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Increasing ambulatory treatment of pediatric minor burns—The emerging paradigm for burn care in children[☆]

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ABSTRACT

Introduction: Innovations in topical burn treatment along with a drive toward value-based care are steering burn care to the outpatient setting. Little is known regarding what characteristics predict outpatient treatment of pediatric minor burns and whether there is a temporal trend toward this treatment paradigm.

Methods: A retrospective cohort study was performed using California's Office of Statewide Health Planning and Development linked emergency department and inpatient database (2005–2013). All patients under 18 years of age with a primary burn diagnosis were extracted. Using patient and facility level variables, we used regression modeling to evaluate predictors of outpatient burn treatment and temporal trends.

Results: There were 16,480 pediatric minor burn encounters during the period. 56.4% were male, 85.3% had <10% total body surface area (TBSA), 76.3% were scald or contact, and 77.3% were at deepest depth 2nd degree. Multiple variables predicted an increased likelihood of discharge home including older age($p<0.001$), smaller TBSA($p<0.001$), and superficial/partial thickness burns(<0.001). Children of Hispanic and Black race were less likely to be discharged home compared to White and Asian peers(p=<0.001). On Poisson modeling, the incidence rate ratio over the 9-year period for home discharge was 1.004 (95% CI 1.001–1.008, $p=0.032$).

Conclusion: Older patients and those with more superficial burns were more likely to be treated as outpatients. Black and non-white Hispanic race was associated with inpatient admission. There is a growing trend toward ambulatory treatment of minor burns in the pediatric population. Further research is needed to assess whether outpatient treatment of pediatric minor burns results in greater readmissions.

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1. Introduction

Burns are a leading mechanism of injury among pediatric patients in the United States and are frequently cared for in emergency departments (ED). In 2015, the Center for Disease Control and Prevention reported 104,940 nonfatal burn injuries and 290 deaths among children aged 0–17 years [1]. ED providers are frontline in burn treatment, and are tasked with evaluation, triage, and treatment of these injuries. Guidance from the American Burn Association (ABA) recommends referral to burn centers for children presenting to facilities that do not have "qualified personnel and equipment for the care of children [2]." Appreciating the vague nature of this recommendation, some within the burn community recommend that any pediatric burn with >5% TBSA should be evaluated by a burn center [3].

For those burns for which inpatient resuscitation and monitoring are not indicated, (i.e. <15% total body surface area for <12 years old, and <20% TBSA for adolescents), the decision for inpatient admission depends on multiple factors including tolerance for wound care, treatment of concomitant injuries, suspicion of abuse/neglect with filing to child protective services, and social support at home. Emerging technologies in the past two decades in the form of occlusive silver dressings [4] have yielded products that can be safely and effectively used to treat partial and full-thickness thickness burns in an ambulatory setting [5,6]. While some patients may eventually need surgical excision of deeper burns, these procedures can be scheduled as outpatients and the children do not have to be subjected to risks of inpatient admission.

Additionally, leaders within the international [7] and US [8] burn community advocate for ambulatory burn care when feasible to limit unnecessary hospitalization, decrease treatment costs, and improve patient experience [9]. We aim to (1) evaluate predictors of home discharge for pediatric burn patients presenting with <20% burns, and (2) determine the significance of the perceived trend toward ambulatory burn care for pediatric burns <20% TBSA. We hypothesize that ED discharge home has increased during the study period.

2. Methods

2.1. Data

The Office of Statewide Health Planning and Development (OSHPD) database captures all patient admissions and emergency department visits in the state of California. This repository creates unique identifiers for all patients, (OSHPD is not a sampled database). The following study utilized a merged non-publically available version that linked the emergency department and inpatient datasets from 2005 to 2013.

2.2. Cohort

Encounters were identified using International Classification of Disease (ICD) 9th edition diagnosis codes for burns: 940*, 941*, 942*, 943*, 944*, 945*, 946*, 948*, 949*. Both principle diagnosis codes and subsequent diagnosis codes were included for the extraction. Focusing on the pediatric population, all patients under age 18 were included. Incident emergency department visits were analyzed in order to avoid confounding repeat ED visits and readmissions. Patients were excluded for concomitant trauma, %TBSA missing, and burn depth missing.

2.3. Variables & data handling

At the patient level, all available demographic variables (age, gender, race/ethnicity, primary payer) were included. Given the general health of the pediatric population, a comorbidity index was not included. At the injury level, ICD-9 codes allowed for specifying: (1) the anatomic location of injury, (2) the mechanism of injury, (3) the size of injury by total body surface area (TBSA) in intervals of 10, and (4) the depth of injury.

At the hospital level, OSHPD provides facility identification, which allowed for identification of unverified burn centers, American Burn Association (ABA) verified burn centers and specifically verified ABA pediatric burn centers. Additional hospital level variables included California zip code, urban vs. rural setting, and bed-size. The year of visit is included for all encounters.

2.4. Analysis

A multivariable logistic model was used to evaluate predictors of home discharge in our cohort. Discharge was defined as discharge from initial ED visit or after transfer to burn center. All variables were included, and model fitness was assessed with a C-statistic. Trends were assessed using the yearly occurrence of home discharges for each year of the study period; this was modeled with Poisson regression using incidence rate ratios [10] as the output. Incidence rate ratios are standard metrics for evaluating changes (and significance) in count data. For this study, we model the ratio of the incidence of discharge versus admission for pediatric minor burns. For disease specific variables, missing data was handled using the missing indicator method [11]. The adjusted proportion of all patients discharged home was generated using a post-estimation predict command. These percentages were geographically mapped for all patient zip codes with at least five burns in the study period. The Stanford Institutional Review Board approved the following study. Analyses were conducted with Stata 15.1 (StataCorp LLC, College Station, TX)

3. Results

There were 108,125 encounters for burn related injuries in the pediatric population (<18 years of age at time of injury) (Fig. 1). 53,621 were excluded for missing TBSA; 34,163 were excluded for missing depth. 2680 encounters were excluded for non-index visits (i.e. secondary ED visits), and 1181 were excluded for TBSA >20%. This yielded 16,480 unique index ED encounters with TBSA <20% and known depth.

The mean age was 4.5 years (SD 5.1), and 56.4% were male (Table 1). 85.3% of encounters were <10%TBSA, and scald/contact burns accounted for 76.3% of all mechanisms; flame burns accounted for 7.4% of visits. Non-accidental injury was identified in a small proportion of visits at 0.7%. The majority of burns (77.3%) were partial thickness (i.e. 2nd degree) injuries; full-thickness burns (i.e. 3rd degree) were seen in 6.1%. In terms of burn location, a 29.0% of all had multiple site burns. The most prevalent site of isolated burn was the hand in 15.1% of encounters. In terms of race, 45.6% of visits were by patients identified as non-white Hispanic, followed by White race in 30.3% of encounters. Black race was the next most frequent race in 7.8% of visits; Asian race made up only 6.3% of encounters. The most frequent payer was public/government in 49.0% of patients, followed by commercial/private insurance in 40.6%. Self-pay and other-payer source accounted for less than 11% of visits. The overwhelming majority of patients (79.0%) were treated within 15 miles of their home zip code. As distance between the patient's home and ED increased, the frequency of patients discharging home declined. 30.2% of patients were treated at burn centers (both American Burn Association verified and non-verified centers).

In evaluating predictors of home discharge, we performed a logistic regression evaluating all demographic, burn, and facility variables available. Regarding demographics, age was strongly associated with disposition, such that older patients were much more likely to be discharged home from the ED (Table 2). Using the youngest cohort as the reference (i.e. age 0–1), each subsequent age group showed increasing odds of home discharge (all significant with $p<0.05$). Adolescents were over two times more likely to be discharged home than their infant peers with an odds ratio of 2.36 (95% CI 1.96–2.83, $p<0.001$). Gender was not significantly associated with disposition. Regarding race/ethnicity, children of non-white Hispanic and Black race were both less likely to be discharged home compared to White and Asian patients, $p<0.001$ for both. Payer impacted the odds of home discharge. Using private/commercial insurance as the reference, self-pay patients were more likely to be discharged home with an odds ratio of 1.53 (95% CI 1.30–1.79, $p<0.001$). Public/government payer was not significantly different from commercial payer.

Evaluating burn characteristics, using larger %TBSA burns as the reference case, those burns between 0–9% TBSA were significantly more likely to be discharged home with an odds ratio of 6.86 (95% CI 6.08–7.72, $p<0.001$). Mechanism of burn also affected discharge disposition. Using flame burns as the reference, scald and contact burns were significantly more likely to be treated as outpatients with an odds ratio of 1.90 (95% CI 1.62–2.23, $p<0.001$). Non-accidental injury was inversely associated with being discharged home yielding an odds ratio of 0.28 (95% CI 0.17–0.45, $p<0.001$). Not surprisingly, burn depth was associated with ED disposition; using full-thickness burns as the reference, children with partial thickness burns had a home discharge odds ratio of 2.24 (95% CI 1.93–2.60, $p<0.001$), and those with superficial burns had a home discharge odds ratio of 5.03 (95% CI 4.34–5.83, $p<0.001$). Finally, the location of burn using trunk as the reference was examined. For anatomically isolated injuries, children with hand burns were more likely to be discharged home with an odds ratio of 1.23 (95% CI 1.10–1.37, $p<0.001$). The head and neck region was a predictor for admission with an odds ratio of 0.81 (95% CI 0.72–0.91, $p<0.001$). When a patient was burned in multiple areas, there was decreased likelihood of home discharge with an odds ratio of 0.37 (95% CI 0.33–0.41, $p<0.001$).

Looking at facility factors, increasing distance between the patient home zip code and treating hospital zip code was inversely associated with the likelihood of home discharge. Greater distances showed a declining odds ratio for discharge home, such that EDs between 76–150 miles away were less predictive of discharge with an odds ratio of 0.57 (95% CI 0.44–0.75, $p<0.001$). When the treating ED was part of a hospital designated as burn center (both American Burn association verified and non-verified), patients had decreased odds of being discharged home, odds ratio 0.14 (95% CI 0.12–0.15, $p<0.001$).

Finally, we evaluated the significance of admission year in disposition of discharge home using the same variables in the logistic model. This yielded an incidence rate ratio over the 9-year period of 1.004 (95% CI 1.001–1.008, $p=0.032$). Adjusted frequency of home discharge was then computed using a post-estimation predict function. This was plotted for each year of the study period

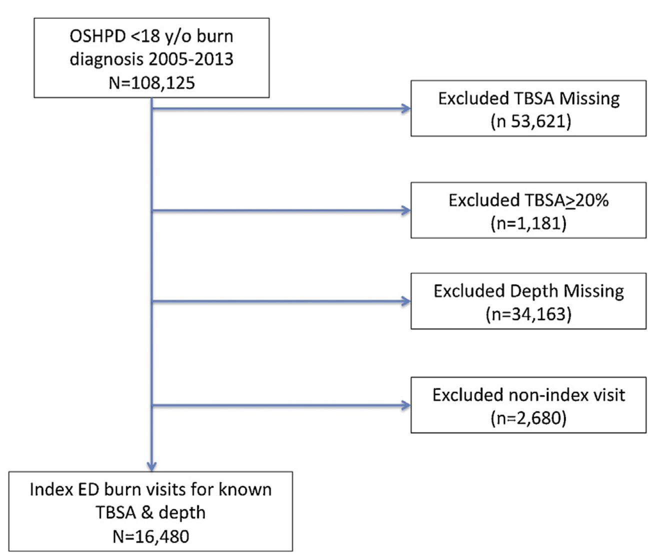

Fig. 1 – Flow diagram of exclusion and inclusion criteria.

Table 1 – Summary statistics.

Characteristic	N=16,480 (%)
Age years, mean (SD)	4.5 (5.1)
Male	9291 (56.4%)
Burn size TBSA	
<10%	14,051 (85.3%)
10–19%	2429 (14.7%)
Type of injury	
Scald & contact	12,579 (76.3%)
Electric	103 (0.6%)
Flame	1216 (7.4%)
Unknown	2582 (15.7%)
Non-accidental injury	109 (0.7%)
Deepest depth	
1st degree	2747 (16.7%)
2nd degree	12,732 (77.3%)
3rd degree	1001 (6.1%)
Burn location	
Multiple location	4787 (29.0%)
Head & neck	1431 (8.7%)
Trunk	2490 (15.1%)
Upper extremity	2177 (13.2%)
Hand	2906 (17.6%)
Lower extremity	2666 (16.2%)
Missing	23 (0.1%)
Race	
White	4994 (30.3%)
Black	1284 (7.8%)
Hispanic	7514 (45.6%)
Asian	1045 (6.3%)
Other	987 (6.0%)
Missing	656 (4.0%)
Payer	
Commercial/private	6694 (40.6%)
Public/Medi-Cal	8076 (49.0%)
Self	1405 (8.5%)
Other	305 (1.9%)
Distance home to hospital (miles)	
≤15	13,025 (79.0%)
16–30	1458 (8.9%)
31–75	1193 (7.2%)
76–150	346 (2.1%)
>150	165 (1.0%)
Burn center[a]	

TBSA, total body surface area.
[a] Includes both accredited and non-accredited burn centers.

(Fig. 2). Additionally, the adjusted probability of home discharge was geographically mapped using patient zip codes (Fig. 3).

4. Discussion

Our analysis documents the first evidence for a trend toward the ambulatory treatment of pediatric burns in California, mirroring findings from the international community [12]. This trend was significant after consideration of multiple factors including patient demographic, facility and burn characteristics. Not surprisingly, many variables predicted the outpatient treatment of minor burns in the pediatric population such as smaller %TBSA, more superficial depth, and patient residence near the incident ED. Notably, non-accidental injury and neglect was a strong predictor of admission, which is reassuring, given that nearly 1.7–10% of burns in children result from neglect [13].

Historically, one of main reasons for inpatient admission was administration of intravenous pain medication with frequent dressing changes. Topical antimicrobial burn ointments including bacitracin and silver sulfadiazine have to be changed at least daily, which subjects patients to significant pain. Today, multiple other silver laden dressings are available which provide equally effective treatment—yet recommended dressing changes are in intervals of 2–4 day (e.g. Mepilex Ag, Molnlycke, Gothenburg, Sweden; Acticoat, Smith & Nephew, London, United Kingdom; Aquacell Ag, ConvaTec, Deeside, United Kingdom) [4,9]. Mepilex Ag came to market in 2007 [14]. Like any new technology, it takes time for adoption and dissemination [15]. These dates overlap with our study period, and thus the progressive trend toward ambulatory treatment of pediatric minor burns coincides with the availability of these products.

An unanticipated finding in our study was the association between inpatient admission and race/ethnicity. Compared to White, Black and non-white Hispanic children had increased odds of inpatient admission. This was significant even after adjusting for payer. While there is no clear explanation, we hypothesize that emergency care and triaging burn providers might profile patient families, and feel less comfortable discharging certain ethnicities home if there no clear plan for follow up. Prior studies evaluating race (i.e. implicit bias) have likewise shown disparities and profiling [16–18]. Further research including qualitative analyses of ED admission patterns could help qualify this finding. Burn providers should be aware of this potential bias in order to provide all children with high quality burn care.

Current literature specifically looking at population level factors for pediatric burn disposition comes from a one year review the Nationwide Emergency Department Sample from 2012 (NEDS) [19]. This showed an overwhelming majority of pediatric burns occur in toddlers with burns <10% TBSA treated in the ED and discharged. Our study results parallel some of the study's findings; we also found that the majority of injuries were scald and contact, occurring in the toddler population. While Johnson et al. focused on transfer to burn centers, we focused on the most common disposition—home discharge. Our findings give additional insight into the associations of race in disposition, along with current temporal trends in light of changing healthcare environment.

Geographic mapping of trends in ambulatory care of burns revealed a subtle finding. The greatest concentration of inpatient treatment of burns was clustered in California's Central Valley. This area has documented challenges with poverty and healthcare resources [20,21]; thus, it is plausible that an area with less robust healthcare services might lean on admission given unpredictable follow up [22]. Additionally, there is no verified burn center in this region for the study interval, which might limit the ability to safely care for pediatric burns in the outpatient setting.

Table 2 – Multivariable model assessing predictors of home disposition in pediatric minor burn ED visits.

Characteristic	Home disposition (n=10,213)	Admit or transfer with admission (n=6267)	Odds ratio	95% confidence interval	p-Value
Age (years)					
<1	1060 (10.4%)	833 (13.3%)	Ref		
1–3	4927 (48.2%)	3528 (56.3%)	1.20	1.06–1.37	0.005
4–5	848 (8.3%)	471 (7.5%)	1.46	1.22–1.75	<0.001
6–9	1239 (12.1%)	579 (9.2%)	1.71	1.45–2.03	<0.001
10–13	880 (8.6%)	365 (5.8%)	1.94	1.60–2.36	<0.001
14–17	1259 (12.3%)	491 (7.8%)	2.36	1.96–2.83	<0.001
Male	5619 (55.0%)	3672 (58.6%)	0.82	0.54–1.23	0.332
Burn size TBSA					
<10%	9647 (94.5%)	4415 (70.5%)	6.86	6.08–7.72	<0.001
10–19%	566 (5.5%)	1863 (29.7%)	Ref		
Type of injury					
Flame	635 (6.2%)	581 (9.3%)	Ref		
Scald & contact	7989 (78.2%)	4590 (73.2%)	1.90	1.62–2.23	<0.001
Electric	68 (0.7%)	35 (0.6%)	0.87	0.52–1.46	0.602
Missing	1521 (14.9%)	1061 (16.9%)	0.84	0.51–1.17	0.606
Non-accidental injury	43 (0.4%)	66 (1.2%)	0.28	0.17–0.45	<0.001
Deepest depth					
1st degree	3164 (31.0%)	726 (11.6%)	5.03	4.34–5.83	<0.001
2nd degree	7469 (73.1%)	5263 (84.0%)	2.24	1.93–2.60	<0.001
3rd degree	122 (1.2%)	879 (14.0%)	Ref		
Burn location					
Trunk	1644 (16.1%)	846 (13.5%)	Ref		
Head & neck	1002 (9.8%)	429 (6.9%)	0.81	0.72–0.91	0.001
Upper extremity	1538 (15.1%)	639 (10.2%)	0.99	0.89–1.11	0.895
Hand	2286 (22.4%)	620 (9.9%)	1.23	1.10–1.37	<0.001
Lower extremity	1803 (17.7%)	863 (13.8%)	0.90	0.81–1.01	0.077
Multiple-site	1921 (18.8%)	2866 (45.7%)	0.37	0.33–0.41	<0.001
Missing	19 (0.2%)	4 (0.1%)	2.15	0.62–7.46	0.226
Race					
White	3391 (33.2%)	1603 (25.6%)	Ref		
Black	780 (7.6%)	504 (8.0%)	0.72	0.61–0.85	<0.001
Hispanic	4413 (43.2%)	3101 (49.5%)	0.71	0.64–0.78	<0.001
Asian	594 (5.8%)	451 (7.25)	1.11	0.91–1.25	0.456
Other	645 (6.3%)	342 (5.5%)	0.95	0.79–1.14	0.568
Missing	390 (3.8%)	266 (4.2%)	1.59	1.29–1.95	0.028
Payer					
Private	4301 (42.1%)	2393 (38.2%)	Ref		
Public/Medi-Cal	4758 (46.6%)	3318 (52.9%)	0.98	0.90–1.07	0.655
Self	1057 (10.4%)	348 (5.6%)	1.58	1.35–1.85	<0.001
Other	97 (1.0%)	208 (3.3%)	0.19	0.14–0.25	<0.001
Distance home to hospital (miles)					
≤15	8726 (85.4%)	4299 (68.6%)	Ref		
16–30	658 (6.4%)	800 (12.8%)	0.75	0.66–0.87	<0.001
31–75	408 (4.0%)	785 (12.5%)	0.59	0.51–0.69	<0.001
76–150	162 (1.6%)	184 (2.9%)	0.57	0.44–0.75	<0.001
>150	91 (1.0%)	74 (1.2%)	0.84	0.71–0.97	0.044
Burn center[a]	1418 (13.9%)	3563 (56.9%)	0.14	0.12–0.15	<0.001

Logistic model, c-statistic 0.889.
Ref, reference.
TBSA, total body surface area.
[a] Includes both verified and non-verified burn centers.

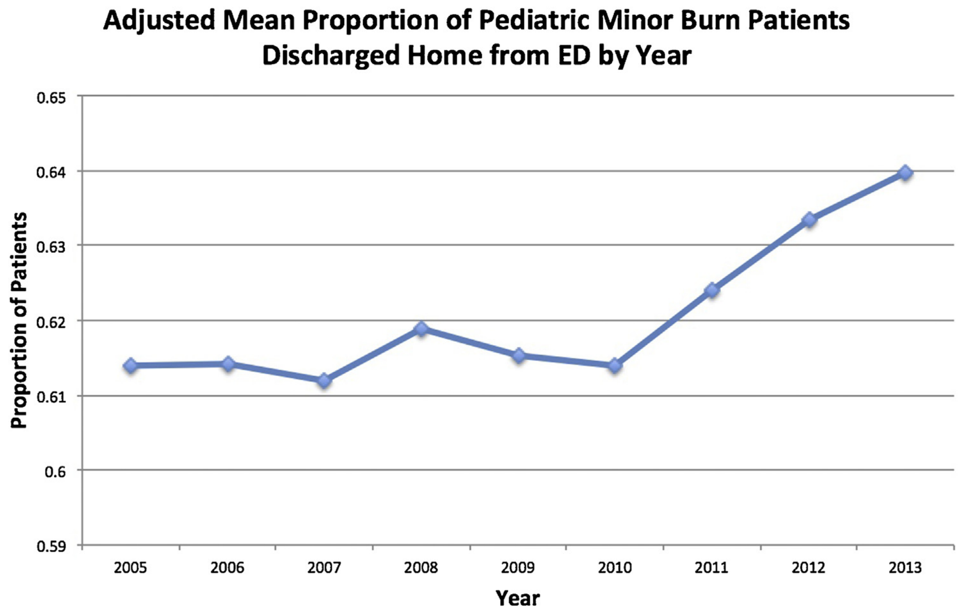

Fig. 2 – Temporal trends in ED discharge of pediatric minor burns. Percentage of home discharge is adjusted for demographics, burn severity, and hospital level factors.

Though the total trend was significant toward ambulatory treatment of pediatric burns, there was a notable inflection in the 2010-2011 interval. The exact reason for this pattern is unclear; however, consideration of the enactment of the Affordable Care Act (ACA) and its implementation during this period could offer an explanation. The ACA increased insurance coverage and established Accountable Care Organizations (ACO) that bear financial risk for their patients

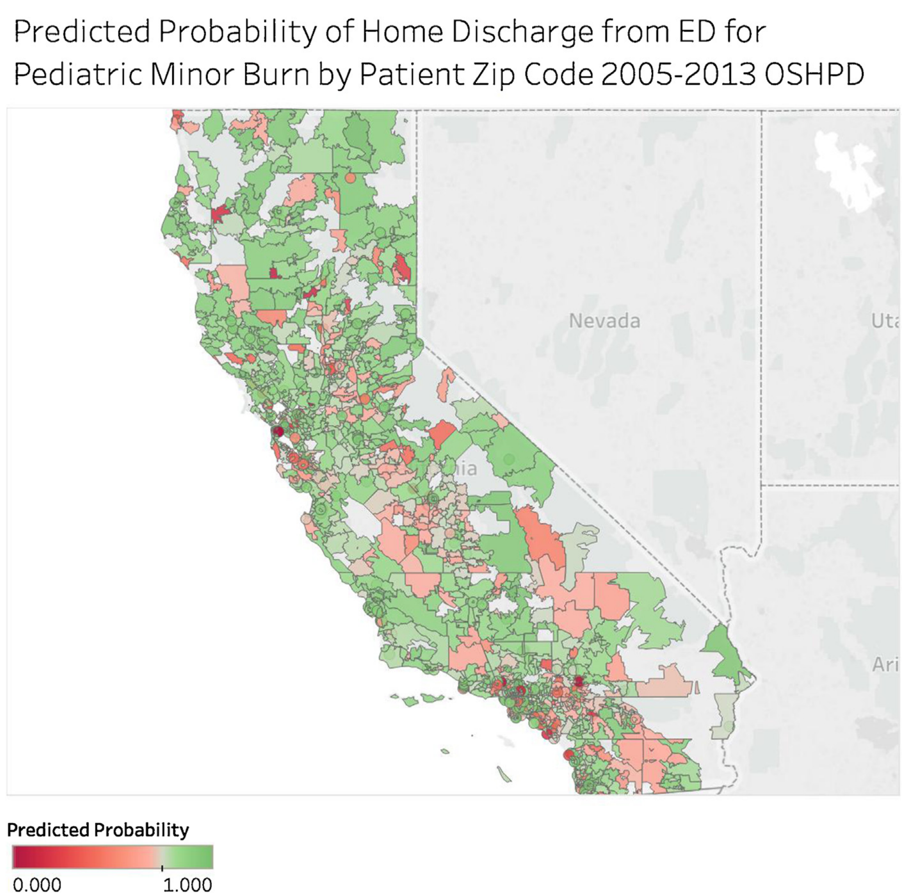

Fig. 3 – Geographic mapping of predicted home discharge by patient zip code across the state of CA. Only zip codes with at least five encounters are plotted.

[23,24]. In these arrangements, incentivized payer-provider delivery systems have been shown to reduce inpatient spending [25] through greater focus on outpatient care. Financial downside risk could motivate health systems to treat their patients in an ambulatory setting. This might affect patients with burns, as inpatient treatment is exceedingly expensive [26]. The authors find no reason to question the safety of ambulatory treatment in pediatric minor burns. Though the ABA does not currently take a stance on who should be treated as outpatient, it may consider promoting outpatient treatment when safe and feasible. Further, US burn center verification requires minimum volumes of admissions, which could perversely incentivize admitting children who could otherwise be safely treated at home. Verification methodology should be revisited in the light of the growing trend toward ambulatory treatment. Regardless of the reason for the trend toward outpatient treatment, additional studies are needed to assess whether these patients are succeeding as outpatients, and whether or not ED revisits and/or readmission rates have changed.

4.1. Limitations

This analysis was limited to a single state and may not represent national trends, although California is the most populous state in the US with 1/8 of the US child population. California might also be an anomaly in that, it is also one of the key states that accepted Medicaid expansion and formation of ACA insurance exchanges [27]. There were many states that did not implement the Affordable Care Act, and it could be worthwhile to evaluate whether the trend in ambulatory treatment of pediatric burns differs between states.

We also acknowledge that partial or full thickness burns in excess of 15% TBSA likely benefit from resuscitation and inpatient treatment [19], and by no means do we advocate for outpatient treatment of this population. ICD-9 codes artificially separate TBSA in intervals of ten; thus, in order to capture those burns between 10–14%—which could foreseeably be treated as outpatients—we necessarily involved the entire 10–19% TBSA grouping. Further, OSHPD only includes encounters from emergency departments and admissions, so we cannot analyze or comment on what occurs in the outpatient clinic setting.

Limitations also include those inherent to using large databases. The accuracy of data is dependent on proper coding and reporting to the state of California. Many of these encounters were likely coded by ED providers who have shown difficulty in accurately diagnosing burn depth and size [28]. Yet, there is no reason to believe there was variation in the quality of ED provider diagnosis of burns year to year. There were also encounters with missing data related to our investigation, which is common in large databases [29]. We excluded those encounters with missing elements that directly involved our investigation such as %TBSA and depth. Even though this led to a significant reduction in the total number of encounters for the study, the alternative of including these data would have required imprecise data management strategies such as multiple imputations. In all likelihood, those encounters with missing data for burn depth and size were superficial and small injuries. Certainly, any burn benefiting from admission will be documented in terms of size and depth. There was no skew in the distribution for missing data between years, so our results should not be affected. Regarding the absolute values we reported for percentage of patients discharged home, this value should be taken in the context of only those encounters where %TBSA and depth were know. The percentage of children who discharge home from the ED with sunburns that never get documented in terms of depth or size is much greater. For other missing data, we included a missing data value (i.e. missing indicator) for all variables and included this in the regression analyses.

For the geographic mapping, we acknowledge that the patient volume for any given zip code fluctuates. Every zip code had at least five patient encounters over the study period. Blank zip codes had less than this threshold and are demonstrated in gray coloring.

5. Conclusion

Independent predictors of outpatient treatment included older patients, more superficial burns, smaller total body surface area percentage, scald/contact mechanism, and hand burns. Non-accidental injury and greater travel distance to ED predicted inpatient treatment. Non-Hispanic white and Asian patients were treated as outpatients more frequently than Hispanic and Black patients. There was significant growth in the trend toward ambulatory treatment of minor burns in the pediatric population, with a notable infection after 2010. This emerging paradigm of burn care could become the standard of care for children with burns who not benefit from intravenous fluid resuscitation and monitoring. Further research is needed to assess whether outpatient treatment of pediatric minor burns results in higher readmission rates.

Conflicts of interest

No authors have any financial disclosures or conflicts of interest regarding the contents of this manuscript.

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