The epidemiologic characteristics and outcomes following intentional burn injury at a regional burn center

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ABSTRACT

Introduction: Intentional burn injury outcomes are usually more severe, have a high mortality and are seen more often in low and middle-income countries. This study will examine the epidemiological characteristics of intentional burn injury patients and mortality outcomes at a regional Burn Center.

Methods: This is a retrospective study of 11,977 patients admitted to a regional Burn center from 2002 to 2015. Variables analyzed were basic demographics (sex, age, and race), total body surface area of burn (%TBSA), presence of inhalation injury, Charlson comorbidity index, intent of injury, mortality, and hospital and ICU length of stay (LOS). Chi-square tests, bivariate analysis and logistic regression models were utilized to determine the effect of burn intent on outcomes.

Results: Eleven thousand eight hundred and twenty-three (n = 11,823) adult and pediatric patients from 2002 to 2015 were included in the study. Three hundred and forty-eight (n = 348, 2.9%) patients had intentional burn injuries (IBI). Patients with IBI were younger, 26.5 ± 20 years compared to the non-intentional burn injury (NIBI) group (32 ± 22 years, $p < 0.001$). Mean %TBSA was significantly higher in the IBI vs. NIBI group at 14.6 ± 20 vs. $6.4 \pm 10\%$, $p < 0.001$, respectively. Overall, Non-whites (n = 230, 66%) were more likely to have IBI, $p < 0.001$. Inhalation injury and mortality were statistically significant in the IBI group compared to the NIBI group, (n = 54,16%) vs. (n = 30, 9%) and (n = 649,6%) vs. (n = 329,2.9%), $p < 0.001$, respectively. Multivariate logistic regression did not show any significant increase in odds of mortality based on burn intent. In subgroup analysis of self-inflicted (SIB) vs. assault burns, SIB patients were significantly older, 38 years (±14.7) vs. 22.4 years (±20.5), $p < 0.001$ and had a higher %TBSA, 26.5 (±29.6) vs. 10.3 (±13.6), $p < 0.001$. Seventy three percent (n = 187, 73%) of assault burn patients were Nonwhite and Whites were more likely to incur self-inflicted burns, (n = 53% $p < 0.001$).

Conclusion: We show that patients with intentional burn injuries have an associated increased %TBSA and inhalation injury without increased adjusted odds for mortality. Intentional burns increase health care expenditures. Violence prevention initiatives and access to mental health providers may be beneficial in reducing intentional burn injury burden.

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1. Introduction

Burns are tissue damage from thermal exposure, radiation, chemical or electrical contact that can result in significant morbidity and mortality. In 2016, 486,000 people with burn injuries received medical treatment and 40,000 individuals were hospitalized due to burn injuries in the United States [1]. Globally, burns account for an estimated 180,000 deaths per year largely in low and middle-income countries and were among the leading causes of disability-adjusted life years (DALYs) lost [2].

Intentional burns are injuries that are self-inflicted or inflicted by others (assault, child abuse or arson) for the purpose of causing harm or death [3,4]. The worldwide incidence of intentional burns for hospitalized patients range between 3 and 10% [4]. According to the American Burn Association (ABA) 2017 National Burn Repository Annual Report, in burn centers across the United States, 3% of burn admissions were due to assault and self- injury [5]. The motivation behind intentional burn injuries are varied from interpersonal conflict, domestic violence, drug and alcohol abuse, homicide or self-immolation [5]. Although rare, intentional burn injuries are associated with higher mortality and worse outcomes compared to the general burn population [6,7]. Intentional burns are also associated with higher medical costs.

There are limited studies that examine intentional burns and mortality outcome. Therefore, we present descriptive epidemiological characteristics and outcomes of intentional burns at a regional burn center. This study is unique in that we were able to analyze, in a subgroup analysis, the characteristic of intentionality as it pertains to self-inflicted versus assault burn injury.

2. Methods

This is a retrospective study of burn patients entered into the UNC Jaycee Burn Center registry from 2002 to 2015. The burn center is a 36-bed unit that has been certified by the American Burn Association. Burn intentionality was determined by ICD 9 and 10 codes or self-report on presentation to the burn unit. Burn intent was defined as intentional (assault, self-inflicted, child abuse or arson) or non-intentional (not premeditated). Patients who had unknown or no documented cause of burn injury were excluded from the study (n = 154).

Burn patient characteristics included sex, age, race, type of burn, presence of inhalation injury, % total body surface area (TBSA), Charlson Comorbidity Index (CCI), and burn circumstance (intentional vs. all other burns). Mortality, hospital and ICU length of stay (LOS) were the outcome variables of interest. Chi-square and bivariate analyses were used to statistically compare the two groups. Multivariate logistic regression was used to estimate the odds of mortality, hospital and ICU LOS in intentional burn injury patients controlling for other confounders (age, TBSA, race, and inhalation injury). Subgroup analysis was done to compare self-inflicted burns and assault burns and to assess the epidemiology of intentional burns among the pediatric population.

Statistical analyses were performed using the Stata IC/15.0 (StataCorp LP, College Station, TX). In all cases, a p-Value <0.05 was considered statistically significant. University of North Carolina Institutional Review Board approved this study.

3. Results

Eleven thousand nine hundred and seventy-seven (n = 11,977) patients were recorded in the burn registry database from 2002 to 2015. After inclusion criteria was met, 11,823 adult and pediatric patient records were reviewed for this study (Table 1). Overall, 69% (n = 8151) of the study population were males with an overall mean age of 31.8 ± 22 years and % mean TBSA of 6.6 ($\pm$10.6). Whites and Non-whites made up an almost equal number of patients, 52% vs. 48%, respectively. The most common type of burn was scald (n = 5709, 48%), followed by flame/fire (n = 4903, 42%) and then chemical or electrical burn (n = 1150, 10%). Seven hundred and three (n = 703, 6%) of patients had inhalation injury and overall mean Charlson Comorbidity index was 0.34 ± 0.94. In the study cohort, 348 (2.9%) patients had intentional burn injuries (IBI). Assault related burns accounted for majority of the intentional burns (n = 132, 38%), followed by child abuse (n = 114,33%), self-inflicted (n = 92, 26%) and arson (n = 10, 3%). Overall mean % TBSA was 6.6 ($\pm$10.6). Median hospital and ICU LOS were 3 (IQR = 1–11) and 5 (IQR = 2–11) days, respectively.

Bivariate analysis comparing the two groups showed that IBI patients had a lower mean age of 26.5 ± 20.4 vs. 32 ± 22 years ($p < 0.001$) in the non-intentional burn injury (NIBI) group. Mean %TBSA in the IBI group was more than twice that in the NIBI group, 14.6 ± 20 vs. 6.4 ± 10, $p < 0.001$, respectively. Non-whites (n = 230, 66%) were almost two times more likely to have IBI compared to Whites (n = 118, 34%), $p < 0.001$. Inhalation injury in the IBI group was significantly higher at 16% (n = 54) vs. 6% (n = 647) in the NIBI group, $p < 0.001$. Mortality was three times greater in patients with IBI compared to the NIBI group, (9% (n = 30) vs. 2.9% (n = 329), $p < 0.001$. IBI patients also had both a higher median hospital and ICU LOS compared to NIBI patients (Hospital: 10 days, IQR: 3–25 vs. 5 days, IQR: 1–11), and (ICU: 7 days, IQR: 1–34 vs. 3 days, IQR: 1–11), $p < 0.001$, respectively. Sex and burn mechanism and comorbidities were not significantly different between the two groups.

Multivariate logistic regression modelling comparing mortality between IBI and NIBI while adjusting for covariates (Table 2) did not show an increased odd for mortality or ICU LOS among IBI patients (OR 1.18, 95% CI: 0.55–2.53, p = 0.666 and OR 1.30, 95% CI: 0.81–2.07, p = 0.275), respectively. However, IBI patients had 2 times the odds of prolonged hospital LOS over the median hospital LOS (OR 2.02, 95% CI: 1.43–2.86, $p < 0.001$).

Within the intentional burn group, we conducted a subgroup analysis (Table 3) to compare self-inflicted (SIB) versus assault related burns. Mean age for SIB patients was more than a decade older than assault burns patients, 38 ± 14.7 vs. 22.4 ± 20.5 years, $p < 0.001$ and SIB patients had higher % TBSA (26.5 ± 29.6 vs. 10.3 ± 13.6, $p < 0.001$ than the assault group. Assault victims were predominantly Non-White (n = 187, 73%), but Whites were more likely to incur self-inflicted burns (n = 49, 53%). Flame/fire burns were

Table 1 – Demographics, characteristics and outcome of burn patients with intentional vs. non-intentional injuries.

	All burns (%) (n = 11823)	Intentional (IBI) (%) (n = 348)	All other burns (NIBI) (%) (n = 11475)	p-Value
Mean age, y (SD)	31.8 (±22)	26.5 (±20)	32 (±22)	<0.001
% Mean TBSA (SD)	6.6 (±10.6)	14.6 (±20)	6.4 (±10)	<0.001
Mean CCI (SD)	0.34 (± 0.94)	0.43 (±1.2)	0.34 (±0.93)	0.192
Sex				0.794
Male	8151 (69%)	238 (68%)	7913 (69%)	
Female	3672 (31%)	110 (32%)	3562 (31%)	
Race				<0.001
White	6129 (52%)	118 (34%)	6011 (52%)	
Non-White	5692 (48%)	230 (66%)	5462 (48%)	
Mechanism				0.634
Flame/fire	4903 (42%)	145 (42%)	4758 (42%)	
Scald	5709 (48%)	172 (50%)	5537 (48%)	
Chemical or electrical	1150 (10%)	29 (9%)	1121 (10%)	
Inhalation injury	703 (6%)	54 (16%)	649 (6%)	<0.001
Mortality rate	338 (2.9%)	30 (9%)	329 (2.9%)	<0.001
Median ICU LOS (IQR)	3 (IQR: 1–11)	7 (IQR: 1–34)	3 (IQR: 1–11)	<0.001
Median Hospital LOS (IQR)	5 (IQR: 2–11)	10 (IQR: 3–25)	5 (IQR: 1–11)	<0.001

CCI = Charlson comorbidity index.
TBSA = total body surface area.
ICU LOS = intensive care unit length of stay.

significantly more common in self-inflicted burns (n = 78, 85%) and scald burns were more common in the assault group (n = 169, 67% $p < 0.001$). Overall, inhalation injury was more common in the intentional burn group, but self-inflicted burns had a higher proportion of inhalation injury compared to assault burns, (n = 32, 36% and n = 22, 9%), $p < 0.001$), respectively. Mortality was also higher in the SIB group compared to the assault group, (n = 22, 24% and n = 8, 3%), $p < 0.001$, respectively. Median hospital and ICU LOS were both prolonged in the SIB group, 12 days (IQR = 2–45) and 8.5 days (IQR = 1–43), respectively, though the difference was not statistically significant for ICU LOS between the two groups.

Multivariate logistic regression analysis comparing assault related burn injury with SIB after controlling for %TBSA, inhalation injury, CCI, age and race (Table 4), showed that SIB was not significantly associated with increased odds for mortality, increased hospital and ICU LOS.

Lastly, we looked at the characteristics of intentional burns in the pediatric population (Fig. 1). One hundred and thirty (n = 130, 37.4%) of the 348 intentional burns occurred in children (age <18). One hundred and twenty-four (n = 124, 95.3%) of the 130 pediatric burns were assault related burns compared to 6 (4.6%) that were self-inflicted. Minority children were more susceptible to assault related burns (n = 92, 74.2%) and Caucasian children were more prone to self-inflicted burns (n = 5, 83.3%).

For pediatric burn mechanism, males made up the majority of the patients (n = 85, 65.4%). The most common burn mechanism among both genders was scald injury. There were 13 reported fire/flame burn injury and 6 chemical/electric injury in males, whereas females had no reports of fire/flame injury and 3 reports of chemical/electrical injury (Table 5).

Table 2 – Odds of mortality, hospital and ICU LOS in intentional burns vs. all other burns.

Variables	Adjusted odds ratio, 95% confidence interval (CI)	p-Value
Mortality	1.18 (0.55–2.53)	0.666
Hospital LOS	2.02 (1.43–2.86)	<0.001
ICU LOS	1.30 (0.81–2.07)	0.275

*Controlling for %TBSA, inhalation injury, CCI, age and race.
CCI = Charlson comorbidity index.
TBSA = total body surface area.
ICU LOS = intensive care unit length of stay.

4. Discussion

In this study, the incidence of intentional burn injury is 3%. Furthermore, burn intent was not associated with an increased odd of mortality and intensive care unit length of stay. However, there was an increased odd of extended hospital LOS. These findings are consistent with prior small and large studies [6,7] and reports from the 2017 ABA National Burn Repository [5]. The poorer outcomes in self-inflicted burns compared to assault related burns from our subgroup analysis are also similar to other studies which showed that self-inflicted burns have a larger % TBSA, higher % of inhalation injury, increased mortality rate and extended hospital length of stay [6,8–10].

The intentional nature of an assault or self-inflicted burn injury may preclude early presentation to the hospital for fear of retaliation. Delayed burn care is associated with increased infection, and mortality due as delayed time to wound excision, debridement and grafting and delayed intervention for inhalation injury [11–13]. Assault-related intentional burns are more

Table 3 – Subgroup analysis: Demographics and outcomes of self-inflicted vs assault burn patients.

	Self-inflicted (%) (n = 92)	Assault (%) (n = 256)	p-Value
Mean age, y (SD)	38 (±14.7)	22.4 (±20.5)	<0.001
% Mean TBSA (SD)	26.5 (±29.6)	10.3 (±13.6)	<0.001
Mean CCI (SD)	0.44 (±1.2)	0.43 (±1.2)	0.925
Sex			0.966
Male	63 (68%)	174 (68%)	
Female	29 (32%)	81 (32%)	
Race			<0.001
White	49 (53%)	69 (27%)	
Non-White	43 (47%)	187 (73%)	
Mechanism			<0.001
Flame/fire	78 (85%)	67 (26%)	
Scald	3 (3%)	169 (67)	
Chemical/electrical	11 (12%)	18 (7%)	
Inhalation injury	32 (36%)	22 (9%)	<0.001
Mortality rate	22 (24%)	8 (3%)	<0.001
Median ICU LOS (IQR)	8.5 (IQR = 1–43)	6 (IQR = 2–31)	0.429
Median Hospital LOS (IQR)	12 (IQR = 2–45)	10 (IQR = 4–20)	0.012

CCI = Charlson comorbidity index.
TBSA = total body surface area.
ICU LOS = intensive care unit length of stay.

Table 4 – Odds for mortality, hospital and ICU LOS in intentional burns.

Variables	Adjusted odds ratio, 95% confidence interval (CI)	p-Value
Mortality	2.13 (0.49-9.16)	0.310
Hospital LOS	1.10 (0.49-2.50)	0.812
ICU LOS	1.14 (0.44-2.93)	0.785

*Controlling for %TBSA, inhalation injury, CCI, age and race.
CCI = Charlson comorbidity index.
TBSA = total body surface area.
ICU LOS = intensive care unit length of stay.

severe due to the use of chemicals, fire or hot liquids [14,15]. In addition, the associated element of surprise impedes the victims ability to react in time to avoid injury likely results in larger and deeper burns with the resultant sequelae. Assault related burns are also associated with domestic disputes with intent to disfigure or causes bodily harm [15].

Self-inflicted burns results in worse outcomes compared to assault burns due to the complexity of intentional self-injury. Self-inflicted burn patients were 11 times more likely to report prior psychiatric treatment, four times more likely to have abused alcohol, report worse pre-burn mental health, and have greater propensity to repeat self-harm [16,17].

For pediatric burns the overall burn incidence ranges from 10 to 12% [18], but the incidence of intentional pediatric burns is rarer [19]. Intentional pediatric burns are more extensive and severe, with long hospital LOS and increased ICU admissions [20,21]. The susceptibility of minority children to assault burns compared to Caucasian children may be explained by difference in socio-economic status and family dynamics. A US multicenter study comparing pediatric intentional to non-intentional burns found that patients with intentional burns were more likely to be African American, have a lower maternal education, no paternal involvement, parental unemployment and higher rates of drug and alcohol abuse among the perpetrator [19]. These social determinants of health may create stressors that trigger abusive actions towards children.

The incidence of self-inflicted burn injury is higher in Caucasian children than other racial groups in our study. There are limited studies that examine the prevalence of self-inflicted burns in the US pediatric population. Studies from the UK and India found cases of self-inflicted burns in their population that ranged from 0 to 6.5% [22–24]. In the US, one study reported a 0.4% incidence of deliberate self-inflicted pediatric burns [25]. Although studies are limited and our sample size is too small to truly explain these differences, psychosocial factors may contribute to the increase prevalence of self-inflicted injury in Caucasian children. According to the CDC, non-Hispanic white children between the ages of 2 to 8 years old were more likely to have mental, behavioral or developmental disorders [26], and in 2016, 3.1 million adolescents in the US aged 12 to 17 had one major depressive episode majority of those who were white [27]. Lastly, the parallel in prevalence of self-inflicted injury in both Caucasian adults and children compared to other racial groups in our study may underscore a larger issue of mental health and additional research is needed to explain these findings.

This study is limited by its retrospective methodology and it is derived from a single regional burn center which may limit the generalizability, however, the cohort of intentional burn injured patients is sizeable. For our pediatric patients, specific social demographics are limited. Information on household

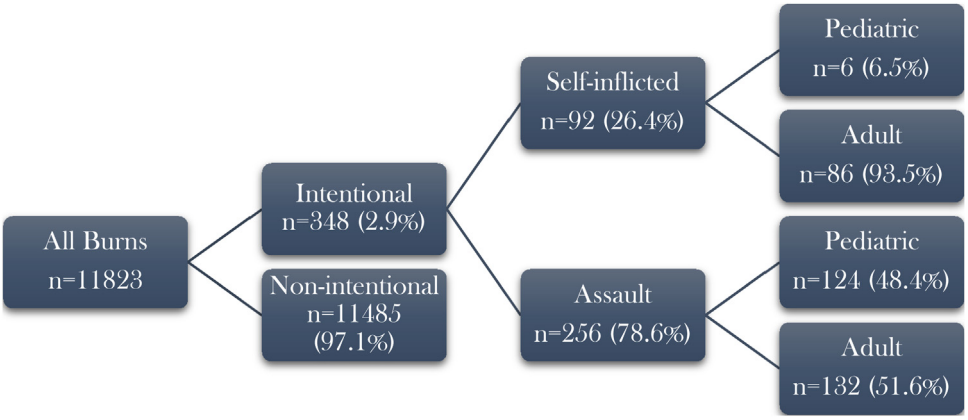

Fig. 1 – Intentional burns in the study population.

Table 5 – Pediatric burn mechanism (age < 18), n = 130.

Burn mechanism	Male (n = 85, 65.4%)	Female (n = 45, 34.6%)
Fire/flame	13	0
Scald	66	42
Chemical/ electrical	6	3

characteristics, socio-economic status, parental education levels and previous history of behavioral or developmental disorders could not be determined.

5. Conclusion

Our study findings showed that patients with intentional burn injuries is associated with increased %TBSA and inhalation injury. Furthermore, patients with intentional burn injury have higher odds for prolonged hospital LOS. Intentional burns, both self-harm or assault burn increase health care expenditures attributable to additional resources for medical, psychiatric, social services and other health care expenses. There must be a high index of suspicion for associated inhalation injury in intentional burn injury victims. Violence prevention initiatives that target the male and minority demographic may be beneficial in reducing assault related intentional burn injury burden and early recognition of and access to mental health services my attenuate self-inflicted burn injury.

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Conflict of interest

The authors have no conflict of interest.

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