University of Alberta

Impact of Introduction of Safety-Engineered Devices on the Incidence of Sharp Object Injury among Health Care Workers in the Capital Region of Alberta

by

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Dedication

I would like to dedicate this thesis to my parents in Shanghai, Meilong Lu and Qinfen Wang.

And sincerely thanks to Prof. Jeremy Beach, who provided valuable opportunities, support and guidance during my studies at the University of Alberta.

Abstract

Information on sharp object injuries occurring at work was obtained for a population of health care workers in the capital region of Alberta from Alberta Health Services to determine the incidence and characteristics of these injuries and the effectiveness of safety devices, introduced in 2007-2008, in preventing them.

During 2003 to 2010, a total of 4707 sharp object injuries were reported with nurses reporting the majority of injuries (53.7%). The injury rate during the introduction of safety-engineered devices declined from 34.47 to 30.17 injuries per 1,000 FTEs per year (rate ratio [RR]: 0.88, 95% CI: 0.78, 0.99, p=0.03) with a significant reduction amongst nurses (RR =0.85, 95% CI: 0.74-0.97, p=0.02). Physician rates decreased significantly after the intervention (odds ratio [OR] =0.83, 95% CI: 0.71-0.97, p=0.02).

This study finding was consistent with most previous studies in which implementation of safety-engineered devices substantially reduce sharp object injuries among health care workers.

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Table of contents

List of Tables

List of Abbreviation

AHE	Alberta Hospital Edmonton/Regional Mental Health
AHS	Alberta Health Services
AIDS	Acquired Immune Deficiency Syndrome
CDC	Centre for Disease Control and Prevention
CNSSN	Canadian Needle Stick Surveillance Network
COM SEC	Community Sector
CROSS CANCER	Cross Cancer Institute
DEVON	Devon General Hospital
DHSSS	Duke Health and Safety Surveillance System
EGH-RENAL	Edmonton General Hospital
EPINet	Exposure Prevention Information Network
ER	Emergency Room
FT SASK	Fort Saskatchewan Community Hospital
FTEs	Full-Time Equivalents
GRH	Glenrose Rehabilitation Hospital
HCW	Health Care Worker
HBV	Hepatitis B Virus
HBeAg	Hepatitis B "e" Antigen
HCV	Hepatitis C Virus
HIV	Human Immunodeficiency Virus
IM	Intramuscular
IV	Intravenous
LCH	Leduc Community Hospital
LPN	Licensed Practical Nurse
NaSH	National Surveillance System for Health care Workers
NECHC	North East Community Health Centre
NOISH	National Institution for Occupational Safety and Health
NON CAPITAL	Non-Capital Hospital

OHS Code	Occupational Health and Safety Code
OHS&W	Occupational Health, Safety and Wellness
OHSA	Occupational Health and Safety Act
OHSAH	Occupational Health & Safety Agency for Healthcare
OR	Odds Ratio
OR	Operating Room
OSHA	Occupational Safety and Health Administration
PEP	Post-Exposure Prophylaxis
PhD	Doctor of Philosophy
PTSD	Post-Traumatic Stress Disorder
RAH	Royal Alexandra Hospital
REDWATER	Redwater Health Centre
RN	Registered Nurse
RR	Rate Ratio
SCH	Sturgeon Community Hospital
SQ	Subcutaneous
UAH	University of Alberta Hospital
UNAIDS	Joint United Nations Program on HIV/AIDS
WESTVIEW	Westview Health Centre
WHO	World Health Organization

Chapter One: Introduction

Millions of health care workers (HCWs) worldwide are exposed to blood-borne pathogens through job-related risk factors such as needlesticks, stabs, scratches, cuts, or other injuries involving blood.[1] Among these, injuries caused by sharp objects are one of the most common ways that health care workers are exposed to blood-borne pathogens in the work place.[2] The Centers for Disease Control (CDC) estimates that, in the United States, approximately 600,000 to one million sharp object injuries occur each year with half of these injuries going unreported (CDC, 2007). According to Visser, injuries from needlesticks and other sharps in Canada are common, with there being around 70,000 per year, or an average of 192 per day.[3]

A sharp object injury is a percutaneous piercing wound typically caused by a hollow-bore needle or sharp instrument, including, but not limited to, needles, lancets, scalpels, and contaminated broken glass.[4] This type of injury can occur at the time people prepare, assemble, use, disassemble, or dispose of sharp objects. In the healthcare work place, sharp object injury has become a major concern to health care workers. Although this exposure is preventable, they are too often accepted as being a part of the job.

More than 20 species of blood-borne pathogens have been identified, which can be transmitted by a sharp object injury including human immunodeficiency virus

(HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV). Health care workers are at high risk of such exposure since hospitalized patients have a higher prevalence of HIV/AIDS, hepatitis B and hepatitis C than the general population.[5]

The first case of occupationally-acquired human immunodeficiency virus (HIV) infection was reported in 1984 and highlighted the risk of occupational exposure to HIV and hepatitis.[3] To date, considerable evidence has described the causative relationship between sharp object injuries and HIV, HBV and HCV infection. The risk of transmission of HIV after a sharp object injury has been described as approximately 0.3%, compared with 3% for HCV and 30% for HBV.[6] In 1993, the Center for Disease Control and Prevention reported that over 1400 health care worker were infected with Hepatitis B following sharp object injuries.[7] Though less has been mentioned about the mental health effects of sharp object injury, they are also an important problem among health care workers and may be a cause of considerable anxiety and distress for affected individuals.[8-13]

To minimize the risk to health care workers of occupational exposure to blood-borne pathogens through sharp object injuries, safeguards have been put in place to prevent such injury, which include but are not limited to policies of universal precautions, vaccination and the introduction of safety-engineered devices. Universal precautions were first introduced in 1985 and referred to routine medical practices for health care workers in which all patients are considered to be possible carriers of blood-borne pathogens and contact is avoided with blood and body fluids from all patients.[14] However, poor compliance with universal precautions has been reported as a risk factor for sharp object injuries.[15-17] Vaccination is considered to be one of the best ways to protect health care workers from blood borne pathogens after a sharp object injury, though it is currently only available for hepatitis B virus.[18]

From 1991, the United States government introduced a number of regulations beginning with the OSHA Blood borne Pathogens standard[19] and culminating in the Needlestick Safety and Prevention Act of 2000[20]. From the more recent regulations, one key component is the use of safety-engineered devices, which are medical sharps that have been designed to include safety features or mechanisms, including design features to eliminate or minimize the risk of injury to the user or others.[21] Safety-engineered devices potentially provide the highest degree of control of risk because they eliminate or control the hazard at its source and are considered to work well in preventing sharp object injuries in the health care settings.[22-26]

Contrary to the United States, Canada has no federal sharps safety law, since Canada's occupational safety and health programs are mainly organized and administered at the provincial level. British Columbia [27], Ontario[21], Alberta[28, 29], Manitoba, Saskatchewan[30] and Nova Scotia have all revised their regulations to include requirements for the use of safety-engineered devices to reduce sharp object injuries and consequent exposure to blood and body fluids.[31] In Ontario, Visser reported that sharp object injuries were reduced by 80% after the mandatory use of safety-engineered devices in the Toronto East General Hospital was introduced.[3]

The Alberta government passed a provincial-level Occupational Health and Safety Code (OHS Code) in November 2003 to include recommendations for the use of safety-engineered devices to reduce sharps injuries and exposure to blood and body fluids, which set standards for protecting the health and safety of workers. There are two sections specifically addressing the hazard of blood-borne pathogen exposures in healthcare workers:

Part 2, "Hazard Assessment, Elimination and Control," states that employers must conduct a hazard assessment to identify existing or potential hazards (including biological hazards) within the workplace, and that employers must then implement measures to eliminate or control the hazards. Engineering controls are specified as the preferred method to eliminate or minimize hazards.

Part 35, "Health Care and Industries with Biological Hazards," requires employers to ensure that: (1) sharps containers are available and used; (2) workers do not recap needles; (3) all biological hazards are included in the hazard assessment; (4) written policies and procedures governing the storage, handling, use and disposal of biohazardous materials are established; (5) and, protocols for post-exposure management of exposed workers are in place.

These requirements were effected in April 2004. The Code was updated in 2009 [29] with engineering controls (such as safety-engineered medical devices) being the preferred method to eliminate or control exposure to biological hazards including blood-borne pathogens. However, it remains unclear how effective safety-engineered devices are in preventing sharp object injury among health care workers in Alberta.

It is hoped that through this retrospective cohort study, a description of the frequency and risk factors for sharp object injuries among health care workers in Edmonton hospitals will be obtained. With the introduction of safety-engineered devices, the incidence of sharp object injury in the health care workplace should be reduced, which would indicate the effectiveness of safety-engineered devices in preventing sharp object injuries.

We anticipate that this research will provide valuable information regarding the effectiveness of safety-engineered devices in reducing sharp object injuries among health care workers, and so facilitate future policy development regarding safety-engineered devices and sharp object injuries.

Chapter Two: Literature Review

2. 1 Background Information

In 1981, the risk of health care workers sustaining harm from sharp object injuries was described by McCormick and Maki.[32] This type of injury can occur at any time people use, disassemble, or dispose of needles or sharp instruments. In the healthcare work place, sharp object injuries pose a recognized occupational hazard to health care workers.

It is estimated by the World Health Organization that 1 in 10 health care workers worldwide sustained a sharp object injury in 2000.[33] In the United States, it is estimated that approximately 600,000 to one million sharp object injuries occur annually. [34] The International Care Worker Safety Centre at the University of Virginia estimated an annual incidence of 295,082 sharp object injuries among health care workers in the US hospitals.[35] In the UK, approximately 100,000 sharp object injuries to health care workers occur each year, [36]and almost 37% of nurses reported that they have sustained a sharp objective injury at some stage during their career. [37] Injuries from sharp objects are also common in Canada.[38] The Canadian Needle Stick Surveillance Network data showed an injury rate of 4.88 injuries per 100 FTEs per year for registered nurses in hospitals in 2000 to 2001. [39] The Canadian Institute for Health Information reported that approximately 66,000 health care workers experienced sharp object injuries out of

Canada's 750,000 health care workers in 2001, representing almost 180 injured health care workers each day. [40] However, the actual number of sharp object injuries remains unknown due to under-reporting. Studies estimate that about half or more of sharp object injuries go unreported. [41-44]

While 90% of reports of occupational infection occur in North America and Europe, 90% of the occupational exposures occur in the developing world. [45] Data from WHO showed approximately four sharp object injuries per worker per year in the African, Eastern Mediterranean, and Asian population. [46] In South Africa, 91% of junior doctors reported sustaining a sharp object injury in the previous 12 months, and 55% of these injuries came from source patients who were HIV positive. [47] Approximately 31% of health care workers had experienced at least one sharp object injury in the previous year in Southern Ethiopia. [48] Seventy-one percent of health care workers had sustained sharp object injuries during the last year in one Chinese Province. [49] In Vietnam, 38% of physicians and 66% of nurses reported sustaining a sharp object injury in the previous nine months. [50] Lack of safety-engineered devices, heavy workloads and poor-compliance were thought to contribute to the exposure of sharp object injuries in many developing countries. [49, 51]

Sharp object injury can result in serious consequences for health care workers since many reported injuries occur with contaminated sharp devices. [52] There are more than 20 species of blood-borne pathogens including human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV), which could be transmitted from donors to health care workers by sharp object injury exposure and cause infection in the person injured. These injuries result in at least 1,000 new cases of health care workers being diagnosed with HIV, hepatitis B, or hepatitis C every year in the United States. [4] Such injuries also cause considerable anxiety and distress for affected individuals. The emotional impact of a sharp object injury can be severe and long lasting, even when a serious infection is not transmitted.

2.2 Impact of Sharp Object injuries on Health Care Workers

2. 2.1 Human Immunodeficiency Virus (HIV)

The first report of a health care worker infection with human immunodeficiency virus acquired through a sharp object injury was published in 1984.[53] This was shortly after HIV and AIDS first became apparent. HIV/AIDS continues to be a pandemic of global proportion and the infection rates/prevalence of HIV are on the rise in many countries. The report from United Nations Program on HIV/AIDS (UNAIDS) and the World Health Organization (WHO) states that in 2010 approximately 2.7 million people became newly infected with HIV, 1.8 million people died from AIDS and an estimated 34.0 million people were living with HIV around the world.[54]

By 2001, CDC had received reports of 57 definitively documented cases and 138 possible cases of occupationally-acquired HIV infection among healthcare personnel in the United States since reporting began in 1985.[55] Six of these individuals were physicians and 24 individuals were nurses, representing the largest occupational category. [55] By 2005, five health care workers in the UK were known to have acquired HIV as a direct result of a sharp object injury. [56]

The typical average risk of HIV infection after an inoculation incident to HIV-infected blood is around 0.3%.[57] The risk after exposure of the eye, nose, or mouth to HIV-infected blood is estimated to be, on average, 0.1% and the risk after exposure of non-intact skin to HIV-infected blood is estimated to be less than 0.1%. [57]

Currently there is no vaccine against HIV. However, results from a small number of studies suggest that the use of antiretroviral drugs after occupational exposures may reduce the risk of HIV transmission.[58] Post-exposure prophylaxis (PEP) is recommended for occupational exposures that pose a risk of transmission. [59]

2. 2.2 Hepatitis C Virus (HCV)

Hepatitis C virus (HCV) was known as non-A, non-B hepatitis before 1989.[60] Currently, HCV has become the most common chronic blood-borne infection in North America. It is estimated that more than 1.3% of Americans have been infected with chronic HCV and the incidence of hepatitis C each year is approximately 19,000 in the United States per year.[61] In healthy blood donors the rate of infection is about 0.02% in northern Europe, but 6% in Africa and as high as 19% in Egypt. [4] Studies have shown that approximately 1% of hospital healthcare personnel have evidence of HCV infection.[62] Sharp object injuries are a major source of HCV infection among health care workers, causing approximately 39% of the HCV infections globally every year.[5]

HCV is transmitted primarily through exposure to large amounts of blood or direct percutaneous exposures to blood.[59] The average risk of infection after a needlestick or cut exposure to HCV-infected blood is approximately 1.8%.[57] Chapman indicated that the transmission of HCV rarely occurs through mucous membrane exposures to blood and the risk of transmission from exposure to fluids or tissues other than HCV-infected blood is very low.[59] HCV has also been identified in saliva and one case report described HCV transmission following a human bite.[63]

Unfortunately, there is no vaccine against hepatitis C virus and no treatment after an exposure that will prevent infection. Immunoglobulin and antiviral therapy are not recommended for PEP after exposure to HCV-positive blood.[59]

2. 2.3 Hepatitis B Virus (HBV)

The Global prevalence of HBV infection is higher than that of HCV.[33] HBV has infected approximately 2 billion people in the world and about 350 million of these are chronic carriers of the virus. [4] The carrier rate is as low as 1% in most western countries, but in Africa and some parts of Asia the carrier rate can be above 10%. [64] Health care workers infected with HBV through occupational exposures during adulthood may have a more favorable prognosis than those infected with HCV. In addition, HBV can be efficiently prevented and at low cost thought immunization, unlike HCV and HIV.

Data from the CDC showed that approximately 46,000 new infections with HBV had occurred in the USA by 2006 and there were an estimated 1.25 million chronically infected Americans who were carriers. [65] The fatality rate among people with acute symptomatic HBV is 0.5% to 1.0%.[66] For those who do not have immunity to HBV, the risk from a single sharp object injury exposure to HBV-infected blood ranges from 6-30% and depends on the hepatitis B e-antigen (HBeAg) status of the source individual, a marker for high levels of circulating HBV DNA.[57]

Though at present there is no specific treatment for acute hepatitis B [59], the best way to prevent hepatitis B is through vaccination. In 1991, the OHSA Bloodborne Pathogens Standard compelled employers in the United States to provide hepatitis B vaccination at no cost which resulted in increased coverage levels in US health care personnel.[67] The annual number of occupational infections in the U.S. has decreased 95% since hepatitis B vaccine became available in 1982, from >10,000 in 1983 to <400 in 2001.[68] In France, the yearly number of cases of occupationally-acquired hepatitis B virus by health care workers dropped from around 600 in the mid-1970s to less than 50 in the recent years, at the same time as compulsory anti-HBV immunization was introduced among health care workers.[69] However, in some developing countries, lack of vaccination coverage against hepatitis B remains a concern.

2. 2.4 Mental Health Effects

A sharp object injury may have a psychological impact, even when seroconversion does not occur, and may cause severe stress, anxiety, and disabling post-injury morbidity.[9] This adversely affects the lives of those suffering injury and of their partner or family, and may force job change or result in an inability to work.[8, 10]

Helen Ornstein, a 36-year veteran nurse was injured with a needle that had been hidden in the bed of a patients dying from AIDS. In the following 6 months, Ornstein suffered not only from symptoms associated with PEP treatment, but also from severe anxiety and panic attacks, depression and ultimately posttraumatic stress disorder (PTSD). Ornstein's physicians considered several factors that contributed to her PTSD, including anxiety associated with HIV testing, adverse effects of PEP medications, the lifestyle changes, and termination of her primary job.[11]

There are studies and reports on the association between mental health status and experiencing sharp object injuries among health care workers. Fisman et al. stated that distraction, anger and rushing were associated with the highest risk of sharp object injuries among health care workers.[12] In addition, not knowing the infection status of the source patient may accentuate the health care worker's stress.[4] A prospective cohort study conducted by Wada et al. among medical residents in Japan reported that more than a quarter of the medical residents (26.1%) had developed depressive symptoms, and a history of sharp object injury was significantly associated with depressive symptoms. [13] Sohn et al. used the Beck Depression Inventory, Hamilton Anxiety Scale and Perceived Stress Scale to measure stress and mental health among health care workers with or without sharp object injury. Health care workers experiencing sharp object injury exhibited significantly higher levels of anxiety and depression than those without such experiences. They reported that their stress and depression levels were significantly elevated after being injured.[8] Health care workers who had not been vaccinated against HBV exhibited significantly higher levels of anxiety.[8]

Though considerable efforts have been made to prevent sharp object injuries, the psychological aspects of these injuries have received little attention. [8] According to the CDC, the use of PEP following exposure to HIV and HBV provides little protection against mental health issues.[11] CDC guidelines for PEP include provision of psychological counseling as an essential component of the management and care of exposed health care workers. [11]

2.3 Risk Factors for Sharp Object Injuries

2.3.1Donor Characteristics

2.3.1.1 High Viral Load

The pathogens most commonly transmitted by sharp object injury to health-care workers in hospitals are HBV, HCV and HIV.[70] Around 350 million people globally suffer from chronic hepatitis B; approximately 125 million people are infected by HCV and almost 33 million people suffer from HIV. [71] The prevalence of HBV and HCV vary worldwide by region, ranging from 0.5% to

10% for hepatitis B and from 1% to 40% for hepatitis C. [72] The prevalence of HIV infection ranges from less than 0.1% in Europe and North American to 0.3% in Latin America and the Caribbean, to 4% in Sub-Saharan Africa. [72] The World Health Organization estimates that approximately 21 million individuals acquire a blood-borne infection from poor injection practices annually. In China, Romania and India it has been estimated that 80% of hepatitis B infections result from reusing syringes.[73] However, the risk of a sharp object injury from an infected source patient is difficult to measure and has not been well studied.[74]

In general, hospitalized patients show a higher prevalence of all three viral diseases than the general population, with median ratios of hospital samples to the general population of 1.9 for HBV, 3.4 for HCV, and 5.9 for HIV infection.[75] A survey of patients admitted to a German University Hospital estimated that the HBV, HCV and HIV prevalence among patients were 5.3%, 5.8% and 4.1%, respectively. [18] The risk of transmission of hepatitis C (approximately 3%), hepatitis B (approximately 30%), and HIV (approximately 0.3%) from patient to health care worker following percutaneous injury depends on a number of factors including viral load of the patient and the amount of blood that passes from one to the other.[76-78] Cheng et al. incorporated an HIV seroprevalence rate of 5% for the emergency department and a 0.7% for the hospital setting.[79] Lulloff et al. reported that 10 of 2,840 sharp object injuries in health care workers were from patients infected with hepatitis B, resulting in a risk of 0.4%.[80] Lanphear et al. found that 50 of 309 sharp object injuries were from patients infected with hepatitis C, resulting in a 16% chance that the patient was infected with hepatitis C if a sharp object injury occurred.[81]

2.3.2 Incident Characteristics

2.3.2.1 Sharp Object Devices

Injuries caused by blood-filled needles, such as phlebotomy needles or vascular access needles, have a much higher risk of pathogen transmission than non-blood-filled needles, such as syringes used for intramuscular injections.[82] These blood-filled devices account for 59% of all National Surveillance System for Health care Workers (NaSH) reported injuries and 90% of the HIV seroconversions documented by CDC. [83] Other devices associated with high rates of sharp object injuries include disposable syringes, suture needles, winged steel needles, scalpel blades, IV catheters needles, and phlebotomy needles.[83, 84] Some have the potential for significant blood contamination.

Hollow-bore needles are usually recognized as the main sharp object device among blood-filled needles. [51, 83, 85-87] Data collected from CDC (2004) reported that 59% of sharp object injuries could be attributed to the use of hollow-bore needles.[83] Ghofranipour et al. estimated that causes of sharp object injury in 60% cases were hollow-bored needles in Iranian hospitals. [85] Smith et al. conducted a cross-sectional survey among nurses in an Australian hospital. The authors reported that the most common causative device was a hollow-bore syringe needle (32.6%), followed by insulin syringe needles (27.9%), IV needles or kits (16.3%), and blood collection needles (9.3%). [88] A study from Cardo indicated that health care workers were more likely to become infected by HIV if a hollow-bore or blood-filled needle was the source of the injury.[89]

Syringes are normally reported as the device responsible for the greatest number of injuries but when the rate is calculated per device usage analysis of injury rates reveals that syringes account for the lowest rate of sharp object injuries and IV catheter stylets accounted for the highest rate.[44, 52, 90-92]

2.3.2.2 Healthcare Setting

The groups of healthcare workers to whom sharp object injuries most commonly occur may vary by location or department within a hospital.[86] Up to a fifth of all healthcare associated sharp injuries occur in the operating theatre. [82] Orthopaedic surgeons may be more prone to sharp object injury due to the prevalence of bone spicules in the operative field and the use of sharp orthopaedic instruments such as drills, saws and wires, according to McCann et al. [93] Data from U.S. EPINet showed that 30.3% of sharp object injuries were reported in operating room/recovery, followed by 28.9% in patient rooms/wards. [52]

Wicker et al. found that the highest risk of acquiring a blood-borne infection via sharp object injury was in the department of internal medicine due to the increased prevalence of blood-borne pathogens in patients under treatment. [18] Jagger, et al. found out that 35% of sharp object injuries occurred in patient rooms and 22% occurred in surgery. [82] Based on data from the CDC, it appears that 40% of sharp object injuries occur in inpatient units, of which 21% occur in medical or surgical wards and 13% in intensive care units.[83] The operating room accounts for 25% of sharp object injury locations, followed by outpatient rooms (9%), procedure rooms (8%), ERs (8%), and laboratories (5%). [83] Smith et al. indicated that approximately half of the sharp object injuries among nurses occurred beside the patient's bed, with 34% occurring in the utility room, 5% in the patient's room, 2% in the operating room and 2% in the emergency department. [88]

2.3.2.3 Circumstance Associated with Sharp Object Injury

Certain activities place health care workers at an increased risk of sustaining a sharp object injury. [86] Sharp object injuries can occur before, during, and after a procedure, before needle or other sharp object disposal, during needle disposal, and after improper disposal. [94] CDC estimated that 41% of sharp object injuries occur after use but before disposal of a sharps device, 39% during a procedure in which sharps devices are being used, and 16% during disposal or shortly after. [83]

Drawing up medication (18.6%) was the most common activity reported by nurses at the time of injury by Smith et al., followed by disposal in a sharps box (16.3%), withdrawing blood (13.9%) and accidental removal of the needle (11.6%). [88] Disposable syringes cause the most sharp object injuries in the United States. Recapping of needles is also known to be a particularly high risky activity. [37, 95] Recapping of a needle after use and drawing blood for laboratory tests were the major reasons for sharp object injury in Iran. [85]

Data from UK EPINet indicated that 20% of sharp object injuries resulted from needles used for intramuscular or subcutaneous injection.[37] Intramuscular or subcutaneous injection represented the activity being undertaken in 21.0% of all sharp object injury exposures in the United States, followed by suturing (19.6%) as the second most frequent activity when injury occurred. [52]

Work organization factors such as short staffing and a poor safety climate have also been reported to contribute to injury [96, 97]. Clarke et al. also indicated that nurses from units with low staffing and poor organizational climates reported twice as many sharp object injuries than nurses on well-staffed units.[96]

2.3.2.4 Working Hours

Adverse schedule characteristics, such as long work hours and working noonday shifts and weekends, significantly increased the risk of sharp object injury. [98] Johnston and O'Conor estimated that 52% of reported sharp object injuries occurred outside normal working hours. [99]

2.3.3 Recipient Characteristics

2.3.3.1 Healthcare Occupations

Several studies have found that doctors, residents, anesthesiologists, surgeons, medical and dental students, and nursing staff were among the highest risk groups for sustaining a sharp object injury. [1, 8, 15-18, 23, 26, 27, 33, 38, 48, 49, 52, 84, 85, 100-122] In the United States, the incidence rate of sharp object injury among medical residents is 0.11 incidents per person-month. [123] Medical residents (and other trainees) are thought to be vulnerable to sharp object injuries due to a lack of experience and skill. [124]

Some studies have shown that surgeons have the highest rate of sharp object injury compared with other specialists and other health care workers. [1, 125] Makary et al. described the frequency of sharp object injury being much higher than commonly assumed among surgeons. Among Surgical residents, 99% of residents had suffered sharp object injury by their final year of training. [125]

Nurses are the occupational group generally reporting the greatest absolute number of sharp object injuries. [17, 27, 44, 52, 82, 112, 120, 126] Jagger, et al. utilizing EPINet data reported that nurses were recipients in approximately 47% of sharp object injuries among all health care workers in the United States. [82] Other studies have also reported that nurses experience the majority of sharp object injuries in the world including half of the exposures that occur in the United States [75, 83] and 70% of exposures occurring in Canada [127]. Nurses, medical doctors and laboratory technicians reported 53.4%, 21.3% and 8.2% respectively of the exposure to sharp object injury by the Canadian Needle Stick Surveillance Network (CNSSN) study. [128]

2.3.3.2 Under-reporting

The under-reporting of sharp object injuries was first identified by Hamory who commented that as many as 40% on sharp object injuries were not reported in 1983. [129] The proportion of under-reporting varied from 41% to 80% among health care workers in the subsequent years. [41-43, 88, 130] Tabak et al. estimated that the overall rate of compliance with the duty to report was 63.3% and highest rate of compliance was among nurses. [17]

Fear of a positive result was reported as a reason for not reporting among health care workers. Rabaud and Burke identified that many injuries were under-reported because health care workers felt they were unable to influence the outcome following injury.[131, 132] Connington and Jeanes concluded that health care workers perceived sharp object injuries as an inevitable part of handling sharp devices which they accept as part of the job. [133, 134] One survey by Occupational Health & Safety Agency for Healthcare in British Columbia (OHSAH) and the University of British Columbia estimated that over 80% of sharp object injuries in Canadian nurses went unreported due to the belief that reporting would not result in correct actions. [44]

Health care workers' lack of knowledge of the reporting process has also been highlighted as a reason for non-reporting, with only approximately 10 percent of health care workers knowing how to report a sharp object injury despite a comprehensive training and education program. [135] Not surprisingly, given health care workers' workload pressures, sharp object injuries may go under-reported if the reporting process in perceived as time-consuming. [131, 133] A survey exploring reasons for non-reporting of sharp object injuries in more than 700 U.S. nurses found that 23% of nurses indicated the reason for not reporting a sharp object injury was “Did not feel at risk of infection”, 21% indicated “Takes too much time”, 13% “fear of discipline from incident”, 9% “Inconvenient reporting process” and 7% stated that they were “Unable to leave work area”. [136]

2.3.3.3 Vaccination

Vaccination would be one of the most effective ways to protect health care workers against blood-borne infection. However, vaccination is currently only available for hepatitis B virus. [18] Wicker et al. indicated that among the preventative measures available, HBV vaccination has the highest potential to reduce the risk of HBV infection by sharp object injury. [18] Vaccination provides protection from blood-borne pathogens for an estimated 90% of recipients. [137] Ninety-five percent of U.S. nurses report receiving HBV vaccine to protect them from occupational exposures. [136] However, Brotherton et al. found that 28% of nurses reported incomplete vaccination and only just over half of the participating hospitals provided vaccination for medical staff in Australian hospitals. [138] The vaccination rates are even lower in developing countries. Approximately 62% of health care workers reported being vaccinated in a study by Jacob et al. in United Arab Emirates hospitals. [15] In 2003, the WHO estimated that only 18% of health care workers in Africa were vaccinated against HBV.[75]

2.3.3.4 Poor-compliance with Universal Precautions

Poor compliance with universal precautions has been reported as a significant risk factor for sharp object injuries in many studies. [15-17] Adams et al. conducted a questionnaire survey via email to all staff in a National Health Service trust in UK among consultants, junior doctors, midwives and theatre staff. Results showed that 67% of junior doctors and 13% of theatre staff did not comply with local sharp object injury protocols. [16] Non-compliance with sharp object injury protocols was most common among senior surgical staff. [16] A revision of the protocol to reduce the time it took to complete all precautions was one strategy thought to improve compliance. [16, 17]

2.3.3.5 Training and Education

Training and education have been identified as integral to developing awareness among health care workers, as well as improving adherence to good clinical practice. [139-141] Ganczak et al. detected fewer sharp object injuries among nurses who received special training about HIV/AIDS. [142]

However, the degree of information retention following training programs is currently unclear. [137] Elliott et al.'s study which prospectively assessed medical students' knowledge of sharp object injuries found that only 14% of medical students could correctly define a sharp object injury and found significant differences in knowledge between first, third, and final year students, with final year students exhibiting the most knowledge and lowest levels of sharp object injuries. [143]

2. 4 Regulatory and Legal Issues Regarding Sharp Object Injury

Throughout North America, various jurisdictions have enacted legislation for the protection of health care workers in the workplace relating to occupational health. [94]

To minimize the risk of occupational exposure to the blood-borne pathogens through percutaneous injuries, the US has introduced a number of regulations beginning with the OSHA Bloodborne Pathogens Standard in 1991[19] and culminating in the Needlestick Safety and Prevention Act of 2000[20]. The US Federal Needlestick Safety and Prevention Act of 2000 authorized the federal Occupational Safety and Health Administration (OSHA) to revise the 1991 Bloodborne Pathogen Standard to mandate the use of sharp object injury prevention devices,[144] which included four major public policy components: adoption of sharp object injury prevention devices; maintenance of a log of all contaminated sharp object injuries; inclusion of frontline workers in the identification, evaluation, and selection of safety-engineered devices; the annual revisions to exposure control measures to select and adopt safety devices. [145]

The US Occupational Safety and Health Agency monitors the use of needles and sharps and mandates the use and evaluation of passive safety systems for sharps at the federal level. Contrary to the United States, Canada has no specific federal sharps safety law, since Canada's occupational safety and health programs are predominately organized and administered at the provincial level. British

Columbia [27], Ontario[21], Alberta[28, 29], Manitoba, Saskatchewan[30] and Nova Scotia have all revised their regulations to include requirements for the use of safety-engineered devices to reduce sharps injuries and exposure to blood and body fluids.[31] The regulation under Ontario's Occupational Health and Safety Act making safety-engineered devices mandatory in all hospitals came into force on September 1, 2008. [40] The Alberta government included a provision requiring the use of safety-engineered devices in the provincial-level Occupational Health and Safety Code (OHS Code) in November 2009 to reduce sharps injuries and exposure to blood and body fluids. [28, 29] These requirements were effected in April 2004; the Code was twice updated in 2009.[29]

2. 5 Intervention by Safety-engineered Devices

2.5.1 Definition of Safety-engineered Devices

The complete elimination of sharp object injuries is theoretically possible by analyzing the hazards and applying control measures using a hierarchy of controls. The most recent preventive strategy to reduce the risk of occupational exposure to sharp object injuries has been the development and introduction of safety-engineered devices (SED) supported by the enforcement of relevant regulations. [137] These devices are medical sharps that have been designed to include safety features or mechanisms, including design features to eliminate or minimize the risk of injury to the user or others.[21] Safety-engineered devices provide the highest degree of control because they eliminate or control the hazard at its source.[22-26]

The National Institute for Occupational Safety and Health (NIOSH) listed safety feature characteristics for evaluating and selecting sharp object injury prevention products including: the device is needleless; the safety feature is an integral part of the device; the device preferably works passively (requires no activation by the user). If user activation is necessary, the safety feature can be engaged with a single-handed technique and allows the worker's hands to remain behind the exposed sharp; the user can easily tell whether the safety feature is activated; the safety feature cannot be deactivated and remains protective through disposal; the device performs reliably; the device is easy to use and practical; the device is safe and effective for patient care. [95]

Throughout the 1990's, devices with sharps injury protection were gradually and voluntarily adopted in US hospitals following the OSHA Bloodborne Pathogens Standard of 1991 and the Needlestick Safety and Prevention Act of 2000.[103]

Safety sharps and needle-free technology are available to prevent sharps-related injury and can include: [146]

(1) Hollow-bore needles with integral sharps protection which can be activated automatically or manually by the user, thereby ensuring the needle is rendered blunt at the earliest opportunity and consequently minimizing the potential for a sharp object injury. These devices are available to replace traditional hollow-bore

needles used for a range of procedures including intramuscular and subcutaneous injections and venesection.

(2) Cannulae are also available from a range of manufacturers with integral sharps protection, which again can be manually or automatically activated to render the introduction stylet blunt at the earliest opportunity.

(3) Self-adhesive anchoring devices can be used as an alternative to suturing both midline and central venous access devices. These self-adhesive devices dispense with the need for suturing and therefore are associated with a lower risk of injury.

(4) Needle-free IV systems can be achieved by connecting a specific needle-free connector to the hub of a cannulae or catheter. Infusions or injections are then administered by connecting the blunt syringe or IV administration set to the needle-free connector.

(5) Scalpels with retractable blades and a safety sheath are also available from a range of manufactures.

2. 5.2 Active vs. Passive Safety Devices

Two categories are usually described for safety-engineered devices: user-activated safety devices and passive safety devices. Active safety devices require a voluntary action by the user to engage the safety device. It requires 1- or 2-handed activation by health care workers after use. [102] In contrast, passive safety devices are automatic, or require no additional action on the part of the user. [21] These devices are automatically operated as an integrated feature in the use of the device. [102]

Studies have shown that a passive safety-engineered device which performs fully automatically was more effective than an active or a semiautomatic safety device. [102, 147] Studies of retractable intravascular devices have shown that active safety-engineered devices with semiautomatic safety features generate more blood splatter into the environment than do non-safety and passive safety devices. [148-150] Tosini et al. found that passive safety devices with automatic safety features caused a sharp object injury 0.06 times for every 100,000 uses while injury occurred with active devices 1.18 to 5.20 times per every 100,000 users. [102]

Passive safety-engineered devices are easier to use because they require little or no change in technique to activate the safety mechanism. [147] These devices are similar to conventional devices with regard to feel, length, balance and weight. [147] Tosini et al. indicated that passive devices require no input from the user and this eliminates the need for elaborate training, which is particularly important for health care workers in situations associated with a high rate of sharp object injuries. [102]

2. 5.3 Effectiveness of Safety-engineered Devices

Safety-engineered devices are widely recognized as an effective method to prevent sharp object injuries among health care workers in hospitals. [1, 23, 26, 38, 51, 102, 108, 109, 118, 119, 151, 152] A review of 17 studies evaluating the effectiveness of safety-engineered device demonstrated a 22-100% reduction in reported sharp object injuries following implementation. [153] Valls et al. found a 93% reduction in relative risk of sharp object injuries after the introduction of safety-engineering devices, compared with the pre-intervention period when health care workers were using conventional devices. [23] Pugliese found that approximately 80% of sharps injuries were preventable through either a procedural change or the introduction of a safety device.[154] In Ontario, Canada, Visser et al. also revealed that sharp injuries were reduced by 80% after the mandatory use of safety-engineered devices in the Toronto East General Hospital was introduced.[38]

Resheathable winged steel needles, also called butterfly needles, are designed so that the needle can be withdrawn into the protection sheath after use. [155] The use of resheathable butterfly needles has been associated with 23% to 59% reduction in sharp object injuries. [155, 156] A reduction in injury rate of 50% to 60% might be possible with phlebotomy devices and resheathable winged steel needles. [41, 155, 157] One study of a shielded safety syringe suggested an 86% reduction in injuries[158], while another controlled study found a 50–61% reduction, but with similar findings in areas which did not introduce safety devices.[159] O'Connor analyzed a retrospective cohort in emergency medical services and reported an association between the introduction of safety engineered cannulae and a reduction of up to 80% in sharp object injuries.[25] A study of safety syringes in a dental setting reportedly reduced the injury rate to zero.[160] Elder et al. suggested up to 50% reduction of sharp object injuries associated with intramuscular injections by using safety-engineered devices utilizing similar shielding technologies as those used for phlebotomy devices.[90] In 1997 CDC indicated that blunt suture needles for suturing the internal fascia could reduce the number of sharp object injuries substantially. [161]

2.5.4 Cost-Effectiveness of SED Interventions

Cost is an obvious concern with safety-engineered devices. It is estimated that the implementation of new safety-engineered devices would amount to $214 million for the United States, [162] which would be an obstacle to the use of safety-engineered devices in hospitals.

However, there are also cost savings due to a reduction in the costs associated with sharp object injuries such as serological tests, counseling, postexposure prophylaxis, time off work and treatment.[102] In 2004, CDC estimated that the direct costs associated with initial follow-up and treatment of healthcare workers who sustain a sharp object injury ranged from $500 to $3,000 per person depending upon the type of treatment provided. [83] It was estimated that a cost of approximately $220 million could be saved through the elimination of new cases of HIV, HBV and HCV. [162]

In addition, the World Health Organization estimated that the amount spent in treating individuals for their infections by sharp object injuries was more than three times the cost associated with using self-disabling syringes. [73]

2.5.5 Why Is the Current Situation Unsatisfactory?

Sharp object injury is still a concern even after the implementation of safety-engineered devices. Training, supervision and support in infection control and effective waste disposal practice may still be inadequate among health care workers. [9]

After initial improvement, an evolving complacency associated with the use of safety-engineered devices may result in a later increase in sharp object injury rates and an overall relaxation and reduction in the standard of care in needle use and disposal. [9] Where safety-engineered devices have been introduced, users may quickly find that sharps bins are filled more quickly as many of these devices have a greater bulk than the traditional syringes and needles they replace. [9]

Training for how to use safety-engineered devices is also important to reduce sharp object injuries. However, in a study by Lamontagne in French hospitals, some injuries occurred during safety-engineered device use because of the lack of activation or misuse of the safety mechanism. [151] Data from U.S. EPINet indicated that 72.4% of sharp object injuries occurring with safety-engineered devices were due to inactivated safety mechanisms. [52] Moreover, the majority of these injuries occurred prior to the activation of the safety-engineered devices. [52]

2.6 Summary

Sharp object injuries are a potential hazard for all health care workers in hospitals and pose a risk of potential transmission of blood borne pathogens such as HIV, HBV and HCV following an inoculation injury. The prevalence of blood-borne infection among patients in hospitals is almost always higher than the general population, [18] which increases the risk and burden for health care workers in hospitals. As the blood-borne viral diseases are becoming increasingly prevalent, health care workers should regard all patients as high-risk, regardless of known viral status. [93] Sharp object injuries remain common and are likely under-reported. Workload pressures and time constraints are associated with under-reporting, along with other factors. To improve reporting, it is essential to understand the behavior of health care workers, including their reasons for not reporting incidents, to raise awareness among all health care workers of the potential dangers of these injuries and to review current reporting processes of sharp object injuries. [137]

Strategies are available to prevent infections due to sharp object injuries including education of health care workers on the risks and precautions, reduction of invasive procedures, use of safer devices, and procedures and management of exposures.[33] Using safety-engineered devices appears to be one of the most effective methods to prevent sharp object injuries among health care workers and can be facilitated through relevant regulation and training. Training and compliance with the use of safety-engineered devices is crucial for reducing such injuries, since some studies have indicated a lack of training can result in the safety mechanism not being activated. [52] It is essential for all health care workers to support advances in technology by encouraging evaluations of safety-engineered devices to identify the degree to which devices may assist in the prevention of occupational exposure to blood borne pathogens.

Although there is some evidence that safety engineered devices can improve safety in some settings, their use in Alberta or the capital region of Alberta has not to date been evaluated.

2.7 Objectives of this Research

The purpose of this study was to investigate the frequency and causes of sharp object injuries in hospitals in the capital region of Alberta, especially during and after the introduction of safety-engineered devices, to determine the incidence of sharp object injury and the effectiveness of safety-engineered devices in preventing these injuries among health care workers.

Chapter Three: Methodology

3.1 Surveillance Data from Alberta Health Services

Data for these analyses came from Alberta Health Services (AHS, was founded by the amalgamation of a number of health regions, including the Capital Region in 2008) blood and body fluid exposure surveillance system held by Workplace Health and Safety (previously called Occupational Health, Safety and Wellness prior to 2008). The population of interest for this study comprised all health care workers employed by Capital Health (prior to 2008) or Alberta Health Services at the same institutions that had previously composed Capital Health (2008 and beyond) reporting sharp object injury to the "Stick-to-It" program. The "Stick-to-It" program provides 24 hour access to a telephone "hotline" for reporting exposures, as well as 24 hour access to an Occupational Health nurse advisor, and a specialist Physician when needed. Surveillance data are collected and interventions implemented to reduce workplace hazards. Data are stored in the database of Exposure Prevention Information Network (EPINet) [163] and MedGate.

The EPINet system was developed in 1991 and provided a standardized method for recording and tracking percutaneous injuries and blood and body fluid contacts. [164] The EPINet system consists of a Needlestick and Sharp Object Injury Report and a Blood and Body Fluid Exposure Report, and accompanying software for entering the data from paperforms. Variables in EPINET include injured body part, job category of the injured worker, area where injury occurred, original purpose of the item that caused injury, type of device that caused the injury, depth of injury, whether the sharp item was "safety designed", location of the injury, dominant hand of the injured worker, etc. MedGate software contains similar variables to EPINET, and was adopted for use by Alberta Health Services as a replacement for EPINet in October, 2008.

Safety-engineered devices were introduced to various departments in a rolling program during 2007 and 2008. During that period, nearly 35,000 health care workers were trained and transitioned to using safety-engineered devices.[28] It was estimated that at the end of 2008 almost every health care worker working in Edmonton hospitals for Alberta Health Services had access to safety-engineered devices in their workplace. The transition to the use of Safety Engineered Devices (SED) has progressed rapidly and their use is now required to be available and utilized within all healthcare settings in Alberta as of July 1, 2010 as legislated by the Government of Alberta, Occupational Health and Safety Code.[28]

We compared the rate of sharp object injury among health care workers before (2003-2006), during (2007-2008), and after (2009-2010) the period of introduction of safety-engineered devices. A retrospective cohort with information available on characteristics of sharp object injury was analyzed utilizing data from EPINET and MedGate of Alberta Health Services, covering major hospitals in the Edmonton area.

3.2 Sample Size Considerations

All reported injuries for the study period were included. Previous studies conducted in the United States with a similar number of reported injuries, have provided statistically significant results on changes in incidence and risk factors. A sample size calculation was conducted using STATA 11.0 utilizing the data from AHS. The statistical power was set at 80% (20% chance of type II error) and alpha was set to 5% (chance of type I error).

The rate of sharp object injury for 2003 - 2006 was 0.03042. Assuming a 15% reduction in incidence of injury with the introduction of safety-engineered devices for 2007/2008 or 2009/2010 a population of 15,971 person-years would give a power of 0.8 for detecting a statistically significant difference between before and during/after the change. With two years of data collection during/after the change we estimated we would have approximately twice the required number of person-years required. As a result, the recommended sample size was 31,942 person-years for both during and after intervention groups (2007/2008 and 2009/2010) and 63,882 person-years for the before intervention group (2003-2006). The actual numbers of participants from AHS were larger (2003-2006: 77,029 person-years, 2007/2008: 47,002 person-years and 2009/2010: 51,005 person-years).

3.3 Statistical Analysis

Original data from EPINET and MedGate was entered and transferred into Microsoft Excel. Analyses of the dataset were performed using and STATA software, version 11.0. Demographic characteristics of injured health care workers (i.e. gender) and of their injuries (i.e. type of device, depth of injury) were described using the data from 2003 to 2010. Frequency and proportion were described as the distribution of sharp object injuries.

Poisson regression methods were utilized to estimate the sharp object injury rate, rate ratio and 95% confidence intervals (95% CI) by using the data from 2006 to 2010 as relevant FTEs information to use as a denominator were only available from the years 2006 to 2010. Injury rates were estimated using sharp object injury counts as the numerator and full-time equivalents (FTEs) as the denominator and expressed as events/1000 FTEs. Full-time equivalents were estimated for each health care worker group using data provided by AHS. FTEs were estimated using the worker's usual work schedule (hours per week) and duration of employment at the hospital each year.[165] Thus, a worker employed for 40 hours per week and employed for the entire year contributed one FTE (1 FTE=2,000 work hours per year per worker).[165] Injury rate ratios between the pre-intervention period (2006) and during the intervention period (2007 to 2008)/after the intervention period (2009 to 2010) were estimated with the statistical significance at the 5% level. Risk factors associated with hospital, occupation and intervention period of safety-engineered devices were estimated by univariate and multivariate models.

There was insufficient data received from Alberta Health Services for physician FTE's to use this as the denominator for estimating injury rates by multiple Poisson regression. As a result, a log-linear model was used to analyze risk factors among the physician group using data from the years 2005-2010. The years 2005 to 2006 were considered the before intervention period, 2007 to 2008 as during intervention period and 2009 to 2010 as after intervention period. A log-linear model was applied to determine whether there were any significant relationships in a 3 by 3 contingency table (physician group by time period). Unadjusted and adjusted odds ratio were estimated by univariate and multivariate log-linear model with risk factors of hospital and intervention period of safety-engineered devices with the statistical significance at the 5% level.

3.4 Preliminary Examination of the Data

An electronic copy of an Excel data file was prepared by Workplace Health and Safety Alberta Health Services (AHS) in January 2011, which contained sharp object injury report data for the years 2003-2010 which had been recorded in the Capital Health area of Alberta. There were 4707 cases in the data file with 35 variables for each case. Data were recorded in EPINet between January 1st, 2003 to October 3rd, 2008 (3338 cases) and in Medgate from October 6th, 2008 to December 31st, 2010 (1369 cases).

A second Excel data file was prepared by the Alberta Health Services in March 2011, containing the number of health care workers by site and occupation from

2004 to 2010 in Edmonton's hospitals. Full site/occupation data was only available from 2006 to 2010. The number of physicians working in the hospitals was not available as they were not considered employees. We estimated incidence rate using the sharp object injury count as numerator and health care workers' FTEs except the physician group from the year of 2006 to 2010 as the denominator. To assess independent associations of univariate/multiple risk factors with sharp object injury rates, Poisson regression was utilized with risk factors of hospitals, occupations and introduction period of the safety-engineered devices.

It was not possible to obtain FTE information for the number of physicians working in the hospital so they could not be included in multiple Poisson regression models. As a result, log-linear regression was used to analyze risk and risk factors among the physician group. The Non-institutional setting was excluded from these analyses as only one sharp object injury was reported during the study period in this setting. The periods included: before the introduction (2005-2006), during the introduction (2007-2008) and after the introduction (2009-2010) of safety-engineered devices. As the analysis was restricted to the physician group, only two risk factors were considered in the multiple log-linear regression model, hospital/setting and introduction period for safety-engineered devices.

3.5 Factors Considered in the Models

The factors included in the Poisson regression model for all occupational groups except physicians were hospitals, job descriptions and introduction period:

- Hospital factors:
    - UAH
    - RAH
    - Other Institutional (Hospital Setting)
    - Non Institutional (Home Care)
- Job description factors:
    - Paramedical Staff
    - Nurse
    - Technician
    - Support Service
    - Other
- Introduction period factors:
    - Before the Introduction Period of Safety-Engineered Devices (2006)
    - During the Introduction Period of Safety-Engineered Devices (2007-2008)
    - After the Introduction Period of Safety-Engineered Devices (2009-2010)

For the physician group, the factors included in the log-linear model were hospital and introduction period:

- Hospital factors:
    - UAH

- RAH
- Other Institutional (Hospital Setting)

- Introduction period factors:
  - Before the Introduction Period of Safety-Engineered Devices (2005-2006)
  - During the Introduction Period of Safety-Engineered Devices (2007-2008)
  - After the Introduction Period of Safety-Engineered Devices (2009-2010)

3.6 Exclusion Criteria

Sharp Object Injury data were provided by Alberta Health Services and included data for all reported injury exposures occurring between 2003 and 2010. For Poisson regression analyses, the hospital risk factors of AHE, CROSS CANCER, EGH-RENAL and NON CAPITAL were omitted, as no such hospital information was provided in the FTEs denominator data. For log-linear regression, the hospital factor of Non-Institutional Setting was excluded as only one sharp object injury was reported during 2005 and 2010.

3.7 Other Considerations

Since data elements were derived from two database systems (EPINet and MedGate), the response categories were slightly different in some variables, where those occurred relevant variables were re-categorized to correspond so as to facilitate analysis. These were reconciled as outlined in Appendix1.

3.8 Ethical Considerations

This study was approved by the University of Alberta Health Research Ethics Board - Health Panel to analyze secondary data provided by the Alberta Health Services (See Appendix 5).

Chapter Four: Results

4.1 Demographic Characteristics for All Health Care Workers

From January 1st 2003 to December 31st 2010, a total of 4707 sharp object injuries were reported to Workplace Health and Safety Alberta Health Services from 15 healthcare settings in the Edmonton area. Staff at the University of Alberta Hospital (UAH) reported the largest proportion of injuries (48.5%), followed by the Royal Alexandra Hospital (RAH) (34.6%). Other Institutional Settings including Alberta Hospital Edmonton/Regional Mental Health (AHE), Cross Cancer Institute (CROSS CANCER), Devon General Hospital (DEVON), Edmonton General Hospital (EGH-RENAL), Fort Saskatchewan Community Hospital (FT SASK), Glenrose Rehabilitation Hospital (GRH), Leduc Community Hospital (LCH), North East Community Health Centre (NECHC), Non-Capital Hospital (NON CAPITAL), Redwater Health Centre (REDWATER), Sturgeon Community Hospital (SCH) and Westview Health Centre (WESTVIEW) accounted for 14.2% of injuries. Sharp object injuries were reported least commonly from Non-institutional settings of Community Sector (COM SEC) accounting for 2.7% of injuries. (Table 1)

Table 1. Distribution of Sharp Object Injury among Health Care Workers by Health Care Settings

Characteristic	Number (%) of Injury (N=4707)
Hospital Identification	
UAH	**2284 (48.52)**
RAH	**1629 (34.61)**
Other institutional (hospital setting)	**666 (14.15)**
AHE	36 (0.76)
CROSS CANCER	3 (0.06)
DEVON	15 (0.32)
EGH-RENAL	16 (0.34)
FT SASK	38 (0.81)
GRH	76 (1.61)
LCH	64 (1.36)
NECHC	36 (0.76)
NON CAPITAL	11 (0.23)
REDWATER	22 (0.47)
SCH	279 (5.93)
WESTVIEW	70 (1.49)
Non institutional (home care)- COM SEC	**128 (2.72)**

4.1.1 Occupation and Department

Nurses, especially registered nurses, reported the biggest proportion of sharp object injury cases (53.7%), followed by physicians (27.7%). The majority of injuries occurred in surgical departments for physicians and residents with 29.7% and 24.0% respectively. The figure for health care workers overall were similar, with injuries occurring in Operating and Procedure Rooms accounting for 52.4% of all injuries, followed by Inpatient Unit (36.3%) and Emergency Department (13.5%). (Table 2)

Table 2. Distribution of Sharp Object Injury among Health Care Workers by Occupations and Departments

Characteristic	Number (%) of Injury (N=4707)
Job Description of Injured Worker	
Nurse	2527 (53.69)
Other	358 (7.61)
Paramedical Staff	160 (3.40)
Physician	1302 (27.66)
Support Service	176 (3.74)
Technician	184 (3.91)

For Those Injuries recorded from EPINet (N=3338)

Characteristic	Number (%) of Injury	% of injury excluding missing data
Where Injury Occurred		**(N=3335)**
Emergency Department	451 (13.51)	13.52
Inpatient Unit	1210 (36.25)	36.28
Intensive Care Unit	300 (8.99)	9.00
Laboratory	123 (3.68)	3.69
Operating and Procedure Room	1750 (52.43)	52.47
Other Area	337 (10.10)	10.10
Home Care	33 (0.99)	0.99
Outpatient Area	108 (3.24)	3.24
missing	3 (0.09)	

4.1.2 Exposure Status

In approximately 92.0% of sharp object injuries, the source patient could be identified, and almost 64.8% of the injured workers were the original user of the sharp item. Most sharp items were contaminated (92.2%) while half were visibly contaminated with blood. Incidents in which the sharp was being used for injection at the time of injury accounted for 27.2% of injuries. Procedures for which the sharp object were being used included IM/SQ procedures, injection/intramuscular/subcutaneous, needle disposal, removing needle from syringe and other injection into IV injection site. Nearly 42.7% of sharp object injuries occurred during use of the item, while after use and before disposal of the item accounted for 30.1 %. Fingers and thumb were more often injured than other body parts accounting for 59.6% and 24.6% of injuries respectively. Injuries to the left side of the body (59.2%) were more common than to the right (38.3%), although more than 87.8% of the individuals injured were right handed. More than half of the injuries were superficial with little or no bleeding, and in 59.4% of injuries the individual was wearing a single pair of gloves when the injury occurred. (Table 3)

Table 3. Distribution of Sharp Object Injury among Health Care Workers by Exposure Status

Characteristic	Number (%) of Injury (N=4707)	% of injury excluding missing data
Was the Source Patient Identified?		**(N=4680)**
Yes	4331 (92.01)	92.04
No	247 (5.25)	5.28
Unknown	102 (2.17)	2.18
missing	27 (0.57)	
Was the Injured Worker the Original User of the Sharp Item?		**(N=4602)**
Yes	3050 (64.80)	66.26
No	1482 (31.49)	32.20
Unknown	46 (0.98)	1.00
Not Applicable	24 (0.51)	0.52
missing	105 (2.21)	
Whether was the Sharp Item Contaminated?		**(N=4583)**
Contaminated	4341 (92.22)	94.72
Uncontaminated	63 (1.34)	1.35
Unknown	179 (3.80)	3.91
missing	124 (2.63)	
Purpose When Injury Occurred		**(N=4597)**
Injection	1280 (27.19)	27.84
Line Procedures	405 (8.60)	8.81
Recapping	21 (0.46)	0.46
Other	1054 (22.39)	22.93
Surgical	1172 (24.90)	25.49
Unknown	141 (3.00)	3.07
missing	110 (2.34)	
How Did Injury Occur?		**(N=4611)**
After Use and Before Disposal	1417 (30.10)	30.73
Before Use of Item	62 (1.34)	1.34
During or After Disposal of Item	400 (8.67)	8.67
During Use of Item	2009 (42.68)	43.57
Other	377 (8.01)	8.18
Unknown	9 (0.20)	0.20
Unsafe Item	3 (0.06)	0.07
Unsafe Placement of Item After Use	334 (7.10)	7.24
missing	96 (2.04)	

Table 3. Distribution of Sharp Object Injury among Health Care Workers by Exposure Status (continued)

Characteristic	Number (%) of Injury (N=4707)	% of injury excluding missing data
Degree of Injury		**(N=4236)**
Severe - Deep stick/cut, Profuse bleeding	113 (2.40)	2.67
Moderate - Skin punctured, Some bleeding	1125 (23.90)	26.56
Superficial - Little or no bleeding	2973 (63.16)	70.18
Splash of Body Fluid in Eyes	15 (0.32)	0.35
Splash of Body Fluid in Mouth	3 (0.06)	0.07
Blood on Unbroken Skin	3 (0.06)	0.07
Unknown	4 (0.08)	0.09
missing	471 (10.01)	
Which Body Side Injured?		**(N=4603)**
Both	12 (0.25)	0.26
Left	2788 (59.23)	60.57
Right	1803 (38.30)	39.17
missing	104 (2.21)	
Which Body Part Injured?		**(N=4648)**
Abdomen	1 (0.02)	0.02
Arm	99 (2.10)	2.13
Back	1 (0.02)	0.02
Buttock	3 (0.06)	0.08
Chest	16 (0.34)	0.34
Chin	1 (0.02)	0.02
Elbow	2 (0.04)	0.04
Eye	18 (0.38)	0.39
Face	8 (0.17)	0.17
Finger(S)	2804 (59.57)	60.33
Foot	13 (0.28)	0.28
Hand	442 (9.39)	9.51
Head/Skull/Scalp	2 (0.04)	0.04
Hip	1 (0.02)	0.02
Leg	44 (0.93)	0.95
Mouth	1 (0.02)	0.02
Nose	1 (0.02)	0.02
Other	2 (0.04)	0.04
Thumb	1156 (24.56)	24.87
Toe(s)	1 (0.02)	0.02
Wrist	29 (0.62)	0.62
missing	59 (1.25)	

Table 3. Distribution of Sharp Object Injury among Health Care Workers by Exposure Status (continued)

For Those Injuries recorded from EPINet (N=3338)

Characteristic	Number (%) of Injury	% of injury excluding missing data
Dominant Hand of the Injured Worker?		**(N=3196)**
Left-handed	266 (7.97)	8.32
Right-handed	2930 (87.78)	91.68
missing	142 (4.25)	
Did the Sharp Item Penetrate?		**(N=3185)**
Double pair of gloves	405 (12.13)	12.75
Single pair of gloves	1982 (59.38)	62.23
No gloves	798 (23.91)	25.05
missing	153 (4.58)	
Was Blood Visible?		**(N=3070)**
Yes	1407 (42.15)	45.83
No	1100 (32.95)	35.83
Unknown	563 (16.87)	18.34
missing	268 (8.03)	

4.1.3 Sharp Injury Devices

Hollow Bore Needles accounted for most injuries (41.1%). This category included winged steel needles, arterial catheter introducer, central line catheter introducers, other vascular catheter introducers, spinal or epidural needles, unattached hypodermic needles, vacuum tube blood collection holder needles and blood gas syringes, and other types of needles. Approximately 41.3% of the injury devices were not safety designed. Among safety-engineered devices, 70.9% of the protective mechanisms were not activated at the time of injury. Almost 50.7% of injuries from safety-engineered devices occurred before devices were activated, while 21.8% occurred during activation and 9.4% after activation. (Table 4)

Table 4. Distribution of Sharp Object Injury among Health Care Workers by Sharp Injury Devices

Characteristic	Number (%) of Injury	% of injury excluding missing data
Device Involved in the Injury		**(N=4538)**
Glass	36 (0.76)	0.79
Hollow Bore Needle	1934 (41.09)	42.62
IV Catheter	282 (5.99)	6.21
Lancet	60 (1.27)	1.32
Other	342 (7.27)	7.54
Other Needle	485 (10.30)	10.69
Scalpel	274 (5.82)	6.04
Suture Needle	949 (20.16)	20.91
Unknown	176 (3.74)	3.88
missing	169 (3.59)	
Was the Device a Safety Design?		**(N=3112)**
Yes	533 (11.32)	17.13
No	1945 (41.32)	62.50
Unknown	634 (13.47)	20.37
missing	1595 (33.89)	
For Those Devices that were Safety Designed (N=533)		
Was the Protective Mechanism Activated?		**(N=529)**
Fully Activated	46 (8.63)	8.70
Partially Activated	104 (19.51)	19.66
Not Activated	378 (70.92)	71.46
Unknown	1 (0.19)	0.19
missing	4 (0.75)	
When Exposure Happened?		**(N=527)**
Before Activated	270 (50.66)	51.23
During Activated	116 (21.76)	22.01
After Activated	50 (9.38)	9.49
Unknown	90 (16.89)	17.08
Null	1 (0.19)	0.19
missing	6 (1.13)	

4.2 Rate and Risk Factors for Health Care Workers (Excluding Physicians)

4.2.1 Univariate Poisson Regression for Most Health Care Workers

4.2.1.1 Risk in Different Hospitals/Settings

Among the different hospitals and settings, the sharp object injury rate in the RAH was the highest with 37.47 injuries per 1,000 FTEs per year, followed by the UAH with 36.09 per 1,000FTEs per year, Other Institutional settings with 31.09 per 1,000 FTEs per year and Non-Institutional settings with 12.05 per 1,000 FTEs per year. (Table 5)

Using Non-Institutional settings as the reference category, the unadjusted rate ratio for the RAH was highest at 3.11 ($p<0.001$, 95%CI: 2.54, 3.80), followed by the UAH at 3.00 ($p<0.001$, 95%CI: 2.46, 3.66) and Other Institutional settings at 2.58 ($p<0.001$, 95%CI: 2.08, 3.20). (Table 5)

Table 5. Rates and Crude Rate Ratio from Univariate Poisson Regression by Hospital/Setting

Hospital	**Injuries Counts**	**FTEs**	**Rate per 1,000 FTEs/year**	**Crude RR 95%CI**	**P-value**
Non Institutional (Home Care)*	108	8960.02	12.05	1.00 (Ref.)	-
Other Institutional (Hospital Setting)*	333	10711.14	31.09	2.58 (2.08,3.20)	**p<0.001**
RAH	732	19536.03	37.47	3.11 (2.54,3.80)	**p<0.001**
UAH	927	25642.00	36.15	3.00 (2.46,3.66)	**p<0.001**

4.2.1.2 Risk for Different Occupations

As shown in Table 6, the sharp object injury rate was highest among nurses (63.58 injuries per 1,000 FTEs/year), followed by technicians (19.30 per 1,000 FTEs/year), support services (18.23 per 1,000 FTEs/year), paramedical staff (12.22 per 1,000 FTEs/year) and others (12.05 per 1,000 FTEs/year). Note that physicians could not be included in this analysis as FTEs for this occupational group were not available. (Table 6)

Using paramedical staff as the reference category, the unadjusted or crude rate ratio for nurses was higher (5.21, $p<0.001$, 95%CI: 4.28, 6.35) than the other groups. The rate ratio for the technician group was second at 1.58 ($p=0.001$ 95%CI: 1.21, 2.07), support services at 1.49 ($p=0.002$ 95%CI: 1.15, 1.93), and others at 0.99 ($p=0.907$, 95%CI: 0.78, 1.24). (Table 6)

Table 6. Rates and Crude Rate Ratio from Univariate Poisson Regression by Occupation

Occupation	**Injuries Counts**	**FTEs**	**Rate per 1,000 FTEs/year**	**Crude RR 95%CI**	**P-value**
Paramedical Staff	106	8677.53	12.22	1.00 (Ref.)	-
Nurse	1521	23885.46	63.58	5.21 (4.28,6.35)	**p<0.001**
Technician	108	5597.17	19.30	1.58 (1.21,2.07)	**p=0.001**
Support Service	128	7019.91	18.23	1.49 (1.15,1.93)	**p=0.002**
Other	237	19669.12	12.05	0.99 (0.78,1.24)	p=0.907

4.2.1.3 Risk During and After the Introduction of Safety-Engineered Devices

A statistically significant decrease in the crude rate ratio occurred during the period of introduction of safety devices when compared with the period before the introduction of safety-engineered devices (Crude RR=0.88, p=0.03, 95%CI: 0.78, 0.99). The crude rate ratio for the comparison of the periods after the intervention group compared with the period before the introduction of safety-engineered devices was 0.97 (p=0.64, 95%CI: 0.86, 1.09). (Table 7)

Table 7. Rates and Crude Rate Ratio from Univariate Poisson Regression for During and After the Intervention Period of Safety-engineered Devices

Period	**Injuries Counts**	**FTEs**	**Rate per 1,000 FTEs/year**	**Crude RR 95%CI**	**P-value**
Before(2006)	398	11545.29	34.47	1.00 (Ref.)	-
During(2007/ 2008)	766	25388.00	30.17	0.88 (0.78,0.99)	**p=0.03**
After(2009/ 2010)	936	27915.90	33.53	0.97 (0.86,1.09)	p=0.64

4.2.2 Multiple Poisson Regression for Health Care Workers (Excluding Physicians)

4.2.2.1 Before vs. During/After Introduction by Hospital/Setting and Occupation

The analysis is shown in Table 8. Among the different hospitals, UAH showed a significant decline in the rate ratio (Adjusted RR=0.80, p=0.013, 95%CI: 0.67, 0.95) when comparing before with during the period of introduction of safety-engineered devices. (Table 8)

Somewhat different effects were seen among the different occupations in the multiple Poisson regression models. Sharp object injuries among nurses showed a significant decline in the adjusted rate ratio (Adjusted RR=0.85, p=0.017, 95%CI: 0.74, 0.97) when comparing before and during the period of safety-engineered devices, whereas injuries among Others demonstrated a significant increase when comparing before and after the introduction of safety-engineered devices (adjusted RR=2.19, p<0.001, 95%CI: 1.44, 3.33). (Table 8)

4.2.2.2 Interaction Effects in the Final Multiple Poisson Regression Model

Among the three risk factor groups for sharp object injuries in the final multiple Poisson regression model, there was a significant interaction between occupation and period in the model comparing before and after the intervention. (Table 8)

Table 8. Adjusted Rate Ratio from Multivariate Poisson Regression among Most Health Care Workers*

	Before (Ref.) vs. During		**Before (Ref.) vs. After**	
	Adjusted Rate Ratio 95%CI	**P-value**	**Adjusted Rate Ratio 95%CI**	**P-value**
Hospital				
Other Institutional (Hospital Setting)*	0.71 (0.39,1.29)	p=0.260	1.51 (0.89,2.55)	p=0.124
Non Institutional (Home Care)*	1.11 (0.80,1.54)	p=0.531	1.22 (0.89,1.68)	p=0.220
RAH	0.92 (0.75,1.13)	p=0.419	0.89 (0.73,1.09)	p=0.261
UAH	0.80 (0.67,0.95)	**p=0.013**	0.98 (0.82,1.16)	p=0.784
Occupation				
Paramedical Staff	0.70 (-0.40,1.24)	p=0.222	0.91 (0.55,1.52)	p=0.722
Nurse	0.85 (0.74,0.97)	**p=0.017**	0.88 (0.77,1.01)	p=0.063
Technician	0.86 (0.51,1.45)	p=0.577	0.90 (0.54,1.50)	p=0.693
Support Service	1.15 (0.66,1.98)	p=0.628	1.59 (0.95,2.68)	p=0.081
Other	1.20 (0.77,1.89)	p=0.417	2.19 (1.44,3.33)	**p<0.001**

* Interaction effect was included in the estimation of rate ratios

4.3 Risk Factors for Physicians

4.3.1 Univariate Log-linear Model for Physician Group

4.3.1.1 Risk in Different Hospital/Setting

Using Other Institutional Settings as the reference, the unadjusted/crude odds ratio for UAH was highest (Crude OR=8.82, p<0.001, 95%CI: 3.73, 6.34) with 582 injuries reported, followed by RAH (Crude OR=4.86, p<0.001, 95%CI: 3.73, 6.34) with 321 injuries. (Table 9)

Table 9. Frequency and Crude Odds Ratio from Univariate Log-linear Model for Hospital/Setting among Physician group

Hospital	**N**	**Crude Odds Ratio 95%CI**	**P-value**
Other Institutional (Hospital Setting)*	66	1.00 (Ref.)	-
RAH	321	4.86 (3.73,6.34)	**p<0.001**
UAH	582	8.82 (6.84,11.37)	**p<0.001**

4.3.1.2 Risk During and After the Period of Introduction of Safety-Engineered Devices

A significant decrease in the crude odds ratio was seen for the period after the introduction of safety-engineered devices (2009/2010) when compared with before the introduction (2005/2006) (Crude OR=0.83, p=0.021, 95%CI: 0.71, 0.97). (Table 10) There was no significant difference when comparing before and during the introduction of safety-engineered devices.

Table 10. Frequency and Crude Odds Ratio from Univariate Log-linear Model for Intervention Period of Safety-engineered Devices among Physicians

Period	**N**	**Crude Odds Ratio 95%CI**	**P-value**
2005-2006 (Before)	344	1.00 (Ref.)	-
2007-2008 (During)	339	0.99 (0.85,1.14)	P=0.848
2009-2010 (After)	286	0.83 (0.71,0.97)	**P=0.021**

4.3.2 Multiple Log-linear Model for Physicians

4.3.2.2 Risk comparing before with during and after periods by Hospital

Results are shown in Table 11. For physicians when using before the period of safety-engineered devices as the reference group, the incidence of sharp object injuries after the introduction at the RAH showed a significant decline in the adjusted odds ratio (Adjusted OR=0.29, p<0.001, 95%CI: 0.21, 0.41), whereas injuries at the UAH were significantly increased as seen in Table 21 (Adjusted OR=1.29, p=0.012, 95%CI: 1.06, 1.57). (Table 11)

4.3.2.2 Interaction Effects in the Final Multiple Log-linear Regression Model

There was a significant interaction between hospitals/settings and introduction period for safety-engineered devices (year) in the final multiple log-linear model. (Table 11)

Table 11. Adjusted Odds Ratio from Multivariate Log-linear Model for among Physicians*

	Before (Ref.) vs. During		Before (Ref.) vs. After	
Hospital	**Adjusted Odds Ratio 95%CI**	**P-value**	**Adjusted Odds Ratio 95%CI**	**P-value**
Other Institutional	1.24 (0.70,2.20)	p=0.467	0.90 (0.49,1.68)	p=0.752
RAH	0.87 (0.68,1.10)	p=0.231	0.29 (0.21,0.41)	**p<0.001**
UAH	1.06 (0.86,1.30)	p=0.597	1.29 (1.06, 1.57)	**p=0.012**

* Interaction effect was included in the estimation of odds ratios

Chapter Five: Discussion

5.1 Overview

A total of 4707 sharp object injuries were reported to Workplace Health and Safety (AHS) as having occurred in 15 hospitals in the capital area of Alberta between 2003 and 2010. The overall sharp object injury rate was 32.38 injuries per 1,000 FTEs per year from 2006 to 2010.

5.1.1 Distribution of Occupation and Department

Nurses are usually reported as the group of with the greatest number of sharp object injuries. Consistent with previous findings, the current study found that 53.7% of sharp object injuries were reported by nurses. In previous studies of health care workers in the United States, nurses reported from 47% to 53.4% of sharp object injuries. [75, 82, 83, 128] Data from the Canadian Needle Stick Surveillance Network study showed that physicians reported 21.3% of sharp object injuries[128], similar to the 27.7% reported by physicians in our study.

The operating room is a common location for sharp object injuries as many sharp instruments are used in surgery. [166, 167] Injuries occurring in operating/procedure rooms comprised 52.4% of all sharp object injuries in our study with 36.3% of injuries occurring in inpatient units. Most previous studies have reported that the operating room is the highest risk site for injuries with Jagger, et al. estimating that up to 50% of sharp object injuries occurred in this site.[82] U.S. EPINet reported that approximately 30.3% of sharp object injuries occurred in the operating theatre.[52] Some studies have indicated that most injuries occurred in the ward areas. For example, a Korean study reported 34% of sharp object injuries occurred in the ward while 28% occurred in the operating room.[84]

5.1.2 Distribution of Exposure Status

Approximately 92.0% of the source patients on whom the sharp objects had been used could be identified, and more than half of the injured workers were the original user of the sharp items. Most sharp items were contaminated (92.24%) and on half there was visible blood. Those findings were consistent with a 2001 EPINet report from the United States, in which 90.7% of source patients could be identified; nearly 57.3% of sharp object injuries occurred to the original users; and approximately 90.3 % of sharp objects were contaminated.[168]

Sharp objects used for injection were involved in the largest proportion of injuries (27.2%). This is consistent with Alamgir et al.'s findings in which the majority of reported sharp object injuries occurred when a needle was used for injection (72.4%). [27] A report from Massachusetts reported that approximately 25% of devices involved in sharp object injuries were being used for injection. [169]

In the current study, approximately 42.7% of sharp object injuries occurred during the use of the item, followed by after use and before disposal with 30.10%. This is similar to Patrick et al.'s report in which sharp object injuries occurred during the use of devices in 43% of cases.[169] Dement et al.showed 52% of sharp object injuries occurred during the use of a sharp device and nearly 42% of exposures occurred after device use or during disposal. [170] These findings differ from Jagger et al.'s 1988 report which showed that 70% of sharp object injuries occurred while preparing for disposal. [91, 170]

Our results showed that fingers were the body part most often injured (59.6%), which is consistent with many other studies. Askarian et al. found that approximately 95.1% of sharp object injuries involved fingers. [51]

In our study, more than half of the injuries were superficial with little or no bleeding, which was consistent with previous studies using EPINet.[23, 168] Approximately 59.4% of injuries penetrated through a single pair of gloves, which is also consistent with a 2001 EPINet report that almost 68.9% of sharp object injuries were through single pair of gloves. [168]

5.1.3 Distribution of Sharp Injury Devices

Approximately 41.1% of sharp object injuries involved hollow bore needles which is similar to previous reports [27, 51, 169]. For example in Askarian et al.'s study of Iranian nurses, hollow bore needles accounted for 72.2% of all sharp object injuries. [51] In our findings, approximately 41.3% of the injury devices were not safety designed, which indicated the need for safety-engineered devices among health care workers.

Among injuries involving safety-engineered devices, protective mechanisms were not activated in nearly 70.9% of injury in our study. Lee et al. also reported that most sharp object injuries occurred when safety devices were not fully activated.[171] Those findings suggest a need for passive safety-engineered devices which are automatic and require no additional action on the part of the user. [21] Tosini et al. indicated that passive (fully automatic) devices were associated with the lowest rate of sharp object injuries since they required no input from the user. [102] As a result, passive safety-engineered devices were recommended as the most effective for sharp object injury prevention compared with other types of devices. [102, 147]

In addition, nearly 50.7% of sharp object injuries caused by safety-engineered devices occurred before activation, while 21.8% occurred during activation and only 9.4% after activation. Similar results were reported by Mendelson et al. in which safety winged steel needle injuries occurred most often before activation (39%) [155] A multi-center French study showed that 40% of the sharp object injuries occurred before activation of the safety feature was appropriate or possible. [102]

5.2 Rates of Sharp Injury and Effectiveness of Safety-Engineered Devices

The Overall sharp object injury rate among most health care workers in the capital region of Alberta was 32.38 injuries per 1,000 FTEs per year, which is consistent with that reported in other studies. The EPINet recording system was also used in a study from a tertiary hospital in the Republic of Korea, and they reported an overall incidence rate of 26 injuries per 1,000 FTEs per year. [84] Dement et al. observed an overall rate of percutaneous exposure of 39 injuries per 1,000 FTEs per year, using data from Duke Health and Safety Surveillance System (DHSSS). [170]

In our study, from 2006 to 2010, the average injury rate in our study significantly decreased from 34.47 per 1,000 FTEs (not including physicians) before intervention to 30.17 during intervention but then increased to 33.53 after the intervention which indicated a potential effectiveness of safety-engineered devices in reducing sharp object injuries during the intervention, although it may be important that these rates exclude physicians. Similar findings but with a larger effect were reported by SeJean Sohn et al.'s study in which the mean annual incidence of sharp object injury in decreased from 34.08 per 1,000 FTEs pre-intervention to 14.25 post-intervention. [24]

5.3 Risk Factors Associated with Safety-engineered Devices

5.3.1 Hospitals:

Most sharp object injuries occurred in the University of Alberta Hospital (48.52%) and Royal Alexandra Hospital (34.61%), followed by Other Institutional Hospitals (14.15%) and Non-Institutional Setting of Community Sector (2.72%). (Table 11) Our study indicated that workers in large hospitals such as UAH and RAH were at significantly higher risk of sharp object injury compared with smaller hospitals or the community sector. Laramie et al.'s finding also reported a consistently higher sharp object injury rate in larger-sized hospital than in medium-sized and small hospital.[172]

In the multivariate models for non-physician, the only hospital with a significant decrease in sharp object injuries was UAH when comparing before and during the introduction period. This may indicate the effectiveness of the intervention process reduction in UAH which is a large-sized hospital in the Capital region of Alberta. Though we have no information on how education and training differed between the UAH and RAH, it seems that the sharp object injuries were effectively reduced during the introduction of safety-engineered devices, although this is not true for the physician group in the UAH.

Laramie et al.'s conclusion that larger-sized hospitals reported more sharp object injuries [172] seemed true for our physician group results. When compared with Other Institutional Settings, the unadjusted/crude odds ratio were significantly higher for the larger-sized hospitals of UAH and RAH. In the multivariate model for the physician group, physicians at the RAH reported significantly fewer injuries after the introduction when comparing the before period. However, there was a significantly increase at the UAH after the introduction when comparing before the introduction period. Other studies have reported similar results in which an initial decrease in injury was followed by an increase [173]. It might be possible to understand why sharp object injuries increased at the UAH by examining the cross tabulation of sharp object injury by hospital and physician group. A Total number of 173 injuries were reported among residents in UAH, while only 1 and 0 were reported in RAH and Other Institutional Settings. Residents are often considered to be at increased risk of sharp object injury due to a lack of medical skill and experience when compared with more experienced physicians. [124] Thus injury risk at the UAH might be higher than at the RAH and Other Institutional Settings because of the number of residents working there. Had there been a change in staffing patterns at the same time as the introduction of safety-engineered devices, this might have diluted any effect at UAH, but emphasized it at RAH. This may well be important as a number of residency programs relocated around that time. It may also be a real effect due to poor compliance or training, or even reflect the ineffectiveness of the devices. Finally it may also be that the increased attention on sharp object injury led to more complete reporting.

Table 12. Cross Tabulation of Sharp Object Injury by Hospitals and Physician Group

	UAH	RAH	Other Institutional	Non Institutional	ALL
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Physician Group					
Dentist	2 (0.04)	0 (0)	0 (0)	0 (0)	2 (0.04)
Medical Student	39 (0.83)	28 (0.59)	9 (0.19)	0 (0)	76(1.61)
Pay Level I	5 (0.11)	0 (0)	0 (0)	0 (0)	5 (0.11)
Pay Level II	38 (0.81)	0 (0)	0 (0)	0 (0)	38 (0.81)
Pay Level III	37 (0.79)	0 (0)	0 (0)	0 (0)	37 (0.79)
Pay Level IV	34 (0.72)	0 (0)	0 (0)	0 (0)	34 (0.72)
Pay Level V	47 (1.00)	1 (0.02)	0 (0)	0 (0)	48 (1.02)
Pay Level VI	8 (0.17)	0 (0)	0 (0)	0 (0)	8 (0.17)
Pay Level VII	1 (0.02)	0 (0)	0 (0)	0 (0)	1 (0.02)
Pay Level VIII	3 (0.06)	0 (0)	0 (0)	0 (0)	3 (0.06)
Physician	211 (4.48)	158 (3.36)	52 (1.10)	1 (0.02)	422 (8.97)
Physician (Not Resident)	26 (0.55)	27 (0.57)	16 (0.34)	0 (0)	69 (1.47)
Resident	282 (5.99)	237 (5.04)	11 (0.23)	0 (0)	530 (11.26)
Resident (Non-Union)	15 (0.32)	1 (0.02)	1 (0.02)	0 (0)	17 (0.36)
Resident (Not Physician or)	1 (0.02)	1 (0.02)	0 (0)	0 (0)	2 (0.04)
Student (Medical)	8 (0.17)	2 (0.04)	0 (0)	0 (0)	10 (0.21)

5.3.2 Occupation:

We found that the sharp object injury rate (excluding physicians) was highest among nurses with 63.58 injuries per 1,000 FTEs per year compared with technicians, support service workers, paramedical staff and others. Among those health care workers and using paramedical staff as the reference group, the unadjusted rate ratio for the nurse group was highest, followed by the technician group and the support service group, which indicated that nurses experience most sharp object injuries in health care settings. This result is similar to most previous studies [75, 82, 83, 128] in which the risk of sharp object injuries was highest among nurses in both frequency and rate, when compared with other health care worker groups. Alamgir et al., however, found a different situation in which the risk among laboratory assistants was 3.41 times higher than the risk among registered nurses. [27]

Considering both Poisson regression and log-linear model, the adjusted injury rate was significantly decreased among nurses when comparing before vs. during the period but not after the period, while for physicians there was a significant decrease only after the intervention and not during the intervention. In these findings, the introduction of safety-engineered devices helped reducing sharp object injuries especially during the period (2007 - 2008) which appeared to be relatively short-lived among nurses but not among physicians. SeJean Sohn et al.'s intervention study found that nurses experienced the greatest decrease followed by ancillary staff, though physicians were not included in this study. [24] Unexpectedly, there was a significant increase in adjusted rate ratio among other health care workers when comparing before and after the introduction period of safety-engineered devices. It is a reasonable assumption that there would be less potential for the intervention to be effective among other group such as aides, security staff, clerks, students, volunteers etc. as they likely use such devices much less frequently. The impact of increased attentions and education on reporting may however be similar to other health care worker groups, tending to increase reporting overall.

5.4 Strengths and Limitations

This study was the first to report the incidence of sharp object injury in Edmonton hospitals since the enactment of the Alberta Occupational Health and Safety Code (OHS Code) of 2004 requiring the use of safety-engineered sharp objects among health care workers and the widespread introduction of safety-engineered devices in the Capital region of Alberta during 2007/2008.We sought to study whether the introduction of safety-engineered devices reduced the sharp object injury rate among health care workers including multiple sites over eight years. Poisson regression and log-linear regression model designs were used in the study in addition to estimating sharp object injury frequency and proportion. Other studies have used a similar approach, estimating FTEs as the denominator when calculating sharp object injury rate. [24, 84, 170]

Our study also had several limitations to be considered in interpreting the findings. First, it is likely that a proportion of cases were missed due to underreporting. There was no way to estimate the impact of underreporting in these data. The extent of underreporting has been estimated by several previous studies varied from 41% to 80%. [41-43, 129] Underreporting of sharp object injury could potentially affect frequency and rate.[170] Importantly in the context of this study, sharp object injury cases and rate could be increased due to awareness of the need of reporting among health care worker as a result of the attention brought by the safety-engineered device program, even without the devices actually having an effect. If anything it would tend to increase numbers and rates across the intervention period, and so would not explain the reduction we saw overall, but may be important in some of the findings.

Second, since our study data for these analyses was from Alberta Health Services blood and body fluid exposure surveillance system which is a self-reporting system, limitation could be introduced by the reliance on the self-reported data and the possibility of recall bias such as misclassification.

Third, our data from this surveillance system in the capital region of Alberta was merged from two systems of EPINet and Medgate. Some slight potential differences between those two systems may exist. We would not anticipate that this had a major effect, however, as we were careful to re-categorize where needed into as near identical categories as possible. This way had lied a more marked effect on analyses of whether protective mechanism of safety-engineered devices were activated. These data were not available in EPINet. Fortunately there was considerable data within Medgate and consequently any conclusions based on those fields are likely reasonably reliable.

Fourth, Person-year information was used as the denominator when estimating sample size but Full-time Equivalent data was used for study analyses. The two are closely linked, although person-year will tend to be higher as not all people work full time. The difference between person-year and FTEs would likely cause no effect on significant results found in the study, and so it is unlikely it would affect our conclusions.

Fifth, not all units may have introduced safety-engineered devices and this would have diluted effect of safety-engineered devices among health care workers. This might explain why the effect seen in this study was smaller than that described in some other studies. [38, 154]

Last but not least, the use of the FTEs as the denominator in our study identified that there were inadequate data for physicians to use FTE to use as a denominator in this group. As a result, sharp object injury rate could not be compared between physician and other health care worker occupation groups. Fortunately, it was still possible to study the main hypothesis, about the effectiveness of safety-engineered devices, in the physician group, albeit using an alternative statistical modeling technique.

Overall, while we recognize there are a number of problems with these data, we would nonetheless be confident that a real reduction in sharp object injuries was associated with the introduction of safety-engineered devices.

Chapter Six: Conclusions

6.1 Conclusions

This before-and-after intervention study provided frequency, rates and possible risk factors for sharp object injuries among health care workers in the capital region of Alberta, which were consistent with other findings. The introduction of safety-engineered devices was effective in reducing sharp object injuries especially during the intervention period for non-physicians, but predominantly after the intervention for physicians. Sharp object injury reduction was associated with both hospital/setting and occupation.

Confirmation of the effectiveness of safety-engineered devices in reducing sharp object injuries is an important affirmation for policy makers of the potential effectiveness of the Alberta Occupational Health and Safety Code in requiring safety-engineered devices be available by health care workers.

6.2 Future Study Suggestions

Though our results indicated that safety-engineered devices played a role in reducing sharp object injuries, the results were not homogenous and other factors need to be considered such as training, education, implementation of universal precautions, etc. in future studies. As Laramie et al. mentioned, increased adoption of safety-engineered devices may also reflect an increased hospital commitment to workplace safety such as improvements in health care worker orientation, training and work practices. [172] Such studies could address whether sharp object injury rates may be reduced by additional training and education during and after the intervention.

Future studies should also try to determine the relationship between the cost of offering safety-engineered devices and their effectiveness in reducing sharp object injuries among health care workers to confirm the cost-effectiveness of safety-engineered devices.

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Appendix 1: Proposed Coding Changes Tables

Proposed Coding Changes for Hospital Identification

Proposed Recoding Label (Value)	Original Coding Label (Value)	Description of Original Coding
UAH (1)	UAH (14)	University of Alberta Hospital
RAH (2)	RAH (11)	Royal Alexandra Hospital
Other Institutional (Hospital Setting) (3)	AHE (1)	Alberta Hospital Edmonton/Regional Mental Health
	CROSS CANCER (3)	Cross Cancer Institute
	DEVON (4)	Devon General Hospital
	EGH-RENAL (5)	Edmonton General Hospital
	FT SASK (6)	Fort Saskatchewan Community Hospital
	GRH (7)	Glenrose Rehabilitation Hospital
	LCH (8)	Leduc Community Hospital
	NECHC (9)	North East Community Health Centre
	NON CAPITAL (10)	Non-capital Hospital
	REDWATER (12)	Redwater Health Centre
	SCH (13)	Sturgeon Community Hospital
	WESTVIEW (15)	Westview Health Centre
Non Institutional (Home Care) (4)	COM SEC (2)	Community Sector

Proposed Coding Changes for Job Description

Proposed Recoding Label (Value)	Original Coding Label (Value)
Nurse (1)	GRAD NURSE TPH(INT'L)(1922) (19)
	GRAD NURSE TPH(INT'L)(2022) (20)
	GRADUATE NURSE TPH(1922) (21)
	GRADUATE NURSE TPH(2022) (22)
	INTERNATIONAL LPN (24)
	LICENSED PRACTICAL NURSE (31)
	NURSE PRACTITIONER (38)
	NURSING ATTENDANT (39)
	NURSING ATTENDANT(+ED ALLOW) (40)
	REGISTERED NURSE (SH) (69)
	REGISTERED NURSE(1922) (70)
	REGISTERED NURSE(2022) (71)
	REGISTERED NURSE(INT'L)(1922) (72)
	REGISTERED NURSE(INT'L)(2022) (73)
	REGISTERED NURSE (68)
	REGISTERED PSYCH NURSE(2022) (74)
	STUDENT (NURSING) (89)
	STUDENT NURSE (90)
	UNDERGRADUATE NURSE(1922) (97)
	UNDERGRADUATE NURSE(2022) (98)
Other (2)	AIDE I -F.S. (G) (1)
	ASSISTANT HEAD NURSE(1922) (3)
	ASSISTANT HEAD NURSE(2022) (4)
	ATTENDANT I - F.S. (G) (5)
	COORDINATOR (8)
	OHSW CONSULTANT II (43)
	OTHER ATTENDANT (46)
	OTHER/UNKNOW (48)
	Other, describe (49)
	PHD LAB SCIENTIST (59)
	RESEARCH ASSISTANT (76)
	SECURITY (84)
	STUDENT (87)
	STUDENT/INTERN OTHER NOT NURSING (92)
	STUDENT OTHER (91)
	TEAM LEADER (94)
	TECHNICAL ATTENDANT (95)
	UNIT CLERK (99)
	VOLUNTEER (100)
	WRKG LEADER - CSS (101)
	WRKG LEADER-ENVIRONMENTAL (102)
Other Paramedical Staff (3)	DENTAL ASSISTANT (10)
	DENTAL HYGIENIST (11)
	DIALYSIS ASSISTANT (14)
	EMT (15)
	INSTRUCTOR(1922) (23)
	LABORATORY ASSIST I (28)
	LABORATORY ASSIST II (29)
	LABORATORY ASSISTANT (30)

	OCCUPATIONAL THERAPIST I (42)
	PARAMEDIC (50)
	Phlebotomist/Venipuncture/IV Team (66)
	PHYSICAL THERAPIST I (60)
	PHYSICAL THERAPIST II (61)
	PSYCH – UNIT 12-1 (64)
	PSYCHIATRIC AIDE (65)
	REMT - Ambulance (75)
	RESPIRATORY THERAPIST I (81)
	RESPIRATORY THERAPIST II (82)
	RESPIRATORY THERAPIST III (83)
	RESPIRATORY THERAPIST (80)
Physician (4)	DENTIST (12)
	MEDICAL STUDENT (36)
	PAY LEVEL I (51)
	PAY LEVEL II (52)
	PAY LEVEL III (53)
	PAY LEVEL IV (54)
	PAY LEVEL V (55)
	PAY LEVEL VI (56)
	PAY LEVEL VII (57)
	PAY LEVEL VIII (58)
	PHYSICIAN (62)
	PHYSICIAN (NOT RESIDENTS OR INTERNS) 63
	RESIDENT (NON-UNION) (78)
	RESIDENT (77)
	RESIDENT (NOT PHYS OR INTERNS) (79)
	STUDENT (MEDICAL) (88)
Support Service (5)	COOK I (7)
	CS-SPD (CSS PRODUCT DISTRIBUTION) (9)
	ENVIRONMENTAL (16)
	ENVIRONMENTAL I (17)
	ENVIRONMENTAL II (18)
	MAINTENANCE WORKER I (32,33)
	MAINTENANCE WORKER III (34)
	NUTRITION & FOOD SERVICES (41)
	REFRIGERATION MECH (67)
	SERVICE WORKER I (85)
	SERVICE WORKER II (86)
	SURGICAL PROCESSOR (93)
Technician (6)	ANAESTHESIA TECH II(U) (2)
	COMBINED LAB&X-RAY TECH I (6)
	DIAGNOSTIC SONOGRAPHER II (13)
	LAB TECH (25)
	LAB TECH I (26)
	LAB TECH II (27)
	MED RAD TECH II (35)
	NUCLEAR MED TECH I (37)
	OPERATING ROOM TECHNICIAN (44)
	ORTHOPAEDIC TECHNICIAN (45)
	OTHER TECHNICIAN (47)
	Technologist (non lab) (96)

Proposed Coding Changes for Locations

Proposed Recoding Label (Value)	Original EPINet Coding Label (Value)
Emergency Department (1)	Emergency Department (1, 13)
Inpatient Unit (2)	Patient Room/Ward (2,21)
Intensive Care Unit (3)	Intensive/Critical Care Unit (3,4,15)
Laboratory (4)	Autopsy/Pathology (9)
	Blood Bank (10)
	Clinical Laboratories (5,11)
Operating and Procedure Room (5)	Dialysis Facility (12)
	Labor and Delivery Room (16)
	Operating Room/Recovery/Cath Lab (6,17)
	Procedure Room (22)
	Venipuncture Center (24)
Other Area (6)	Other, describe (7, 18)
	Service/Utility Area (23)
	Outside Patient Room (20)
Home Care (7)	Home-care (14)
Outpatient Area (8)	Outpatient Clinic/Office (8,19)

Proposed Coding Changes for Whether Contaminated

Proposed Recoding Label (Value)	Original Coding Label (Value)
Contaminated (1)	Contaminated (1)
	Yes (5)
Uncontaminated (2)	Uncontaminated (3)
	No (2)
Unknown (3)	Unknown (4)

Proposed Coding Changes for Description of Purpose

Proposed Recoding Label (Value)	Original Coding Label (Value)
Injection (1)	IM/SQ Procedure (15)
	Injection, intramuscular/subcutaneous (17)
	Needle Disposal (18)
	Other injection into IV injection site or port (21)
	Removing needle from Syringe (24)
Line Procedures (2)	Heparin or saline flush (14)
	IV Procedure (16)
	To connect IV line (35)
	To place an arterial/central line (40)
	To start IV or setup heparin lock (41)
Recapping (3)	Recapping (23)
Other (4)	Biopsy Needle (2)
	Bite, Human (3)
	Clean Sharp Through Dirty Glove (5)
	Cleaning Equipment/Instruments (6)
	Cleaning Patient Area (7)
	Hand to Hand Passing (13)
	Not a True Exposure (19)
	Other (20)
	Other, describe (22)
	Searching Patient Belongings (25)
	Sharp Instrument (26)
	Sharp in Bed (27)
	Sharp in Trash (28)
	Sharp on Procedure Tray (29)
	Skin Contact (30)
	Splash/Spray of Blood/Body Fluid (31)
	Stuck by Other Health Care Provider (32)
	To contain a specimen or pharmaceutical (36)
Phlebotomy (5)	Analyzing Specimen (1)
	Blood Draw (4)
	Fingerstick/heel stick (12)
	To draw a venous blood sample (37)
	To draw an arterial blood sample (38)
	To obtain a body fluid or tissue sample (39)
Surgical (6)	Cutting (8)
	Drilling (9)
	Electrocautery (10)
	Epidural Insertion (11)
	Suture Needle (33)
	Suturing (34)
Unknown (7)	Unknown (42)
	Unknown/not applicable (43)

Proposed Coding Changes for Mechanism of Injury

Proposed Recoding Label (Value)	Original Coding Label (Value)
After Use and Before Disposal (1)	Between steps of a multi-step procedure (5)
	Disassembling device or equipment (8)
	In preparation for reuse of reusable ins (12)
	Other after use, before disposal (15)
	While recapping a used needle (22)
Before Use of Item (2)	Before use of item (4)
During or After Disoisal of Item (3)	While putting the item into the disposal (21)
During Use of Item (4)	Direct patient contact (7)
	During use of item (9)
Other (5)	Other (14)
	Other, describe (17)
	Restraining patient (18)
	Withdrawing a needle from rubber or other (23)
Unknown (6)	Unknown (20)
Unsafe Item (7)	IV tubing/bag/pump leaked/broke (11)
	Other body fluid container spilled/leaked (16)
	Specimen container broke (19)
Unsafe Placement of Item After Use (8)	After disposal, item protruding from trash (1,2)
	After disposal, stuck by item protruding (3)
	Device left on floor, table, bed or other (6)
	From item left on or near disposal contact (10)
	Item pierced side of disposal container (13)

Proposed Coding Changes for Injury Device

Proposed Recoding Label (Value)	Original Coding Label (Value)
Glass (1)	Capillary tube (3)
	Glass item, other (7)
	Glass item, unknown type (8)
	Glass slide (9)
	Medication ampule (12)
	Pipette, glass (28)
	Specimen/test tube, glass (35)
	Vacuum tube, glass (44)
Hollow Bore Needle (2)	Needle, Winged steel (15)
	Needle, arterial catheter introducer (16)
	Needle, central line catheter introducer (17)
	Needle, other vascular catheter (20)
	Needle, spinal or epidural (21)
	Needle, unattached hypodermic (22)
	Needle/holder vacuum tube blood collection (24)
	Syringe, blood gas (38)
	Syringe, disposable (39)
	Syringe, other type (40)
	Syringe, prefilled cartridge (41)
IV Catheter (3)	IV catheter (10)
Lancet (4)	Lancet (11)
Other (5)	Bone chip (1)
	Bone cutter (2)
	Drill bit (4)
	Electrocautery Device (5)
	Fingernails/teeth (6)
	Microtome blade (13)
	Pickup/forceps/hemostats (26)
	Pin (27)
	Razor (29)
	Retractors, skin/bone hooks (30)
	Scissors (33)
	Staples, steel sutures (36)
	Towel clip (42)
	Trocar (43)
	Wire (45)
Other Needle (6)	Needle on IV tubing (14)
	Needle, describe (18)
	Needle, other non vascular catheter (19)
	Needle, unknown type (23)
Scalpel (7)	Scalpel, disposable (31)
	Scalpel, reusable (32)
Suture Needle (8)	Suture Needle (37)
Unknown (9)	Other sharp item (please describe) (25)
	Sharp item, not sure what kind (34)

Proposed Coding Changes for State of Device Activation

Proposed Recoding Label (Value)	Original Coding Label (Value)
Fully Activated (1)	Fully Activated (1)
	Yes, fully (6)
Partially Activated (2)	Partially Activated (4)
	Yes, partially (7)
Not Activated (3)	Not Activated (3)
	No (2)
Unknown (4)	Unknown (5)

Proposed Coding Changes for Body Side

Proposed Recoding Label (Value)	Original Coding Label (Value)
Both (1)	B (1)
Left (2)	L (2)
	Left (3)
Right (3)	R (4)
	Right (5)

Proposed Coding Changes for Degree of Injury

Proposed Recoding Label (Value)	Original Coding Label (Value)
Severe - Deep stick/cut, Profuse bleeding (1)	Severe - Deep stick/cut, Profuse bleeding (5) Severe-deep stick/cut, profuse bleeding (6)
Moderate - Skin punctured, Some bleeding (2)	Moderate - Skin punctured, Some bleeding (2) Moderate-skin punctured, some bleeding (3)
Superficial - Little or no bleeding (3)	Superficial - Little or no bleeding (9) Superficial-little or no bleeding (10)
Splash of Body Fluid in Eyes (4)	Splash of Body Fluid in Eyes (7)
Splash of Body Fluid in Mouth (5)	Splash of Body Fluid in Mouth (8)
Blood on Unbroken Skin (6)	Blood on Unbroken Skin (1)
Unknown (7)	Needlestick from Trash (unknown source) (4)

Appendix 2: Sample Size Calculation

Original numbers (2003-2006 vs 2007-2008/2009-2010)

(1). Raw data of sharp object injury by AHS:

Calendar Year	Needlestick Incidents (raw)	Staff Count	Rate (raw)	Year	Incidents	Person -year	Rate (raw)
2003	582	18,161	0.03205	2005-2006	2343	77,029	0.03042
2004	554	18,824	0.02943				
2005	610	19,227	0.03173				
2006	597	20,817	0.02868				
2007	----	22,608	0.02464	2007-2008	1124	47,002	0.02391
2008	----	24,394	0.02324				
2009	----	24,986	0.02369	2009-2010	1240	51,055	0.02429
2010	----	26,069	0.02486				

(2). Sample Size Calculation Given by STATA.

```
. sampsi 0.03042 0.02586, power(0.8) alpha(0.05) ratio(0.5)

Estimated sample size for two-sample comparison of proportions

Test Ho: p1 = p2, where p1 is the proportion in population 1
              and p2 is the proportion in population 2
Assumptions:

      alpha =   0.0500  (two-sided)
      power =   0.8000
         p1 =   0.0304
         p2 =   0.0259
      n2/n1 =   0.50

Estimated required sample sizes:

         n1 =    31941
         n2 =    15971
```

Appendix 3: EPINET (Needlestick & Sharp Object Injury Report)

Needlestick & Sharp Object Injury Report

EPINet™ FOR MICROSOFT® ACCESS

EXPOSURE PREVENTION INFORMATION NETWORK

V1/US 8/2000

Last Name:____________________________ **First Name**:_____________________

Injury ID:*(office use only)* S__________ Facility ID:*(office use only)*________ **Completed By**:_____

1) Date of Injury: ☐☐ ☐☐ ☐☐☐☐ **2) Time of Injury:** ☐☐ ☐☐

3) Department where Incident Occurred:____________________________________

4) Home Department:____

5) What is the Job Category of the Injured Worker: (check one box only)

- ☐ 1 Doctor *(attending/staff)*; specify specialty______________
- ☐ 2 Doctor *(intern/resident/fellow)* specify specialty_________
- ☐ 3 Medical Student
- ☐ 4 Nurse: specify ☐ 1 RN ☐ 2 LPN ☐ 3 NP ☐ 4 CRNA ☐ 5 Midwife
- ☐ 5 Nursing Student
- ☐ 18 CNA/HHA
- ☐ 6 Respiratory Therapist
- ☐ 7 Surgery Attendant
- ☐ 8 Other Attendant
- ☐ 9 Phlebotomist/Venipuncture/IV Team
- ☐ 10 Clinical Laboratory Worker
- ☐ 11 Technologist *(non-lab)*
- ☐ 12 Dentist
- ☐ 13 Dental Hygienist
- ☐ 14 Housekeeper
- ☐ 19 Laundry Worker
- ☐ 20 Security
- ☐ 16 Paramedic
- ☐ 17 Other Student
- ☐ 15 Other, describe:______________________

6) Where Did the Injury Occur? (check one box only)

- ☐ 1 Patient Room
- ☐ 2 Outside Patient Room *(hallway, nurses station, etc.)*
- ☐ 3 Emergency Department
- ☐ 4 Intensive/Critical Care unit: specify type:_____________
- ☐ 5 Operating Room/Recovery
- ☐ 6 Outpatient Clinic/Office
- ☐ 7 Blood Bank
- ☐ 8 Venipuncture Center
- ☐ 9 Dialysis Facility *(hemodialysis and peritoneal dialysis)*
- ☐ 10 Procedure Room *(x-ray, EKG,etc)*
- ☐ 11 Clinical Laboratories
- ☐ 12 Autopsy/Pathology
- ☐ 13 Service/Utility *(laundry,central supply,loading dock,etc)*
- ☐ 16 Labor and Delivery Room
- ☐ 17 Home-care
- ☐ 14 Other, describe:______________________

7) Was the Source Patient Identifiable? (check one box only)

☐ 1 Yes ☐ 2 No ☐ 3 Unknown ☐ 4 Not Applicable

8) Was the Injured Worker the Original User of the Sharp Item? (check one box only)

☐ 1 Yes ☐ 2 No ☐ 3 Unknown ☐ 4 Not Applicable

9) The Sharp Item was: (check one box only)

- ☐ 1 Contaminated (known exposure to patient or contaminated equipment)
- ☐ 2 Uncontaminated (no known exposure to patient or contaminated equipment)
- ☐ 3 Unknown

was there blood on the device? ☐ 1 Yes ☐ 2 No

10) For What Purpose was the Sharp Item Originally Used? (check one box only)

- ☐ 1 Unknown/Not Applicable
- ☐ 2 Injection, Intra-muscular/Subcutaneous, or Other Injection through the Skin *(syringe)*
- ☐ 3 Heparin or Saline Flush *(syringe)*
- ☐ 4 Other Injection into *(or aspiration from)* IV injection site or IV Port *(syringe)*
- ☐ 5 To Connect IV line *(intermittent IV/piggyback/IV infusion/other IV line connection)*
- ☐ 6 To Start IV or Set up Heparin Lock *(IV catheter or winged set-type needle)*
- ☐ 7 To Draw Venous Blood Sample
- ☐ 8 To Draw Arterial Blood Sample
- ☐ 16 To Place an Arterial /Central Line
- ☐ 9 To Obtain a Body Fluid or Tissue Sample *(urine/CSF/amniotic fluid/other fluid, biopsy)*
- ☐ 10 Finger stick/Heel Stick
- ☐ 11 Suturing
- ☐ 12 Cutting
- ☐ 17 Drilling
- ☐ 13 Electrocautery
- ☐ 14 To Contain a Specimen or Pharmaceutical *(glass item)*
- ☐ 15 Other; Describe: ______________________

if used to draw blood was it? ☐ Direct stick? ☐ Draw from a Line?

11) Did the Injury Occur? (check one box only)

- ☐ 1 Before Use of Item *(item broke/slipped, assembling device, etc.)*
- ☐ 2 During Use of Item *(item slipped, patient jarred item, etc)*
- ☐ 15 Restraining patient
- ☐ 3 Between Steps of a Multi-step Procedure *(between incremental injections, passing instruments, etc.)*
- ☐ 4 Disassembling Device or Equipment
- ☐ 5 In Preparation for Reuse of Reusable Instrument *(sorting, disinfecting, sterilizing, etc.)*
- ☐ 6 While Recapping Used Needle
- ☐ 7 Withdrawing a Needle from Rubber or Other Resistant Material *(rubber stopper, IV port, etc.)*
- ☐ 16 Device Left on Floor, Table, Bed or Other Inappropriate Place
- ☐ 8 Other After Use-Before Disposal *(in transit to trash, cleaning, sorting, etc.)*
- ☐ 9 From Item Left On or Near Disposal Container
- ☐ 10 While putting Item into Disposal Container
- ☐ 11 After Disposal, Stuck by Item Protruding from Opening of Disposal Container
- ☐ 12 Item Pierced Side of Disposal Container
- ☐ 13 After Disposal, Item Protruded from Trash Bag or Inappropriate Waste Container
- ☐ 14 Other: Describe:______________________

12) What Type of Device Caused the Injury? (check one box only)
☐ Needles-Hollow Bore
☐ Surgical
☐ Glass

Which Device Caused the Injury? (check one box from one of the three sections only)

Needles *(for suture needles see "**surgical instruments**")*

☐ 1 Disposable Syringe
- ☐ a Insulin
- ☐ b Tuberculin
- ☐ c 24/25-gauge needle
- ☐ d 23-gauge needle
- ☐ e 22-gauge needle
- ☐ f 21-gauge needle
- ☐ g 20-gauge needle
- ☐ h Other

☐ 2 Pre-filled cartridge syringe (includes Tubex™ *, Carpuject ™* -type syringes)
☐ 3 Blood gas syringe *(ABG)*
☐ 4 Syringe, other type
☐ 5 Needle on IV line *(includes piggybacks & IV line connectors)*
☐ 6 Winged steel needle *(includes winged-set type devices)*
☐ 7 IV catheter stylet
☐ 8 Vacuum tube blood collection holder/needle *(includes Vacutainer™ *–type devices)*
☐ 9 Spinal or Epidural Needle
☐ 10 Unattached hypodermic needle
☐ 11 Arterial catheter introducer needle
☐ 12 Central line catheter needle *(cardiac, etc.)*
☐ 13 Drum catheter needle
☐ 14 Other vascular catheter needle *(cardiac, etc.)*
☐ 15 Other non-vascular catheter needle *(ophthalmology, etc.)*
☐ 28 Needle, not sure what kind
☐ 29 Other needle, please describe:_____________

Surgical Instrument or Other Sharp Items *(for glass items see "**glass**")*

☐ 30 Lancet *(finger or heel sticks)*
☐ 31 Suture needle
☐ 32 Scalpel, reusable *(scalpel, disposable code is 45)*
☐ 33 Razor
☐ 34 Pipette *(plastic)*
☐ 35 Scissors
☐ 36 Electro-cautery device
☐ 37 Bone cutter
☐ 38 Bone chip
☐ 39 Towel clip
☐ 40 Microtome blade
☐ 41 Trocar
☐ 42 Vacuum tube *(plastic)*
☐ 43 Specimen/Test tube *(plastic)*
☐ 44 Fingernails/Teeth
☐ 45 Scalpel, disposable
☐ 46 Retractors, skin/bone hooks
☐ 47 Staples/Steel sutures
☐ 48 Wire (suture/fixation/guide wire
☐ 49 Pin *(fixation, guide pin)*
☐ 50 Drill bit/bur
☐ 51 Pickups/Forceps/Hemostats/Clamps
☐ 58 Sharp item, not sure what kind
☐ 59 Other sharp item: Describe:_____________

Glass

☐ 60 Medication ampule
☐ 61 Medication vial *(small volume with rubber stopper)*
☐ 62 Medication/IV bottle *(large volume)*
☐ 63 Pipette *(glass)*
☐ 64 Vacuum tube *(glass)*
☐ 65 Specimen/Test tube *(glass)*
☐ 66 Capillary tube
☐ 67 Glass slide
☐ 78 Glass item, not sure what kind
☐ 79 Other glass item: Describe:_____________

12a) Brand/Manufacturer of Product: *(e.g. ABC Medical Company)* _____________________________

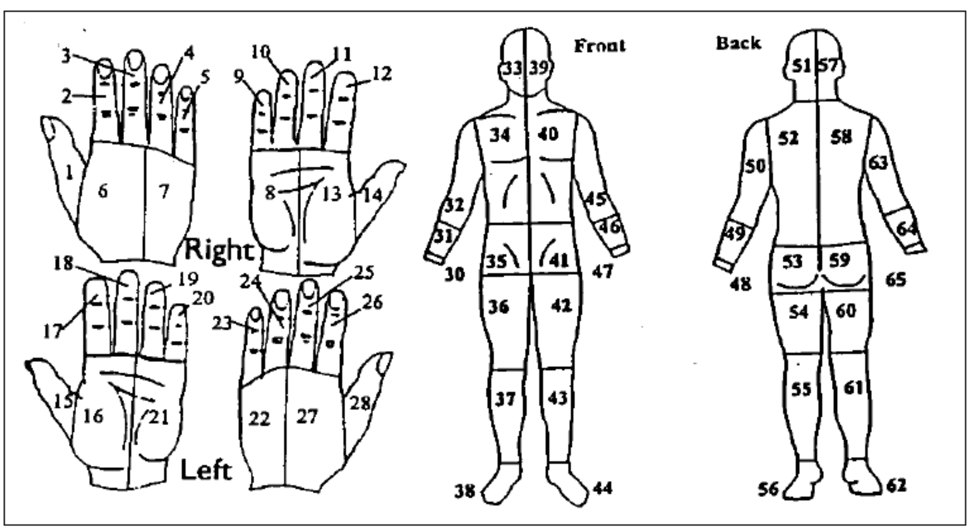
12b) Model:
☐ 98 Please Specify:_____________________________ ☐ 99 Unknown

13) If the Item Causing the Injury was a Needle or Sharp Medical Device, Was it a" Safety Design" with a Shielded, Recessed, Retractable, or Blunted Needle or Blade?
☐ 1 Yes
☐ 2 No
☐ 3 Unknown

13a) Was the Protective Mechanism Activated?
☐ 1 Yes, fully
☐ 2 Yes, partially
☐ 3 No
☐ 4 Unknown

13b) Did Exposure Incident Happen?
☐ 1 Before activation
☐ 2 During activation
☐ 3 After activation
☐ 4 Unknown

14) Mark the Location of the Injury in the box below:



15) Was the Injury?
- ☐ 1 Superficial *(little or no bleeding)*
- ☐ 2 Moderate *(skin punctured, some bleeding)*
- ☐ 3 Severe *(deep stick/cut, or profuse bleeding)*

16) If Injury was to the hand, did the Sharp Item Penetrate?
- ☐ 1 Single pair of gloves
- ☐ 2 Double pair of gloves
- ☐ 3 No gloves

17) Dominant Hand of the Injured Worker:
- ☐ 1 Right-handed
- ☐ 2 Left-handed

18) Describe the Circumstances Leading to this Injury *(please note if a device malfunction was involved)*:

____

____

____

____

19) For Injured Healthcare Worker: If the Sharp had no Integral Safety Feature, Do you have an Opinion that such a Feature could have prevented the Injury? ☐ 1 Yes ☐ 2 No ☐ 3 Unknown

Describe: ____

____

____

____

20) For Injured Healthcare Worker: Do you have an Opinion that any other Engineering Control, Administrative or Work Practice could have prevented the Injury? ☐ 1 Yes ☐ 2 No ☐ 3 Unknown

Describe: ____

____

____

____

Cost:

Lab charges (Hb, HCV, HIV, other)

__________ Healthcare Worker

__________ Source

Treatment Prophylaxis (HBIG, Hb vaccine, tetanus, other)

__________ Healthcare Worker

__________ Source

__________ **Service Charges** (Emergency Dept, Employee Health, other)

__________ **Other Costs** (Worker's Comp, surgery, other)

__________ **TOTAL** (round to nearest dollar)

Is this Incident OSHA reportable? ☐ 1 Yes ☐ 2 No ☐ 3 Unknown

If Yes, Days Away from Work? __________

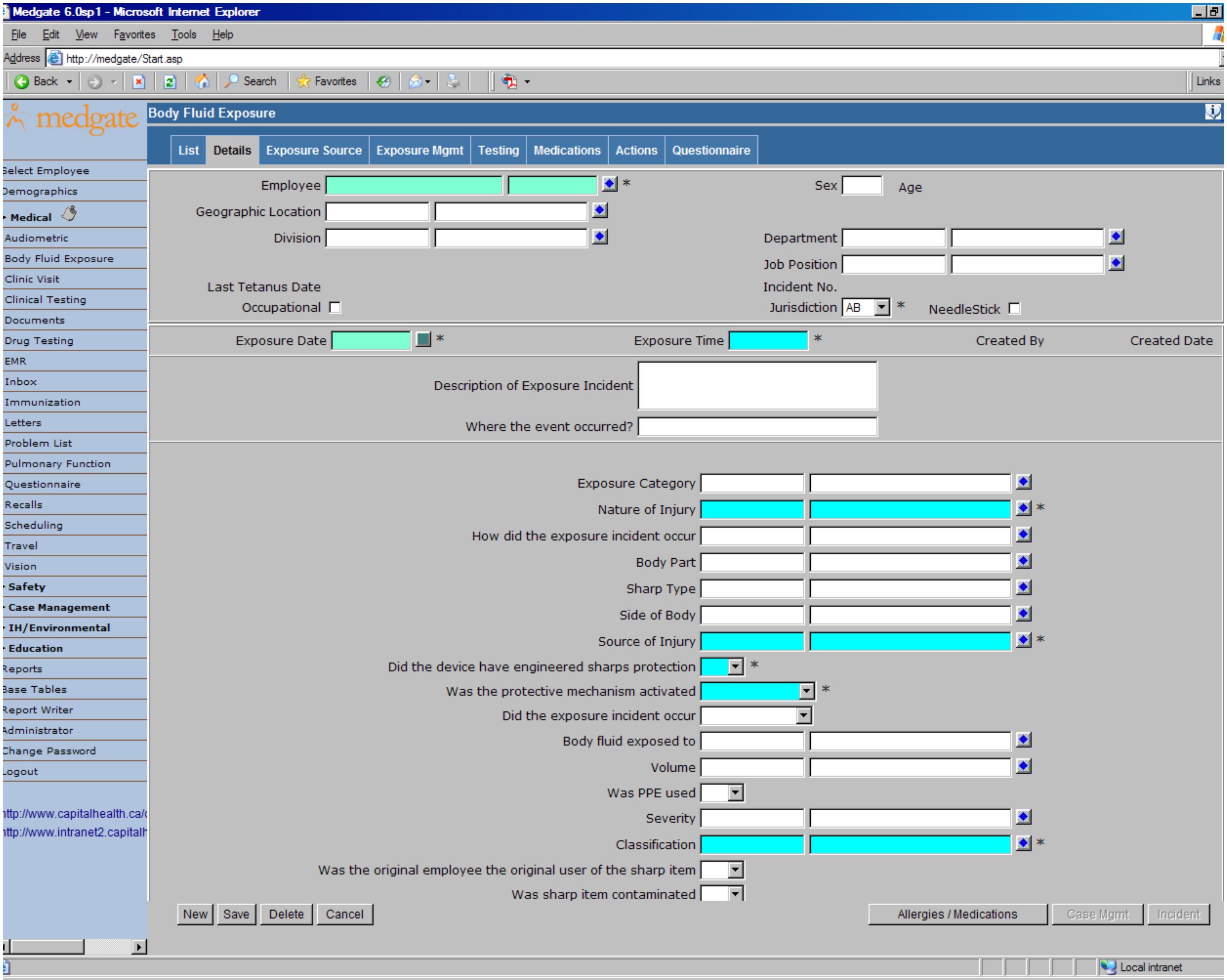
Days of Restricted Work Activity? ___________

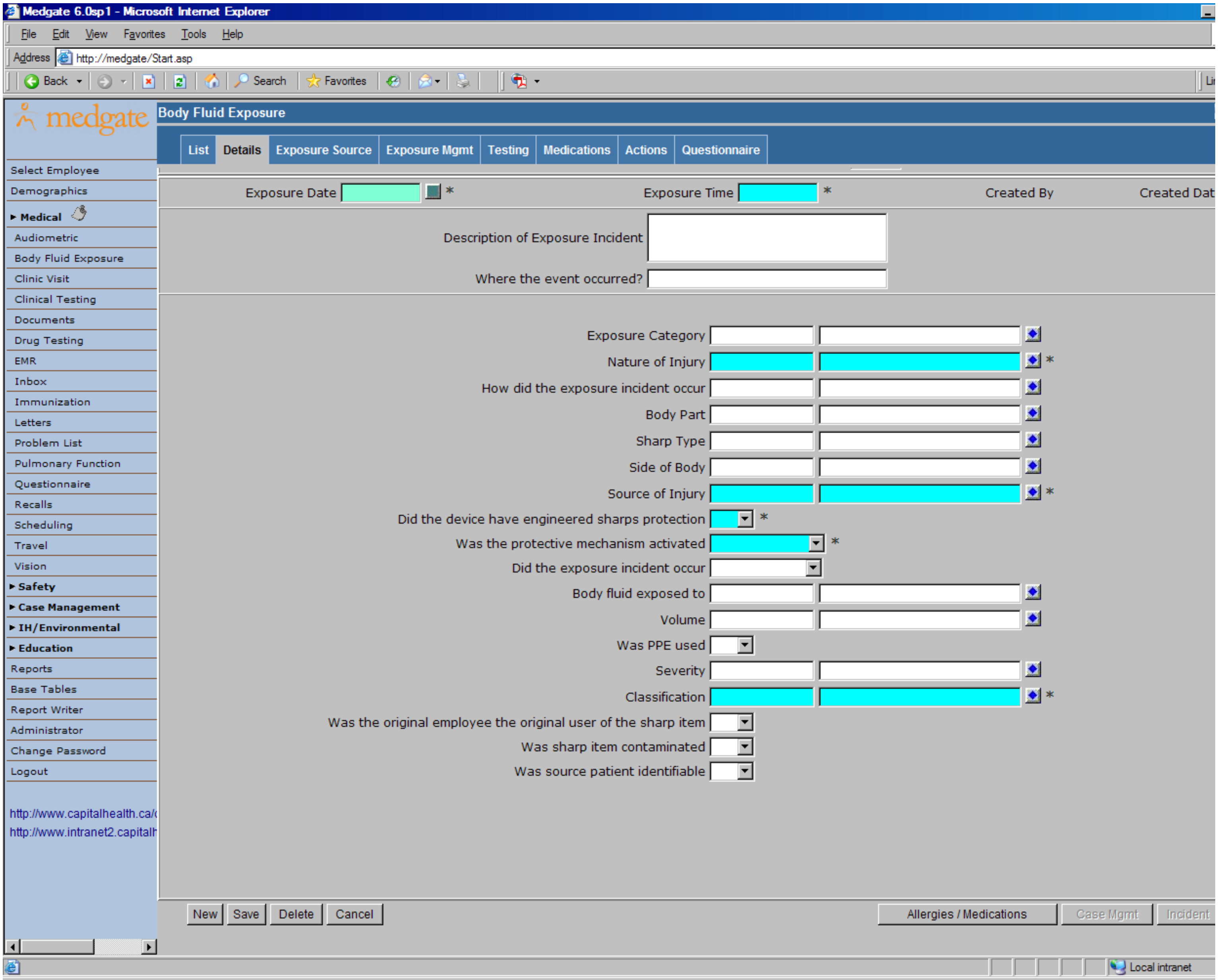
Does this incident meet the FDA medical device reporting criteria? (Yes if a device defect caused serious injury necessitating medical or surgical intervention, or death occurred within 10 works days of incident.)

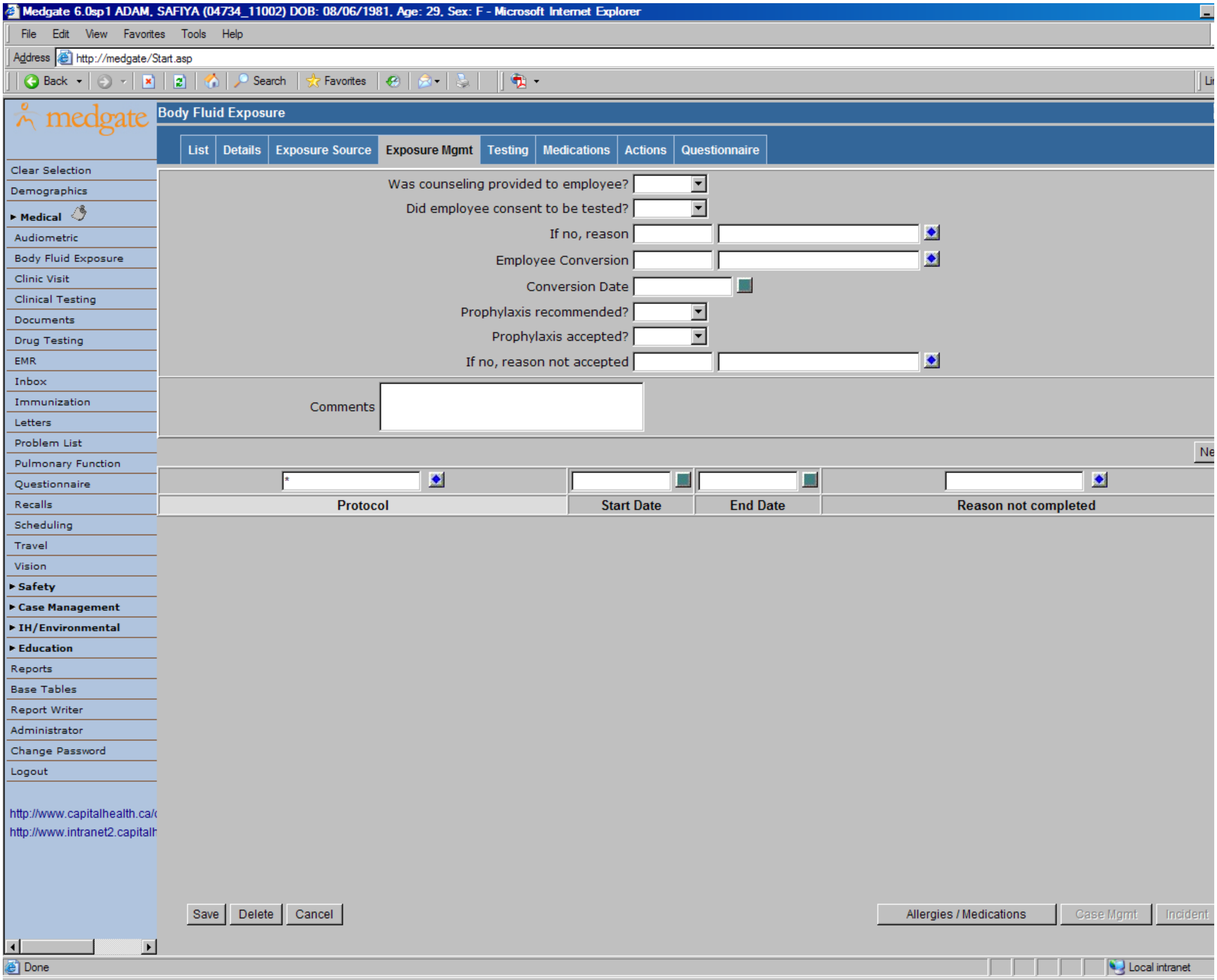
☐ 1 Yes *(If Yes, follow FDA reporting protocol.)* ☐ 2 No

* Tubex™ is a trademark of Wyeth Ayers; Carpuject™ is a trademark of Sanofi Winthrop; VACUTAINER™ is a trademark of Becton Dickinson. Identification of these products does not imply endorsement of these specific brands.

Appendix 4: MedGate System Screenshot




Medgate 6.0sp1 - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://medgate/Start.asp
Back Search Favorites
medgate
Body Fluid Exposure
List Details Exposure Source Exposure Mgmt Testing Medications Actions Questionnaire
Select Employee
Demographics
Medical
Audiometric
Body Fluid Exposure
Clinic Visit
Clinical Testing
Documents
Drug Testing
EMR
Inbox
Immunization
Letters
Problem List
Pulmonary Function
Questionnaire
Recalls
Scheduling
Travel
Vision
Safety
Case Management
IH/Environmental
Education
Reports
Base Tables
Report Writer
Administrator
Change Password
Logout
Exposure Date *
Exposure Time *
Created By
Description of Exposure Incident
Where the event occurred?
Exposure Category
Nature of Injury *
How did the exposure incident occur
Body Part
Sharp Type
Side of Body
Source of Injury *
Did the device have engineered sharps protection *
Was the protective mechanism activated *
Did the exposure incident occur
Body fluid exposed to
Volume
Was PPE used
Severity
Classification *
Was the original employee the original user of the sharp item
Was sharp item contaminated
Was source patient identifiable
New Save Delete Cancel
Allergies / Medications
Case Mgmt
Incident
Local intranet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Body Fluid Exposure
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Problem List
Pulmonary Function
Questionnaire
Recalls
Scheduling
Travel
Vision
Safety
Case Management
IH/Environmental
Education
Reports
Base Tables
Report Writer
Administrator
Change Password
Logout
Was counseling provided to employee?
Did employee consent to be tested?
If no, reason
Employee Conversion
Conversion Date
Prophylaxis recommended?
Prophylaxis accepted?
If no, reason not accepted
Comments
Protocol
Start Date
End Date
Reason not completed
Save Delete Cancel
Allergies / Medications
Case Mgmt
Incident
Done
Local intranet

Appendix 5: Letter of Ethical Approval

Approval Form

Date:	September 6, 2011
Principal Investigator:	Jeremy Beach
Study ID:	Pro00022282
Study Title:	Evaluating the Effectiveness of Alberta Legislation for Reducing Sharp Object Injuries among Hospital based Health Care Workers - pilot study
Approval Expiry Date:	September 4, 2012

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application, including revisions received August 31, 2011, has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services administrative approval, and operational approval for areas impacted by the research, should be directed to the Alberta Health Services Regional Research Administration office, #1800 College Plaza, phone (780) 407-6041.

Sincerely,

Dr. Jana Rieger
Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).