Halton Healthcare

Emergency Response Plan: Hazard Identification and Risk Assessment (HIRA)

Emergency Preparedness Department

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HAZARD IDENTIFICATION AND RISK ASSESSMENT

INTRODUCTION

Guided by the Emergency Management and Civil Protection Act, all communities within Ontario operate using a risk-based approach to emergency management. This paradigm has proven to be a highly successful method for minimizing loss of life and property in emergency situations, and has been adopted by many public and private organizations. Further, this risk-based approach has become part of both general and industry-specific best practice, as outlined by the Canadian Standards Association in guidelines such as the Z1600 (Emergency Management and Business Continuity Programs) and the Z8000 (Canadian Health Care Facilities).

With the importance of risk-based emergency management now well-recognized throughout the healthcare industry, provisions for such programs have also become a critical part of accreditation guidelines:

> *The organization's leaders develop and implement plans for preventing and mitigating potential disaster and emergencies. Prevention refers to measures taken to avoid an incident or stop an emergency or disaster from occurring. Mitigation refers to actions taken to reduce the risks and impacts posed by hazards. Prevention and mitigation plans should be based on information obtained from hazard identification, risk assessment, and business impact analysis (Section 14.1, Leadership, Qmentum Standards).*

An important step in emergency preparedness is to identify all hazards that may affect Halton Healthcare Services (HHS), and assess their associated risks to determine which hazards are most likely to result in an emergency. This approach both satisfies accreditation requirements and also allows for a systematic, targeted approach to emergency preparedness. The results of a risk assessment can be used to guide an annual or multi-year emergency management cycle.

In addition to identifying high-priority hazards, this proactive approach to emergency management can result in a more disaster-resilient environment. Success in meeting this challenge can be found by answering the following questions:

- What hazards exist within or surrounding each HHS site?
- How frequently do they occur?
- How severe can their impact be on the hospitals' staff, patients, infrastructure, finances, and reputation?
- Which hazards pose the overall greatest threat to the organization?

To address these questions, a comprehensive hazard identification and risk assessment (HIRA) is required. The current iteration of the Halton Healthcare Services HIRA was completed in August 2014. In order to ensure emergency preparedness activities are kept up with evolving risks, the HIRA should be reviewed annually and updated as required. This guide was designed to allow for efficient annual renewal, using minimal time and financial resources.

METHODOLOGY

There are a number of different methods for conducting an organizational risk assessment. The methods used for this document are a combination of the following strategies, which comprise a collection of government and industry-recommended best practices**:**

- Ontario's Hazard Identification and Risk Assessment
- British Columbia's Hazard, Risk, and Vulnerability Analysis
- Kaiser Permanente's Hospital Hazard and Vulnerability Assessment

The first step in this process was to identify all possible hazards – no matter how unlikely, provided a greater than zero chance – that might impact a Halton Healthcare Services site or its surrounding community. A full list of hazards, and their definitions, can be found in **Appendix A**.

Second, each hazard was scored based on the relative risk it posed. The risk score was a combination of two dimensions: likelihood and consequence. Consequence was further broken down into the potential impacts on people, property, finances, and reputation. Scores were determined through examination of archived data, academic resources, and meetings with subject matter experts. The goal was not to obtain exact measures of risk, but rather to outline a relative ranking to guide future priorities. The parameters of the scoring system follow:

Risk = [Likelihood] x [Sum of Consequences]

Likelihood: Likelihood provides a standardized view of how often a given hazard event may occur, either in the hospital or its community. The ranking scale is from 1-5, with 1 being the lowest possible rank and 5 being the highest. Likelihood is based on a combination of history and best estimates of future frequency of events.

1 – Unlikely (but not impossible) to occur within a 100 year period in the hospital or community, or a rating of 2 in nearby municipalities

2 – May occur every 100 years in the hospital or community, or a rating of 3 in similar/nearby Ontario municipalities

3 – May occur every 10 years in the hospital or community, or a rating of 4 in similar/nearby Ontario municipalities

4 – May occur every year in the hospital or community, or a rating of 5 in similar/nearby Ontario municipalities

5 – Multiple occurrences per year in the hospital or community

Consequence: For the purpose of this document, consequence is defined as the anticipated impact from a given event in a worst-case scenario. This measure is based upon the logic that it is always preferable to over-respond to an emergency. Consequence can be broken down into

four components, each of which is of critical concern to a hospital. These four aspects are human impact, physical/infrastructure impact, financial impact, and damage to reputation.

Human Impact: The cost of a given event in human terms; lives lost and people injured. This impact is ranked for each event on a scale of 1 to 5, with 1 being the lowest possible score and 5 being the highest.

1 – Injury or illness unlikely

2 – Low probability of injuries or illness

3 – High probability of injuries or illness

4 – High probability of injuries or illness and low probability of death

5 – High probability of injuries or illness and high probability of death

Physical Impact: The cost of a given event in terms of loss of the use of hospital property or equipment, whether destroyed, damaged, or requiring clean-up. This impact is ranked for each event on a scale of 1-5, with 1 being the lowest possible score and 5 being the highest.

1 – Property damage or loss of access unlikely

2 – Minor clean-up or recovery time

3 – Minor damage, temporary loss of access

4 – Major damage, prolonged loss of access

5 – Indefinite loss of access to the affected area; complete rebuild

Financial Impact: The cost of the impact of a given event in terms of dollar cost, whether for repair/replacement or for unbudgeted incident response costs. This also includes insurance claims, where appropriate. This impact is ranked for each event on a scale of 1-5, with 1 being the lowest possible score and 5 being the highest.

1 – Negligible

2 - Generates expenditures or an insurance claim under $100 000

3 – Generates expenditures or an insurance claim of under $1 million

4 – Generates expenditures or an insurance claim of under $10 million

5 – Generates expenditures or an insurance claim over $10 million

Reputation Damage: The cost of the impact of a given event in terms of damage to corporate or facility reputation. While often overlooked in such exercises, the impacts can affect patient census, staff recruitment, funding, and fundraising efforts. This impact is ranked for each event on a scale of 1-5, with 1 being the lowest possible score and 5 being the highest.

> **1 – Reputation unlikely to be affected**
>
> **2 – Limited negative local media coverage and/or public stigma**
>
> **3 – Negative regional media coverage and strong public stigma**
>
> **4 – Negative national media coverage, fundraising and/or recruitment affected**
>
> **5 – Permanent association of adverse event with hospital, large affect on fundraising and/or recruitment**

This scoring system yields a minimum total risk score of 4, and a maximum of 100.

RESULTS

The full rankings of each hazard by both likelihood and consequence can be found in **Appendix B.** The results have been summarized in the following tables according to three different risk classifications: High, Moderate, and Low Preparedness Priorities. In general, infrastructure failure is the most likely hazard while technological hazards pose the highest consequences.

High Preparedness Priorities *(Top 10; scores 36 – 100)***:** with both a high likelihood of occurrence and high potential impact on the hospital. High preparedness priorities are hazards that are candidates for immediate mitigation and preparedness efforts to reduce the likelihood or consequences of occurrence. Possible risk reduction measures include physical fortification, redundant pathways, staff training, and acquisition of response resources.

Moderate Preparedness Priorities *(scores 26 – 35)***:** Events with either a high likelihood of occurrence and low magnitude of impact, or low likelihood but high consequence. Such potential risk exposures should be addressed in terms of mitigation and preparedness activities, after high priority events, as time and resources become available.

Low Preparedness Priorities *(scores 4 – 25)***:** Events with a low incidence of occurrence and low potential impact, or events which have already received substantial mitigation and preparedness efforts. These events should be monitored for changes in frequency or consequence, but do not require immediate action otherwise.

It should be noted that these results do not necessarily take into account mitigation and preparedness efforts that are already underway. In some cases, sufficient measures may already be in place. This should be considered when interpreting results.

High Preparedness Priorities			
Pandemic / Epidemic – External	60	Contamination – Food	36
Infectious Disease – Internal)	44	Hazardous Materials – External	36
Electrical Failure – Primary	40	HVAC Failure	36
Contamination – Water	39	IT Failure	36
Computer Virus / Cyber Attack	36	Water Supply Disruption	36

Moderate Preparedness Priorities			
Extreme heat	35	Medical Gas Failure	30
Flood – Internal	33	Missing Patient	30
Fuel Supply Failure	33	Transportation Accident	30
Serious Adverse Event	33	Violent Behaviour – Patient	30
Ice Storm / Freezing Rain	32	Blizzard / Snowstorm	28
Fire / Explosion – Internal	32	Severe Summer Storm	28
Supply Chain Disruption	32	Tornado	28
Child Abduction	30	Workplace Injury	28
Electrical Failure – Total	30	Fire Incident – Minor	28
Extreme Cold	30	Fire System Failure	28
Hazardous Materials – Internal	30	Telecommunications Failure	27
Mass Casualty Incident	30	Sewer Failure	26

Low Preparedness Priorities			
Electrical Failure – Secondary	24	Air / Space Object Crash	19
Severe Winds	24	Civil Disorder	18
Violent Person – Non-Patient	24	Hurricane	18
Violent Person – Active Shooter	24	Steam Failure	18
Fire / Explosion – External	22	Geomagnetic Storm	16
Flood – External	22	Structural Collapse	16
Hostage Incident	22	Nuclear Plant Fallout	13
Labour Disruption	22	Soil Subsidence	12
Bomb Threat	20	Earthquake	10
Pipeline Explosion	20	War	5
Terrorism	19		

RECOMMENDATIONS FOR ACTION

The purpose of this risk assessment was to identify mitigation and preparedness priorities based on the relative threat each hazard poses. This prioritized list should help to guide and support an annual cycle of emergency management activities. Prior to progressing, however, each hazard should be assessed for pre-existing risk management strategies already in place. In some cases risk control measures may already be adequate. In others, residual risk may still require further efforts to be taken. Interviews with subject matter experts and review of existing emergency plans is an effective way to make this assessment.

Where it is deemed that new risk management strategies are required, it is recommended that actions be taken to reduce risk working from hazards of highest priority to lowest priority. Where possible, however, an all-hazards approach to mitigation and preparedness should be taken, where the relative risk of multiple hazards can be reduced by a single measure (for example, an extreme weather plan could cover tornados, hurricanes and severe storms).

There are two ways of decreasing risk: reducing the likelihood and reducing the consequences. Both likelihood and consequence reduction can be achieved through mitigation measures (such as redundancies in case of failure or built-in physical resistance to prevent damage). Consequences can further be reduced through preparedness measures that allow for a more efficient response (such as written plans to guide response, staff training to ensure response is executed effectively, and resource acquisition to support response).

Halton Healthcare Services has already undertaken a number of preparedness activities to reduce risk. It is recommended that actions be taken to first address areas where gaps remain between relative risk and mitigation efforts. After high priority hazards have been reviewed and mitigated, focus can be shifted to moderate priority hazards as allowed by current resources. In general, assessment should proceed from the highest ranked risks to the lowest.

It should be emphasized that measures taken to reduce likelihood or consequences of hazard events may fall under the scope of a variety of hospital groups, such as Emergency Preparedness, Maintenance, Security, Occupational Health and Safety, or any other HHS department, as applicable. For each risk reduction measure, one department or position should be given primary accountability. Progress should be reviewed at monthly intervals and this risk assessment should be updated annually to reflect changes in risk.

The HHS HIRA should be updated annually as part of a recurring cycle, with the results serving to assist in the identification of future priorities for emergency preparedness activities. Particular focus should be placed on assessing risks at the New Oakville Hospital once relocation of the Oakville site is complete.

APPENDIX A – HAZARD DESCRIPTIONS

NATURAL HAZARDS

Blizzard/Snowstorm
During the winter, Halton Region commonly experiences blizzards and snowstorms. These events are often characterized by periods of heavy snowfall, cold temperatures, and high winds. Winter storm warnings are often issued hours in advance of such events. Injuries may occur related to reduced visibility and dangerous ground conditions. Infrastructure may also be impacted due to snow and ice accumulation. Due to its proximity to Lake Ontario, Oakville-Trafalgar Memorial Hospital faces the highest risk of this type of event.

Contamination – Food
Food may be contaminated by a biological, chemical, or physical agent. This contamination is more likely to occur as the food source or processing centre, but contamination within HHS is also possible. When Recall Notifications are issued by the Canadian Food Inspection Agency affected products will be removed from circulation and alternate suppliers will be used. However, in some cases staff and patients eating from a contaminated source will be exposed to a pathogen prior to its identification. Effects will vary by agent, but death of susceptible patients and illness is likely.

Contamination – Water
Drinking water may be contaminated by a biological, chemical, or physical agent. This type of event differs from disrupted water supply by the actual ingestion of contaminated water. It is likely that the majority of staff and patients drinking from a contaminated source will be exposed to the pathogen prior to its identification. Effects will vary by agent, but death of susceptible patients and widespread illness is likely. Significant damage to hospital reputation would follow.

Earthquake
Earthquakes can occur at any time or location, but are most common along active fault lines. Southern Ontario frequently experiences low magnitude earthquakes which go unnoticed, but a small risk of a moderate earthquake does exist. In the event of a larger magnitude event, sudden, brief shaking may cause damage to infrastructure. Injuries may also occur, with the most vulnerable being patients with mobility issues or those undergoing surgical procedures.

Extreme Cold
Environment Canada issues Cold Alerts in Southern Ontario in anticipation of temperatures or wind chill of -30^{o}C or below. These alerts occur multiple times each year, and may last for days at a time. Health impacts are minimized by hospital heating and environmental control systems; however, extreme municipal power demand may lead to electrical failures which could exacerbate existing medical conditions if patients lose warmth. Infrastructure damage due to

thermal contraction is also possible in cases of rapid temperature drop. The hospital may experience an increase in patients seeking warmth if municipal power fails.

Extreme Heat

Environment Canada issues Heat Alerts in anticipation of temperatures or humidex values of 40^{o}C or above. These alerts occur multiple times a year in Halton Region and can last for days at a time. Health impacts are minimized by hospital cooling and environmental control systems; however, extreme municipal power demand may lead to electrical failures which could exacerbate existing medical conditions if patients cannot be cooled. Physical damage is rare, but high temperatures may affect some equipment and power infrastructure. The hospital may experience an increase in patient visits due to heat-related illness.

Flood – External

External flooding can stem from a number of sources, including overflow from nearby water sources, heavy rains, or significant snow melts. None of the Halton Healthcare sites are located within a 100-year flood plain, but the potential remains due to extreme weather events. In the case of external floodwater breach, damage could occur to the hospital as well as its infrastructure and equipment. Reconstruction or cleanup should be anticipated. Patient injuries may also occur, particularly if patients must be evacuated. The most likely impact would be loss of access to the hospital due to washed out roads near Georgetown and Milton Hospitals.

Geomagnetic Storm

With the continued evolution of technology, solar activity represents a threat to electronics and communications systems. Large ejections of solar mass can disturb the Earth's atmosphere, resulting in widespread infrastructure failure. Events of this nature are very rare and impacts are not well understood. Electrical and communication systems may fail, with recovery time unknown. Health consequences are similarly difficult to predict, but patients that rely on certain medical devices may be vulnerable.

Hurricane

Hurricanes are tropical cyclones with heavy rain and winds reaching at least 118 km/hr. In the summer, hurricanes are common along the Atlantic corridor. While direct impact is unlikely, Southern Ontario can be affected by large storms depending on the storm track, though typically hurricanes are downgraded to Tropical Storms by the time they reach Ontario. Patient injuries and building/infrastructure damage may be caused by heavy winds and flash flooding.

Ice Storm/Freezing Rain

Ice storms are prolonged periods of freezing rain. Both events are characterized by temperatures at or below zero degrees, and mixed precipitation consisting of sleet, rain or snow. Ice accumulation may be rapid or gradual, affecting roads, buildings, and any other external surface. Minor injuries to staff, patients, or visitors may occur due to slips and falls outside of the hospital. Buildings can suffer damage due to ice accumulation and water seepage, and interruption of electrical or water infrastructure is common. Access to the hospital due to downed trees and obstructed roads is possible, particularly surrounding

Oakville-Trafalgar Memorial Hospital.

Infectious Disease – Internal

Hospital-acquired infectious diseases are a common complication of medical care. Causes may include poor hand hygiene, non-sterile equipment, or failure to follow proper quarantine procedures. Even with strict adherence to protocol, however, having a high concentration of infected patients within a small area can lead to rapid spread of disease. Severity will based on the pathogen, widespread illness is likely, with the possibility of patient deaths as well. Spread of disease within the hospital, particularly if related to negligence, may be devastating to the public reputation of the hospital.

Pandemic/Epidemic – External

A human health emergency caused by infectious disease is a leading public health concern in Ontario. An epidemic represents an illness within a limited region, whereas a pandemic refers to a worldwide event. The disease may be spread by direct or indirect contact, through droplets, airborne, blood-borne, or vector-borne. Health impacts will vary based on the nature of the infecting agent, and effects are more likely to be severe in those with weaker immune systems (such as the elderly, the very young, or those with immune deficiencies). Health care providers are also vulnerable, and there is a high potential for the disease to spread within the hospital. Infrastructure impacts are unlikely, but quarantine measures may cause disruptions to certain hospital processes or departments.

Severe Summer Storm

Environment Canada issues multiple Severe Thunderstorm warnings each year in Halton Region. These severe summer storms are often characterized by lightning, hail or heavy rainfall, and winds above 90 km/hr. Injury to patients within hospital buildings is highly unlikely; however, severe winds can cause damage near windows. Lightning, winds, and precipitation have the ability to damage infrastructure. In rare cases, severe storms can develop into a more damaging tornado.

Severe Winds

Environment Canada issues Wind Alerts in anticipation of sustained winds of 60 km/hr or for gusts up to 90 km/hr in the absence of a tornado or thunderstorm. Injury to patients or staff may occur outside of the hospital or near windows due to high winds or blown objects. Damage to buildings is possible, but the largest concern is damage to municipal electricity infrastructure.

Soil Subsidence

Land subsidence is the downward sinking of land caused by loss of support below the surface. Possible causes include earthquakes, removal of groundwater, and the affect of seasonal temperatures on soil. None of the Halton Healthcare sites are located on high-risk land, but land subsidence is unpredictable. While the sudden formation of sinkholes is rare, gradual subsidence can damage the foundation of buildings and disrupt gas, water, and electrical lines. Repairs and reconstruction would have a large financial impact.

Tornado
Halton Region falls in the southern periphery of Ontario's tornado alley. Often formed as part of a severe thunderstorm, tornados are defined by a violently rotating column of air in contact with the ground. Tornado intensity varies, with wind speeds ranging from 60 to 500 km/hr. A major tornado would cause significant structural damage and multiple injuries or fatalities, though Southern Ontario rarely sees this magnitude of event. Weak tornadoes are more likely and have more moderate effects; patients outdoors or near windows may suffer injuries, and infrastructure may suffer mild damage. However, even a weaker tornado making direct contact with a hospital building could be catastrophic.

HUMAN-CAUSED HAZARDS

Bomb Threat
A bomb threat is the reported presence or threat of placement of an explosive device within the facility or on hospital property. In the absence of an actual explosive device there is low risk to patient health or physical property. However, until security or Halton Regional Police Service clears the matter, access to certain areas may be lost and some operations may be suspended. In case of evacuation, minor injuries may occur. Depending on how far the event escalates, widespread media coverage and negative public reaction may occur.

Child Abduction
Child abduction is the illegal removal of an infant or child from the facility or department. This is a very focused event with little chance of harm to patients or staff beyond the individual victim. Exceptions may exist if the assailant is confronted and turns violent, though this is rare. Infant abductions from Canadian hospitals are featured prominently in national media, with acute negative impacts on hospital reputation.

Civil Disorder
Civil disorder is the breach of law or general rule by a group of people, and may take many different forms. Disorder may be non-violent (e.g. blocked access to particular routes or buildings), or violent (e.g. acts of aggression towards people or physical property. Civil disorder is typically centered in large, dense populations, but may occur in smaller communities such as those in Halton Region. Possible results include minor injuries or property damage.

Computer Virus/Cyber Attack
As the hospital network increasingly integrates technology into daily processes we become more vulnerable to harm through our computer systems. Computer viruses often enter systems and propagate unknown to users. Common sources include external tools such as USB storage devices, malignant e-mail attachments, and downloads from external websites. Viruses may also breach the system as part of a malevolent act aimed at damaging hospital infrastructure. Cyber attacks in isolation of viruses may include intentional hacking of the system network to obtain or modify sensitive information. These incidents are typically localized, with

consequences dependent on the scope of the event. A significant breach may lead to loss of access of critical information, altered function of some systems and medical devices, and damaged reputation in the event of leaked health information.

Hostage Incident
A hostage incident develops when a group or individual holds another group or individual against their will. Motivations may vary and targets may include patients, staff, or visitors. There is a localized event, with high risk of harm to hostages and intervening staff. Loss of access to affected areas will occur, with duration depending on the duration of the event. Hostage events will feature prominently in national media.

Labour Disruption
Labour disruptions are often the result of organized, legal job action. Groups involved may involve internal hospital staff from various departments and external contract staff. Direct impacts on patients are rare, but staff shortages may lead to reduced capacity to conduct regular hospital operations, and loss to some areas or services may occur. Financial costs may accumulate in prolonged disruptions, and reputation may be impacted if events are isolated to Halton Healthcare.

Mass Casualty Incident
A mass casualty incident is any event in which medical resources such as personnel and equipment are overwhelmed by the number and severity of casualties. A mass casualty incident may be medical (e.g. disease, chemical exposure) or traumatic (e.g. explosion, transportation accident) in nature. Mass casualty incidents may be triggered by any number of external hazards, including, but not limited to: HAZMAT events, pandemics, intentional violence, and extreme weather. Likelihood of these events increases with mass gatherings of people, such as during community festivals, sporting events, and concerts. Mass casualty incidents will rarely impact the hospital directly, but Halton Healthcare resources may be overwhelmed through patient surge.

Missing Patient
Missing patients are adult patients that have been away from their unit for an excessive or unexpected period of time. Consequences are typically low for this type of event. Exceptions may occur when high-risk or violent patients are missing, or if blame is placed on the hospital in the media.

Serious Adverse Event
Serious adverse events are incidents that result in death, disability, or prolonged hospitalization of existing patients due to errors in healthcare management. Adverse events are common in the healthcare industry. By definition, these events result in great harm towards one or more patients. Associated costs may be high, and reputation may be negatively impacted.

Terrorism
Terrorism is an act conducted with the intention to conduct harm to people, property,

businesses, or the environment. Like HAZMAT accidents, terrorist acts are typically of CBRNE nature, with explosive devices the most common. Terrorism may also take the forms of cyber attacks or intentional sabotage, and can be conducted by a group or individual, including past or current employees. Targeted attacks against the hospital will vary based on the nature of the event, but results likely include severe injuries, extensive damage to hospital property, prolonged loss of services, and loss of public confidence in safety. Fortunately there is no history of this type of event in Canada.

Violent Person – Patient

Violent patients are individuals receiving medical treatment, voluntarily or involuntarily, that are actively displaying physical aggression, or represent a threat of aggression or violence towards themselves, others, or their surroundings. These situations have the potential to lead to injury to those involved (including both the aggressor and those responding to the situation). Damage to infrastructure is common, and temporary loss of access to the isolated area may occur.

Violent Person – Non-patient

A violent individual (non-patient) may be a past or present employee, a spouse of a patient or employee, or an individual with no connection to the hospital. Whereas violent patients often act due to medical conditions, a violent individual often acts with criminal intent. Due to this focus, these events are typically more severe but less frequent than violent patients. Weapons may be involved, and incidents can lead to injuries and loss of access to affected areas, with a chance to progress to a hostage situation.

Violent Person – Active Shooter

In very rare situations, a violent person or hostage incident may escalate to an active shooter. An active shooter may be a past or present patient, past or present employee, or an individual with no connection to the hospital. Active shooting events are characterized by intent to injure Due to this focus, these events are typically more severe but less frequent than violent patients. Weapons may be involved, and incidents can lead to injuries and loss of access to affected areas, with a chance to progress to a hostage situation.

War

International conflict involving armed combat has the ability to affect Canada at any time. However, given the political state of the world in the early 21st century, it is extremely unlikely any combat would take place in Southern Ontario. Furthermore, the Geneva Conventions protect hospitals from being targeted by acts of international aggression. Any effects would likely be related to nation-wide business and supply disruptions, with little hospital impact.

Workplace Injury

Due to the nature of healthcare delivery injuries in the workplace may occur to both clinical and non-clinical staff. Serious injuries may occur, resulting in more than one day of lost time as well as associated costs and medical treatment. These events are related to performance of regular duties in isolation of other risk categories such as hazardous materials exposure or violent

individuals. Occupational Health and Safety definitions within this category include bodily reaction/exertion, contacts with objects/equipment, and falls.

TECHNOLOGICAL HAZARDS

Air/Space Object Crash
While exceptionally rare, any location on earth can be struck by an air or space object. This includes air transportation accidents such as malfunctioning planes, natural space objects such as meteorites, and man-made space objects such as satellites. None of the Halton Healthcare sites lie within a heavy air traffic corridor making this type of event highly unlikely. Consequences would be related to the size of the object making impact, but in most cases the event would lead to multiple fatalities and catastrophic damage.

Fire Incident – Minor
Small fire incidents are those that originate within the hospital but are isolated events and can be easily controlled by hospital staff. These fires are commonly started due to failure of small electronics or medical device malfunctions. Occasionally these fires are intentionally started by patients. Human impacts are generally limited to smoke inhalation or patient movement due to residual smells. Damage is typically limited and costs are minimal unless the event progresses to a working fire stage.

Fire/Explosion – Internal
Internal fires or explosions are those that are located within the hospital itself, regardless of whether the fire originated internally or externally. These events are extremely unlikely but much more damaging and harmful than external fires or explosions. The majority of internal fires are small, localized events, but the situation may progress to a working fire where intervention by the fire department is required. Unless a fire is controlled quickly and patients evacuated, there is a significant risk of injury and death to patients and staff. Damage to property will be extensive, with considerable reconstruction required. Access to affected areas may be lost indefinitely. Associated costs of recovery will be significant. The Milton and Georgetown sites are at higher risk as they are not completely covered by a sprinkler system.

Fire/Explosion – External
Fires are events of destructive burning caused by the ignition of a fuel/material, combined with oxygen, which produces heat and often open flame. Fires lead to or are caused by explosions, which is the sudden, violent release of energy caused by gases under pressure. Triggers of both fires and explosions may include intense heat, electricity, or chemical reactions. The events leading to an external fire or explosion or unpredictable, but events near the hospital may result in damage to hospital infrastructure, injuries to patients and staff, and influx of new patients injured in the event. The most common injuries include burns and complications due to smoke inhalation or carbon monoxide poisoning.

Hazardous Materials – Internal

The hospital industry is at relatively high risk of HAZMAT accidents due to the high concentration of CBRNE materials on site. The effects of a HAZMAT incident may be immediate or delayed. External HAZMAT events are impossible to predict, and are often the result of transportation or industrial accidents. Events in close proximity to the hospital may lead to evacuation, a shelter-in-place directive, decontamination, or injury/illness to staff, patients, and the public.

Hazardous Materials – External

A hazardous materials (HAZMAT) incident is the unintentional release of material capable of causing harm to humans or the environment. These incidents are often characterized by the acronym CBRNE, which describes the material's properties as one or more of: chemical, biological, radiological, nuclear, or explosive. The effects of a HAZMAT incident may be immediate or delayed. External HAZMAT events are impossible to predict, and are often the result of transportation or industrial accidents. Events in close proximity to the hospital may lead to evacuation, a shelter-in-place directive, decontamination, or injury/illness to staff, patients, and the public.

Pipeline Explosion

A pipeline explosion refers to the rupture of a pipeline, valve component, or pumping station, triggered by damage, failure, or operator error. These explosions may be particularly violent due to the fuel (commonly oil or natural gas) passing through the system. Impacts may be felt both due to the explosion and due to energy supply failure. Southern Ontario has extensive pipeline systems giving rise to the risk, with a natural gas pipeline approximately 800 metres from Milton District Hospital. Consequences are unlikely, but include damage to physical infrastructure, injuries to patients and the public, loss of services related to fuel disruption, forced evacuation, or a shelter-in-place directive from Halton Region.

Nuclear Plant Fallout

Each of the Oakville, Milton, and Georgetown hospitals is less than 75 kilometres from the Pickering Nuclear Generating Station. While this distance is far enough to avoid direct damage in case of nuclear disaster, the U.S. Natural Resources Defense Council warns that any structure within 50 miles (80 km) lies within the fallout zone. Radioactive particles could be transported along with ash or dust from a major explosion, contaminating the physical and natural environment. Immediate health effects would be unlikely, but costly, wide-scale decontamination of hospital property and equipment would be required to avoid future illness.

Structural Collapse

The loss of structural integrity in a building or structure that results in the structure losing shape, caving in, flattened or reduced to debris. Damage leading to collapse may occur gradually over time, or suddenly in a result to a specific triggering incident. A high probability of injury or death exists, with extensive reconstruction and prolonged or indefinite loss of access expected.

Transportation Accident
A transportation accident may result from a large scale collision between vehicles on a roadway, train derailment, or a marine accident. Accidents are more likely during periods of inclement weather but otherwise difficult to predict. Due to the proximity of all Halton Healthcare hospitals to major highways and railways, transportation accidents may impact any of the hospital sites. Georgetown and Milton are approximately 100 and 400 metres away from freight rail lines, respectively. If HAZMAT materials are involved, the event should be considered a hazardous materials incident. Non-HAZMAT transportation accidents may result in secondary fires or explosions, and may cause damage to infrastructure or trigger a mass casualty incident.

INFRASTRUCTURE FAILURE

Electrical Failure - Primary
Disruption of electrical supply may affect the entire hospital or just select locations within some buildings. This can be triggered by external events such as severe weather or municipal power outages, or may stem from internal failure. Consequences should be limited by emergency generator back-ups feeding power to critical life safety equipment. Non-emergency areas and equipment will be powered down and remain off-line until the disruption is resolved, causing loss of access to some facilities and interventions. Without proper lighting, patients with decreased mobility who are alone at the time of failure may suffer minor injuries from falls. The Oakville site has two main electrical feeds, while Milton and Georgetown have only one.

Electrical Failure – Secondary (Generator)
In addition to loss of fuel supply, emergency generators may fail due to improper maintenance or prolonged periods of time without use. Generator failure may go unnoticed without consequence if regular electrical supply is functioning correctly. However, some equipment relies primarily on emergency power; these devices will have to be switched over to the main grid. Public awareness of generator failure will likely lead to damaged reputation.

Electrical Failure – Total
A worst-case scenario for any hospital is loss of both primary and backup power. If generators fail during a primary electrical failure access will be lost to critical medical equipment. Many interventions may become impossible, and patients relying on devices for life-sustaining therapies may have to be evacuated. Drugs, food, and medical devices that require careful temperature control may have to be replaced, and reputational damage may be extensive.

Fire System Failure
The fire system can fail due to problems with detectors, alarms, fire doors, sprinkler systems, and water supply. Unless systems fail during an active fire, effects on patients will be negligible; however some costs and loss of access may occur during repairs.

Flood - Internal

An internal flood refers to a flood event that originates within the hospital facility itself. Causes may include ruptured pipes, damaged water tanks, or sewage failure. The most probable consequence is damage to physical infrastructure and equipment within the hospital. Extensive cleanup or minor reconstruction may be required, shutting off access to isolated areas. If patient areas are affected and evacuation required, minor injuries may occur. Halton Healthcare IT services and infrastructure may be particularly at risk, as IT servers are housed below ground level at the Oakville site.

Fuel Supply Failure

Interruption of supply is often due to problems with fuel transport infrastructure, but may also be a result of regional fuel shortages. Emergency power generators rely on diesel fuel to function, with several days of reserve kept on site. Boilers rely on natural gas for heating, but diesel can be used as a redundancy. If these supplies are interrupted, loss of heating, hot water, and sterilization equipment will occur, with impacts most severe in the winter.

HVAC Failure

Heating, ventilation, and air conditioning systems play a critical role in controlling the environment within the hospital. Temperature control failure in concert with extreme external weather can lead to acute illness in patients with difficulty thermoregulating. Ventilation controls tightly regulate airflow, and failure would increase the chance of transmission of airborne illness. Portable ventilation systems exist as back-ups, but until they are in place disruption to the system may result in redistribution or evacuation of high-risk patients on a case by case basis. Limited downtime of some hospital areas may occur depending on the nature of the failure, though HVAC failures are typically brief in duration.

IT Failure

Information technology services have become critical to numerous administrative processes within the hospital system, some of which are related to patient care. The most common cause of failure is unauthorized system changes without proper oversight, leading to inadvertent problems. In most cases of disruption, disaster recovery processes would return service within 72 hours. While direct effects on patient or staff health are unlikely, failure of IT services would disrupt a number of processes and business activities, and have moderate financial impact. Communication and documentation systems may be impacted.

Medical Gas Failure

Medical gasses include oxygen, nitrous oxide, and nitrogen, and others, used both for direct patient care and the powering of medical equipment. Medical vacuum is also part of this system. Portable back-ups of these gasses exist, but disruption can lead to failure at the various endpoints resulting in harm to patients, and shutdown of affected areas. Leaks and escaped gas should be treated as HAZMAT incidents, and can lead to illness or injury in patients, visitors, and staff. The Georgetown site has fewer medical gasses and is less vulnerable; Milton is more resilient as it has larger portable reserves.

Sewage Failure
Sewage failure is the inability of the sewer system to carry water away from the hospital, either due to internal or external blockage, or external failure or over-capacity. Failure to remove excess water may lead to localized discharge of water into the facility. Depending on the source of this water, it may contain biological or chemical waste that can cause illness, either through direct contact or contamination of food, water, or sterile medical equipment. In severe cases of sewage failure, internal flooding may result, causing further damage. Such incidents will likely be damaging to the hospital's reputation.

Steam Failure
The hospital steam system is used to help in some environmental controls, such as heating and humidification, as well as sterilization procedures. Failure to the steam system is unlikely to have direct impacts on patients except during times of extreme cold, but it can lead to disruption or regular processes and downtime to the systems reliant on steam to function. Steam failures are typically brief due to rapid response time and redundant boilers.

Supply Chain Disruption
Hospitals are complex institutions that rely on a multitude of products provided by external vendors. Each HHS site typically stores five days worth of supplies., but prolonged interruption of supply chains that provides medical devices, equipment, or pharmaceuticals can impact patient care and facility functioning. As a result, without redundancy certain interventions may be impossible, and costs to seek alternative supplies may be significant.

Telecommunications Failure
Telecommunications include internal and external phone systems, radios, and switchboard. These systems may fail due to operator error, IT failures, extremely high volume, or an external disruption. Without functioning telecommunications systems there is an increased likelihood of medical errors. There may be financial costs related to repair and downtime, and inability for the public to reach the hospital may result in negative publicity.

Water Supply Failure
Water supply is essential for drinking, food preparation, air conditioning, humidification, hygiene, and plumbing. Disruption may occur if the municipal supply is lost or contaminated, or if an internal issue (such as a leak) forces a localized shutdown. Prolonged absence of water may lead to illness or death, with impacts more severe in the winter. Without a constant water source certain procedures will be cancelled, triggering loss of access to some facilities. Lack of water will also impair response to other hazards, such as HAZMAT decontamination or fire suppression. The cost of alternative water attainment may be significant.

APPENDIX B – RISK SCORES

Risk assessments are not a precise science – rather, they are an estimation of the probability of future events and their impacts. The data in the following tables should be interpreted as best estimates rather than absolutes. Furthermore, as the assessment is based in part on the organization's hazard history, it is often impossible to separate the original risk from the residual risk left after existent mitigation efforts are considered. As a result, some hazards may reflect an already-mitigated risk level while others represent the true, original risk. Similarly, in some cases the consequences may actually be related to response rather than the initial hazard.

In order to ensure as much accuracy as possible within this document, comprehensive research was conducted using a number of resources. For a full list of sources see **Appendix C**.

NATURAL HAZARDS	Likelihood Score	Consequence Components				**Total Risk**
		Human	Physical	Financial	Reputation	
blizzard/snowstorm	4	2	2	2	1	**28**
contamination – food	3	4	2	3	3	**36**
contamination – water	3	5	2	3	3	**39**
earthquake	1	2	3	3	2	**10**
extreme cold	5	3	1	1	1	**30**
extreme heat	5	3	1	2	1	**35**
flood – external	2	2	3	3	3	**22**
geomagnetic storm	2	1	2	3	2	**16**
hurricane	2	2	3	3	1	**18**
ice storm	4	2	3	2	1	**32**
infectious disease – internal	4	4	1	3	3	**44**
pandemic/epidemic – external	4	5	2	4	4	**60**
severe summer storm	4	2	2	2	1	**28**
severe winds	3	2	3	2	1	**24**
soil subsidence	1	1	4	4	3	**12**
tornado	2	4	4	4	2	**28**
TECHNOLOGICAL HAZARDS	Likelihood Score	Consequence Components				**Total Risk**
		Human	Physical	Financial	Reputation	
air/space object crash	1	5	5	5	4	**19**
fire/explosion – external	2	2	3	3	3	**22**
hazardous materials – external	3	3	3	3	3	**36**
hazardous materials – internal	3	2	4	2	2	**30**
nuclear plant fallout	1	3	3	4	3	**13**
pipeline explosion	2	2	3	3	2	**20**
fire incident – minor	4	2	2	1	2	**28**
structural collapse	1	4	4	4	4	**16**
transportation accident	3	3	3	2	2	**30**
fire/explosion – internal	2	5	4	4	3	**32**

HUMAN-CAUSE HAZARDS	Likelihood Score	Consequence Components				**Total Risk**
		Human	Physical	Financial	Reputation	
bomb threat	2	2	3	2	3	**20**
child abduction	3	2	2	2	4	**30**
civil disorder	2	2	2	2	3	**18**
computer virus/cyber attack	3	1	3	4	4	**36**
hostage incident	2	3	3	2	3	**22**
labour disruption	2	2	2	3	4	**22**
mass casualty incident	3	4	1	3	2	**30**
missing patient	5	2	1	1	2	**30**
serious adverse event	3	3	1	3	4	**33**
terrorism	1	5	5	5	4	**19**
violence– patient	5	2	1	2	1	**30**
violence – non-patient	3	3	2	1	2	**24**
violence – active shooter	2	5	2	1	4	**24**
war	1	2	1	1	1	**5**
workplace injury	4	2	1	2	2	**28**
INFRASTRUCTURE HAZARDS	Likelihood Score	Consequence Components				**Total Risk**
		Human	Physical	Financial	Reputation	
electrical failure – primary	5	2	3	2	1	**40**
electrical failure – secondary	3	2	2	3	1	**24**
electrical failure – total	2	4	4	3	4	**30**
fire system failure	4	1	2	2	2	**28**
flood – internal	3	2	4	3	2	**33**
fuel supply failure	3	2	3	3	3	**33**
HVAC failure	4	2	2	2	3	**36**
IT failure	4	2	3	2	2	**36**
medical gas failure	3	3	3	2	2	**30**
sewer failure	2	3	4	3	3	**26**
steam failure	2	2	3	2	2	**18**
supply chain disruption	4	2	2	2	2	**32**
telecommunications failure	3	2	2	2	3	**27**
water supply disruption	3	3	3	3	3	**36**

Note that site differences exist as a function of geography, infrastructure, and equipment:

- Infectious Disease – Internal = 33 at Milton and Georgetown
- Flood – External = 11 at Oakville-Trafalgar and New Oakville
- Fire/Explosion – Internal = 30 at Oakville-Trafalgar and New Oakville
- Fire Incident – Minor = 21 at Milton and Georgetown
- Pipeline Explosion = 10 at Oakville-Trafalgar, New Oakville, and Georgetown
- Transportation Accident = 24 at Oakville-Trafalgar, New Oakville, and Milton
- Electrical Supply Failure = 35 at Oakville-Trafalgar and New Oakville
- Medical Gas Failure = 24 at Milton
- Sewer Failure = 24 at Milton and Georgetown
- Steam Failure = 18 at Oakville-Trafalgar, New Oakville, and Milton

APPENDIX C – RESOURCES USED

The following resources and personnel were consulted throughout this project. These resources – particularly subject matter experts – add significant value to the risk assessment process, and are recommended for inclusion in future reviews of the HHS HIRA. In addition, these individuals should be included in assessment of existing mitigation/preparedness measures when looking to identify gaps in current emergency management strategies. They may also provide assistance in the creation and adoption of new emergency management measures.

This list should be updated annually to reflect changes in personnel and industry standards.

Accreditation Canada (September 2011). Qmentum Program Standards: Leadership.
Hospital accreditation standards and guidelines referring to organizational leadership and disaster/emergency management activities within healthcare institutions.

British Columbia Provincial Emergency Program (January 2004). Hazard, Risk and Vulnerability Analysis Tool Kit.
A detailed guide of risk assessment methodology, including processes for conducting research and analyzing risks. Also includes definitions for a broad range of hazards.

Canadian Standards Association (September 2011). CSA-Z8000: Canadian Health Care Facilities.
Standards to guide best practices in risk management and other issues related to patient safety, specific to hospitals and other Canadian healthcare facilities.

Canadian Standards Association (September 2011). CSA-Z8000: Canadian Health Care Facilities.
Standards to guide best practices in emergency management and business continuity in private and public entities.

Campbell, Jo (August 2014). Phone Conversation.
Manager, Laboratory. Expert on HHS laboratory hazardous materials, particularly Georgetown and Milton sites.

Coppola, Damon (March 2011). Introduction to International Disaster Management (2nd ed.).
A comprehensive review of emergency management practice and a diverse range of common hazards.

Emergency Management Ontario (January 2012). Hazard Identification and Risk Assessment for the Province of Ontario.
A detailed review of hazards affecting communities within the province of Ontario. A useful guide for identifying and defining hazards, as well as sample methodology.

Etherington, Scott (July 2014). Interview.
Logistics Manager at Halton Healthcare Services. Expert on HHS supply chain management.

Halton Region (July 2014). Risk Profile.
A breakdown of the top 10 hazards as revealed by Halton Region's Hazard Identification and Risk Assessment from 2013. Frequency and magnitude scores, as well as vulnerable populations, infrastructure, and response capabilities are outlined.

Hrapovich, Elma (August 2014). Interview.
Director, Food Services. Expert on HHS food management, including purchasing, processing, and contingency planning.

Landesman, Linda Y. (March 2005). Public Health Management of Disasters: The Practice guide (2nd ed.).
A comprehensive review of disaster management planning and response with focus on public health.

Kopinak, Bob (July 2014). Interview.
Manager, Parking and Security at Halton Healthcare Services. Expert on HHS security risks and protocols.

Martin, Gary (July 2014). Interview.
Supervisor, Plant Operations at Oakville-Trafalgar Memorial Hospital. Expert on HHS infrastructure, maintenance and engineering systems.

McLaughlin, Paul (July 2014). Interview.
Technician, Plant Operations at Oakville-Trafalgar Memorial Hospital. Expert on HHS infrastructure, maintenance, and engineering systems.

Stockman, Kassondra (August 2014).
Emergency Preparedness Advisor at Halton Healthcare Services. Expert on HHS hazards, emergency codes, emergency preparedness, emergency response, and fire safety.

Town of Oakville (April 2008). Flood Study Area.
A map of floodplain areas in Oakville from an assessment conducted in 2008.

Yates, Cam (June 2014). E-mail Correspondence.
Manager, Information Systems, at Halton Healthcare Services. Expert on HHS telecommunications and information technology services.

Walker, Catherine (August 2014). E-mail Correspondence.
Manager, Laboratory. Expert on HHS laboratory hazardous materials, particularly Oakville-Trafalgar Site.

APPENDIX D – HAZARD ASSESSMENT TEMPLATE

Hazard: _____ Date: _____

Name: _____

Position: _____

HHS Site (check all that apply):
- ☐ Georgetown
- ☐ Milton
- ☐ Oakville

Likelihood:
- ☐ 1 = Unlikely to occur within a 100 year period (or a rating of 2 in nearby municipalities)
- ☐ 2 = May occur once in a 100 year period (or a rating of 3 in nearby municipalities)
- ☐ 3 = May occur once in a 10 year period (or a rating of 4 in nearby municipalities)
- ☐ 4 = May occur once in a 1 year period (or a rating of 5 in nearby municipalities)
- ☐ 5 = May occur multiple times in a 1 year period

Human Impact:
- ☐ 1 = Injury or illness to patients/staff unlikely
- ☐ 2 = Low probability of injuries or illness
- ☐ 3 = High probability of injuries or illness
- ☐ 4 = High probability of injuries or illness and low probability of death
- ☐ 5 = High probability of injuries or illness and high probability of death

Physical Impact:
- ☐ 1 = Property damage or loss of access unlikely
- ☐ 2 = Minor clean-up or recovery time
- ☐ 3 = Minor damage or temporary loss of access
- ☐ 4 = Major damage or prolonged loss of access
- ☐ 5 = Indefinite loss of access or rebuild required

Financial Impact:
- ☐ 1 = Negligible financial impact
- ☐ 2 = Expenditures or insurance claims under $ 100 000
- ☐ 3 = Expenditures or insurance claims under $ 1 million
- ☐ 4 = Expenditures or insurance claims under $ 10 million
- ☐ 5 = Expenditures or insurance claims over $ 10 million

Reputation Impact:
- ☐ 1 = Reputation unlikely to be affected
- ☐ 2 = Limited negative local media coverage or public stigma
- ☐ 3 = Negative regional media coverage and strong public stigma
- ☐ 4 = Negative national media coverage, fundraising or recruitment affected
- ☐ 5 = Long-term negative association with hospital, large fundraising/recruitment impact