

**A Three-Year Retrospective Analysis of Pediatric Burn Infections at UPMC Mercy Burn Center**

by

**Shevaitha Tamarah Shyamalan**

B.S. in Biology, Monmouth University, 2020

Submitted to the Graduate Faculty of the  
Department of Infectious Disease and Microbiology  
Graduate School of Public Health in partial fulfillment  
of the requirements for the degree of  
Master of Public Health

University of Pittsburgh

2022

UNIVERSITY OF PITTSBURGH  
GRADUATE SCHOOL OF PUBLIC HEALTH

This essay is submitted

by

**Shevaitha Tamarah Shyamalan**

on

April 22, 2022

and approved by

**Essay Advisor**

Mohamed Yassin, M.D., Ph.D.- Infectious Disease Physician, Director of Infection Control,  
Associate Professor

UPMC Mercy

University of Pittsburgh Department of Medicine

Heather Dixon, MSN- Quality Director

UPMC Mercy

Jeremy Martinson, Ph.D.- Assistant Professor, MPH-PEL Program Director

Infectious Disease and Microbiology

Graduate School of Public Health

University of Pittsburgh

Copyright © by Shevaitha Tamarah Shyamalan

2022

# **A Three-Year Retrospective Analysis of Pediatric Burn Infections at UPMC Mercy Burn Center**

Shevaitha Tamarah Shyamalan, MPH

University of Pittsburgh, 2022

## **Abstract**

**Background:** Burns are serious injuries due to the many ways it can cause short term and long-term damage to victims. Burns leave patients very susceptible to infection, which can further disrupt the healing process. It is possible for patients to acquire infections during their stay. UPMC Mercy has the only American Burn Association-accredited burn center in Western Pennsylvania. Burn data is reported to the American Burn Association's National Burn Registry (ABA-NBR). Hospital acquired burn infections are reported to the ABA-NBR, as well as to the CDC's National Healthcare Safety Network (NHSN).

**Methods:** A three-year descriptive retrospective analysis was done on pediatric patients admitted to UPMC Mercy Burn Center (MBC) from 2018 to 2020. We utilized inclusion criterion of length of stay (LOS) greater than 1 day, total body surface area (TBSA) of 10% or higher, and age less than 18 years on admission. Additional collected data included age, gender, LOS, injury severity score (ISS), mechanism of injury (MOI), positive cultures, antibiotics, and reported hospital-associated infections (HAIs).

**Results:** MBC evaluated 1,059 patients from 2018 to 2020. The total amount of pediatric burn patients was 208. The number of pediatric burn patients excluded was 181. There were 27 inpatient pediatric burn patients with TBSA's of 10% or greater. The average: TBSA was 16.3 (SD= 8.58), age was 5 (SD= 5.26), and ISS was 8 (SD= 7.86). There were zero inhalational lung injuries in these patients. Of these 27 patients, 4 patients had confirmed and reported HAIs, one of

which were caused by a multidrug resistant organism (MDRO). The most prevalent HAI was CAUTIs/SUTIs. There was 1 confirmed case of child abuse and 29 cases of suspected child abuse or neglect.

**Conclusion:** The Mercy Burn Center has low HAI rates in pediatric burn victims compared to the national average. The collaboration between the burn team and infection prevention team is the key for better outcomes for burn victims.

**Public Health Significance:** Child abuse, abandonment, and neglect is a serious public health concern. It is important to study and identify these incidents of child burn abuse and neglect to prevent them.

## Table of Contents

Preface.....	x
1.0 Introduction.....	1
1.1 Severe Pediatric Burn Injuries.....	1
1.2 Healthcare-Associated Infections (HAIs) in Burn Patients .....	3
1.3 Burn Infection and HAI Treatment.....	6
1.4 The UPMC Mercy Burn Center.....	9
1.5 Infection Prevention in Burn Centers.....	11
1.6 Analysis Aims.....	12
1.7 Public Health Significance .....	13
2.0 Methods.....	14
2.1 Sample Selection and Data Abstraction .....	14
2.2 Study Design.....	15
2.3 Statistical Analyses .....	16
3.0 Results .....	17
3.1 Inpatient Pediatric Burn Patients with 10% TBSA or Greater .....	17
3.2 Inpatient Pediatric Burn Patients with HAIs .....	23
3.3 Pediatric Burn Patients with Child Abuse, Neglect, and Abandonment as MOI...	26
4.0 Discussion.....	27
4.1 Limitations .....	29
4.2 Future Directions.....	29
5.0 Conclusions.....	30

<b>Bibliography .....</b>	<b>31</b>
---------------------------	-----------

## **List of Tables**

<b>Table 1. Summart of pediatric inpatient burn patient data Data collected from patient EHRs</b>	
.....	<b>19</b>
<b>Table 2 Summary of TBSA, LOS, age, and ISS means, maximum, and minimum</b>	<b>20</b>
<b>Table 3. Summary of positive quantitative, aerobic, blood, and urine cultures and MRSA</b>	
<b>screenings from inpatient pediatric burn patients Data collected from microbiology report</b>	
<b>on patient EHRs</b>	<b>22</b>
<b>Table 4. Summary of inpatient pediatric burn patients with confirmed HAIs</b>	<b>24</b>



## List of Figures

<b>Figure 1. (a-d) Histogram summary of patient age, ISS, LOS, and TBSA. Calculated using Stata SE 16.0 using “histogram” as input.....</b>	<b>20</b>
<b>Figure 2. Types of frequencies of MOIs Mercy inpatient burn patients that had each type of MOIs.....</b>	<b>21</b>

## **Preface**

I would first like to thank Dr. Mohamed Yassin and Heather Dixon for all their guidance and support throughout my practicum and essay writing process. Their knowledge and expertise in the infection prevention field made this essay possible. I would also like to thank Katie Palladino, MPH from the UPMC Mercy Infection Prevention Team. She helped me to better understand infection prevention at the Mercy Burn Unit and assisted me with data.

I would also like to thank Dr. Jeremy Martinson for advising me throughout my MPH journey and for being on my essay committee. If it were not for him, I would have never taken the opportunity to learn about the infection prevention field. I lastly want to thank Dr. Linda Frank, who is the MPH-MIC Program Direction and an IDM Professor. She, along with Dr. Yassin, created the infection prevention class and practicum, where I got to learn about this fascinating field. I am very grateful for the doors this class, practicum, and essay have opened for me and the connections and memories that I have made along the way.

## **1.0 Introduction**

The pediatric population is very susceptible to burns, causing them to be affected short term and/or long term, depending on their burn injury severity. Due to the lack of cognitive development in children, as well as their smaller size, they are more prone to encountering fires and hot objects and sustaining a burn injury (Rivas et al., 2018). Younger children are not able to conceptualize the danger of fires and hot objects. Without proper parental supervision, they can easily get injured. Almost one fourth of all burn injuries happen to children under the age of 16 and the majority of these burn injuries are in children less than five years of age (Bayat et al., 2010). Many pediatric burn injuries are minor, like first degree thermal burns, and do not require hospitalization. Often, a visit to the emergency room or doctor's office will cure the minor burn injury (Krishnamoorthy et al., 2012). Morbidity of severe burns can include, scarring, infections, loss of bone or muscle, or multiple organ failure.

### **1.1 Severe Pediatric Burn Injuries**

More severe burns, such as trauma-related burns, will require hospitalization, preferably to a hospital with a burn unit or center. A specialized burn unit will have trained doctors, surgeons, respiratory therapists, anesthesiology and pain management consultants, physical therapists, occupational therapists, and nurses that will treat and rehabilitate the patient, so they are able to function to their best ability (Krishnamoorthy et al., 2012). More severe burns often require an extended length of stay (LOS), often greater than one day of stay. These types of burns tend to

have a larger total burn surface area (TBSA), which is the percentage of external skin that has been burned. This is determined by using the Lund-Browder Chart, which utilizes the variation in each patient's body shape that correlates with their age. This chart ultimately provides accuracy when calculating TBSA and will help to determine patient treatment. Burn injuries that are or greater than 10% TBSA in pediatrics are considered serious due to the higher risk for going into hypovolemic shock (Dai et al., 2010).

Severe burn injuries will also have higher injury severity scores (ISS), which is used to triage high-risk trauma patients and assess the probability of patient survival. The formula to calculate this score takes into account injuries to the head and neck, face, thorax, abdomen, and extremities. Each of these categories are scored on a scale from zero to 6, where zero means no injuries and 6 means unrevivable injuries. Each of these scores are squared and then totaled to give the ISS. The ISS scale ranges from 1 to 75 (Reynolds et al., 2011).

It is also possible for patients to sustain an inhalational injury from the mechanism of injury (MOI); inhaling the smoke can irritate and destroy the lining of the esophagus causing for breathing difficulties. It is crucial for interventionalists to keep the patent and clear for the patient to breathe on their own. Inhalational injuries can prolong a patient's LOS and worsen their condition, so they are important to treat immediately upon patient arrival (Sen, 2017). Intubation, as well as the use of N-acetylcysteine (NAC) and bronchodilators, is often required for the treatment of inhalational injuries (Shubert, 2021). The use of ventilation can assist the patient in breathing after an inhalational injury, however prolonged ventilation can lead to ventilator-associated pneumonia (VAP).

Certain severe burns injuries are also more prone to developing an infection. Burn injuries will heavily destroy and disturb the skin, which is the body's first line of defense against infection.

Other major functions of the skin is to also maintain homeostasis and thermoregulation, as well as carry out metabolic and neurosensory functions. When the skin is severely burned, many of these functions will be altered, putting the body more at risk to developing an infection, which would worsen the patient's condition and possibly increase the LOS (Church et al., 2006). An extended LOS can also increase the chance for infection caused by multidrug-resistant organisms (MDROs), like methicillin-resistant *Staphylococcus aureus* (MRSA). Patients who have pre-existing medical conditions or who have a compromised or an underdeveloped immunity are more at risk to develop an infection. Certain MOIs can also increase this risk as well. If a patient is able to survive the first 72 hours after a burn injury, they are more at risk for contracting an infection, which is the most common cause of death in burn patients (Lachiewicz et al., 2017).

Children under two years old have thinner skin layers and less insulation subcutaneous tissue, so they can lose heat and fluid very easily following a severe burn injury. This further contributes to infection and can ultimately lead to sepsis, which is the patient's response to infection resulting in organ dysfunction. The interventional team's goal is to avoid infection and sepsis because these can lead to multiple organ dysfunction syndrome (MODS); infection, sepsis, and MODS are main causes of death in burn injury patients (Zhang et al., 2021).

## **1.2 Healthcare-Associated Infections (HAIs) in Burn Patients**

A major area of concern for hospitalized burn patients is the ability to develop a healthcare-associated infection (HAI), due to their vulnerable condition. HAIs can be obtained through the use or insertion of a medical device, undergoing a surgical procedure, or acquisition of a microorganism after hospital admission. HAIs are associated with high mortality and morbidity.

The Centers for Disease Control and Prevention (CDC) states that every year, around one in 25 hospitalized U.S. patients gets diagnosed with at least one HAI and that more infections can be acquired in healthcare settings in general. There is an increase in mortality due to HAIs, causing for about two million deaths annually (CDC, 2017). Pediatric populations are more prone to acquiring HAIs due to their lack of understanding of hygiene underdeveloped immune system. It is also common for children to move around and probe at their injury sites, open wounds, or inserted medical devices, thus putting them at risk for infection (Northway et al., 2011).

There are many types of HAIs that hospitalized burn patients are susceptible to. One type is a central line-associated blood stream infection (CLABSI), which is a type of blood stream infection (BSI) where a bacteria or virus enters the bloodstream via the central line. A central line is a tube that is placed in a major vein in the chest, neck, or groin to deliver medications and fluids, or to collect blood. Central lines are often placed in more critical patients and can stay in place from weeks to months, allowing it to become a portal of entry for bacteria to enter into the bloodstream and cause infection. Due to this risk, central lines must be placed properly, in line with hospital protocol, be checked frequently, and the dressing should be carefully changed often. Fevers and redness around the central line are often seen with CLABSIs, so physicians will order for a blood culture to see if there is a bacteria or fungus present causing the infection.

Central lines need to be inserted by medical staff after completing proper hand hygiene and donning appropriate personal protective equipment (PPE), which includes sterile gloves and gown, cap, mask, and large sterile drape. Proper hand hygiene consists of washing hands with warm water and soap for at least twenty seconds. The skin of the patient is also prepped with an antiseptic, typically chlorhexidine gluconate (CHG). CHG is a broad-spectrum antimicrobial and is approved for sensitive and burned skinned. Once the CHG has dried completely, the central line

can be placed. It is also important that the medical staff performs proper hand hygiene and doffing of PPE after insertion (CDC, 2011). The catheter site should be cared for using CHG during frequent dressing changes. CHG discs, like Biopatch, can be placed near the catheter site to further prevent infection. Catheter hubs, needless connectors, and injection ports need to be disinfected with 70% alcohol or CHG prior to being used (Han et al., 2010).

CLABSIs can be caused by *Serratia marcescens*, *Staphylococcus aureus*, *Pseudomonas spp.* or *Candida spp.*, and many more (Lin et al., 2017). The presence of the microorganism must be confirmed by a laboratory test in order to conclude that the patient has a laboratory-confirmed bloodstream infection (LCBI). The central line also must be in place for more than two days during the current hospital admission in order for a CLABSI to be considered and reported (NHSN, 2022).

Another type of HAI seen in burn patients is a catheter-associated urinary tract infection (CAUTI), which is a type of urinary tract infection (UTI). These are the most common HAI and cause more than 30% of infections (CDC, 2015). An indwelling urinary catheter, also known as a Foley catheter, is a drainage tube that is placed into the urinary bladder via the urethra and is used to collect urine in a drainage bag connected to the tube. CAUTIs are caused by bacteria that enter the urinary tract via the urinary catheter, thus causing infection. Urinary catheters have similar pre- and post-insertion protocols, including hand hygiene, donning and doffing of PPE, and skin area prep, in order to prevent CAUTIs. Another way to prevent CAUTIs is to make sure the urine bag is positioned below the bladder so the secreted urine cannot reach the bladder. There should also be no tugging on the tubing, as well as no kinks in the catheter tubing. The catheter should be monitored to make sure the drainage system is kept closed (CDC, 2010).

CAUTIs can be caused by *Escherichia coli* (*E. coli*), *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, or *Enterobacter spp.*, but *E. coli* is most common (CDC,

2015). CAUTIs can present symptomatically or asymptotically. Symptoms include fever, rigor, suprapubic or costovertebral angle pain or tenderness, or delirium. Patients must present with at least one symptom in order for a CAUTI diagnosis to be considered. A urine analysis is usually done first to look for leukocyte esterase or a significant amount of white blood cells. If the urine analysis comes back confirming either of these, a urine culture is done. The urinary culture must confirm the presence of the microorganism and the indwelling urinary catheter needs to be in place for more than two consecutive days during the current hospital admission for a CAUTI to be considered and reported. If all these criteria are met, this event can be reported as a symptomatic urinary tract infection (SUTI) (NHSN, 2022).

The CDC uses surveillance data to monitor and prevent infections. The National Healthcare Safety Network (NHSN) is a surveillance system managed by the CDC. It tracks data on HAIs from healthcare facilities in order to ultimately reduce HAIs. Prevention measures to reduce HAIs, presence of MDROs, and healthcare staff safety and vaccination can be reported through NHSN. The NHSN Patient Safety Component Manual includes the criteria for reporting HAIs and is used by many hospital staff, especially by infection prevention teams.

### **1.3 Burn Infection and HAI Treatment**

Antibiotics are used to treat burn infections and are given under a few routes of administration to reduce morbidity and prevent mortality. The purpose of antibiotics administration is to kill or reduce bacteria causing an infection in the body. Antifungals are also prescribed when a culture tests positive for a fungal organism present. The most common route for



antibiotics for burn infections are topical, oral, ophthalmic, otic, or intravenous (IV). Based off culture and sensitivity results, doctors will prescribe an appropriate antibiotic.

Topical antibiotic ointments are often prescribed to apply to the burn wound because its antimicrobial agents can kill microorganisms that would normally delay healing. They are indicated when there is a suspicion of risk of infection and are proven to reduce mortality due to burn wound sepsis. They can be used prophylactically to decrease colonization and infection. Bacitracin-polymixin B, Silver sulfadiazine, Mafenide, or Mupirocin are examples of antibiotic ointment given to pediatric patients. They are applied at least once per day in areas indicated by their attending physician. Bacitracin is effective against gram-positive bacteria and Polymixin B is effective against *Pseudomonas*, which is a Gram-negative bacillus. Mupirocin is very effective against *Staphylococcus aureus* and is the only topical ointment that has the ability to fight MRSA (Cartotto, 2017). Silver sulfadiazine is also effective against *Pseudomonas aeruginosa* (Oaks & Cindass, 2022).

The presence of MDROs can cause CLABSIs, causing for increased mortality and morbidity in all patients. This makes treating CLABSIs more challenging, especially in vulnerable patients (Alfil et al., 2021). Vancomycin is typically indicated for CLABSI treatment, especially if MRSA or *Staphylococcus aureus* is apparent in the blood culture. Cephalosporins, like cephazolin, ceftriaxone, or cefepime, or carbapenems are indicated if *Pseudomonas aeruginosa*, or any other multidrug-resistant Gram-negative bacilli, is detected. Antifungals from the echinocandin class are used for *Candida spp.* colonization (Han et al., 2010).

In certain situations, the central line must be removed in order to effectively treat the CLABSI. CLABSIs caused by infection of *S. aureus*, fungi, mycobacteria, or a Gram-negative bacillus or enterococcus will require the removal of the central line. This is followed by treatment

with a systemic antibiotic for one to two weeks (Mermel et al., 2009). If the patient is exhibiting symptoms of fever, sepsis, or shock for over 36 hours, or if the blood culture remains positive for over 72 hours after administering antibiotics, it is also recommended to remove the central line. The recurrence of a CLABSI in a patient during the same hospital stay is also an indication for central line removal (Haddadin et al., 2021). The central line should also be removed once it is not needed.

There is an issue of over ordering urine cultures because this ultimately leads to the overprescribing of antibiotics to treat CAUTIs. The overuse of antibiotics leads to antibiotic resistance, thus causing prolonged LOS, increased mortality, and high medical costs (Miller et al., 2014). Physicians must differentiate between colonization and symptomatic infection when there are atypical bacteria present in the urine. The patient must present with symptoms and with a significant number of bacterial species in order to be treated with antibiotics. Antibiotic treatment for CAUTIs that are confirmed SUTIs are usually cephalosporins, like cephazolin, cefuroxime, and ceftriaxone, which can be administered through IV. In severe cases when a patient is presenting with urosepsis or are hemodynamically unstable, piperacillin-tazobactam can be given (Inge, 2010). Gentamicin bladder irrigation can be used to treat SUTIs in patients who cannot take antibiotics orally. It is delivered into the bladder through the catheter (Children's Seattle, 2021).

According to the CDC, prolonged catheter insertion is the main risk factor for acquiring CAUTIs and can lead to further complications, such as cystitis and sepsis, so it is vital that catheters are removed when they are no longer needed (CDC). CAUTIs can also extend the LOS by two to four days (Vargas et al., 2020). In some cases, the catheter can become obstructed from biofilm formation or crystal precipitate formation from *Proteus mirabilis* in the urine (Cravens et al., 2000).

Hydrotherapy is the treatment using warm water to cleanse and heal the burn injury. This process gently removes dead tissue so new tissue can grow. Bacteria is also removed in the process of washing the skin, thus reducing the risk for infection. Hydrotherapy can be done anywhere from twice daily to once weekly. Many burn centers provide hydrotherapy to their burn patients that qualify for it, however there is no standardized practice for this yet. CHG is also used within dressings to promote decolonization of wounds. CHG bathing can also be done with a low concentrated CHG solution (Hibiclens) used to wash burn wounds, followed by placing CHG cloths or wipes onto intact skin. This method has been shown to reduce MDRO acquisition, like extended spectrum beta-lactamase (ESBL) and *E. coli* (Miller-Willis et al., 2020). In some burn units, implementing twice daily CHG bathing has significantly decreased HAIs (Popp et al., 2014). Patients are highly encouraged to continue using CHG for decolonization and bathing after hospital discharge. There is no standard protocol for CHG bathing for burn patients yet, but it is widely used.

#### **1.4 The UPMC Mercy Burn Center**

The University of Pittsburgh Medical Center Mercy (UPMC Mercy) is a 500-bed tertiary acute care hospital in Western Pennsylvania. The UPMC Mercy Burn Center (MBC) is the only hospital in Western Pennsylvania with a Level I Regional Resource Trauma Center attached, so they receive many severely burned trauma victims of all ages. MBC has both inpatient and outpatient services for pediatric and adult patients. The MBC team consists of trauma and plastic surgeons, infectious diseases doctors, nurses, physician assistants (PAs), and more. Their approach to treating burns is multi-faceted so many other departments and units play a major role in

treatment. Dietitians, respiratory technicians, occupational therapists, physical therapists, infection preventionists, and many other healthcare professionals contribute to providing care for the patient. Overall, the goal is to treat burn wounds and injuries, provide skin grafting, prevent and treat infection, rehabilitate, and provide emotional support to patients and their families.

The use of environmental disinfection services is important throughout UPMC Mercy, but especially inside MBC in order to patients safe and infection-free. Air and water quality assessments are regularly done to look for any contaminants as well. The presence of contaminants could cause infection and worsen the patients' condition. MBC nurses perform rectal and groin swabs weekly, which are then sent to the lab to screen for ESBL, carbapenem-resistant *Enterobacterales* (CRE), vancomycin-resistant enterococcus (VRE), and MRSA. MBC has burn-specialized trauma surgeons who carry out excision and grafting procedures on burn patients who require them. MBC also commonly uses hydrotherapy to treat their patients with serious burns.

MBC has 9 beds inside of individual bedrooms to reduce infection to allow privacy for burn patients. Each room is set to have positive air pressure to keep the vulnerable burn patients from developing infection. The air pressure inside the positive pressure room is more than the air pressure in the surrounding environment. Almost every room has a positive pressure ante room, which is an adjacent space for staff and visitors to don and doff their respective PPE. By having positive pressure in patient rooms and anterooms, contaminants from the surrounding environment will not be able to enter the patient rooms. Each room also has patient contact precautions displayed on the door, so staff and visitors know what PPE needs to be worn prior to entering the room, in addition to completing hand hygiene. MBC also has a playroom that was specially made to accommodate pediatric burn patients. Child life specialists and infection preventionists maintain

the room by making sure the toys and books in this room are safe and clean for pediatric burn patients to use (UPMC).

MBC is also verified by the American Burn Association (ABA), which is an organization that aims to “improve the lives of everyone affected by a burn injury,” (ABA). This organization does burn-related research, education, care, and prevention. There are 68 hospitals that are verified by the ABA and that share their burn injury and outcome data to improve burn care; this is done through the ABA burn registry. MBC voluntarily reports their burn injury patient data to the ABA Burn Registry, which then contributes to the ABA’s National Burn Repository (NBR) report. The NBR is an annual public report that contains a detailed analysis of all burn injury data including average LOS, average MOI, mortality rates, and more analyses based off the type of burn (ABA, 2017). The NBR and ABA verification is a vital resource that MBC uses for improving burn patient services and outcomes.

### **1.5 Infection Prevention in Burn Centers**

Pennsylvania is one of the states required by law to report their HAI data to NHSN. UPMC Mercy’s Infection Prevention Team reports MBC HAIs to NHSN. They use the most recent NHSN Patient Safety Component Manual to see if an infection meets HAI reporting requirements. The manual contains detailed chapters of criteria and definitions for each type of common HAI and for special types of infections, like burn-related infections. Reporting HAIs to NHSN helps to further study HAI pathogens and risk factors. This ultimately will prevent or reduce antibiotic resistance and future HAIs (CDC, 2017).

Infection prevention (IP) in the burn unit is essential, given the increased susceptibility of patients to develop an infection due to compromised first line of immune defense, the skin. It is crucial to have an Infection Preventionist supervising burn centers and burn patients regularly. Some of the roles of Infection Preventionists (IPs) in the burn center is to check for patient positive cultures and assign contact precautions, accordingly, ensure that all staff and visitors are donning and doffing all necessary PPE correctly, and checking air and water quality. They also check that each patient's room has the appropriate signage to indicate that PPE and hand hygiene are required to enter patients' room. Hand hygiene and wearing PPE are heavily enforced by IPs in the burn center. Proper PPE can include gloves, gowns, face shields, goggles, hair covers, shoe covers, and masks. Hand hygiene must be done before and after entering patients' rooms. This entails washing hands with warm water and soap for 20 seconds or more. Additional precautions that are put into place when building a burn center is having individual rooms for each patient with an anteroom, as well as positive pressure patient rooms and anterooms.

### **1.6 Analysis Aims**

Through this three-year descriptive retrospective analysis, we aim to study MBC inpatient pediatric patients with burns equal or greater than 10% TBSA, as this puts pediatric patients more at risk for developing an infection (Dai et al., 2010). We also aim to further investigate how many of these patients developed HAIs reported to NHSN. Using descriptive statistics, we will determine the most common microorganism, HAI, MOI, and topical antibiotic treatment. We will also assess how many patients had burn injuries and complications from child abuse or child abandonment or neglect being the MOI.

## **1.7 Public Health Significance**

Child abuse, abandonment, and neglect is a serious public health concern. Repeated child abuse can cause for adverse childhood effects and these effects can manifest physically, mentally, and socially throughout a child's life. Around 1 in 7 children experience child abuse and neglect every year (CDC, 2021). Approximately ten percent of burn unit admissions of children are caused by child abuse. Pediatric patients that are victims of child abuse via burn injury are usually younger than 20 years old and often less than 2 years old. It is common that MOIs consisting of child abuse result in a greater LOS and higher mortality rate (US Department of Justice). According to one study, hospital admission is only required and seen in 6% of children who have burn injuries from abuse (Toon et al., 2011). This shows that not all children are receiving the medical attention that they need for treatment and potential rescuing from their situation. Upon hospital admission, physicians and nurses are conscious to look for signs of abuse in children that present with injuries. They will alert hospital social workers of any suspected abuse and/or abandonment and they will further investigate. The social workers are trained to interview the child separately from their parents or guardians, so they can safely disclose if they were abused or not.

In some cases, children can get burned in the absence of their parents or guardian supervision. It is important to study and identify these incidents of child abuse, abandonment, and neglect in order to better prevent them. This also helps to remove abusers and neglectful parents or guardians from their children's life in order to improve their lives. This could eventually decrease the hospital admissions to burn units, and thus decrease burn injuries and burn-related infections.

## **2.0 Methods**

This single-center study is a retrospective descriptive analysis of pediatric inpatient burn victims admitted and treated at UPMC Mercy's Burn Center from January 1<sup>st</sup>, 2018, to December 31<sup>st</sup>, 2020.

### **2.1 Sample Selection and Data Abstraction**

The general sample for this analysis consists of pediatric burn patients that went to MBC for burn care between 2018 and 2020; these patients were also voluntarily reported by MBC to the ABA Burn Registry. This patient dataset includes name, medical record number (MRN), admittance and discharge date, LOS, TBSA, vent days, age, discharge disposition, complications, date of birth, ISS, and MOI. MBC treated a total of 1,059 inpatient and outpatient adult and pediatric patients with burn injuries over the three-year span. During this time span, 208 patients were pediatric patients between the ages of less than one year to 17 years old. 113 of the pediatric patients were outpatient and had an LOS of 1 day or less. 95 MBC pediatric patients were inpatient and had an LOS greater than 1 day.

The sample consists of MBC inpatient pediatric patients ( $LOS > 1$ ) with a TBSA of 10% or greater because this criterion makes patients more prone to infection (Dai et al., 2010). Out of the 95 MBC pediatric inpatient patients, there were 27 patients that had a TBSA of 10% or greater during the three-year span.



Patient electronic health records (EHRs) were accessed via Core PowerChart. Patients' data were extracted and placed in an Excel spread sheet. The clinical notes contain detailed reports on emergency department (ED) evaluations, inhalation injury presence, the Lund-Browder chart for calculating TBSA, and infectious disease consultations. Reading through all of these made us better understand the patient's condition and progress throughout their treatment for their burn injury. By inputting the patient's MRN, all their medical and treatment history from all UPMC locations are available. Using this, we collected information regarding the antibiotics prescribed, blood and urine cultures, complications during treatment, and patient reports. This was done for the 27 MBC pediatric inpatient patients for their hospitalization for their burn injury.

The UPMC Mercy Infection Prevention Team keeps records of all their reported and confirmed HAIs. Information collected on these records include basic patient identifying information, date of HAI event, hospital admission date, number of days between admission and event or between procedure to event, event type, and name of pathogen detected. It is also indicated on here if a central line or urinary catheter was in place or not. This record was assessed and narrowed down to focus on our sample of interest, which is MBC pediatric inpatient patients with a TBSA of 10% or more, during 2018-2020. There were 4 patients in this criterion that had a reported and confirmed HAI.

## **2.2 Study Design**

In the 27 MBC pediatric inpatient patients, the average LOS, TBSA, age, and ISS were calculated. All positive cultures including blood, urine, respiratory, skin and soft tissue were recorded. Antibiotics were reported as topical or systemic. Burn infections were recorded as well.

Additionally, pediatric patients who had child abuse or child abandonment being the MOI were recorded.

### **2.3 Statistical Analyses**

Descriptive statistics were used to calculate the mean of TBSA, ISS, age, LOS, and number of days in between admission and HAI event. The mode function was used to determine the most common topical antibiotic, MOI, and HAI. A bar chart was done to show the distribution of TBSA, LOS, ISS, MOI, and age among the sample of interest. This was done using Stata SE 16.0's "summarize" and "histogram" functions.

### 3.0 Results

#### 3.1 Inpatient Pediatric Burn Patients with 10% TBSA or Greater

There were no pediatric deaths from burn injuries in MBC from 2018-2020. There were 27 patients identified out of the totals 95 in patient pediatric patients treated at MBC (Table 1). Out of these 27 patients, 11 were males and 16 were females. One patient required the use of a ventilator for one day upon admission, but did not have any inhalational injuries from the burn. The average LOS was 13 days (SD= 9.64) of hospitalization in the unit (Table 2 and Figure 1c). The average TBSA was 16.28 (SD= 8.58) (Figure 1d). The average age of the patients was 5 years old (SD= 5.26), the youngest patient was 2 weeks old, and the oldest patient was 17 years old (Figure 1a). The average ISS was 8 (SD= 7.96); the lowest ISS was 4, which most patients had as their ISS, and the highest ISS was 36 (Figure 1b). There were many types of MOIs among the 27 patients, but the most common one was contact with other hot fluids (Figure 2). Other common MOIs were exposure to ignition of other clothing and apparel, contact with hot food, and exposure to flames in uncontrolled fire (not in building).

Bacteria found in blood cultures were *Enterococcus faecalis*, *Serratia marcescens*, and MRSA (Table 3). Bacteria found in urine cultures were *P. mirabilis*, *S. marcescens*, *Enterococcus spp.*, *E. coli*, *P. aeruginosa*, and *Enterobacter cloacae*. Bacteria from the quantitative cultures include *S. marcescens*, *K. pneumoniae*, MRSA, *P. mirabilis*, *Acinetobacter*, and *P. aeruginosa*. Bacteria from the aerobic culture were *Morganella morganii*, MRSA, *P. aeruginosa*, *Providencia rettgeri*, and *S. aureus*. 3 patients screened positive for MRSA, which was the only MDRO found

in these patients. The most common bacteria detected were MRSA and *P. aeruginosa*; these were both separately responsible for causing an HAI in two different patients.

The most common topical antibiotic given was bacitracin polymyxin B and this was prescribed very early on during the patients' hospitalization. This was prescribed to 16 patients during their stay. Based off clinical notes, patients who used this did not develop skin-related or wound infections. Silver sulfadiazine and mafenide were other commonly prescribed topical antibiotic ointments as well. In addition to antibiotic use, most patients received hydrotherapy. 17 patients underwent hydrotherapy for their burns during their hospitalization.

The most common IV antibiotic administered was cefazolin. This was given to every patient who underwent an excision and graft surgery during the preparation for the procedure. There were 18 patients who underwent an excision and received an autograft, allograft, or xenograft, and thus received cefazolin intravenously. Cefepime and ceftriaxone were given via IV to some patients who had burn-related infections and fevers. Vancomycin and piperacillin-tazobactam were given intravenously to a few patients with more serious burn injuries or infections. There were 6 patients that were on IV antibiotics for more than 3 days. The most common oral antibiotic given was amoxicillin and this was given to 3 patients who had ear infections, either related to their burn injury or from prior infection.

**Table 1. Summart of pediatric inpatient burn patient data**

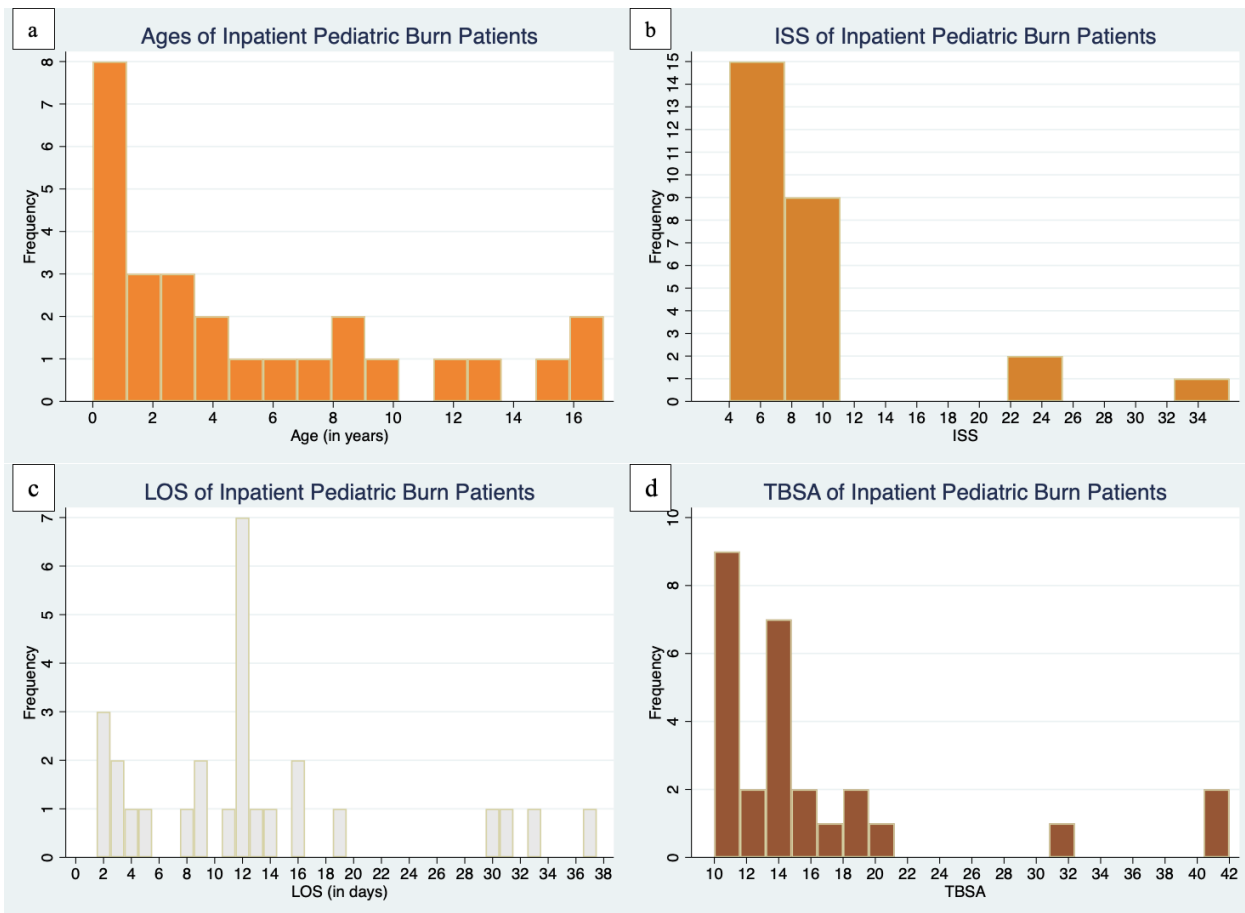
Data collected from patient EHRs

LOS	TBSA	Vent Days	Injury type	Age	Discharge Disposition	Complications	ISS	MOI	Sex
31	15.75	0	Burn	2 months	Alive	None	9	Contact with running hot water, initial encounter	M
11	13.5	0	Burn	7	Alive	None	4	Exposure to ignition of other clothing and apparel, initial encounter	M
16	17	0	Burn	2	Alive	None	9	Contact with hot food, initial encounter	M
13	20	0	Burn	10	Alive	None	9	Explosion of other specified explosive materials, initial encounter	F
37	32	1	Burn	17	Alive	Burn Graft Loss Requiring Repeat Procedure	36	Exposure to flames in uncontrolled fire, not in bldg, init	M
12	11.5	0	Burn	4	Alive	None	4	Exposure to ignition of other clothing and apparel, initial encounter	F
2	41.5	0	Burn	4	Alive	None	25	Explosion and rupture of unspecified gas cylinder, initial encounter	M
8	14	0	Burn	3	Alive	None	9	Contact with fats and cooking oils, initial encounter	F
4	10.5	0	Burn	6 months	Alive	None	9	Child physical abuse, suspected, initial encounter	M
12	16	0	Burn	1	Alive	None	9	Child physical abuse, suspected, initial encounter	F
12	12	0	Burn	1	Alive	None	9	Contact with other hot fluids, initial encounter	F
2	10	0	Burn	1	Alive	None	4	Contact with hot food, initial encounter	F
14	14	0	Burn	15	Alive	Catheter-associated Urinary Tract Infection	4	Explosion on board unspecified watercraft, initial encounter	F
2	11.5	0	Burn	12	Alive	None	4	Exposure to flames in uncontrolled fire, not in bldg, init	M
3	11	0	Burn	2 weeks	Alive	None	4	Contact with hot water in bath or tub, initial encounter	F
12	18.25	0	Burn	1	Alive	None	4	Contact with other hot fluids, initial encounter	M
16	13.75	0	Burn	8	Alive	None	4	Contact with other hot fluids, initial encounter	F
3	18.5	0	Burn	3	Alive	Sepsis/Bloodstream Infection	9	Child neglect or abandonment, suspected, initial encounter	F
9	10.15	0	Burn	6	Alive	None	4	Exposure to ignition of other clothing and apparel, initial encounter	M
5	11.2	0	Burn	3	Alive	None	4	Exposure to flames in controlled fire, not in bldg, init	F
19	11.5	0	Burn	5	Alive	Central line-associated Bloodstream Infection	4	Discharge of firework, initial encounter	F
9	13.5	0	Burn	8	Alive	None	4	Contact with other hot fluids, initial encounter	M
33	42	0	Burn	16	Alive	Catheter-associated Urinary Tract Infection	25	Exposure to ignition of highly flammable material, initial encounter	F
30	13.5	0	Burn	13	Alive	None	4	Contact with hot water in bath or tub, initial encounter	F
12	10.5	0	Burn	2	Alive	None	9	Child neglect or abandonment, suspected, initial encounter	F
12	12.5	0	Burn	2	Alive	None	4	Contact with hot food, initial encounter	F
12	14	0	Burn	1	Alive	None	4	Exposure to flames in uncontrolled fire in bldg, init	M

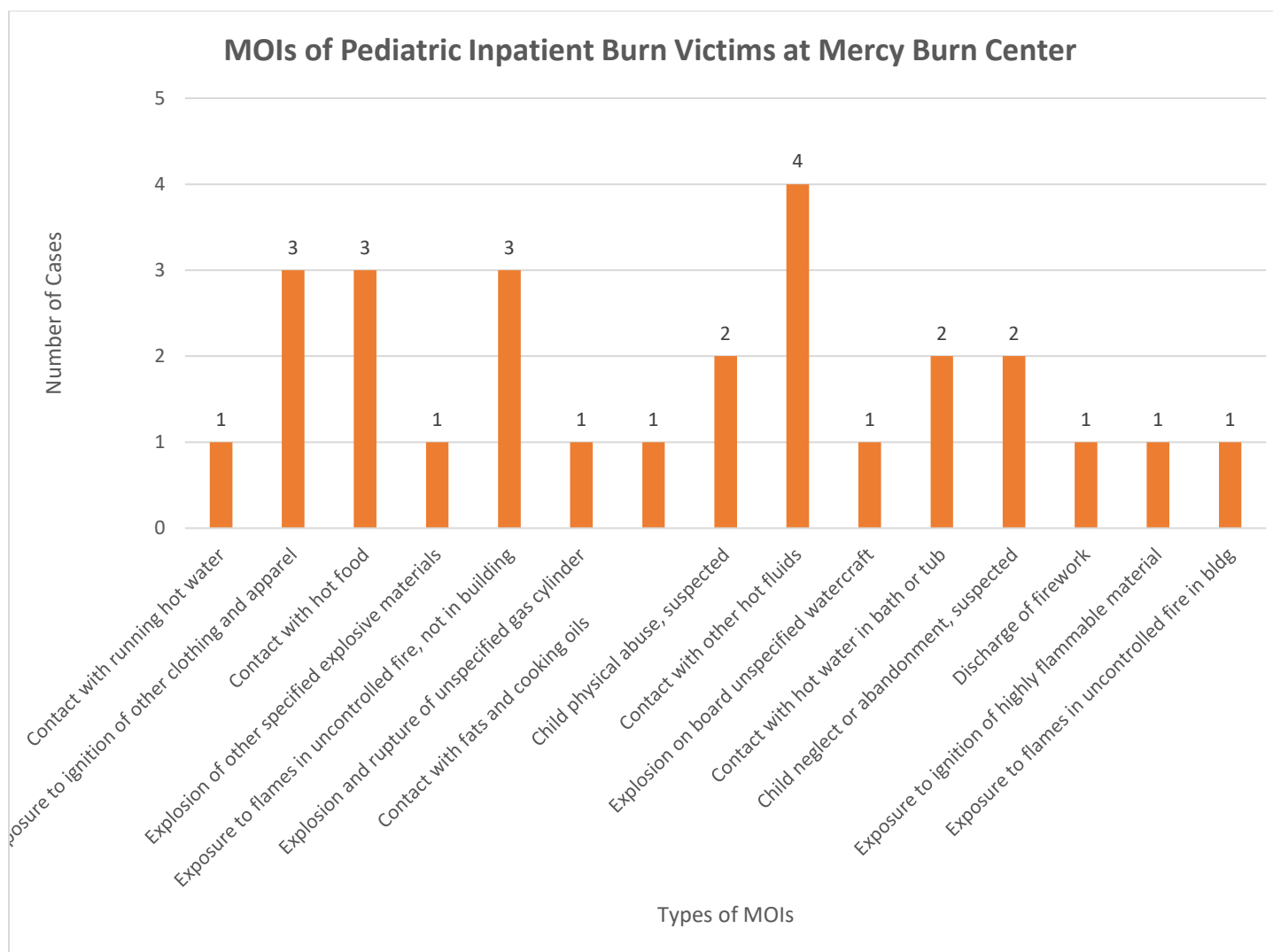
**Table 2 Summary of TBSA, LOS, age, and ISS means, maximum, and minimum**

Calculated using Stata SE 16.0 using “summarize” as input.

Variable	Obs	Mean	Std. Dev.	Min	Max
TBSA	27	16.28148	8.575593	10	42
LOS	27	13	9.647638	2	37
Age	27	5.37037	5.256118	0	17
ISS	27	8.407407	7.860609	4	36



**Figure 1. (a-d) Histogram summary of patient age, ISS, LOS, and TBSA.** Calculated using Stata SE 16.0 using “histogram” as input.



**Figure 2. Types of frequencies of MOIs**

Mercy inpatient burn patients that had each type of MOIs

**Table 3. Summary of positive quantitative, aerobic, blood, and urine cultures and MRSA screenings from inpatient pediatric burn patients**

Data collected from microbiology report on patient EHRs

Quantitative culture	Aerobic culture	Blood culture	Urine culture	MRSA screen	HAI
<i>S. marcescens</i> , <i>K. pneumoniae</i> , MRSA, <i>P.mirabilis</i> , <i>Acinetobacter</i>			<i>P. mirabilis</i>	positive	
<i>P. aeruginosa</i>			<i>E. coli</i> , <i>Enterococcus</i> spp.		CAUTI
		<i>E. faecalis</i>			
		MRSA		positive	BSI
		<i>S. marcescens</i>	<i>S. aureus</i> , <i>P.aeruginosa</i>		CLABSI
			<i>E. cloacae</i> , <i>E. coli</i>		CAUTI
	<i>M. morgani</i> , MRSA, <i>P. aeruginosa</i> , <i>P. rettgeri</i> , <i>S.aureus</i>			positive	



### **3.2 Inpatient Pediatric Burn Patients with HAIs**

Among the 27 MBC inpatient pediatric patients with 10% TBSA or more, there were 4 patients that had confirmed HAIs that were reported to NHSN. All four of these patients were females. In these 4 MBC pediatric inpatient patients, the most prevalent HAI was determined using the HAI records reported to NHSN. The average LOS, TBSA, ISS, age, and number of days in between admission and HAI event were calculated. The average age for these four patients was 10 years old. The oldest patient was 16 years old, and the youngest patient was 3 years old. The average LOS for these patients was 17 days; the greatest LOS was 33 days and the shortest was 4 days. The average amount of days between admission and day of HAI event was 9 days. The lowest number of days leading up to the HAI event was 4 days and the highest amount was 14 days. The average TBSA was 21.5 and the TBSA ranged from 11.5 to 42 in these patients. The average ISS was 10.5; the lowest ISS was 4 and the highest was 25 (Table 4). The MOIs for these patients were suspected child neglect or abandonment, discharge of firework, explosion on board of unspecified watercraft, and exposure to ignition of highly flammable material.

**Table 4. Summary of inpatient pediatric burn patients with confirmed HAIs**

Gender	Age	Days: Admit to Event	Event Type	Specific Event	Culture	Pathogen 1	Pathogen 2	TBSA	LOS	ISS	MOI
F	3	4	BSI	LCBI	blood	MRSA		18.5	4	9	Child neglect or abandonment, suspected, initial encounter
F	5	14	CLABSI	LCBI	blood	Serratia marcescens		11.5	19	4	Discharge of firework, initial encounter
F	15	7	CAUTI	SUTI	urine	<i>Escherichia coli</i>	Enterococcus spp.	14	14	4	Explosion on board unspecified watercraft, initial encounter
F	16	12	CAUTI	SUTI	urine	<i>Enterobacter cloacae</i> complex		42	33	25	Exposure to ignition of highly flammable material, initial encounter

The types of reported and confirmed HAIs were: CAUTIs/SUTIs, LCBI/BSI, and LCBI/CLABSI; two patients had CAUTIs/SUTIs, one patient had a BSI, and one patient had a CLABSI. CAUTIs/SUTIs were the most common HAI among all MBC inpatient pediatric patients. These four HAIs took place in 2019 and 2020. The different types of bacteria that caused these HAIs include *S. aureus*, *S. marcescens*, *E. coli*, *Enterobacter cloacae* complex, and *Enterococcus* spp.

The first patient identified from the sample of interest with a HAI was from 2019 (Table 4, row 3). This 15-year-old female patient had a CAUTI/SUTI that was detected 7 days after admission. This patient's urine culture tested positive for *E. coli* and *Enterococcus* spp. The patient also had a Foley catheter in place, high white blood cell (WBC) count, and a fever, which all indicate a CAUTI/SUTI. This patient also has solitary kidney, which is a condition where the patient has only one kidney. The patient was treated with gentamicin irrigation, nitrofurantoin (Macrobid), and ceftriaxone for the CAUTI/SUTI. This patient was also treated with bacitracin polymyxin B and mafenide for topical antibiotics.

The other patient with the CAUTI/SUTI was a 16-year-old female (Table 4, row 4). This patient's urine culture found *Enterobacter cloacae* complex 12 days after admission. A Foley catheter was placed in the patient with difficulty 4 days before the urine culture was done. This was followed by the patient having a temperature and elevated WBC count. Fosfomycin and cefuroxime was given orally to treat the CAUTI/SUTI. The patient also received bacitracin polymyxin B and mafenide, as well as hydrotherapy, to treat their burn wounds.

The patient with the LCBI/BSI was transferred from Children's Hospital of Pittsburgh (CHP) to MBC to get treated for their burn injury, but was shortly transferred back to the Pediatric ICU at CHP to be treated for sepsis. This patient was a 3-year-old female with anemia (Table 4,

row 1). The patient's blood culture came back positive for MRSA after 3 days of hospitalization. During the patient's stay, they received clindamycin through a feeding tube (Dobhoff tube) and topical silver sulfadiazine as antibiotics.

The patient with the LCBI/CLABSI was a 5-year-old female (Table 4, row 2). This patient's blood culture revealed *S. marcescens* 14 days after admission. This patient had a peripherally inserted central catheter (PICC line) placed at CHP and was then transferred to MBC. The patient developed a fever, which lead to blood cultures to be taken from the PICC line. The patient was treated with vancomycin and cefepime via IV.

### **3.3 Pediatric Burn Patients with Child Abuse, Neglect, and Abandonment as MOI**

Among the 240 MBC inpatient and outpatient burn patients, there were 30 suspected child abuse, abandonment, and neglect cases. There was also one confirmed child abuse case. There were 12 patients admitted with suspected child abuse, 15 patients with suspected abandonment or neglect, and 2 patients with suspected unspecified child maltreatment.

The one confirmed child abuse case was a four-month-old male patient that came to the UPMC Mercy Emergency Department with facial burns and had healing rib fractures. This patient had a 4% TBSA and an ISS of 1. The unusual combination of injuries made ED physicians consider child abuse and further examination proved that child abuse was the MOI. When the parents were interviewed separately by social workers, they had conflicting stories, which further indicated that they were involved in the abuse. The patient was treated for their injuries and had a LOS of 4 days. The patient did not require any antibiotic prescriptions.

## 4.0 Discussion

It is possible that the two patients that were transferred to MBC (Table 4, row 1 and 2) obtained the bacteria that caused the HAI from the facility they were previously at. It is also possible that their younger age and less developed immune system put them further at risk for BSIs. It is more common that a longer LOS leads to an increased risk of BSI; thus, in the 3-year-old patient with a LOS of 4 (Table 4, row 1), the chance of developing a BSI from MBC seems unlikely. The 5-year-old patient (Table 4, row 2) seems to have either acquired the infection from the previous hospital or the PICC line was contaminated somehow at MBC.

The two patients with CAUTIs were both teenage females around the same age (Table 1, row 3 and 4). It is known that UTIs are more prevalent in adolescent females due to the more complex anatomy of female genitalia. This could have made the Foley catheter insertion more difficult or could have allowed for increased contamination, leading to infection. The 15-year-old patient with the CAUTI (Table 4, row 3) had the pre-existing condition of solitary kidney, which could have increased the risk for acquiring a CAUTI. There was noted difficulty when placing the Foley catheter into the 16-year-old patient (Table 4, row 4), so this could have contributed to contamination or irritation, causing the CAUTI.

One of the four HAIs reported was caused by an MDRO, MRSA (Table 4, row 1). Due to this patient's short LOS, it is unknown how this patient was treated for it and how long it took to clear the infection. There were 3 patients in total that screened positive for MRSA (Table 3). Other MDROs like ESBL, CRE, and VRE were not found in any of the inpatient pediatric burn patients at MBC during the three-year span. It is important to conduct active surveillance for MDROs, especially in the burn unit due to the patients' critical immune condition. MBC screens for MDROs

using rectal and groin swabs weekly, which can help identify the colonization of MDROs prior to severe symptoms presenting. The continuous use of hand hygiene and PPE, along with patient isolation, can prevent the infection and spread of MRSA.

According to the CDC, yearly 1 in 25 hospitalized patients gets diagnosed with an HAI. Out of 95 inpatient pediatric burn patients, MBC only had 4 patients with HAIs over a three-year span, which is significantly less than the national average. This shows that MBC staff's burn wound care and IPs' efforts are effective, however the goal is to have zero HAIs. MBC staff and IPs could collaborate their expertise to explore the potential benefits of using antimicrobial impregnated catheters or silicone catheters in burn patients to further prevent CAUTIs in pediatric burn patients. MBC staff and IPs should also continue to promote central line and indwelling catheter care, hand hygiene, and PPE usage throughout the unit. MBC's continuous environmental disinfection services and positive pressure anterooms and single-patient rooms are great ways to prevent infection in burn patients. This ultimately helps to isolate the patient and should be practiced and recommended to all burn centers.

Preventing burn infections can be done within a hospital, however preventing burns caused by neglect or abandonment is done at home. There are campaigns to educate parents and guardians on the importance of fire safety in the house. These promote being conscious of hot items around the house and using physical measures to prevent children from encountering hot items. Water temperatures should be set to a lower temperature to prevent scald burns. More importantly, constant supervision and disciplining of younger children can ultimately prevent burns. It is more difficult to prevent child burn abuse and maltreatment, however hospital staff, teachers, and other community members that frequently interact with younger children can look out for repeated unusual burns and inconsistent injuries, as these could indicate child abuse.

#### **4.1 Limitations**

Our study had multiple limitations. First, the sample size was small, however, severe burns are rare. This small sample size is likely acceptable in rare disorders. Second, the retrospective descriptive nature with no control group does not allow risk factor determination and is vulnerable to many confounding variables. Third, this was a single-center study done at a tertiary acute care hospital in a city, so data may not be generalizable to other burn centers in hospitals.

#### **4.2 Future Directions**

This study provides basic data on pediatric burn victims that could direct resources for infection prevention efforts. Larger prospective multi-center studies could provide additional data to guide burn infection prevention and treatment efforts. An analysis can be done with other burn centers in other cities to further study pediatric burn infections. The timeframe can also be expanded to 5 years as well.

## **5.0 Conclusions**

Preventing burns and burn infections are impossible, however the ongoing collaboration between the burn team and infection prevention team is vital for better outcomes for pediatric burn patients. The UPMC Mercy Burn Center has low HAI rates in pediatric burn victims compared to the national average. Pediatric burn populations are susceptible to acquiring infections, thus appropriate IP measures, like hand hygiene and PPE donning and doffing, need to be enforced in burn units. Preventing pediatric burns and pediatric burn abuse and abandonment can mainly be done at home; younger children need to be supervised constantly by parents or community members to promote their safety.



## Bibliography

- 2022 *NHSN Patient Safety Component Manual*. Centers for Disease Control and Prevention. (2022). Retrieved from [https://www.cdc.gov/nhsn/pdfs/pscmanual/pscmanual\\_current.pdf](https://www.cdc.gov/nhsn/pdfs/pscmanual/pscmanual_current.pdf)
- Al-Sayyed, B., Le, J., Al-Tabbaa, M. M., Barnacle, B., Ren, J., Tapping, R., & Aiyer, M. (2019). Uncomplicated Urinary Tract Infection in Ambulatory Primary Care Pediatrics: Are We Using Antibiotics Appropriately?. *The journal of pediatric pharmacology and therapeutics : JPPT : the official journal of PPAG*, 24(1), 39–44. <https://doi.org/10.5863/1551-6776-24.1.39>
- American Burn Association. (2017, May 10). *Who we are*. American Burn Association. Retrieved from <https://ameriburn.org/who-we-are/>
- Appropriate Use and Prompt Removal of Indwelling Urinary Catheters*. Centers for Disease Control and Prevention. (n.d.). Retrieved from <https://www.cdc.gov/infectioncontrol/pdf/strive/CAUTI102-508.pdf>
- Bayat, A., Ramaiah, R., & Bhananker, S. M. (2010). Analgesia and sedation for children undergoing burn wound care. *Expert review of neurotherapeutics*, 10(11), 1747–1759. <https://doi.org/10.1586/ern.10.158>
- Burn injuries in child abuse - office of justice programs*. (n.d.). Retrieved from <https://www.ojp.gov/pdffiles/91190-6.pdf>
- Cartotto, R. Topical antimicrobial agents for pediatric burns. *Burn Trauma* 5, 33 (2017). <https://doi.org/10.1186/s41038-017-0096-6>
- Centers for Disease Control and Prevention. (2017, December 14). *Healthcare-associated infections (HAIs)*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/winnablebattles/report/HAIs.html>
- Centers for Disease Control and Prevention. (2017, October 19). *NHSN's Stated Purposes*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/nhsn/about-nhsn/technology.html>
- Centers for Disease Control and Prevention. (2015, November 5). *Catheter- Associated Urinary Tract Infections Background*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/infectioncontrol/guidelines/cauti/background.html>

- Centers for Disease Control and Prevention. (2010, November 24). *Frequently asked questions about catheter-associated urinary tract infections*. Centers for Disease Control and Prevention. Retrieved from [https://www.cdc.gov/hai/ca\\_uti/cauti\\_faqs.html](https://www.cdc.gov/hai/ca_uti/cauti_faqs.html)
- Centers for Disease Control and Prevention. (2021, March 15). *Preventing child abuse & neglect*. Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/violenceprevention/childabuseandneglect/fastfact.html>
- Church, D., Elsayed, S., Reid, O., Winston, B., & Lindsay, R. (2006). Burn wound infections. *Clinical microbiology reviews*, 19(2), 403–434. <https://doi.org/10.1128/CMR.19.2.403-434.2006>
- Cravens, D. D., & Zweig, S. (2000). Urinary catheter management. *American family physician*, 61(2), 369–376.
- Dai, T., Huang, Y. Y., Sharma, S. K., Hashmi, J. T., Kurup, D. B., & Hamblin, M. R. (2010). Topical antimicrobials for burn wound infections. *Recent patents on anti-infective drug discovery*, 5(2), 124–151. <https://doi.org/10.2174/157489110791233522>
- Gentamicin Bladder Irrigation* . Children's Seattle . (2021, March). Retrieved from <https://www.seattlechildrens.org/pdf/PE1769.pdf>
- Haddadin Y, Annamaraju P, Regunath H. Central Line Associated Blood Stream Infections. [Updated 2021 Aug 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK430891/>
- Han, Z., Liang, S. Y., & Marschall, J. (2010). Current strategies for the prevention and management of central line-associated bloodstream infections. *Infection and drug resistance*, 3, 147–163. <https://doi.org/10.2147/IDR.S10105>
- Inge, L. D. (2010, August 19). *Management of catheter-associated urinary tract infections*. U.S. Pharmacist – The Leading Journal in Pharmacy. Retrieved from <https://www.uspharmacist.com/article/management-of-catheter-associated-urinary-tract-infections>
- Krishnamoorthy, V., Ramaiah, R., & Bhananker, S. M. (2012). Pediatric burn injuries. *International journal of critical illness and injury science*, 2(3), 128–134. <https://doi.org/10.4103/2229-5151.100889>
- Lachiewicz, A. M., Hauck, C. G., Weber, D. J., Cairns, B. A., & van Duin, D. (2017). Bacterial infections after burn injuries: Impact of Multidrug Resistance. *Clinical Infectious Diseases*, 65(12), 2130–2136. <https://doi.org/10.1093/cid/cix682>
- Lin, K.-Y., Cheng, A., Chang, Y.-C., Hung, M.-C., Wang, J.-T., Sheng, W.-H., Hseuh, P.-R., Chen, Y.-C., & Chang, S.-C. (2017). Central line-associated bloodstream infections among

- critically-ill patients in the era of bundle care. *Journal of Microbiology, Immunology and Infection*, 50(3), 339–348. <https://doi.org/10.1016/j.jmii.2015.07.001>
- Mermel, L. A., Allon, M., Bouza, E., Craven, D. E., Flynn, P., O'Grady, N. P., Raad, I. I., Rijnders, B. J., Sherertz, R. J., & Warren, D. K. (2009). Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*, 49(1), 1–45. <https://doi.org/10.1086/599376>
- Miller, L., Kahn, K., Eells, S. J., Choi, S., Riva, M., Go-Wheeler, M., Hossain, T., & Grein, J. (2014). The frequency of antibiotic treatment of positive urine cultures in hospitalized patients that are not utis: A three hospital survey. *Open Forum Infectious Diseases*, 1(1). <https://doi.org/10.1093/ofid/ofu052.09>
- Miller-Willis, K. L., Thomas, M., & Joe, V. C. (2020). Chlorhexidine gluconate for burn wound cleansing: Reduction in multi-drug resistant organism acquisition. *Journal of Burn Care & Research*, 41(Supplement 1), S45–S46. <https://doi.org/10.1093/jbcr/iraa024.074>
- Northway, T., Langley, J. M., & Skippen, P. (2011). Health Care–Associated Infection in the Pediatric Intensive Care Unit: Epidemiology and Control—Keeping Patients Safe. *Pediatric Critical Care*, 1349–1363. <https://doi.org/10.1016/B978-0-323-07307-3.10097-7>
- Oaks RJ, Cindass R. Silver Sulfadiazine. [Updated 2022 Jan 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK556054/>
- Reynolds, P., Scattoloni, J.A., Ehrlich, P., Cladis, F.P., Davis, P.J., CHAPTER 30 - Anesthesia for the Pediatric Trauma Patient, Editor(s): Peter J. Davis, Franklyn P. Cladis, Etsuro K. Motoyama, Smith's Anesthesia for Infants and Children (Eighth Edition), Mosby, 2011, Pages 971-1002, ISBN 9780323066129, <https://doi.org/10.1016/B978-0-323-06612-9.00030-4>.
- Rivas, E., Sanchez, K., Cambiaso-Daniel, J., Gutierrez, I. L., Tran, J., Herndon, D. N., & Suman, O. E. (2017). Burn injury may have age-dependent effects on strength and aerobic exercise capacity in males. *Journal of Burn Care & Research*, 39(5), 815–822. <https://doi.org/10.1093/jbcr/irx057>
- Sen, S. Pediatric inhalation injury. *Burn Trauma* 5, 31 (2017). <https://doi.org/10.1186/s41038-017-0097-5>
- Shubert J, Sharma S. Inhalation Injury. [Updated 2021 Jun 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK513261/>

- Toon, M. H., Maybauer, D. M., Arceneaux, L. L., Fraser, J. F., Meyer, W., Runge, A., & Maybauer, M. O. (2011). Children with burn injuries--assessment of trauma, neglect, violence and abuse. *Journal of injury & violence research*, 3(2), 98–110. <https://doi.org/10.5249/jivr.v3i2.91>
- UPMC Mercy Burn Center. UPMC. (n.d.). Retrieved from <https://www.upmc.com/locations/hospitals/mercy/services/burn-center>
- Vargas, V., Rivera, E., Sidhu, T., Zaballero, L. L., & Karanas, Y. L. (2020). Prevention of CAUTIs in a Burn ICU. *Journal of Burn Care & Research*, 41(Supplement 1), S138. <https://doi.org/10.1093/jbcr/iraa024.218>
- Zhang, P., Zou, B., Liou, Y.-C., & Huang, C. (2021). The pathogenesis and diagnosis of sepsis post burn injury. *Burns & Trauma*, 9. <https://doi.org/10.1093/burnst/tkaa047>