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Epidemiological analysis of pediatric burns in the Dominican Republic reveals a demographic profile at significant risk for electrical burns[☆]

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ABSTRACT

Objective: Pediatric burns are preventable with legislative and infrastructural changes. Although retrospective audits of many low- and middle-income countries have aided preventative efforts, the epidemiological status of burns in the Caribbean is not known. This study characterizes pediatric burns in the Dominican Republic (DR) and compares these to age-matched North American records captured by the National Burn Repository.

Methods: A retrospective audit of 1600 patients admitted to the Unidad de Niños Quemados Dra. Thelma Rosario Hospital, the island's only major pediatric burn center, between January 2010 to March 2017 was performed. Epidemiological variables analyzed included age, gender, burn mechanism, year, month, city, admission duration, nationality, mortality, and %TBSA. **Results:** Pediatric burn patients in the DR sustained larger burns (8.2% vs. 6.5% TBSA) and spent more days in the hospital (10 vs. 6 days). Females were overrepresented (M:F = 1:1.5) and mortality amongst admitted patients was 4-fold higher (2.8% vs. 0.7%). Electrical burns were significantly overrepresented in DR (21%) compared to age-matched North American patients (2%). Although electrical burns were smaller (4% TBSA), compared to scald (14% TBSA), and flame (19% TBSA), these burns preferred hands and had a high mortality rate (3%). No significant seasonality in burn mechanisms were observed. Finally, we report geographical and age group differences in the distribution of burn mechanisms and highlight particularly vulnerable subpopulations.

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Conclusion: This investigation identifies a demographical profile where electrical burns account for a significant percentage of the burn population. This provides a basis for concentrating preventative efforts in vulnerable populations.

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1. Introduction

Burns are a preventable type of injury. If sustained during childhood, serious morbidity can persist through adolescence and well into adulthood. Although high-income countries have significantly reduced burn mortality rates through preventative and acute care strategies, most of such strategies have not been adopted by low- and middle-income countries (LMIC) [1,2]. Additionally, burn patients in LMIC are more prone to developing long-term complications such as wound malignancies due to impeded extracellular matrix turnover [3,4] and compromised rehabilitative outcomes due to non-standardized burn rehabilitation standards [5]. Not surprisingly, burns continue to be the leading cause of disability-adjusted life years lost in LMIC [6]. Development of preventive strategies such as education of vulnerable populations and training of communities in basic first-aid can drastically reduce the frequency and severity of burns sustained. An essential prerequisite to developing effective preventative strategies, however, is an assessment of risks unique to each region. To this end, burn-related epidemiological studies typically report data from retrospective institutional audit which reveal demographical and temporal profile of patients admitted. From this, systematic reviews elucidate emerging regional trends and propose candidate risk factors which function to enable them.

This effort has imparted insights into epidemiological characteristics of burn injuries seen in LMIC. For example, 15 independent pediatric burn unit audits converged in suggesting that infants and toddlers (age 0–4 years) were at a disproportionate risk of burns as this group accounted for half of all pediatric burns [2]. Not all demographical trends, however, are clear-cut. In studies assessing gender distribution, most pediatric studies converged in suggesting a significantly higher frequency of males [2,7–9], but studies assessing a broader age range revealed more conflicting results [10,11]. They found a reversal of gender trend with increasing age as males were overrepresented in the 0–4 year category, but thereafter, a higher incidence was reported for females [10,11]. An explanation of this trend was change in activities with age as girls are brought closer to the kitchen which exposes them to open flames and hot substances [2]. Investigations have also asked how burns occur in LMIC. Converging evidence suggest that scalding from hot liquids account for nearly a third to a half of all burns seen in LMIC [2,12]. Hot objects and flame follow scald burns in children [2,12]. Interestingly, two burn mechanisms which are extremely rare in LMIC are electrical and chemical burns [2]. Although few rural regions in countries like Bangladesh receive relatively high volumes of acid (chemical) assault victims [13], very few reports have characterized electrical burns as a prominent source of injury.

Although literature synthesized from LMIC summarizes 139 studies characterizing 34 countries [2], no Caribbean country is included in this coverage. This investigation reports a retrospective review of UNIQUEM Burn Center, the island's only pediatric burn facility located in Santiago, Dominican Republic (DR), and compares these findings to North American (NA) records captured by the American Burn Association's (ABA) National Burn Repository (NBR). UNIQUEM is a 20-bed burn unit at the Arturo Grillon Children's Hospital and houses clinicians specializing in burn reconstructive surgery, physical and occupational therapists, psychologists, and social workers. UNIQUEM is affiliated with Shriners Hospitals for Children in Boston, USA, and works with Shriners to coordinate hospital transfers for severely injured cases. The unit also collaborates with Haitian hospitals to share pediatric critical care, rehabilitation, and educational resources. We found that pediatric burns in the Dominican were more severe, resulted in a higher mortality rate, and most strikingly, exhibit a unique distribution of burn mechanism where electrical burns account for a significant portion of the population.

2. Materials and methods

2.1. Ethics approval

The retrospective audit was approved by the Conjoint Health Research Ethics Board at the University of Calgary. Since UNIQUEM Hospital does not have an ethics review board, permission to transfer data (without patient identifiers) was obtained in writing. Informed consent was not needed for this study.

2.2. Dominican Republic pediatric burns database

Electronic data for all patients (n=1600) admitted to UNIQUEM from January 2010 to March 2017 was extracted. An excel file (devoid of patient identifiers) was electronically transferred to Calgary investigators (VG, SS, RH). The following epidemiological variables were extracted from electronic medical records: date of admission, sex, age, percentage of total body surface area (%TBSA), burn mechanism, anatomical site, location, date of discharge, outcome, nationality and admission duration. Since UNIQUEM captured patient data in Spanish, the entire dataset was first translated using an offline translation plugin (Google Translate for Microsoft Excel™). The entire dataset was hand searched for discrepancies in translation and queries were resolved through an email correspondence with CMNM. No patient was excluded in the analysis.

2.3. National Burn Repository

Access to the National Burn Repository Version 8.0 was obtained on May 8th 2017 by completing the ABA's NBR Data

Request form (Supplementary File 1). Age-matched patient records (n=31,379) were compared to the DR database to elucidate regional differences in burn epidemiology. No patient record was excluded in the analysis.

2.4. Statistical analysis

All statistical analysis was performed using GraphPad Prism Version 7.0 for Mac OSX. Pearson's chi-square for goodness of fit was used to compare categorical distribution of burn mechanisms in the DR with an expected distribution based on NBR records. Chi-square was also used to determine if cities and age categories exhibited burn mechanism distribution which differed from an expected distribution based on cumulative DR averages. Unpaired Welch's t-test was used to compare differences in %TBSA and admission duration between the DR and NA records. Ordinary one-way ANOVA, followed by Tukey's multiple comparisons test, was performed to assess difference in means on continuous variables (age, %TBSA, admission duration). Family-wise alpha was maintained at 0.05 (95% confidence interval) for all comparisons and P values <0.05 were considered statistically significant.

3. Results

From January 2010 to March 2017, 1600 pediatric burn patients were admitted to the Unidad de Niños Quemados Dra. Thelma Rosario Hospital from fifty-one different Dominican and Haitian cities (Fig. 1). Amongst these, majority of the admitted cases were from Santiago (45.50%), Puerto Planta (5.75%), Moca (5.56%), and La Vega (5.06%; Fig. 1A and B). The remaining forty-seven cities constituted 38% of all admitted cases (Fig. 1C). The mean age of admitted patients was 5.3 years (SD: 4.8), ranging from 3 days to 19.7 years (Fig. 2A). Majority (99%) of the cases were between the pediatric age (birth to 18 years) range. The mean TBSA coverage was 11% and most (76%) of all burns treated were between 0-10% TBSA (Fig. 2B). The female-to-male ratio was approximately 1.5:1. There were 45 deaths among the 1600 patients, giving a mortality rate of 2.8%.

3.1. Clinical features unique to the Dominican Republic

In comparison to North American patients, pediatric burn victims in the DR sustained larger %TBSA burns (8.2% vs. 6.5%, R²=0.02, P<0.0001; Fig. 3B) and spent more days in the hospital

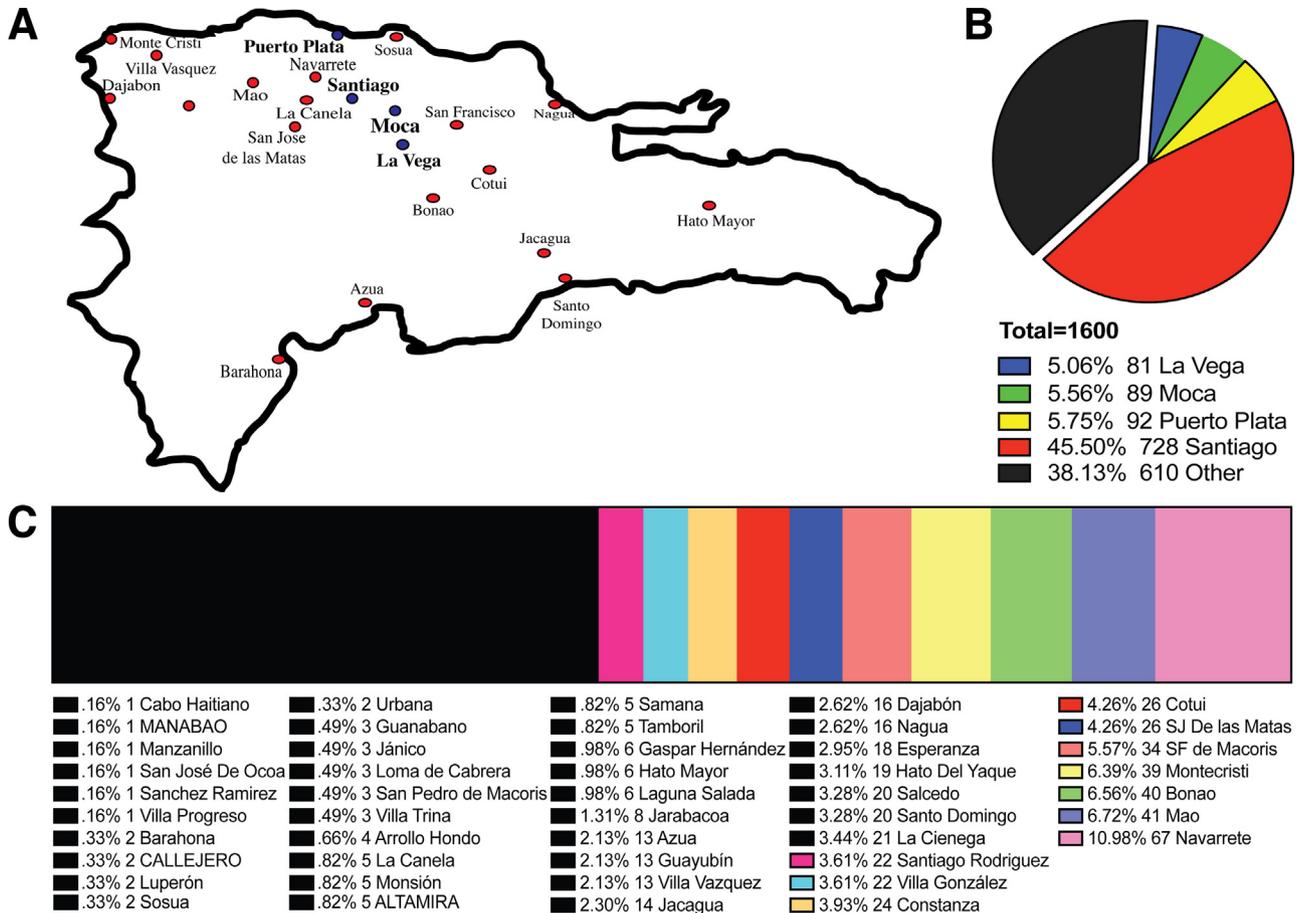


Fig 1 – Geographical coverage of Unidad de Niños Quemados Dra. Thelma Rosario Hospital based on all sixteen hundred patients admitted. The geographical location (A) of all major (B) and minor (C) contributors to this burn unit are illustrated. Bolded city names accompanied by blue dots highlight major contributors whereas regular font names with red dots highlight minor contributors. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

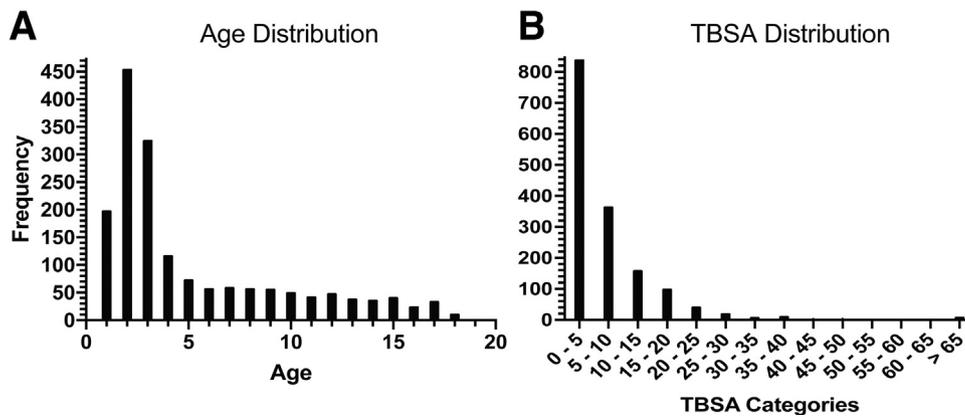


Fig. 2 – Age (A) and total body surface area (TBSA, B) binned frequency distribution.

(10 days vs. 6 days, $R^2=0.007$, $P<0.001$; Fig. 3C). Pediatric burns in the DR effected a larger proportion of females (60% in DR vs. 35% in NA) and yielded a nearly 4-fold higher mortality rate (2.8% in DR vs. 0.7% in NA).

3.2. Etiology

Scald, electricity, and flame were the three most common burn mechanisms in the Dominican Republic which accounted for 49% (782/1600), 21%(333/1600) and 13% (214/1600) of all cases respectively ($\chi^2=405.1$, $P<0.001$; Figs. 1 A and 2 A). Comparison with age-matched records in the NBR revealed significant differences in the distribution of burn mechanisms ($\chi^2=3161$, $P<0.0001$; Fig. 1A).

Most significant deviation from the NBR’s expected values were pediatric burns due to flame (13.4% in DR vs. 27.3% in NA) and electricity (20.8% in DR vs. 1.9% in NA). Although the average age of flame (7.4 years) and electrical (7.3 years) burns were similar, scald burns (3.6 years) effected significantly younger children ($F=123.7$, $R^2=0.16$, $P<0.0001$, Fig. 4C). Burn mechanisms also differed in the extent of %TBSA inflicted ($F=4.33$, $R^2=0.006$, $P<0.05$). Compared to flame (19.2%) and scald (14.1%) burns, electrical burns (2.6%) covered a significantly smaller surface area ($P<0.05$; Fig. 4D) and were most frequently seen in hands compared to other anatomical regions (Fig. 7A). Admission duration was also shortest for electrical burns (5.6 days) compared with flame (14.9 days) and scald (8.2 days; Fig. 4F).

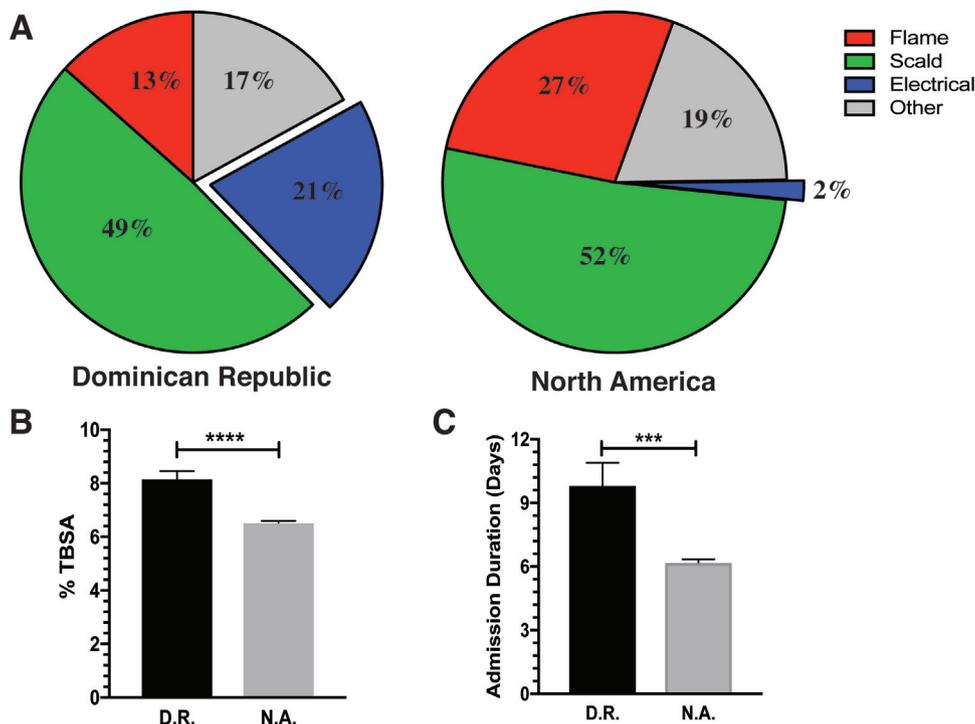


Fig. 3 – Significant regional differences exist in pediatric burns seen in the Dominican Republic (D.R.) when compared with North America (N.A.). The percentage of three leading burn mechanisms (flame, scald, and electrical) are contrasted to highlight differential susceptibility to each in the two populations (A). The percentage of total body surface area (%TBSA) burnt (B) and admission duration (C) is compared to highlight severity of burn injuries in the two populations. Error bars represent SEM. *** = $P<0.001$, **** = $P<0.0001$.

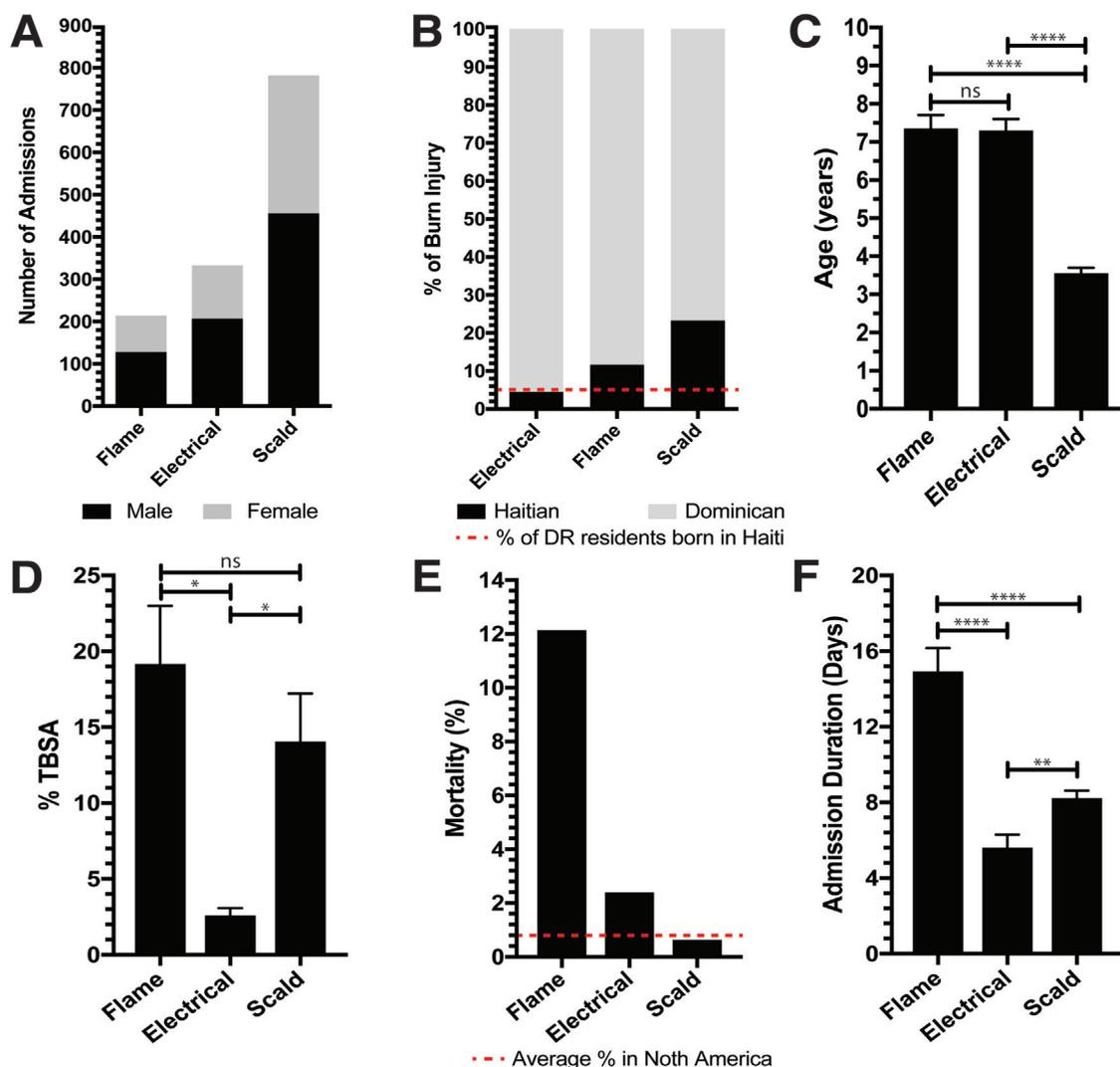


Fig. 4 – Clinical features unique to each burn mechanism seen in the Dominican Republic. Number of incidences (A), nationality of patients (B), age (C), percentage of total body surface area (%TBSA) (D), mortality (E), and admission duration (F) for flame (n=214), electrical (n=333) and scald (n=782) burns are compared. * = P < 0.05, ** = P < 0.01, * = P < 0.001, ns = P > 0.05. Error bars represent SEM.**

3.3. Temporality and age distribution

Burn mechanisms did not exhibit seasonality as the proportion of electrical ($\chi^2=11.91, P=0.3702$), scald ($\chi^2=18.57, P=0.0692$) and flame ($\chi^2=12.22, P=0.3470$) cases were evenly distributed over the 12 months (Fig. 5B). Similarly, no differences were observed in the distribution of burn mechanisms over the 8 years reviewed (Fig. 5A). Interestingly, a trend favoring electrical burns (with a concomitant reduction in scald burns) was observed when percentage of burn mechanisms were compared across binned age categories (Fig. 5C and D).

3.4. Geographical distribution

Significant regional differences were observed in the distribution of burn mechanism as cities such as Puerto Plata ($\chi^2=13.8, P<0.05$), Navarrete ($\chi^2=40.21, P<0.0001$), and Cotui ($\chi^2=40.4, P<0.0001$) deviated significantly when cumulative DR

averages were used as expected values (Fig. 6A and B). To further elucidate features of vulnerable populations, electrical burns from Santiago and Navarrete were analyzed for gender and age distribution (Fig. 7B-D). This analysis revealed that females in Navarrete with a mean age of 7.4 years (compared to DR-wide female mean of 5.3 years) were particularly vulnerable to electrical burns (Fig. 7C and D).

4. Discussion

Investigation of burn epidemiology in LMIC is imperative for adopting effective and individualized burn prevention strategies. Based on available literature from identified LMIC countries, the World Health Organization classified Eastern Mediterranean Region, the South East Asian Region, and the African Region as areas which sustain a disproportionate burden of burn injuries [6]. Despite most Caribbean countries

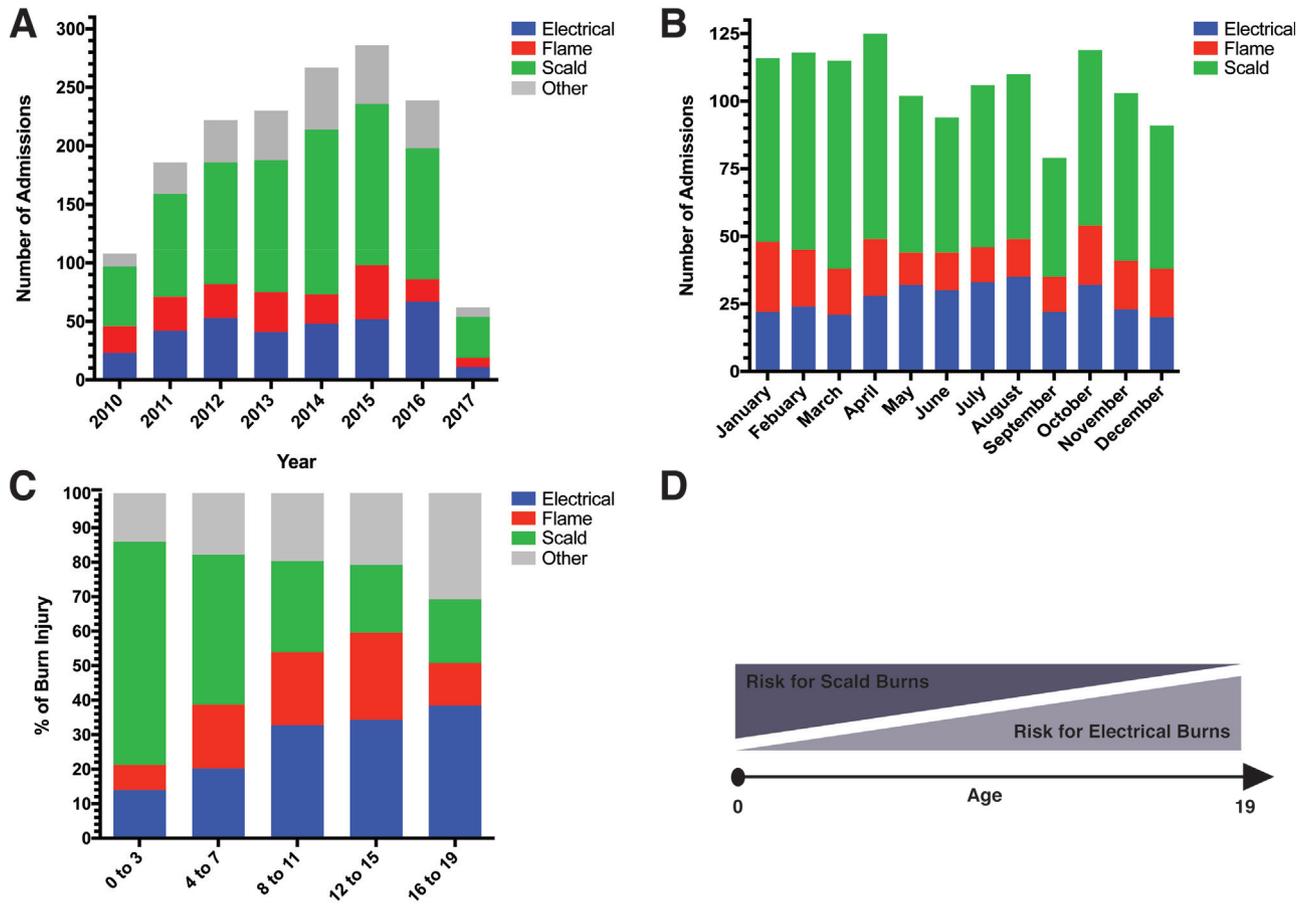


Fig. 5 - Demographical and temporal features of the three burn mechanisms seen in the Dominican Republic. Number of admissions for flame, electrical and scald burns are compared longitudinally by year (A) and by month (B) over the review period of January 2010 to March 2017. Age was converted into categorical variables to illustrate differential susceptibility of flame, electrical and scald burns for each 4-year category (C). Schematic illustrating the risk of scald and electric pediatric burns as a function of age (D).

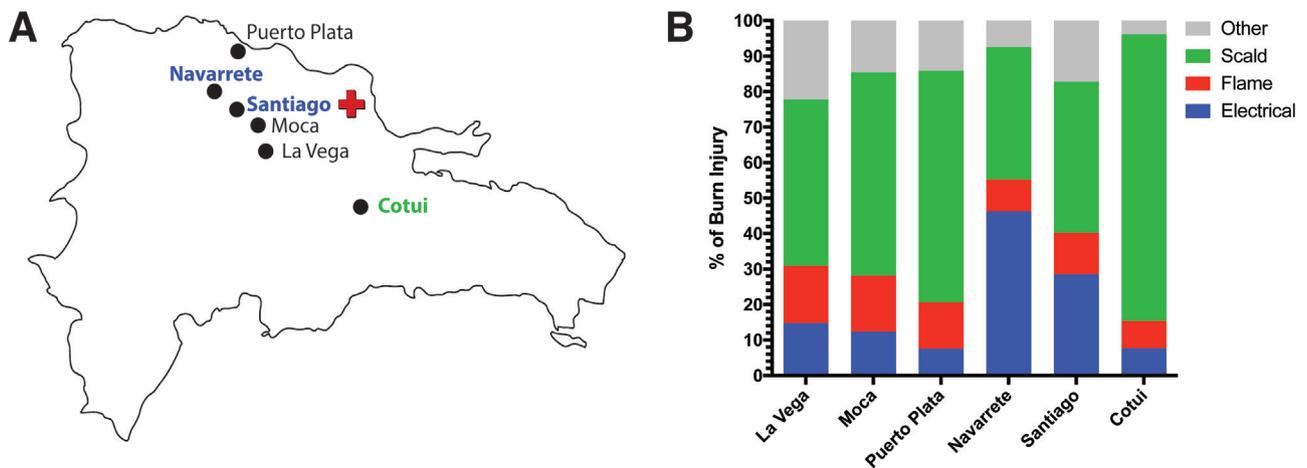


Fig. 6 - Geographical differences in susceptibility to burn mechanisms within the region covered by UNIQUEM. A Dominican Republic map illustrates the approximate location of cities covered by UNIQUEM (A). Patients from cities in blue sustain greater than expected electrical burns whereas cities in green sustain greater than expected scald burns. Red cross represents the location of UNIQUEM (A). Percentage of burn injury mechanism seen in 6 major cities covered by UNIQUEM is also illustrated (B). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

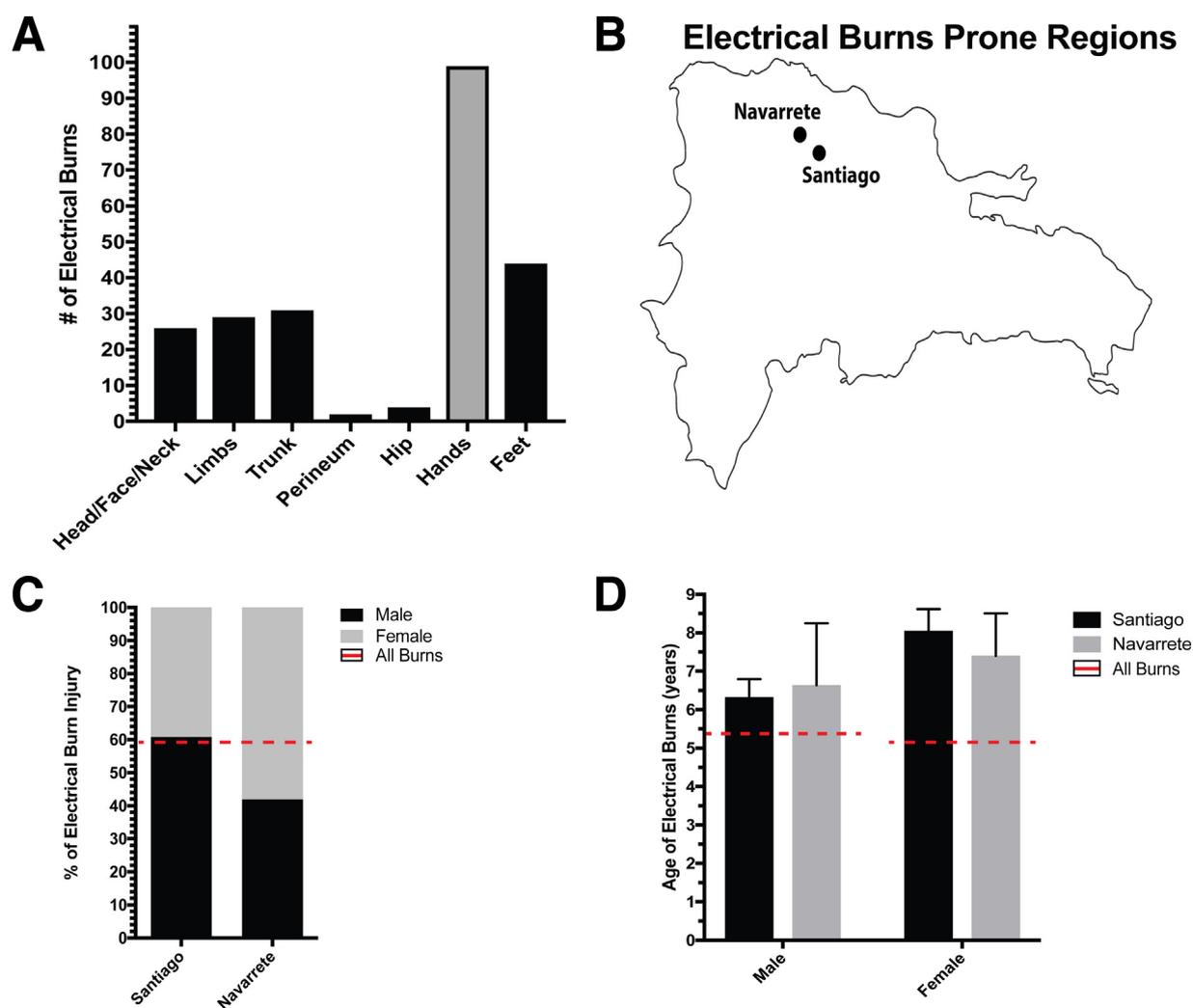


Fig. 7 – Clinical features unique to electrical burns in the Dominican Republic. Number of electrical burns sustained at different anatomical regions (A). Grey bar represents a higher than expected distribution for hands compared to the remaining anatomical sites. Location of the two cities with the highest proportion of electrical burns are illustrated on the Dominican map (B). Difference in gender (C) and age (D) distributions, in comparison to national (DR-wide) means, are illustrated.

qualifying the World Bank's classification of LMIC, the epidemiological status of burns in this region has not been reported. As a consequence, these countries have escaped systematic surveillance of burn trends and have not adopted burn prevention programs developed with regional risks in mind. This report is the first to describe the epidemiology of burn patients in the Dominican Republic (a middle income country [4]) between January 2010 to March 2017. We found that in comparison to North American patients, pediatric burn victims in the Dominican Republic sustained larger burns, spent more time in the hospital, had a higher mortality rate, and females were overrepresented. More strikingly, we found a unique distribution of burn mechanisms where scald (49%), electrical (21%), and flame (13%) were the leading sources of burns. This is significant because the proportion of pediatric electrical burns seen in this region is unlike other LMIC previously characterized. However, findings from this study should be interpreted with caution as the patient data reviewed did not include outpatients, whose burns are known to be less severe.

Electrical burns are unlike thermal burns because they inflict extensive localized destruction of tissue through which the current passes. They can affect multiple organ systems depending on the trajectory of the current and can require aggressive resuscitation efforts to restore circulatory volume [14]. There is only a handful of examples where electrical burns are described as a significant source of injury. One such example is the Southern part of Turkey [15,16] where electrical burns accounted for 21% of all burns admitted [17]. The first report which described this pattern in 1989 found that electrical burns preferentially targeted electricians and blue collar workers who were exposed to high voltage transmission lines (100-134,000V) [15]. Subsequent studies, however, revealed that electrical burns were also the leading mechanism of injury in late childhood (7-15 years) [16]. A vast majority of these injuries occurred at home (74%) and happened more frequently during the summer months (42%) [16]. Although our findings mirror the age range (8-19 years) susceptible for electrical burns in the Dominican Republic (Fig. 3C and D), we

did not find significant seasonality for any of the burn mechanisms (Fig. 3B). Since our patient records did not capture the location of the burn, we were not able to identify the specific places (i.e. playgrounds, school, house) which are uniquely vulnerable to particular burn types.

Several enablers of pediatric electrical burns have been proposed. These include uninsulated electrical wirings, lack of knowledge, and systemic architectural risks such as utility poles being too low in height or situated close to residential settings [15,16]. Oral contact with electrical cords and contact with wall sockets (directly or through conductive objects such as metal pins) are also common sources of electrical burns in children [18]. Since the identity of risk factors specific to the DR region are not known, this study provides a rationale to systematically investigate household and infrastructural enablers. Such an effort can establish effective and sustainable community-wide prevention programs aimed at reducing the frequency and severity of burns.

Conflict of interest

Sinha: None.

Martinez: None.

Hartley: None.

Alvarez: None.

Yoon: None.

Biernaskie: None.

Nickerson: Consultant for ConvaTec, Inc.

Gabriel: None.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.burns.2018.03.014>.

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