Writing a Standard Operating Procedure for the Philadelphia Fire Department
Emergency Response Employees’ Mucous Membrane and Non-intact Skin
Exposures to BBP and OPIM

Christine Fung, Master of Public Health Candidate

June 14, 2012

A Community Based Master’s Project Presented to the Faculty of Drexel University School of Public Health in Partial Fulfillment of the Requirement for the Degree of Master of Public Health
ACKNOWLEDGEMENTS

Many thanks to the following people and organizations who helped make this project a success

Advisor: Curtis E. Cummings MD, MPH
Preceptor: Captain Nancy Belsky, FSP ECO
Jennifer Taylor, PhD, MPH
Igor Burstyn, PhD
Fire Commissioner Lloyd Ayers
The Philadelphia Fire Department
Cathy Nguyen
Alice Chen
Kevin Houck
# Table of Contents

Abstract......................................................................................................................4

Introduction and Statement of the Problem.........................................................5

Background and Significance.............................................................................7

Specific Aims......................................................................................................13

Research Design and Methods.......................................................................14

Results..................................................................................................................20

Discussion..........................................................................................................23

Conclusions and Recommendations.................................................................29

References..........................................................................................................30

List of Appendices

Appendix A............................................................................................................36

Appendix B............................................................................................................37

Appendix C..........................................................................................................49

Appendix D..........................................................................................................57
ABSTRACT

Writing a Standard Operating Procedure for the Philadelphia Fire Department Emergency Response Employees’ Mucous Membrane and Non-intact Skin Exposures to BBP and OPIM

Christine Fung MPH(c)
Curtis E. Cummings MD MPH¹, Nancy Belsky Capt. FSP ECO²
¹Drexel University School of Public Health, ²Philadelphia Fire Department Infection Control Office

Background: Emergency Response Employees (EREs) comprise firefighters and paramedics and are at risk for bloodborne infections such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). EREs increase their risk when they are performing basic and advanced life saving skills. Some EREs might be at increased risk for developing HBV infection if they are not immune when exposed. Other risk factors include splashes of blood or body fluids from patients.

Objectives: To evaluate and analyze the Philadelphia Fire Department (PFD) EREs exposure to bloodborne pathogens (BBP) and other potentially infectious materials (OPIM), and to compose a standard operating procedure (SOP) specific to the PFD.

Methods: A retrospective study was conducted to analyze the PFD EREs’52 mucous membrane and 38 non-intact skin exposures to BBP and OPIM from 2001 to 2011. The data analysis involved examining the causes and risk factors that affect the occurrence of mucous membrane and non-intact skin exposures such as age, years of experience, paramedic activities, and behavioral and environmental factors. In addition, the rates of mucous membrane and non-intact skin exposures were calculated according to call volume.

Results: Our study found PFD paramedics non-intact skin and mucous membrane exposures were 21.1 and 6.25 times (respectively) lower compared to other studies. The mucous membrane exposure rate was 194/1,000,000 calls and the non-intact skin exposure rate was 156/1,000,000 calls. Mucous membrane exposures occurred most often on Mondays, Wednesdays and Fridays. Non-intact skin exposures occurred most often Wednesdays and Fridays. Trends in paramedic activities or environmental factors related to mucous membrane and non-intact skin exposures were exhibited. Combative patients spat in the paramedics’ eyes on 24 different occasions, and combative patients scratched, bit or cut paramedics11 times. Fluid splash from endotracheal tubes and nasal intubation into the paramedics’ eyes occurred 11 times. Gloves ruptured, torn or removed occurred 11 times. Behavioral factors for mucous membrane and non-intact skin exposures included assault and removal of the paramedics’ mask by patients. To date, there has been no seroconversion to HBV, HCV, and HIV among the EREs.

Conclusion: Although there have been no seroconversions to HBV, HCV, and HIV via non-intact skin and mucous membrane exposures, these bloodborne pathogens are of serious concern to the PFD. EREs are advised to complete their HBV vaccine series and should use appropriate personal protective equipment and take extra precautions to minimize the risk of a bloodborne pathogen exposure.
Introduction

Emergency response employees (EREs) comprise “firefighters, law enforcement officers, paramedics, emergency medical technicians and other persons…who in the course of professional duties, respond to emergencies in the geographic area involved” (CDC, DHHS, and Public Health Service, 1994, 13424). For the purposes of this study, emergency response employees comprise firefighter-emergency medical technicians (firefighter-EMT) and paramedics. The EREs are at risk of sustaining non-intact skin and mucous membrane exposures to bloodborne pathogens (BBP) and other potentially infectious materials (OPIM). At the Philadelphia Fire Department (PFD), there have been 90 reported cases of non-intact skin and mucous membrane exposures from 2001 to present.

Overall significance of the study

The purpose of this project is to evaluate and analyze the PFD EREs’ exposure to BBP and OPIM, and to compose a standard operating procedure (SOP) specific to the PFD. The SOP will inform the EREs how to prevent mucous membrane and non-intact skin exposures through the use of personal protective equipment (PPE), and engineering and work practice controls.

This study has an overall significance for the EREs because very few studies have focused on prehospital workers. The EREs work in unpredictable environments that increase their risk for exposure compared to controlled hospital settings (Leiss et al., 2006). There is limited information about the EREs’ non-intact skin and mucous membrane exposures. One study found that non-intact skin exposures were underreported by paramedics who did not consider their abraded skin and “contact with the patient’s blood to be serious enough to warrant reporting” (NIOSH, 2010). Overall, little is known about the EREs’ risks and risk factors for non-intact skin and mucous membrane exposures (Leiss, 2009). Therefore, this study provides insight and analyzes causes and risk factors for the exposures such as paramedic activities and environmental circumstances (e.g., broken glass and jagged metal, drug paraphernalia, injured or hostile patients, and patients with altered mental status).
Statement of the problem

The problem addressed by this study is mucous membrane and non-intact skin exposures in EREs, and their need for a written SOP. This study examines the PFD EREs’ potential exposure to blood and body fluids that might cause exposure to hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), and OPIM. OPIM include cerebral spinal fluid (CSF), synovial fluid, peritoneal fluid, pleural fluid, amniotic fluids and any other body fluid that has gross visible blood.

Significance of the problem

EREs can have non-intact skin and mucous membrane exposures to bloodborne infectious agents. Some of the factors that increase EREs’ risk for an exposure include paramedic activities, environmental circumstances and mechanism of exposure. A study of U.S. paramedics revealed that an estimated 60% of mucosal exposure events were caused by the “patients vomiting, spitting or coughing up blood or fluid containing blood” (Leiss, Sousa and Boal, 2009, 141). Additionally, more than 40% of non-intact skin exposure events were caused by “patients being uncooperative or combative” (Leiss, Sousa and Boal, 2009, 141). In addition to infections, non-intact skin and mucous membrane exposure to BBP and OPIM can cause emotional and psychological effects. It can also generate costs for the PFD and the City of Philadelphia because of medical laboratory tests, treatments, and follow-up care (Twitchell, 2003).
Background and Significance

Literature review

EREs are at risk for bloodborne infections, particularly HBV, HCV and HIV. Over 20% of the 150,000 paramedics in the U.S. encounter exposure to blood annually (Leiss, Sousa & Boal, 2009, 139). Specifically, U.S. paramedics experience approximately “25,000 non-intact skin exposures” yearly (Leiss et al., 2009, 884). “Non-intact skin is skin that is broken, cut or abraded” (Leiss et al., 2009, 884). One study conducted a mail survey and examined the paramedics’ risk of blood exposure to non-intact skin over a 12 month period. It determined that the risk was 8.7% (Leiss et al., 2009). The study also noted that the “incidence rate for non-intact skin exposure in U.S. paramedics was twice the rate of either needlesticks or blood exposures to the mucous membrane of the eyes, nose or mouth” (Leiss, 2009, 884).

In addition to non-intact skin exposures, Leiss, Sousa, and Boal (2009) analyzed mucous membrane exposures. They reported that 4.7% were to the nose, 71.8% were to the eyes and 23.5% were to the eyes and nose. Approximately 50% of the mucous membrane exposure events occurred “when the paramedics resuscitated the patients” (Leiss, Sousa & Boal, 2009, 140). About 20% of the events occurred when the patient was being restrained by paramedics. Therefore, the EREs’ risk for occupational exposure increases each time they are in contact with patients, perform medical procedures and transport them.

EREs’ risk for exposure to HBV, HCV and HIV is increased when they perform basic and advanced life saving skills (i.e., intubation, administration of intravenous (IV) fluids and medication) in the back of a moving ambulance, enclosed area or confined space with poor lighting (Matthews et al., 2008). They also increase their risk by working and treating patients in urban areas. An older study stated that, in some areas, the “rate of HIV infection among ED patients is reported 8% and increasing. The rate among urban trauma victims alone may be as high as 16 %” (Eustis, Wright, Wrenn, Fowlie, & Slovis, 1993, 514). A more recent source estimated the range of HIV infection in ED patients to be 2-17% (Rothman, 2003). Some of the patient-related risk factors include blood splashes or body fluids from combative head injury, diabetic or seizure patients and intravenous drug users, as well as patients’ vomit, saliva or cough
(Matthews et al., 2008; NIOSH, 2010). The risk could be reduced by the using proper personal protective equipment (PPE).

According to the Centers for Disease Control and Prevention (CDC), numerous individuals with HBV, HCV and HIV are unaware of their disease and could potentially transmit their infection to other people. One study indicated that some EREs have higher HBV risk due to a higher prevalence of HBV infection in the community. “For example, a study of Salt Lake City fire-rescue personnel reported a seroprevalence of 0.6% with a community prevalence of 8.0/100,000, whereas in Seattle, the seroprevalence of the fire-rescue personnel was 25%, with a community prevalence of 60.4/100,000” (Carillo, Flemming & Lee, 1996, 2). In another study, the HIV seroprevalence was examined in the hospital emergency department in three major US cities. The “HIV seroprevalence rates in patients who arrived by ambulance were 8.3, 7.7 and 4.1 per 100 patient visits” (Marcus et al., 1995, 777).

The CDC estimated that “1.2 million people have chronic hepatitis B” (CDC, 2010). Each year about “40,000 people become infected with HBV” (CDC, 2010). Hepatitis B is a “contagious liver disease that results from an infection with the hepatitis B virus” (CDC, 2010). An infected person can develop acute or chronic hepatitis B. Acute hepatitis B refers to a new infection during the first 6 months after an exposure has occurred (CDC, 2010). In contrast, chronic hepatitis B refers an active infection for a long period of time. Some individuals with acute and chronic hepatitis B might be asymptomatic while others might develop symptoms. For acute hepatitis B, some of the symptoms are “fever, abdominal pain, joint pain, jaundice, vomiting, and nausea, and gray-colored bowel movements” (CDC, 2010). Chronic hepatitis B can lead to hepatic cirrhosis, liver failure and cancer.

EREs’ risk for HBV infection is increased by “two-to-six fold compared to the general population” (Kunches, Craven, Werner, & Jacobs, 1983, 269). Some EREs are at risk for a bloodborne infection because they have not completed their HBV vaccine series at time of hire. The transmission rate for HBV infection by the mucutaneous route is high among some unvaccinated healthcare workers (Leiss et al., 2006, 723). “The average risk of HBV in an unvaccinated healthcare worker is approximately 30%” (Twitchell, 2003, 42). In the PFD, the Fire Service Paramedic Exposure Control Officer (ECO) becomes concerned when there is no identified source patient. A source patient is an individual who had medical treatment or
assistance from EREs and could potentially expose the EREs to a bloodborne infection. The ECO determines whether the reported exposure meet the criteria for a bloodborne pathogen exposure. Next, physicians determine whether the exposure is significant or non-significant. If the exposure is determined to be significant, the ECO then works through a legal process of obtaining source patient results. If the source patient is found “positive for both HBsAg and HBeAg, [the EREs have a] risk of developing clinical hepatitis 22% to 31%” (Twitchell, 2003, 42).

Approximately “3.2 million individuals in the United States have HCV” and about “17,000 individuals become infected each year” (CDC, 2010). Similar to hepatitis B, hepatitis C is “a liver disease that results from an infection with hepatitis C virus” (CDC, 2010). A person can also develop an acute or chronic hepatitis C virus and be asymptomatic. An individual with acute hepatitis C can develop symptoms similar to those of acute hepatitis B. For chronic hepatitis C, an individual can experience “liver problems such as liver damage, cirrhosis, liver failure or liver cancer” (CDC, 2010).

A study of paramedics revealed that the “transmission rate for HCV by the mucocutaneous route was estimated at 0.4%, greater than the HIV needlestick transmission rate of 0.3 %” (Leiss et al., 2006, 723). In the healthcare worker population, HCV transmission from mucous membrane, fluid or tissue exposure to blood is rare. There has been 1 documented case of HCV transmission through non-intact skin (Saiman, Siegel and the Cystic Fibrosis Foundation Consensus Conference on Infection Control Participants, 2003). An epidemiological study of HCV suggested that “environmental contamination with blood containing HCV is not a significant risk for transmission in the healthcare setting” (CDC, 2001, 6).

Among EREs, the Philadelphia Firefighters Union performed an HCV screening of 2146 workers, both active and retired, in 1999. After CDC review, the screening revealed that 3% of the EREs tested positive for HCV antibodies (Boal, Hales & Ross, 2005, 242). However, the screening did not indicate whether the HCV infection was related to an occupational or non-occupational exposure. Even though the risk for HCV is low, one study reported that the expected HCV seroconversion is “between 5.8 and 118.9 per 100,000 employee-years for EMT-paramedics [and] 3.4 to 33.7 for firefighter-EMTs in the U.S.” (Boal, Hales & Ross, 2005, 240).
An estimated 1.2 million individuals in the U.S. have HIV and about 50,000 become infected with HIV annually (CDC, 2011). The risk for HIV infection from a mucous membrane exposure is estimated to be 0.09%. The non-intact skin exposure risk has not been quantified, but has been stated to be much lower than the mucous membrane exposure risk for HIV transmission. Additionally, “the risk for HIV transmission after the exposure to fluids or tissues other than infected blood has not been quantified but is probably considerably lower than for blood exposure” (CDC, 2001, 8). Since 1981 there have been 57 documented cases of occupationally acquired HIV infection in the U.S. Of these cases, 0 have been paramedics and EMTs. Further, there have been 138 cases of “possible occupational transmission of HIV/AIDS” (CDC, 2001). These cases were considered possible occupational transmission because they were not documented, proved or disproved as occupational. Of the 138 cases, 12 were paramedics or EMTs (Boal, Hales, and Ross, 2005).

Standard precautions are appropriate measures to reduce transmission of bloodborne pathogens and infectious diseases to staff and patients that all healthcare professionals should take. These include use of personal protective equipment (PPE) (Tarrac, 2008; Harris and Nicolai, 2010). As a barrier between the EREs and blood or OPIM, PPE can reduce the EREs’ risk for bloodborne infections. Ninety-three percent of U.S. paramedics reported that mask and eyewear significantly minimized blood exposure. Paramedics also stated that PPE effectively protected them from bloodborne infections. However, 25% to 33% of paramedics report that “masks, eyewear and safety needles” affect their ability to perform procedures (Matthews et al., 2008, 746; Eustis, 1995; Harris, 2010). Other reasons PPE were not worn were insufficient time to don PPE, difficulty with using PPE, or faulty PPE (Matthews et al., 2008; Bentley, 1996). For example, a face shield or goggle does not provide full protection due to “unprotected gaps” or insufficient “seal above the eyes” (Bentley, 1996, 1). Bentley (1996) suggested better and improved PPE to protect the healthcare workers whereas other studies recommended more education and training on the use of PPE or change in work practices (Matthews et al., 2008; Department of Health and Human Services, 2010; Rischitelli, Lasarev, McCauley, 2005).

Each HBV, HCV and HIV infection can cost over one million dollars for medical treatments and procedures, laboratory testing, follow-ups, physician’s evaluation, and lost wages (Twitchell, 2003, 38). Also, follow-up care for an exposure that was considered to be high risk
but did not result in a bloodborne infection can cost over $3000 per injury (Twitchell, 2003). Moreover, the costs in human terms are immeasurable. After an exposure, the EREs may experience psychological or emotional problems that could affect his/her duties (Twitchell, 2003).

**Conceptual models or theoretical frameworks**

This project developed an SOP for prevention of mucous membrane and non-intact skin exposures. The SOP utilized or incorporated laws, guidelines, recommendations and procedures from the following sources: the Occupational Safety and Health Administration (OSHA), the Centers for Disease Control and Prevention (CDC), the National Institute for Occupational Safety and Health (NIOSH), the National Firefighter Protection Association (NFPA) and the Philadelphia Fire Department Infection Control Office (PFD ICO). The laws, guidelines and recommendations utilized include but are not limited to the OSHA Act of 1970, OSHA’s Access to Employee Exposure and Medical Records Standard (29 CFR 1910.1020), OSHA’s Bloodborne Pathogens Standard (29 CFR 1910.1030), PA Act 96 (also known as the Bloodborne Pathogens Standard Act), NFPA’s Guide to Managing an Emergency Service Infection Control Program, CDC guidelines titled “Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HBV, HCV, and HIV and Recommendations for Postexposure Prophylaxis” and “Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HIV and Recommendations for Postexposure Prophylaxis,” and procedures used by or published by the PFD ICO.

**Contribution of project to the PFD**

An analysis of causes and risk factors provided insight on how mucous membrane and non-intact skin exposures occurred, and helped guide the development of an SOP for the PFD. The SOP will inform and educate the PFD EREs regarding the engineering and work practice control methods and specific personal protective equipment (PPE) to use in specific situations to prevent mucous membrane and non-intact skin exposures to BBP and OPIM. The intended impact of the SOP was to reduce the number of mucous membrane and non-intact skin exposures, minimize the psychological stress and economic costs, and decrease the risk for bloodborne infections and their adverse health effects.
This project did not include an analysis and development of an SOP for airborne pathogens such as measles, tuberculosis, and chicken pox. In addition, this project did not include droplet transmission such as diphtheria, novel influenza viruses, Neisseria meningitis, rubella, mumps, Pertussis, plague (pneumonic) and SARS-CoV although these exposures are also of concern for the PFD. It did not include vector control, waterborne pathogens and fire ground exposures such as urine and fecal matter found in patients’ homes.
Specific aims of the study

The purpose of the study is to analyze the mucous membrane and non-intact skin exposures and to create an SOP to reduce the mucous membrane and non-intact skin exposures to BBP and OPIM in the PFD. These objectives were achieved through the following specific aims:

- Examine causes of mucous membrane and non-intact skin exposures in the PFD (i.e., paramedic activities, environmental circumstances and use of PPE)
- Determine risk factors that predict the occurrence of mucous membrane and non-intact skin exposures, i.e., age, years of experience, and shift (time of day worked)
- Develop an SOP for prevention of mucous membrane and non-intact skin exposures that was site specific to the PFD
Research design and methods

Overview of study design

A retrospective study was conducted to examine the PFD EREs’ mucous membrane and non-intact skin exposures to BBP and OPIM over a ten year period from 2001 to 2011. The EREs’ records were gathered by the exposure control officer (ECO) at the PFD ICO. The records included information that pertained to the cause and circumstances of mucous membrane and non-intact skin exposures, which was utilized in the data analysis. The data analysis involved examining the causes and risk factors that affect the occurrence of mucous membrane and non-intact skin exposures. After the analysis, an SOP was created for use by the PFD EREs. The SOP protocols will inform the EREs on how to prevent mucous membrane and non-intact skin exposures.

Subjects

Sample definition: At present, there are 1,333 firefighter-EMTs and 234 paramedics in the PFD. Subjects for this study were all certified PFD paramedics who reported mucous membrane and non-intact skin exposure incidents to the ECO at the PFD ICO. Subjects excluded from study were firefighter-EMTs, administrative staff and civilians.

Sample size: In this study, 52 cases of mucous membrane exposures and 38 non-intact skin exposures with 6 simultaneous exposures with both mucous membrane and non-intact skin were analyzed.

The information on the mucous membrane and non-intact skin exposure events was compiled from May 16, 2001 to December 31, 2011 by the ECO. May 16, 2001 was the start date because the PFD ICO was established on that date. Data since May 2001 provided more information on mucous membrane and non-intact skin exposures compared to earlier data. The data contain descriptions of the environmental circumstances or acts that led to the EREs’ non-intact skin and mucous membrane exposures, source patient testing, medical treatment received and the physician’s classification of the exposure (i.e., significant, non-significant). December 2011 was the end date for the study.
Source(s) of subjects: All PFD members who were previously entered into the database because of exposure or potential exposure.

Recruitment and enrollment procedures: All PFD members were eligible. However, this study only focused on PFD members in the ICO database. No recruitment or enrollment was performed. Analysis was restricted to paramedics.

This is a retrospective study that focused on the EREs and their mucous membrane and non-intact skin exposures to BBP and OPIM. The data were sanitized and de-identified by the ECO.

Data collection methods and procedures

Prior to this study, the ECO abstracted the EREs’ bloodborne pathogen exposure (BBPE) records and injury reports to create a database of the reported exposures. The data used in this study were de-identified for review, and were password protected and kept at the PFD ICO.

Variable definition and measurement: In this project, 19 variables were studied. The variables were from the PFD ICO existing data and included the following: date of birth, age, appointment date, longevity date, date of exposure or event, day, time, rank, battalion, medic unit/platoon, years of experience, non-intact skin (blood or OPIM exposure), eye/ mucous membrane splash or contact with blood or OPIM, explanation or other comment, source patient testing, healthcare personnel (HCP) final disposition, physician’s determination, ERE seroconversion post exposure or discharge, use of PPE, and call volume. The information on PPE use was abstracted from existing records.

- **Date of birth** was used to calculate paramedics’ age.
- **Age** was calculated at the time of exposure event.
- **Appointment date** was the date of hire. It was used to calculate the years of experience prior to exposure.
- **Longevity date** was the original appointment (date of hire). The longevity date indicates any discrepancy between the original appointment (date of hire) versus a newer appointment (date of hire) if an exposure occurred prior to the newer appointment (date
of hire). In addition, the longevity date was used to calculate the years of experience prior to exposure.

- **Rank** was recorded as Fire Service Paramedic (FSP) or Fire Paramedic (FP). FSPs were paramedics hired by the PFD who had previously certified by the Pennsylvania Department of Health. FPs were firefighters who were trained to become paramedics by the PFD. They later became certified by the Pennsylvania Department of Health as EMT-paramedics. [Note: Neither firefighter-EMTs nor FSP (EMT-paramedics) has dual role responsibilities within the PFD.]

- **Battalion** comprised engine or ladder company and medic units

- **Medic unit/platoon** was either staffed with 2 paramedics or 1 paramedic and 1 firefighter-EMT.

- **Date of exposure** was recorded as month, day and year

- **Day** was entered as day of the week and was analyzed together with mucous membrane and non-intact skin exposures

- **Time of day** was used to determine the specific time in which the mucous membrane and non-intact skin exposures were more likely to occur and time was be entered as the hour.

- **Years of experience** was recorded as the number of years the EREs had been employed at the PFD and was used to determine whether mucous membrane and non-intact skin exposures were associated with years of experience.

- **Use of PPE** was open-ended and comprised the following but was not limited to: fluid shields, goggles, gloves and masks.

- **Healthcare personnel (HCP) final disposition** was discharge or seroconversion after evaluation, treatment, and follow-up. It is the final outcome of the case.

- **Physician determination of exposure** was indicated as significant or non-significant. Significant exposure was defined as “direct contact with a patient’s blood or body fluids (i.e., needlestick or cut with a sharp object, contact of mucous membrane or contact with non-intact skin) during the course of rendering healthcare or occupational services” (SOP). Non-significant exposure was defined as an exposure that did not meet the definition of a significant exposure as defined by OSHA’s Bloodborne Pathogen Standard.
• **Source patient testing** was performed whenever possible based on the physician’s determination of significance of exposure.

• **Date of exposure** was recorded as the month, day, and year the exposure occurred.

• **Explanations or comments on exposures** were used to determine the behavioral and environmental factors that may have contributed to the mucous membrane or non-intact skin exposure. Explanations were read to determine if exposures involved the following: handling combative patients: patients spat blood or salvia at paramedics; handling combative patients: patients scratched, bit or cut paramedics; dextrose stick; fluid from endotracheal tube (ETT) or nasal intubation splashed to paramedics’ mucous membrane; gloves ruptured, torn, or removed; cannulating a vein; combative patients pulling non-rebreather (NRB) mask off face and blood splashed to paramedics’ mucous membrane; IV or IV catheter; open wound; cut; contact with blood on stretcher; performed cardiopulmonary resuscitation (CPR); resuscitating patient with bag valve mask (BVM) and blood sprayed to paramedics’ mucous membrane.

• **ERE seroconversion** was defined as an ERE who had no bloodborne infection at baseline testing postexposure and could have converted. To date, there have been no seroconversions.

• **Call volume** is the number of EMS runs, and was used to determine the rate of mucous membrane and non-intact skin exposures.

• [Note: Possible exposure was defined as a hospital reporting an exposure until the ECO investigates and rules out exposure risk as per the Ryan White Act. A reportable incident non-exposure was defined as an ERE who believed he or she had an exposure and reported it to the ECO. After the investigation, disease and/or exposure was ruled out.]

**Instrument development and use preparation:** Since 2001, the data have been collected by the ECO. The ECO de-identified the PFD’s existing Excel spreadsheets and merged them for this project. No new instruments were used.

**Data management and file development activities:** The project used data previously compiled by the ECO. The ECO has abstracted data from the EREs’ medical records and exposure reports, and has de-identified data prior to the study.
Description and precautions to be taken regarding methodological weaknesses and potential problems: This project used data that have been collected and reported to the ECO. The data do not include all exposure incidents but only those that have been reported. Therefore, there was a possibility of underreporting in this study. On the other hand, there could have been over-reporting of exposures due to perceived risk for bloodborne infection. Some EREs reported incidents that were not actual exposures with a risk for bloodborne infection such as blood on intact skin. This stems from anxiety, emotional and psychological distress from the job and the event. Some EREs’ reports could be inaccurate.

Analysis Plan

Specific Aim 1: Examined the causes of mucous membrane and non-intact skin exposures in the PFD. A qualitative assessment was conducted reviewing the exposure reports generated and compiled by the ECO.

Specific Aim 2: Determined the risk factors that affect the occurrence of mucous membrane and non-intact skin exposures. A quantitative assessment was performed using Statistical Package for the Social Sciences (SPSS™) and Microsoft Excel™. The quantitative assessment comprised rates of exposure, numbers and percentages, tables and graphs.

Specific Aim 3: Developed an SOP for prevention of mucous membrane exposure that was site specific to the PFD. This objective was achieved by analyzing the 46 cases of mucous membrane exposures, 32 cases of non-intact skin exposures and 6 simultaneous exposures (that included mucous membrane and non-intact skin) from May 16, 2001 to December 31, 2011. An integration of the federal, state and local laws, and the analysis from this study provided a premise for writing protocols addressing specific issues or situations to prevent mucous membrane and non-intact skin exposures. The SOP adhered to the PFD’s format and guidelines as indicated in Directive #1: Directive System. The SOP included the “subject, purpose, definitions, responsibility, procedure, guidelines and pertinent information” (PFD, 2008). The SOP was utilized for implementing procedures as well as educating, training and disciplining EREs.
**Human Subjects Consideration**

This was a retrospective study. The use of human subjects was limited to previously collected, de-identified data. No new data were collected. All existing data abstracted from the human subjects’ records and exposure reports were previously compiled by the ECO. The data used for this project did not contain identifiers but contained information pertaining to the mucous membrane and non-intact skin exposures, causes and risk factors. The principal investigator and co-investigators had authorization to access the data. The data were stored electronically in the PFD ICO and were password protected. The ECO and investigators received HIPPA training. All information in the data remained confidential.

In addition, this study did not involve recruiting human subjects, did not require obtaining informed consent, and involved only minimal risk. Lastly, the SOP will be beneficial to the EREs in the PFD. The SOP will educate the EREs on work practice control techniques and specific PPE to use in particular situations to minimize their exposures to HBV, HCV, HIV and OPIM.
Results

Trends and outcomes were evaluated. Of the 52 mucous membrane exposures, 38 were determined by physicians to have been exposures of clinical significance, 12 were determined to be non-significant exposures and 6 were unknown. Of the 38 non-intact skin exposures, 19 were determined by physicians to have been exposures of clinical significance, 6 were determined non-significant exposures and 13 were unknown. See Figures 1 and 2, and Table 1 in Appendix B, graphics.

Testing was conducted on 25 source patients and analyzed in this study. Of the 25, 18 (72%) tested positive: 9 positive tests for HCV, 7 positive tests for HBV, and 2 for HIV. One source patient had both HBV and HCV positive tests. See Table 2 in Appendix B.

Call volume

Incidence rates were calculated according to call volume. The average annual call volume (arithmetic mean) over the study period was 243,182.1 calls. The incidence rate of eye/mucous membrane exposure was 194/1,000,000 calls and the incidence rate for non-intact skin exposure was 142/1,000,000 calls. See Figure 3 in Appendix B.

The PFD paramedics’ risk of blood exposure to non-intact skin over the 11 year period was 1.5%. The PFD paramedics’ risk of blood exposure to eye/mucous membrane over the 11 year period was 2.0%. See Box 1 in Appendix B.

At present, there are 1333 firefighter-EMTs and 234 paramedics in the PFD. This study focused on paramedics because paramedics had more non-intact skin and mucous membrane exposures compared to firefighter-EMTs. Thirty-eight non-intact skin and 52 mucous membrane exposures, and 6 simultaneous exposures (both non-intact skin and mucous membrane) occurred in paramedics. In contrast, 23 non-intact skin and 25 mucous membrane exposures occurred in firefighter-EMTs. Time constraints prevented analysis of firefighter-EMTs.

Paramedics’ age and years of experience were evaluated. The mean age was 32.8. The age range was 22 to 56 and the standard deviation for age was 8.65. The mean years of experience prior to non-intact skin or mucous membrane exposure were 5.45. The range for years of experience was 0.1 to 29.1 and the standard deviation was 4.82. In addition, a moderate
positive correlation of 0.698 was shown between age and years of experience. For further information, see Figure 4 in Appendix B.

There was a large range in the amount of work experience prior to mucous membrane and non-intact skin exposures. The mean time until mucous membrane or non-intact skin exposures were 5.45 years with a median time of 3.83 years. The range was 0.1 years to 29.1 years.

The days of the week with the highest number of mucous membrane exposures were Mondays (9), Wednesdays (9) and Fridays (9). The day with the least number of mucous membrane exposures was Sundays (5). Non-intact skin exposures occurred most often on Wednesdays (8) and Fridays (7) with the least number of non-intact skin exposures on Sundays (1). See Figure 5, Appendix B.

Non-intact skin exposures by time of day were examined. The highest number of non-intact skin exposures was between 11PM and 12AM. Very few non-intact skin exposures occurred between 12AM and 8AM. The highest number of mucous membrane exposures occurred between 10PM and 11PM. The fewest mucous membrane exposures occurred between 12AM and 8PM. For complete distribution of non-intact skin and mucous membrane exposures by time of day see Figure 6 in Appendix B.

Frequency of exposures by platoon was evaluated. For the purposes of this study, a platoon is a crew comprised of 2 paramedics or 1 paramedic and 1 firefighter-EMT. The platoon letter is the assignment that dictates the work schedule rotation. [For example, platoons A, B, C, and D work two 10 hour day works and two 14 hour night works. Previously, platoons A, B, C, and D comprised both firefighter-EMTs and paramedics. Currently, platoons E, F, G and H are paramedics only, and platoons A, B, C, and D are firefighter-EMTs only.] The greatest numbers of mucous membrane exposures were platoon B and platoon C (17.5 and 25 respectively). In addition, there were 15 mucous membrane exposures in Platoon D and Platoon E. The highest numbers of non-intact skin exposures were Platoon B and Platoon C. [For further details regarding platoons, see discussion and Tables 3 and 4 in Appendix B.]
Table 5 of Appendix B displays behavioral and environmental factors that may have contributed to non-intact skin and mucous membrane exposures. The explanation or comments section of the data showed the following: 24 of the mucous membrane exposures involved handling combative patients who spat blood or saliva at paramedics; 3 involved a dextrose stick that flexed and sprayed to paramedics’ mucous membrane; 11 involved fluid from endotracheal tube (ETT) and nasal intubation splash to paramedics’ mucous membrane; 8 involved gloves torn or removed and blood splashed to paramedics’ mucous membrane; 1 involved a combative patient pulling a non-rebreather (NRB) mask off face and blood splashed; 1 involved bagging patient with bag valve mask (BVM) and blood or brain matter sprayed into paramedic’s mucous membrane; 11 of the non-intact skin exposures involved patients who scratched, bit or cut paramedics; 1 involved cannulating a vein; to paramedics’ mucous membrane); 6 involved intravenous (IV) or IV catheter; 7 involved open wound; 8 involved cuts; 1 involved contact with blood on stretcher; and 1 delivered and performed CPR on newborn: concerned about mother’s HIV status.

EREs seroconversion was also evaluated. To date there has been no seroconversion to HIV, HBV and HCV among paramedics or Firefighter-EMTs at the PFD (since the inception of the ICO).

No significant correlations were found with years of experience. The Pearson’s R test had a p-value of 0.432. For eye/ mucous membrane exposure and years of experience, the Pearson’s R test had a p-value of 0.669.

Lastly, there was very limited information on use of PPE. For the purpose of this study, it was difficult to determine whether paramedics wore PPE at time of mucous membrane or non-intact skin exposure event. Presumptively due to the use of Universal Precautions (later known as Body Substance Isolation and currently known as Standard Precautions), in most cases, gloves at minimum were used to reduce or eliminate transmission of blood or body fluids, unless otherwise stated by the exposed paramedic. In some cases, paramedics reported not wearing gloves due to extraordinary circumstances. However, in this study we were not able to quantify the use of eye protection. As a result, we cannot determine whether the use of PPE was effective or ineffective in preventing exposures.
Discussion

To our knowledge, this is the first study that reports data on paramedics’ non-intact skin and mucous membrane exposure that is based on healthcare records.

This study found that BBP exposure for non-intact skin and mucous membrane in the PFD were 21.1 and 6.25 times (respectively) lower than in other reports (Leiss et al., 2009). [Note: See boxes 3, 4 and 5 in Appendix B.] The likely reason is that PFD data are cases managed by the PFD ICO, while other studies are from self-reports only. Our finding of zero seroconversion is not unexpected given that the risk is low for mucous membrane and non-intact skin exposures. However, with 18 of 25 (72%) tested source patients infected with HBV, HCV, or HIV these exposures had the potential to put the paramedics at risk but were ruled out. Of the 7 cases in which there were no source patients to be tested the exposed paramedics were followed at appropriate intervals based on the current CDC guidelines. To date, there have been no seroconversion and they have all been discharged.

PFD Paramedics had more non-intact skin and mucous membrane exposures than do firefighter-EMTs. The reasons might include their skill set and the activities they perform. Paramedics perform more “extensive pre-hospital care” compared to firefighter-EMTs (BLS, 2009, 1). For example, paramedics “administer medications orally and intravenously …performed endotracheal intubations, and used monitors and other complex equipment” (BLS, 2009, 1). In contrast, firefighter-EMTs fight fires as well as provided basic care to patients. Patient care involved examining patient’s condition and handling “respiratory, cardiac and trauma emergencies” (BLS, 2009, 1).

In comparison to our data, Merchant, Nettleton, Mayer and Becker (2009) examined the first responders’ characteristics such as median age and age range. They reported the first responders’ median age as 30 years and the age range from 15 to 58. This report differs slightly different from our PFD data. A possible reason for the age differences might be career professionals versus volunteers. Further, our study found a moderate positive correlation of 0.698 for age and years of experience.

In addition to age and years of experience, it is important to note temporal patterns. Merchant et al. (2009) studied the “first responders’ visits to emergency departments for blood or
body fluid exposures” in relation to temporal patterns. They found first responders’ peak in emergency department visits to be Fridays in April followed by Tuesdays in October. These findings agree with this study in regards to occurrence of exposures on Fridays followed by Tuesdays. One plausible reason might have been more activities occurring on Fridays versus other days of the week (i.e., Sunday). However, this study did not compare exposures by month or season. Furthermore, Merchant et al. (2009) noted that first responders’ visits occurred more frequently at 7 PM than at 7AM. Our study did not examine paramedics’ visits to the emergency departments but rather the time of the exposure event. Most often, paramedic eye/ mucous membrane exposures occurred from 10PM to 11PM and non-intact skin exposures occurred between 11PM and 12AM. A plausible reason for the exposures occurrence at night could be due to fatigue resulting from shift work. Calls could also be more frequent at those times, but those data were not available.

Furthermore, platoon rotation was considered in this study because platoon rotation and shift work might have possibly played a significant role in the rate of mucous membrane and non-intact skin exposures to EREs. At the beginning of the study period, platoons A, B, C, and D were evaluated because all paramedics and firefighter-EMTs worked the same rotation. [Note: Firefighter-EMTs were excluded from this study.] The schedule consisted of 2 ten hour day works, two 14 hour night works followed by 4 days off which started on the following last night work. The shift rotation began 1 day later each time. As the analysis continued; however it became difficult to determine whether shift work contributed to the rate of mucous membrane and non-intact skin exposures. There were numerous shift changes, transfers, addition of system status management units, ALS and BLS units, and addition of four platoons. The complexity of platoon rotation became difficult to analyze.

Although there were difficulties analyzing platoons, this study calculated the percentages of mucous membrane and non-intact skin exposures by platoon. Platoon B and platoon C had the highest percentage of mucous membrane and non-intact skin exposures followed by platoons D, E and A. This indicates that platoon rotation might have contributed to the paramedic’s fatigue. Currently, platoons A, B, C and D are basic life support (BLS) units and firefighters work in these platoons. [Note: Firefighter-EMTs were excluded from this study.]
In contrast, platoons E, F, G and H are advanced life support (ALS) units and paramedics currently work these platoons (and had previously worked platoons A, B, C or D). Platoons E and F include 12 hour day work, and platoons G and H include 12 hour night work. The rotation is 2 shifts on, 2 shifts off, followed by 3 shifts on and 2 shifts off. In addition, there are twelve system status units. Platoons E and F were in service for day work from 8am-8pm. The rotation of shifting day work to night work and vice versa could have increased paramedics’ stress levels and impacted their health.

According to Rosa and Colligan (1997), shift work affect workers’ circadian rhythm and make workers fatigue. “Fatigue can accumulate to unsafe levels” and result in burnout (Rosa and Colligan, 1997, 8). Alexander and Klein (2001) observed burnout among Scottish ambulance workers. They suggested that burnout corresponded with long duration on the job, reduced amount of recovery time between incidents and “more frequent exposures to incidents” (Alexander and Klein, 2001, 76).

In addition to stress, another contributing factor that might have led to exposures was skill deterioration. According to Wood, Kalinowski, Miller and Newton (2004), paramedics’ skills declined after 6 to 12 months of training. Additionally, Garza, Gratton, Coontz, Noble, and Ma (2003) indicated that experienced paramedics were just as likely as new paramedics to have skills deteriorate. Katz and Falk (2001) investigated paramedics’ placement of endotracheal tubes on patients. They reported that paramedics incorrectly placed endotracheal tubes into patients and patients had adverse reactions such as gag reflex or absence of breathing. Their report found that 4 endotracheal tubes contained vomitus. Although the investigators did not study eye/ mucous membrane exposures, paramedics could be exposed to patients’ vomitus with blood or body fluids by handling endotracheal tubes.

This study found that fluids from endotracheal tubes (ETT) and naso-tracheal tubes splashed into paramedics’ mucous membrane or face on 11 different occasions. These fluids included medication, patients’ blood, vomitus, saliva or pleural fluid. For further details on exposures, see Table 5 in Appendix B.

Another factor that contributed to paramedics’ mucous membrane exposures was combative patients’ saliva or blood. In this study, 24 cases combative patients spat in the
paramedics’ eyes. This might cause an exposure to BBP. This finding agrees with another study. Leiss et al. (2009) found more than one-third of patients were combative or uncooperative, and that more than half of the mucous membrane exposures resulted from “patients vomiting, spitting, or coughing blood or fluid containing blood” (p.141).

Along with eye/ mucous membrane exposure, non-intact skin exposure occurred when paramedics’ handled combative patients. Some combative patients were suicidal, or under the influence of alcohol or drugs. Of the 83 patients for whom we have data, 35 (42.2%) were combative patients who bit, scratched or otherwise assaulted paramedics. This agrees with Leiss et al.’s study, which found that 40% of non-intact exposures occurred when paramedics handled combative or uncooperative patients. Leiss et al. found that paramedics’ risk of blood exposure to non-intact skin over a 12 month period was 8.7%. However, our study found that PFD paramedics’ risk of blood exposure was 1.5% over an 11 year period.

Incidence rates of eye/ mucous membrane and non-intact skin exposures were calculated using call volume. The incidence rate is the average number of exposures divided by the average call volume. This study found that the incidence rate over an 11 year period for eye/ mucous membrane and non-intact skin exposures was low compared to the Leiss study. A plausible reason might be different study designs and methods of capturing data. This was a retrospective study and the ECO recorded information as reported by the paramedics after the eye/ mucous membrane or non-intact skin exposure. The exposure event was usually reported to the ECO within hours of the occurrence. In addition, the ECO conducted source patient testing (if and when the exposure criteria were met), conducted case management, post management and follow-up, and recorded physician determination of exposure. Therefore, the ECO coordinated post-exposure clinical care and case management including source patient testing if applicable.

For the intended purposes of our study, only significant and non-significant exposures were analyzed due to time constraints. Further, our study showed that there appeared to be an over-reporting of non-intact skin exposures rather than under-reporting of exposures as indicated in Leiss et al.’s study. Our study showed that the PFD paramedics’ incidence rate of blood exposure to non-intact skin and mucous membrane over an 11 year period were 21.1 and 6.25 times (respectively) lower than other studies (Leiss et al., 2009). [Note: See Table 7 in Appendix B.] Approximately 90% of reported blood exposure might not have been true exposures. This
was likely because of risk based analysis and proper post-exposure case management as conducted by the ECO in the PFD ICO.

**Limitations**

There are several limitations in this study. First, there might be errors in recall and reporting. Paramedics might not have remembered specific details of how the mucous membrane or non-intact skin exposure, for example, when an exposure event occurred quickly. In addition, paramedics’ knowledge of patient’s disease status (i.e., HIV, HBV, or HCV) might have increased their fear and they might then have reported having an exposure to the patient’s blood. Second, this study had 90 exposures (both non-intact skin and mucous membrane) over the last 11 years. This sample size is small and has low statistical power.

Third, there is incomplete information for some cases. Before February 2002, cases were sent to the ICO but these cases were not handled by the current ECO until March 2002 and much data not collected. Fourth, the PFD ICO does not have actual database software and real-time database entry. Without a real database, record keeping and capturing information involve a lengthy process. All information is entered manually one by one onto an Excel spreadsheet. Fifth, sifting through data is a lengthy process. There are approximately 2,950 entries of exposure reports. In addition, the spreadsheet includes additional types of unrelated exposures such as tuberculosis, meningitis, chicken pox, SARS, pertussis, scabies, scarlet fever, scratches, human bite, Herpes simplex type I, waterborne pathogens, vector control, river rescue, and fire ground that are not part of this study, and do not comprise bloodborne pathogen exposure. The investigators had to exclude these entries one by one.

Sixth, few misclassification of exposures were found in the Excel spreadsheet. For example, some exposures were marked as mucous membrane exposures in 2001. However, when the ECO reexamined the cases, they were actually cases of meningitis or tuberculosis. The reason for the misclassification of exposures was because the cases were not handled by the ECO officially until March 2002. Cases with misclassification of exposures were removed from this study.

Seventh, there were difficulties in abstracting information on use of PPE. We found that a majority of the cases did not have information unless otherwise indicated such as gloves worn
and torn or no eye protection. It was difficult to determine whether paramedics wore PPE at time of mucous membrane or non-intact skin exposure event. Therefore, we could not determine whether PPE was effective or ineffective in preventing exposures.

Eighth, there were challenges in obtaining call volume data. The ECO was able to obtain call volume from 2006 to 2011 through e-mail archives. However, there were challenges in obtaining the remaining real-time call volume in a timely manner. Another challenge was the method by which the call volume data was recorded. Call volume data from 2001 to 2007 were entered in Microsoft Word and call volume data from 2008 to 2011 was entered in Excel. For analysis, the call volume data were reorganized and entered as medic units by year and call volume for each medic unit.

Strengths of the study

First, the ECO captured information on mucous membrane and non-intact skin exposures directly from paramedics. This method was stronger than a mail survey because the ECO had qualitative information captured on the environment (when paramedics arrived on the scene) and how the mucous membrane and non-intact skin exposures occurred. The data included source patient testing as well as the number of source patients who were tested positive and physician determination of exposures. Also this method is immediate, less subject to recall bias than is a mail survey of past events. Second, this study analyzed the PFD call volume from 2001 to 2011. The call volume added value to this study because it allowed investigators to observe the trend of exposures. This study found that there were a low number of exposures per 1,000,000 calls over an 11 year period compared to other studies (Leiss et al., 2009). Third, this study showed that the incidence rate of blood exposure to non-intact skin and mucous membrane were 21.1 and 6.25 times (respectively) lower compared to other studies (Leiss et al., 2009). Fourth, this study found that approximately 90% of exposures were not true exposures; this indicated ERE over-reporting.
Conclusion

Although there has been no seroconversions to HBV, HCV and HIV via non-intact skin and mucous membrane exposures, these bloodborne pathogens are of serious concern to the PFD. EREs should complete their HBV vaccination. If EREs do not develop antibodies for protection against HBV, they should take extra precautions to reduce their risks from blood or OPIM. Additionally, our study showed that blood and OPIM exposures to non-intact skin and mucous membrane were 21.1 and 6.25 times (respectively) lower than other studies (Leiss et al., 2009). This was likely because of proper case management by the PFD ICO.

Recommendations

A database should be created for the PFD ICO. A database would allow the ECO to record and capture exposures in a timely and efficient manner. In addition, a database would allow analysts to evaluate data, identify trends for exposures and might determine which battalions and medic units have higher exposures (as examples). Furthermore, it was important to write an SOP for the PFD ICO. The SOP should be implemented in the PFD. The SOP will inform EREs on how to prevent non-intact skin and mucous membrane exposures. Lastly, continuing education and training on how to use PPE properly and methods to prevent non-intact skin and mucous membrane exposures should be performed annually.
References


Leiss, J.K., Sousa, S., & Boal, W.L. (2009). Circumstances surrounding occupational blood exposure events in the national study to prevent blood exposure in paramedics. Industrial Health, 47, 139-144. doi:10.2486/indhealth.47.139


Appendix A- Information documented by the exposure control officer (ECO) following a mucous membrane or non-intact skin exposure

Information documented in spreadsheet

- Rank
- Date of birth
- Age
- Appointment date
- Longevity date
- Years of experience
- Date of reported event
- Day
- Time
- Battalion
- Medic unit/ platoon
- Non-intact skin to blood or other potentially infectious materials (OPIM)
- Eye/ Mucous membrane splash or contact with blood or OPIM
- PPE used or not
- Source patient testing
- HCP written or final disposition
- Physician’s determination
- ERE seroconversion post exposure or discharge
- Call volume

Unusual occurrences documented in spreadsheet

- Date
- Time
- Exposure while examining medic unit and unintentionally touching blood found on stretcher
- Assault with injury and BBP exposure
- Combative patients spit to EREs’ eyes and face
- Glove tore while handling patient
- Fluid/ mucous splash from endotracheal tube (ETT) to EREs’ eyes
- D-stick blood splash to EREs’ eyes
- Patients removing EREs’ mask
Appendix B- Analysis of Mucous Membrane and Non-intact Skin Exposures

Figure 1. Physician determination: Significance of Mucous Membrane Exposure

![Bar chart showing frequency of physician's determination]

- **Significance of Eye/Mucous Membrane Exposure**

  - **Significant Exposure**
  - **Non-Significant Exposure**
  - **Unknown**

  Frequency

  - Eye mucous membrane

  Physician's Determination
Figure 2. Physician Determination: Non-intact Skin Exposure

Significance of Non-intact Skin Exposure

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Significance</th>
<th>Non-significant Exposure</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Significant Exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Non-Significant Exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Physician’s Determination

Non-intact skin exposure
Table 1. Significance of Eye/Mucous Membrane and Non-intact Skin Exposure

<table>
<thead>
<tr>
<th>HCP Final Disposition</th>
<th>Eye/Mucous Membrane Exposure</th>
<th>Non-intact Skin Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Exposure</td>
<td>34</td>
<td>19</td>
</tr>
<tr>
<td>Non-significant Exposure</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Unknown</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 2. Source Patient Testing

<table>
<thead>
<tr>
<th>Source Patient testing</th>
<th>Number</th>
<th>% of Significant Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25</td>
<td>29.8</td>
</tr>
<tr>
<td>Positive</td>
<td>18</td>
<td>21.4</td>
</tr>
<tr>
<td>*HBV</td>
<td>7</td>
<td>8.33</td>
</tr>
<tr>
<td>*HCV</td>
<td>9</td>
<td>10.7</td>
</tr>
<tr>
<td>*HIV</td>
<td>2</td>
<td>2.38</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>4.8</td>
</tr>
<tr>
<td>Not Applicable</td>
<td>14</td>
<td>16.7</td>
</tr>
<tr>
<td>Significant Exposure</td>
<td>6</td>
<td>7.1</td>
</tr>
<tr>
<td>Unknown</td>
<td>10</td>
<td>11.9</td>
</tr>
<tr>
<td>Missing</td>
<td>7</td>
<td>8.3</td>
</tr>
</tbody>
</table>
Call volume has increased over the years. In 2001, the call volume was 196,204 and in 2011 the call volume was 273,557.
The scatter plot shows a moderate correlation of 0.698.
Figure 5. Distribution of Exposures by Day of the Week

The day of the week with the highest number of mucous membrane exposures was Mondays (9), Wednesdays (9) and Fridays (9). The day with the least number of mucous membrane exposures was Sundays (5). Non-intact skin exposures occurred most often on Wednesdays (8) and Fridays (7) with the least number of non-intact skin exposures on Sundays (1).
Non-intact skin exposures by time of day were analyzed. Most non-intact skin exposures occurred between 11PM and 12AM. Very few non-intact skin exposures occurred between 12AM and 8AM. Most mucous membrane exposures occurred between 10PM and 11PM. The least number of mucous membrane exposures occurred between 12AM and 8PM.

[There are 6 missing values for time of day in this figure.]
### Table 3. Mucous Membrane Exposure by Platoon

<table>
<thead>
<tr>
<th>Platoon</th>
<th>Number of Mucous Membrane Exposures</th>
<th>% of Total Mucous Membrane Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>17.5</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>7.5</td>
</tr>
<tr>
<td>G</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: There are 11 mucous membrane exposures that have missing platoon information and 1 mucous membrane exposure that occurred in which the platoon is not applicable. In addition, the percentages above do not include the missing and non-applicable.

### Table 4. Non-intact Skin Exposures by Platoon

<table>
<thead>
<tr>
<th>Platoon</th>
<th>Number of Non-intact Skin Exposures</th>
<th>% of Total Non-intact Skin Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>33.3</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>1</td>
<td>4.17</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: There are 13 non-intact skin exposures that have missing platoon information and 1 non-intact skin exposure that occurred in which the platoon is not applicable. In addition, the percentages above do not include the missing and non-applicable.
Table 5. Behavioral and Environmental factors of Mucous Membrane and Non-intact Skin Exposures

<table>
<thead>
<tr>
<th>Behavioral and Environmental factors</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involved handling combative patients: Patients spat blood or saliva at paramedics</td>
<td>24</td>
</tr>
<tr>
<td>Involved handling combative patients: Patients scratched, bit or cut paramedics</td>
<td>11</td>
</tr>
<tr>
<td>Involved D-stick: Blood sprayed to paramedics’ mucous membrane</td>
<td>3</td>
</tr>
<tr>
<td>Fluid from endotracheal tube (ETT) splashed into paramedics’ mucous membrane or face</td>
<td>11</td>
</tr>
<tr>
<td>Gloves ruptured, torn, or removed: blood splashed to paramedics’ mucous membrane</td>
<td>8</td>
</tr>
<tr>
<td>Involved canulating a vein</td>
<td>1</td>
</tr>
<tr>
<td>Combative patients pulled non-rebreather (NRB) mask off face (and blood splashed to paramedics’ mucous membrane)</td>
<td>1</td>
</tr>
<tr>
<td>Involved IV, IV Catheter</td>
<td>6</td>
</tr>
<tr>
<td>Involved open wound</td>
<td>7</td>
</tr>
<tr>
<td>Involved cut</td>
<td>8</td>
</tr>
<tr>
<td>Involved contact with blood on stretcher</td>
<td>1</td>
</tr>
<tr>
<td>Delivered and performed CPR on newborn: Concerned about mother’s HIV status</td>
<td>1</td>
</tr>
<tr>
<td>Involved bagging patient with bag valve mask (BVM) and blood or brain matter sprayed into paramedics’ mucous membrane</td>
<td>1</td>
</tr>
</tbody>
</table>
Box 1. Calculations: PFD Paramedics’ Risk of Blood Exposure

PFD paramedics’ risk of blood exposure to non-intact skin

- 38 non-intact skin exposures divided by 11 years \(\Rightarrow 38/11 = 3.45\) non-intact skin exposures/year
- 3.45 non-intact skin exposures/ year divided by 234 PFD paramedics \(\Rightarrow 0.0147\) approximately 0.015
- \(0.015 \times 100\% = 1.5\%\) (This is the PFD paramedics’ risk of blood exposure to non-intact skin over the 11 year period.)

PFD paramedics’ risk of blood exposure to eye/mucous membrane

- 52 eye/mucous membrane exposures divided by 11 years \(\Rightarrow 4.73\) eye/mucous membrane exposures/ year
- 4.73 eye/mucous membrane exposures/ year divided by 234 PFD paramedics \(\Rightarrow 0.0202\) \(\Rightarrow\) approximately 0.02
- \(0.02 \times 100\% = 2.0\%\) (This is the PFD paramedics’ risk of blood exposure to eye/mucous membrane exposure over the 11 year period.)
**Box 2. Difference between Studies: Incidence Rates for blood to Non-intact Skin and Eye/Mucous Membrane Exposures**

<table>
<thead>
<tr>
<th>Leiss et al. study indicated incidence rates for blood exposure</th>
<th>Our study: Incidence Rates for Blood Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Non-intact Skin Exposure = 3.0/10,000 calls</td>
<td>➢ Non-intact Skin Exposure=</td>
</tr>
<tr>
<td>➢ Eye/Mucous Membrane Exposure = 1.1/10,000 calls</td>
<td>156/1,000,000 calls =&gt; 1.56 non-intact skin exposures/10,000 calls</td>
</tr>
<tr>
<td></td>
<td>➢ Eye/Mucous Membrane Exposure=</td>
</tr>
<tr>
<td></td>
<td>194/1,000,000 calls =&gt; 1.94 eye/mucous membrane exposures/10,000 calls</td>
</tr>
</tbody>
</table>

**Box 3. Calculations: Non-intact Skin Exposure**

<table>
<thead>
<tr>
<th>Our study indicated incidence rates for blood exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Non-intact Skin Exposure= 156/1,000,000 calls =&gt; 1.56 non-intact skin exposures/10,000 calls</td>
</tr>
<tr>
<td>➢ 1.56 non-intact skin exposures divided by 11 years=&gt; 1.56/11= 0.142 non-intact skin exposures/ year</td>
</tr>
<tr>
<td>➢ 3.0 non-intact skin exposures/10,000 calls divided by 0.142 non-intact skin exposures (from our study) = 21.1</td>
</tr>
<tr>
<td>➢ Leiss et al. reported <strong>21.1 times</strong> more blood exposure to non-intact skin than our study.</td>
</tr>
</tbody>
</table>
Box 4. Calculations: Mucous Membrane Exposure

Our study indicated incidence rates for blood exposure (continued)

- **Eye/Mucous Membrane Exposure** = 194/1,000,000 calls => 1.94 eye/mucous membrane exposures/10,000 calls

- 1.94 eye/mucous membrane exposures/10,000 calls divided by 11 = 0.176

- 1.1 eye/mucous membrane exposure (Leiss et al. study) divided by 0.176 eye/mucous membrane exposure (from our study) = 6.25

- Leiss et al. reported **6.25 times** more blood exposure to eye/mucous membrane than our study.
Appendix C- Notes on Behavioral and Environmental Influences of Mucous Membrane and Non-intact Skin Exposures

**Types of combative patients**

- Diabetic patients
- Head injury
- Assault to paramedic: Patient assault member and the patient’s blood splash to the paramedic’s eyes, mouth
- Seizure patients
- Combative patients’ consumption of alcohol and/ or drug overdose led them to become agitated and jittery; and they spat into paramedics’ eyes and face

1. **Involved handling combative patients: Patients spat saliva or blood at/ onto paramedics**

   A. Sometimes patients vomited. To prevent patients from aspirating, they are turned over. However, in one particular case, the paramedic’s eyeglasses slid and the patient sprayed blood to the paramedics’ eyes
   
   B. Several reports of bloody sputum to eye.
   
   C. There were other reports of patients saliva into the paramedics’ eyes without blood
   
   D. In other instances, there were patients who were combative intravenous drug users. In one case, a patient bit his tongue and had a scratched face and spat blood onto the paramedic’s eyes and face.
   
   E. In another case, a suicidal patient spat into the paramedic’s eyes after being restrained and handcuffed by the police [to prevent further injury to the patient].
   
   F. There were other reports of patients with gunshot wounds and that blood splashed onto paramedics’ arms and face as the paramedic was attending the patient. [Specifically, a patient had a gunshot wound on his face and the patient’s blood splashed onto the paramedic arms and face. Meanwhile another person was holding the patient but the patient would not let go of the paramedic. Eventually the police pulled off the patient. It was reported that the paramedic had blood all over his arms.]
2. **Involved handling combative patients: Patients scratched, bit or cut paramedics**
   A. Some combative patients were under the influence of alcohol or drugs. They were agitated and jittery and became violent. They kicked, punched, scratched, and bit paramedics.
   B. There were several cases of simultaneous exposures. In one case, a combative patient bit the paramedic’s skin and gloves were torn. In addition, the paramedic had abraded skin on his leg.
   C. Further, the paramedic had a mucous membrane exposure because the patient spat bloody saliva into the paramedic’s eyes.
   D. In another case, a paramedic was returning to the station and noticed a man robbing someone and was being chased down by another man. The crew left the ambulance, chased the alleged robber and tackled him to the ground. The crew members got into a scuffle with the alleged robber and the other man arrived on the scene. While the medic turned to see the man identify himself as a police officer, the alleged robber punched the medic in the face and mouth and was sprayed with blood from the alleged robber who had blood in and around his mouth and chin. Further, the medic reported a laceration to his right hand across his knuckles. The medic was concerned about being exposed to BBP and wished to be evaluated.

3. **Involved D-stick: Blood sprayed to paramedics’ mucous membrane**
   A. A dextrose stick (aka D-stick) is a finger stick test that checks the patient’s blood sugar level.
   B. In this study, a combative diabetic patient or seizure patient hit a D-stick while the paramedics were attempting to check their blood sugar level, and blood on the D-stick sprayed into the paramedic’s nose.
   C. In other instances, the D-stick flexed. The blood on the D-stick then sprayed into the paramedic’s eyes.
4. Intubation and ventilation

A. A cardiac arrest patient was intubated by the paramedic’s partner as she attempted to start an IV. The IV was unsuccessful. Therefore, the epinephrine was administered via the endotracheal tube (ETT). Meanwhile, the paramedic’s partner performed CPR and the paramedic was splashed with ETT fluid to her eye and face.

B. Note: This ETT fluid contained a mixture of epinephrine, normal saline solution (NSS) and sputum.

C. A patient had a gunshot wound (GSW) to the head. The paramedic attempted to perform intubation and the patient had an intact gag reflex. This resulted in an eye splash.

D. Paramedic stated that a pink frothy fluid from the ETT splashed onto his face when the bag valve mask (BVM) separated during pt. care transfer at the Emergency Department. [When a patient has congestive heart failure, fluid is filled in the lungs and the patient cannot breathe. He/she needed air. Therefore, the paramedic used a BVM to create positive pressure back down and gave diuretics to patient to excrete the fluid.]

E. A paramedic reported a blood splash to the face and mouth from a patient with a Gastrointestinal (GI) bleed when the BVM came apart after the patient had been intubated. The paramedic stated that the tube was in the lungs but the blood must have gotten into BVM mask connector area prior to intubation.

F. During and after nasal intubation, blood and medication fluid from the ETT splashed to the paramedic’s eyes.

G. Patient had bloodied nose and sprayed blood all over the paramedic’s face while the paramedic attempted to perform a nasal intubation

5. Gloves ruptured, torn, or removed: blood splashed to paramedics’ mucous membrane

A. The gloves had blood and the paramedic removed them. However, during the removal process, the blood splashed into the paramedic’s eyes.
B. A paramedic reported that Tegaderm, an IV site cover (that sticks to the skin and is used to protect the IV site from contamination), got stuck on her glove as she attempted to remove the IV catheter from the patient's arm. The paramedic believed that she got the patient's blood from the venipuncture and normal saline solution (NSS) splashed to her eye because the Tegaderm was stuck to the IV catheter. When the paramedic attempted to get the Tegaderm off her glove, it inadvertently pulled the IV catheter out of the pt's arm.

C. Tape got stuck on the paramedic's gloves while she attempted to secure an IV on an unresponsive patient and the glove ripped. The paramedic further reported that the gloves were bloodied because the IV site was not tamponaded and the patient’s blood flowed from the IV catheter in the patient’s vein prior to connection of the NSS IV tubing. Blood had seeped down the torn glove onto a cut sustained by the paramedic over the past weekend from a patient’s toenail that scratched her hand. Then the paramedic replaced gloves.

6. **Combative patients pulled non-rebreather (NRB) mask off face (and blood splashed to paramedics’ mucous membrane)**

   A. A combative Motor Vehicle Crash (MVC) patient had facial trauma and he kept pulling off the non-rebreather (NRB) mask because he felt suffocated (or couldn’t breathe) and removed the NRB. After, the patient spat blood into the paramedic’s eyes and mouth.

7. **Involved IV, IV Catheter**

   A. An IV attempt was unsuccessful and the IV catheter was removed. During the removal process, a few drops of the patient’s blood splashed into the paramedic’s nose.

   B. In several instances, unresponsive patients became combative and pulled the IV. Blood was reported to have been sprayed onto hands, arms, legs along with saliva and a lot of sweat while attempting to restrain the patient.

   C. Infiltrated IV site (on the patient). Blood soaked through the paramedic’s uniform pants and onto the paramedic’s knee and calf.
8. Involved cannulating a vein
   A. The patient complained about having trouble breathing. The paramedic tried to cannulate the patient’s vein while enroute to the hospital but had difficulty tamponading the IV site. Although the paramedic used 4x4's to control bleeding, some of the blood got onto the tourniquet. As the paramedic removed the tourniquet, blood splashed onto his face and onto his lips.
   B. Note: A tourniquet is an elastic band that is tied around an extremity to allow the patient’s vein to become engorged so that the vein can be cannulated with an IV catheter.

9. Involved open wound
   A. Patients’ wound: There were some cases of combative patients with critical gunshot wounds. In two cases, a combative patient had a gunshot wound on his chest. It has been reported that there were blood everywhere and that it had gotten into the paramedics’ eyes, faces and uniform.
   B. Paramedic wound: Paramedic shaved leg before going to work. While on the job, the paramedic got blood on her shaven leg.
   C. Paramedic wound: Blood to exposed nail bed- no further information
   D. Paramedic wound: The paramedic reported that she was putting the O2 bottle back into the storage compartment in the squad. However, the compartment door slammed and smashed her finger. The paramedic reported that the glove broke and that the patient’s blood on the outside portion of the glove mixed with her own blood from the exposed nail bed on her 5th finger.
   E. A patient’s varicose vein on the leg had burst. The patient attempted to control the bleeding by placing a shirt over it. The paramedics arrived on scene and started to dress and bandage the patient’s leg. However, the patient pulled the shirt away from his leg during the bandaging process and blood splashed into the paramedic’s mouth.
10. Involved a cut
   A. A paramedic had a cut on a hand with a possible blood contact but there was no further information.
   B. In other cases, nitrile gloves tore easily. The paramedics’ might have already sustained cuts before, during or after their performance activities.
   C. Some paramedics sustained abraded knee, legs, etc. from combative patients.
   D. Paramedic’s hand was abraded after her glove was torn while she attempted to restrain an unconscious/ unresponsive intravenous drug abuse (IVDA) user. The patient became combative after the first IV attempt. The IV site blew and the IV site was bleeding. The paramedic reported that she had blood inside her glove and the patient’s blood was mixed with her own blood while she attempted to restrain the combative patient.

11. Involved Human bite
   A. A patient assaulted and bit the paramedic’s hand. This resulted in a BBP exposure because the patient had blood in his or her mouth.
   B. A patient bit the paramedic through his uniform shirt. An injury was sustained on the paramedic’s right shoulder as well as a cut on the back left calf. Further, the right knee was stiff and sore.
   C. A combative suicidal patient became irritated when the paramedic attempted to restrain the patient’s wrists to prevent him from injuring himself. The patient then bit and broke the paramedic’s skin on the middle and 5th finger.

12. Involved contact with blood on stretcher
   A. In this situation, the stretcher was not checked and decontaminated thoroughly by the paramedics at the end of their shift. The next day, a new crew of paramedics assumed that all equipment in the medic unit was cleaned. However, there was blood on the stretcher, and one touched it.
13. Delivered and performed CPR on newborn: Concerned about mother’s HIV status
   A. The mother of the newborn reported that she had HIV. The paramedic was concerned about a possible BBP exposure risk. Blood was reported to be everywhere after the newborn was delivered.
   B. Paramedic arrived on the scene to find a newborn not fully delivered and hanging out between the mother’s legs. The newborn had agonal breathing and a heart rate of 20. The paramedic helped with the completion of delivery and performed cardiopulmonary resuscitation (CPR).
   C. The paramedic reported ventilating the newborn with a bulb syringe because there was no smaller equipment available.

14. Involved bagging patient with bag valve mask (BVM) and blood or brain matter sprayed into paramedics’ mucous membrane
   A. The paramedic responded to a shooting. The patient had a gunshot wound (GSW) to the forehead and was unresponsive with agonal respirations. BLS and ALS were performed. The paramedic found that the patient had an intact gag reflex and was resuscitated with a BVM. During the resuscitation process, blood and brain matter sprayed up into the medic’s left eye.
Disclaimer: The standard operating procedures (SOPs) for mucous membrane and non-intact skin exposures are confidential and are not included in this paper.
## Appendix D - Timeline for Project Activities 2011-2012

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Project development</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRB Submission</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of computer files/ data entry</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data analysis</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report Writing</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dissemination of findings</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>