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Demographics and clinical outcomes of adult burn patients admitted to a single provincial burn centre: A 40-year review

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ABSTRACT

Introduction: This study evaluated trends in demographics and outcomes of cutaneous burns over a forty-year period at a Canadian burn centre.
Methods: Retrospective review was performed of all consecutive adult burn admissions to the Vancouver General Hospital (VGH) between 1976 and 2015. Comparison was made to the 2016 American Burn Association – National Burn Repository.
Results: There were 4105 admissions during study period. Both overall admissions and admissions per 100,000 BC residents declined ($p < 0.0001$). Males represented three quarters of admissions. There was a decrease in large burns ($p < 0.05$). Flame burns were most commonly associated with larger TBSA, ICU stays, and mortality.
Mortality decreased from 11.3% to 2.8% ($p < 0.05$). Factors found to affect mortality included: increased length of stay, age and burn size, male gender, and number of complications. Baux50 and rBaux50 increased, from 102.8 to 116.7 and 112.2 to 125.3 respectively ($p < 0.05$, respectively).
Conclusions: This study represents the largest report on burn epidemiology in Canada. The incidence of burns has decreased significantly over the last forty years. Mortality has improved over this time frame, as evident by increases in Baux50 and rBaux50 scores. Further data is largely in concurrence with that of the National Burn Repository's amalgamation of US centres.

1. Introduction

Analysis of population level data has shaped conventional management of thermal injuries as they exist today. Advances as a result have led to paradigm shifts in all aspects of burn care. These include but are not limited to: changes in treatment strategies, such as a tendency towards earlier excision and grafting accompanied by increased outpatient management; the generation of accurate models of mortality stratification including the revised Baux (rBaux) score; and the induction of targeted mass level preventative measures such as hot water tank temperature regulation [1–11].

The Vancouver General Hospital burn unit was opened in 1969 and shortly after began collecting patient demographics and data on clinical outcomes. It was not until 1975 that

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procurement of this data became standardized to represent a formal data collection process marking the introduction of the British Columbia Burn Registry. This database has continued to be rigorous in its data acquisition and now provides a rare opportunity to look at the progression of burn care and the trends that followed over the course of the last 40 years.

Other burn centres have published large reviews of epidemiological data [12–20]. However, this study offers the largest review of a single Canadian burn centre. Currently, the American Burn Association National Burn Repository (ABA-NBR) represents the largest database of its type, amalgamating input from 103 burn centres [21]. Every year, the ABA publishes a report on the preceding ten years, with an update on trends in burn parameters and care. The ABA-NBR, however, is almost solely populated by American sites with few international burn units contributing. Specifically, Canadian representation is lacking, with only four Canadian hospitals submitting data in the current edition. In addition, there is very little population level data reported from Canadian centres in the literature [18,22]. Further epidemiological studies within Canada from individual burn centres is needed to facilitate identification of risk factors, prediction of future burden of disease, and to establish a standard of care to be developed for these unique regions. To this end, we aimed to assess burn care at a Canadian burn centre over a forty-year period between 1976 and 2015. Given that there has been no study of such length reported in Canada, and only a handful elsewhere, it provides a unique opportunity to assess the state of affairs of burn care in Canada over a longitudinal time frame.

2. Subjects and methods

2.1. Patient population

The burn unit at Vancouver General Hospital (VGH) serves as the primary referral centre for adults across the province of British Columbia benefiting from specialized burn care serving a population of 5.1 million. In addition, an associated outpatient Burn Clinic provides focused care for thermal injuries that can be treated without admission, offering primary management and longitudinal follow-up to all burn victims with about 1000 visits annually.

This study represents an analysis of all adults (≥18 years) admitted to VGH with cutaneous thermal injury for treatment over a forty-year period between 1976 and 2015. Patients exclusively with inhalational injury were excluded as well as patients under the age of 18 years of age as care of pediatric patients changed from Vancouver General Hospital to BC Children's Hospital during this time frame. Incidence rates are demonstrated per 100,000 people per year using the current publicly accessible population data for the province of British Columbia.

2.2. Data source

Beginning in 1976, with the aim of statistically assessing quality of burn care delivered, a centralized burn database was created to record demographics, injury parameters, and treatment course of all patients with cutaneous thermal injuries presenting to Vancouver General Hospital. This database has been maintained and curated by multiple staff/registrars since its inception, with retrospective entry of all data points after patient discharge. In this study, all unique entries between 01/01/1976 and 12/31/2015 were extracted. Each entry represents a unique admission for a thermal injury to Vancouver General Hospital. Entries were queried for demographics (age, sex, ethnicity), injury parameters (TBSA, Baux score, etiology of injury, and associated inhalational injury), treatment course in hospital (length of stay, number of operations, complications, days on a ventilator, and length of ICU stay), as well as discharge disposition. Mortality in this study was defined as a death while on the burn unit due to any cause. Revised Baux score was calculated by adding age, TBSA, and 17 points if there was a concomitant inhalational injury [5]. Unique entries with incomplete or missing data were excluded, accounting for 0.68% of all entries (28/4133).

Two external datasets were used in analysis; the first was publicly available census data for the province of British Columbia. Population data was obtained from bcstats.gov.bc.ca and included the total population of British Columbia over the time frame of interest [23]. The second was the 2016 ABA-NBR report which assessed cumulative data in the preceding ten years from Burn Centres across the United States, with nominal input from parts of Canada and Europe (two Swedish and one Swiss centre). With the intention of delineating the standard of burn care in Canada, the ABA-NBR data reports served as a comparison to our own database throughout this study.

2.3. Statistics

Descriptive statistics were performed using Prism8 Graphpad (Version 8) and SPSS Software (Version 21). Trends in overall admissions, mortality, number of operations, and admissions by ethnicity were modeled with linear regression. Quantile regression was used to assess trends in TBSA as well as LOS/TBSA. Predictors of mortality were calculated using binomial logistic regression. A *priori* selected variables included gender, length of stay, number of complications incurred, burn etiology, presence of an inhalational injury, burn size (TBSA), gender, age, and year in which burn occurred. Finally, Baux50 and revised Baux 50 (rBaux) scores were calculated using simple logistic regression analysis.

Due to the size of data, entries were grouped into cohorts of 5 and 10 years for relevant plots. For all reported outcomes, statistical significance was set at p-value <0.05, and p-values for each calculation are reported.

3. Results

3.1. Admission demographics

Over the forty-year period between 1976 and 2015, there were 4105 unique adult admissions to the Vancouver General Hospital burn unit for thermal cutaneous injuries. The annual number of burns admitted peaked in 1979 at 162 and a steady decline has been noted since, with the fewest burns, 52, admitted in 2008 (Fig. 1, $p < 0.0001$). Incidence per 100,000 BC residents has also shown a reliable drop over the course of the study ($r^2 = 0.93$, $p < 0.0001$), despite a rapid rise in the

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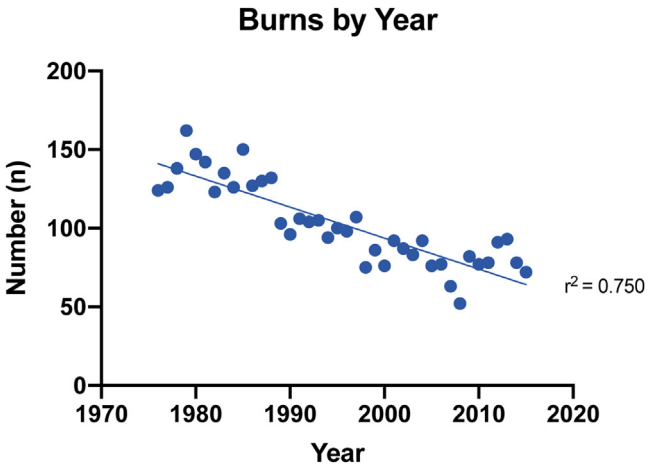

Fig. 1 – All burns by year of admission. There was a significant ($p < 0.0001$) decrease in the number of admissions between 1976 and 2015.

population (Fig. 2). The average age of all admissions was 43.6 years of age. Males represented 75.8% of admissions (Fig. 3), a value similar to that of the 2016 ABA NBR for both America (67.6%) and International (70.8%) sections.

Among ethnic groups, most patients were Caucasian (78.1%), followed by Asian (13.4%), with very few identifying as Black (0.6%), Hispanic (0.0%), or other (5.0%) (Fig. 4). An increase in the number of Asian patients was noted with time, peaking in 1996 –2005 (17.8%), while other ethnicities remained stable. This was found to be 15.3% higher than the reported value in the American section of the ABA-NBR, and 13.8% higher than the International section. The proportion of Hispanic, Black, and patients of other ethnicities remained stable, and significantly lower than seen in either of the comparative reports.

3.2. *Burn characteristics*

The size of burns over the course of study changed very little for small and medium sized burns (<10% TBSA). This was evident by analyzing 1st quartile and median TBSA burns by year, which revealed no change in the 1st quartile TBSA ($p = 0.484$), and median TBSA ($p = 0.878$). The size of large burns however (75th TBSA percentile of all admitted per year), has trended down over the course of 40 years ($p = 0.023$, Fig. 5).

The most common etiology of thermal injuries seen were burns due to flame (60.2%), with scald burns comprising the clear majority of remaining presentations (26.8%), both of which remained stable. Burns due to other causes (contact with a hot object, electrical, and chemical) were relatively few with no trend noted (Fig. 6). Fire/flame burns represented a clear majority of burns associated with mortality and mechanical ventilation in the ICU.

3.3. *Course in hospital*

When length of stay (LOS) in hospital was adjusted for burn size (TBSA), a very evident decrease in number of days per TBSA spent was noted between 1976 (median = 3 days/TBSA) to 2015 (median = 1.25 days/TBSA) ($p < 0.0001$) (Fig. 7). The most drastic decline occurred for long hospital stays in which the 75th percentile of days spent in hospital per TBSA was 7.8 in 1976, as compared to a mere 2.0 days per TBSA in 2015 ($p < 0.0001$). When admissions were subdivided into 'short stay' (≤2 days) or 'regular' admissions (>2 days), there was a significant trend towards overall fewer admissions, but also an increased proportion of short stay admissions (Fig. 8, $p < 0.0001$).

In 1983, data on burn patients with admissions to the ICU was added to the burn database. The proportion of patients admitted to the Intensive Care Unit (ICU), increased from 14% of all admissions in 1985 to 24% in 2015 (Fig. 9, $p < 0.005$). There was also a concomitant increase in the number of patients who, on admission, were placed on the ventilator (Fig. 10, $p = 0.0005$). However, the proportion of burns admitted with an associated inhalational injury showed no overall change and remained stable over the course of study (Fig. 11, $p = 073$).

Beginning in 1998, the number of operations during the course in hospital was recorded. Over this time, the number of

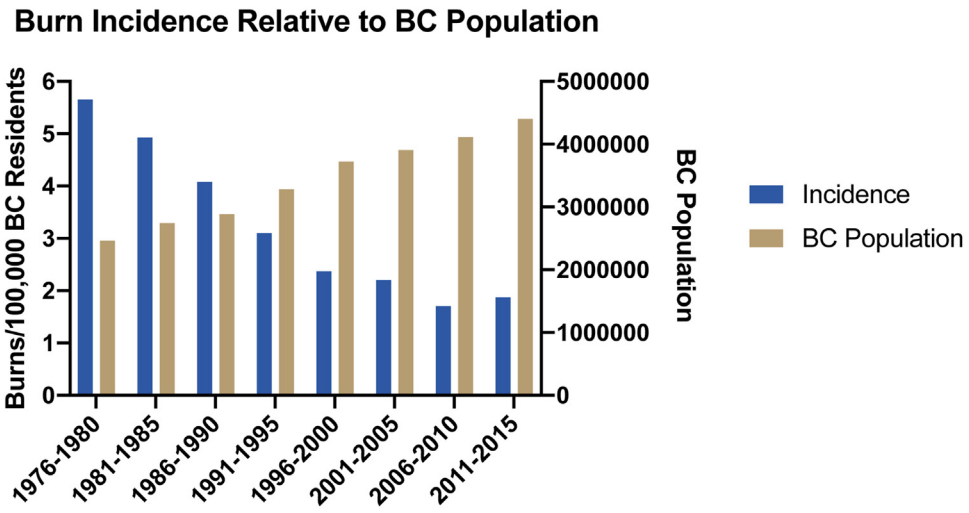

Fig. 2 – Burn incidence per 100,000 BC residents (left) and population of BC (right). There was both a significant increase in the BC population with a concomitant decrease in the incidence of burns undergoing admission to the burn unit ($p < 0.0001$).

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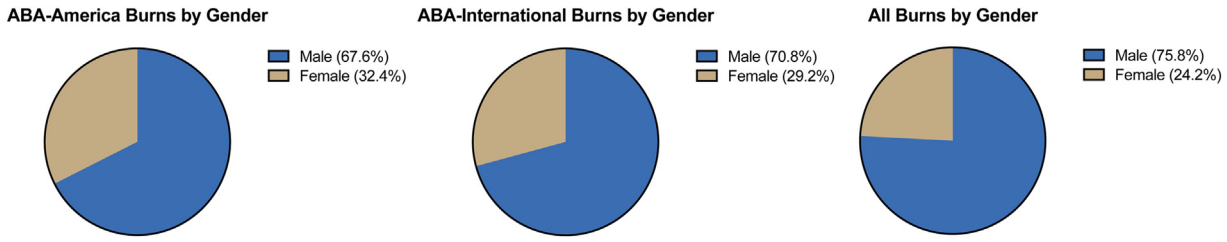

Fig. 3 – Gender of all burns admitted by ethnicity as compared to the ABA Burn Report from 2006 to 2015 within the United States as well as international sections.

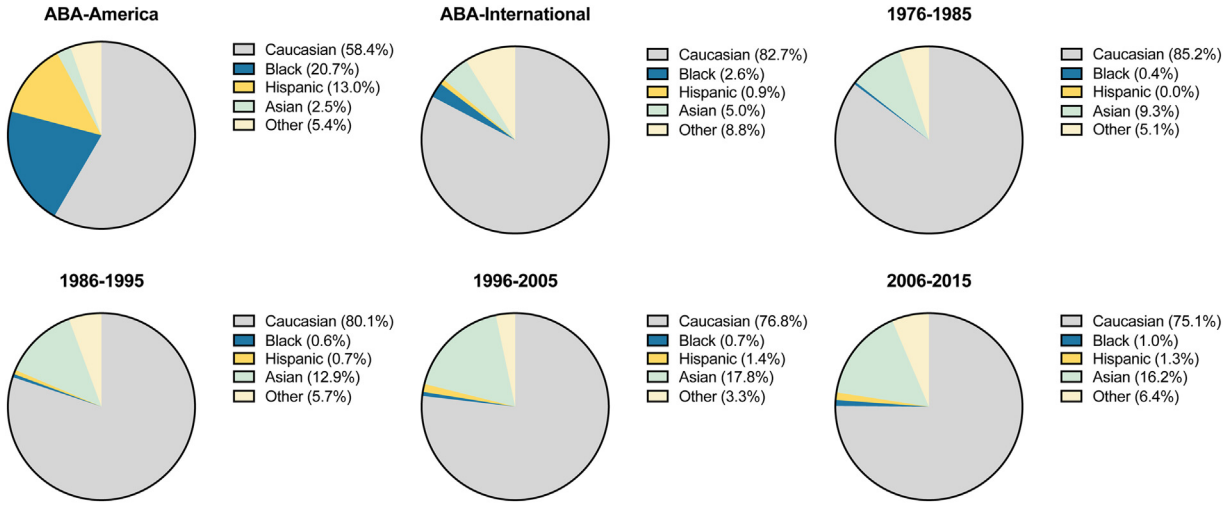

Fig. 4 – Pie charts representing proportion of burn admissions every ten years by ethnicity. Comparison charts are made to that reported in the ABA Burn Report from 2006 to 2015 within the United States as well as international sections.

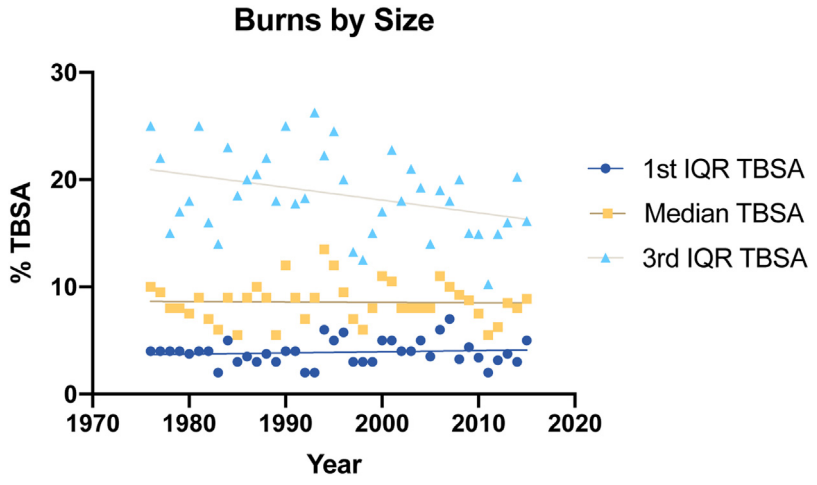

Fig. 5 – TBSA of all burns over the course of study. Burns are classified by first quartile, second (median), and third quartile per year.

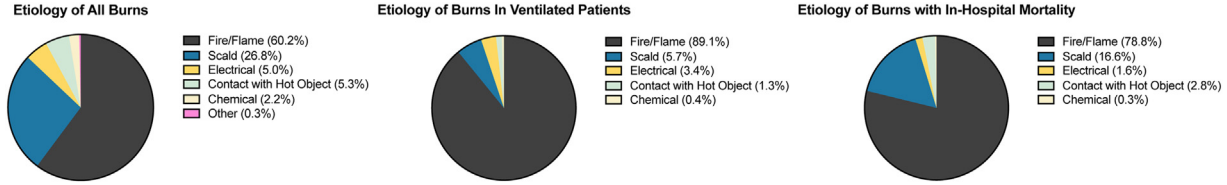

Fig. 6 – Burns by Etiology divided into all burns, those on the ventilator, and those associated with in-hospital mortality.

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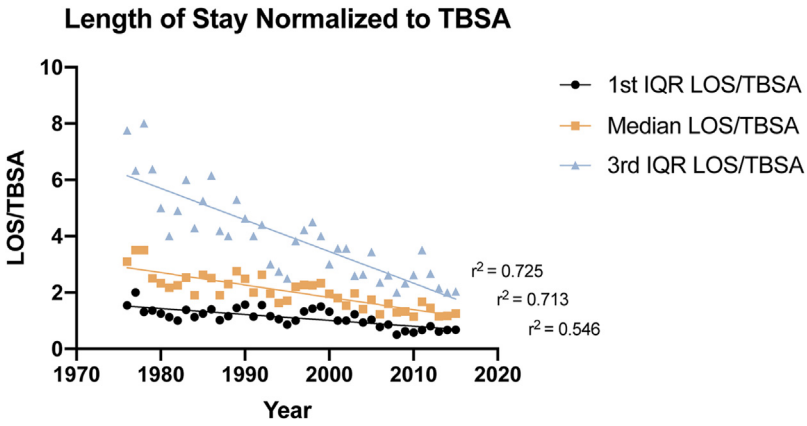

Fig. 7 – Hospital length of stay normalized to TBSA. First, second (median), and third interquartile ranges for LOS/TBSA. All groups demonstrated a significant decrease ($p < 0.0001$).

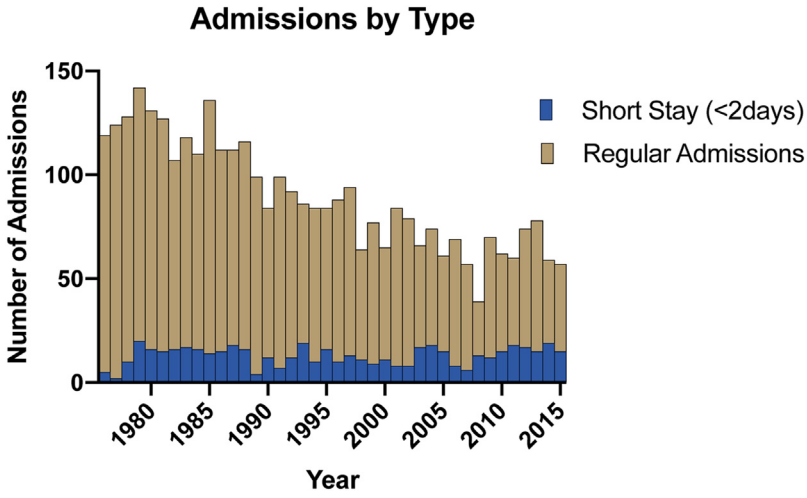

Fig. 8 – Admissions by year divided into regular admissions (>2 days) and short stay admissions (<2 days).

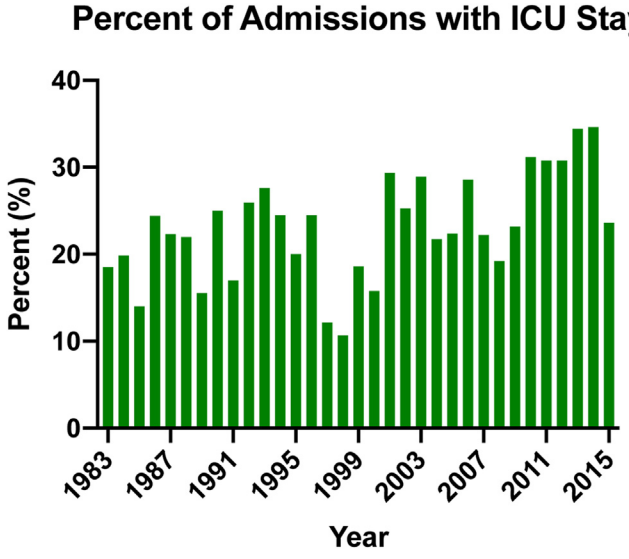

Fig. 9 – Proportion of admissions with a stay in the intensive care unit (ICU). There was a significant ($p = 0.0016$) increase ($R^2 = 0.28$) in the proportion of patients who received ICU care. Collection of data on ICU admissions began in 1983.

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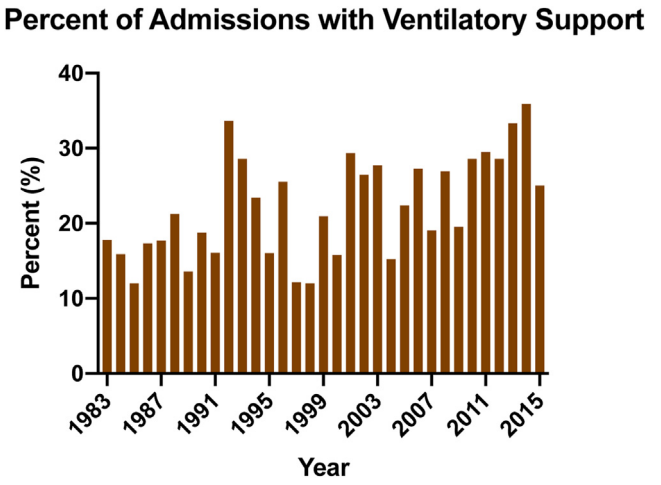

Fig. 10 – Proportion of admissions to the ICU on the ventilator. There was a significant ($p = 0.0005$) increase ($R^2 = 0.33$) over the course of study. Collection of data on ventilator use began in 1983.

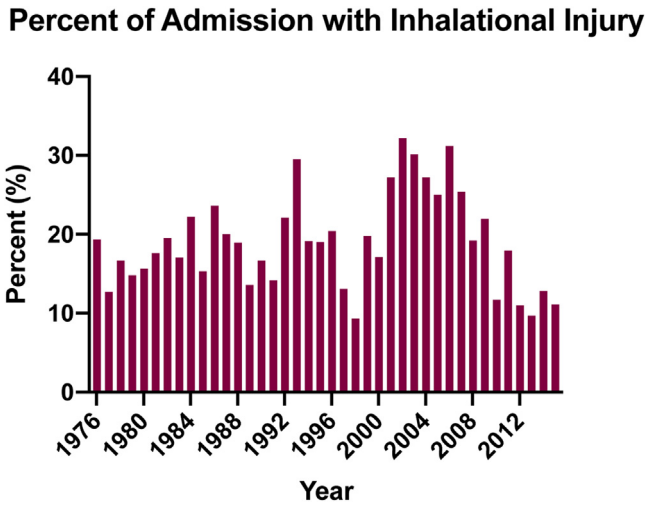

Fig. 11 – Proportion of burns with a concomitant inhalational injury. There was an appreciable ($p = 0.0001$) decrease ($R^2 = 0.32$) in the number of inhalational injuries.

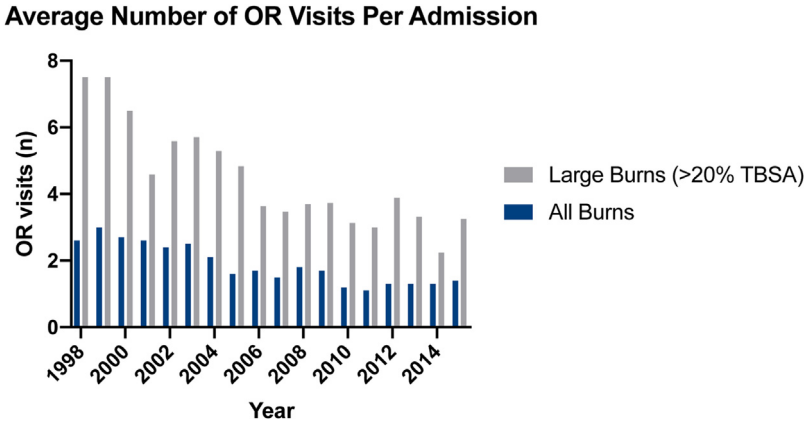

Fig. 12 – Average number of operations per patient admit, separated by year. Since number of OR visits were documented (1998), there has been a significant decrease in the average number of ORs per patient for all admissions ($p < 0.0001$, $R^2 = 0.84$) and for large burns >20% TBSA ($p < 0.0001$, $R^2 = 0.81$).

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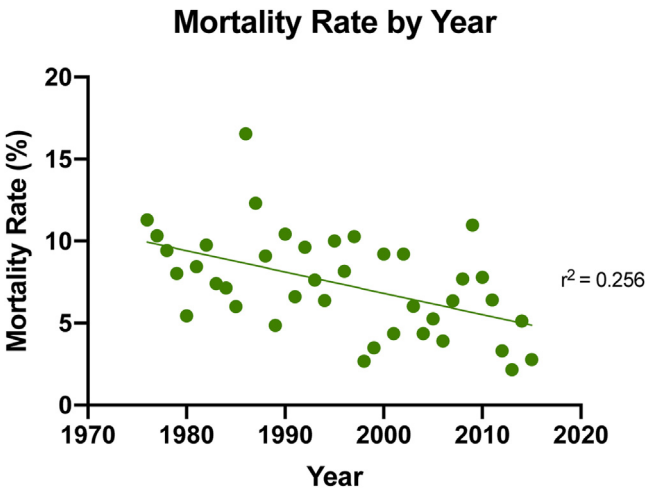

Fig. 13 – Rate of mortality by year. A steady decline has been noted since 1976 ($p < 0.001$).

visits to the operating room was halved from 3 per person in 1999, to 1.4 in 2015 (Fig. 12, $p < 0.0001$). Further analysis revealed that this trend was exaggerated for large burns of 20% TBSA or greater. In this sub-population, the average number of operations decreased from 7.5 in 1998 to 3.25 in 2015 (Fig. 12, $p < 0.0001$).

3.4. *Mortality*

Between 1976 and 2015 there were 316 burn related deaths among 4105 patients seen at the VGH Burn Centre (overall mortality of 7.7%). Binomial logistic regression was used to determine predictors of mortality. Date of presentation was a significant predictor in mortality ($p < 0.001$), with a drop in average mortality from 11.3% in 1976 to 2.8% in 2015 (Fig. 13). Other factors found to influence mortality, assessed by binomial logistic regression, were increased LOS, age and increased burn size (both components of the Baux score), male gender, and number of complications incurred in hospital (Table 1). Etiology of thermal injury was not a significant predictor of mortality rate.

Complications most frequently associated with mortality were assessed and are reported in Fig. 14. As expected, pneumonia, renal failure, and wound infections were the three most commonly reported complications in patients with in-hospital mortality. There all showed a significant decline over the study period ($p < 0.05$).

Table 1 – Binomial regression model assessing variables and their effect on in-hospital mortality.

Variable	SE	95% CI	β	*p*-value
LOS	0.007	0.907–0.931	0.919	<0.001*
Inhalational Injury	0.292	1.131–3.556	2.005	0.017*
Complications	0.049	1.648–1.995	1.813	<0.001*
Age	0.007	1.082–1.114	1.098	<0.001*
TBSA	0.007	1.096–1.081	1.096	<0.001
Year	0.01	0.973–0.954	0.973	0.005*
Female Gender	0.24	0.285–0.730	0.456	0.001*
Etiology	–	–	–	1

β, beta coefficient, SE, standard error; CI, confidence interval.
* Statistically significant.

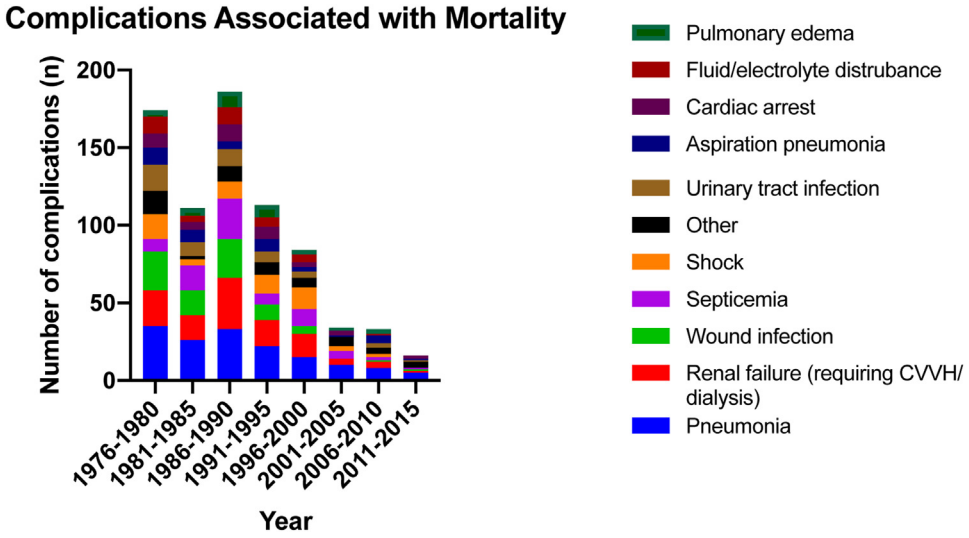

Fig. 14 – Common complications in patients with in-hospital mortality.

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Table 2 – Baux 50 and revised Baux 50 scores for each ten-year cohort. This represents the score at which 50% of patients are expected to survive.

	Year			
	1976–1985	1986–1995	1996–2005	2006–2015
Baux 50	102.8 +/– 1.7	98.1 +/– 1.7	103.3 +/– 1.8	116.7 +/– 4.4
rBaux 50	112.2 +/– 2.0	109.1 +/– 2.0	113.8 +/– 2.3	125.3 +/– 4.8

rBaux, Revised Baux Score (Age + Weight + 17*Inhalational Injury).

3.5. *Baux score*

Baux score (age + TBSA) and revised Baux score (age + TBSA + 17 if inhalation injury present) were calculated for all patients [5]. Baux50 and rBaux50 values were calculated for ten-year increments using simple logistic regression analysis (Table 2). This represents the value at which 50% of people with an equal score would be expected to survive. There was no appreciable change between 1976 and 2005. However, a significant ($p < 0.0001$) increase in both Baux50 and rBaux50 was noted between 2006 and 2015.

4. Discussion

This study provides a detailed analysis of acute burn management and longitudinal trends in burn care over a forty-year period at a large Canadian centre. Given the paucity of data on burn epidemiology in Canada, it also represents an opportunity to establish a basis for data on Canadian burn statistics. The strength of this study is derived from its longevity and size allowing for what is, to our knowledge, both the longest and largest population level study on burn care in Canada.

4.1. *Admission demographics*

From 1976 to 2015, there was a rapid expansion in the population of the greater Vancouver area. This has led to an almost doubling in the catchment population of our Burn Unit over the time frame of this study. Despite this rise, a significant decrease in the number of burns receiving care at our centre was noted. This decrease was likely due to contributions of numerous factors. First and foremost, public education on burn risk factors and burn prevention has become increasingly evident in recent years. As previously mentioned, population level preventative techniques have led to a significant decline in the number of burns seen in developed countries [6–8]. It also seems reasonable that the increasing comfort level of both emergency physicians and trained surgeons in managing minor burns at community hospitals has prevented many of what would be previously transferable burns from seeing the doors of our centre [24]. Alongside this competency, infrastructure at these peripheral hospitals has improved significantly to accommodate an increasing population which has made caring for thermal injuries more appropriate and convenient in this setting. At our centre, we have also increasingly performed outpatient day surgery on small but deep/full-thickness burns that previously would have undergone admission in the past. Taken together, it becomes evident that the decreased number of admissions is multifactorial in nature.

Like the 2016 ABA-NBR and other North American data, the ratio of male to female burn patients hovered around 3:1 [12,18,21]. This did not vary significantly and remained stable over the course of our study. Previous reports have indicated that males are more likely to not only sustain burns but suffer more extensive burns [14]. These findings were corroborated in our patient population.

Review of patient ethnicities in our database varied significantly from that seen in the NBR. This was a difference we had anticipated given the unique population differences between the United States and Canada, and specifically in Vancouver where 50% of the population is defined as a visible minority [25]. Overall, this included a larger number of Asian patients presenting to our centre, and fewer Hispanic and Black patients. These differences were apparent even when compared to Seattle alone, a mere 3-h drive from Vancouver [12]. The increase in Asian patients treated in our centre is reflective of population changes seen in Vancouver over the course of this study, namely an increase in the Asian population relative to Caucasian [23]. Previous studies examining the ethnic variation in this specific population found that the Asian sub-population were more likely to sustain burns in the metro Vancouver area and had a higher proportion of female patients, whereas patients of indigenous descent were more likely to sustain burn trauma in remote settings [25].

4.2. *Burn characteristics*

As with the decline in overall number of thermal injuries, a steady drop in burn size was concurrently noted. This decrease was more evident for larger burns (75th centile TBSA) than small burns (25th centile) and median TBSA. Previous studies have indicated that men are more likely to sustain larger burns, as well as burn injury due to flame, which most often occur in the workplace [14,26]. More stringent safety regulations on job sites accompanied by improved protective equipment may be responsible for lowering the number of large flame burns seen [27]. Like most other available data, including the ABA-NBR, flames represented the largest portion of thermal injuries seen in our centre, with scald injuries representing a clear second. A non-significant trend towards fewer scald burns was observed, but there was no clear deflection point in these to correlate with the introduction of water temperature regulations in the early 2000s.

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4.3. *Course in hospital*

Tendencies towards shorter hospital stay with increased outpatient management of carefully selected burns represents one of the paradigm shifts in burn care that occurred over the course of this study – this took place in 2007 at our centre. Previous reports have shown improved patient outcomes and an overall significant reduction in resource utilization and cost [1–3,28]. As expected, a marked trend towards decreased length of stays was noted over the course of our study. This trend was apparent across all admissions but was most evident for what were previously very long stays in hospital (75th centile of LOS/TBSA). Despite only beginning to collect number of operations performed in 1998, a very appreciable drop in surgeries performed was apparent. This more aggressive surgical approach represents a tendency towards earlier and more extensive excision and grafting with each operation, leading to fewer OR visits for each patient [9–11]. To a lesser extent, the decrease number of ORs also likely reflects the drop in burn size for larger burns as noted above (Fig. 5).

Burns receiving critical care demonstrated unexpected results; both the overall number of patients admitted to the ICU and placed on a ventilator increased, but there was no significant change in the number of inhalational injuries. A modest trend can be appreciated however, particularly beginning in 2007, towards fewer inhalational injuries (Fig. 11). It is likely that this drop in inhalational injuries correlates with a paradigm shift that occurred around this period on how these injuries were formally diagnosed. Prior to 2007 inhalational injury was diagnosed by a combination of classically taught clinical exam findings, with or without fibreoptic bronchoscopy [29]. However, in 2009 strict criteria were proposed for the diagnosis and grading of inhalational injuries and therefore it is likely that prior to this, incidence of inhalational injury was overestimated [30]. The subsequent drop in diagnosed inhalational injuries following this time period is likely more reflective of the true incidence.

4.4. *Mortality*

A weak trend towards lower mortality rates was documented over the forty-year study period. While this is promising, when compared to the 2016 ABA-NBR (representing years 2006–2015), the mortality rate at our centre, 5.5%, is slightly higher than reported in both the US and International centres at 3.3% and 4.6% respectively. It should be noted that this likely represents a slight overestimate of mortality in the last 10 years at our centre, which almost certainly lies closer to the international reported mortality. Of the 28 patients that were excluded from this study due to incomplete entries in the burn database, 20 of these patients were from 2009. This represents 19.6% (20/102) of the patients admitted that year.

Factors that were found to be predictors of mortality (inhalational injury, age, burn size, year of injury, and complications in hospital) were as expected. Age and TBSA (+/- inhalational injury) represent the components of the Baux score (and revised Baux score), one of the most widely cited calculations used to predict mortality [18]. Finally, a more recent year of injury acting as a protective factor is consistent with advances in burn care that have occurred over the last 40 years, allowing for the ability to treat larger and more critical burns.

4.5. *Baux score*

The advancement in burn care provided at our centre can be quantified by the improvement in Baux scores in the final ten years of this study. Both the Baux50 and revised Baux50, scores at which 50% of patients with an equal score would survive, demonstrated an increase by ~13 points to a score of 116.7 and 125.3 respectively (Table 2). These results are comparable and even surpass those seen in modern reviews [31]. Notably, the 2016 NBR estimates the Baux50 at 110 [21].

4.6. *General*

With a study of such size, it is important to consider the limitations. First and foremost, this does not represent population level data for Canada, but is merely a piece of the picture, comprising data from the Province of British Columbia alone with a population just over 5.1 million people. Given both the sheer size and population diversity of Canada, further epidemiological studies from large Canadian burn centres are needed to help accurately establish a standard of burn care in Canada. There are also several considerations to make with our database. For example, the dataset does not include thermal injuries in our province that were treated in community hospitals or patients who died before reaching our burn centre. This may have led to a very small subset of patients being excluded from the analysis. Secondly, though not reported here, place of burn injury has been reported separately for this population [25]. This information is a key component in formulating public health preventative measures and facilitating access to appropriate care from rural areas. Finally, though we made comparisons to the international section of the ABA-NBR, the Canadian centres contributing to this section represented the most relevant pieces of information to this study, however we were unable to distinguish between those and the European centres which together comprised the international section.

4.7. *Conclusions*

This study represents the largest and longest report on burn epidemiology in Canada, covering forty years of burn management at a major Canadian burn centre. The incidence of burns presenting to the Vancouver General Hospital Burn Unit has dramatically decreased despite an increase in the relevant catchment population. Flame burns continue to represent the most common etiology of thermal injury; however, the size of burns has declined considerably. Importantly, shorter hospital stays, fewer large burns, and improved management strategies have led to a decrease in the mortality of burns within our centre, a figure that continues to fall with time. Data from our centre in the last ten years is largely matched to that of the international section in the ABA-NBR report covering 2006–2015. Further studies are needed to help establish a standard of burn care in Canada.

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Conflict of interest

The authors have no conflicts of interest to declare.

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