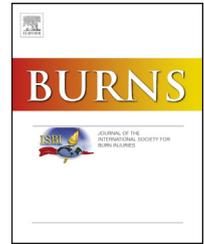


Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Incidence, severity and pattern of burns in children and adolescents: An epidemiological study among immigrant and Swiss patients in Switzerland

Julia Elrod^{a,*}, Clemens M. Schiestl^a, Christoph Mohr^a, Markus A. Landolt^{b,c}

^a Pediatric Burn Center, Division of Plastic and Reconstructive Surgery, University Children's Hospital Zurich, Steinwiesstrasse 75 8032, Zurich, Switzerland

^b Department of Psychosomatics and Psychiatry, University Children's Hospital Zurich, Steinwiesstrasse, 75 8032, Zurich, Switzerland

^c Division of Child and Adolescence Health Psychology, Department of Psychology, University of Zurich, Steinwiesstrasse, 75 8032, Zurich, Switzerland

ARTICLE INFO

Article history:

Accepted 7 February 2019

Keywords:

Burns
Pediatrics
Socio economic status
Children
Vulnerable
Citizenship

ABSTRACT

Background: Despite advances in surgical management and critical care for burn surgery, morbidity and mortality of patients with severe burns remains high. Especially in the pediatric population, burns often lead to devastating consequences such as the necessity of corrective surgery until adulthood. Worldwide, 80%–90% of all severe burns occur in low to middle income countries. But also in high income countries, burns are distributed inequitably. Risk factors include age, sex, socioeconomic status, and ethnicity.

Aim: The objective of this study was to determine the typical demographics and injury-related data of pediatric burn patients in order to contribute to preventive measures. Special interest was paid to the question of whether the incidence of severe burns is higher among patients with an immigration background.

Patients and methods: Patient records of the 4373 patients admitted to the Pediatric Burn Unit of the University Children's Hospital of Zurich from 2006 to 2018 were analyzed. Demographic data and injury patterns are presented descriptively. Temporal trends concerning duration of hospitalization and setting (inpatient versus outpatient), differences in relative incidence and in burn mechanism in distinct cohorts (by nation and Human Development Index (HDI)) and seasonal trends were analyzed. Furthermore, risk factors for large burns and for (prolonged) inpatient treatment were examined using a multivariate approach.

Results: Temporal resolution shows considerable variation between inpatient and outpatient treatment ($p > 0.001$) and with shorter hospital stays ($p = 0.004$). Swiss citizens and patients with an immigration background from very highly developed countries sustain a significantly lower incidence of heat-related injuries than all others ($p < 0.001$). The most common burn causes among all children, independent of their country of citizenship, are related to kitchen items or hot tea and coffee ($35.57\% \pm 4.01\%$ resp. $32.39\% \pm 5.95\%$). Logistic regression revealed that migration background from a low HDI country is significantly associated with larger burns ($>5\%$ TBSA) and with a need for inpatient treatment.

* Corresponding author.

E-mail address: Julia.Elrod@kispi.uzh.ch (J. Elrod).

<https://doi.org/10.1016/j.burns.2019.02.009>

0305-4179/© 2019 Elsevier Ltd and ISBI. All rights reserved.

Conclusion: The study emphasizes the need for highly specific measures of burn prevention and indicates the necessity of focusing on certain target groups who are especially vulnerable to burns, such as immigrants from less developed countries.

© 2019 Elsevier Ltd and ISBI. All rights reserved.

1. Introduction

Thanks to significant advances in both burn care and in intensive care management, morbidity and mortality of burn injuries has decreased significantly over the past decades in most countries across the world [1]. The majority of all burn-related deaths occur in low income countries; [2] however, mortality in severely burned patients remains substantial even in highly developed countries such as the US, according to data from the National Burn Repository from 2016 [2]. Moreover, fire-related burns remain one of the leading reasons for a loss of disability-adjusted life years (DALYs) in low and middle-income countries, leading to a loss of almost 18 million DALYs worldwide [3,4]. Severe burns are often accompanied by drastic sequelae, such as scar contractures which can lead to a limitation of movement and cause disfigurement of the body, and even restrain facial expression. Especially in pediatric patients who are still in their growth phase, repetitive surgical interventions to correct scar contractures are often necessary until adulthood [5]. These are associated with missing time in school, difficulties in finding employment and challenges in social interaction [6–12]. Furthermore, the psychological consequences of burn injuries, including anxiety, depression and post-traumatic stress disorder can be impairing [13–16].

The incidence of burns varies considerably across distinct cohorts, both from a global perspective and within each population. With regard to the pediatric population, risk factors for an increased incidence are, for example, lack of supervision, parental illiteracy, crowded housing situations, poor education level and low socioeconomic status (SES) [17–20]. Fire injuries have been reported as showing the strongest correlation with social class among all childhood injuries in England and Wales, with fire-related mortality being 16 times higher in the lowest SE class than in the highest one [21]. From a global perspective, the large majority (80–90% depending on the means of assessment) of all burns arise in middle to low income countries [22,23]. For instance, the incidence of burns among children living on the African continent is three times the world average for the same age group, resulting in a major public health [22,24]. However, since most countries do not keep a burn registry, data concerning incidence and injury patterns are often not accurate [25].

Considering the extent of burn injuries globally and the serious long-term consequences in terms of function, aesthetics and social integration, great importance has to be given to preventive measures. Effective prevention of (burn) injuries consists of four stages: assessment, analysis, implementation of preventive measures, and monitoring of their outcome [22].

The aim of this retrospective study was to perform this first and second stage in order to contribute to better prevention. To achieve this, the records of the 4373 burn patients treated in

the Department of Pediatric Burns at the University Children's Hospital in Zurich from 2006 to 2018 were analyzed in terms of demographics, injury patterns, accident related circumstances and risk factors.

We hypothesized that certain risk factors, such as an immigration background have a significant influence on the incidence of burn injuries. We also hypothesized that a majority of all pediatric burns and scald injuries is caused by only few major types of accidents. Furthermore, we aimed at assessing predictors of (1) burns $\geq 5\%$, of (2) inpatient treatment, and of (3) prolonged length of stay (LOS).

2. Materials and methods

The study was approved by the ethics commission of Zurich (Kantonale Ethikkommission Zurich, KEK-ZH-Nr. 2018-01664). It was conducted at the University Children's Hospital Zurich, the Swiss referral center for pediatric burns.

By using the electronic hospital information system (HIS) all patients treated at our hospital (inpatient and outpatient department) from 2006 (year of introduction of the HIS) to 2018 were identified via diagnosis codes for burns. From these children and adolescents, the following data was extracted in an anonymized manner, according to ethical regulations: age at injury, date of admission and discharge, medical history, diagnosis, results of the physical examination, type of treatments, and citizenship. Re-admission and follow-ups were excluded, as were largely incomplete data sets. Patients from Saudi Arabia, Qatar, the United Arab Emirates and Kuwait were excluded as well because there were no immigrants among the patients from these four countries. Instead, all of them were selectively sent to Switzerland for treatment and returned to their home country after completion of the acute treatment phase. Therefore, including them in the analysis would distort the results. In a few cases, automated data extraction resulted in slightly incomplete data sets because the treating physician had written the diagnosis in the wrong field in the HIS. In such cases, one of the investigators had to look up the information manually in the HIS. With regard to Total Body Surface Area (TBSA) involved, missing values were completed by calculating the TBSA according to the body locations affected, as described in the physical examination report and/or corresponding images. Importantly, the physician responsible for this completion was blinded with regard to the patients' citizenship. The resulting Excel file was imported into a software written in Python (Python 3.6.6, 2018, Python Software Foundation), customized for this specific study purpose. The word-pattern-matching algorithm specifically coded for this application enabled the extraction of mechanisms of injury and pattern of injury (anatomical site and TBSA) in an automated manner without manual intervention. Next, the resulting data was encoded in a standardized manner. For this

purpose, synonyms and alternative spelling methods or orthographic errors were corrected and grouped accordingly. The grouping of patients by country was performed according to their actual citizenship, as indicated in the electronic patient record. Neither the place of birth, nor the parents' citizenship was considered for this classification. Citizenships of patients were classified according to the HDI. HDI is a composite index, comprising life expectancy, education and per capita income indicators. Four categories were then formed, according to the *Human Development Report*, by means of fixed cutoff points, resulting in the following four groups: "very high development" (Group A; HDI 0.800 or greater), "high development" (Group B; HDI 0.700-0.799), "medium development" (Group C; HDI of 0.550-0.699) and "low development" (Group D; HDI of less than 0.550) [26,27].

Data concerning the population of the State (Kanton) of Zurich was requested from the cantonal statistical office of Zurich (Kanton Zürich, Direktion der Justiz und des Innern, Statistisches Amt). From this, information about the citizenship and age of the residents was extracted. In order to calculate the relative incidence of burns within each nationality, first the arithmetic mean of the population weighted by patients by year between 2006 and 2017 was calculated. The overall number of patients with Swiss citizenship was divided by the obtained mean population (Swiss citizens between 0-17 years, living in the canton of Zurich). The same was performed with every other citizenship (patients from the country divided by weighted arithmetic mean numbers of minors from that country living in the canton of Zurich). Relative frequencies were determined by defining the incidence of Swiss citizens as being 1 and determining relative numbers for all other nations. The same was performed for each of the four HDI groups.

The data was analyzed using SPSS statistical software for Macintosh, release 25. Demographic data, mechanisms of injury and injury patterns were presented descriptively,

means and standard deviations (SD) were calculated. Temporal shifts in the treatment setting (outpatient vs inpatient), seasonal distributions of specific injury mechanisms and the proportion of scalds within distinct HDI groups were examined by means of Chi-square tests. Differences of mean TBSA in burns and in scald injuries were examined by means of a Student T-Test. To examine changes in duration of hospitalization across years and to compare the incidence of heat-related injuries in distinct HDI groups, Univariate ANOVAS were calculated. Multivariate analyses were used to assess the role of individual predictors on outcomes. For logistic regression analysis predicting size of burns, TBSA was dichotomized (<5% "small" vs. \geq 5% "moderate to large"), since burns \geq 5% TBSA tend to result in more complications and as a result often entail the necessity of repeated corrective surgeries. To investigate the odds of having a moderate or large burn (TBSA \geq 5%), the following predictors were tested: male sex, young age, scald, migration from a lower HDI country (group C, D). For prediction of treatment setting (inpatient vs. outpatient), TBSA was included as an additional predictor in a second logistic regression model. Multivariate linear regression analysis was applied to assess predictors of prolonged LOS using the same predictor variables. For all analyses, p-levels of less or equal to 0.05 were considered statistically significant.

3. Results

3.1. Demographics and general injury data

Between 2006 and July 2018, 4373 children and adolescents were treated in the Children's Hospital for burns, of which 1872 (42.81%) were girls. The mean age and standard deviation were 46.60 ± 47.30 months, whereby the majority (2650 cases, 60.60%) were children between 1 year and 5 years of age, 622

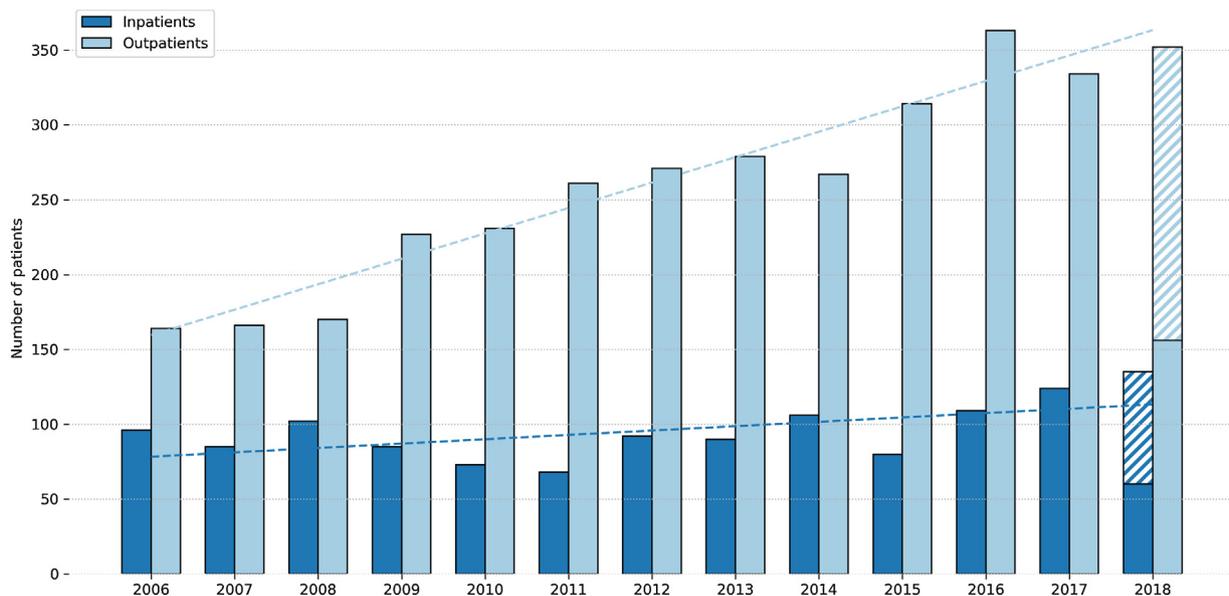


Fig. 1 – Patients treated for burns by treatment setting (inpatients in dark blue and outpatients in light blue) and by year. Missing data for the current year (2018) were supplemented by means of extrapolation (dark and light blue respectively, dashed). Analysis of temporal trends shows a significant shift towards outpatient treatment ($p < 0.001$, $\chi^2 = 23.26$, Chi-squared test). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

(14.22%) were under 1 year and 1101 (25.18%) patients were older than 5 years.

Inpatient treatment was required by 1170 (26.76%) patients, whereas 3203 (73.24%) attended the outpatient unit only. This corresponds to a mean of 92.50 ± 15.97 inpatients per year (range: 73 in 2011–123 in 2017) and a mean of 253.92 ± 65.48 outpatients per year (range: 164 in 2006–363 in 2016). Fig. 1 depicts the temporal trends for inpatients and outpatients separately from 2006–2018. A significant shift towards out-patient treatment occurred in this period ($\chi^2=23.26$, $p<0.001$).

Mean LOS (inpatients only) was 11.81 ± 17.39 days (range: 1–204 days) and temporal dissolution showed a significant decline during the 12 years ($F=2.44$, $p=0.04$) as shown in Fig. 2.

In most cases, more than one body site was affected. Involvement of the upper extremities was most common (2794 cases 66.32%), followed by the thorax (1548 cases, 37.74%), the lower extremities (1157 cases, 27.46%) and finally the head (1075 cases, 25.52%). In 77 patients TBSA was neither indicated nor could it be calculated by means of the reported medical status. In the remaining 4296 patients, mean TBSA was $3.46\% \pm 5.53\%$ (range: 1%–85%). Of these, 3379 (78.65%) patients suffered from burns $<5\%$ TBSA, 839 (19.53%) sustained a burn between 5% TBSA and 19% TBSA, only 78 (1.82%) had a burn injury $\geq 20\%$ TBSA. Separate assessment of TBSA by etiology showed a mean of $2.56\% \pm 5.65\%$ (range: 1–85%) in burns and a significantly higher mean of $4.16\% \pm 5.12\%$ (range: 1–70%) in scalds ($F=29.34$, $p<0.000$).

3.2. Countries of origin

Overall, patients from 86 different countries were treated. For analyses, countries <10 patients were excluded, leaving 25 nations, as shown in Table 1.

Next, the relative incidence by country was calculated from the above 26 countries. Incidence of Swiss citizens was defined as 1. Only 4 countries showed an incidence slightly below

Switzerland (<1), synonymous to a lower frequency of pediatric burns in each of these four immigrant groups in comparison to Swiss citizens. All four countries belong to group A. As shown in Fig. 3, highly developed countries tend to be clustered on the left side of the graph and countries with a lower level of development tend to be located on the right side of the graph. The highest incidence was found for citizens of Pakistan (3.62-fold the Swiss citizens), followed by Iraq (2.97-fold the Swiss citizens) and Eritrea (2.54-fold the Swiss citizens). Relative incidence of burns shows a significant correlation with the HDI of patients' country of citizenship, where more developed countries are less at risk of sustaining a heat-related injury. (Relative incidences are as follows: A: mean 1.04 ± 0.14 ; B: mean 1.89 ± 0.44 ; C: mean 2.91 ± 0.43 ; D: 2.19 ± 0.45) ($F=4483.92$; $p<0.001$, data not shown).

3.3. Burn mechanism and cause

In terms of etiology, scalds were most frequent (2381 cases, 55.45%), followed by burns (1965 cases, 44.93%), whereas electrical accidents and chemical accidents were rare (23 cases (0.53%) and 4 cases (0.09%) respectively). Conversely, an assessment of the mechanism of injuries by HDI shows a significantly increased proportion of scalds (of all heat-related injuries) in less developed countries (53.09% in group A, 57.95% in group B, 62.07% in group C, 70.78% in group D) ($\chi^2=23.26=23.26$; $p<0.001$) as shown in Fig. 4.

A detailed look at the causes of injury amongst all children and adolescents was performed, revealing the 20 most common mechanisms, as shown in Table 2. The assessment of the mechanism of injury by HDI yielded very similar results for all 4 groups (data not shown).

Injuries were grouped into 11 categories according to the setting in which they took place, and displayed by HDI, as shown in Fig. 5. Across all 4 HDI groups, the majority of injuries were caused either by kitchen-related items (39.92% in group A, 33.49% in group B, 31.08% in group C, 37.78% in group D) or

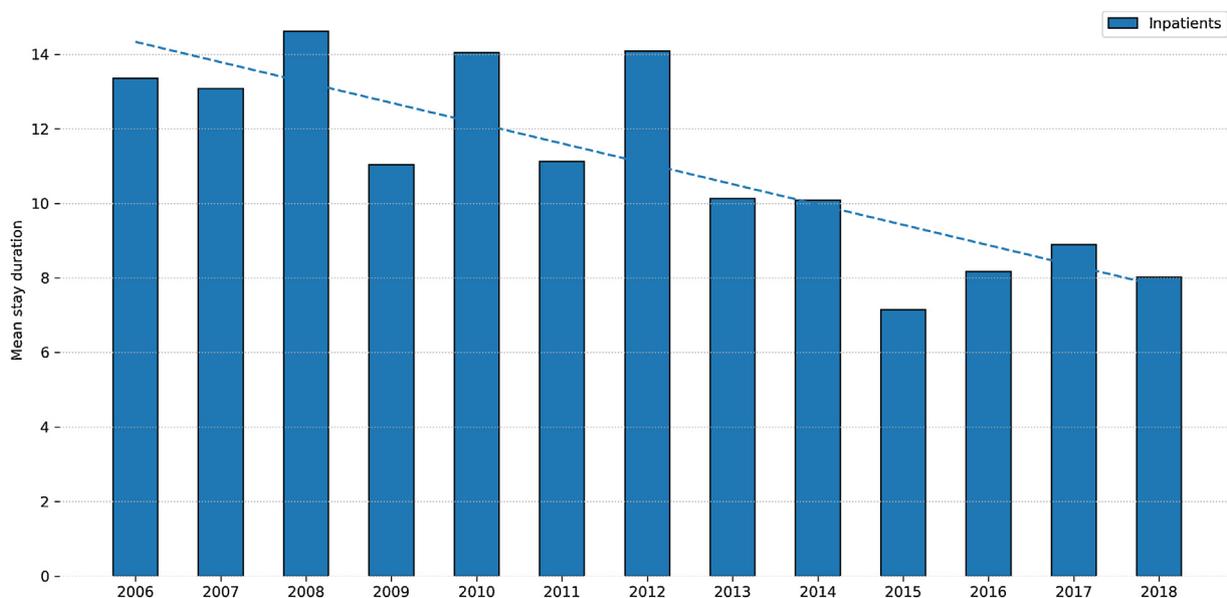


Fig. 2 – Mean duration of hospitalization by year. Mean length of stay (inpatients only) shows a significant temporal decline ($F=2.43$; $p=0.04$).

Table 1 – Most frequent countries of citizenship of the patients treated in the Children’s Hospital and according to total numbers, percentage of all patients, relative incidence of burns within each cohort (Rel. Inc.) and Human Development Index (HDI). Nations are sorted by frequency of patients.

Ranking	Nation	Patients	(%)	Rel. Inc.	HDI
1	Switzerland	2965	69.80	1.00	A
2	Germany	258	5.90	1.50	A
3	Kosovo	113	2.58	1.64	B
4	Turkey	101	2.31	2.32	B
5	Portugal	93	2.13	1.10	A
6	Italy	84	1.92	0.83	A
7	Eritrea	60	1.37	2.54	D
8	Macedonia	57	1.30	1.05	B
9	Sri Lanka	43	<1	1.90	B
10	Spain	30	<1	1.16	A
11	Afghanistan	26	<1	2.24	D
12	India	25	<1	2.48	C
13	Iraq	24	<1	2.97	D
14	France	23	<1	0.90	A
15	Syria	22	<1	1.33	D
16	Austria	21	<1	1.03	A
17	Great Britain	20	<1	0.77	A
18	Bosnia and Herzegovina	18	<1	1.64	B
19	Netherlands	16	<1	1.34	A
20	Somali	16	<1	1.97	D
21	Pakistan	13	<1	3.62	C
22	Poland	13	<1	1.07	A
23	USA	13	<1	0.96	A
24	China	11	<1	1.90	B
25	Brazil	10	<1	1.22	A

were related to hot tea and coffee (23.50% in group A, 36.10% in group B, 35.14% in group C, 34.81% in group D). Kitchen-related items primarily included electrical appliances (baking ovens, stoves, re-heaters, toasters, microwaves, electric kettles), the

ingestion of food (in the kitchen) and handling hot devices such as plates, pots, cans, metal sheets etc. Conversely, injuries related to hot tea and coffee were recorded in a category of their own.

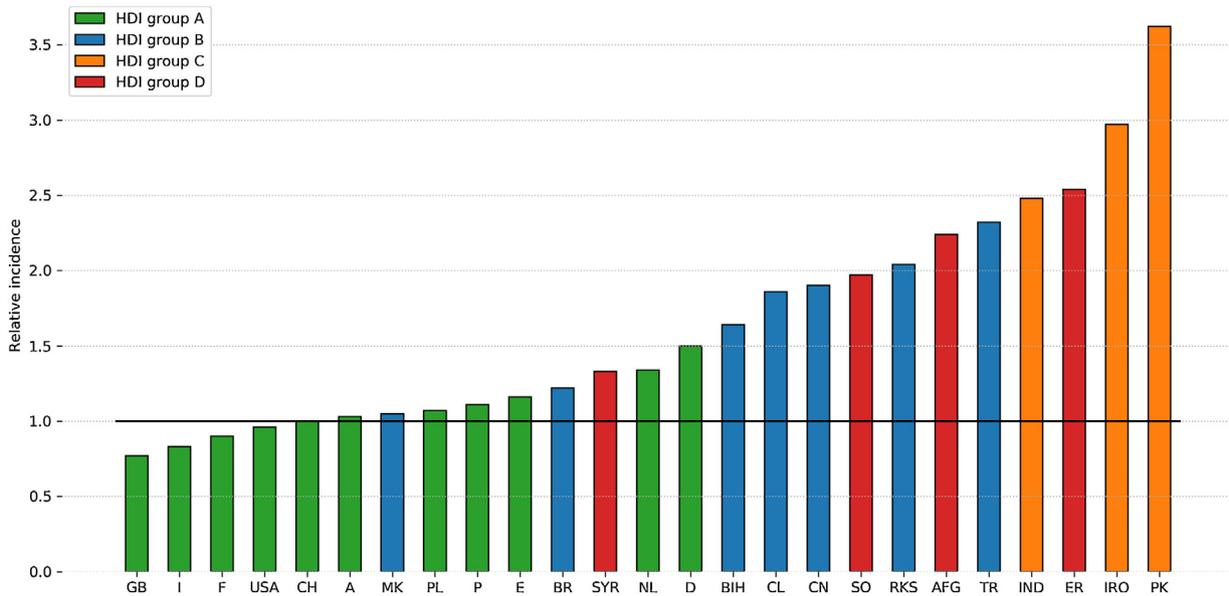


Fig. 3 – Relative incidence of burns in distinct groups of patients by country from which patients emigrated. Countries belonging to Human Development Index (HDI) group A in red, B in blue, C in orange and D in red. Incidence of native Swiss patients is defined as 1, also indicated by the horizontal black line. Countries from left to right: Great Britain (GB), Italy (I), France (F), United States of America (USA), Switzerland (CH), Austria (A), Macedonia (MK), Poland (PL), Portugal (P), Spain (E), Brazil (BR), Syria (SYR), The Netherlands (NL), Germany (D), Bosnia and Herzegovina (BIH), Sri Lanka (CL), China (CN), Somalia (SO), Kosovo (RKS), Afghanistan (AFG), Turkey (TR), India (IND), Eritrea (ER), Iraq (IRQ), Pakistan (PK). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

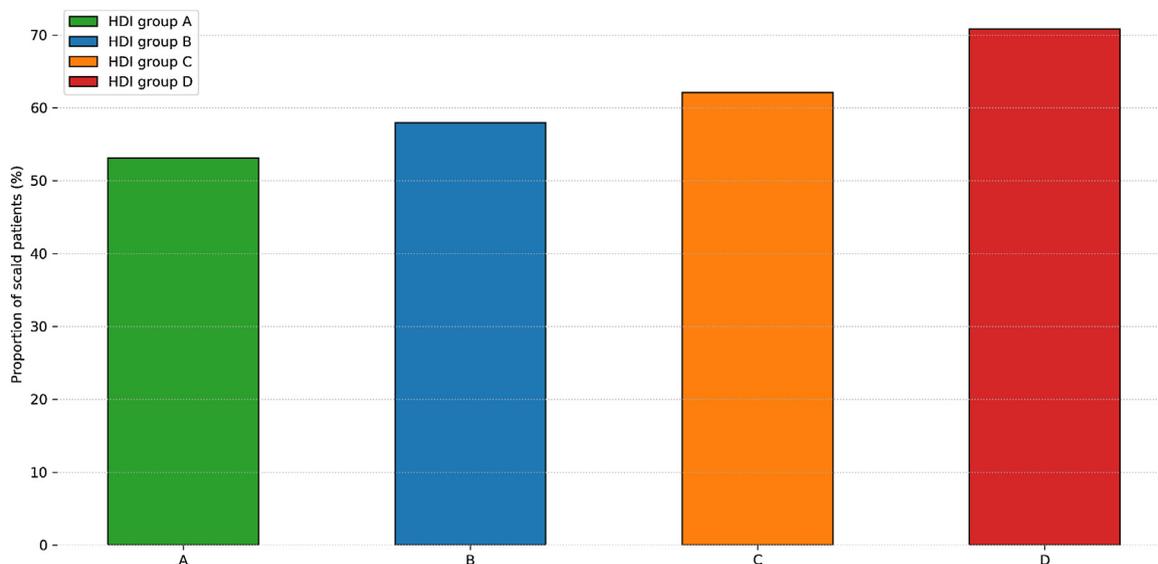


Fig. 4 – Ratio of scald to burn injuries increases from Human Development Index (HDI) group A to group D. HDI group A in red, B in blue, C in orange and D in red. The proportion of scald (from all heat related injuries) increased significantly from group A to group D ($p < 0.001$; $\chi^2 = 23.26$, Chi-squared test). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Plotting the overall number of patients treated from 2006–2017 by month did not show any notable, seasonal fluctuations as shown in Fig. 6a. However, an assessment of injuries caused by distinct etiologies showed kitchen, and tea and coffee-related injuries to occur significantly more often in winter as opposed to barbecue, furnace and heater related injuries, which arose more often in summer ($\chi^2 = 116.96$; $p < 0.000$), see Fig. 6b, c, and d. Conversely, fireworks and explosions occurred most frequently during the two typical festivities: New Year's Eve/ New Year's Day (December 31st and January 1st) and during the

Swiss National Day (August 1st) or shortly before these events, mostly due to the early purchase of the fireworks, see Fig. 6e.

3.4. Risk factors for burns $\geq 5\%$, inpatient treatment and prolonged hospital stay

The results of the logistic regression analysis for the prediction of TBSA $\geq 5\%$ are depicted in Table 3. Young male patients whose families had emigrated from a lower developed country (HDI-categories C and D) and who suffered a scald injury (as opposed to a burn injury) were at an increased risk of sustaining a moderate or large injury (larger or equal to 5% TBSA). Specifically, there was an almost four times higher risk of a moderate to large injury when sustaining a scald rather than a burn.

Furthermore, the data in Table 4 shows that inpatient (vs. outpatient) treatment was significantly predicted by the same variables mentioned above as well as by a higher TBSA burned. Notably, the odds for being treated on the inpatient unit was 1.8 times higher in HDI groups C and D.

In contrast, a longer inpatient treatment was significantly predicted by scald injury and TBSA. Association with immigration from a less developed country was not significant, most likely due to high standard deviations, as shown in Table 5.

Table 2 – Mechanisms of burns. Top 30 causes from inpatients and outpatients, mechanisms, total number of cases and percentage of all patients indicated.

Rank	Mechanism	Cases	% of all
1	Stove, oven	673	17.98
2	Tea	652	17.41
3	Fire pit, chimney	314	8.39
4	Coffee	284	7.59
5	Hot water n.s.	259	6.92
6	Soup	176	4.70
7	Porridge	133	3.55
8	Milk	87	2.32
9	Baby bottle	79	2.11
10	Drinking, n.s.	65	1.74
11	Candle	64	1.71
12	Lamp	61	1.63
13	Water boiler	53	1.42
14	Bath water	52	1.39
15	Rice	52	1.39
16	Vehicle	39	1.04
17	Fire	36	<1
18	Boiling water	35	<1
19	Oil	34	<1
20	Fireworks	30	<1

4. Discussion

In this study, the demographics and injury-related data of 4373 patients treated in our inpatient and outpatient department from 2006–2018 were analyzed, as a first step in the process of developing targeted measures of prevention.

A unique feature of our study is a considerably large sample size from one single referral center for pediatric burns. This center is responsible for the treatment of severe pediatric

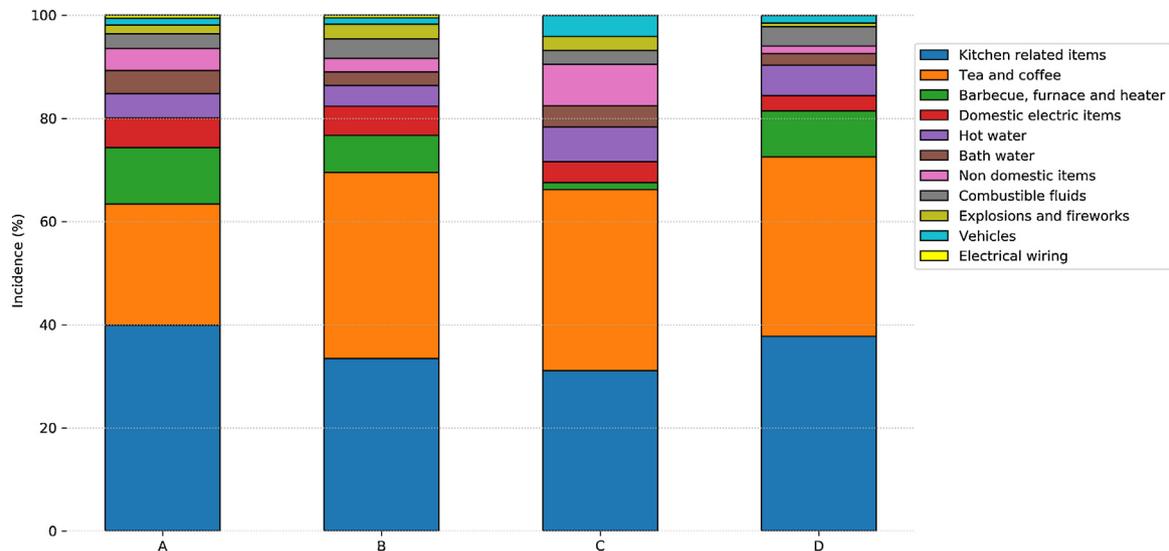


Fig. 5 – Mechanisms of injury by HDI. Mechanisms of injury were sorted into 11 categories, as indicated in the legend on the right, and distribution was assessed separately for each HDI group. Kitchen-related injuries and injuries related to hot coffee and tea were most frequent across all groups.

burns from almost the whole country [28], allowing the determination of representative data. Another asset is the multicultural population of Switzerland, which is reflected in the investigated cohort of patients including 2965 non-Swiss citizens with 85 different immigration backgrounds.

Many of our basic findings concerning demographics are in line with previous studies conducted in other pediatric burn centres [29–33] and a study conducted at our own center in the period 2004–2009 [34]. Among these are the preponderance of males (57%) and the majority (61%) of all patients being between 1 and 5 years of age. The latter is a result of children's urge to explore, their curiosity and concurrent lack of awareness of risks and danger [22]. The extent of burns in our study is somewhat lower than in previous studies [29,31,34], which can be attributed to the fact that outpatients were included in our study. However, these findings have been reported repeatedly and were not the focus of this examination.

Temporal analysis showed a similar number of inpatients over the 12 years, with a concomitant significant increase in outpatients. This corresponds to a shift to outpatient treatment over time. Concurrently, the mean LOS (counting inpatients only) showed a significant decline over time. Overall mean LOS was comparable to studies in other pediatric burn centers, for example, one conducted in Ireland (mean: 11.5 days, range 2–52 days) [35]. There may be a number of reasons for the tendency to minimize the length of stay for children and adolescents. Likely explanations are the gradual setup of post-discharge management protocols and increased home assistance, including the rising availability of transitional care services [36]. The general effort in the last decade to constrain hospital costs by replacing costly inpatient treatment with more economic outpatient treatment might also influence the setting of patient management in our cohort [37]. Possibly, a growing awareness of the benefit of the familiar home environment on health also plays a role. A study conducted on pediatric burns treated in Styria, Austria from

1989 to 2012 [29] also reported a steady numbers of inpatients over the years, but unlike in our study, failed to find a shift towards outpatient treatment.

The current investigation hypothesized that children and adolescents with an immigration background have a higher incidence of burns and that a majority of all burns are caused by a small number of distinct injury mechanisms only. In this study, the HDI, the composite index used by the United Nations to classify a country's level of development was used [26,27]. The index has, however, been criticized repeatedly for a number of methodological and statistical reasons by several economists [38,39]. However, as to our knowledge there is no better alternative. Calculation of the relative incidence of burns in the 25 most frequent nations showed a clearly elevated incidence in less developed countries.

In terms of injury mechanism, there were more scalds than burns across all 4 HDI groups; however, the imbalance increased continuously from Group A to group D. Comparable studies conducted in highly developed countries including citizens and non-citizens revealed similar percentages; in the Austrian study, for example, scalds made up 65% [29]. However, other investigations, such as one conducted in Hong Kong [40], found scald injuries to make up 92% of all injury mechanisms. This high percentage is most probably attributed to country-specific housing and cooking practices, including hot soup or kettles often placed in the living room. In contrast, a study conducted at the Children's Hospital in Michigan [31] revealed scalds to make up 48% of all cases only.

In order to develop strategies for highly effective and specific means of prevention, a detailed look at the 20 most frequent mechanisms of injuries was conducted, revealing that, across all groups, it is not burning homes or explosives, but rather everyday items such as ovens, tea and chimneys that jeopardize young patients. This finding is in line with previous [30,31,40]. In support of our hypothesis, only a few mechanisms are responsible for the majority of all burns (Table 2). De Souza [30] had grouped pediatric burn

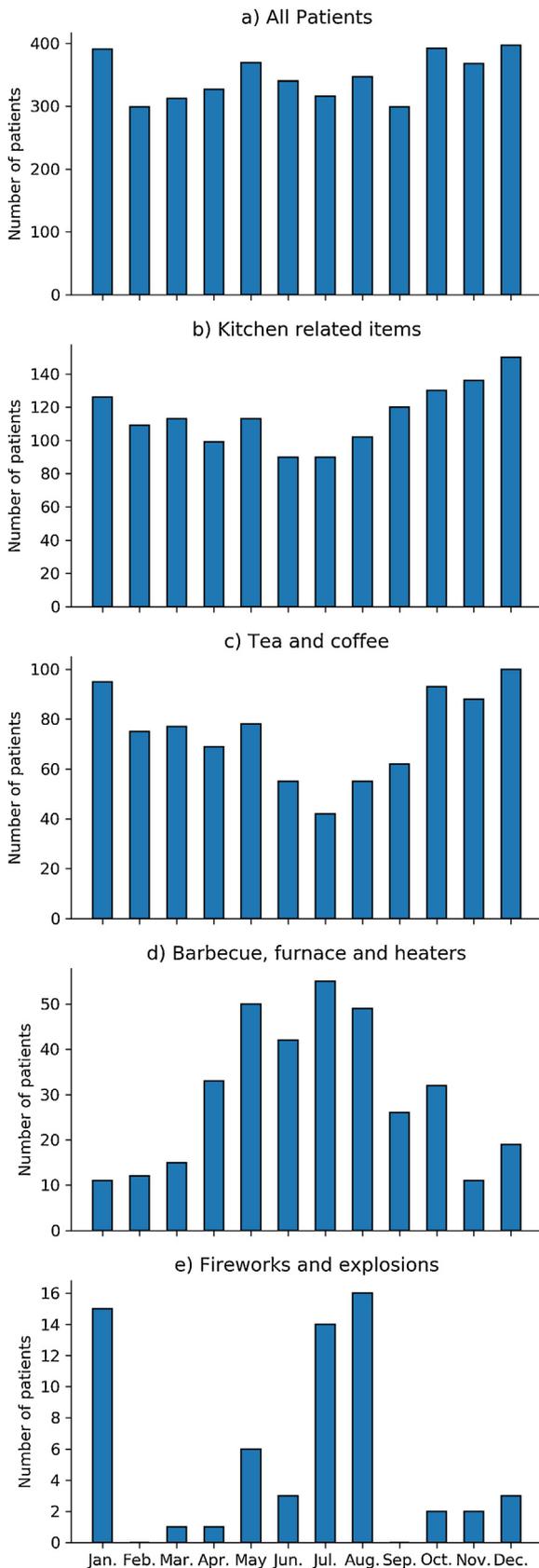


Fig. 6 – Number of patient (inpatients and outpatients) by month. Jan.=January, Feb.=February, Mar.=March, Apr.=April, Jun.=June, Jul.=July, Aug.=August, Sep.=September, Oct.=October, Nov.=November, Dec.=December. (a) All

mechanisms in the U.S. from 1990-2006 according to consumer product, revealing kitchen-related injuries to be the most common. This finding is in line with our study, with the difference that tea and coffee-related injuries were separately categorized in our study. We believe this more detailed consideration is of paramount importance in order to develop highly specific means of prevention.

The analysis of overall burn incidents by month did not result in any considerable variances, which is in line with other publications that had not revealed any major seasonal clustering [41,42]. However, the significant seasonal accumulation of specific mechanisms of injuries shows a strong dependency of temperature and the related leisure activities (such as barbecuing in the summer). Interestingly, there were more explosions and fireworks injuries related to the Swiss national holiday (August 1) than to New Year’s Eve.

To determine specific and independent risk factors associated with burns $\geq 5\%$ TBSA, with inpatient treatment (as opposed to out-patient treatment) and with a longer hospital stay, multivariate analyses were performed, revealing that amongst others, immigration background from a less developed country (HDI group C and D) was a significant risk factor for burns $\geq 5\%$ TBSA. Likewise, low HDI was significantly associated with inpatient treatment and with a longer hospital stay; however, the latter is not statistically significant, probably due to a high standard deviation. In a somewhat similar manner, a study by Gholson on orthopedic procedures in adults had demonstrated non-white race to be a risk factor for prolonged LOS [43]. Gholson surmises that race might be a partial surrogate for a low SES. It is conceivable that immigration background from a country with a low HDI correlates with a lower SES as well, with regard to our study. Thus, in the present study, SES might be responsible for some of the findings involving HDI of the countries of origin of the patients. Lastly, non-white patients have a genetically increased risk of more severe scarring [44] with consecutive negative long-term consequences concerning function and aesthetics; however, this question was not part of the investigation.

Several conclusions can be drawn from these findings. In pediatric burns, certain populations, including children and adolescents with an immigration background from a low HDI, do not only show a significantly higher incidence of burns, but injuries are also more severe (larger TBSA), tend to lead to inpatient treatment and the patients spend more time in hospital.

Conversely, it would be premature to conclude from these findings that an immigration background leads to an increased susceptibility for burns. The data merely exhibit a correlation

patients, (b) Kitchen related items (e.g. electrical kitchen devices, dishes and hot food but no tea, no coffee), (c) Tee and coffee related injuries, (d) Barbecue, furnace and heater related injuries, (e) Firework and explosion related injuries. Examination of seasonal distribution showed kitchen related injuries and injuries caused by hot tea and coffee to occur significantly more often in summer and barbecue, furnace and heater related injuries more often in winter ($\chi^2=116.96$; $p<0.001$).

Table 3 – Summary of logistic regression analysis predicting injuries $\geq 5\%$ TBSA.

Prediction of TBSA $\geq 5\%$					
Variable	B	SE	Odds ratio	95% confidence interval	p-Value
Male sex	0.29	0.08	1.34	1.14-1.56	<0.001
Age at incident	0.07	0.01	1.01	1.01-1.01	<0.001
HDI group C and D	0.416	0.15	1.52	1.12-2.05	0.007
Scald	1.38	0.89	3.95	3.32-4.71	<0.001

The values written in bold indicate the significance of the results.

Table 4 – Summary of logistic regression analysis predicting inpatient treatment (as opposed to outpatient treatment).

Prediction of inpatient treatment					
Variable	B	SE	Odds ratio	95% confidence interval	p-Value
Male sex	0.18	0.08	1.20	1.02-1.40	0.026
Age at incident	0.02	0.01	1.00	1.00-1.00	0.075
HDI group C and D	0.59	0.16	1.80	1.33-2.45	<0.001
Scald	0.37	0.88	1.45	1.22-1.72	<0.001
TBSA	0.32	0.15	1.38	1.34-1.42	<0.001

The values written in bold indicate the significance of the results.

Table 5 – Summary of multiple linear regression analysis predicting prolonged length of hospitalization.

Prediction of prolonged inpatient treatment					
Variable	B	SE	Odds ratio	95% confidence interval	p-Value
Male sex	0.181	0.81	1.199	1.022-1.406	0.800
Age at incident	0.002	0.001	1.002	1.000-1.003	0.876
HDI group C,D	-0.589	0.156	0.555	0.409-0.753	0.065
Scald	0.371	0.088	1.449	1.219-1.723	<0.000
TBSA	0.320	0.015	1.377	1.338-1.418	<0.000

The values written in bold indicate the significance of the results.

between these factors; however, they do not demonstrate a causal relationship. Several confounding factors could be responsible for this correlation, such as the SES of the groups of patients examined. It is widely known that low SES is a risk factor for burns [17,18,22] and Pecks [22] findings suggest that the SES accounts for an increased burn susceptibility to a greater degree than do cultural or educational factors. This fact is all the more relevant because burns in turn and the associated necessity of inpatient treatment often result in difficulties in returning to school and enduring the reactions of others or enduring physical limitations in children [8,12], and are a risk factor for financial loss in adults [9,10], possibly leading to a lower SES. If we want to break this vicious circle, special efforts should be made to protect these vulnerable groups of patients from burns in the first place and assist them with school reentry if drastic injuries have occurred, for example by providing sophisticated school reentry programs taking into account individual needs [45]. Also, it is fundamentally necessary that information concerning precautionary measures is provided in several languages and that preventive measures are easily accessible, for example, they should target refugees as well. Furthermore, preventive

measures should focus on the major mechanisms of injury, which occur primarily in the kitchen or are related to hot beverages. Ultimately, since domestic burns are often related to crowded housing [20], interventions that target childhood and adolescent SES, especially childhood poverty are an important aspect to consider.

5. Limitations

The present study has several limitations. From a methodological point of view, some of the numbers might be imprecise because the automated processing of the large number of patients by means of the specifically coded software does not allow more precise considerations, such as the evaluation of vague descriptions of the injury mechanism. Therefore, for instance the determination of the precise circumstance or setting of the injury (e.g. the patient's house vs. school/kindergarten etc.) such as performed by Delgado et al. [17] would be relevant to setting up preventive measures. In other cases, this information was simply missing. In a similar manner, information concerning

TBSA has to be treated with some caution because estimates of TBSA at admission tend to be higher than the actual extent, and are often not corrected later on, probably skewing our data concerning mean TBSA. Regarding immigration background, a major drawback is the lack of precise information concerning the time point of immigration, the circumstances etc. Due to the lack of this information, the citizenship of the patient at the time of admission was used, regardless of the place of birth of a patient or his parents. Since obtaining Swiss citizenship can be a lengthy process, some of these families may actually have spent their entire lives in Switzerland and still have a foreign citizenship only. The lack of information about the immigration history impedes the differentiation between recently immigrated children and adolescents and those raised and socialized in Switzerland. This might lead to a risky generalization, suggesting a correlation between certain immigrant groups and the incidence of burns, which in reality might only be true for those who have recently immigrated and not been raised in Switzerland. Moreover, the calculation of the absolute incidence of pediatric burns from the available data was not possible because the determination of the absolute incidence of any disease assumes a well-defined catchment area. It is, however, impossible to determine the precise catchment area of our Burn Centre, which is both a referral center for severe burns for almost the entire country (thus corresponding to a very large catchment area) and also serves as a primary burn center that treats non-severe burns from a much smaller catchment area.

The largest limitation of this study is probably the lack of specific and validated information concerning the SES of patients and their families. The absence of correction for the SES (in citizens and non-citizens) impedes consideration of this possible confusing factor. Thus, interpreting the data concerning immigration background without prudence might lead to the incorrect assumption that an immigration background itself leads to an increased incidence of burns. Concurrently, the multivariate analyses conducted in this study constitute its main strengths and unique quality. This method allowed the assessment of the importance of individual predictors of more severe burns or (prolonged) LOS, while simultaneously controlling for the effects of other predictors on these outcomes.

6. Conclusion

The study emphasizes the need for highly specific measures of burn prevention and indicates the necessity of focusing on certain target groups who are especially vulnerable to burns, such as immigrants from less developed countries.

Financial disclosure statement and conflicts of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

REFERENCES

- [1] Smolle C, Cambiaso-Daniel J, Forbes AA, Wurzer P, Hundeshagen G, Branski LK, et al. Recent trends in burn epidemiology worldwide: A systematic review. *Burns* 2017, doi:<http://dx.doi.org/10.1016/j.burns.2016.08.013>.
- [2] American Burn Association. National Burn Repository[®] 2016. Version 12.0. All Rights Reserved Worldwide. 311 S. Wacker Drive, Suite 4150, Chicago, IL 60606, 312-642-9260, www.ameriburn.org, <https://ameriburn.org/education/publications/>.
- [3] Novelli B, Melandri D, Bertolotti G, Vidotto G. Quality of life impact as outcome in burns patients. *G Ital Med Lav Ergon* 2009;31:A58-63.
- [4] GLOBAL HEALTH ESTIMATES 2014. SUMMARY TABLES: DALY BY CAUSE, AGE AND SEX, 2000-2012, June 2014. World Health Organization Geneva, Switzerland. http://www.who.int/healthinfo/global_burden_disease/GHE_DALY_Global_2000_2012.xls.
- [5] Ogilvie MP, Panthaki ZJ. Burns of the developing breast. *J Craniofac Surg* 2008;19:1030-3.
- [6] Schneider JC, Bassi S, Ryan CM. Barriers impacting employment after burn injury. *J Burn Care Res* 2009;30:294-300.
- [7] Esselman PC. Burn rehabilitation: an overview. *Arch Phys Med Rehabil* 2007;88:.
- [8] Esselman PC. Community integration outcome after burn injury. *Phys Med Rehabil Clin North Am* 2011;22:351-6.
- [9] Esselman PC, Askay SW, Carrougner GJ, Lezotte DC, Holavanahalli RK, Magyar-Russell G, et al. Barriers to return to work after burn injuries. *Arch Phys Med Rehabil* 2007;88:.
- [10] Mason ST, Esselman P, Fraser R, Schomer K, Truitt A, Johnson K. Return to work after burn injury: a systematic review. *J Burn Care Res* 2012;33:.
- [11] Moi AL, Wentzel-Larsen T, Salemark L, Hanestad BR. Long-term risk factors for impaired burn-specific health and unemployment in patients with thermal injury. *Burns* 2007;33:37-45.
- [12] Staley M, Anderson L, Greenhalgh D, Warden G. Return to school as an outcome measure after a burn injury. *J Burn Care Rehabil* 1999.
- [13] Park Y, Choi KA, Jang YC, Oh SJ. The risk factors of psychosocial problems for burn patients. *Burn* 2008;34:24-31.
- [14] Riggio RE, Watring KP, Throckmorton B. Social skills, social support, and psychosocial adjustment. *Pers Individ Dif* 1993;15:275-80.
- [15] Blumenfeld M, Schoeps M. Reintegrating the healed burned adult into society: psychological problems and solutions. *Clin Plast Surg* 1992;19:599-605.
- [16] Kravitz M, McCoy BJ, Tompkins DM, Daly W, Mulligan J, McCauley RL, et al. Sleep disorders in children after burn injury. *J Burn Care Rehabil* 1993;14:83-90.
- [17] Delgado J, Ramirez-Cardich M, Gilman R, Lavarello R, Dahodwala N, Bazan A, et al. Risk factors for burns in children: crowding, poverty, and poor maternal education. *Inj Prev* 2002;8:38-41.
- [18] Shai D. Income, housing, and fire injuries: a census tract analysis. *Public Health Rep* 2006;121:149-54.
- [19] Forjuoh SN. Burns in low- and middle-income countries: a review of available literature on descriptive epidemiology, risk factors, treatment, and prevention. *Burns* 2006;32:529-37.
- [20] Patel DD, Rosenberg M, Rosenberg L, Foncarrada G, Andersen CR, Capek KD, et al. Poverty, population density, and the epidemiology of burns in young children from Mexico treated at a U.S. pediatric burn facility. *Burns* 2018;44:1269-78.
- [21] Roberts I. Cause specific social class mortality differentials for child injury and poisoning in England and Wales. *J Epidemiol Commun Health* 1997;51:334-5.

- [22] Peck MD. Epidemiology of burns throughout the world. Part I: distribution and risk factors. *Burns* 2011;37:1087–100.
- [23] Dissanaik S, Rahimi M. Epidemiology of burn injuries: highlighting cultural and socio-demographic aspects. *Int Rev Psychiatry* 2009;21:505–11.
- [24] Hyder AA, Kashyap KS, Fishman S, Wali SA. Review of childhood burn injuries in sub-Saharan Africa: a forgotten public health challenge. *African Saf Promot A J Inj Violence Prev* 2008;2:1–5.
- [25] Dongo AE, Irekpita EE, Oseghale LO, Ogbemor CE, Iyamu CE, Onuminya JE. A five-year review of burn injuries in Irrua. *BMC Health Serv Res* 2007;7:1–5.
- [26] Copyright © 2018 By the United Nations Development Programme 1 UN Plaza, New York, NY 10017 USA. A catalogue record for this book is available from the British Library and Library of Congress. Editing and production: Communications Development Incorporated, Washington DC, USA. <http://hdr.undp.org/en/2018-update>.
- [27] United Nations Development Programme. Human Development Reports – About Human Development. 2018. <http://hdr.undp.org/en/humandev/>.
- [28] Das Beschlussorgan der Interkantonalen Vereinbarung über die HSM. Entscheid zur Planung der hochspezialisierten Medizin (HSM) im Bereich der Behandlung von schweren Verbrennungen bei Kindern. (2011).
- [29] Trop M, Herzog SA, Pfuertscheller K, Hoebenreich AM, Schintler MV, Stockenhuber A, et al. The past 25 years of pediatric burn treatment in Graz and important lessons been learned. An overview. *Burns* 2015;41:714–20.
- [30] D'Souza AL, Nelson NG, McKenzie LB. Pediatric burn injuries treated in US emergency departments between 1990 and 2006. *Pediatrics* 2009;124:1424–30.
- [31] Shah A, Suresh S, Thomas R, Smith S. Epidemiology and profile of pediatric burns in a large referral center. *Clin Pediatr (Phila)* 2011;50:391–5.
- [32] Spinks A, Wasiak J, Cleland H, Beben N, MacPherson AK. Ten-year epidemiological study of pediatric burns in Canada. *J Burn Care Res* 2008;29:482–8.
- [33] Langer S, Hilburg M, Drücke D, Herweg-Becker A, Steinsträsser L, Steinau HU. [Analysis of burn treatment for children at Bochum University Hospital]. *Unfallchirurg* 2006;109:862–866.
- [34] Moehrlen T, et al. Trauma mechanisms and injury patterns in pediatric burn patients. *Burns* 2018;44:326–34.
- [35] Dempsey MP, Orr DJA. Are paediatric burns more common in asylum seekers? An analysis of paediatric burn admissions. *Burns* 2006;32:242–5.
- [36] Bundesamt für Statistik & Schweizerische Eidgenossenschaft. Spitem: Synthese nach Kanton. (2017).
- [37] Carey K, Stefos T. Measuring inpatient and outpatient costs: a cost-function approach. *Health Care Financ Rev* 1992;14-2-115 [pii].
- [38] Wolff H, Chong H, Auffhammer M. Classification, detection and consequences of data error: evidence from the human development index. *Econ J* 2011, doi:<http://dx.doi.org/10.1111/j.1468-0297.2010.02408.x>.
- [39] Monni S, Spaventa A. Beyond GDP and HDI: shifting the focus from paradigms to politics. *Development* 2013, doi:<http://dx.doi.org/10.1057/dev.2013.30>.
- [40] Tse T, et al. Paediatric burn prevention: an epidemiological approach. *Burns* 2006;32:229–34.
- [41] Lari AR, Alaghebandan R, Nikui R. Epidemiological study of 3341 burns patients during three years in Tehran, Iran. *Burns* 2000;26(1):49–53, doi:[http://dx.doi.org/10.1016/S0305-4179\(99\)00102-3](http://dx.doi.org/10.1016/S0305-4179(99)00102-3).
- [42] Chien WC, Pai L, Lin CC, Chen HC. Epidemiology of hospitalized burns patients in Taiwan. *Burns* 2003;29:582–8.
- [43] Gholson JJ, Frcsc NON, Otero JE, Gao Y, Shah AS. Patient factors systematically influence hospital length of stay in common orthopaedic procedures. *Iowa Orthop J* 2017;37:233–7.
- [44] Thompson CM, et al. Genetic risk factors for hypertrophic scar development. *J Burn Care Res* 2013;34:477–82.
- [45] Blakeney P, et al. Efficacy of school reentry programs. *J Burn Care Rehabil* 1995, doi:<http://dx.doi.org/10.1097/00004630-199507000-00018>.