PORTABLE SURGICAL BAG PACK

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons.) Mechatronic Engineering

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"PORTABLE SURGICAL BAG PACK"** was prepared by **ERIC CHUA SHI KHANG** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons.) Mechatronic Engineering at Universiti Tunku Abdul Rahman.

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ABSTRACT

Natural disaster is defined as a disaster that occurred due to the changes in the nature of our mother earth. The natural disasters are categorise into four main categories which are geological, hydrological, and meteorological and wildfires. Examples of geological and hydrological disaster are earthquake and tsunami. The example for meteorological and wildfires are cyclone, tornado and cyclone. These disasters had caused the countries around the world suffer great casualties. By referring to figures 2.3.9 and 2.3.10, the estimation of death toll due to natural disasters at the year 2010 is 297, 728 and 235, 272 at the year 2008. The reasons of the death toll keep increasing are lack of surgical facilities in disaster areas and also post-surgery infection. Hence, a portable surgical bag pack was created to overcome these problems. The main purpose of this portable surgical bag pack is to save the lives of victims by using a more convenient surgical facilities at the affected areas. It contained the most general surgical kit, surgical medium and simple medical accessories. A GPS tracking system also can be installed into this bag pack. The advantageous of this bag pack are its light weight and convenient to carry from one place to another by single person.

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LIST OF SYMBOLS / ABBREVIATIONS

c_p	specific heat capacity, J/(kg·K)
h	height, m
K_d	discharge coefficient
M	mass flow rate, kg/s
P	pressure, kPa
P_b	back pressure, kPa
R	mass flow rate ratio
T	temperature, K
v	specific volume, m^3
α	homogeneous void fraction
η	pressure ratio
ρ	density, kg/m^3
ω	compressible flow parameter
ID	inner diameter, m
MAP	maximum allowable pressure, kPa
MAWP	maximum allowable working pressure, kPa
OD	outer diameter, m
RV	relief valve

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

A lot of natural disasters happened unexpectedly around the world. There are millions of people died and affected by those disasters. The number of people dead and suffered severe injuries keep increasing even after the natural disaster occurrence. Some of them lost their lives due to diseases outbreak, infections and failed to receive treatment within a certain period of time. There are many reasons that cause these tragedies and one of the reasons is ineffective response. Official Institution failed to response as quickly as possible because those disasters happened too random and unpredictable. Besides, victims at the disaster areas often faced the problem of medical and daily supplies shortage. One of the common pathetic incident is victims pass away due to late treatment on their survivable injuries. Some of them lost their lives due to post-surgery infection. Hence, a portable surgical bag pack was created. This product can be carried easily from one place to another. This product also can be cleaned up with the supply or resources around the disaster areas.

Portable surgical bag pack is a type of bag that can be used by medical personnel to perform simple surgery at disasters and remote areas. It consists of a sterilized medium for surgery. In the clean medium, the percentage of post-surgery infection can be reduced.

1.2 Problem Statement

There are few problems that will be faced after a natural disaster. Some of the problems create huge impact towards economic and others. However, the main problem which requires immediate action was the victims who suffered at the areas affected by the disasters.

By looking at Haiti earthquake 2010 and Indian Ocean tsunami 2004, more than 500 thousands of lives had lost (Wikipedia, 2016). These casualties are due to the destructive power of disasters and late arrival of medical support. However, the most difficult challenge that most of the people faced in natural disaster areas is the ineffective response from their own country or international aid agencies.

Firstly, this problem had created another serious problem which is lack of surgical facilities on site. Lacking of these facilities had caused more people died especially those with survivable injuries.

There are portable medical containers that carry a lot of advances medical and surgical facilities to the disaster area. However, this container needs to be carried using a helicopter or any other air transport. This is because the surface of the earth becomes rugged. This issue had caused land vehicles facing difficulties to enter the areas. Furthermore, air transports need time and sufficient budget to send to the desired location.

Secondly, the challenging problem that we faced in the disaster areas is post-surgery infection. Post-surgery infection is a type of infection that often occurred at the victims' wounds after receiving a surgery. There are many possibilities and causes that might lead to post-surgery infections. One of the main causes is dirty surgical environment. Surgeries are to be conducted at decontamination area. This is to prevent bacteria, virus, and other germs from entering the wound.

1.3 Aims and Objectives

Throughout the development, the focus had been put on how to overcome these three problems which are common but troublesome.

1. Lack of surgical facilities
2. Post-surgery infection
3. Transportation of portable medical container

The portable surgical bag pack is invented to solve these problems. First of all, this bag pack can be carried easily by one person from one place to another. It does not require any transports because medical or non-medical personnel can walk into the disaster areas by carrying this bag pack together to save the survivable injuries patients.

Secondly, this bag pack has a sealed area which is sterilized. Performing surgery inside the space can reduce the possibilities of suffering post-surgery infection.

Thirdly, the bag pack is able to solve the "lack of surgical facilities" problem. This is because anyone who enters those areas can carry this bag along. For example, if there are 20 people volunteers entering the affected areas, then there will be 20 surgical bag packs available in that area. With this bag pack, these problems can be reduced and solved. Hence, more lives can be saved and the number of casualties can be reduced.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural Disaster

A natural disaster is a kind of adverse event that caused by the natural process of the earth. There are many types of natural disasters that occur around the world. Those natural disasters are being categorized into geological disasters, hydrological disasters, meteorological disasters, wildfires (Alexander, 1993).

2.1.1 Geological Disaster

Geological disaster is a type of disaster caused by shifting in the tectonic plate and unstable earth crust activities like the earthquake, avalanches, mudslides and volcanic eruptions. These disasters occurred instantly and randomly. Other than suffering damages, casualties and impact from different aspects are huge and severe. Disasters that being categorized as geological disasters normally occurred in large scale and causing negative impacts to the affected areas (Rastall, 1944).

2.1.1.1 Earthquake

Earthquake is the most common natural disaster that occurred around the world and the effects are not optimistic. This is because earthquake creates a tremendous amount of destruction. The destructive power had led to serious casualties, tumbling of constructions and others. According to national geographic reports, there are eight earthquakes strike somewhere every year and around 10,000 people and above lost their lives due to the earthquake (National Geographic, 2015).

Throughout the past 20 years, there are few high destructive levels' earthquakes occurred that affect several countries. There are a lot of people dead or suffer injuries due to the earthquake. One of the most famous earthquakes is Haiti earthquake. Haiti had been attacked by an earthquake with a magnitude of 7.0 at the year 2010. This disaster had caused huge negative impacts toward their economy and infrastructure. According to the societies estimation stated in Wikipedia, there are as many as three million people being affected by this earthquake (Wikipedia, 2016). The

Haiti government reported the death toll had reach 230 thousand in the mid of February, 2016.

According to a report in USGS, there are total of 699,093 of death and 743, 177 injuries caused by earthquakes from the year 2004 to 2010. (USGS, 2016)

2.1.1.2 Volcanic Eruption

Volcanoes can be a root cause of various kind of natural disasters and it has a close relationship with earthquake and tsunami (Robock, 2000). The eruption itself can cause widespread of disasters because of the continuous explosions and falling rocks.

Moreover, the lava that flows out from the volcanoes will destroy the flora and fauna around the affected areas. The worst part is that the lava can damage infrastructure and cause life-threatening events to occur.

Through the years, one of the volcano disasters occurred at Nyiragongo, the Democratic Republic of Congo in the year 2002. The eruption occurred at January and destroyed 15% of the city of Goma. A large amount of lava had flown out from the volcano which caused a devastating damage to the infrastructure of the city and split the city into several sections. However, the casualties suffered was not serious (around 147 people killed) due to early detection and quick responses. However, more than 400, 000 people in the city were evacuated (Natural Disaster Association, no date).

2.1.1.3 Mudslides and Avalanches

Landslides, mudslides, and avalanches are another kind of geological disasters which can happen at anywhere that has loud sound, loose soil and lack of flora. These disasters mostly occur at places which have hills or places that are sloppy.

Avalanches mainly occur due to a loud sound produced which caused a mass amount of snow vibrate and fall from higher areas to lower areas. Besides that, skiers might be triggered the avalanches as well. Avalanches can bury or flood a whole village in few seconds (Riya, 2014).

On the other hand, landslides and mudslides are similar. There will be a mass amount of sand or mud fall down due to many reasons like heavy rain, lack of trees holding the land, inefficient water distribution system, and others. In Algeria November 10, 2001, landslides had occurred at Bab El-Oued quarter of Algiers, more than 700 people were killed (Brar, 2013).

2.1.2 Hydrological Disasters

2.1.2.1 Tsunami

Tsunami is the second most common natural disaster that brought a devastating destructive power to the countries or cities that near to the sea. A tsunami can be occurred due to several reasons. It can happen due to volcanic eruption and earthquake under the sea as well. When tsunami occurs, a huge wave will occur and the magnitude of the wave can be as high as 9 meters.

There are quite a few tsunamis occurred around the world. One of the most serious tsunami is India ocean tsunami at 2004 and Japan tsunami at 2015. By ignoring the impact of the other aspects, India ocean tsunami had caused 230, 000 people dead in 14 countries (Wikipedia, 2016). The casualties were very pathetic. The tsunami had the longest faulting ever observed which is between 8 to 10 minutes are. Due to this tsunami, there are a lot of buildings being destroyed and a lot of survivors were homeless until today (Wikipedia, 2016).

For Japan tsunami 2015, an earthquake occurred under the sea that near Kagoshima and Satsunan islands. The magnitude of the earthquake is seven. This disaster had caused nuclear radiation leakage from one of the nuclear reactor power plants in Japan. This is because the walls of the power plant are not designed to withstand the huge impact of the tsunami. This issue had caused the cooling system malfunction and lead to explosions occurred due to overheat.

The casualties suffer is not high but it took away 18,000 people lives in estimation and 230, 000 of civilians have yet back to their home due to the disaster and the radiation (BBC, 2015).

2.1.3 Meteorological Disaster

Meteorological disasters are disasters that caused by extreme weather. For example, sudden hot, cold, and windy at the environment that related to earth atmosphere. Some of the examples are blizzards, drought, cyclonic storms, and tornadoes.

2.1.3.1 Blizzards

Blizzard is a severe winter storm. This phenomenon often occurs in countries that have winter seasons. Blizzard rarely causing huge casualties but it does impact local

economic activities. One of the most serious blizzards ever occurred is located at United State. A huge scale of wheat crops was destroyed.

One of the most devastating blizzards ever happened in the world is "The Blizzard 1949". Nebraska was having a bad winter period during the disaster happened. The road was blocked because of snow fall heavily. The sleet and the wind are between 50-70 miles per hour. However, there was no major casualties but causes a huge impact on the economy of the country as theory had hired 6, 000 men workforce (Reinhardt & Ganzel, no date).

2.1.3.2 Drought

Drought occurred when there is an abnormal dryness of land. This event causes crop failure due to lack of water. Drought often occurs in a long period of time and temperature rises which caused a lot of people suffering heat struck.

The well-known drought is Millennium Drought in Australia. This disaster had occurred from the year 2001 to 2009. The article of "The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society" had mentioned that

"…the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [2010] found that the period 1997–2009 had the lowest average rainfall since 1900 (but with some above-average precipitation years), whereas Van Dijk and Renzullo [2009] found that surface water resources scarcity already started to develop around 1994." (Dijk, et al., 2013)

Australian had suffered negative economic impact as the water usage is reduced. As the reduction of water increase, the water usage in irrigation was reduced 31% to 33% from the year 2007 to 2008 compare to the year 2000 and 2001. This issue had caused the dairy, cereals, rice and meat all experienced significant price rises in 2007 and 2008. (Kirby, et al., 2013) However, with the current technologies, drought often cause life-threatening problems because it happened over a long period of time. During that period of time, proper actions and precaution had been taken by the people to avoid any unnecessary losses.

2.1.3.3 Cyclonic Storms

Cyclonic storms are typhoons, hurricane, and cyclone. These disasters are forms over the seas and oceans. The level of severity that the storms caused are unpredictable. Thus, the destructive power cannot be looked down as well.

One of the well-known hurricanes is hurricane Katrina which happened at United State at the year 2005. This hurricane had caused 1,833 people died and leave millions of people homeless. According to Kim Ann Zimmermann, there are 80% of New Orleans and large portions of nearby parishes became flooded, and the floodwaters did not recede for weeks when the hurricane made a landfall. (Zimmermann, 2015)

The Article wrote by Kim also mentioned that those affected countries haven fully recover after 10 years of the disaster occurred. She stated that

"...Ten years later, the region was still recovering from Katrina. The New Orleans metro area's population had dropped dramatically, from 1.386 million in 2005 to 1.04 million in 2006. By 2014, it had climbed back to 1.252 million, according to the U.S. Census Bureau. The number of housing units and business establishments had also fallen and by 2014 had not returned to pre-2005 levels." (Zimmermann, 2015)

From the statement made by Kim, natural disasters can destroy anything in few moments but to recover from the damage consume longer time.

2.1.3.4 Tornadoes

Tornado is a very dangerous rotating column of air that in contact with the surface and the cloud. The wind speed of tornadoes can reach 177 kilometres per hour. However, the most dangerous tornado can achieve the wind speed up to 300 kilometres per hour (New World Encylopedia, 2015).

The most recent and deadliest tornado had struck Joplin, Missouri. This tornado had stricken Joplin on May 22, 2011. (CNN, 2014) According to Katie Walmsley who wrote "Rebuilding Joplin a year after tornado", 161 people dead and hundreds more injured. In this city, a lot of people are struggling to find permanent houses as most of the infrastructure located at Joplin were flattened. (Walmsley, 2012)

After one year of the disaster, the city is still working on recovering and according to Kate, there are almost 130,000 volunteers had spent hours to recover the

city. Hence, a tornado might be a small disaster compare to tsunami or earthquake but the destructive power is immeasurable.

2.1.4 Wildfires

Wildfires are a lot of fires that burn off everything. This disaster normally occurred at places that are too dry and full of dead crops like trees and grass. Hence, drought can be the main trigger for wildfires outbreak. Besides that, a lightning strike will cause wildfires outbreak as well.

A well-known wildfires outbreak is Peshtigo fire which occurred at United State and Victoria Bushfire in Australia in the year 2005. This fire outbreak had killed more than 1700 people. Throughout the year, people had considered this tragedy as a disaster. However, this natural disaster was caused by logging, building or railroad and industries. (Burt, 2011)

2.2 Effects after Natural Disasters

There are many negative effects brought by natural disasters. The effects can be categorized into few section for example economic, health, casualties, diseases outbreak, infrastructure and others.

2.2.1 Economic

Most of the natural disasters will cause a huge impact towards economic of the countries involved. Affected countries will use a huge amount of money to save and support the lives of the victims. All those emergency services and features like temporary accommodation, water, food, medical supply, search and rescue and others required a tremendous amount of money.

For example, Nepal had engaged by an earthquake in the year 2015. The earthquake had 7.9 magnitudes and struck around 80km northwest of Kathmandu. This earthquake had affected eight million people. Upon the people affected, the country had suffered great losses. The country's economic losses were estimated to be around 10 billion USD. According to Information Handling Services (IHS), the amount cost for rebuilding is five billion USD in estimation. Moreover, the high unemployment rate which is more than 40% had made the economy worse (Jazeera, 2015).

On the other hand, Japan was suffering a great economy losses due to earthquake, tsunami, and meltdown. People called this as “Triple Disaster”. These disasters also cause great impact towards global economy. In this disaster, around 138,000 buildings were demolished and almost $360 billion of economy losses were incurred (Ferris, 2016).

2.2.2 Search and Rescue Missions

Search and rescue mission is a very important section in saving people lives after a natural disaster attack. There are a lot of people trapped inside collapsed buildings, mud, landslides, and a mass amount of snow which form avalanches, and others.

The importance of rescue mission teams was emphasized by the statement above. Often the teams provided are not enough as too many people need to be rescued when disaster struck. Moreover, accidents might happen during the mission and the rescuers lost their lives upon saving the others.

In Nepal earthquake, there were eight helicopters and more than one thousand members of national disaster respond and sixteen military and civilians aircraft had dispatched just for search and rescue missions. Almost ten million was spent for setting up these teams (Jazeera, 2016).

2.2.3 Public Health Issues

Public Health is another serious issue that faced by many countries and victims after a natural disaster struck. A lot of people will suffer various kind of sickness and diseases which causing them to face death at the end. However, public health is a long-term problem. It may take several weeks or months for the problems to surface. The “attack” that strike public health is unpredictable and the effects are fatal. Hence, a lot of precaution and health issues need to be considered to reduce the possibility of diseases outbreak and other deadly phenomena that might occur which threaten public health.

According to “Communicable Diseases Working Group on Emergencies” of world health organization, the “potential impact of communicable diseases is often presumed to be very high in the chaos that follows natural disasters. Increases in endemic diseases and the risk of outbreaks, however, are dependent upon many factors that must be systematically evaluated with a comprehensive risk assessment.” (World Health Organization, 2006). World Health Organization also mentioned that the

contagious diseases that cause death in the disaster area are diarrhea, acute respiratory infections, measles, malaria, and malnutrition. (Lemonick, 2011)

There are few examples that public health is being threatened and increase the severity of casualties. First is Haiti earthquake. There was a cholera outbreak after 10 months of the earthquake struck. This diseases outbreak had caused 470,000 people fall into sick and almost 7,000 people dead. Cholera mostly spread at areas which are not hygiene, deficient water treatment, and poor waste management (Center For Disaster Philanthropy, 2016).

Besides that, measles and meningitis are also communicable diseases that will outbreak in the event of natural disasters occurrence. Both of the diseases spread with the association of crowding. Measles is a high level of viral infection of the respiratory system. It is a contagious disease that can spread via contact with mucus and saliva. According to Valencia Higuera, this infection can "live on surfaces for several hours. As the infected particles enter the air and settle on surfaces, anyone within close proximity can become infected." Other than the mucus, the possibility of being infected is high if a person uses the infected victim's drinking glass and sharing eating utensils (Higuera, 2005). In 1991, there is a measles outbreak in Philippine due to the concentration of people after the eruption of Mt. Pinatubo and the number of reported cases of this disease has more than 18,000 (World Health Organization, 2006). There is a morbidity and mortality weekly report stated that the death rate had reached 26/10,000 among a group of tribes which was evacuated from the slope of the volcano (Centers for Diseases Control and Prevention, 2001).

On the other hand, a huge natural disaster not only will cause great diseases outbreak. Some small disaster will also trigger some acute illness as well. For example, an earthquake can cause the spores in soil release. One of the spores is called *coccidioides immitis*. These spores will lead to *clinical coccidiomycosis*. This case had happened at Northridge, CA earthquake of 1994 in a small community in Southern Ventura County. Besides that, other natural disasters like wildfires or volcanoes can cause the people around that areas suffering respiratory and ocular problems.

Furthermore, there is a disease called tetanus that might outbreak after natural disaster occurrence. This disease will not be transmitted from one person to another. However, contaminated wounds particular in population where routine vaccination coverage levels are low, are associated with morbidity and mortality from tetanus

(World Health Organization, 2006). There is a case of tetanus outbreak at Aceh after a tsunami occurred in the year 2004. An article stated there is total of 106 cases of tetanus reported (Lemonick, 2011).

Other than diseases, wound infection is also a very serious problem faced by the people in disaster area during recovery phase. In recovery phrase, 'wound infections among survivors of the 2004 tsunami in Southeast Asia were polymicrobial, with over 600 organisms ultimately identified. Most prominent among these were *Aeromonas species, E.coli, Klebsiella pneumonia, and Pseudomonas aeruginosa*. Some of these organisms were resistant to all licensed antibiotics. Additionally, 24 cases of hurricane-associated Vibrio vulnificus and V. parahaemolyticus wound infections were reported, with six deaths' (Lemonick, 2011).

Those examples above had clearly explained that percentage of diseases outbreak and infection are higher when in poor public health areas which natural disasters occurred. This issue will directly affect those who suffering survivable injuries. Their wounds will be infected by those bacteria and their health condition become worse. In other words, the chances of suffering post-surgery infection will become higher. This will lead to death and thus increase the number of death toll.

In a nutshell, the health impact in term of diseases outbreak and infection attack had taken away so many innocent lives. We can realize that the destructive power of natural disasters is immeasurable.

2.2.4 Casualties

Almost all countries or areas affected by natural disaster suffer great casualties. A lot of people died and suffered severe injuries in the event of natural disasters occurrence. Some of them drown, killed by collapsing building, burned by fire and others.

According to United Stated Geological Survey, there are more than 230,000 people killed in 14 countries in Indian Ocean earthquake 2004. The death toll mentioned above included those who are missing after the disaster occurred.

By analysing the data collected from 1994 to 2013, there are estimated of 6873 natural disasters occurred throughout the world. There had been 1.35 million lives lost which claimed that there are 68,000 people lost their lives each year.

According to EM-DAT data, earthquake including tsunami had killed around 750,000 people from 1994 to 2013. Among the disasters, the tsunami is the deadliest

because this disaster caused an average of 79 death in 1000 people affected (International Federation of Red Cross and Red Crescent Societies, 2014). Besides earthquake and tsunami, there str also other disasters which bring serious casualties in term of injuries, not death toll.

One of the examples is flooding. Flooding is the most common disaster happened around the world and it happened to affected 2.5 billion people (Relief Web, 2015). Besides flooding, storm stands as the second most frequent disaster occurred around the world (Relief Web, 2015). Storm and flooding do not cause heavy death toll but a lot of people are being affected by these two disasters. For example, there are 244, 000 people lost their lives due to storm (tornadoes, cyclones) in the past two decades (Relief Web, 2015).

2.2.5 Environmental Impact

Besides causing death and economic impact, the mother earth will have a few changes that cause a huge impact to the environment. However, the magnitude of the impact depends on the type of the natural disaster occurred.

For example, mudslide will not bring huge impact because it commonly occurs in a small area. However, there are negative impacts toward environment because the geography of the land does have a certain degree of change. Haze might occur if the mudslide is worse or on a larger scale. Besides, if it happened in small scale then flooding will not cause a huge impact to the environment. However, flooding did cause huge negative economic impact and lot of people are being affected.

In contrast, earthquake and tsunami will cause a huge impact to the environment. This is because both the disaster occurred in large scale and the degree of destruction cannot be compared to flood and mudslide. When the earthquake happened, the surface of our mother earth changes. This will affect other system on the earth crust for example ecosystem, groundwater, biodiversity, and others.

For example, the Indian Ocean Tsunami on 2004. According to an article, the earthquake had caused great damage to the ecosystems such as mangroves, coral reefs, forests, coastal wetlands, vegetation, sand dunes and rock formations, animal and plant biodiversity and groundwater (Wikipedia, 2016). Moreover, industries being destroyed and the liquid chemical waste had spread around causing water and air

pollutions. This pollution directly affected the aqua life ecosystem and cause a lot of aqua flora and fauna died.

Not only Indian Ocean Tsunami, the Japan tsunami on 2015 also cause huge environment impact. This is because there is nuclear radiation leakage which causing a lot of lives lost and fishes died due to the radiation. In addition, the water and the ocean within several kilometers in radius are inconsumable as the radiation of nuclear reaching hazardous level.

On the other hand, many roads were destroyed or the collapsed infrastructure will caused many roads being blocked. This issue had blocked all the ground transportation from the safety areas into disaster areas. This lead to incapability of providing medical supplies to the victims in the disaster areas. When there were shortage of medical supply in the disaster areas, more victims will lost their lives (Safeer, 2014).

2.3 Statistics

The statistics below show the data collected from EM-DAT, CRED, University of Louvain, Belgium. The sources include assumption where all the death toll, damage losses, and cost are all reported.

2.3.1 Number of Disaster, by Development Level

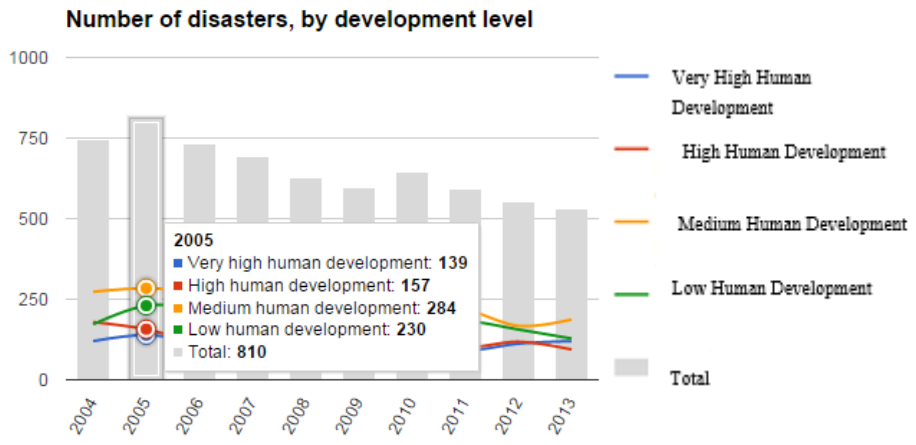


Figure 2.1: Bar Chart of Number of Disasters, by development level (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.1 shows us the statistic of the number of disasters by development level against years from 2004 to 2013. From the graph, we can observe the highest amount of number of disasters occurred is in year 2005 which is 810.

From the graph, different colour of lines indicates different level of human development. Blue stands for very high human development, red stands for high human development, orange stands for medium and green stands for low. Throughout the year, medium human development (orange) has the highest amount of disasters occurred. Followed by low (green), high (red) and very high (blue).

2.3.2 Number of Disaster, By Region

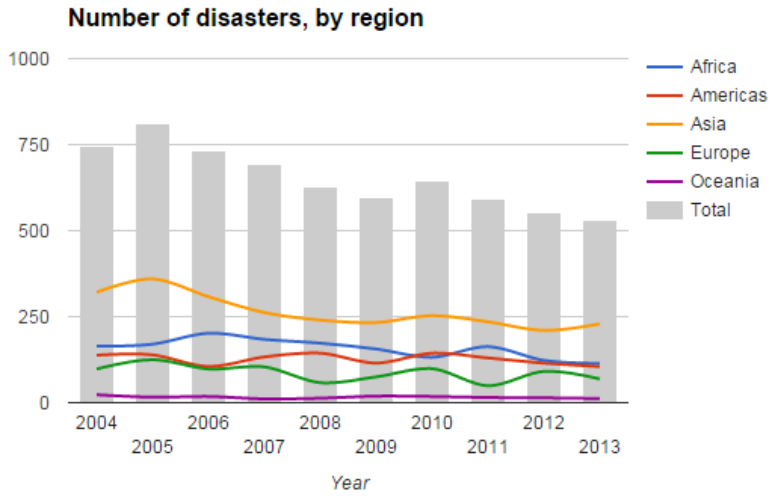


Figure 2.2: Bar Chart of Number of Disasters, by region (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.2 presents the number of disasters by region against the years from 2004 to 2013. In this graph, we observe that different colour of line represents different regions. From the lines, we understand that Asia has the highest average number of disasters occurred. In Asia, the number of disasters occurred is more than 250 from the year 2004 to 2014 except the year 2008 and 2009. Moreover, most of the countries that located at Asia region are countries with medium and low human development.

On the other hand, the highest amount of disasters occurred is in the year 2005 where Asia occupy 44.44% of the total number of disasters. The numbers are shown in figure 2.3.

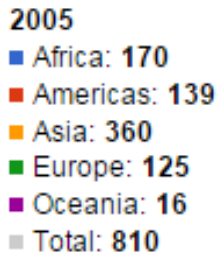


Figure 2.3: Number of Disasters, by region (2005) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.3 Number of People Killed by Disasters, by Development Level

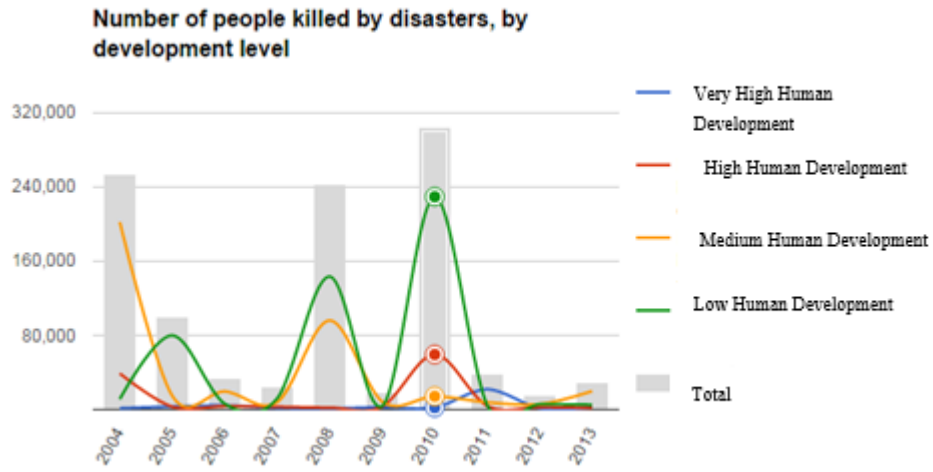


Figure 2.4: Bar Chart of Number of People Killed by Disasters, By Development level (International Federation of Red Cross and Red Crescent Societies, 2014)

Graph 2.4 shows the number of people killed by disasters (by human development level) against a certain period of the time which is from year 2004 to year 2013. According to the graph, there are 1,043,410 people killed by disasters and year 2010 take up 29.18% (highest). We can observe that 2010 had a surge in the number of people killed by disasters. This is because a massive earthquake takes place at Haiti which takes away lots of lives in that year. On the other hand, among the line, low human development seems to have the highest average number of people killed (green). A number of people lost their lives for low human development level occupy 47.62% of the total people killed by natural disasters. Figure 2.5 shows the amount of people killed in the year 2010.

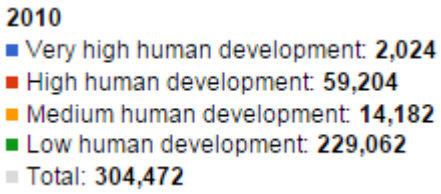


Figure 2.5: Number of People Killed by Disasters, By Development level (2010) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.4 Number of People Affected by Disasters, by Development Level

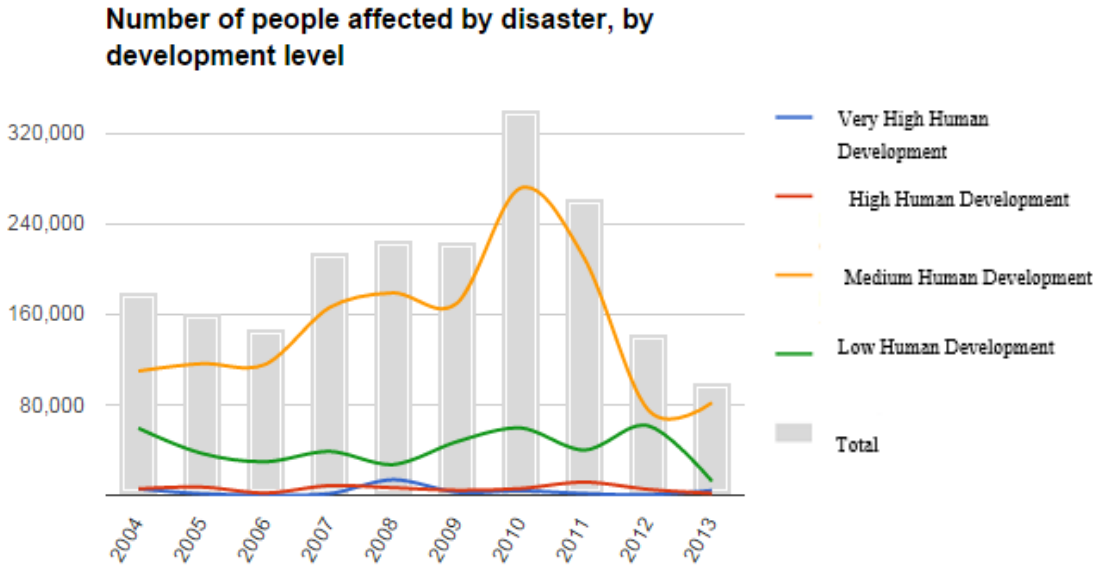


Figure 2.6: Bar Chart of Number of People affected by Disasters, By Development level (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.6 is presenting us the number of people affected by disaster (by development level) against the year 2004 to the year 2013. From the graph, we understand that the number of people being affected (excluded death toll) is fairly high every year. According to the graph, the lowest amount of people being affected is at the year 2013 which is 99,837 people.

From the graph, we can observe that there are more than 320,000 people affected in the year 2010 and most of the people are under medium human development. This number might be due to Haiti earthquake which seriously causing the landscape of the whole county increases by 2.4 meter.

Figure 2.7 shows us the amount of people being affected by a natural disaster where medium human development has the highest number, follow by low human development then high level and very high level.

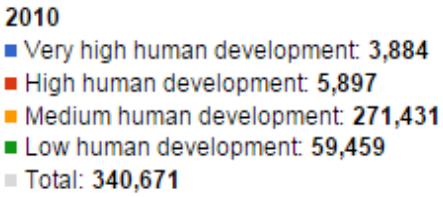


Figure 2.7: Number of People affected by Disasters, By Development level (2010) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.5 Total Amount of Disasters Estimated Damage

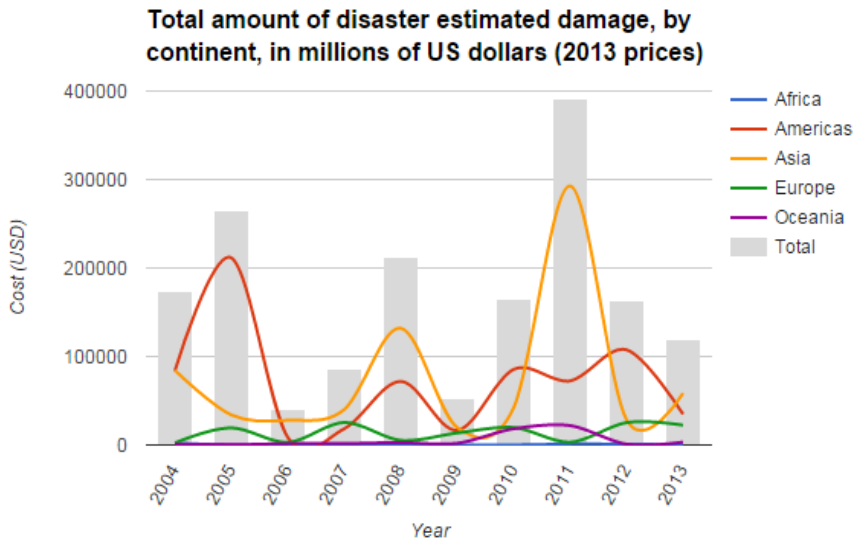


Figure 2.8: Bar Chart of total amount of disaster estimated damage (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.8 present to us the total amount of disaster estimated damage (by continent and in millions of US dollars) against the year from 2004 to 2013. From the graph we observed that the damage caused by natural disasters in year 2011 is the highest. The amount is 391,231 million US dollar which is almost 400,000 million. The countries that suffer the most damage in the year 2011 are countries at Asia region. In Asia, the damages suffer is 74.8% as shown in Figure 2.9.

On the other hand, the year that suffers the least damage is 2006 follow by 2009. However, Asia still is the region that facing the highest damage cost. Besides that, Americas suffer great damage cost at the year 2005 and the reason may be due to hurricane Katrina.

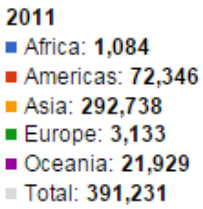


Figure 2.9: Total Amount of Estimated Damage Caused by Disasters (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.6 Natural Disaster in 2013

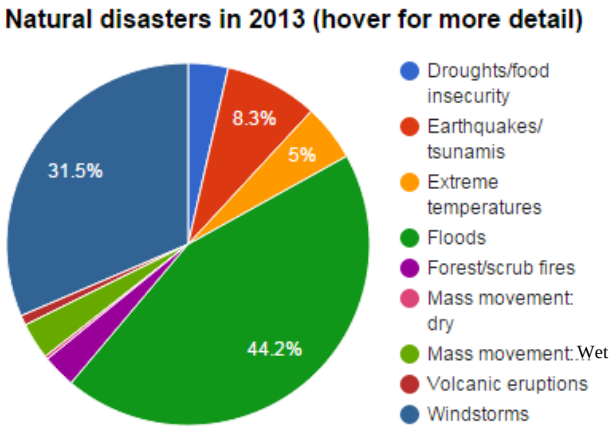


Figure 2.10: Pie Chart of natural disasters in 2013 (International Federation of Red Cross and Red Crescent Societies, 2014)

The pie chart above shows us the natural disasters in 2013. From the chart, we can observe that floods are the most common and happened the most at the year 2013. It occupies 44.2% of all other type of disasters. The second highest is drought or food insecurity. The third one goes to earthquakes or tsunami (8.3%) and the fourth one goes to extreme temperatures.

However, in the year 2013, the natural disasters were the lowest in term of numbers. The contribution of windstorms to the total numbers of disasters is the highest (31.5%) compare to the proportion to the decade which is 26%.

2.3.7 Total Number of People Reported Killed (2013)

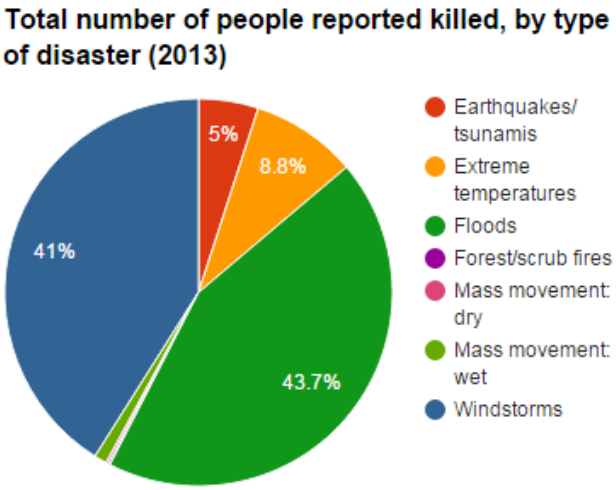


Figure 2.11: Pie Chart of Total Number of People Reported Killed (International Federation of Red Cross and Red Crescent Societies, 2014)

The pie chart shown in figure 2.11 is about the total number of people killed (reported) by type of disasters at the year 2013. From the information given in figure 2.11, flood occurred the most in this particular year. Hence, the number of people killed is the highest of all which is 9819 people in year 2013. The second most is windstorms which occupy 41% to the total death caused by disasters in the year 2013.

Besides that, the death toll caused by earthquake and tsunami are fairly low which is 5%. This may due to the earthquake or tsunami do not occur much or the disaster often occurred at a place that does not have heavy population. Hence, the damages and the death toll is low compare to previous year.

2.3.8 Total Number of People Reported Killed (2004-2013)

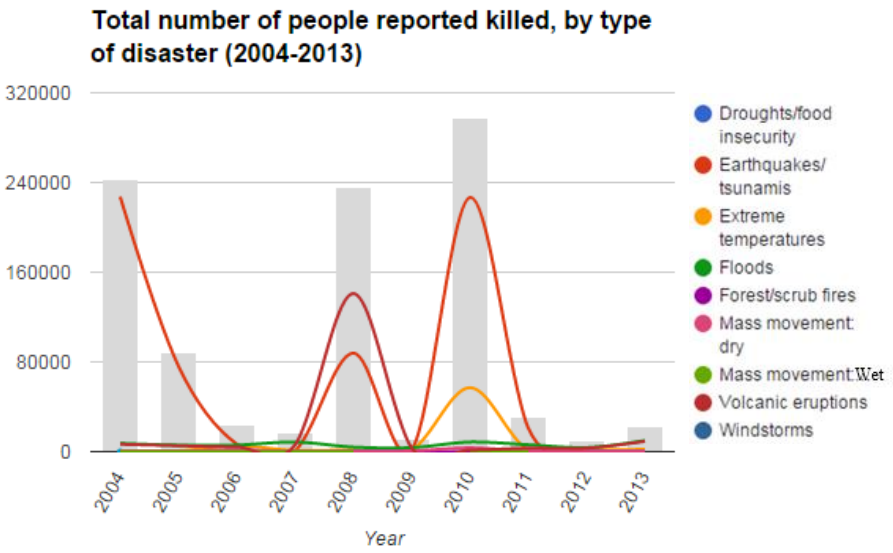


Figure 2.12: Bar Chart of Total Number of People Reported Killed (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.12 shows us the total number of people reported killed (by type of disasters) against the year 2004 to 2013. Throughout this ten years, earthquake and tsunami had killed the most people. From the statistic given, there are 649,584 people reported killed. Earthquake might happen in a few times but the death it brought is large.

According to figure 2.12, the year 2010 has the highest reported death toll. That is due to Haiti earthquake which causes huge casualties to the country affected. The second highest is the year 2004, this is due to Indian Ocean tsunami that affected 14 countries and causes huge casualties and death toll.

However, windstorm had killed a great number of people in the year 2008. The amount of people dead is 140,958. It is 60% of the total number of people reported killed in the year. That may due to the hurricane in Cincinnati and Louisville.

Figure 2.13 and figure 2.14 show the amount of people reported killed in the year 2010 and 2008 by different type of disasters.

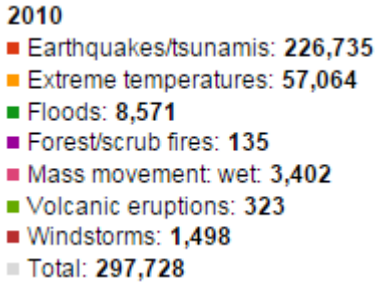


Figure 2.13: Total Number of People Reported Killed (2010) (International Federation of Red Cross and Red Crescent Societies, 2014)

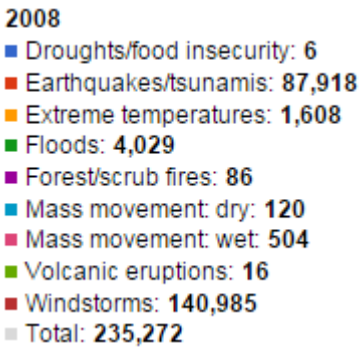


Figure 2.14: Total Number of People Reported Killed (2008) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.9 Total Number of People Reported Affected (2013)

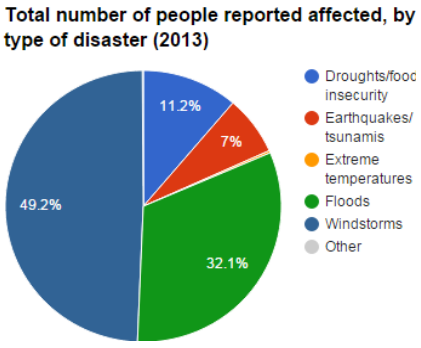


Figure 2.15: Pie Chart of Total Number of People Reported Affected (International Federation of Red Cross and Red Crescent Societies, 2014)

Pie chart in figure 2.15 shows us the total number of people affected by the type of disasters in the year 2013. In this chart, windstorms occupy 49.2% of the total affected people. Second goes to flood and third goes to drought or food insecurity.

The figure of the people affected by windstorms (49,124) is the third highest of the decade for windstorms and it is far above the decade's average figure. However, the number of people reported affected is the least compared to the whole decade.

2.3.10 Total Number of People Reported Affected (2004 - 2013)

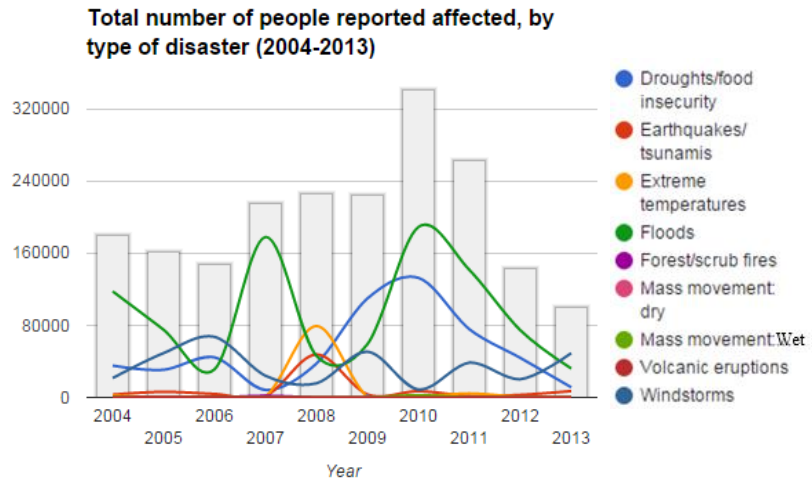


Figure 2.16: Bar Chart of Total Number of People Reported Affected (International Federation of Red Cross and Red Crescent Societies, 2014)

The figure above shows the total number of people reported affected (by type of disaster) against the year 2004 to year 2013. From the graph, the flood has the highest figure in affecting the people. In the year 2010, the amount of people reported affected by the flood is 188,870. The second goes to drought/food insecurities that contribute 132,525 people affected which is 39% of the total.

On the other hand, year 2013 has the least amount of people affected by natural disasters among the decade. The total amount contributing 5% to the total of the people reported affected by different type of disasters along the decade.

Figure 2.17 shows the figures about people reported affected by different type of disasters.

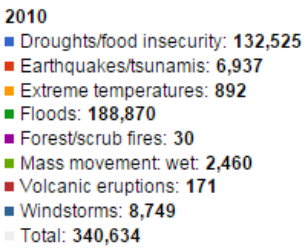


Figure 2.17: Total Number of People Reported Affected (2010) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.3.11 Total amount of Disasters Estimated Damage (2013)

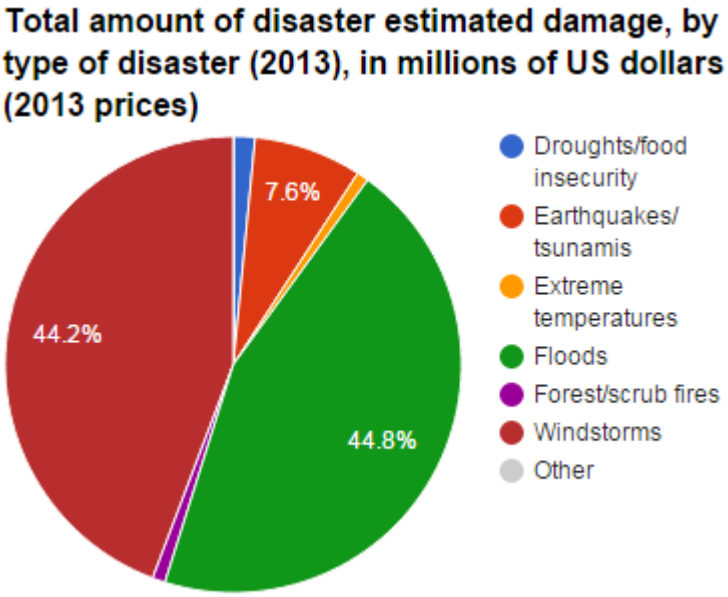


Figure 2.18: Pie Chart of Total Amount of Disaster Estimated Damage (2013) (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.18 shows the total amount of disaster estimated damage, by the type of disasters (in millions of US dollars) in the year 2013. According to the pie chart, there are two major disasters cause the tremendous amount of damages which are windstorms and floods. Windstorms had cause 44.3% (52 million) while floods had cause 44.8% (53 million). Both the disaster has only 0.6% (around 1 million) difference. At the year 2013, earthquake and tsunami had caused 7.6% damages which are about 9 million throughout the year.

2.3.12 Total Amount of Disaster Estimated Damage (2004 - 2013)

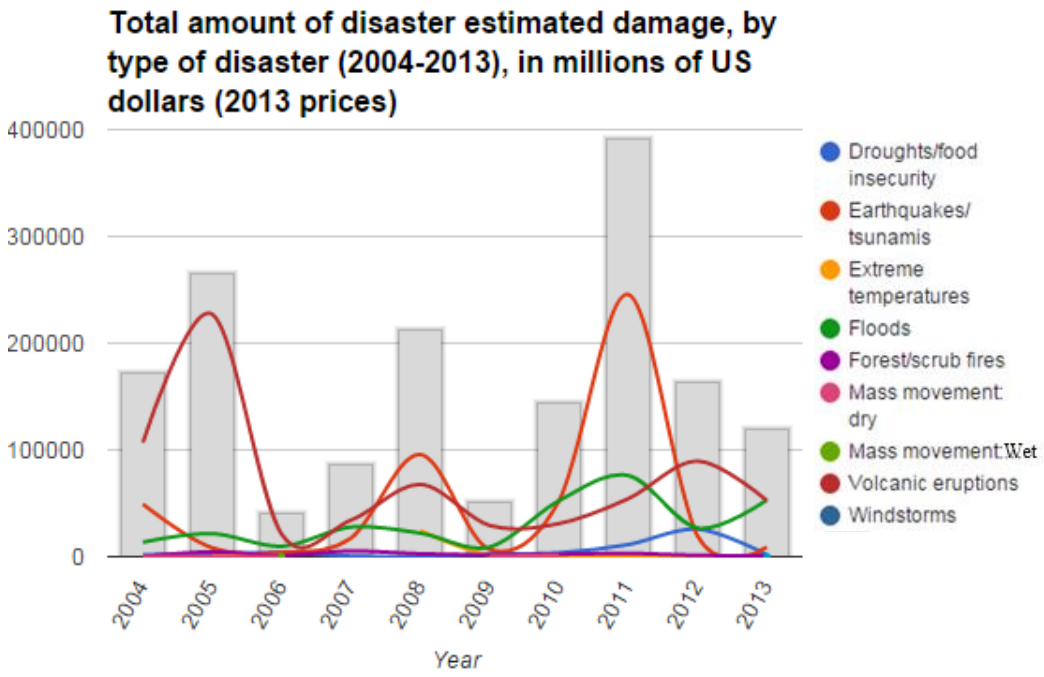


Figure 2.19: Bar Chart of Total Amount of Disaster Estimated Damage (2004-2013) (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.19 presents the total amount of disaster estimated damage, by type of disaster (in millions of US dollars) from the year 2004 to the year 2013. According to the data collected, the damages caused by windstorms is the highest at the year 2004 and 2005. However, earthquake and tsunami had caused great damage at the year 2008 and 2011.

For overall, the year 2011 suffer huge losses which have an amount of 391 million. Among the disasters, the earthquake had occupied 63% of the total damages losses. The second highest damage losses go to the year 2005. Windstorms had brought great damage which amounts to 227 million. It is the second highest damages losses through the decade as well.

Figure 2.20 and figure 2.21 had shown the figure of estimated losses that suffer by the world at the year 2011 and 2005.

Figure 2.20: Total Number of People Reported Killed (2011) (International Federation of Red Cross and Red Crescent Societies, 2014)

Figure 2.21: Total Number of People Reported Killed (2005) (International Federation of Red Cross and Red Crescent Societies, 2014)

2.4 Reasons of Increasing Casualties

The casualties that caused by most natural disasters like earthquake, tsunami, and storm wind are heavy and in mass amount. However, the casualties continue to increase after the disaster occurred. There are many reasons that cause the continuous rising of amount of dead people.

Treatment was required immediately when victims suffered injuries. Some injuries that suffered by the victims in disasters area required immediate surgery or operation to save their lives. However, lack of surgical facilities and clean rooms causes them to line up and wait for their turn. This issue causes most of the victims dead due to late treatment on their survivable injuries.

On the other hand, post-surgery infection is also one of the main issue that causing the number of casualties increased.

2.4.1 Lack of Surgical Facilities

Surgical facilities are very necessary for disaster areas because a lot of people need to undergo surgery to save their lives. For example, amputation, laceration, crush injuries, haemorrhage, debridement and other minor yet deadly injuries.

When disasters occur, the surrounding infrastructures will be destroyed and potentially including local healthcare hospital and medical facilities. Ideally, the medical team should take actions immediately after the occurrence of natural disasters to reduce the morbidity and mortality. However, most of them took more than 24 hours in term of respond. The reason of quick respond is because "thousands—of lives are lost at the first days following the event because of the lack of medical/surgical facilities to treat those with potentially survivable injuries." (Andrews & Quintana, 2015).

In the article written by Russell and Leonidas, there is a way to reduce the amount of death in disaster area which is to "get the medical/surgical “boots on the ground” at a disaster site before the injured have died of potentially survivable injuries" (Andrews & Quintana, 2015). According to few reports of Haiti earthquake, the Executive Director of Partners for Health, Ophelia Dahl, estimated more than 20,000 people who suffering survivable injuries died every day the first week following the Haiti earthquake. The reason that caused such tragedy happened was because there were no surgical facilities available (katiecouric: Disaster in Haiti, 2010). Besides that, it was being confirmed that the first and only international team that arrived in Port-au-Prince within 24 hours with surgical capabilities was the Icelandic Association for Search and Rescue (Jónasdóttir, 2010).

The information above had clearly explained that lack of surgical facilities will bring such severe consequence even though it is unintentional. In addition, there are several types of survivable injuries that might cause death if not receive treatment as fast as possible. Table 2.1, table 2.2 and table 2.3 show the injuries and several explanations.

Table 2.1: Type of Injuries and the Descriptions (a)

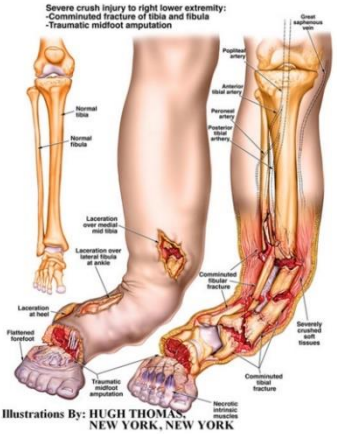
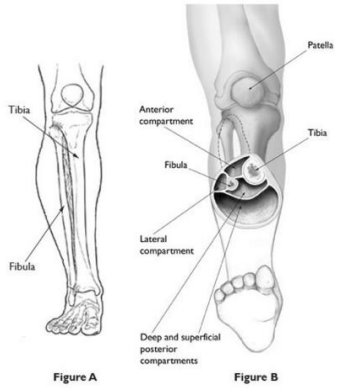
Injury	Description
Crush Injury (Book-Med, 2015) (affect 3–20 % of victims)  	1. Direct pressure that damage to the soft tissues like muscles, skins, blood vessels. 2. May lead to compartment syndrome. 3. Injured extremity is exposed to substantial crushing force for a prolonged period of time, crush syndrome may take place. 4. Categories into two stages: • Heavy crush injuries • Light crush injuries
Compartment Syndrome (Amerixan Academy of Orthopeadic Surgeons, 2009)  	1. Developed when swelling or bleeding within a compartment 2. Caused by compression of tissues in a confine space. 3. May result in permanent disability and tissues death. 4. Often occur at the front part of lower leg like calf.
Sprain (Medline Plus, 2016)  	1. Stretch or torn on ligaments. 2. Ankle and wrist are the most common area that sprain might occurred.

Table 2.2: Type of Injuries and the Descriptions (b)

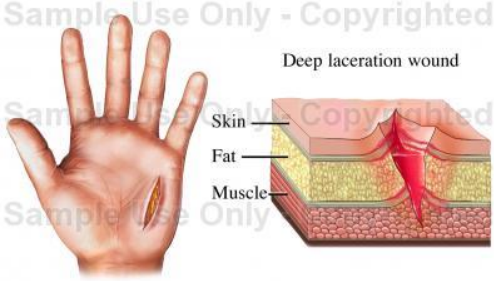
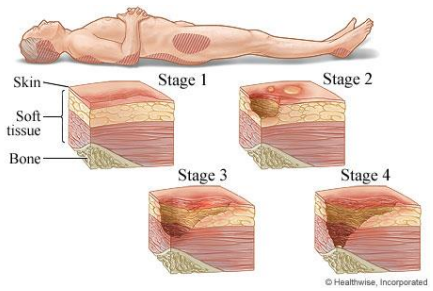
<table>
<tr><th>Injury</th><th>Description</th></tr>
<tr><td>Haemorrhage (Wikipedia, 2016)
(external bleeding)</td><td>1. Cause by variety of accidents, which will lead to shock.
2. General term is bleeding.
3. Bleeding can origin from many parts of body.
• Mouth –Haemoptysis
• Upper head—intracranial haemorrhage
• Lung—Pulmonary haemorrhage
4. Classified to 5 grades:<table><tr><td>Grade 0</td><td>No bleeding</td></tr><tr><td>Grade 1</td><td>Minor bleeding</td></tr><tr><td>Grade 2</td><td>Moderate amount blood loss</td></tr><tr><td>Grade 3</td><td>Huge amount blood loss (transfusion require)</td></tr><tr><td>Grade 4</td><td>Deliberating blood loss, retinal or cerebral associated with fatality</td></tr></table></td></tr>
<tr><td>Laceration (INJURY INFROMATION, 2014)
 
</td><td>1. Injury that result in irregular break in skin.
2. The level is not as serious as crush injury.
3. There are five common type of laceration
• Split laceration
• Over-stretching
• Grinding compression
• Cut laceration
• Tearing</td></tr>
</table>

Table 2.3: Type of Injuries and the Descriptions (c)

Injury	Description
Fracture (American Academy Orthopaedic Surgeons, 2012)  	1. General term is broken bones. 2. Caused by any serious compression or stretch in any accident. 3. Will have symptoms like swelling, bruising, and deformity. 4. Few common type of bone fracture: • Stable fracture • Compound fracture • Transverse fracture • Oblique fracture • Comminute fracture
Burn (Khan & Salon, 2016)  	1. Damage to skin cause by fire. 2. Classified into three level. • First degree—non-blister skin • Second degree—blister and some thickening of skin 5. Third degree—widespread with a leathery appearance

2.4.2 Post-surgery Infection

Post-surgery infection is a kind of infection that infect someone who just received a certain degree of surgery (Horan, 1992). This infection commonly happened in disaster areas. The method of preventing such infection required “appropriate preoperative antibiotics, and a variety of preventive measures aimed” stated by David and James (Reichman 2009). The reason of people receiving immediate treatment or surgeries is to save their lives from survivable injuries. This indicates that the surgical instruments will be kept reusing by those doctors to perform surgeries on many people.

Furthermore, we understand that resources and advanced cleaning facilities are very limited in disaster areas during the recovery phase. When the equipment keep

being used on victims and person in charge do not put much effort on sterilizing and disinfect the equipment, the bacteria, viruses or germs will eventually survive and stay at the equipment or surgical instruments. When the instruments being reused, those microorganisms will spread into the victims through the wound. The bacteria that settled on the surgical instruments will invade the victims wound and results in post-surgery infection. (Spagnolo, 2013) This issue end up causing infection to occur on the victim's body. The infection was defined as post-surgery infection. In Haiti earthquake, a lot of orphanages had suffered post-surgery infection due to the outbreak of lice (Bayard, 2010). There are many types of post-surgery infection as shown in table 2.4 and table 2.5.

Table 2.4: Type of Diseases and Infection and the Description (a)

Type of Diseases/infection	**Description**
Tetanus (Wikipedia, 2016) **(infection)**	1. Also, known as lockjaw and infection characterized by muscle spasms. 2. Other symptoms may include fever, sweating, headache, trouble swallowing, high blood pressure, and a fast heart rate. 3. Caused by an infection with the bacterium Clostridium tetani. 4. Diagnosis is based on the presenting signs and symptoms. 5. Does not spread between people.
Staphylococcus aureus (Amy, 2015) (Stöppler, 2016) **(infection)**	1. Staphylococcal aureus bacteria are classified as Gram-positive cocci based on their appearance. 2. Capable of surviving at various levels of oxygenation, and are generally very hardy organisms. 3. Invade via broken skin or mucous membranes. 4. Those who had surgical incision would have the risk of having staph infection.

Table 2.5: Type of Diseases and Infection and the Description (b)

Type of Diseases/infection	Description
Streptococcus (NHS Choices, 2016) (Medline Plus, 2016) **(infection)**	1. Genus of coccus Gram-positive bacteria belonging to the phylum Firmicutesand the order Lactobacillales. 2. Divided into two important groups: • **alpha-haemolytic** – made up of two groups, including Streptococcus pneumoniae • **beta-haemolytic –** made up of several groups, including Group A and Group B streptococci 3. Group A strep (strep A) are often found on the surface of the skin and inside the throat. 4. Spread in droplets in the coughs and sneezes of people who are infected or direct contact.
Pseudomonas (Cafasso, 2005) (Thompson, 2014) **(infection)**	1. Genus of Gram-negative, aerobic Gammaproteobacteria, belonging to the family Pseudomonadaceae containing 19 validly described species. 2. Spread through medical equipment. 3. Spread to patients who are weak because of illness, surgery, or treatment, they can cause very serious infections. 4. People with puncture wounds may get dangerous pseudomonas infections of the blood, bone, or urinary tract. Bacteria can get into the body through IV needles or catheters.

2.4.3 Diseases Outbreak

One of the other reasons that cause casualties increase is diseases outbreak. The world organization had categorized the diseases and infections outbreak into three phases.

Table 2.6: Phases of Diseases Outbreak (Isidore, 2012)

Phases	Description
Phase 1	1. when victims are extricated and initial treatment was provided. 2. Took about 4 days
Phase 2	1. occurred in the period between 4 days to 4 weeks. 2. It is defined as the post-impact phase where the diseases might start to spread around the area
Phase 3	1. recovery phase which occurred after 4 weeks. 2. the period where those victims who are incubated for a long period of time become clinically apparent. 3. The diseases might be able to expand into an epidemic.

One of a disease that spread across the disaster areas is cholera. Cholera had spread across Haiti after a few weeks of Haiti earthquake 2010. More than 6% of Haitians have had to suffer this disease. After 5 years, a report been written that more than 700,000 Haitians had suffered cholera and death toll had increased to around 9,000.

In a nutshell, there are many factors that causing the number of casualties keep increasing. In order to reduce or control the number of casualties to the minimum, a lot of precaution steps need to be taken and medical responses need to be fast.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Portable Surgical Bag Pack

Portable Surgical Bag Pack is a Bag type “surgical room”. This bag pack allows medical personnel perform simple emergency surgery to save victims’ life from survivable injuries. Figure 3.1 shows the CAD design of the bag pack version 1.

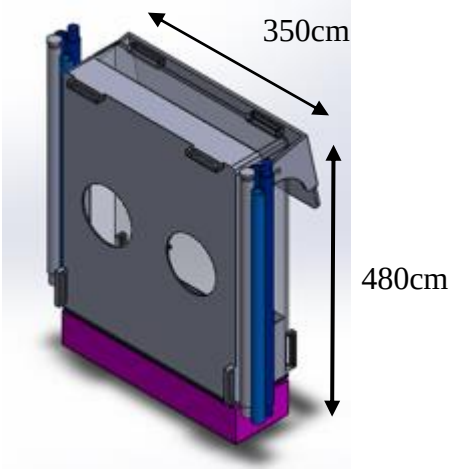


Figure 3.1: CAD design of portable surgical bag pack

This bag pack is 480mm x 350mm in size and 3 kg in weight. This bag pack is made of acrylic with 3mm thick. The purpose of using 3mm thick acrylic is because of its transparent characteristic. The reason for making it transparent is to enable users to look into the sealed area (open) while performing simple operations. The original design of this bag had a small storage (figure 3.9) that located underneath the bag. The purple small storage is used to store some large package or necessary equipment for example stretcher. Figure 3.2 demonstrate how the bag look like when it is being opened.

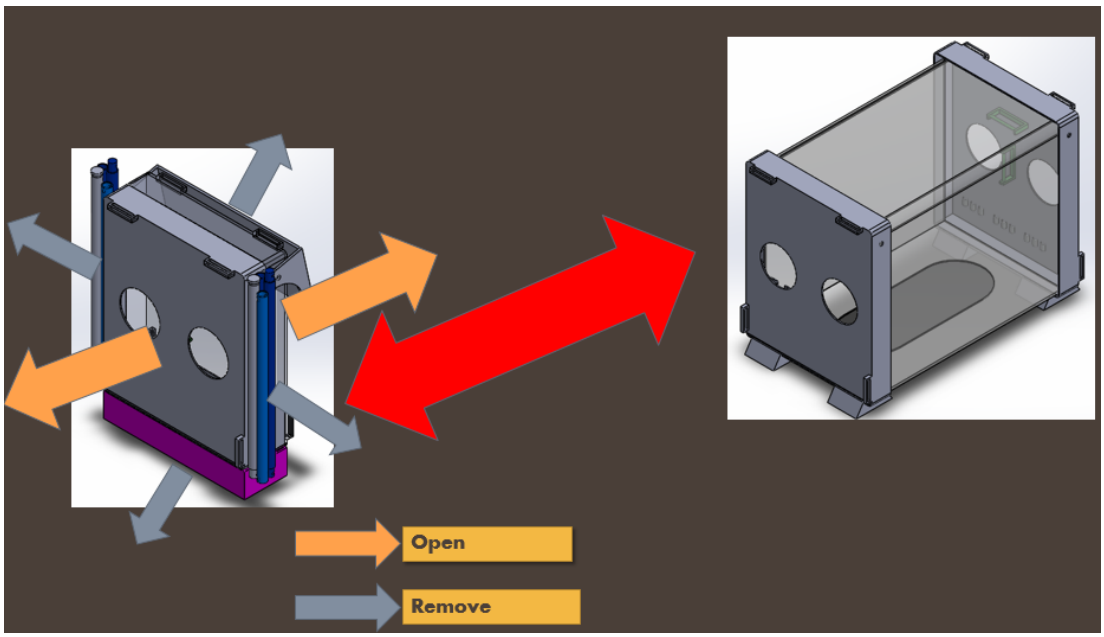


Figure 3.2: Physical looking of the bag

The bag pack has a transparent and flexible plastic at the middle as well and it is called “surgical medium”. The internal space of the surgical medium is sterilized and sealed to isolate from the outer dirty environment to avoid the infection of exaggerate viruses, bacteria, and germ. In other words, that surgical medium is a small “clean room” for medical personnel to perform simple surgery. In addition, the surgical medium is the crucial design of the whole bag. If the cleanliness of the surgical medium is worse, the probability of the victims suffering post-surgery infection or site surgical infection (SSI) will increase. Chapter 4 will continue the detail explaination of the components inside the bag.

3.2 Bag Body

The main reason for creating this type of surgical bag pack is to solve the lack of surgical facilities issue in affected disaster areas and to reduce the risk of victims from suffering post-surgery infection. One of the advantages regarding this surgical bag is its convenience and ease to carry around in disaster area. Moreover, the bag only needs one person to carry. Thus, 20 surgical bags can be carried to disaster area if there are 20 doctors entering affected areas.

In order to be able to perform simple surgery in affected areas, the simplest and crucial equipment are needed. Thus, those equipment are attached to the wall of the bag’s body.

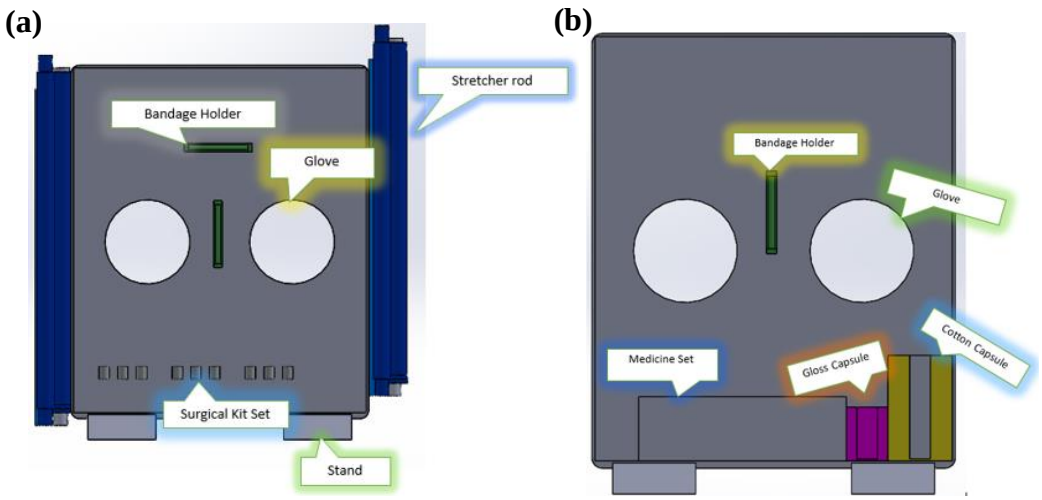


Figure 3.3: (a) Front Bag Body and (b) Back Bag Body

Figure 3.3 shows the bag body that faces inwards. For bag body (a), there is bandage holder for holding bandage. Below the cover has a surgical kit set holder. That surgical knife and scissors will be held by those holders inside the bag. The two big circular holes are box gloves which have high durability. Doctors' hands are to put into the glove in order to reach the wound and perform any surgery. For bag body (b), there is a cotton capsule for putting cotton and a gloss capsule for storing gloss. There is medicine set small container which is for putting any necessary medicines or equipment that is necessary for treating the particular wound. The bandage holder is used to hold bandage. Back bag cover (b) is for second or assistant doctor who might be needed by the main doctor who are performing the simple surgery The dimension of the bag covers are shown in figure 3.4.

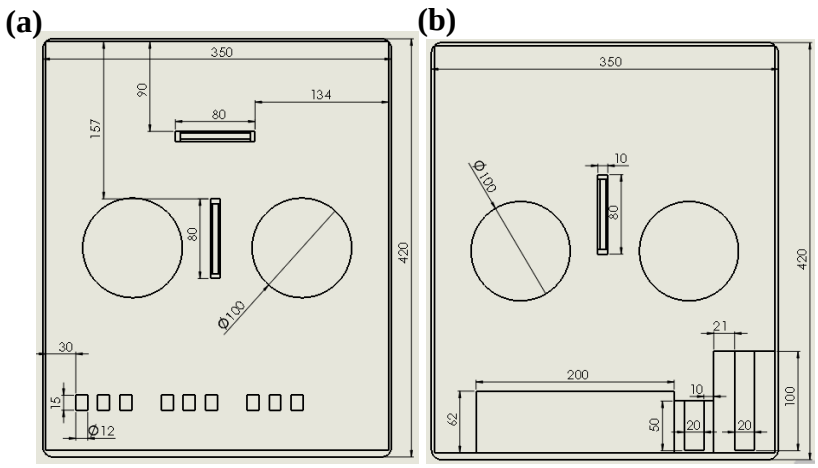


Figure 3.4: (a) Dimension of Front Bag Cover and (b) Back Bag cover in centimeter

Figure 3.5 shows the apprearence and physically looking of the front bag body and back bag body.

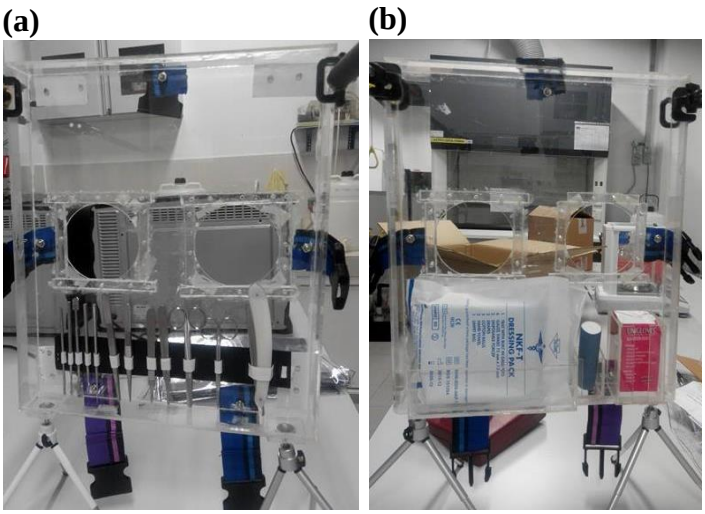


Figure 3.5: Real Prototype of (a) Front Bag Cover and (b) Back Bag Cover

The material selected for constructing the bag pack is 3mm thick acrylic. The main reason is because of its transparency features. However, there are several other advantages of using acrylic. First, it is transparent which can provide vision to the doctors while performing surgery. Secondly, acrylic has a high melting point which is about 160°C (Wikipedia, 2017). As we know, one of the method to conduct decontamination and disinfection is water bath the entire surgical accessories under boiling water which is 100°C for at least one minutes. This technique can kill all microorganism except for several bacteria (Fulghum, 2012). Hence, soaking the acrylic made body cover into 100°C water bath for more than a minute will not cause any damage.

Thirdly, acrylic has half the weight of glass and it has almost 20 to 30 times more resistant to stroke. The light weight can reduce the burden of doctors on carrying around disaster areas and the hardness can ensure the bag is undamaged while falling or others. Fourthly, glass has only 90% light transmission while acrylic has 92% (INDUFLEX, 2009). This difference might not give significant results but acrylic does provide a better vision compare to glass. Hence, there are several advantages of choosing acrylic as the main body of the bag.

3.3 Surgical Kit Set

Surgical Instrument is an important section in this bag because those instruments are "hands and legs" of doctors while performing surgery. In disaster areas, a lot of victims are waiting for treatment to their survivable injuries. However, different injuries need different treatment. In other words, every type of injury requires different combination of the surgical instrument for the doctors to perform the surgery. Hence, different sets of the surgical kit are needed to provide ease to the doctor to perform surgery.

DRE is a premier surgical and medical equipment supplier. A total of 72 type of surgical instrument sets is formed by them including "Basic Hand Surgery", "Knee Surgery", "Amputation" and others (DRE, 2017). By knowing what type of injuries suffered by the victim, the doctors can pre-setup the surgical bag with the required surgical instruments only and perform surgery. Figure 3.7 is a sample of disposable minor surgery general surgical instrument set.

Product Category	**general surgical instruments set**
Logo Print	As Customer Demand Or MPC
Raw materials	1 x Tray
	1 x Drape Laminated Green 75 x 110cm
	2 x Gallipot, 60ml
	2 x Halstead Mosquito Forceps Straight
	1 x Needle Holder
	1 x Non Toothed Dissecting Forceps
	1 x Iris Scissors Straight
	1 x Iris Scissors Curved
	1 x Toothed Dissceting Forceps
	1 x Blade N.15
	1 x Drape Epidural 60 x 75cm cen fen + 1 strip
	2 x Towel Dressing 43 x 38cm
	5 x NW Swabs, 10 x 10 cm, 4ply
	1 x Yellow Bag & 1 Tie

Figure 3.6: Minor Surgery General Surgical Instruments Set (Dansu-China Health Care Co.Ltd, 2017)

3.4 Middle Surgical medium

The most crucial part of the surgical bag is the middle sterilized internal space which is called surgical medium. This medium is being sterilized before putting into use. The purpose of this surgical medium is to isolate the space from the outer environment for the doctor to perform surgery.

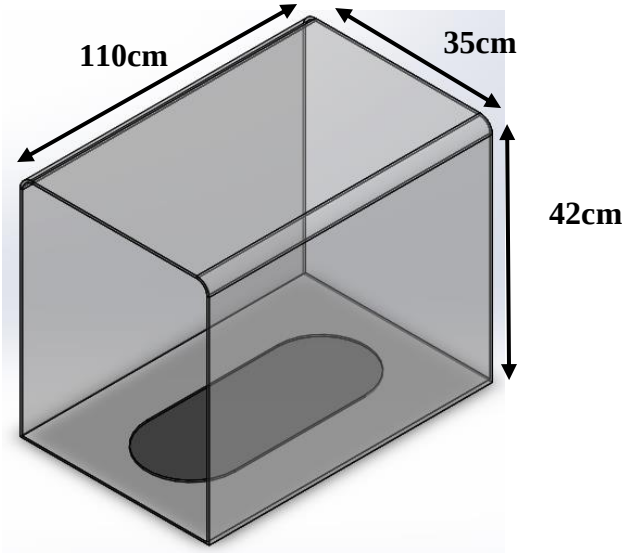


Figure 3.7: Middle Surgical medium (internal space)

The figure above is the middle surgical medium. The openable hole of the medium will be place above the wounded area. The advantage of this medium is its sterile features. Sterile is defined as free from bacteria and other microorganisms (FARLEX, 2017). The sterility will be proved by an experiment conducted in chapter 4. Thus, this sterile space will reduce the risk of the victim's wound being infected.

The material used for creating the surgical medium is clear transparent cellophane. Cellophane is 'transparent hydrated cellulose, viscose film obtained from the pulp of coniferous trees or natural cotton.' (Techno Clip, 2010). Cellophane has a tensile strength of 35 to 75 Mn/m^2 and a melting point of 175°C to 205°C before expansion. In other words, the transparent cellophane film that being used for creating the surgical medium is stretchable and it is strong enough to prevent damage from overstretching. Next, disinfection by using water bath can be performed manually because the melting point is high enough to withstand 100°C boiling water. Besides that, transparent cellophane can provide a vision for the doctors to perform surgeries.

3.5 Bandage Holder, Cotton Holder, Gauze Capsule, Medicine Set

At the inner part of back bag cover, there are few holders and small containers which are bandage holders, cotton capsule, gauze capsule, gauze capsule and also medicine set. Cotton and gauze capsule are used to put cotton and gauze inside for doctors to use. Bandage holders are for holding any bandage that is required. It can also be used to hold a large set of gauze or cotton.

The medicine set is for putting any extra accessories that are or will be needed in the surgery. Some of the examples are stitches, staple, glue and others.

3.6 The Purple Container

In figure 3.2, we can see that there is a purple colour container that located beneath the surgical container. The purple container act like an extra storage of the surgical bag. It is used to store the stands for the surgical container, the fabric of the stretcher and some general medical supply including ethanol sprayer. Besides that, the purple container is made of transparent acrylic as well.

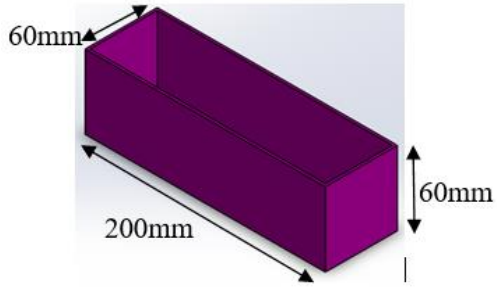


Figure 3.8: Purple Container

3.7 Extra Features

There are some extra features that are added into the portable surgical bag pack to make it more reliable and useful.

3.7.1 GPS coordinated system

GPS coordinate system is installed into the bag mainly for search and rescue missions. Some of the disasters happened at the area which is very remote and only can walk into the areas or by helicopters. Hence, the rescuer can send the coordinate to the rescue centre and ask for a helicopter for the rescue mission. The example of the readymade GPS system is shown in the figure below:

Figure 3.9: G60 GPS Tracker (Digital Matter, 2017)

GPS tracker installation is an option for users. Some of the situation might not use GPS tracker for example disaster area which struck by the natural disaster. The main purpose of this surgical bag is to perform surgeries. However, GPS devices might come into handy for those search and rescue missions. They will need GPS tracker for recusing people as mentioned above.

3.7.2 Stretcher

The stretcher is a very important equipment for carrying one victim from one place to another. In this bag pack, the fabric of the stretcher can be stored inside the purple container and the rods can be attached at the side of the bag. By having a stretcher, doctors or rescuers are able to carry victims easily and reduce the severity of the victims' wounds. Victims at remote area can be carried out easier. Figures below show the different type of stretchers that can be used in disaster areas.

Figure 3.10: Example of Different Type of Stretchers (Rescue Tech 1, 2017)
(Mortuarymall, 2017)
(AllBiz, 2017)

3.7.3 Lighting System

There are a lot of victims when a natural disaster occurred. Moreover, more than 80% are injured and they need to receive immediate surgery to save their lives. Thus, surgical facilities need to be able to operate 24 hours.

In order to provide a clearer and better vision at night for the doctors to perform surgery, the bag had LED light strip installed. The light strips are power up by a 12-volt rechargeable battery. This feature will allow the medical personnel to perform simple surgeries at night or dark places.

3.7.4 Storage Bag

There will be another extra two bags for storage. The reason of having two more extra small bags are to store extra medical supply for example cotton, gauze, and others. The small bag also can be used to store small yet important devices for example defibrillator and SPO2 meter. Furthermore, extra set of surgical instruments can also be stored inside the small bags.

3.8 Sterility Testing

Sterility testing is an experiment on testing the level of sterility of the surgical medium after attaching together with the bag covers. Figure 3.11 is a complete model that being used to conduct the sterility experiment.

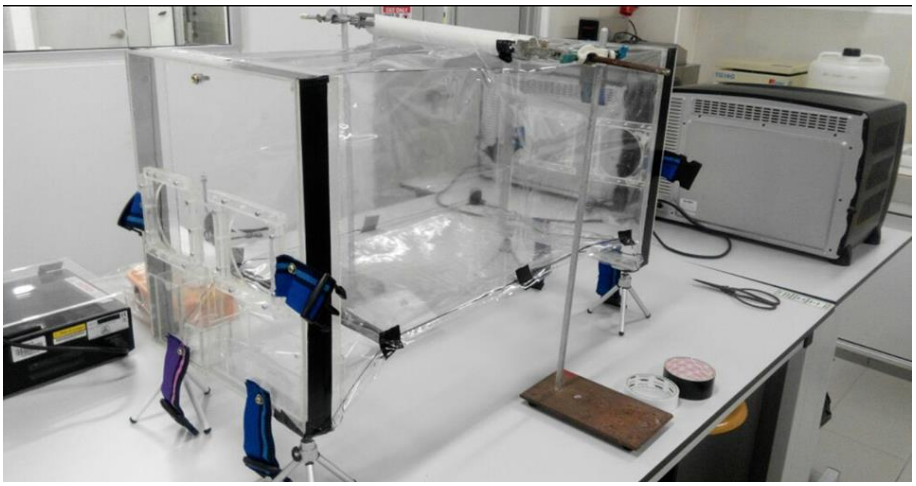


Figure 3.11: Testing Model

In Figure 3.11, black tape can be seen around the sealing edge between the surgical medium. The purpose is to increase the capability of sealing and prevent the internal environment in contact with the outer environment.

The experiment can only be conducted after the setup. The experiment is called “internal space sterility test”. The objective of this experiment is to determine the sterility or cleanliness of the surgical medium. The test was conducted by putting a nutritious medium into the internal space of the surgical bag. The nutritious medium was exposed to the surgical medium’s environment with different amount of time period. After exposing, the nutritious medium was sealed and put into an oven for 4 to 7 days. The sterility or cleanliness of the surgical medium was being verified by identifying the presence of any microorganism growing in the nutritious plate. The medium is considered as “unclean” if there are microorganism growing. If there is no microorganism grow on the plate, then the surgical medium is considered “clean”.

3.9 Work Plan

The process of making the bag pack is not very difficult. First of all, Solidworks was used to design several prototypes. Solidworks is a CAD software that used to design engineering product, manufacturing line, and others. However, design in figure 3.6 was being rejected.

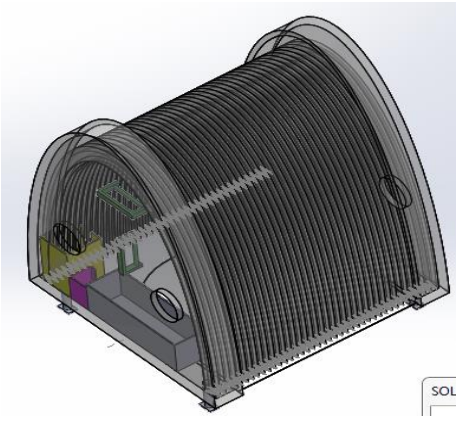


Figure 3.12: Design Version 1

The design work will probably use two to three weeks to complete. After that, design framework was sent to any manufacturer who has the laser cutting technology

to cut the shape of acrylic according to the design. This stage will take about four days to one week.

After finish cutting, one week time was used to assemble the frame of the surgical bag (bag cover 1, 2) using chloroform. After the assembly work, the surgical bag development was proceeded by making the surgical medium. This surgical medium took more than two weeks to do because this part is the most crucial part of the surgical bag. Thus, the time consuming were three weeks maximum. After that, the remaining one or two weeks were used to add the extra features into the bag. Lastly, remaining time was used to do the reports.

Figure 3.13 is regarding the time I had spent to create the surgical bag. Figure 3.14 is presenting the future work plan.

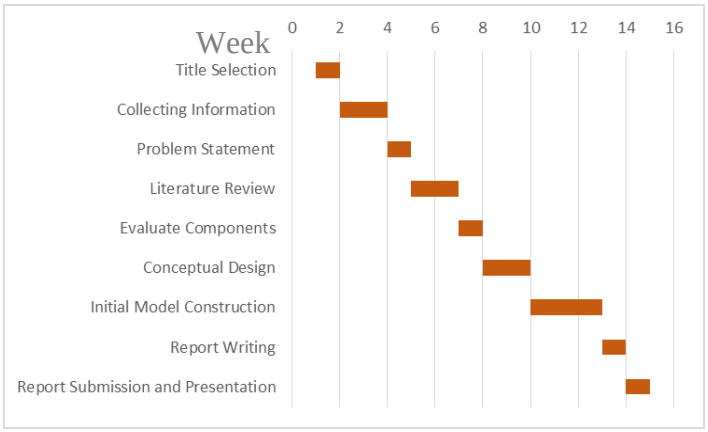


Figure 3.13: Semester 1 Work Plan

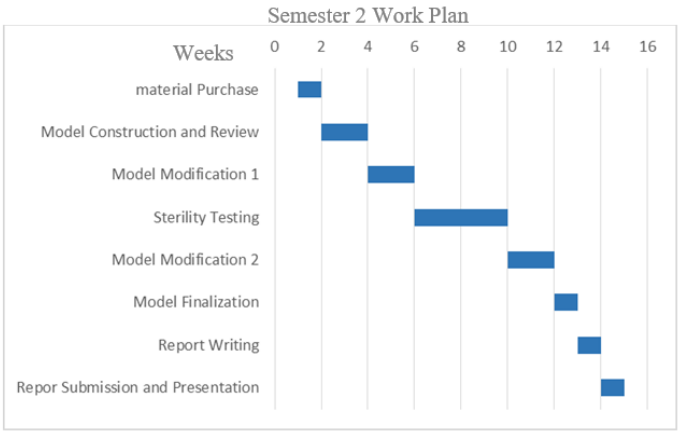


Figure 3.14: Semester 2 Work Plan

CHAPTER 4

CHALLENGES FACED IN MAKING SURGICAL BAG PACK

4.1 Version 1 Surgical Bag

Throughout the entire process of making the surgical bag, various kind of challenges and problems were faced. Version 1 surgical bag was being constructed during semester 1. Before constructing, several designs of the surgical bag were submitted to the supervisor and co-supervisor. However, the designs were being rejected due to several reasons. The figure below is the first version's design.

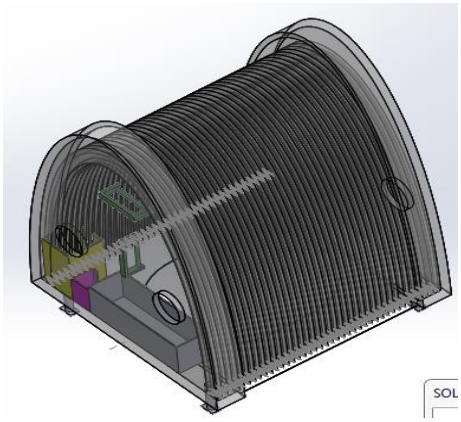


Figure 4.1: Surgical Bag Version 1

There are several reasons causing the first design being rejected. Firstly, the entire structure is half oval in shape. This structural design will limit the space of surgical medium. When space is being limited, doctors are hard to conduct any surgeries. Secondly, there are too many curls at the surgical medium. This will affect the vision of the doctors. Thirdly, the structure is too low in height and unstable because there is no structure to increase the height and stable the entire surgical container. Hence, the first design was rejected and it was being modified.

After taking some pieces of advice and recommendations from my supervisor, Mr. Chai Tong Yuen, and co-supervisor, Mr. Teoh Boon Yeoh. The second design was accepted and proceeded to the manufacturing stage.

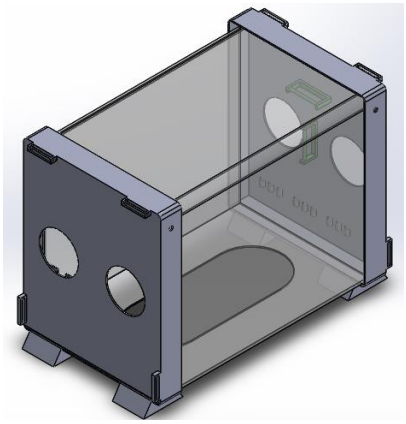


Figure 4.2: Design Version 2

For the first prototype, acrylic with 3mm thickness was chosen. The reason for using acrylic is because of its heat resistance, transparent characteristic and light as describe in section 3.2.

The bag bodies were then constructed by using the mentioned acrylic. In order to obtain smooth cutting edges and surfaces, laser cutting was used. The result is shown in figure 4.3.

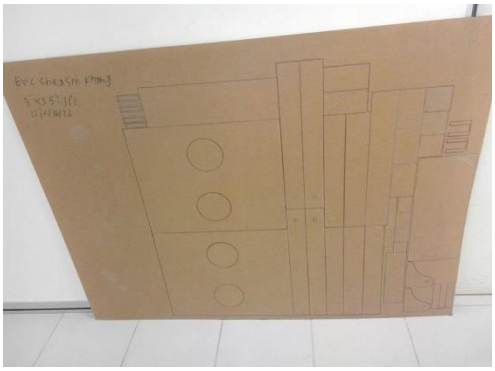


Figure 4.3: Laser Cutting Product (Frame of Surgical Bag)

After laser cutting, all the parts were removed from the frame at KBS 001 workshop for assembly stage.

In assembly stage, all the parts were “glued” together according to the design by using chloroform. Chloroform is a chemical which reacts with acrylic to form a very sticky layer. This sticky layer will ensure two acrylic boards glued firmly. Moreover, the glued part can be sealed with no leakage of water and air. Thus,

assembly stage played an important role because appropriate assembly and gluing acrylics together can improve the probability of creating a sterile medium.

After finish assembled the frame of surgical bag, advises were given by the technician of the mechanical workshop to let it dry for 24 hours. This is to ensure the applied chloroform is dried completely and all the edges and surfaces were glued firmly. Figures 4.4 shows the frame of the surgical bag which was finish assembled.

Figure 4.4: Surgical Bag Framework

The next step was gluing the capsules and bandage holder together with the bag covers. Chloroform was being used to stick the capsules and bandage holders onto the bag body cover 2 (figure 3.5). After that, the entire frame was left inside the workshop to dry. This process takes one day to complete. After it was dried, the entire frame was kept in the mechatronic lab (KB612).

The next part is the surgical medium. For this part, transparent cellophane was selected as the main material for constructing the surgical medium. The reason is because of its transparent characteristic and it is foldable. However, the cellophane is too soft which causing the surgical medium keep collapsing and changing shape. In order to solve this problem, few bendable steel rods were added to hold the shape of the surgical medium. The red arrows indicating the steel rods in figure 4.5.

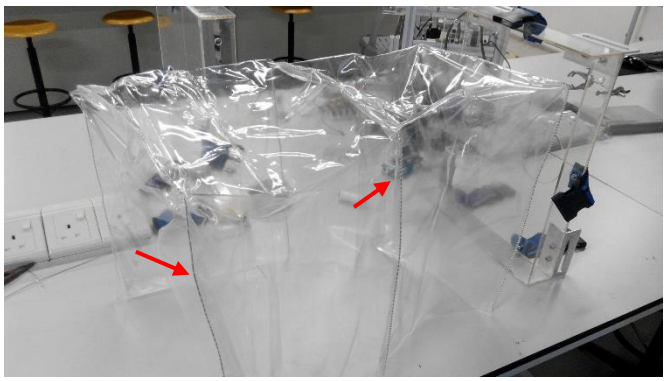


Figure 4.5: Surgical Medium

The figure above shows the first surgical medium during “initial model construction” state. The red arrows are pointing at the bendable steel rods that being added in order to prevent the surgical from collapsing. After that, the surgical medium was stuck onto the bag body. However, a set of surgical instrument holder was stuck to the side of surgical front bag body before combining the bag covers and the surgical medium together.

The surgical instruments and necessary supplies were put into the surgical bag after the sealing of surgical medium was done as shown in figure 4.6.

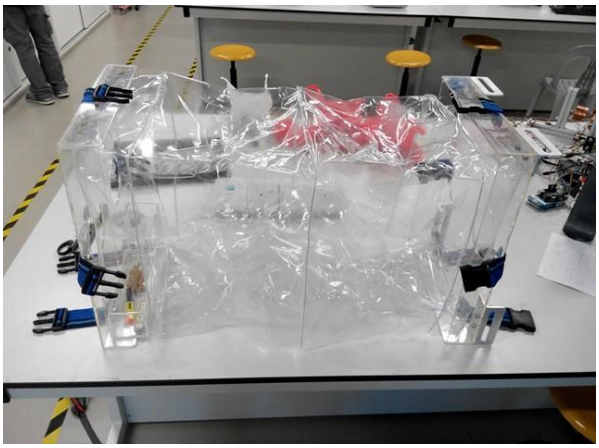


Figure 4.6: Surgical Bag Pack Version 1

After that, gloves were glued onto the front bag cover and back bag cover and sealed properly. The gloves were sealed properly to ensure the air from outside which contains various microorganism from entering the surgical medium. This is because the microorganism will cause infections toward the victims’ wound.

Figure 4.7: Surgical Bag Version 1 with gloves (open and close)

The figure above shows the complete surgical bag pack with the gloves. Figures 4.8 shows the method of carrying the bag.

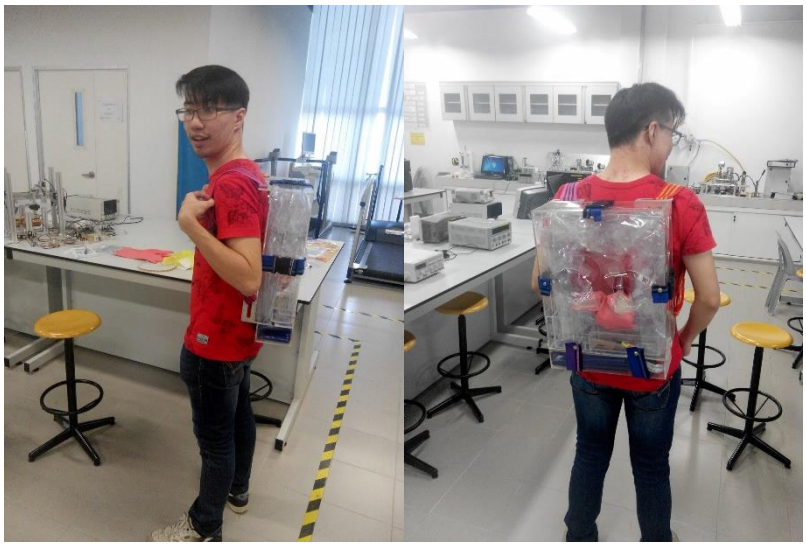


Figure 4.8: Surgical Bag Carrying Method

After the first development, a meeting was conducted with my supervisors to identify the challenges. The purpose of the meeting was to improve the first prototype's reliability and others. Figures below are the examples of the method of using the surgical bag on site which I had taken during the competition.

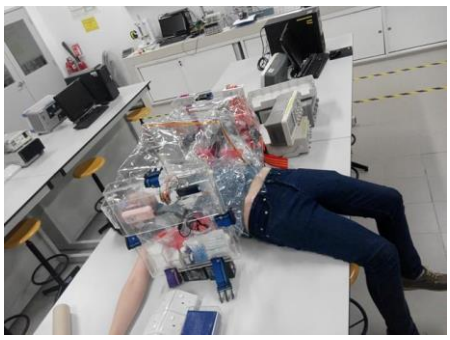


Figure 4.9: Surgical Bag Using Method

4.2 Problems Identification and Solutions

The first model was made during week 10 to week 12 of final year project part one. It was being reviewed by supervisors and it had a lot of limitations causing it unable to perform as what was expected. A meeting was conducted to identify the problems and limitation of the prototype and below are the lists of the problems.

1. The surgical medium is not properly sealed.
2. The surgical medium does not have curve shape.
3. The stands of the surgical bag are not high enough.
4. The gloves are too short.
5. The position and location of light dependent diodes (lighting system) are not suitable.
6. The prototype keep falling inward and outward.
7. Poor Sealing

Figure 4.10: Problem Listing

4.2.1 Improper and Poor Sealing of Surgical Medium

Several problems were encounter in the version 1 surgical bag. First of all, the surgical medium was not properly sealed and the sealing is poor. This is a serious problem because the air from the outer environment can flow into the surgical medium freely. In other words, microorganism and bacteria will invade and contaminate the surgical medium. Moreover, the surgical instruments will be contaminated together. Thus, the objectives of creating a sterilized surgical medium were failed to achieve.

Proposed Solution:

First of all, the design of the first prototype was revised and re-design. Figure 4.11 is the example of new design.

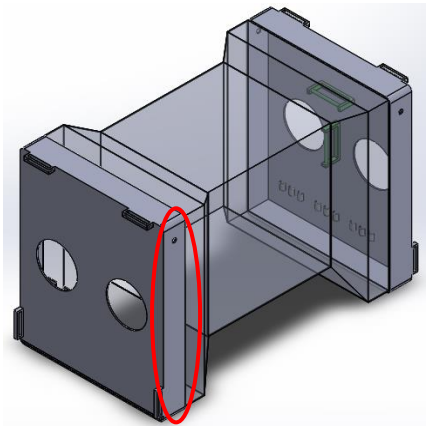


Figure 4.11: Design 2

The design of the surgical medium was shrunk in size. However, the outer part of the surgical medium is having the same dimension with the bag cover. This is because sealing will be performed between the outer part of the surgical medium and the bag covers. By having the same dimension, the sealing can be performed easily and the capability of isolating the inner space from the outer environment is increased.

4.2.2 Absence of Curve Shape at the Bottom of the Surgical Medium

Secondly, the bottom part of the surgical medium does not curve. In figure 4.10, the surgical medium was being pushed upward by the body of the victim. This had caused both the bag cover slanted several degrees. Doctors will face difficulty in using the surgical bag because the bag cover will keep slanting inward and outward. This issue will cause the doctor unable to perform any surgery. Hence, the surgical bag failed to fulfil one of the objectives.

Proposed Solution:

From figure 4.12, the surgical medium was re-designed with a curve. The purpose is to avoid the bag cover from falling inwards or outward as shown in figure 4.10. However, the internal space of the surgical medium is smaller compared to the previous design. The design is being shown in the following figure.

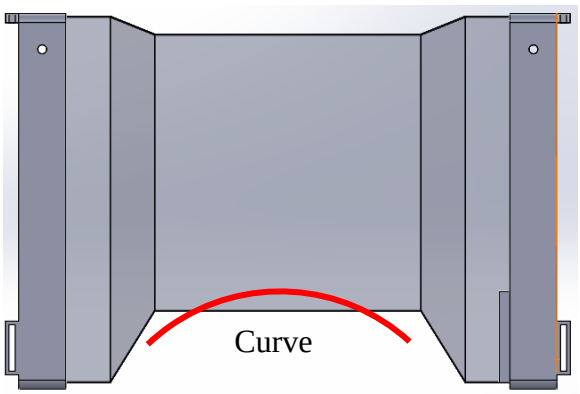


Figure 4.12: Surgical Medium Design 2

With this curve design, the surgical bag can be used in a more flexible way. Besides that, the surgical bag can be used on victims with the bigger size. This is because the curve design allows the surgical bag to be placed on top of a bigger size victims without causing tilting or falling.

4.2.3 The Height of Stands for Surgical Bag

The third problem that was being identified is the stands for the surgical bag are not high enough. This problem will cause the surgical bag slanted as well. Besides that, the stands were unable to mount firmly with bag covers which lead to the bag covers keep shaking while doctors were using. Hence, surgery cannot be performed properly and the main objective fails to achieve.

Proposed Solution:

The absence of extendable stands had caused the surgical bag unable to use on victims who are large in size. This is because larger size victim will push the surgical medium upward which causing the surgical bag slanted. Hence, the first model was being redesigned by adding four mini tripods with adjustable height. The purpose is to increase the height of the surgical back and the adjustable tripod made it available to treat people with bigger size. Besides that, the stands are installed firmly onto the bag cover which reduces the possibilities of the bag slanting inward and outward. The figure 4.13 is the new CAD design of the surgical bag and figure 4.14 shows the real prototype with the stands.

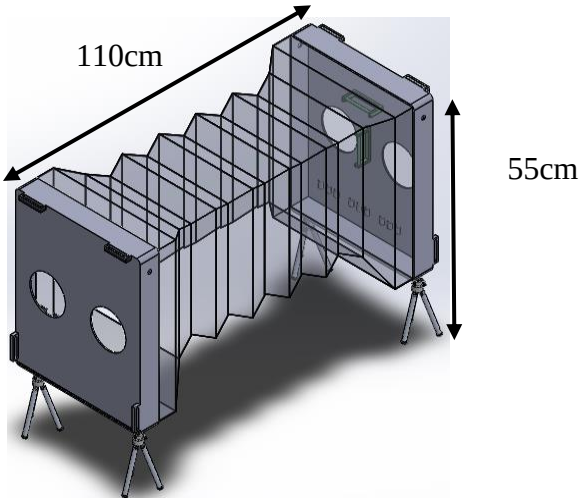


Figure 4.13: Stands (CAD)

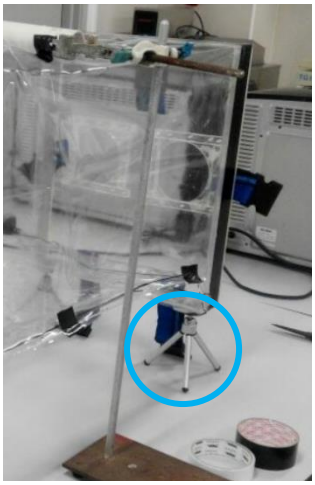


Figure 4.14: Stands (Prototype)

4.2.4 Short Gloves

The fourth problem was the glove too short. The area of movement in the surgical medium was being restricted due to the short glove. This had limited the size and type of wound that can be treated using this surgical bag.

Proposed Solution:

The glove will be replaced with a longer and better quality shoulder-length rubber glove as shown in figure 4.15. This is because the gloves have better quality and heat resistivity. However, the desired gloves were not manage to obtain due to financial limitation.

Figure 4.15: Shoulder length Rubber Gloves

4.2.5 Lighting Issues

The fifth problem is the location of the lighting system. The light emission diode (LED) should have installed in an area that is outside the surgical medium instead of inside. This is because fixing the light inside had restraint the doctor in adjusting the direction of light. This issue will affect the vision of doctors when surgeries are performed at a darker area or night time.

Proposed Solution:

The LED light was being removed from the internal space of the surgical medium. A conventional type torch light was used to increase the mobility, vision, and brightness of the environment when doctors are performing simple surgeries.

4.2.6 Unstable Surgical Bag

The sixth problem was the bag covers keep falling inwards. This issue was caused by the static stands and the absence of curve surgical medium. The effect is the same which is causing doctors or surgeon unable to perform surgery. Thus, the surgical bag fails to achieve its main objective.

Proposed Solution:

In order to solve this problem, a hard frame or structure is needed. Hence, two extendable rods were used to hold the structure from keep falling inward or outward.

The whole structure was able to be in a stable condition while forces were applied from the left side or right side. The figure below shows the extendable rod that holding the surgical bag's structure together.

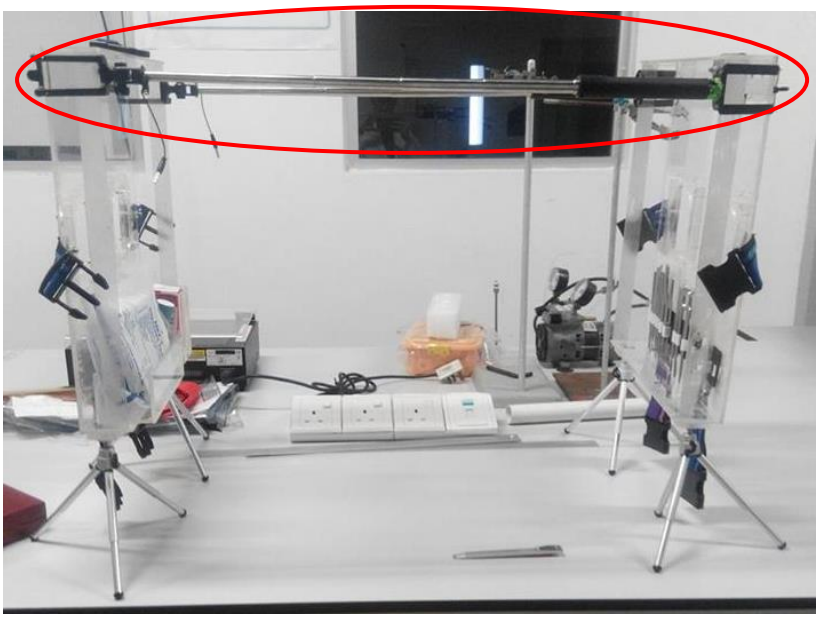


Figure 4.16: Extendable Rods

Figure 4.17: Extendable Rod Holder

4.2.7 Poor Sealing

The surgical medium was hard to seal nicely and firmly onto the bag covers. This is because the cellophane is too soft. It will keep pulling the bag covers inward if the

length is too long. Besides that, cellophane will have a lot of leftover folding marks after using repeatedly. This has caused the cellophane to break easily. Moreover, the leftover marks will affect the visual of the doctor towards the wound via the space of surgical medium. On the other hand, cleaning work is very challenging because the water bath is needed and it is hard to immerse the warm water into the inner space of surgical bag in order to kill all the microorganism.

Proposed Solution:

In order to solve this problem, the surgical medium was switched into a disposable surgical medium. The purpose of switching is to increase the convenience of users to set up before conducting surgery and clean up after the surgery. In other words, the surgical medium is one-time use only. The figure below is a CAD drawing example of the disposable surgical medium.

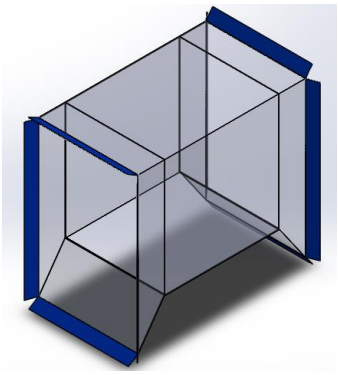


Figure 4.18: Disposable Surgical Medium

From figure 4.18, we can observe that there are blue strips at the end of the surgical medium. The function of those blue strips is attaching the surgical medium together with the bag cover. They are detachable after using. On the other hand, we had removed the hole that located beneath the middle of the surgical medium. The reason is to ensure the inner space is in sterile condition after attaching together with the bag cover. However, there is a problem which is how to make sure the inner space is free from microorganism before sealing and after sealing?

In order to solve this problem, some studies were done and 30% to 70% concentration ethanol was selected to be the sterile agent. The first reason is because ethanol has the ability to kill variety of microorganism in a certain period of time from

10 seconds to 1 hour. According to a paper published by centers of diseases control and prevention, CDC “Pseudomonas aeruginosa was killed in 10 seconds by all concentrations of ethanol from 30% to 100% (v/v), and Serratia marcescens, E coli and Salmonella typhosa were killed in 10 seconds by all concentrations of ethanol from 40% to 100%. The gram-positive organisms Staphylococcus aureus and Streptococcus pyogenes were slightly more resistant, being killed in 10 seconds by ethyl alcohol concentrations of 60%–95%. However, Isopropyl alcohol (isopropanol) was slightly more bactericidal than ethyl alcohol for E. coli and S. aureus” (Rutala & Weber, 2008). Besides that, alcohol occasionally is used to disinfect or decontaminate external surface of an equipment (Rutala & Weber, 2008).

However, ethanol has several drawback and limitation. First of all, ethanol is advised to store in cool and air-ventilated area. Secondly, ethanol evaporates rapidly which difficult to extend the exposure time. Thirdly, the paper written by Rutala and Weber stated that ‘Alcohols are not recommended for sterilizing medical and surgical materials principally because they lack sporicidal action and they cannot penetrate protein-rich materials.’ (Rutala & Weber, 2008).

Despite the drawbacks, ethanol can be considered as a good sterilant for the surgical medium. An experiment was conducted in the lab to prove its capability. On the other hand, hydrogen peroxide can be chosen as an alternative solution instead of ethanol. This is because hydrogen peroxide poses higher rate of bactericidal and virucidal activity. According to Rutala and Weber, ‘a concentration of 6% to 25% of hydrogen peroxide shows a promise as chemical sterilants’ (Rutala & Weber, 2008). From this statement, hydrogen peroxide can be a better choice in sterilizing the internal spaces of the surgical medium after installation.

The advantage of using hydrogen peroxide compare to ethanol is its characteristic of producing destructive hydroxyl free radicals which are able to destroy DNA, membrane lipids, and other essential cell components.

With these two solutions and the studies, the possibility of achieving sterility in the surgical medium is higher. So, an experiment was conducted to prove the capability of achieving sterility using ethanol with 70% concentration. The detail of the experiment was discussed in chapter 4.

In a nutshell, there are a lot of challenges and failure were encounter in the first model. A lot of modification are done onto the first model to improve the reliability

and performance capability of the surgical bag pack. The figure below is an example of a complete modified model that being use for testing.

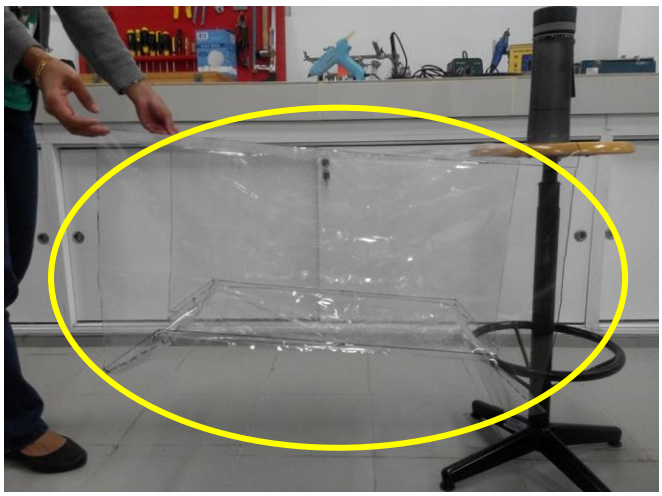


Figure 4.19: Disposable Surgical Medium (real)

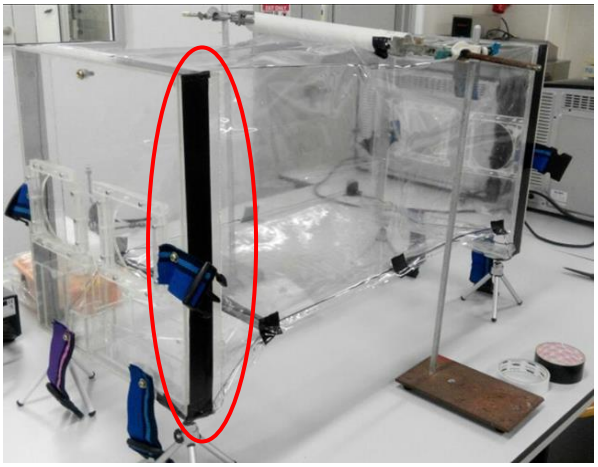


Figure 4.20: Disposable Surgical Bag 2 (real)

CHAPTER 5

RESULT AND DISCUSSION

5.1 Surgical Medium Sterility Testing

Sterility testing was conducted to prove the inner space of the surgical medium is clean and free from microorganism. The procedures were discussed in section 5.2.

5.2 Procedures

Before conduct the experiment, there are few materials and equipment need to be prepare.

Equipment:

1. Gloves
2. Mask
3. Parafilm
4. Oven (37°C)
5. Laminar Flow Machine
6. Laboratory Wiper

Material:

1. Agarose (Nutritious Medium)
2. 70% concentration Ethanol
3. Clorox
4. Water/distilled water

First of all, eight agarose plates are prepared by using agarose solution/ powder. After the preparation of agarose plates, the whole set of the surgical bag was washed by using Clorox and water. The top part of bag covers was immersed into the mixture of Clorox and water for 4 to 5 minutes. Then the covers were turned upside down and the bottom parts were being immersed for 4 to 5 minutes. After this, the covers were wiped and dry.

Then, same procedures were carried out to the surgical medium. After cleaning the covers and medium, ethanol with 70% concentration was sprayed onto the inner space of the surgical medium and bag covers. Then, the surgical medium was stuck

together with the bag covers using double tape and black tape. Figure 5.1 shows the surgical bag which had been cleaned. Then the surgical bag was placed in the laboratory KB 615 with normal environment condition (temperature of 20 to 26 degree Celsius and humidity of 82%).

After that, the four holes for attaching gloves were sealed by using cellophane. One of the holes was openable for putting in and taking out the agarose plates. Then ethanol was sprayed in the inner space of the surgical bag and wiped using laboratory wiper.

Next, agarose plates were separated into three batches. Each batch consisted of 3 plates. For the first batch, the first plate was opened in a laminar machine (clean environment); the second one was opened in the laboratory (dirty environment) and the third one was opened in the surgical medium (unknown environment). These three plates were exposed to surrounding environment for two hours.

After two hours, those agar plates were sealed according to the opening order using parafilm. Then those agar plates were transferred into an oven of 37 degree Celsius. The agarose is being observed every day and result were taken.

Same procedures were conducted onto second and third batches. However, the exposure period was extended. The second batch was exposed to the respective environment for three hours while the third batch was more than twelve hours. The result and data were collected from day one to day three to observe the presence of the microorganism.

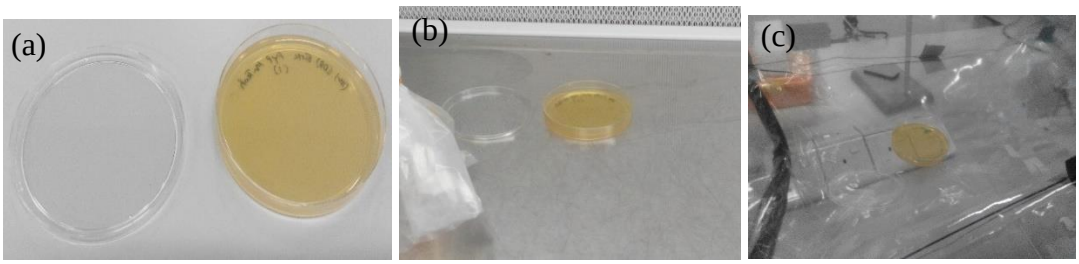


Figure 5.1: Sample Agarose Plate at Different Environments:
(a)Normal environment
(b) Laminar Flow Machine environment
(c) Surgical Bag Environment

5.3 Sterility Testing Explanation

The reason of washing the entire surgical bag is to remove dirt that can be seen clearly with our naked eyes. Then the reason of spraying ethanol onto the bag before sticking the surgical medium and bag cover together is to kill those microorganisms at the surface of the surgical medium and surgical bag body covers. After combining together, three holes for gloves was sealed firmly are to completely isolate the surgical medium from the normal environment.

However, there is a hole for gloves which is sealed partially. The purpose is to provide a pathway for inserting or taking out the agar plate. Then, the procedure also mentioned that the ethanol is sprayed the second time. This purpose is to further cleaning and provide a clean environment.

After that, agarose plates will open in three different environments. The purpose of putting one plate in the laminar machine is to prove that there will be no microorganism able to grow in this clean environment and the nutritious plate is free from microorganisms. The second plate is opened in normal environment condition and it is used to prove the surgical bag is put in an environment which contain unknown microorganism. The third plate is put in the surgical bag for testing whether the space in clean or not. If there is microorganism growing on the plate, then the surgical bag is not sealed properly which causing space become “unclean”. If there is none, then it is proven that the surgical medium is sealed properly and the probability of microorganism going into the medium is very low. Besides that, it also proven that ethanol is usable for keeping the inner space from microorganisms.

After that, each batch is carried out with same procedures but the time frame is different. The reason is to observe whether after a longer period of time, will the surgical medium is decontaminated or not.

5.4 Result

There are several results that I have collected from the experiment. Red indicating unknown microorganism, brow indicating spores, blue indicating bacteria, and yellow indicating fungus. The figures label with “(Status [batch] ; D[Day] ; H[Hour]” where the status indicate the plate is located at the clean bench, the working bench or the dirty bench. “[Day]” indicates the number of days of the nutritious plate placed in the oven for microorganisms to grow. “[Hour]” stands for the period of exposure.

Batch 1 (Day1; 2 hours exposure):

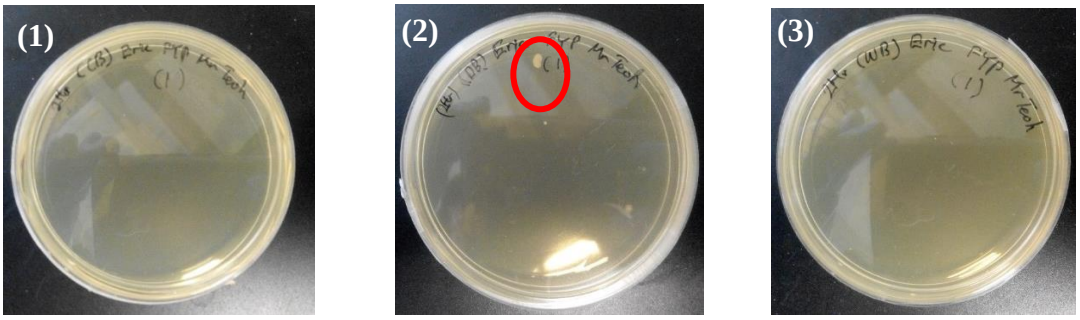


Figure 5.2: Batch 1 Agarose Plates (a):

(1) Clean Bench (CB1;D1;H2)

(2) Dirty Bench (DB1;D1;H2)

(3) Working Bench (WB1;D1;H2)

Batch 1 (Day 2; 2 hours exposure):

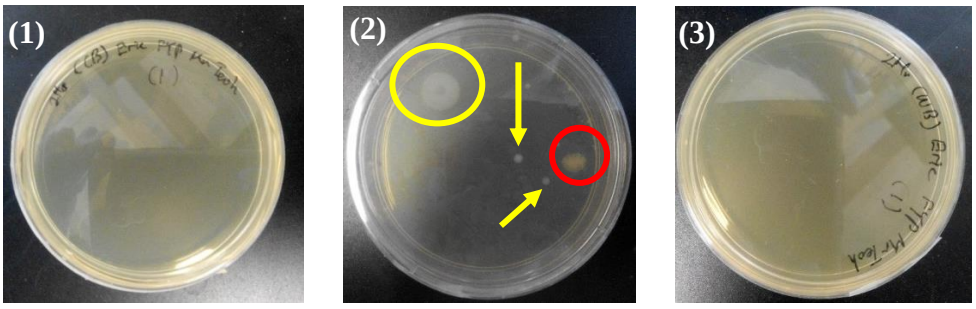


Figure 5.3: Batch 1 Agarose Plates (b):

(1) Clean Bench (CB1;D2;H2)

(2) Dirty Bench (DB1;D2;H2)

(3) Working Bench (WB1;D2;H2)

Batch 1 (Day 7; 2 hours exposure):

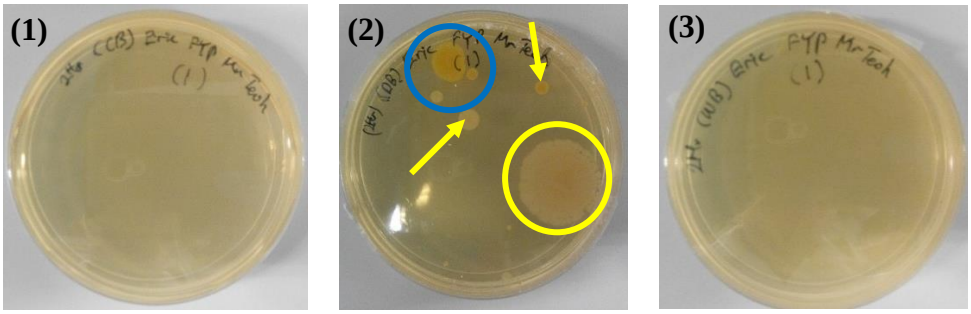


Figure 5.4: Batch 1 Agarose Plates (c):

(1) Clean Bench (CB1;D7;H2)

(2) Dirty Bench (DB1;D7;H2)

(3) Working Bench (WB1;D7;H2)

Batch 2 (Day 1; 3 hours exposure):

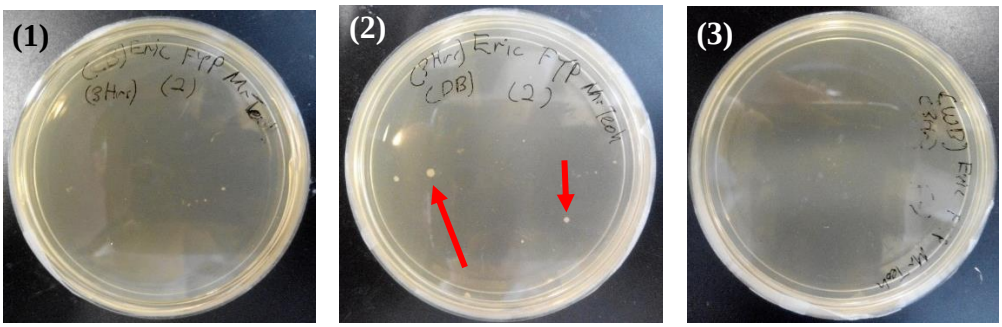


Figure 5.5: Batch 2 Agarose Plates (a):

(1) Clean Bench (CB2;D1;H3)

(2) Dirty Bench (DB2;D1;H3)

(3) Working Bench (WB2;D1;H3)

Batch 2 (Day 6; 3 hours exposure):

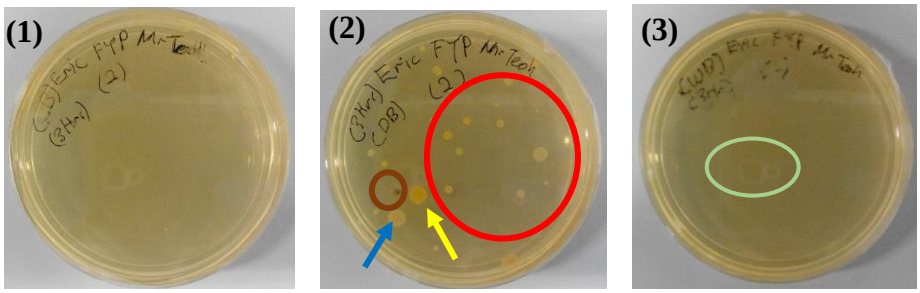


Figure 5.6: Batch 2 Agarose Plates (b):

(1) Clean Bench (CB2;D6;H3)

(2) Dirty Bench (DB2;D6;H3)

(3) Working Bench (WB2;D6;H3)

Batch 3 (Day 4; >12 hours):

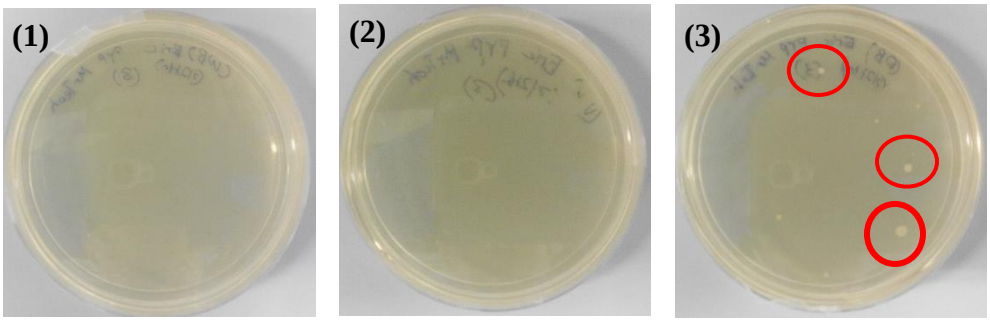


Figure 5.7: Batch 3 Agarose Plates (a):

(1) Working Bench Sample 1 (WB3;D4;H>12)

(2) Working Bench Sample 2 (WB3;D4;H>12)

(3) Dirty Bench (DB3;D4;H>12)

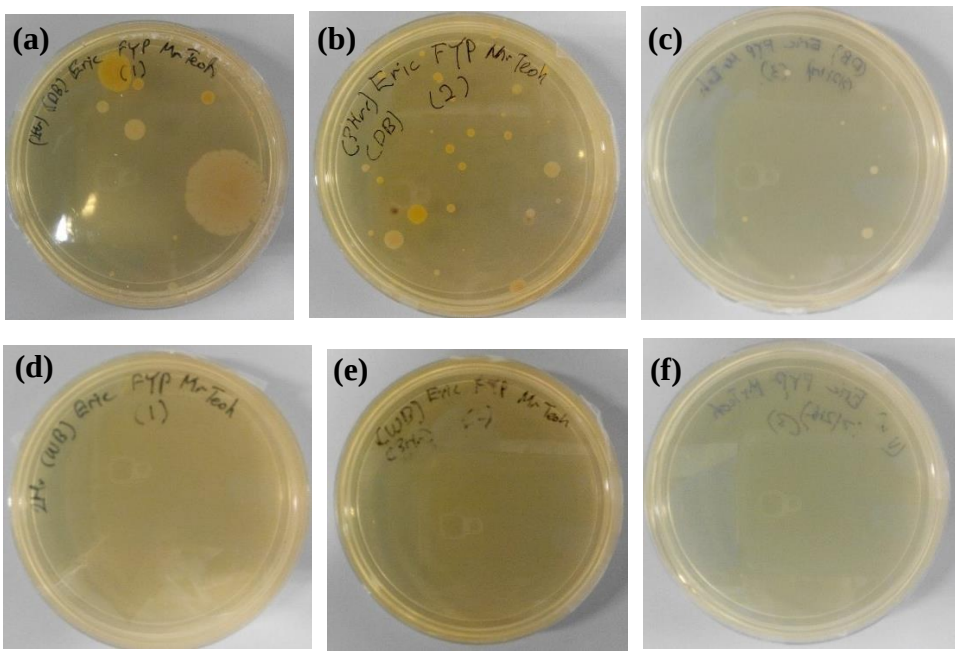


Figure 5.8: Comparison Between Dirty Bench and Working Bench

(a) Batch 1 Dirty Bench (DB1;D7;H2)

(b) Batch 2 Dirty Bench (DB2;D6;H3)

(c) Batch 3 Dirty Bench (DB3;D4;H>12)

(d) Batch 1 Working Bench (WB1;D7;H2)

(e) Batch 2 Working Bench (WB2;D6;H3)

(f) Batch 3 Working Bench Sample 2 (WB3;D4;H>12)

5.5 Discussion

The results of this experiment were being presented in section 5.4. Each batch consisted of three agar plates. Each plate was exposed to three different environments as explained in the procedure. The nutritious plate exposed in laminar air flow machine was labelled as clean bench (CB). The plate exposed to laboratory environment was labelled as dirty bench (DB) and the third plate that exposed to the inner space of surgical medium was labelled as working bench (WB).

For batch one, the nutritious plates were exposed to different environment for two hours and placed in a 37-degree Celsius oven for microorganisms to grow. After one day, there were nothing grown in the clean bench (Figure 5.2: (1)) and working bench (Figure 5.2: (3)). However, some unknown microorganisms were growing in the dirty bench (Figure 5.2: (2)). These results had shown that the inner space of surgical medium was “clean” and almost free from microorganisms after two hours of

exposure to surrounding environment. In order to identify the unknown microorganisms, the nutritious plates were left in the oven for a week to let the microorganisms grow. The results are shown in figure 5.4: (1), (2) and (3).

There are still no microorganisms growing in the working and clean bench of the nutritious plates as shown in figure 5.4: (1) and figure 5.4: (3). However, the microorganisms growing in the dirty bench were identified as shown in figure 5.4: (2). Those microorganisms were bacteria and fungi. Thus, the results indirectly proved that the surgical bag was almost free from microorganism while operating in a normal environment for two hours.

For the second batch, the exposure time had been increased to three hours. The results were positive as well. This is because the working bench's nutritious plate did not contain any microorganism growing (figure 5.5: (3)) after one day. On the other hand, there were some unknown microorganisms growing in the dirty bench (figure 5.5: (2)). In order to verify the working bench for batch two was free from microorganisms, the agar plates were placed in the oven for few more days. At day sixth, results were taken and showed no sign of microorganisms growing in the working bench (figure 5.6: (3)) but the microorganism growing in the dirty bench increased (figure 5.6: (2)). However, there was a shape circle by green circle that has a likelihood of growing microorganism as shown in figure 5.6: (3). Hence, a detail observation was carried out by lab officer and it was proven that the shape formed was water vapour. So, the surgical bag has a good surgical environment after exposed to normal environment for three hours.

Batch three was exposed to the surrounding for more than twelve hours. The purpose was to test the sterility of the inner space of surgical medium if it will be used for more than twelve hours. The second reason is the agarose medium cannot be exposed to the surrounding for too long as it will dry out and crack eventually.

In order to observe the presence of microorganisms, the agarose plates were left in the oven for four consecutive days. Figure 5.7: (1), (2), and (3) are the results for batch three. From these three figures, the sample 1 and sample 2 of the working bench have no sign of microorganism growing. However, there are unknown microorganisms growing for the dirty bench. These results had proved that the surgical bag able to maintain in "clean" stage after 12 hours operation. On the other hand,

comparison had been done in Figure 5.8 to present the overall results of the experiment clearly.

From these results, the percentage of microorganisms growing in the working bench is low for exposure of two hours, three hours and more than twelve hours in the surgical medium. Thus, the capability of maintaining the sterility of surgical medium using double tape and black tape method has been verified. Besides that, the capability of ethanol to conduct disinfection and decontamination within the surgical medium is good. Thus, the objectives of the experiment were achieved.

CHAPTER 6

CONCLUSION

6.1 Conclusion

The idea of creating a surgical bag with a “clean” and sterile inner space for operation is achieved. With the results provided, the possibilities of suffering post-surgery infection can be reduced. Besides that, the prototype is light, easy to carry and pre-set up. With the light weight and user friendly advantage, doctors and surgeons are encouraged to carry the surgical bag to disaster areas. Besides that, the survivable injuries can be treated as fast as possible to reduce the percentage of losing lives. The example of the injuries that can be treated by this surgical bag are laceration, debridement, bleeding, compartment syndrome, burn, and sprain. Moreover, the hygiene advantage can reduce the percentage of victims from suffering post-surgery infection.

In conclusion, the lack of surgical facilities in disaster areas can be overcomed. This prototype is able to achieve the objectives and aims stated.

6.2 Recommendation

6.2.1 General Improvement

This surgical bag can be further improved and further developed into a more useful, helpful and user friendly bag. For example, use hydrogen peroxide instead of ethanol as hydrogen peroxide poses as a better sterilant. Besides that, increase the size of the surgical back bag will provide more space for movement and able to install more equipment. A harder, foldable and yet transparent plastic can be used to replace cellophane to simplify the design of the prototype.

6.2.2 Doctors Review

A doctor had reviewed the prototype and provided some opinions and suggestion as shown below:

1. Providing clean air to the operating environment
2. Reduction of package weight

3. Flexible when operating space is limited
4. Allows surgeon to move more freely for the more awkward manoeuvres
5. You are able to produce multiple specialize sets for various procedures, all inflated using the same pump, and this will reduce cost

The main idea regarding the overall review from this doctor is applying the angiographic equipment which has adhesives surface to seal off areas of operation. The original email is shown in appendix A.

6.2.3 Poster Competition

The concept of this project was presented in UTAR LKC FES Final Year Project Poster Competition for January 2017 trimester and won 1st runner-up under Applied Engineering (Technical skills for the design and integration of systems, the execution of new product designs, and the improvement of manufacturing processes) track.

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APPENDICES

APPENDIX A: Doctor's Review

CHUA SHI KHANG ERIC <chua4me@1utar.my>

Portable Surgical Backpack

1 message

Teh Yong Guang <tehyongguang@yahoo.com> Mon, Apr 3, 2017 at 7:30 PM

To: chua4me@1utar.my
Cc: Teoh Boon Yew <daniel_tby@hotmail.com>

Dear Eric,

Congratulation on the completion of your prototype! You invested a lot of time into this project and it shows.

Thank you also for the invitation to evaluate you project.

The strength of your idea and concept:
1. There is a need for this sort of equipment, although niche
2. You have identified one of the main sources of infection related to surgical procedures- the air
3. Your "surgical tent" idea is a workable model and can be further improved

Extrapolating from your "Surgical Tent" concept, consider an inflatable tent rather than one which is supported by solid structures. This tent is continuously supplied with air that has undergone some form of filtration process to produce near "surgical air" quality. The benefits of this are:
1. Providing clean air to the operating environment
2. Reduction of package weight
3. Flexible when operating space is limited
4. Allows surgeon to move more freely for the more awkward manoeuvres
5. You are able to produce multiple specialize sets for various procedures, all inflated using the same pump, and this will reduce cost

Also consider adopting technology from the latest angiographic/surgical equipment suppliers which have adhesive surfaces to seal off areas for operation.

The following are just examples
https://www.merit.com/peripheral-intervention/solutions/procedural-trays-packs-kits/patient-cover/

Do try and identify local suppliers.

Overall your idea has the potential to be developed into a very useful product that can benefit those in war zones or remote places where immediate medical attention is needed.

All the best in your future undertakings.

TehYG

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