,341.56	13,777.74	15,119.30	8.87
15	104688	404.12	6,424.54	6,828.66	5.92
16	104179	224.30	10,364.29	10,588.59	2.12
17	105326	2,109.22	52,107.30	54,216.52	3.89
18	104220	823.98	22,194.45	23,018.43	3.58
19	104039	45.73	7,129.62	7,175.35	0.64
20	103165	1,177.38	7,845.11	9,022.49	13.05
21	119993	1,316.16	44,957.10	46,273.26	2.84
22	103481	14.33	707.34	721.67	1.99
23	104698	635.16	18,621.24	19,256.40	3.3
24	104037	30.48	3,851.28	3,881.76	0.78
25	103621	264.88	15,004.10	15,268.98	1.73
26	103765	33.91	2,538.12	2,572.03	1.32
27	103566	5.14	10,889.78	10,894.92	0.05
28	104215	535.72	14,378.16	14,913.88	3.59
29	108989	211.09	18,296.38	18,507.47	1.14
	Total	32,832.06	536,309.39	569,141.45	

Figure 9-Optimistic TDC Vs TPC



5.2.2.1.1. Optimistic Scenario Outstanding Points

1. i=2; SAP No.103163; Container Specimen 800ML

If the components are discarded as shown in Table 6 as the optimistic scenario, discarding cost will be reduced by $30,260 and 71.89% for a year, which is significant.

Table 6*-Current Vs Optimistic Fluctuating Factors I*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Optimistic			100%			
Plastic Wrap	Current	50%				50%	
	Optimistic		100%				
Specimen Container	Current	50%				50%	
	Optimistic	100%					

2. i=5, SAP No.104315; Glove Exam PVC PWD/FR

Gloves have high usage frequency in hospitals and therefor have high discarding cost. If the components of this product are discarded as shown in Table 7 as the optimistic scenario, discarding cost will be reduced by $1,938 and 29.51% for orders made in a year.

***Table** 7-Current Vs Optimistic Fluctuating Factors II*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Optimistic			100%			
Box	Current	50%				50%	
	Optimistic		100%				
Glove	Current	50%				50%	
	Optimistic	80%				20%	

3. i=12, SAP No.104318; Wipe Wet Dispenser Can

Since this product has a large and hard plastic container, its proper disposal can make a considerable improvement. If the components of this product are discarded as shown in Table 8 as the optimistic scenario, discarding cost will be reduced by $807 and 26.38% for orders made in a year.

***Table 8**-Current Vs Optimistic Fluctuating Factors III*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Optimistic			100%			
Empty Container	Current	100%					
	Optimistic		100%				
Wipe	Current	100%					
	Optimistic	100%					

4. i=14, SAP No.104316; Glove Exam PVC PWD/FR

If the components of this product are discarded as shown in Table 9 as the optimistic scenario, discarding cost will be reduced by $562 and 29.51% for orders made in a year.

***Table 9-**Current Vs Optimistic Fluctuating Factors IV*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Optimistic			100%			
Box	Current	50%				50%	
	Optimistic		100%				
Glove	Current	50%				50%	
	Optimistic	80%				20%	

5. i=21, SAP No.119993; IV Lac Ringers 1000ML

If the components of this product are discarded as shown in Table 10 as the optimistic scenario, discarding cost will be at least reduced by $2,240 and 62.99% for orders made in a year, which is considerable.

***Table 10**-Current Vs Optimistic Fluctuating Factors V*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Optimistic			100%			
Plastic Wrap	Current	20%				80%	
	Optimistic		100%				
IV Bag	Current	20%				80%	
	Optimistic	100%					

5.2.2.1.2. Model Output Variation

By applying suggested possible improvement actions as optimistic disposal scenario for sample products, the saving expected would be $38,624 for orders made in a year.

Chart 7 illustrates the difference between the current discarding cost and the optimistic discarding cost for the top five products (in terms of absolute savings). These amounts will be more significant if improvements applied for all other similar products within the hospital. This will be discussed in detail in the Product Specific Analysis Section (Section 5.3).

***Figure 10**-Current TDC Vs Optimistic TDC I*

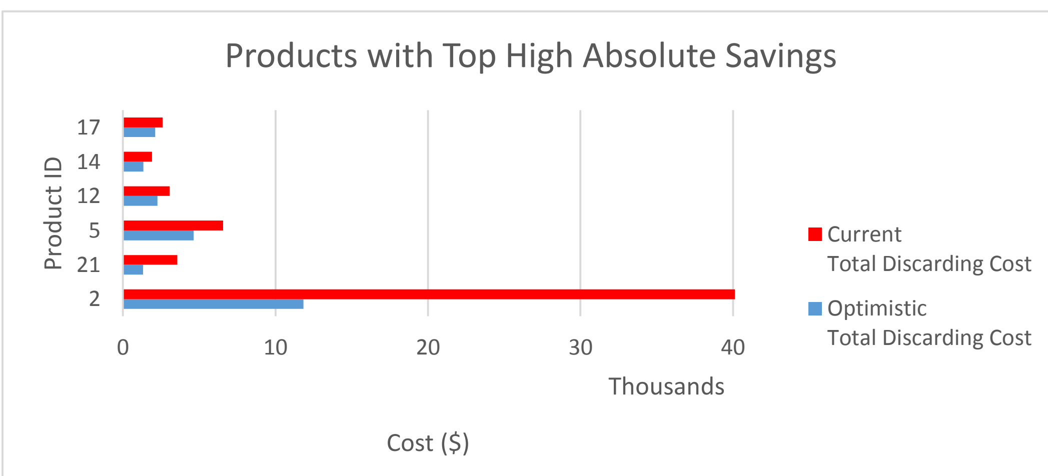
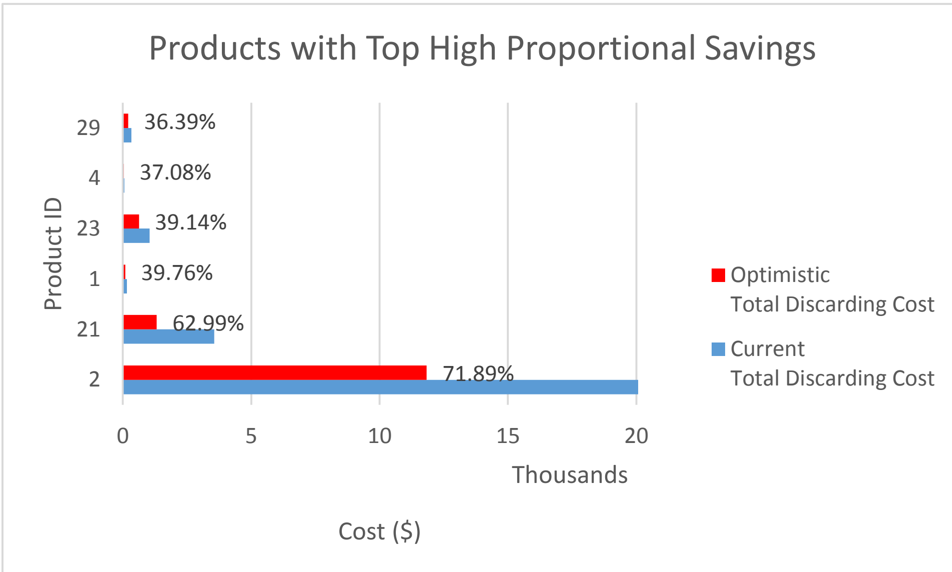


Chart 8 presents the current annual total discarding cost and the optimistic annual total discarding cost for the top five projects (in terms of proportional savings).

***Figure 11**-Current TDC Vs Optimistic TDC II*



5.2.2.1.3. Conclusion

The results visibly show that even small changes like discarding a plastic container in recyclables instead of general waste can have significant reduction in waste cost especially for heavier and bigger components of the products.

For some of the products, there is a very small difference between the current and the optimistic discarding cost. This is because some of them are regulated to be discarded in certain streams, therefore there is not a great chance for improvement in their disposal behavior. These products will be discussed in detail in the Product Specific Analysis Section (Section 5.3).

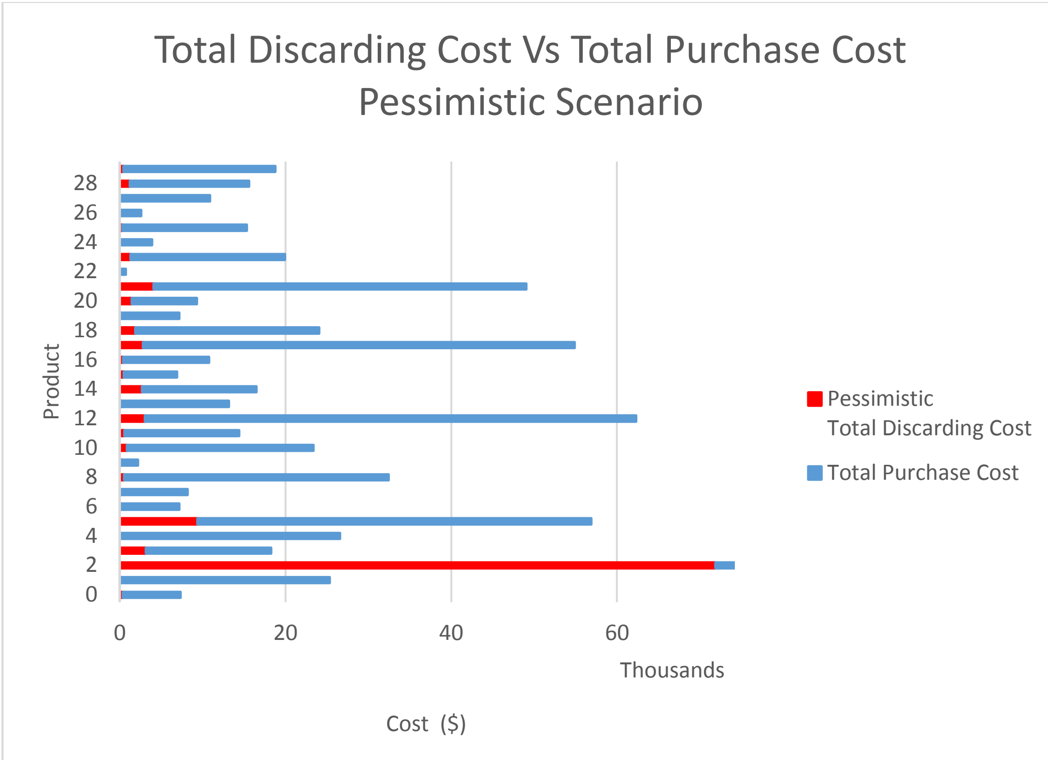
5.2.2.2. Pessimistic Discarding Scenario

In the pessimistic scenario we take into account common disposal mistakes, such as disposing of non-soiled gloves in bio-waste, and assume that all products are disposed of in this mistaken manner. We account for the disposal mistakes for all products at the same time, meaning this is the worst case. Discarding mistakes can be caused by personal mistake, lack of knowledge, hastiness or ease of access. Accordingly the fluctuating factors of the model which show the portion of each component discarded in different streams will be changed. Fluctuating factors values are defined based on conducted observations and expert opinion. The model is ran with the pessimistic values and the results are shown in Chart 9 and Table 11.

Table 11*-Pessimistic Discarding Scenario Results*

Product ID	**SAP No.**	**Pessimistic Scenario**			
i		**Total Discarding Cost ($)**	**Total Purchase Cost ($)**	**Total Cost ($)**	**% Total Discarding Cost to Total Cost**
0	100341	373.49	6,948.82	7,322.31	5.1
1	104016	192.80	25,140.24	25,333.04	0.76
2	103163	71,878.55	8,510.67	80,389.22	89.41
3	103144	3,140.32	15,139.55	18,279.87	17.18
4	102778	56.98	26,531.72	26,588.70	0.21
5	104315	9,360.38	47,528.27	56,888.65	16.45
6	104105	192.58	6,991.36	7,183.94	2.68
7	103883	109.59	8,066.58	8,176.17	1.34
8	104069	517.61	31,940.22	32,457.83	1.59
9	103496	239.94	1,948.46	2,188.40	10.96
10	104174	882.37	22,487.76	23,370.13	3.77
11	105499	553.83	13,836.70	14,390.53	3.85
12	104318	3,060.30	59,231.19	62,291.49	4.91
13	103965	224.37	12,921.30	13,145.67	1.71
14	104316	2,711.45	13,777.74	16,489.19	16.44
15	104688	491.65	6,424.54	6,916.19	7.11
16	104179	422.41	10,364.29	10,786.70	3.92
17	105326	2,798.08	52,107.30	54,905.38	5.1
18	104220	1,863.26	22,194.45	24,057.71	7.74
19	104039	48.91	7,129.62	7,178.53	0.68
20	103165	1,472.81	7,845.11	9,317.92	15.81
21	119993	4,096.18	44,957.10	49,053.28	8.35
22	103481	17.17	707.34	724.51	2.37
23	104698	1,305.49	18,621.24	19,926.73	6.55
24	104037	32.61	3,851.28	3,883.89	0.84
25	103621	323.53	15,004.10	15,327.63	2.11
26	103765	38.78	2,538.12	2,576.90	1.5
27	103566	6.98	10,889.78	10,896.76	0.06
28	104215	1,211.42	14,378.16	15,589.58	7.77
29	108989	452.59	18,296.38	18,748.97	2.41
	Total	108,076.43	536,309.39	644,385.82	

Figure 12-Pessimistic TDC Vs TPC



5.2.2.2.1. Pessimistic Scenario Outstanding Points

1. i=2; SAP No.103163; Container Specimen 800ML

If the components of this product get discarded as shown in Table 12, discarding cost will be increased by $29,785 and 70.76% for containers ordered within a year. This amount is significant.

Table 12*-Current Vs Pessimistic Fluctuating Factors I*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Pessimistic			100%			
Plastic Wrap	Current	50%				50%	
	Pessimistic					100%	
Specimen Container	Current	50%				50%	
	Pessimistic					100%	

2. i=5, SAP No.104315; Glove Exam PVC PWD/FR

Based on conducted observations and expert opinion, 80% of the used gloves are safe to be discarded in general waste. For this type of glove, if the components get discarded as shown in Table 13, discarding cost will be increased by $2,790 and 42.47% for gloves ordered within a year. This is significant since there are many different types of gloves used in hospital with the same behavior.

Table 13*-Current Vs Pessimistic Fluctuating Factors II*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Pessimistic			100%			
Box	Current	50%				50%	
	Pessimistic					100%	
Glove	Current	50%				50%	
	Pessimistic					100%	

3. i=14, SAP No.104316; Glove Exam PVC PWD/FR

This type of glove has the same disposal behavior as the previously discussed one, *i=5*. If the components of this product get discarded as shown in Table 14, discarding cost will be increased by $808 and 42.47% for gloves ordered within a year.

Table 14*-Current Vs Pessimistic Fluctuating Factors III*

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Pessimistic			100%			
Box	Current	50%				50%	
	Pessimistic					100%	
Glove	Current	50%				50%	
	Pessimistic					100%	

4. i=18, SAP No.104220; Glove Exam Nitrile PWD/FR

This type of glove also is similar to the previously discussed ones, *i=5* and *i=14*. If the components of this product get discarded as shown in Table 15, discarding cost will be increased by $604 and 47.97% for gloves ordered within a year.

Table 15-Current Vs Pessimistic Fluctuating Factors IV

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharp
Cardboard Packaging	Current			100%			
	Pessimistic			100%			
Box	Current	50%				50%	
	Pessimistic					100%	
Components	**Scenario**	**General Waste**	**Recyclables**	**Cardboard**	**Organics**	**Bio-Waste**	**Sharp**
Glove	Current	50%				50%	
	Pessimistic					100%	

5. *i=21, SAP No.119993; IV Lac Ringers 1000ML*

If the components of this product get discarded as shown in Table 16, discarding cost will be increased by at least $540 and 15.19% for this type of IV Ringers ordered within a year.

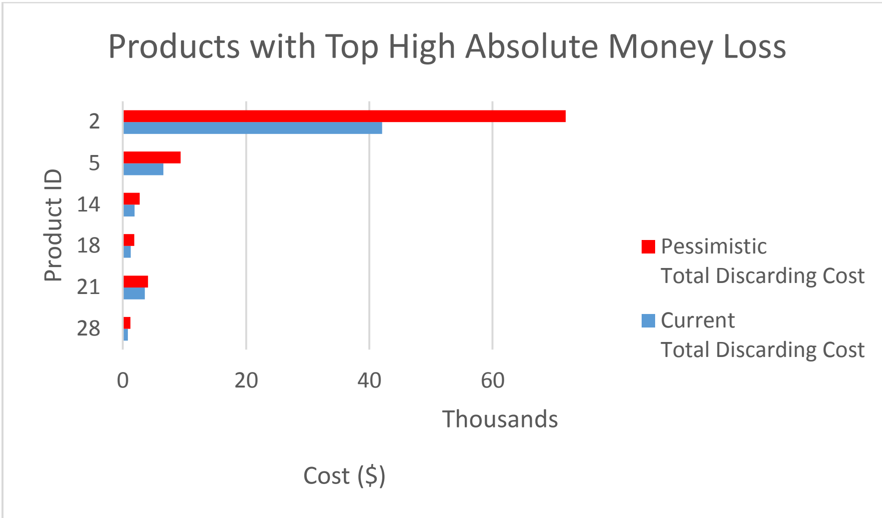
Table 16-Current Vs Pessimistic Fluctuating Factors V

Components	Scenario	General Waste	Recyclables	Cardboard	Organics	Bio-Waste	Sharps
Cardboard Packaging	Current			100%			
	Pessimistic			100%			
Plastic Wrap	Current	20%				80%	
	Pessimistic					100%	
IV Bag	Current	20%				80%	
	Pessimistic					100%	

5.2.2.2.2. Model Output Variation

Chart 10 illustrates the difference between the current discarding cost and the pessimistic discarding cost for sample products with the largest change in costs.

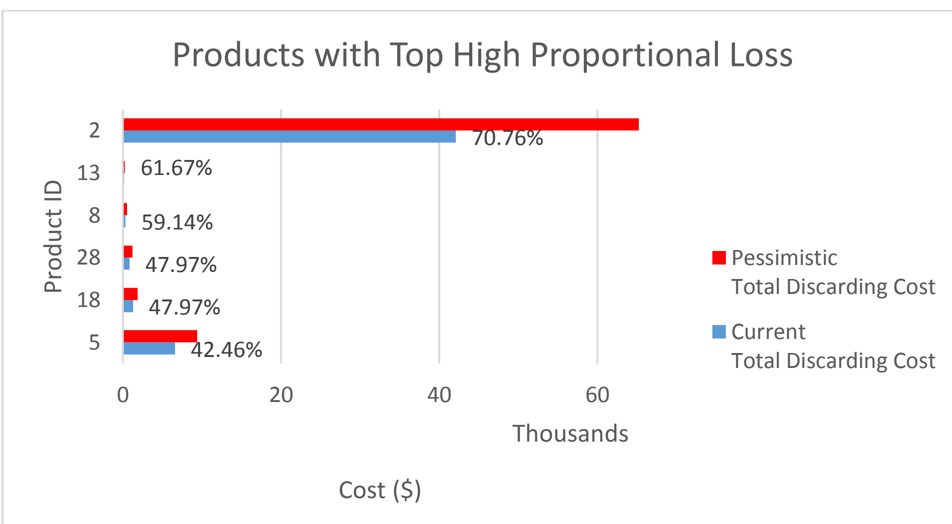
Figure 13*-Current TDC Vs Pessimistic TDC I*



As illustrated in the chart, the cost increase is significant for some products. This will become more so if no action is taken to modify mistakes for all other similar products. Common discarding mistakes and their effects on waste cost will be discussed in detail in the Product Specific Analysis Section (Section 5.3).

Chart 11 presents the current discarding cost and the pessimistic discarding cost for sample products with regard to their proportional change in cost.

Figure 14*-Current TDC Vs Pessimistic TDC II*



5.2.2.2.3. Conclusion

Comparing the current scenario to the pessimistic scenario illustrates that improper disposal will increase the overall waste cost considerably. This implies the importance of source segregation to achieve the goal of waste cost reduction.

As previously described, some of the products are not sensitive to different disposal scenarios, for example sharps or batteries. These products are highly regulated and improper disposal for these items in not a common mistake and hence not considered in our pessimistic scenario analysis. When compared to the current scenario, the change in discarding cost is very low and driven from changes in the disposal of their packaging. This will be discussed in more details in the Product Specific Analysis Section (Section 5.3).

Also worth observing is that some components are disposed of more cheaply in bio-waste than in general waste. This is an unexpected result as the parameters for bio-waste are much more costly than general garbage. However, when products are very light relative to their volume this can occur as bio-waste costs exclude volume whereas general wastes costs include both volume and weight. This was observed in the following products:

- i=19, SAP No.104039; Catheter IV Auto guard 24G
- i=24, SAP No.104037; Catheter IV Auto guard Safety 22G
- i=26, SAP No.103765; Kit Arterial Blood Sample 1ML

Since the objective of natural resources related research is to reduce cost while not increasing environmental risks, it is important to try to reduce flow of non-hazardous waste discarded in hazardous streams. For this reason, although it is cheaper to discard very light components like plastic wraps, gloves, plastic bags, etc. in streams with lower final discarding cost per weight, it is more important to have them discarded in a more appropriate stream.

These types of components have to be compressed prior to disposal in order to be discarded optimally. Light and soft products like plastic wraps or gloves will be compressed enough in buckets and accordingly will not have higher discarding cost if discarded in the proper stream. But hard light products like some paper and plastic wraps have to be compressed before being dumped to avoid this problem.

As an example, product IV Catheter (i=19) has a hard plastic wrap. The effect of getting compressed and discarded in discarding cost is shown in Table 17. The money difference is not significant, but it will be more considerable when applied to all products' hard wraps.

Table 17-*Compression Prior To Disposal Effect*

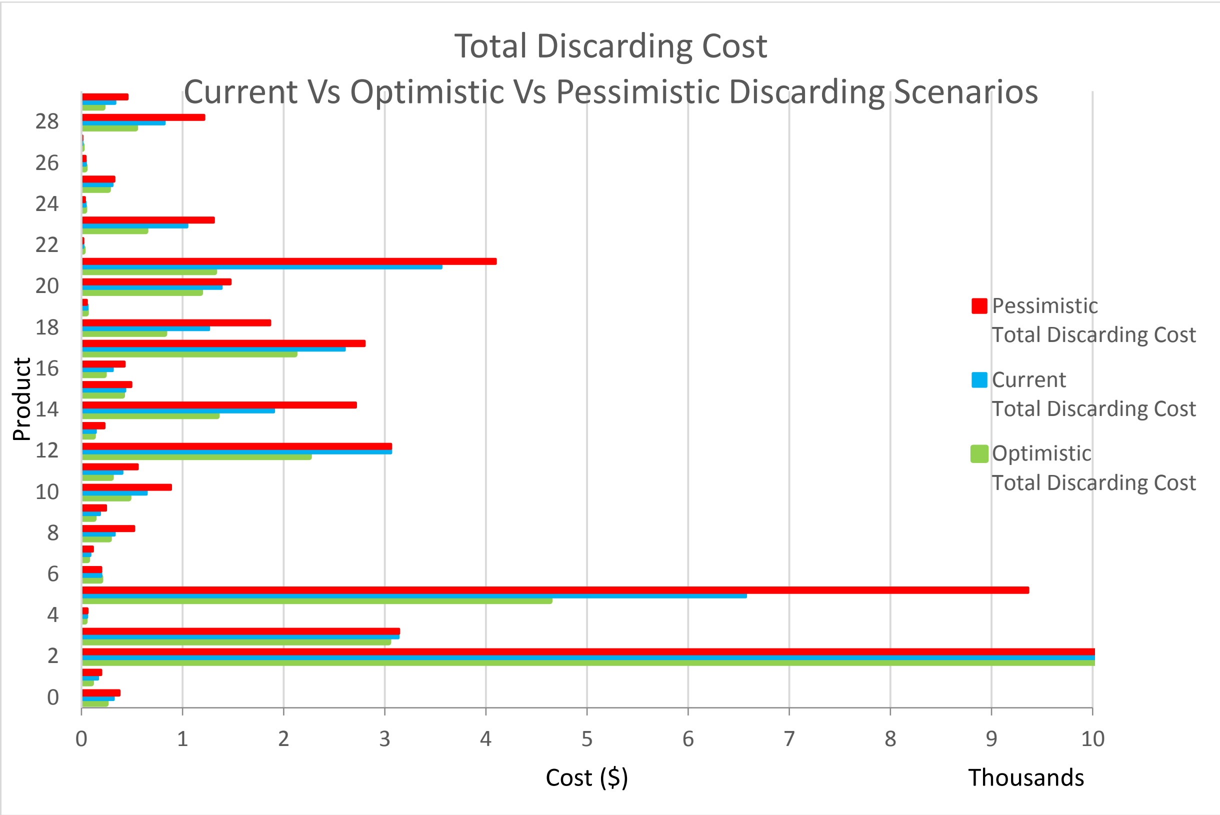
i=19	**Cubic Meters**	**Optimistic DC ($)**	**Current DC ($)**	**Pessimistic DC ($)**
Volume	0.00038	45.73	56.1	48.91
Compressed Volume	0.00018	41.1	46.89	47.03

Generally in order to achieve to the optimal discarding cost it is essential to make sure the components are compressed prior to disposal.

5.2.3. Summary

As demonstrated, the model can be used to compute the discarding cost of each product. Three scenarios, current, optimistic and pessimistic discarding scenarios have been run for thirty sample products to demonstrate how different factors influence the overall waste cost. Chart 12 shows sample products' discarding cost variation in the different scenarios.

***Figure 15**-Current Vs Optimistic Vs Pessimistic TDC*



5.3. Product Specific Analysis

In this section the thirty sample products from the IWK are reviewed in detail in order to highlight their proper disposal strategy. Next we classify these products based on the following:

- General Specification
- Disposal Specification

- Product Classification

And report a detailed breakdown of their costs under the current, optimistic, and pessimistic scenarios. From this classification and cost analysis disposal strategies are provided. From this analysis, it is possible for the hospital to derive disposal strategies for other products with similar classifications.

5.3.1. Definitions

5.3.1.1. General Specification

General specification of the products can help in recognizing them. As discussed earlier in the Implementation of the Model Section (Section 4.4), Table 3 presented visual characteristics of sample products in the IWK. Those characteristics can be expanded for all other products in the hospital. The following characteristics are considered;

- *Large and Hard*

Products which are large and hard cannot be compressed when discarded, therefore will occupy a great space in waste removal buckets or containers. For this reason these kinds of products are potential to affect waste cost and should be considered for disposal process review.

- *Heavy*

Heavy products are very effective on waste cost because the final disposal costs mostly are calculated based on waste weight. Therefore their disposal process should be reconsidered to make sure they are discarded properly.

- *High Usage*

Even if a product is cheap to be discarded, if it is used highly in the health center, discarding cost will affect the overall waste cost. Therefore as discussed before, highly used products are the most important ones to review.

- *Recyclables*

Recyclables are very important as sorting them is valuable for both the organization and the environment. For this reason products which can be recycled should be considered as potential products to reduce cost or make revenue.

- *Specialized Packs*

Specialized packs are important since they are very common in the hospital and also when they are opened, all the components inside have to be discarded even if they are not used. Therefore there may be lots of money-saving opportunities through their proper disposal.

- *Non-Hazardous*

Since hospital hazardous waste disposal rules are strictly enforced and generally complied with, there is little opportunity for improvement or savings. For this reason non-hazardous products have a higher potential for enhancing proper disposal methods and savings.

- *Expensive Products with Low Purchasing Cost*

A product type of particular concern in this study are those which are cheap to purchase but expensive to dispose of. Since they are cheap to purchase they are often overlooked as a priority product. This is particularly problematic when these products are heavy, large and hard or highly used.

5.3.1.2. Disposal Specification

In this section, we will categorize our products based on their characteristics at the time of disposal.

- *Dischargeable Products - Waste Cost Reduction if Discharged*

Some products at the time of discard contain different non-hazardous material. If this non-hazardous material is discharged before getting discarded, they will be lighter and also can be dumped in a cheaper non-hazardous stream. This action can effectively reduce waste cost while is also an environmental friendly improvement.

- *Not Visibly Soiled Products - Waste Cost Reduction if Not Soiled*

Some products can be discarded in cheaper non-hazardous streams if they are not visibly soiled by blood or blood products.

- *Ineffective Products - Special Waste Stream Disposal*

Products which are discarded in special streams (e.g. Sharps) are strictly enforced and generally complied with. As a result, there is little opportunity for improvement or savings for products in this classification. Disposal specifications of sample products are summarized in Table 18.

***Table 18**-Disposal Specification of Sample Products*

Product ID	Description	Dischargeable Products	Not Visibly Soiled Products	Ineffective Products
0	Glove Exam Single		✓	
1	Syringe Sampling			✓
2	Container Specimen	✓		
3	Tubing Suction Non Conduct			✓
4	Set Blood Collection Safety			✓
5	Glove Exam		✓	
6	Tubing Oxygen Supply			
7	Gel Ultrasound			
8	Set Enteral Feed Pump		✓	
9	Bag Patient Belonging	✓		
10	Glove Surgical Neolon		✓	
11	Glove Surgical Neolon		✓	
12	Wipe Wet Dispenser Can	✓		
13	Enteral Delivery Pump		✓	
14	Glove Exam PVC		✓	
15	Urethral Catheterization Tray	✓	✓	
16	Surgical Glove Neolon		✓	
17	Sterile Delivery Pack	✓	✓	✓
18	Glove Exam Nitrile		✓	

Product ID	Description	Dischargeable Products	Not Visibly Soiled Products	Ineffective Products
19	Catheter IV Auto guard			✓
20	Bath Sitz with Graduated Bag	✓	✓	
21	IV Lac Ringers	✓		
22	Toothbrush			
23	Liner Suction System Flex	✓		
24	Catheter IV Auto guard Safety			✓
25	Needle Blunt Fill Safety			✓
26	Kit Arterial Blood Sample			✓
27	Device Bag Access Blood			✓
28	Glove Exam Nitrile		✓	
29	Cleanser CRM	✓		

5.3.1.3. Products Classification

As previously explained products can be categorized in different classes based on their characterization and disposal treatment. Products in the same class have the same disposal pattern and the same disposal strategy can applied. Our sample products have been categorized in Appendix D in the following categories:

- Dischargeable – can be discharged and then discarded in a cheaper stream.
- Hazardous if soiled by blood or blood products – is counted as bio-waste, otherwise is general waste.
- Hospital special pack
- No contact with hazardous materials – can be discarded in non-hazardous streams.
- Strictly Controlled – have to be discarded in one special stream.

Some of the products in the IWK SAP which are in the same class with these product are also listed in the table provided in Appendix D.

5.3.2. Analysis

I. Gloves

General Specification

Gloves are used for medical examinations to avoid risk of contamination. They are highly used in hospitals with different types and purposes. They are small and light but as they are highly used, their discarding cost is significant.

There are 74 different gloves in the IWK SAP which have the same pattern for disposal. The following gloves are studied in this thesis.

- i=0; SAP No.100341; Glove Exam Single Sterile LT-FR
- i=5; SAP No.104315; Glove Exam PVC PWD/FR
- i=10; SAP No.104174; Glove Surgical Neolon
- i=11; SAP No.105499; Glove Surgical Neolon
- i=14; SAP No.104316; Glove Exam PVC PWD/FR
- i=16; SAP No.10479; Surgical Glove Neolon 2G 7.0
- i=18; SAP No.104220; Glove Exam Nitrile PWD/FR
- i=28; SAP No.104215; Glove Exam Nitrile PWD/FR

High usage while being small and light are the main characteristics of gloves. They are flexible in volume and can be compressed while discarded. They are generally cheap to purchase and for these reasons are not considered special or expensive to get discarded. However, since they are used so frequently their total discarding cost is significant.

Disposal Specification

Gloves can safely get discarded in general waste if not visibly soiled by blood or blood products [11], otherwise have to get discarded in bio-waste. Based on conducted observations and expert information, in 20% of the cases gloves are visibly soiled and have to get discarded in bio-waste yellow bags.

If not visibly soiled gloves get discarded correctly in general waste instead of having all gloves discarded in bio-waste for different reasons like lack of knowledge or hastiness, there will be a significant reduction in total discarding cost.

To emphasize the importance of glove products, the discrepancy between the cost of the optimistic scenario and the pessimistic scenario is shown in Table 19.

Table 19*-Optimistic and Pessimistic Cost Discrepancy I*

Product ID	Description	Annual Discrepancy ($)
0	Glove Exam Single Sterile LT-FR	130.33
5	Glove Exam PVC PWD/FR	4,729.08
10	Glove Surgical Neolon	413.83
11	Glove Surgical Neolon	259.74
14	Glove Exam PVC PWD/FR	1,369.88
16	Surgical Glove Neolon 2G 7.0	198.11
18	Glove Exam Nitrile PWD/FR	1,039.21
28	Glove Exam Nitrile PWD/FR	675.7

Products Classification

Gloves are in the “Hazardous if Soiled by Blood or Blood Products” class of products. Dressings, sponges, diapers and pads are other products in this category. There are 74 different types of gloves in the IWK SAP which have the same strategy for disposal.

Some other products in the IWK SAP which are in the same class with these products are listed in appendix D. Another 232 products have been identified in the IWK SAP system that are in this class and therefore have the same disposal strategy. A detailed breakdown of glove costs under the current, optimistic, and pessimistic scenarios is shown in Table 20.

Table 20-Sample Metrics I

		i=0	i=5	i=10	i=11	i=14	i=16	i=18	i=28
Total Purchase Cost ($)		6,948.8	47,528.2	22,487.7	13,836.7	13,777.7	10,364.2	22,194.4	14,378.2
Current Scenario	Total Discarding Cost ($)	317.84	6,570.1	642.18	403.07	1,903.1	306.75	1,259.18	818.67
	Total Cost ($)	7,266.6	54,098.4	23,129.9	14,239.7	15,680.9	10,671	23,453.6	15,196.8
	%Total Discarding Cost to Total Cost	4.37	12.14	2.78	2.83	12.14	2.87	5.37	5.39
Optimistic Scenario	Total Discarding Cost ($)	243.16	4,631.3	468.55	294.09	1,341.5	224.3	823.98	535.72
	Total Cost ($)	7,191.9	52,159.5	22,956.3	14,130.7	15,119.3	10,588.5	23,018.4	14,913.9
	%Total Discarding Cost to Total Cost	3.38	8.88	2.04	2.08	8.87	2.12	3.58	3.6
	Total Discarding Cost Difference ($)	74.68	1,938.8	173.63	108.98	561.63	82.44	435.2	282.95
	%Reduction	23.5	29.51	27.04	27.04	29.51	26.88	34.56	34.56
Pessimistic Scenario	Total Discarding Cost ($)	373.49	9,360.3	882.37	553.83	2,711.45	422.41	1,863.26	1,211.42
	Total Cost ($)	7,322.3	56,888.6	23,370.1	14,390.5	16,489.1	10,786.7	24,057.7	15,589.6
	%Total Discarding Cost to Total Cost	5.1	16.45	3.77	3.845	16.44	3.92	7.74	7.77
	Total Discarding Cost Difference ($)	-55.65	-2,790.2	-240.20	-150.76	-808.25	-115.67	-604.08	-392.75
	%Reduction	-17.51	-42.47	-37.4	-37.40	-42.47	-37.7	-47.97	-47.97

A summary of the disposal strategy for all components of the glove product follows:

- Cardboard packaging should be discarded in cardboard stream.
- Boxes and plastic wraps have to be discarded in recyclables.
- Products in the “Hazardous if Soiled by Blood or Blood Products” class, have to get discarded in general waste unless they are visibly soiled by blood or blood products. If soiled, they have to get discarded in bio-waste.
- Following the disposal strategy for products in this class, visibly soiled gloves have to go to bio-waste and the rest have to be discarded in general waste.

- Although it is safe if not visibly soiled gloves get discarded in general waste but most of the times they are simply discarded in bio-waste for the reason of being faster or lack of knowledge. Therefore, it is very important to educate staff how to sort gloves and similar products and facilitate it by placing designated bins for general waste and bio-waste in a way that sorting does not cause any delay or distraction.
- Savings arisen from optimistic discarding strategy for some types of glove are not as significant as others in this study, since their usage is less, for example, see product 0 vs. 5. Likewise disposal mistakes do not result in a significant cost increase for them. The consideration is that improper disposal will cause a higher money increase than saving resulted from proper disposal for most of the studied gloves. This acknowledge the importance of proper disposal of these products in waste cost reduction.

II. Products Containing Sharps

General Specification

- i=1; SAP No. 104016; Syringe Sampling;

Sampling syringe is used for collecting an arterial blood sample to determine its gases. These syringes are designed in a way that can minimize air exposure to prevent altering blood gas values. This product is small, light and frequently used in the hospital. It is cheap to purchase and contains sharps which are required to be discarded in a special stream. It comes in boxes, paper and plastic wraps.

- i=4; SAP No. 102778; Set Blood Collection Safety;

This set is used to facilitate blood collection which is an everyday clinical duty. This blood collection set is an expensive product to purchase and as it contains needles which is a special hospital waste. Blood collection set in the IWK comes in boxes and has hard plastic wraps.

- i=19; SAP No.104039; Catheter IV Auto guard 24G

- i=24; SAP No.104037; Catheter IV Auto guard Safety 22G;

IV catheter contains needles and has to be discarded in sharps. There is no other improvement for products like this rather than proper disposal for their wraps and packages. In the optimistic disposal it is assumed that the box and plastic wrap are correctly disposed in recyclables and in the pessimistic disposal they are discarded in bio-waste. The cost difference arisen from this action is very low as shown in Table 21 for orders made within 2013. This is because the wrap is very light.

- i=25; SAP No. 103621; Needle Blunt Fill Safety;

Needle Blunt is a kind of needle used for drawing up medication or accessing IV bags. This kind of needle is more appropriate for faster and safer filling. It is suitable for viscous medication too [121]. This product is very common in the IWK. It is small, light and cheap to purchase. Needle blunt comes in boxes and plastic wraps. It is a kind of needle which makes it a special product for disposal.

- i=26; SAP No. 103765; Kit Arterial Blood Sample;

The Arterial Blood Sampling Kit is intended for sampling of arterial blood for the measurement of blood gases, co-oximetry, electrolytes, total magnesium and the metabolites. This cheap product is very small. It contains a syringe which make it a special hospital waste. It comes in cardboard packaging and hard plastic wraps.

- i=27; SAP No. 103566; Device Bag Access Blood;

Device Access Bag is designed to access directly to IV bags for adding or removing fluid [122]. It is a highly expensive product to purchase. It is small and comes in boxes and plastic wraps. It contains sharps which makes it a special product for disposal.

Disposal Specification

These products contains sharps, therefore have to be discarded in sharps and there is no other improvement action to be taken. The only improvement that can be done is discarding their paper and plastic wraps in recyclables instead of bio-waste. This will result in discrepancy between the costs of the optimistic and the pessimistic scenarios as shown in Table 21. As illustrated the difference is low for the reason of being strictly under disposal regulations.

Table 21*-Optimistic and Pessimistic Cost Discrepancy II*

Product ID	Description	Annual Discrepancy ($)
1	Syringe Sampling	95.54
4	Set Blood Collection Safety	22.78
19	Catheter IV Auto guard 24G	3.18
24	Catheter IV Auto guard Safety 22G	2.12
25	Needle Blunt Fill Safety	58.65
26	Kit Arterial Blood Sample	4.86
27	Device Bag Access Blood	1.84

Products Classification

These products are in the “Strictly Controlled” class of products. All types of products which contain sharps are in this class. Needles, syringes, lancets, blades and clinical glasses are other products in this category. Some other products in the IWK SAP which are in the same class with them are listed in appendix D. Another 263 products have been identified in the IWK SAP system that are in this class and therefore the same disposal strategy can be taken for all of them.

A detailed breakdown of these products’ costs under the current, optimistic, and pessimistic scenarios is shown in Table 22.

A summary of the disposal strategy for all components of these products follows:

- Cardboard packaging has to be discarded in cardboard stream.
- Boxes and wraps have to be discarded in recyclables.
- Products in the “Strictly Controlled” class, are required to get discarded in one special stream based on regulations.
- Following the disposal strategy for products in this class, these products have to be discarded in sharps because they contain needles. According to HCW regulations, this is done absolutely correct in hospitals because of appropriate background education and proper marks and signs for sharps disposal all across the health center.

Table 22-*Sample Metrics II*

		i=1	i=4	i=19	i=24	i=25	i=26	i=27
Total Purchase Cost ($)		25,140.24	26,531.72	7,129.62	3,851.28	15,004.1	2,538.12	10,889.78
Current Scenario	Total Discarding Cost ($)	54.35	54.35	56.1	37.4	303.65	39.93	6.88
	Total Cost ($)	26,586.07	26,586.07	7,185.72	3,888.68	15,307.75	2,578.05	10,896.66
	%Total Discarding Cost to Total Cost	0.2	0.2	0.78	0.96	1.98	1.55	0.06
Optimistic Scenario	Total Discarding Cost ($)	34.19	34.19	45.73	30.48	264.88	33.91	5.14
	Total Cost ($)	26,565.91	26,565.91	7,175.35	3,881.76	15,268.98	2,572.03	10,894.92
	%Total Discarding Cost to Total Cost	0.13	0.13	0.64	0.78	1.73	1.32	0.05
	Total Discarding Cost Difference ($)	20.15	20.15	10.38	6.92	38.77	6.02	1.74
	%Reduction	37.08	37.08	18.5	18.5	12.77	15.07	25.29
Pessimistic Scenario	Total Discarding Cost ($)	56.98	56.98	48.91	32.61	323.53	38.78	6.98
	Total Cost ($)	26,588.7	26,588.7	7,178.53	3,883.89	15,327.63	2,576.9	10,896.76
	%Total Discarding Cost to Total Cost	0.21	0.21	0.68	0.84	2.11	1.5	0.06
	Total Discarding Cost Difference ($)	-2.63	-2.63	7.19	4.79	-19.88	1.16	-0.1
	%Reduction	-4.84	-4.84	12.82	12.82	-6.55	2.89	-1.44

- The paper and plastic wraps or boxes have to be disposed of in recyclables while are discarded in general waste and bio-waste in reality because these product are medical equipment which are in contact with blood. This causes staff to treat the wraps as soiled parts which have to go to bio-waste. This can be improved by educating staff about the recyclable components of the products.
- Blood sampler type products are commonly used in hospitals. The total discarding cost is low as the product is very light and small. There is a small amount of saving possible for this product through proper disposal of its wrap.

- Because the blood collection set product is expensive to purchase as well as being very light and small, its total discarding cost is a very small fraction of its total cost.
- For the IV catheters, as previously discussed in the Model Outputs Section (Section 5.2), their hard plastic wraps have to be compressed prior to disposal. Otherwise the cost of improper disposal would be less than proper disposal as shown in Table 17.

III. Containers

General Specification

- i=2; SAP No. 103163; Container Specimen;

Specimen containers are used to keep urine or stool specimens. The main characteristic of these products is that they are large and hard and therefore will occupy a great volume in bins when discarded and cannot be compressed because they are hard. In addition to the appearance specifications, they are used frequently in the hospital but since they are cheap to purchase are often overlooked as a priority product. They are not hazardous and comes in cardboard packaging and plastic wraps.

- i=7; SAP No. 103883; Gel Ultrasound;

Ultrasound gels are applied to patient's body to facilitate effective transmission of ultrasonic waves into the body [123]. They are not expensive to purchase but have plastic bottles which do not contain any hazardous material and can be recycled. They come in cardboard packaging.

- i=9; SAP No. 103496; Bag Patient Belonging;

Patient belonging bags are very light plastic bags which are purposed to keep patients belongings while staying in the hospital. They are highly used in the IWK by patients. They are cheap to purchase and comes in cardboard packaging.

- i=12; SAP No. 104318; Wipe Wet Dispenser Can;

Wipe dispensers are used in hospitals for immediate surface decontamination [124]. The main characteristic of them is having large and hard cans which can be recycled. As recyclables do not have disposal cost and even in some hospitals can be used as a money recovery stream, being a large and hard recyclable is an important money saving feature. They are expensive to purchase and come in cardboard packaging.

- i=20; SAP No. 103165; Bath Sitz with Graduated Bag;

A sitz bath is a warm water bath containing medication used for pain relief purposes [125]. These light products are large and hard and therefore cannot be compressed while discarded. For this reason they are expensive products to discard. They are also expensive products to purchase. Sitz bath comes in cardboard packaging and plastic wraps.

- i=21; SAP No. 119993; IV Lac Ringers;

Lactated ringer's solutions are sterile solutions used to balance body fluid. They are commonly used in hospitals. They are available in different volumes and types for different applications. Having light bags containing liquid that is not considered as hazardous material are the main characteristics of these products. They are not expensive to purchase and their empty disposed bags are not heavy. They come in cardboard packaging and plastic wraps.

- i=23; SAP No. 104698; Liner Suction System Flex;

Liner suctions are used for collection of fluids collected during suction procedure. They are highly used in the IWK. They are not expensive products but are large and cannot be compressed, therefore are considerable products in terms of disposal. They come in cardboard packaging.

- i=29; SAP No. 108989; Cleanser CRM;

Disinfectant Cream Cleanser is a product used for general disinfection applications in the hospitals. It will be discarded after being finished and the empty bottle is large and recyclable. It is expensive to purchase and comes in cardboard packaging.

Disposal Specification

These products' contents are not hazardous and can be safely discharged in designated sinks. This results in lighter containers which can be disposed of in cheaper streams e.g. general waste or recyclables. A common mistake is to discard the container and contents as bio-waste. This will result in discrepancy between the costs of the optimistic and the pessimistic scenarios as shown in Table 23 for orders made within the study time period. For some products like patient belongings bags or wipe cans, common disposal alternatives are general waste as the pessimistic disposal and recyclables as the optimistic disposal.

Sitz baths are not visibly soiled for 90% of the cases and can be discharged in designated places and safely be discarded in general waste. If the bath and the bag do not get empty, they will be heavier and have to be discarded in bio-waste which is more expensive. The pessimistic scenario is discarding all the components of this product in bio-waste while the empty bag can safely goes to general waste and the empty pan can be discarded in general waste for 90% of the cases.

Table 23*-Optimistic and Pessimistic Cost Discrepancy III*

Product ID	Description	Annual Discrepancy ($)
2	Specimen Container	60,045.46
7	Ultrasound Gel	48.57
9	Patient Belonging Bag	117.57
12	Dispenser Wipe Can	807.27
20	Sitz Bath	295.43
21	IV Ringer	2,780.02
23	Liner Suction	670.32
29	Cleanser	241.49

Products Classification

These containers are in the "Dischargeable" class of products. All types of products which contain non-hazardous material and can be discharged are in this class. Some other products in the IWK SAP which are in the same class with these product are listed in appendix D. Another 67 products have been identified in the IWK SAP system that are in this class and therefore have the same disposal strategy.

A detailed breakdown of these containers' costs under the current, optimistic, and pessimistic scenarios is shown in table 24.

Table 24*-Sample Metrics III*

		i=2	i=7	i=9	i=12	i=20	i=21	i=23	i=29
Total Purchase Cost ($)		8,510.6	8,066.5	1,948.4	59,231.1	7,845.1	44,957.1	18,621.2	18,296.3
Current Scenario	Total Discarding Cost ($)	42,093.2	85.3	181.15	3,060.3	1,383.81	3,556.05	1,043.74	331.84
	Total Cost ($)	50,603.8	8,151.88	2,129.61	62,291.4	9,228.9	48,513.1	19,664.9	18,628.2
	%Total Discarding Cost to Total Cost	83.18	1.05	8.51	4.91	14.99	7.33	5.31	1.78
Optimistic Scenario	Total Discarding Cost ($)	11,833.1	61.02	122.36	2,253.03	1,177.3	1,316.16	635.16	211.09
	Total Cost ($)	20,343.7	8,127.6	2,070.82	61,484.2	9,022.4	46,273.2	19,256.4	18,507.4
	%Total Discarding Cost to Total Cost	58.16	0.75	5.91	3.66	13.05	2.84	3.3	1.14
	Total Discarding Cost Difference ($)	30,260.1	24.29	58.79	807.27	206.43	2,239.9	408.58	120.75
	%Reduction	71.89	28.47	32.45	26.38	14.92	62.99	39.14	36.39
Pessimistic Scenario	Total Discarding Cost ($)	71,878.5	109.59	239.94	3,060.3	1,472.81	4,096.18	1,305.49	452.59
	Total Cost ($)	80,389.2	8,176.17	2,188.4	62,291.5	9,317.92	49,053.3	19,926.7	18,749
	%Total Discarding Cost to Total Cost	89.41	1.34	10.96	4.91	15.81	8.35	6.55	2.41
	Total Discarding Cost Difference ($)	-29,785.3	-24.29	-58.79	0.00	-89.01	-540.12	-261.75	-120.75
	%Reduction	-70.76	-28.47	-32.45	0	-6.43	-15.19	-25.08	-36.39

A summary of the disposal strategy for all components of these containers products follows:

- Cardboard packaging has to be discarded in cardboard stream.
- Plastic wraps have to be discarded in recyclables.
- Products in the "Dischargeable" class have to get discharged completely in designated sinks and then can get discarded safely in cheaper non-hazardous streams.
- Following the disposal strategy for products in this class, containers have to be discharged and discarded in general waste or, if possible, in recyclables.
- Since saving for proper disposal of most of these products e.g. product 2 is highly significant, it is required to make sure all staff are educated about it. The results imply that the optimistic discarding cost is significantly less than the pessimistic discarding cost for this product. For this reason it is very important to make sure it is discarded properly. Applying the discussed improvement action for these products can considerably affect total cost of them.
- For products like wipe dispenser cans, in addition to the wipes that have to get discarded in general waste, the plastic container can be recycled. In some areas of the hospital recycle bins are not located beside other bins for different reasons such as lack of space or complication in clinical areas. For this reason educating staff on how effective this simple action can be on hospital costs is considerably important.

IV. Non-hazardous Products

General Specification

- i=6; SAP No. 104105; Tubing Oxygen Supply;

Oxygen supply tubing is used to connect all breathing devices to the oxygen supply [126]. This tubing is very common in the IWK. It is not in contact with medical hazardous material and is not soiled when discarded. It is cheap to purchase and flexible for disposal. These products come with cardboard packaging and have very light paper and plastic wraps.

- i=8; SAP No. 104069; Set Enteral Feed Pump;
- i=13; SAP No. 103965; Enteral Delivery Pump;

Delivery pumps are used to feed water or formula to patient's body. The sets do not contain any hazardous material and are safe to be discarded like other general waste. They are light and are not large to be discarded because of the flexible tubing part of them. They are expensive to purchase and come in cardboard packaging and plastic wraps.

- i=22; SAP No. 103481; Toothbrush;

Toothbrushes are used frequently in the IWK for the patients but is not HCW and can be treated as a regular household waste. It is cheap to purchase and as is light, therefore is also a cheap product to discard. This product comes in cardboard packaging and two separate plastic wraps.

Disposal Specification

These non-hazardous products can safely be discarded in general waste. Typically since it is clear that they are not soiled they are discarded properly. For products like toothbrushes which are non-medical, there is not a great potential for improvement in its disposal. Discrepancy between the costs of the optimistic and the pessimistic scenarios result from how their paper and plastic wraps are disposed. In the optimistic scenario they are disposed as recyclables and in the pessimistic scenario, they are disposed as garbage. This is shown in Table 25 for orders made within the study time period.

Table 25*-Optimistic and Pessimistic Cost Discrepancy IV*

Product ID	Description	Annual Discrepancy ($)
6	Oxygen Tubing	2.78
8	Enteral Feed Pump	242.42
13	Enteral Delivery Pump	107.82
22	Toothbrush	2.84

Products Classification

These products are in the "No Contact with Hazardous Materials" class of products. Products in this class can be discarded in cheaper non-hazardous streams. Many different types of products which are used for various medical purposes but are not in direct contact with hazardous material are in this class. Some other products in the IWK SAP which are in the same class with these products are listed in appendix D. Another 39 products have been identified in the IWK SAP system that are in this class and therefore have the same disposal strategy.

A detailed breakdown of these products' costs under the current, optimistic, and pessimistic scenarios is shown in Table 26.

A summary of the disposal strategy for all components of these non-hazardous products follows:

- Cardboard packaging has to be discarded in cardboard stream.
- Paper and plastic wraps have to be discarded in recyclables.
- Products in the "No Contact with Hazardous Materials" class, are not in direct contact with any hazardous material. They can safely get discarded in cheaper non-hazardous streams based on regulations.
- Following the disposal strategy for products in this class, these product have to be discarded in general waste.
- Delivery pump sets are mostly discarded in bio-waste because it is assumed that all used medical equipment has to be discarded in this way. Therefore it is important to train staff that used medical equipment which do not have any contact with hazardous material are safe to be discarded in general waste or even recyclables if permitted. This product is expensive to purchase and total discarding cost is not a great fraction of product total cost in this case. As the set is very light and flexible in volume, the contributed saving for proper disposal is not highly significant.

***Table 26**-Sample Metrics IV*

		i=6	i=8	i=13	i=22
Total Purchase Cost ($)		6,991.36	31,940.22	12,921.3	707.34
Current Scenario	Total Discarding Cost ($)	192.02	325.24	138.78	15.75
	Total Cost ($)	7,183.38	32,265.46	13,060.08	723.09
	%Total Discarding Cost to Total Cost	2.67	1.01	1.06	2.18
Optimistic Scenario	Total Discarding Cost ($)	189.8	275.19	116.55	14.33
	Total Cost ($)	7,181.16	32,215.41	13,037.85	721.67
	%Total Discarding Cost to Total Cost	2.64	0.85	0.89	1.99
	Total Discarding Cost Difference ($)	2.22	50.06	22.23	1.42
	%Reduction	1.16	15.39	16.02	9.01
Pessimistic Scenario	Total Discarding Cost ($)	192.58	517.61	224.37	17.17
	Total Cost ($)	7,183.94	32,457.83	13,145.67	724.51
	%Total Discarding Cost to Total Cost	2.68	1.59	1.71	2.37
	Total Discarding Cost Difference ($)	-0.56	-192.37	-85.59	-1.42
	%Reduction	-0.29	-59.14	-61.67	-9.01

V. Hazardous Products

General Specification

- i=3, SAP No.103144; Tubing Suction Non Conduct;

A Suction Tube is a tube which is attached to the suction machine to clear liquids from an area of concern. It is used with different applications in various areas like hospital rooms, operation room and emergency clinics [127]. Suction tubes are highly used in the IWK. This product is a light and is cheap to purchase. It comes in cardboard packaging and thick plastic wraps which are hard and light.

Disposal Specification

This product is used for medical purposes which involves discarding in bio-waste as is in contact with hazardous materials. The only improvement action that can be taken for this product is for the hard plastic wrap which can be disposed of in recyclables instead of being discarded in bio-waste. This is a common mistake because it is more convenient. This accounts for the cost discrepancy of $101 between the optimistic and pessimistic scenarios for orders made within the study time period.

Products Classification

This product is in the "Strictly Controlled" class of products. All of the products which are in contact with hazardous material such as human blood and blood products when used are in this class. Sharps and batteries are other products in this category which have to be discarded in their own streams and do not have any other options.

Some other products in the IWK SAP which are in the same class with this product are listed in appendix D. Another 269 products have been identified in the IWK SAP system that are in this class and therefore have the same disposal strategy. A detailed breakdown of suction tube costs under the current, optimistic, and pessimistic scenarios is shown in Table 27.

A summary of the disposal strategy for all components of the suction tube product follows:

- Cardboard packaging has to be discarded in cardboard stream.
- Plastic wraps have to be discarded in recyclables.
- Products in the "Strictly Controlled" class, are required to get discarded in one special stream based on regulations.
- Following the disposal strategy for products in this class, this product have to be discarded in bio-waste because of being contaminated with hazardous material, blood or blood products.
- As the wrap for this product is a thick plastic which is not soft and light, and the product itself has to be discarded in a special stream, saving is just made by discarding plastic wrap in recyclables.

- Since this product or similar ones have to be discarded in bio-waste, wraps are mostly discarded by mistake in the same stream. Although savings are not significant but it is suggested to educate staff that all plastic and paper wraps are safe to be discarded in recyclables and if this is done for all similar products, the saving will be substantial.
- Total discarding cost of the suction tube product is a great portion of its total cost which implies that it is an expensive product to get discarded. It is highly used in the hospital and as is required to be discarded in bio-waste which is expensive. For this reason it needs closer attention for usage and purchase policies since there is not a lot to be done to reduce total discarding cost.

Table 27*-Sample Metrics, i=3*

Total Purchase Cost($)		15,139.55
Current Scenario	Total Discarding Cost ($)	3,134.24
	Total Cost ($)	18,273.79
	%Total Discarding Cost to Total Cost	17.15
Optimistic Scenario	Total Discarding Cost ($)	3,039.31
	Total Cost ($)	18,178.86
	%Total Discarding Cost to Total Cost	16.72
	Total Discarding Cost Difference ($)	94.92
	%Reduction	3.03
Pessimistic Scenario	Total Discarding Cost ($)	3,140.32
	Total Cost ($)	18,279.87
	%Total Discarding Cost to Total Cost	17.18
	Total Discarding Cost Difference ($)	-6.09
	%Reduction	-0.19

VI. Special Hospital Pre-packs

General Specification

- i=15; SAP No. 104688; Urethral Catheterization Tray;

Urethral catheterization is a medical procedure to drain urine directly from the patient's bladder [128]. Catheterization tray is a pack of different products required for this special medical purpose. When the pack is opened, all the components have to be discarded regardless if they are used or not.

Packs are common products in hospitals. They are ordered based on different treatment or operation requirements. They are a combination of different products wrapped together to be sterilized. Different products require different disposal strategies. Packs are generally expensive to purchase and are ordered based on treatment requirements. This product comes in cardboard packaging and plastic wraps. It contains the following sub products;

- Graduated Basin
- Plastic Forceps
- Gloves
- Prep Cup
- Rayon Balls
- PVP Solution
- Lubricant
- Specimen Container
- Fenestrated Drape
- Towel
- Under Pad
- CSR Wrap

- i=17; SAP No. 105326; Sterile Delivery Pack;

Sterile delivery pack is a combination of required surgical equipment used during delivery process. This special type of packs is very expensive to purchase. It comes with cardboard packaging and plastic wraps. Sub products of this package is as follows;

- Sterilization Wrap
- Table Cover
- Drape
- Syringe

- Sponge
- Pad

The difference between this product and catheterization tray which causes a great difference in their total cost, is their purchasing price and order quantities. Sterile delivery pack is highly used in the IWK and is a very expensive pack while the catheterization tray is used less and is cheaper to purchase.

Disposal Specification

These products are a combination of other different products, therefore each product in the pack has its own disposal specification. The pessimistic scenario for their disposal is discarding all the parts in bio-waste while a fraction of some of them can be discarded in cheaper streams if not soiled or if they can be discharged. For example, consider the catheterization tray in the optimistic scenario, the wrap get discarded in recyclables, the basin, cup, PVP package, lubricant package and specimen container get discharged and then disposed in general waste, not visibly soiled gloves and sterilization wrap are discarded in general waste. The discrepancy between the costs of the optimistic and the pessimistic scenarios are shown in Table 28 for orders made within the study time period.

Table 28*-Optimistic and Pessimistic Cost Discrepancy V*

Product ID	Description	Annual Discrepancy ($)
15	Catheterization Tray	87.53
17	Delivery Pack	688.86

Products Classification

These products are in the “Hospital Special Packs” class of products. Products in this class are complex. Each pack includes different products which require different disposal. The classification of the contents of the packages of these two products is shown in table 29.

Table 29-Special Packs' Component Classification

Product	Component	Class
Catheterization Tray	**Graduated Basin**	Dischargeable
	Plastic Forceps	Hazardous if Soiled by Blood or Blood Products
	Gloves	Hazardous if Soiled by Blood or Blood Products
	Prep Cup	Dischargeable
	Rayon Balls	Hazardous if Soiled by Blood or Blood Products
	PVP Solution	Dischargeable
	Lubricant	Dischargeable
	Specimen Container	Dischargeable
	Fenestrated Drape	Hazardous if Soiled by Blood or Blood Products
	Towel	Hazardous if Soiled by Blood or Blood Products
	Under Pad	Hazardous if Soiled by Blood or Blood Products
	CSR Wrap	Hazardous if Soiled by Blood or Blood Products
Delivery Pack	**Sterilization Wrap**	Hazardous if Soiled by Blood or Blood Products
	Table Cover	Hazardous if Soiled by Blood or Blood Products
	Drape	Hazardous if Soiled by Blood or Blood Products
	Syringe	Strictly Controlled
	Sponge	Hazardous if Soiled by Blood or Blood Products
	Pad	Hazardous if Soiled by Blood or Blood Products

Some other products in the IWK SAP which are in the same class with these products are listed in appendix D. Another 34 products have been identified in the IWK SAP system that are in this class and therefore have the same disposal strategy. A detailed breakdown of these packs' costs under the current, optimistic, and pessimistic scenarios is shown in Table 30.

__Table 30__-Sample Metrics V

		i=15	i=17
Total Purchase Cost ($)		6,424.54	52,107.3
Current Scenario	Total Discarding Cost ($)	431.76	2,602.3
	Total Cost ($)	6,856.3	54,709.6
	%Total Discarding Cost to Total Cost	6.3	4.76
Optimistic Scenario	Total Discarding Cost ($)	404.12	2,109.22
	Total Cost ($)	6,828.66	54,216.52
	%Total Discarding Cost to Total Cost	5.92	3.89
	Total Discarding Cost Difference ($)	27.65	493.08
	%Reduction	6.4	18.95
Pessimistic Scenario	Total Discarding Cost ($)	491.65	2,798.08
	Total Cost ($)	6,916.19	54,905.38
	%Total Discarding Cost to Total Cost	7.11	5.1
	Total Discarding Cost Difference ($)	-59.89	-195.79
	%Reduction	-13.87	-7.52

A summary of the disposal strategy for all components of these packs follows:

- Cardboard packaging has to be discarded in cardboard stream.
- Plastic wraps have to be discarded in recyclables.
- Products in the “Hospital Special Packs” class, are special products for disposal. As they get opened, every component inside have to be discarded and cannot be used anymore. A unique disposal strategy cannot be allocated to this class of products. The strategy to take for these products is to control their usage based on necessity and obligate users to sort the component prior to disposal.

- Following the disposal strategy for products in this class, the components have to be discarded based on their classifications and disposal strategies. Disposal strategy for the contents of these packages is illustrated in table 31.

***Table 31**-Components Disposal Strategy*

Component	Disposal Strategy
Graduated Basin	Have to be discharged and then discarded in general waste.
Plastic Forceps	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Gloves	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Prep Cup	Have to be discharged and then discarded in general waste.
Rayon Balls	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
PVP Solution	Have to be discharged and then discarded in general waste.
Lubricant	Have to be discharged and then discarded in general waste.
Specimen Container	Have to be discharged and then discarded in general waste.
Fenestrated Drape	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Towel	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Under Pad	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
CSR Wrap	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Sterilization Wrap	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Table Cover	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Drape	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Syringe	Have to be discharged in sharps.
Sponge	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.
Pad	If soiled by blood or blood Products, have to get discarded in bio-waste. Otherwise have to be discarded in general waste.

- Educating and obligating staff on how to sort different products in a package is important but is not possible most of the time. Because the packs are used for critical reasons that require more consideration on treatment and sorting for disposal may be time consuming or may lead to distraction.

- For the catheterization tray product, savings per each unit is $3 which is not very significant. If sorting will affect treatment process or cause distraction, it is not recommended to separate different products. Discharging "Dischargeable" products and discarding them in bio-waste also do not cause a great cost difference. Saving contributed through proper disposal for this combined product is not as significant as expected. This is because products inside the tray are all light and will not make a great difference is total discarding cost if disposed correctly and they are mostly bio-waste. But money increase resulted from improper disposal is greater than money reduction from proper disposal.
- Packs are used in one of the most critical areas of hospitals, therefore it is hard to sort the components of packs correctly. Facilitating the required areas with appropriate bins in a way that the staff can reach the correct place easy and fast and educate involved staff on how this small sorting actions can save for the hospital are suggested for this purpose.
- Only visibly soiled components of the packs have to go to bio-waste and those which are not soiled or can be discharged and become safe can be discarded in cheaper streams like general waste or recyclables.

Chapter 6: Conclusion

6.1 Comparison

As discussed before the main purpose of this study is to facilitate estimating the final cost of products in the hospital so everyone is informed of the real cost of products which they are using and discarding. This will affect purchasing, using and discarding processes. In this section results from running the model for suggested scenarios are compared. This will guide policy-makers to modify current procedures into a cheaper and safer ones.

6.1.1 Products with High Discarding Cost

The sample products are sorted based on Order Frequency (Qi), Purchase Cost (PCi), Discarding Cost (DCi) and Total Discarding Cost (TDCi). In Table 32 we list the top ten products in each of these metrics.

Table 32*-Sorted Products I*

Product ID Sorted Based on Q_i per Unit	Product ID Sorted Based on PC_i	Product ID Sorted Based on DC_i	Product ID Sorted Based on Annual TDC_i
5	17	2	2
14	27	12	5
25	12	17	21
18	15	20	3
28	8	15	12
10	13	3	17
0	29	21	14
21	4	23	20
11	20	29	18
1	19	13	23

As illustrated in the table, some of the products have high annual total discarding cost while discarding cost of a unit of them is not high, for example Product 5, 14 and 18. This is because these products are frequently ordered. Another important result as shown in Table 32 is that most of the products with the highest annual TDC are not expensive to purchase, for example Products 2, 5, 21, 3. This further demonstrates that purchasing cost is not a good indicator of products which are expensive to discard.

Being cheap to purchase but expensive to discard is an important consideration for purchasing, usage and disposal strategies. Since these kinds of products are cheap to purchase, they may be overlooked when trying to reduce inventory costs. However, since they are expensive to discard, their total cost is worthy of consideration.

6.1.2 Products with High Potential Improvement

Table 33 presents the top ten IWK sample products with significant difference between their optimistic and current annual TDC. The higher the difference between the products' optimistic and current TDC is, the higher the necessity for improvement.

Table 33*-Sorted Products II - Largest to Smallest*

Product ID Sorted Descending (Based on Optimistic and Current Annual Total Discarding Cost Differences)	**Description**	**Comment (Product Class)**
2	Container Specimen	Dischargeable
21	IV Lac Ringers	Dischargeable
5	Glove Exam PVC	Hazardous if Soiled by Blood or Blood Products
12	Wipe Wet Dispenser Can	Dischargeable
14	Glove Exam PVC	Hazardous if Soiled by Blood or Blood Products
17	Sterile Delivery Pack	Hospital Special Pack
18	Glove Exam Nitrile	Hazardous if Soiled by Blood or Blood Products
23	Liner Suction System Flex	Dischargeable
28	Glove Exam Nitrile	Hazardous if Soiled by Blood or Blood Products
20	Bath Sitz with Graduated Bag	Dischargeable

Based on the results, these products mainly include dischargeable products. This implies the requirement of educating staff on proper disposal strategies taken for products in the "Dischargeable" class. The IWK can simply save $33,922 annually, if products 2,21,12,23 and 20 get discharged prior to disposal and then get discarded in non-hazardous streams. Similar gains could be expected for 67 other products in this class as presented in appendix D.

The next group of products in the IWK with significant difference between their current and optimistic TDC are gloves. For this reason it is highly important to educate staff how to sort used gloves for disposal. For these four sample gloves presented in Table 33, if the right portion which is not soiled when discarded goes to general waste, IWK can achieve $3,219 annually. This amount will be significantly higher if improvement applied for all 74 different types of gloves in the IWK as shown in appendix D.

In general, products with a large difference between the optimistic and pessimistic annual TDC are products which are the most sensitive to changes in disposal practices. For example, if current discarding cost is close to the pessimistic discarding cost than there is a larger room for improvement. If the current discarding cost is close to the optimistic discarding cost than there is little room for improvement however current disposal practice should be maintained or costs could rise substantially. Table 34 sorts products in decreasing order based on their optimistic annual TDC and pessimistic annual TDC difference.

Gloves and dischargeable products are the most sensitive to changes in disposal practices. From another aspect products with low difference between their optimistic and pessimistic discarding costs are not sensitive to changes and hence should be of less concern to IWK managers. As shown in Table 34 products from the "Strictly Controlled" are insensitive as there is little difference between the pessimistic and optimistic discarding costs. This is to be expected since there disposal practice is strictly monitored and highly complied with.

__Table 34__-Sorted Products III - Largest to Smallest

Product ID Sorted Descending (Based on their Optimistic and Pessimistic Annual TDC difference)	**Description**	**Optimistic Vs Pessimistic Cost Difference ($)**	**Comment-Product Class**
2	Container Specimen 800ML	60,045.46	Dischargeable
5	Glove Exam PVC PWD/FR	4,729.08	Hazardous if Soiled
21	IV Lac Ringers 1000ML	2,780.02	Dischargeable
14	Glove Exam PVC PWD/FR	1,369.88	Hazardous if Soiled
18	Glove Exam Nitrile PWD/FR	1,039.21	Hazardous if Soiled
12	Wipe Wet Dispenser Can	807.27	Dischargeable
17	Sterile Delivery Pack	688.86	Hospital Special Pack
28	Glove Exam Nitrile PWD/FR	675.7	Hazardous if Soiled
23	Liner Suction System Flex	670.32	Dischargeable
10	Glove Surgical Neolon	413.83	Hazardous if Soiled
20	Bath Sitz with Graduated Bag	295.43	Dischargeable
11	Glove Surgical Neolon	259.74	Hazardous if Soiled
8	Set Enteral Feed Pump 500 ML	242.42	No Contact with Hazardous Materials
29	Cleanser CRM 1L	241.49	Dischargeable
16	Surgical Glove Neolon 2G 7.0	198.11	Hazardous if Soiled
0	Glove Exam Single STER	130.33	Hazardous if Soiled
9	Bag Patient Belonging	117.57	Dischargeable
13	Enteral Delivery Pump 1200 ml	107.82	No Contact with Hazardous Materials
3	Tubing Suction Non Conduct	101.01	Strictly Controlled Stream
1	Syringe Sampling 2CC	95.54	Strictly Controlled Stream
15	Urethral Catheterization Tray	87.53	Hospital Special Pack
25	Needle Blunt Fill Safety 18G	58.65	Strictly Controlled Stream
7	Gel Ultrasound 250ML	48.57	Dischargeable
4	Set Blood Collection Safety	22.78	Strictly Controlled Stream
26	Kit Arterial Blood Sample 1ML	4.86	Strictly Controlled Stream
19	Catheter IV Auto guard 24G	3.18	Strictly Controlled Stream
22	Toothbrush	2.84	No Contact with Hazardous Materials
6	Tubing Oxygen Supply 7FT	2.78	No Contact with Hazardous Materials
24	Catheter IV Auto guard Safety	2.12	Strictly Controlled Stream
27	Device Bag Access Blood	1.84	Strictly Controlled Stream

6.2 Numerical Analysis

In summary, the main conclusions that have been learned through numerical analysis in this study are as follows:

- Proper disposal of dischargeable products can reduce waste cost significantly. As numerical results show there is a great difference between their optimistic and pessimistic discarding costs. Specifically for those which are hard, relatively cheap to purchase and frequently used. If the contents of these products were discharged in designated sinks prior to disposal, then they would be significantly lighter and can get discarded in cheaper streams. In IWK there are at least 75 products identified as dischargeable product.
- Strictly controlled products which are required to be disposed in a special stream are a group of products in the hospitals with low improvement potential. In IWK, at least 10,098 items are identified to be strictly controlled. When comparing the discarding costs computed for the optimistic, current and pessimistic scenarios, very little difference is found. The reason for this is there is little ambiguity regarding where to dispose the product and compliance is high. Compliance is high because staff can directly see the danger associated with improper disposal. For example, it is likely obvious that disposing a needle in any way other than in a sharps container is associated with a high risk of being stuck. Furthermore, these products are small, frequently used and inexpensive dispose of. However, lessons can be learned by studying why and how the disposal strategy for these products are unambiguous and highly complied with.
- Products like gloves in which their disposal depends on use are also important. At the IWK, at least 233 items are required to be discarded as bio-waste only if soiled by blood or blood products. In contrast with strictly controlled products, there is some ambiguity in terms of which stream they should be disposed in. A large discrepancy is founded in comparing the optimistic and pessimistic scenarios which speaks to the potential cost of noncompliance with their proper disposal methods.
- Operating rooms account for about 33 percent of all hospital supply costs, and one of the most wasteful products in the operating room are surgical pre-packs [9]. Surgical pre-packs (or special packs) contain the specific products needed for a specific surgery type. They are wasteful because they often contain more products than needed the majority of the time and once the pre-pack is opened, all

products within the pack cannot be reused. In IWK, at least 36 hospital pre-packs are identified which require educating staff how to discern components included in a pack for proper disposal methods.

- Our conclusions are organized by product classification for two reasons. The first is that it allows our numeric results from the 29 products to be extended to 657 products which have the same classification. Secondly it is consistent with literature, which finds that continuously increasing discarding costs of hospitals medical waste is caused by both misclassification and the improper disposal of wastes [114].

6.3 Applications

In this section promising applications of the model, limitations and future steps are discussed. As a specialized hospital, the IWK is relatively small in comparison to regional hospitals found across Canada. Even so, their purchasing catalog contains over 10,000 unique SKUs. As such, improvements in waste disposal methods must be addressed systematically, beginning with high priority products. The proposed methodology in this study can identify products with the highest priority to be investigated.

High consumption is likely the most apparent way to prioritize products as the higher a product is utilized the more often it is discarded, and higher the potential for improvement. The annual total cost which is defined as sum of the annual total discarding cost and total purchasing cost of a product in this study, is another way to discern priority products. An alternate approach to achieve this purpose is the ratio of purchasing cost to discarding cost. This ratio is particularly well suited at identifying problematic products with abnormal discarding costs.

Priority products could also be those with the highest potential to save money. Using the proposed model it is straightforward to test different disposal scenarios (e.g. optimistic and pessimistic) and compare results to the current scenario. Analyzing the difference between the proposed scenario and the current scenario directs prioritization. A large difference among the optimistic scenario and the current scenario implies a priority product. In the examined products in this study, this is most apparent in the products with dischargeable contents.

Priority products could be products which are a priority for government managers of landfills and waste management facilities. Their priorities are often set with the aim to reduce environmental impacts and often enforced with financial incentives or disincentives, e.g. tipping fees. These fees can be directly related to applicable products with the described methodology. Product characteristics could determine priority as well. Solid heavy products are typically associated with high tipping fees.

Through this study we also found that staff members comply with disposal strategies when they are unambiguous. This is particular true with sharps, as risk associated with their improper disposal can directly be seen. Furthermore, compliance can also be increased with incentives. This was seen at the IWK when profits from the recycling program where given to the staff education fund.

The costing model has been programmed in this study using Python 2.7 with a user interface designed in Microsoft Excel. Microsoft Excel aids eliminating complications of a programming interface. A Microsoft Excel template is designed to input data into the model. The model is then run for desired products, entered into the Excel sheet. The final results including total cost of each product is then exported into another Excel sheet. Coupling the python program with Excel, hospitals do not have to deal with programming to calculate discarding cost, they only need to manage and enter data into the Excel, run the model and achieve the results in Excel.

By computing a dollar figure for the correct and incorrect disposal strategies, the advantages of complying can be easily demonstrated. Outlining financial loss derived from common disposal mistakes can promote staff attentiveness. Furthermore, since the advantages and disadvantages can be related to single products, they are more relatable and relevant to staff than more aggregate figures. Communicating this information effectively is obviously equally as important and an area of future research. However, simple messaging such as supply room posters outlining expected money saving and loss is likely a reasonable first step. Proper color coding and detectable signs coupled with informing banners are help with this purpose. Combine this with a focus on priority products and quick improvements are expected.

This project also helped eliminate ambiguity around correct disposal strategies. Although computing the discarding cost per product did not directly communicate to staff where a product should be disposed, it did provide management with structured information on the variety of waste streams, cost factors and product components. Through breaking the product down into its components, the system structure became more transparent and it became easier to communicate exactly which components should go where and what the cost advantages would be. But there are also possible downsides of improving and obligating the source segregation. Educating and obligating staff on how to sort different products is important but is not recommended for some instances if lead to distraction especially in critical areas such as Operation Rooms, which time and concentration on treatment is the first priority. Failure to educate staff properly on separation techniques may also lead to more errors of putting hazardous waste in a nonhazardous stream.

Knowing discarding cost per product helps purchasers and users appreciate the entire cost associated with a product. A process which adds the discarding cost to the purchase price is analogous to Environmental Handling Fees (EHFs). In Nova Scotia EHFs are charged to new products such as tires and electronics, at the time of purchase to cover their future discarding costs. By charging EHFs consumers accept responsibility for the entire life-cycle of the product they are purchasing. Using the model outputs, such a process could be implemented at hospitals to influence purchasing and consumption decisions.

Implementing EHFs into the purchasing process in a way that does not disrupt patient care is a significant challenge and an area for future research. There are numerous ways in which EHFs could be used. For example, an EHF can be charged to a manager's cost-center at the time of purchase. This method directly impacts managers purchasing decisions and is consistent with typical application of EHFs. This approach however, may be too extreme as many medical products are vitally important and running out of them may have extreme consequences. A second method may be to simply advise managers at the time of purchase what the EHF of their product is and identify alternative products with lower EHFs. This approach is less inhibiting to their current operations but may be less effective. Another approach to implement EHFs could involve passing these fees onto suppliers or working with suppliers to decrease them, e.g. through reduced packaging or different materials.

6.4 Limitations

The main limitation inhibiting the model from daily use is the lack of detailed information on the physical properties of the product components and packaging. In particular, the weight and volume data, which was collected manually for the proof of concept application, is needed for wider implementation. The ideal way to overcome this lack of data would be to have it provided by suppliers. Currently this is not available for the majority of products at the partner hospital, however, it is something that could be requested particularly when (re)negotiating contracts. When manual collection is absolutely necessary, it would be advisable to start with priority products and take care to identify common components between products to expedite the process.

A second limitation is values for the fluctuating variable $P_{i,k,j}$which indicates the stream the discarded product component is disposed in. Expert opinion was used in the proof of concept and three realizations of $P_{i,k,j}$ were considered. Results are sensitive to this parameter and it should be defined carefully. However, for many components the variability in $P_{i,k,j}$ is low, making choosing an appropriate value straightforward. For example, cardboard is likely to end up in the cardboard stream and $P_{i,k,j}$ is easily determined for all cardboard components. For products with multiple disposal streams, performing sensitivity analysis on this parameter is recommended. If it is highly sensitive for certain components then consider more formal methods such as audits or surveys.

Another limitation relates to the scope and the choice of costs to include in the model. The costs that are considered were limited to external costs paid to third party contractors who were responsible for removing waste and its final disposal in addition to purchase costs. Other costs exists, in particular, internal costs, such as those related to collecting and sorting waste. The dominant internal cost is likely labor related to custodial work.

Data limitation related to the physical properties of the product components and packaging also hindered validation efforts. Ideally, we would like to have compared our annual discarding costs with the actual annual discarding costs but this would require that all products be analyzed with our model. As this was not possible our validation effort are qualitative and based on those suggested by Law and Kelton [129]. They include:

- *Collect high-quality information and data through conversations with subject-matter experts.* This study was administrated by working closely with staff who are familiar with different aspects of the system on a continuing basis to build an accurate model.
- *Collect high-quality information and data through observations of the system.* Data required to build the model is collected from historical records or manually collected during the study.
- *Collect high-quality information and data through using the experience and intuition*. As the suggested model did not exist prior to this study, expert experience and intuition is used to hypothesize the fluctuating parameters of the model.
- *Interacting with the managers involved in decisions regarding waste management to facilitate the model application in decision making processes.*
- *Performing sensitivity analysis to assure model performance upon desired factors which are supposed to be effective based on collected information and expert opinion.*
- *Validating outputs by confirming the output data being closely resemble the expected values.* This was also accomplished by discussing model outputs with subject-matter experts.

6.5 Conclusion

In conclusion, the demonstrated approach is aimed to be a significant first step in connecting environmental concerns to hospital budgets, purchasing decisions and staff compliance with waste management strategies. This approach takes into account laws which govern waste disposal and have the objective to limit environmental harm. The setting for the model, a hospital, was purposely chosen due to the high variety of product types, waste streams and strict regulations. The model is sufficiently general for other industries, and in particular those which outsource waste removal from their property and therefore have numerous contracts and cost factors.

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Appendix A: IWK Waste Streams Source Segregation

Waste Stream	Source Segregation Bin
General waste	
Recyclables	
Organics	
Infectious waste	

Waste Stream	Source Segregation Bin
Sharps	
Cytotoxic waste	
Pharmaceutical waste	

Appendix B: IWK Waste Streams Central Storages

Waste Stream	Central Storage
General waste / Cardboard	
Recyclables	
Organics	
Infectious Waste	

Waste Stream	Central Storage
Confidential waste	

Appendix C: IWK Sample Products' Components' Measurements

Product ID	Product SKU No.	Description	k	Components	n_k	w_i,k (Kg)	v_i,k (m3)
0	100341	GLOVE EXAM SENICARE SINGLE STER MD LT-FR	1	Cardboard Packaging	1	0.46	0.03
			2	Cardboard Box	4	0.17	0.01
			3	Plastic Wrap	400	0.001	0.0002
			4	Gloves	400	0.01	0.0001
1	104016	SYRINGE ABG SAMPLING 2CC	1	Boxboard	1	0.42	0.003
			2	Paper & Plastic Wrap	100	0.0004	0.0001
			3	Arterial Blood Sampler (Syringe)	100	0.0034	0.00001
2	103163	CONTAINER SPECIMEN COMMODE 800ML	1	Cardboard Packaging	1	0.64	0.04
			2	Plastic Wrap	200	0.01	0.002
			3	Specimen Container(EMPTY)	100	3.20	0.01
3	103144	TUBING SUCTION NON CONDUCT STER 7MM 6FT	1	Cardboard Packaging	1	0.59	0.04
			2	Plastic Wrap	40	0.01	0.0004
			3	Non Conductive Suction Tube	40	0.12	0.001
4	102778	SET BLOOD COLLECTION SAFETY 23G 12IN	1	Boxboard	1	0.12	0.003
			2	Hard Wrap	50	0.001	0.0001
			3	Blood Collection Set	50	0.003	0.0001
5	104315	GLOVE EXAM SENSICARE PVC MD PWD/FR	1	Cardboard Packaging	1	0.42	0.02
			2	Boxboard	10	0.04	0.002
			3	Exam Gloves	1000	0.01	0.0001
6	104105	TUBING OXYGEN SUPPLY 7FT	1	Cardboard Packaging	1	0.31	0.02
			2	Paper & Plastic Wrap	50	0.001	0.00001
			3	Oxygen Supply Tubing	50	0.04	0.0003
7	103883	GEL ULTRASOUND DOPPLER 250ML	1	Cardboard Packaging	1	0.28	0.01
			2	Bottle & Cap (EMPTY)	24	0.04	0.0005
8	104069	SET ENT FEED PUMP INFINITY ZEVEX 500 ML	1	Cardboard Packaging	1	0.43	0.02
			2	Plastic Wrap	30	0.001	0.0001
			3	Delivery Set	30	0.07	0.002
9	103496	BAG PATIENT BELONGING DRWSTRNG 18.5 X 22	1	Cardboard Packaging	1	0.46	0.02
			2	Belonging Bag (EMPTY)	500	0.02	0.001

Product ID	Product SKU No.	Description	k	Components	n_k	w_i,k (Kg)	v_i,k (m3)
10	104174	GLOVE SURG NEOLON 2G 6.5 PWD AND LT-FR	1	Cardboard Packaging	1	0.46	0.03
			2	Cardboard Box	4	0.19	0.01
			3	Plastic Wrap	200	0.002	0.0003
			4	Gloves	400	0.02	0.0003
11	105499	GLOVE SURG NEOLON 2G 6.0 PWD AND LT-FR	1	Cardboard Packaging	1	0.46	0.03
			2	Cardboard Box	4	0.19	0.01
			3	Plastic Wrap	200	0.002	0.0003
			4	Gloves	400	0.02	0.0003
12	104318	WIPE WET PERCEPT DISPENSER CAN	1	Cardboard Packaging	1	0.58	0.04
			2	Container (EMPTY)	12	1.03	0.003
			3	RTU Wipes	1920	0.01	0.0001
13	103965	SET ENT FEED PUMP INFINITY ZEVEX 1200ML	1	Cardboard Packaging	1	0.43	0.02
			2	Plastic Wrap	30	0.001	0.0001
			3	Delivery Set	30	0.08	0.002
14	104316	GLOVE EXAM SENSICARE PVC LG PWD/FR	1	Cardboard Packaging	1	0.42	0.02
			2	Boxboard	10	0.04	0.002
			3	Exam Gloves	1000	0.01	0.0001
15	104688	TRAY CATHETER URETHERAL DISP	1	Cardboard Packaging	1	0.61	0.04
			2	Plastic Wrap(1)	16	0.001	0.0001
			4	Graduated Basin(EMPTY)(1)	16	0.02	0.002
			5	Plastic Forcep(2)	32	0.01	0.00002
			6	Gloves	32	0.01	0.0001
			7	Prep Cup (EMPTY)	16	0.004	0.0003
			8	Rayon Ball	80	0.01	0.00004
			9	PVP Solution(EMPTY)	16	0.003	0.00001
			10	Lubricant Package(EMPTY)	16	0.003	0.00004
			11	Specimen Container(EMPTY)	16	0.01	0.0001
			12	Fenestrated Drape	16	0.01	0.001
			13	Towel	16	0.01	0.0003
			14	Under Pad	16	0.01	0.0003
			15	CSR Wrap	16	0.01	0.0004

Product ID	Product SKU No.	Description	k	Components	n_k	w_i,k (Kg)	v_i,k (m3)
16	104179	GLOVE SURG NEOLON 2G 7.0 PWD AND LT-FR	1	Cardboard Packaging	1	0.46	0.03
			2	Cardboard Box	4	0.19	0.01
			3	Plastic Wrap	200	0.002	0.0003
			4	Gloves	400	0.02	0.0003
17	105326	PACK DLV IWK GRACE	1	Cardboard Packaging	1	1.24	0.12
			2	Plastic Wrap	15	0.01	0.001
			3	Sterilization Wrap	15	0.13	0.00000001
			4	Table Cover	15	0.13	0.01
			5	Drape	15	0.13	0.01
			6	Syringe	15	0.01	0.0003
			7	Sponge	15	0.01	0.00004
			8	Pad	15	0.10	0.000000001
18	104220	GLOVE EXAM NITRILE ALOETOUCH MD PWD/FR	1	Cardboard Packaging	1	0.42	0.02
			2	Boxboard	10	0.05	0.002
			3	Exam Gloves	500	0.01	0.0001
19	104039	CATHETER IV AUTOGUARD 24G 0.56IN	1	Cardboard Packaging	1	0.23	0.01
			2	Boxboard	4	0.05	0.002
			3	Paper & Plastic Wrap	200	0.003	0.0004
			4	IV Catheter	200	0.01	0.0004
20	103165	BATH SITZ WITH GRADUATED BAG TURQUOISE	1	Cardboard Packaging	1	1.26	0.13
			2	Plastic Wrap	10	0.01	0.0004
			3	SITZ Bath	10	0.26	0.01
			4	Container (EMPTY)	10	0.07	0.0003
21	119993	IV LAC RINGERS 1000ML 07953254	1	Cardboard Packaging	1	0.37	0.02
			2	Plastic Wrap	12	0.01	0.0003
			3	IV Ringer(Empty)	12	0.09	0.0003
22	103481	TOOTHBRUSH ORAL PED GUM CRITTERS USFT	1	Cardboard Packaging	1	0.41	0.02
			2	Plastic Wrap	12	0.01	0.0001
			3	Plastic Hard Case	144	0.004	0.0001
			4	Tooth Brush	144	0.01	0.0002
23	104698	LINER SUCTION SYSTEM FLEX DISP 1500ML	1	Cardboard Packaging	1	1.34	0.14
			2	Liner(Empty)	50	0.07	0.002

Product ID	Product SKU No.	Description	k	Components	n_k	w_i,k (Kg)	v_i,k (m3)
24	104037	CATHETER IV AUTOGUARD SAFETY 22G 1IN	1 2 3 4	Cardboard Packaging Boxboard Paper & Plastic Wrap IV Catheter	1 4 200 200	0.23 0.05 0.003 0.01	0.01 0.002 0.0004 0.0004
25	103621	NEEDLE BLUNT FILL SAFETY 18G 1.5IN	1 2 3 4	Cardboard Packaging Boxboard Wrap Needle	1 10 1000 1000	0.30 0.02 0.0002 0.001	0.01 0.001 0.00001 0.00001
26	103765	KIT ARTERIAL BLOOD SAMPLE LITH HEP 1ML	1 2 3	Cardboard Packaging Wrap Syringe(No Needle)	1 200 200	0.84 0.01 0.01	0.07 0.0004 0.0001
27	103566	DEVICE BAG ACCESS BLOOD 2300E	1 2 3	Boxboard Wrap Bag Spike(Sharps)	1 25 25	0.12 0.001 0.01	0.004 0.0002 0.0001
28	104215	GLOVE EXAM NITRILE ALOETOUCH LG PWD/FR	1 2 3	Cardboard Packaging Boxboard Gloves	1 10 500	0.42 0.05 0.01	0.02 0.002 0.0001
29	108989	CLEANSER CRM 1L FLIP TOP	1 2	Cardboard Packaging Cleanser Bottle(Empty)	1 12	0.43 0.27	0.03 0.002

Appendix D: Products Classification

Dischargeable - have to be discharged prior to disposal				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
2	103163	CONTAINER SPECIMEN	104719	CONTAINER URINE
23	104698	LINER SUCTION SYSTEM FLEX	111555	CONTAINER POLETHELNE
20	103165	BATH SITZ WITH BAG	111777	CONTAINER HISTOLOGY
21	119993	IV LAC RINGERS 1000ML	177819	CONTAINER SAMPLE WIDE-MOUTH
12	104318	WIPE WET DISPENSER CAN	103340	IV NACL 0.9% 500ML JB1323
29	108989	CLEANSER CRM 1L FLIP TOP	103343	IV NACL 0.9% 250ML JB1322P
7	103883	GEL ULTRASOUND DOPPLER	103348	IV DEX 5% NACL 0.45% 1000ML JB1074
9	103496	BAG PATIENT BELONGING	103351	IV DEX 10% IN H20 1000ML JB0164
			103352	IV DEX 3.3% NACL 0.3% 1000ML JB1034
			103355	IV DEX 5% NACL 0.2% 1000ML JB1094
			103359	IV DEX 5% NACL 0.9% 500ML JB1063
			103360	IV DEX 10% IN H20 250ML JB0162P
			103390	IV KCL 40MM DEX 5% NACL 0.45% 1L JB1674
			103391	IV KCL 20MM DEX 5% NACL 0.2% 1L JB1614
			103392	IV KCL 20MM NACL 0.9% 1L JB1764
			103961	IV KCL 40MM NACL 0.9% 1000ML JB1984
			103962	IV KCL 20MM LAC RINGERS JB2024
			104020	IV KCL 40MM DEX 5% NACL 0.9% 2B2454X
			104128	IV KCL 40MM LAC RINGERS 1000ML JB2034
			119983	IV DEX 10% IN WATER 500ML 07930250
			119984	IV DEX 3.3% NACL 0.3% 500ML 7942150
			119986	IV DEX 5% 250ML 07922225
			119987	IV DEX 5% 500ML 07922250
			119988	IV DEX 5% 1000ML 07922254
			119989	IV DEX 5% NACL 0.45% 1000ML 07926254
			119990	IV DEX 5% NACL 0.9% 1000ML 07941254
			119992	IV LAC RINGERS 500ML 07953250
			119994	IV NACL 0.9% 250ML 07983225
			119995	IV NACL 0.9% 500ML 07983250
			119996	IV NACL 0.9% 1000ML 07983254
			119997	IV NACL 0.45% 1000ML 07985254
			120012	IV LAC RINGERS DEX 5% 500ML 07929250
			122673	IV DEX 5% NACL 0.9% 500ML 07941250
			129017	IV KCL 20MM DEX 5% NACL .45% 1L 07902254

Dischargeable - have to be discharged prior to disposal				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			129019	IV KCL 20MM DEX 3.3% NACL .3% 1L
			151500	IV NORMOSOL R 1000ML 07670254
			151551	IV NACL 0.9% 50ML 07984850
			151553	IV DEX 5% 50ML 07923850
			151554	IV NACL 0.9% 100ML 07984853
			170080	IV DEX 5% NACL 0.225% 1000ML
			170081	IV DEX 5% NACL 0.225% 500ML 7924250
			170082	IV DEX 5% NACL 0.45% 500ML 7926250
			170083	IV KCL 20MM DEX 5% NACL 0.9% 1L
			170084	IV KCL 20MM NACL 0.9% 1L 7115254
			170086	IV KCL 40MM DEX 5% NACL 0.9%
			170087	IV KCL 40MM NACL 0.9% 1000ML
			103380	FORMULA PRO-PHREE 400GM CAN #309
			104356	CLEANSER TSPR 2 250 ML
			173559	DISPENSER MANUAL FOAM HAND WASH ECO
			100410	SANITIZER HAND 70% ALC PUMP BTL 540ML
			104149	SANITIZER HAND ANTISEPTIC MANORAPID 1L
			151313	SANITIZER HAND PURELL 70% ALC PUMP 354ML
			154343	SOAP HAND BACTISTAT AE TRIC 0.3% PUMP 1L
			170992	SOAP WASH HAND FOAMING GENTLE ENDURE
			173559	DISPENSER MANUAL FOAM HAND WASH ECO
			173724	WALL BRACKET WHITE PLSTC HANDWIPE
			173872	SOAP HAND BACTISTAT AE TRIC 0.3% WD 1.2L
			100422	SANITIZER HAND GEL ENDURE BAG 1L
			109094	BAG PAPER KRAFT 3LB
			108502	BAG STEAM MICRO QUICK CLEAN
			109031	BAG PAPER KRAFT 8LB
			109088	BAG PAPER KRAFT 50LB
			109089	BAG PAPER KRAFT 20LB
			109399	BAG SANDWICH WX
			106278	BAGS STOR 3X5 ZPLK
			103577	BAG PAPER KRAFT 2LB

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
5	10431 5	GLOVE EXAM SENSICARE PVC MD PWD/FR	100330	GLOVE SURG SENSICARE ALOE 7.0 PWD LT-FR
14	10431 6	GLOVE EXAM SENSICARE PVC LG PWD/FR	100336	GLOVE EXAM SENISCARE POLYS 8.5 PWD/LT-FR
18	10422 0	GLOVE EXAM NITRILE ALOETOUCH MD PWD/FR	100338	GLOVE EXAM SENISCARE POLYS 8.0 PWD/LT-FR
28	10421 5	GLOVE EXAM NITRILE ALOETOUCH LG PWD/FR	100339	GLOVE SURG ORTHO ENCORE 8.0 PWD-FR LTX
10	10417 4	GLOVE SURG NEOLON 2G 6.5 PWD AND LT-FR	100347	GLOVE EXAM UNIVERSAL PVC 3G XS LT-FR
16	10417 9	GLOVE SURG NEOLON 2G 7.0 PWD AND LT-FR	100362	GLOVE SURG TRIUMPH LT 5.5 PWD FR LTX
0	10034 1	GLOVE EXAM SENICARE SINGLE STER MD LT-FR	100362	GLOVE SURG TRIUMPH LT 5.5 PWD FR LTX
20	10316 5	BATH SITZ WITH GRADUATED BAG TURQUOISE	100366	GLOVE SURG TRIUMPH LT 6.0 PWD FR LTX
11	10549 9	GLOVE SURG NEOLON 2G 6.0 PWD AND LT-FR	100366	GLOVE SURG TRIUMPH LT 6.0 PWD FR LTX
			100368	GLOVE SURG TRIUMPH LT 6.5 PWD FR LTX
			100370	GLOVE SURG TRIUMPH LT 7.0 PWD FR LTX
			100372	GLOVE SURG TRIUMPH LT 7.5 PWD FR LTX
			100376	GLOVE SURG TRIUMPH LT 8.0 PWD FR LTX
			100388	GLOVE EXAM SENICARE SINGLE STER LG LT-FR
			103400	GLOVE EXAM DSPS O GLV STER SM PWD/LT-FR
			103401	GLOVE EXAM DSPS O GLV STER MD PWD/LT-FR
			103402	GLOVE EXAM DSPS O GLV STER LG PWD/LT-FR
			103417	GLOVE SURG EUDERMIC 8.5 PWD/FR LTX
			104180	GLOVE SURG NEOLON 2G 7.5 PWD AND LT-FR
			104183	GLOVE SURG NEOLON 2G 8.0 PWD AND LT-FR
			104229	GLOVE EXAM NITRILE ALOETOUCH SM PWD/FR
			104493	GLOVE PCTV SM NS OPEX PWD/FR
			104853	GLOVE EXM 9.5IN SM LTX-FR SFSKN NTR
			105498	GLOVE SURG NEOLON 2G 5.5 PWD AND LT-FR
			105498	GLOVE SURG NEOLON 2G 5.5 PWD AND LT-FR
			105500	GLOVE SURG NEOLON 2G 8.5 PWD AND LT-FR

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			106293	GLOVE SURG MICROTOUCH 6.5 BEADED PWD LTX
			106294	GLOVE SURG MICROTOUCH 7.0 BEADED PWD LTX
			106295	GLOVE SURG MICROTOUCH 7.5 BEADED PWD LTX
			106296	GLOVE SURG MICROTOUCH 8.0 BEADED PWD LTX
			106355	GLOVE SURG MICROTOUCH 6.0 BEADED PWD LTX
			108977	GLOVE SURG ORTHO EUDERMIC 6.5 PWD/FR LTX
			108979	GLOVE SURG OTHO ALOETOUCH 7.5 PWDFR LTX
			109004	GLOVE SURG EUDERMIC 7.5 PWD/FR LTX
			109008	GLOVE SURG EUDERMIC 6.5 PWD/FR LTX
			109465	GLOVE EXM MD LTX NS DMDGRP PWD/FR BEADED
			109672	GLOVE EXM MD LTX DRMCLN X-AM PWD/FR
			110101	GLOVE EXAM SENISCARE POLYS 7.5 PWD/LT-FR
			110569	GLOVE NPRN THUMB
			110594	GLOVES SNSCR PLISPRN PWD/FR Sz.5.5
			110883	LINER GLOVE COTTON LARGE
			111163	GLOVE EXM SM LTX DRMCLN X-AM PWD/FR
			111220	GLOVE SURGICAL 6.5 PWD/LT-FR ALOE
			111357	GLOVE SRG 6 LTX STER ENCR PWD/FR BEADED
			111742	GLOVE EXM XL SNSCR PWD/FR
			114196	GLOVE SRG 6.5 LTX-FR STER DRPRN LCK CUF
			114991	GLOVE EXM SM NS NTR PWD/FR BEADED CUF
			115181	GLOVES SNSCR PLISPRN PWD/FR Sz.6.0
			115347	GLOVE EXM 9.5IN LG LTX-FR SFSKN NTR
			115361	GLOVE EXM 9.5IN MD LTX-FR SFSKN NTR
			117096	GLOVE SURG ORTHO ENCORE 6.5 PWD-FR LTX
			117188	GLOVE SURG ORTHO ENCORE 7.5 PWD-FR LTX
			147814	GLOVE:ORTHO 7.5 BX/50
			154102	GLOVE EXAM NITRILE ALOETOUCH XL PWD/FR

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			154320	GLOVE EXAM SENSICARE PVC SM PWD/FR
			154793	GLOVE SURG EUDERMIC 8.0 PWD/FR LTX
			154793	GLOVE SURG EUDERMIC 8.0 PWD/FR LTX
			154794	GLOVE SURG EUDERMIC 7.0 PWD/FR LTX
			154795	GLOVE SURG EUDERMIC 6.0 PWD/FR LTX
			166841	GLOVE EXAM NON-LATEX X-SM MEDITOUCH
			172685	GLOVE X-SML ANSEL PF
			176518	GLOVE NTRL ARCTICBLUE SM 200PK
			176593	GLOVE NITRILE MEDIUM PK100
			102867	SPONGE LAP STERILE 4PLY 12 X 12IN LT-FR
			102868	SPONGE LAP STERILE 4PLY 18 X 18IN LT-FR
			103650	SPONGE GELFOAM ABSORBABLE 8 X 12CM
			103651	SPONGE GELFOAM ABSORBABLE 2 X 6CM
			103940	SPONGE ROUND NON STERILE XRAY LARGE
			103946	SPONGE NONWOVEN BULK NON STER 4PLY 4X4IN
			103947	SPONGE NONWOVEN STERILE 4PLY 4 X 4IN
			103948	SPONGE NONWOVEN STERILE 4 PLY 4 X 8IN
			103950	SPONGE GAUZE XRAY NON STER 12PLY 3 X 3IN
			103952	SPONGE 3 PNT LG BULK
			103953	SPONGE PEANUT XRAY STERILE 5PK 3/8IN
			103954	SPONGE GAUZE XRAY NON STERILE 2 X 2IN
			103957	SPONGE LAP ABS STERILE 4 X 18IN
			109046	SPONGE NONWOVEN NON STERILE 4PLY 3 X 3IN
			109050	SPONGE NONWOVEN STERILE 4PLY 4 X 3IN
			109547	SPONGE SRG 3X1IN CTTND PTT 1 STNG RADOPQ
			110471	SPONGE SRG .5X.5IN CTTND PTT 1 STNG
			110472	SPONGE SRG 2X.5IN CTTND PTT 1 STNG

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			**Similar Products**	
ID No.	**SAP No.**	**Description**	**SAP No.**	**Description**
			115565	SPONGE SRG 2IN 2IN 12 PLY RADOPQ STER
			115567	SPONGE TNSL STNG RADOPQ
			117052	SPONGE SRG 5/16IN CTTND PTT RND
			118697	SPONGE XRAY DETECTABLE 16 PLY 4 X 4IN
			121111	ANTIFOG SPONGE + SOLN SOFT PK 20PK/CS
			124876	SPONGE SURGICAL CYLINDER 3/8 X 0.75IN
			147754	SPONGE SRG 6X1IN CTTND PTT 1 STNG RADOPQ
			161250	DRESSING SPONGE EXCILON AMD IV 2X2IN
			175864	SPONGE TOPPER 2X2IN
			183353	SPONGE DURAFORM 1 IN X 3 IN SINGLE
			100201	DRESSING TEGADERM TRANSPARENT 6 X 7CM
			100210	DRESSING COVERPLAST ADH STER 5 X 7.2CM
			100212	DRESSING TRANSP POST OP 6.5 X 5CM LT-FR
			100213	DRESSING OPSITE POST OP 15.5 X 8.5CM
			100215	DRESSING JELONET STERILE 10 X 10CM
			100221	DRESSING OPSITE TRANSP IV3000 10 X 14CM
			100225	DRESSING OPSITE 30 X 28CM LT-FR
			100226	DRESSING OPSITE POST OP 9.5 X 8.5CM
			100230	DRESSING ADAPTIC DIGIT LARGE 2.8CM
			103224	DRESSING MEPORE SURGICAL STERILE 9X20CM
			103232	DRESSING MESALT 5 X 5CM
			103234	DRESSING KALTOSTAT 2.8 X 4.5IN LT-FR
			103236	DRESSING INTRASITE HYDROGEL 8GM
			103238	DRESSING AQUACEL HYDROFIBER STER 6 X 6IN
			103262	DRESSING MESORB XABSB 10 X 13CM
			103265	DRESSING MEPILEX LITE NONBORDER 10X10CM
			103270	DRESSING MEPITEL SOFT SILICONE 10 X 18CM
			103274	DRESSING 8X6IN ALVN FM
			103281	DRESSING ALLEVYN NONADH 5 X 5CM
			103290	DRESSING AQCL AG 15X15CM

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			103301	DRESSING MEPILEX BORDER 12.5 X 12.5CM
			103302	DRESSING MEPITEL SOFT SILICONE 7.5X10CM
			103524	DRESSING OPSITE TRANSP IV3000 6 X 8.5CM
			103617	DRESSING PRIMAPORE WOUND 8.2 X 10CM
			103618	DRESSING PRIMAPORE WOUND 10 X 25CM
			103619	DRESSING PRIMAPORE WOUND 10 X 20CM
			103646	DRESSING COVERPLAST ADH STER 3.8 X 3.8CM
			103647	DRESSING COVERPLAST ADH FABRIC 3.8X2.2CM
			103648	DRESSING SALINE WET 12PLY 10 X 20CM
			103649	DRESSING JELONET VASELINE 10 X 40CM
			103652	DRESSING OPSITE TRANSP STER 6 X 7CM
			103785	DRESSING RETAINER BURN NET SIZE 6 25YD
			103786	DRESSING RETAINER BURN NET SIZE 10 25YD
			103802	RETAINER DRESSING SURGILAST 5IN X 50YD
			103804	DRESSING RETAINER TUBEGAZ A1 .625INX50YD
			103817	DRESSING DUODERM CGF X-THIN 5X10CM LT-FR
			103818	DRESSING DUODERM CGF XTHIN 10X10CM LT-FR
			103882	DRESSING GAUZE BURN STER 18X18IN 3PK
			103938	DRESSING TELFA STERILE 3 X 8IN
			103939	DRESSING TELFA STERILE 3 X 4IN
			103941	GAUZE DRESSING STERILE ABD 5 X 9IN
			103943	DRESSING GAUZE STERILE 4 PLY 3 X 3IN
			104115	DRESSING TRACH STERILE 3 X 3IN
			104216	DRESSING ADAPTIC NON ADH STER 7.6X7.6CM
			104217	DRESSING ADAPTIC NON ADH STER 7.5X20.3CM
			104218	DRESSING ADAPTIC NON ADH STER 7.5 X 40CM
			104246	DRESSING KCI VAC GRANUFOAM SMALL
			104249	DRESSING KCI VAC GRANUFOAM LARGE
			104313	DRESSING OPSITE TRANSPARENT 10 X 14CM
			104314	DRESSING TEGADERM TRANSPARENT 7 X 10CM
			104804	DRESSING ADAPTIC DIGIT SMALL 2.0CM
			104805	DRESSING ADAPTIC DIGIT MEDIUM 2.4CM
			108869	DRESSING MEPILEX BORDER 10 X 10CM

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			108975	DRESSING GAUZE BURN STER 18X18IN 10PK
			110132	DRESSING TRANSP 7X6CM PU ADH HPOAL WTPRF
			110133	DRESSING TEGADERM TRANSPARENT 4 X 4.6IN
			111242	DRESSING TEGADERM TRANSPARENT 12 X 10CM
			112662	DRESSING DNTL 18X2IN HMST SPNG NS
			112774	DRESSING AQUACEL SILVER 12 X 8IN
			113232	DRESSING ELASTOP CLS 7.2X2.2CM LG PD
			113314	DRESSING HDRCLD 10X10CM CTNV HDR ABS ADH
			114286	DRESSING MEPITEL SOFT SILICONE 5 X 7.5CM
			114292	DRESSING ALLEVYN NONADH 15 X 15CM
			114462	DRESSING TRANSP 18X10CM MPFRM
			114783	DRESSING MEPILEX BORDER LITE 7.5 X 7.5CM
			114867	DRESSING PRIMAPOR ADHESIVE .25 X 14.8CM
			115581	DRESSING ACTICOAT BURN 10 X 20CM
			117216	DRESSING BACTIGRAS WND 0.5% CHG
			117673	DRESSING AQUACEL SILVER 4 X 4IN
			117840	DRESSING ELASTOPLAST 2 X 2CM LT-FR
			118272	DRESSING MEPILEX BORDER 4 X 5CM
			118342	DRESSING TEDADERM TRANSPARENT 4 X6.125IN
			119482	DRESSING MEPILEX BORDER LITE 5X12.5CM
			119485	DRESSING KCI FM SLVR MD
			131340	403708 DRESSING AQCL AG(SILVER) 4X4
			136641	DRESSING AQUACEL AG 10 X 10CM
			141818	DRESSING MESALT 10 X 10CM
			141819	DRESSING MPFRM SCAR 5X7.5
			141826	DRESSING MEPILEX BORDER 10 X 20CM
			155082	DRESSING DUODERM CGF 10 X 10CM LT-FR
			156401	DRESSING AQUACEL HYDROFIBER .75 X 18IN
			159064	DRESSING RSTR CNTCT LYR W/SILVER 4X5IN
			159736	DRESSING MEPORE PRO 9 X 10CM
			159737	DRESSING MEPORE PRO 6 X 7CM
			159810	DRESSING MEPILEX TRANSFER 20 X 50CM
			159854	DRESSING INTERDRY SILVER TEXTILE 10X12FT
			159854	DRESSING INTERDRY SILVER TEXTILE
			159854	DRESSING INTERDRY SILVER TEXTILE

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			159856	DRESSING TRAC WHITE FOAM 10 X15CM
			160403	DRESSING MEPITEL ONE 5.0 X 7.5CM
			161143	DRESSING FOAM BIATAIN AG NON ADH 10X10CM
			161250	DRESSING SPONGE EXCILON AMD IV 2X2IN
			163874	VAC KIT SIMPLACE DRESSING FOAM MEDIUM
			167145	DRESSING FOAM BIATAIN AG NON-ADHESIV 4X8
			167231	DRESSING MEPILEX BORDER 10 X 30CM
			167430	DRESSING MEPITEL ONE 17 X 25CM
			167432	VAC DRESSING GRANUFOAM SILVER MEDIUM
			169313	DRESSING TEGADERM IV ADVANCED 8.5X11.5CM
			170632	DRESSING TELFA ISLAND AMD 10.1 X 20.3CM
			175298	DRESSING TEGADERM ADV 6.5CM X 7CM
			176804	DRESSING MEPILEX AG 7.5X7.5CM FOAM
			176805	DRESSING MEPILEX BORDER AG 10X20CM
			176806	DRESSING MESALT 2CMX1M
			176811	DRESSING MEPILEX XABXB 15X20CM
			177284	DRESSING FILM MEPITEL 10X12CM
			102865	PAD NURSING DISPOSABLE
			103490	PAD PREP POVIDONE IODINE MEDIUM
			103717	PAD FOAM SELF ADHERING 20 X 30CM
			103780	PADDING COTTON WEBRIL UNDERCAST 3INX4YD
			103781	PADDING COTTON WEBRIL UNDERCAST 4INX4YD
			103792	PADDING COTTON WEBRIL UNDERCAST 2INX4YD
			103850	PAD CLEANER CAUTERY TIP
			103972	PATCH EYE ORTOPAD WHITE REGULAR
			104038	PAD ABDOMINAL CLOSED END STERILE 8 X 8IN
			108937	PADDING COTTON WEBRIL UNDERCAST 6INX4YD
			109045	PAD MATERNITY CURITY 4.3 X 12.25IN
			110304	PAD THN ULT MAXI ALWAYS
			114316	PAD MAXI THN ULT PRIMA STAYFREE
			114514	PATCH F JR EYE BRTHBL NWVN ORTOPAD
			114515	PATCH M JR EYE BRTHBL NWVN ORTOPAD
			178771	PAD ABSORBENT CLOUD 9 40 IN X 5.5 IN

Hazardous if Soiled by Blood or Blood Products - if soiled is bio-waste and if not is general waste				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			183245	PATCH EYE ORTOPAD JUNIOR WHITE
			183334	PAD UNIV SORB MED WGHT
			103184	DIAPER PAMPER BABY DRY SIZE 5
			104263	DIAPER,HUGGIES,#5,46'S
			104843	DIAPER PAMPERS SWADDLER PREMIE XSMALL
			109036	DIAPER PAMPERS BABY DRY SIZE 3
			109037	DIAPER PAMPERS SWADDLER BABY DRY SIZE 1
			109038	DIAPER PAMPERS BABY DRY SIZE 4
			109054	DIAPER PAMPERS BABY DRY SIZE 2
			109083	DIAPER PAMPERS BABY DRY SIZE 6
			109084	DIAPER PAMPERS SWADDLER BABY DRY NEWBORN
			109085	DIAPER PAMPERS SWADDLER PREMIE SMALL

Hospital Special Packs				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
17	105326	PACK DLV IWK GRACE	104716	PACK SURG CYSTOSCOPY GYN 9520E
15	104688	TRAY CATHETER URETHERAL DISP	105148	PACK SURGICAL CSTM BREAST SBA30BRQE*
			105256	PACK SRG LAP
			105265	PACK SRG LAPSCP
			105275	PACK P GYN SRG PRC
			105286	PACK SRG C-SECTION
			105296	PACK MIN LAP SRG PRC PED
			105306	PACK TNSL IWK GRACE HOSP
			105317	PACK CSTM ORTH SRG PRC
			105337	PACK SRG LAP PED
			105347	PACK BSC EYE SRG PRC
			105368	PACK CRD SRG PRC
			105378	PACK SRG BSC TYMPL
			105917	PACK PED BSIN SET IWK-HLTH
			113147	PACKING WND VAG
			113147	PACKING WND VAG
			113394	PACK SRG CRNTMY
			113395	PACK SRG NEURO BSC

Hospital Special Packs				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			113396	PACK SRG ORAL OSTM
			113397	PACK SURGICAL WISDOM TEETH SEN30WTIW
			113398	PACK SRG BSC ORTH SPNL
			113925	PACK HALIFA SRG PRC
			114684	PACK SRG ASCP
			114982	PACK UNV FRENCH TPE OPTIMA
			115579	PACK CARDIOLOGY IWK GRACE HOSP
			115620	PACK CYSTO IWK GRACE HSP
			115746	PACK FESS IWK GRACE
			116539	PACK MIC EYE IWK GRACE HSP
			116694	PACK PED LAPAROS IWK
			116904	PACK HALIFAX SPRT 3/8
			117596	PACK UFE EMBOL IWK HEALTH CENT
			129003	PACK TEST STEAM BIOLOGICAL INDICATOR
			132040	UPC-21L PACK PRNT CLR SNY
			141847	TEST PACK INTEGRATOR COMPLY STEAM/CHEM

No Contact with Hazardous Materials - Can be discarded in general waste or recyclables				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
8	104069	SET ENT FEED PUMP INFINITY ZEVEX 500 ML	103564	SET EXTN ENTERAL FEED 60IN
13	103965	SET ENT FEED PUMP INFINITY ZEVEX 1200ML	154368	TUBE FEEDING ENTERAL 109CM 8FR LT-FR
22	103481	TOOTHBRUSH ORAL PED GUM CRITTERS USFT	159015	TUBE FD ENTERAL 8FR X 36IN NWT CORFLO
6	104105	TUBING OXYGEN SUPPLY 7FT	103151	TUBE NG FEED 42IN 100CM 8FR
			103635	TUBE NG FEED 12IN 30CM 3.5FR
			103636	TUBE NG FEED XRAY STERILE 15IN 5FR
			103637	TUBE NG FEED 36IN 91CM 5FR
			103639	TUBE NG FEEDING SILASTIC 43IN 8FR
			103641	TUBE NG FEED 42IN 100CM 10FR
			103642	TUBE ENT FEED G BARD BUTTON 24IN 18FR
			103668	SET EXTN FEED Y KANGAROO STERILE
			103871	SET FEEDING ENTRISTAR 90 DEG 8884741821
			103973	TUBE NG FEEDING INDWELL 42IN 8FR

No Contact with Hazardous Materials - Can be discarded in general waste or recyclables				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			103975	TUBE NG FEEDING INDWELL 20IN 6.5FR
			103976	TUBE NG FEED INDWELL 36IN 6.5FR
			104207	TUBE GASTRO FEED MIC KEY LP 1.2CM 14FR
			104208	TUBE GASTRO FEED MIC KEY LP 1.7CM 14FR
			104209	TUBE GASTRO FEED MIC KEY LP 2.5CM 14FR
			107154	FEEDER SPCL NEEDS 150ML
			109090	SET ENT FEED GRAVITY KANGAROO 1000ML
			110210	TUBE GASTRO FEED MIC KEY LP 2.3CM 14FR
			112177	TUBE GASTRO FEED MIC KEY LP 4.5CM 14FR
			112992	TUBE GASTRO FEED MIC KEY 2.0CM 14FR
			116583	FEEDER,MINI-HABERMAN
			117646	TUBE GASTRO FEED MIC KEY LP 1.5CM 14FR
			154368	TUBE FEEDING ENTERAL 109CM 8FR LT-FR
			155069	TUBE GASTRO FEED MIC KEY LP 3.5CM 14FR
			159936	SET ENT FEED PUMP KANG 924 1000ML
			160032	SET EXTN NASOGASTRIC FEED MINI-BORE 62IN
			161330	TUBE GASTRO FEED MIC KEY LP 4.0CM 14FR
			161975	TUBE GASTRO FEED MIC KEY LP 3.0CM 14FR
			166458	TUBE FEEDING TRANSGASTRIC LOW PROFILE
			173149	PUMP FEEDING KANGAROO 924
			173663	SET ENT FEED PUMP KANG JOEY 500ML
			173664	SET ENT FEED PUMP KANG JOEY 1000ML
			176025	PUMP KANGAROO "JOEY" FEEDING
			176474	TUBE NG FEEDING INDWELL 10FR 42"
			176932	TUBE FEEDING TRANSGASTRIC 16 FR X 1.7
			176933	TUBE FEEDING TRANSGASTRIC 16 FR X 2.0

Strictly Controlled - have to be discarded in one special stream				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
3	103144	TUBING SUCTION NON CONDUCT STER 7MM 6FT	100089	SUCTION POOLE W TUBING 6FT STER LT-FR
1	104016	SYRINGE ABG SAMPLING 2CC	103465	TUBE TANDEM SUCTION SYSTEM 20IN
25	103621	NEEDLE BLUNT FILL SAFETY 18G 1.5IN	103710	TUBE TANDEM MEDI VAC SUCTION 18IN
4	102778	SET BLOOD COLLECTION SAFETY 23G 12IN	111001	SET TUBING SUCTION IRRG GYRUS W SPIKE
26	103765	KIT ARTERIAL BLOOD SAMPLE LITH HEP 1ML	111533	TUBE SUCTION YANKAUER ON OFF SWITCH STER
19	104039	CATHETER IV AUTOGUARD 24G 0.56IN	116413	TUBING SUCTION CLEAR STERILE 10FT 7MM
24	104037	CATHETER IV AUTOGUARD SAFETY 22G 1IN	167441	TUBE SUCTION YANKAUER BULB TIP LT-FR
27	103566	DEVICE BAG ACCESS BLOOD 2300E	170433	TUBING SUCTION TRUMPET CORE 5 X 32 CM
			100649	NEEDLE ELECTRODE DISP STERILE 2.82IN
			100840	NEEDLE BONE MARROW ILLINOIS 15G 4.7CM
			100860	NEEDLE 20GX1
			100861	NEEDLE FLTR 5-MICRON 19G X 1.51IN
			100887	NEEDLE BLUNT FILL FILTER 18G 1.5IN
			100900	NEEDLE HYPO SAFETYGLIDE 25G 1IN
			100905	NEEDLE HYPO SAFETYGLIDE 22G 1.5IN
			100905	NEEDLE HYPO SAFETYGLIDE 22G 1.5IN
			100906	NEEDLE HYPO SAFETYGLIDE 23G 1IN
			100907	NEEDLE HYPO SAFETYGLIDE 25G 5/8IN
			100907	NEEDLE HYPO SAFETYGLIDE 25G 5/8IN
			103437	TIP CAUTERY PENCIL NEEDLE STERILE 1IN
			103587	NEEDLE HYPO ECLIPSE SAFETY 27G 0.5IN
			103588	NEEDLE HYPO MONOJECT SAFETY 21G 1.5IN
			103589	NEEDLE HYPO MONOJECT SAFETY 20G 1IN
			103594	NEEDLE HYPO MONOJECT SAFETY 23G 1IN
			103602	NEEDLE HYPO ECLIPSE SAFETY 25G 1.5IN
			103605	NEEDLE SPINAL SPROTTE DISP 24G 3.5IN
			103606	NEEDLE SPINAL SPROTTE DISP 23G 4.75IN
			103607	NEEDLE SPINAL QUINCKE SHORT 22G 1.5IN
			103608	NEEDLE SPINAL QUINCKE 20G 3.5IN
			103609	NEEDLE SPINAL QUINCKE 22G 3.5IN
			103611	NEEDLE EPIDURAL TOUHY 17G 3.5IN

Strictly Controlled - have to be discarded in one special stream				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			103612	NEEDLE SPINAL WHITACRE 25G 3.5IN
			103613	NEEDLE SPINAL QUINCKE 22G 2.5IN
			103628	NEEDLE 15CM 18GA LNCT PRC DISP ECHTP
			103768	NEEDLE BIOPSY TRUE CUT STER 14G 11.4CM
			103772	NEEDLE BLOOD COLLECTION SAFTY 22GX1.25IN
			103773	NEEDLE BLOOD COLLECTION SAFETY 21G 1.25
			104307	NEEDLE FISTULA STERIFLO MEDISYSTEMS 16G
			104735	NEEDLE PRICK TST ALLERSHARP
			105513	NEEDLE BX 8GA 4IN JMSHD BN MRW
			106586	NEEDLE SUBDERMAL 29G 12MM PURPLE
			106587	NEEDLE SUBDERMAL 29G 12MM BLACK
			107248	NEEDLE SPNL 1.25IN 20GA BD QNCK STER YLW
			109471	NEEDLE HLDR MAYO HAGAR 6
			109630	NEEDLE SPNL 1IN 25GA BD QNCK THNWL SHRT
			109642	NEEDLE SPNL 5IN 22GA BD QNCK LNG STER
			109647	NEEDLE ART 21GA 1IN GW WNG ADPR AMC/3
			110223	NEEDLE AUTOSAMPLER MDS
			110261	NEEDLE IO 4.7CM 15GA IL BN MRW LNCT PNT
			110583	NEEDLE JAMSHIDI BONE MARROW 13G 9CM
			111468	NEEDLE INST MAG
			111593	NEEDLE HPO 25GA 7/8IN PRCSNGL REG BVL
			112924	NEEDLE SPNL 25GX5IN PNCL PT
			112965	NEEDLE IO 3CM 18GA INFS STD TIP LANCET
			112978	NEEDLE BX 18GA 130MM MAG
			112978	NEEDLE BX 18GA 130MM MAG
			113480	NEEDLE HPO 30GA .5IN ECLPS SF SHLD STER
			113482	NEEDLE 1.5IN 16GA BLNT MNJCT
			113641	NEEDLE CORSON
			113739	NEEDLE AMNIO 15CM 20GA ECHTP SDPRT ASP
			113908	NEEDLE SUT 5 .5 CRC TPR PNT MAYO CATGUT
			114392	NEEDLE 1IN 18GA BLNT MNJCT
			114403	INJECTOR NEEDLE STAINLESS
			114456	NEEDLE SPNL QNCK 18GX3IN

Strictly Controlled - have to be discarded in one special stream				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			114573	NEEDLE 1IN 23GA BLNT MNJCT
			114648	NEEDLE SPRT 22GX2.75
			114779	NEEDLE BIOPSY TISSUE MAGNUM 14G 100MM
			114809	NEEDLE JAMSHIDI BONE MARROW 11G 4IN
			115045	NEEDLE 10CM 20GA LNCT PRC DISP ECHTP
			115630	NEEDLE BX PRO-MAG 1 2.2
			115632	NEEDLE ASP 1.5IN 18GA STRNL/IL
			116062	NEEDLE IO 3CM 16GA INFS STD TIP LNCT
			116142	NEEDLE SPRT PAJUNK 22GX1
			116764	NEEDLE BX 18 GAX10 CM
			117063	NEEDLE DEFLUX MTL ONLY 23GA
			117148	NEEDLE BX 18GA 160MM MAG
			117148	NEEDLE BX 18GA 160MM MAG
			117292	NEEDLE PERCUTANEOUS BSDN-18-7.0
			117330	NEEDLE 15CM 22GA LNCT PRC DISP ECHTP
			117574	NEEDLE SYR BIOP 70X1.6MM 16G
			120547	NEEDLE HYPO PRECISIONGL 25G 5/8IN
			123353	NEEDLE HOMER MAMMALOK 20G 5CM ULT BLN
			123354	NEEDLE HOMER MAMMALOK BRST 20G X 10CM
			123358	NEEDLE HOMER MAMMALOK 20G 7.5CM
			126475	NEEDLE DNTL 27GA LNG MNJCT HTLHB DISP
			136853	NEEDLE SPINAL QUINCKE 18G 3.5IN
			141936	NEEDLE HYPO 22G X1.5IN BVL
			151904	NEEDLE 20GX3.5IN TUO
			153998	DRIVER EZ-IO POWER SMALL NEEDLES
			154292	NEEDLE HYPO MONOJECT SAFETY 18G 1.5IN
			154293	NEEDLE HYPO MONOJECT SAFETY 21G 1IN
			156073	SPINAL NEEDLE WHITACARE 22G x 5"
			158172	NEEDLE DISP SINGLE SBDRM ELTRD
			159086	NEEDLE SPINAL WHITACARE 27G X 5IN
			160010	NEEDLE EPIDURAL TUOHY 18 GA 3.5IN
			166836	NEEDLE BIOPSY DISP MAGNUM
			168166	NEEDLE E1860T 18GA TOUHY
			168168	NEEDLE E1745T 17GA 4.5IN TOUHY
			169130	NEEDLE EPIDURAL TUOHY 18 GA X 2 IN
			173477	NEEDLE EXTENDER S/S 4IN

Strictly Controlled - have to be discarded in one special stream				
Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			173607	NEEDLE GRIPPER MICRO SAFTY BC 22G 0.75IN
			173608	NEEDLE MICRO-GRIPPER SAFETY 22G 1IN
			173609	NEEDLE MICRO-GRIPPER SAFETY 22G 1 1/4IN
			175219	NEEDLE BIOPSY CHIBA 22-10.0
			175262	NEEDLE MAGNUM-CORE BIOPSY 14X10-7CM
			176084	NEEDLE ACCESS INSUFF 14 GA
			176482	NEEDLE FLOW HIGH GAUGE 16
			176758	NEEDLE DRIVER CRVD HEANEY 21CM
			176774	NEEDLE VERRES 150MM 6"
			177014	NEEDLE ASPIRATION 16 GA OVA-STIFF OVUM
			177134	NEEDLE VERRES 100MM
			177542	NEEDLE BULK STRL 16G 3/4IN PRECGLD ORNG
			177784	NEEDLE PORT 1" 19GA GRPR W/O "Y" STER
			178769	NEEDLE HOLDER MAYO/HAGAR 6IN
			182996	NEEDLE # 2 STAGO
			182997	NEEDLE # 3 STAGO
			183010	NEEDLE INSUFFLATION STEP SHORT 14 GA
			103407	BLADE SURGICAL CLIPPER 4406 LT-FR
			103439	CAUTERY TIPBLADE,6 ,E15516
			103443	TIP CAUTERY PENCIL BLADE STERILE 1IN
			103921	BLADE SURGICAL CARBON STEEL STER BP SZ10
			103922	BLADE SURGICAL CARBON STEEL STER BP SZ11
			103923	BLADE SURGICAL CARBON STEEL DISP SIZE 12
			103924	BLADE SURGICAL CARBON STEEL STER BP SZ15
			103925	BLADE SURGICAL CARBON STEEL STER BP SZ21
			103926	BLADE MYRINGOTOMY EAR #71
			104017	PENCIL CAUTERY RS INCL BLADE AND HOLSTER
			104287	CAUTERY W BLADE PENEVAC SMOKE EVAC 10FT
			104600	BLADE SW 25X6X.6MM CLBRT NS
			104821	BLADE SW 30X10X.4MM CLBRT NS
			106387	BLADE SW MICROPOWER MICRO100 MIC 25.5
			106828	BLADE 5MM TRPHN CRNL SRG STER DISP
			106832	BLADE 15.8MM 8.75MM TRPHN SHRP UNFRM EDG

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Sample Product			**Similar Products**	
ID No.	**SAP No.**	**Description**	**SAP No.**	**Description**
			107300	ELECTRODE SURGICAL BLADE EZ CLEAN 2.75IN
			108875	BLADE HK # 179752040
			109661	BLADE DERMATONE 1.25-4.25
			110031	BLADE BEAVER EYE
			110314	BLADE BEAVER EYE
			110403	BLADE HST RZR GM TY
			110805	BLADE SAG COARSE ST 9.5W 25.5L 0.4MM
			110805	BLADE SAG COARSE ST 9.5W 25.5L 0.4MM
			111052	BLADE 15 STRHT OPTH MNBLD SRG STER DISP
			111346	BLADE SW HALL 35X10X.6MM STRNM SS STER
			111346	BLADE SW HALL 35X10X.6MM STRNM SS STER
			112554	BLADE BAND SAW 3/8
			113871	BLADES NEURO F/ P4413
			113923	BLADE HEINE #3 FBR OPTC
			114600	BLADE LANCET # 8688-98
			115290	BLADE SW 25X10X.6MM OSC NS
			115291	BLADE SAW # 532.063
			115396	BLADE WISONSIN #1 OPTC
			116431	BLADE ESCP 4MM TRCT SHVR STER
			116677	BLADE SET ESCP SHVR 40D 12D ADND TNSL
			116866	BLADE 7IN ANG SKMR SRG
			117243	BLADE STRHT ESCP 110MM 2.9MM SLVR BL
			118964	BLADE FULL HANDLE SHORTCUT ANGLED 4MM
			121643	BLADE 2.3MM ANG BVL UP FULL HNDL OPTH
			124853	BLADE MN RND SHRP D/B 6900
			134050	12-634-1C BLADE FTHR DISP
			135901	BLADE SAG FINE ST 9.5W 25.5L 0.4MM
			147207	BLADE SW MCHC ME 25.4X7.9X.58MM RECIP SS
			147489	BLADE CRTLG SRG
			150515	BLADE FULL RDS ASCP 4.5MM SHVR STER DISP
			150517	BLADE ASCP 4.5MM RZRCT SHVR STER DISP
			151482	BLADE TYMPANO PLASTY STER 60 DEG 2.5MM
			151483	BLADE EYE MICRO SHARP 15 DEG 5MM
			154376	BLADE MICRO SHARP 15 DEGREE

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Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			156122	BLADE OSCL FINE ST 18.5W 28.5L 0.4MM
			156122	BLADE OSCL FINE ST 18.5W 28.5L 0.4MM
			158525	HOOK WIDE BLADE W/ SHELF SMALL
			161092	HOOK WIDE BLADE W/SHELF MD TI
			161093	HOOK WIDE BLADE W/SHELF LG TI
			161555	BLADE TRI-CUT EM
			167853	BLADE SAW F/OSCILL 70/49 X 14 X 4MM
			168177	HOOK BLADE WIDE 8
			168179	BLADE RECIP FLAT 38.0W 0.4MM
			168179	BLADE RECIP FLAT 38.0W 0.4MM
			168191	BLADE ACCU-EDGE TRIMMING SHORT
			175528	BLADE SCALPEL #60 POINT TIP
			175660	BLADE SAW # 532.047S
			175663	BLADE SAW # 519.106S
			175969	BLADE LARYNGOSCOPE MAC SZ 2
			176325	BLADE LARYNGOSCOPE FO INTERGRATE MAC 1
			176375	BLADE LARYNGOSCOPE FO INTERGRATE MAC 2
			176377	BLADE LARYNGOSCOPE FO INTERGRATE MAC 3
			176378	BLADE LARYNGOSCOPE FO INTERGRATE MAC 4
			176379	BLADE LARYNGOSCOPE FO INTERGRAT MILLER 0
			176380	BLADE LARYNGOSCOPE FO INTERGRAT MILLER 1
			176381	BLADE LARYNGOSCOPE FO INTERGRAT MILLER 2
			176382	BLADE LARYNGOSCOPE FO INTERGRAT MILLER 3
			180524	BLADE SZ 3 DISP CHNLD MED ADLT
			184190	BLADE EDGE INSULATED COATED 4 IN
			103106	SYRINGE TB 26G 3/8 1ML
			103410	SYRINGE IRR BULB EAR DISP 3OZ
			103714	SYRINGE SLIP TIP STERILE 5ML LT-FR
			103718	SYRINGE ORAL MED CAP CLEAR NONSTER 60ML
			104006	SYRINGE IRR TOOMEY CATH /LUER ADPT 70CC
			104011	SYRINGE INSULIN SAFETYGLIDE U100 29G 1ML
			104012	SYRINGE INSULIN SAFETYGLID U100 30G .5ML
			104351	SYRINGE ORAL MED CAP CLEAR NONSTER1ML

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Sample Product			Similar Products	
ID No.	SAP No.	Description	SAP No.	Description
			104352	SYRINGE LOSS OF RESISTANCE
			104370	SYRINGE ORAL MED CAP CLEAR NONSTER 3ML
			104390	SYRINGE ORAL MED CAP CLEAR NONSTER 5ML
			104405	SYRINGE ORAL MED CAP CLEAR NONSTER 10ML
			104418	SYRINGE ORAL MED CAP CLEAR NONSTER 20ML
			109016	SYRINGE LUER LOCK STERILE 10ML LT-FR
			109017	SYRINGE LUER LOK CONTROL STER 10ML LT-FR
			109018	SYRINGE LUER LOK STERILE 20ML LT-FR
			109019	SYRINGE LUER LOK STERILE 30ML
			109020	SYRINGE LUER LOCK STERILE 60ML LT-FR
			109022	SYRINGE IRR BULB STER 50ML LT-FR
			109023	SYRINGE LUER LOK STERILE 1ML LT-FR
			109450	SYRINGE MEDRAD ANGIO DISP QUICKFILL
			109864	SYRINGE CATHETER TIP 2OZ 60ML LT-FR
			111694	SYRINGE 10UL C/W REMOVEABLE
			113881	SYRINGE 10-20ML ENV MED
			115138	SYRINGE U100 INSN ULFN 2
			115596	SYRINGE 20ML VAC LOK FOUR
			117062	SYRINGE DEFLUX,1.0 ml (D-0100)
			128523	SYRINGE POSIFLUSH NONSTER 0.9% NACL 5MLL
			131820	SYRINGE STELLANT DISP 200ML
			151454	SYRINGE POSIFLUSH NONSTER 0.9% NACL 10ML
			151454	SYRINGE POSIFLUSH NONSTER 0.9% NACL 10ML
			151455	SYRINGE POSIFLUSH STERILE NACL 0.9 10ML
			160030	SYRINGE NASOGASTRIC FEED NON STER 60ML
			160031	SYRINGE NASOGASTRIC FEED NON STER 30ML
			160148	SYRINGE LUER LOCK STERILE 5ML LT-FR
			160455	SYRINGE NASOGASTRIC FEED NON STER 10ML
			160760	SYRINGE BULKAMID HYDROGEL
			161800	SYRINGE LUER LOCK STERILE 3ML LT-FR
			167131	SYRINGE FLUSH BRAUN PUMP 0.9%NACL 10ML
			173227	SYRINGE HEPARIN IV FLUSH 10U/ML 5ML FILL

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Sample Product			**Similar Products**	
ID No.	**SAP No.**	**Description**	**SAP No.**	**Description**
			173228	SYRINGE HEPARIN IV FLUSH 1U/ML 2ML FILL
			177061	SYRINGE 250UL PE200 AUTOSMPLR
			180997	SYRINGE NEBULIZER CONTINUOUS AERONEB
			181002	SYRINGE ATERION MARK 7 MEDRAD
			182995	SYRINGE HAMILTON STAGO
			183321	SYRINGE ORAL 1 ML CLEAR W CAP
			183322	SYRINGE ORAL 3 ML CLEAR W CAP
			183323	SYRINGE ORAL 5 ML CLEAR W CAP
			183324	SYRINGE ORAL 10 ML CLEAR W CAP
			183325	SYRINGE ORAL 20 ML CLEAR W CAP
			183326	SYRINGE ORAL 60 ML CLEAR W CAP
			103983	BATTERY ALKALINE SIZE AAA PROCELL
			103985	BATTERY SCP HNDL RCHRG 71000 71670 NICD
			103991	BATTERY ALKALINE 9V PROCELL
			103992	BATTERY ALKALINE SIZE AA PROCELL
			103993	BATTERY ALK C PRCL
			103994	BATTERY ALK D PRCL
			104023	BATTERY NURSE CALL CR2477 3V
			105294	BATTERY DFBR SL LD ACD LFPK
			107431	BATTERY VNT INTNL AVEA
			109670	BATTERY 6 VOLT SQ SPRG
			110664	BATTERY 6 VOLT SCR TOP
			113134	BATTERY SLA
			115304	BATTERY SM DRV # 532.003
			116046	BATTERY SRG DRVR SM NS
			117203	BATTERY 12V 2.3AH
			132212	LC-R127R2P BATTERY 12V 7.2 AH
			133491	6487180 BATTERY MOD
			139956	LCRD1217P BATTERY PAC 2200XL
			173630	BATTERY 1.5V 76A/A76 BUTTON