Published in final edited form as:

J Burn Care Res. 2008 ; 29(4): 632–637. doi:10.1097/BCR.0b013e31817db951.

Hospital Costs Associated With Pediatric Burn Injury

Matthew B. Klein, MD^{*,†}, William Hollingworth, PhD[‡], Frederick P. Rivara, MD, MPH[§], C. Bradley Kramer, MPA^{*}, Shelley W. Askay, PhD^{||}, David M. Heimbach, MD^{*}, and Nicole S. Gibran, MD^{*}

^{*} Burn Center, University of Washington, Seattle, Washington

[†] Division of Plastic Surgery, University of Washington, Seattle, Washington

[‡] Department of Radiology, University of Washington, Seattle, Washington

[§] Department of Pediatrics, University of Washington, Seattle, Washington

^{||} Rehabilitation Medicine, Harborview Medical Center, University of Washington, Seattle, Washington

Abstract

Modern burn care is a resource intensive endeavor requiring specialized equipment, personnel, and facilities in order to provide optimum care. The costs associated with burn injury to both patients and society as a whole can be multifaceted and large. The purpose of this study was to evaluate the association between hospital costs, patient characteristics, and injury factors in a cohort of pediatric patients admitted to a regional burn center. We performed a review of the hospital charges accrued by pediatric patients (age <16 years) admitted to our burn center from 1994 to 2004 and explored the relationship between baseline patient, injury and hospital course characteristics and total costs. Hospital charges were converted to 2005 dollar costs using an inflation index and a cost to charge ratio. Univariate and multivariate regressions were performed to identify the factors most significantly associated with cost. In addition, we performed a subset cost analysis for patients with burns more than 20% TBSA. A total of 1443 pediatric patients (age <16) were admitted to our burn center during the study period. The overall mean hospital cost in 2005 dollars was \$9026 (SD = \$25,483; median = \$2138). Area of full thickness burn was the only patient or injury factor significantly associated with greater hospital costs ($P < .05$) on multivariate analysis. No single anatomic area was associated with increased hospital costs when adjusted for total overall burn size. Injury severity was the most significant factor impacting index hospitalization costs following pediatric burn injury. Further studies defining the long-term societal costs impact of burn injury are needed as are studies that evaluate the impact of burn injury on quality of life.

Modern burn care is a resource intensive endeavor requiring specialized equipment, multidisciplinary personnel, and facilities. The costs associated with burn injury to both patients and society can be multifaceted and large. Given that the sequelae of burn injury may require ongoing physical, occupational, and psychological therapy as well as repeated in-patient surgical procedures, the costs associated with burn care may persist for years after the initial injury.

These long-term care and cost considerations are perhaps even more significant in the pediatric population. Children who sustain severe burn injury can typically expect medical

and psychological care that extends years beyond their injury. In addition, pediatric injuries impact parents and/or other caregivers, as well as siblings in the family. During the, often lengthy, postinjury hospitalization, parents often miss prolonged periods of work in order to be at their children's bedside. Following discharge, arrangements for home care also need to be made which frequently result in more missed work days for parents.

Although the costs associated with other illnesses, such as chronic pulmonary disease, spinal cord injury, and diabetes have been well studied,^{1–5} little is known about the costs of either the index hospitalization or the long-term care costs associated with burn injury.

There are several potential benefits to quantifying the costs associated with burn injury. First, it allows for comparison of the impact on societal cost across different types of injuries. This could be very helpful from a policy perspective in that these data could inform decisions regarding prevention effort resource allocation.⁶ In addition, defining the life-long costs associated with burn injury can be helpful in life-care planning and medicolegal issues arising from the injury. Finally, it also provides an important baseline against which future improvements in care can be measured.

The purpose of this study was to provide an analysis of the initial hospital costs associated with pediatric burn injury in a cohort of patients admitted to a regional burn center as the first step in quantifying the costs associated with pediatric burn injury.

METHODS

Study Overview

We performed a review of the hospital charges accrued by pediatric patients (age <16 years) admitted to our burn center from 1994 to 2004 and explored the relationship between baseline patient and injury characteristics (ie, information available at time of admission) and total costs. Approval for the conduct of this study was obtained from our institution's Human Subjects Committee.

Data Sources

All data were obtained from the burn center registry, which contains basic baseline demographic and injury characteristics for all patients admitted to the burn center, including payer status and hospital charges.

Data Analysis

The following baseline variables were collected for each patient: age, geographic location, burn cause, payer status, total body surface area (TBSA) burned, TBSA grafted (used to represent percent full thickness burn), presence of inhalation injury, total hospital length of stay, anatomic burn location, and discharge disposition. Inhalation injury was determined by the attending surgeon based on history, physical examination, and/or bronchoscopy. Payer status was classified as commercial (private, Health Maintenance Organization), or noncommercial (Medicaid, uninsured, and other).

To evaluate the potential impact of geographic location of a patient's home on hospital costs, rural urban commuting codes (RUCA) codes were used to designate urban vs rural living situation. Briefly, cities and zip codes are categorized from 1 to 10 based on population size and commuting relationships.⁷ These codes were then converted to a scale of 1 to 4 (from most urban to most rural) based on a classification system developed by the Washington State Department of Health.⁸

Since only total hospital charges were included in our databases, total hospital charges were converted to costs using a hospital-specific CCR of 0.35.⁹ To adjust for the potential effect of inflation on hospital charges, all charges were converted to 2005 dollars before the charge to cost conversion using the Consumer Price Index-U (<http://oregonstate.edu/cla/polisci/faculty/sahr/sahr.htm>).

Univariate analyses were performed to determine the association between the baseline patient and injury characteristics and total hospital costs. Injury year was also evaluated by univariate analysis to determine if there was a significant association between year of treatment and costs following adjustment for inflation. All covariates found to have a *P* value of $<.10$ were included in a multivariate linear regression model to determine the baseline patient and injury variables associated with hospital costs. Because of the skewed distribution of costs, with a few high cost outliers, we re-ran the univariate and multivariate analysis using a log transformation of cost as the dependent variable. These secondary analyses confirmed the primary analysis on untransformed cost data, therefore we only present the untransformed cost results.

Finally, since the majority of patients admitted to the burn center have burns that are quite small and require relatively short periods of hospitalization and we are most interested in the costs associated with severe burn injury, we performed a subgroup analysis of patients with severe burns (TBSA $\geq 20\%$).

RESULTS

A total of 1443 pediatric patients (age <16) were admitted to our burn center during the study period. Charge data were available on 654 (45%) of these patients. Because of the large amount of missing data on charges, we compared the patient and injury characteristics of those patients that had charge data available with those that did not. Burn size, age, payer status, and inhalation injury status did not significantly differ between these two patient groups. The baseline patient and injury characteristics of these patients are summarized in Table 1. The average patient age was 5.4 years (SD = 5.1) and the majority of patients were male (69%). Scald burns were the most common cause. The average TBSA burned was 8.2% (SD = 9.3; range 1–75) and the average TBSA grafted was 2.1 (SD = 6.8; range 0–65). The average length of stay was 8.0 days (SD = 13.4) and average number of operations was 0.4 (SD = 1.1). Patient payer status and modified RUCA code are also shown in Table 1. The majority of patients had commercial insurance (48%) and lived in relatively urban areas.

The overall mean hospital cost in 2005 dollars was \$9026 (SD = \$25,483; median = \$2138). Univariate linear regression was performed to evaluate the association between a number of baseline patient and injury characteristics on total costs (Table 2). Higher TBSA burned, higher TBSA grafted, noncommercial insurer, and rural residence were all significantly associated with greater hospital costs ($P < .05$). The majority of patients (75%) did not undergo excision and grafting, but those that did had significantly higher total costs. Anatomic location of burn and year of injury were not significantly associated with total costs. Next all covariates with a *P* value of $<.10$ were entered into a multivariate linear regression model (Table 3). After adjustment for other covariates in the multivariate linear regression (Table 3), only TBSA grafted was found to significantly impact total hospital costs; for each additional percent point of TBSA grafted hospital costs increased by \$2639 (95% CI = 1833, 3445, $P < .001$).

In the subgroup of patients with more severe burn injuries (TBSA $\geq 20\%$) (Table 4), the mean burn size was 32.7% and the mean burn surface area grafted was 16.9%. In this group,

29% of patients had commercial payer status (as compared with over 50% in those with nonsevere burns). Average total hospital costs for this group was \$63,806 (SD = 62,858, median = 39,422). Total burn size, total burn size grafted, and rural living situation were all associated with increased hospital costs. As in the overall study population, patients undergoing excision and grafting procedures had significantly higher total hospital costs. Commercial status was not found to be significantly associated with increased costs (Table 5). On multivariate analysis only total burn size and total burn size grafted reached statistical significance.

DISCUSSION

The costs associated with burn injury—both with the initial hospitalization and following discharge—can be tremendous. Injury has been estimated to account for 15% of all medical costs during childhood (age 1–19).^{6,10} The resources required to provide optimum care are extensive and given the chronicity of burn injury, these requirements may persist for several years. Given the potential lifelong impact of burn injury, the costs associated with pediatric burn injury are particularly intriguing.

In this study, we sought to identify the baseline patient and injury characteristics associated with higher hospital costs during the index hospitalization. Not surprisingly, markers of injury severity were most strongly associated with higher costs. Total burn size and total full thickness burn (measured by the proxy of % TBSA grafted) were independently associated with higher hospital costs in a multivariate model. Typically, patients with more severe injuries require a greater number of operations and a longer hospitalization (including more time in the intensive care unit), which are two of the principal contributors to total hospital costs.

Other factors we explored as potential important contributors to hospital costs were payer status and rural vs urban location of home. Payer status can serve as a surrogate for socioeconomic status. The association between lower socioeconomic status and outcome following injury has been well described.^{11,12} Patients with lower socioeconomic status tend to have worse access to health care and worse overall health status, which would increase susceptibility to complications of injury such as infection that would increase hospital length of stay and increase costs. In addition, pediatric patients from poorer families may not have the resources to provide adequate care at home. Therefore, treating physicians may have a higher threshold to discharge poorer patients to their homes if complex daily wound care was still needed. Furthermore, patients from lower socioeconomic status may be less likely to have working smoke detectors, flame retardant sleepwear, or regulated water heater temperatures—factors which could increase the risk of burn injury and severity of burn injury.^{13,14} In this study, the subgroup of patients in the more severe injury group had a significantly higher proportion of patients with noncommercial payer status. In addition, when adjusted for total burn size, patients with noncommercial payer status had significantly longer lengths of stay (data not shown). However, on regression analysis payer status was not significantly associated with hospital costs.

Living in the most rural areas (RUCA 4) was also associated with a significant increase in hospital costs on univariate analysis, but this relationship was not significant on multivariate analysis. Our hypothesis in exploring the impact of rural versus urban location was that patients who lived in the most rural areas may have also been from lower socioeconomic strata and have fewer local resources to assist with home care. Furthermore, patients from more rural areas may have worse access to local physicians and to the burn center in Seattle, which could make regular follow-up difficult. Therefore, there would be a tendency to keep these patients in the hospital longer so that on discharge there would be very few anticipated

needs that would require more frequent follow-up. In addition, it is also possible that firefighter response times in rural areas may be longer, which could impact the duration of exposure to the fire therefore increasing the extent and depth of injury as well as the risk of inhalation injury. However, our findings suggest that living circumstances were not as significant an independent predictor of hospital costs as injury severity.

Although the majority of pediatric patients admitted to the burn center have burns that are small (<20% TBSA), we expect patients with more severe injuries will have greater injury-related costs. Thus, we performed a subgroup analysis on patients with burns $\geq 20\%$ TBSA. In this subgroup, the total burn size and total burn size grafted remained the injury variables that most significantly impacted cost. In addition, patients who lived in the most rural areas tended to have higher costs in this subgroup. However, payer status was not significantly associated with higher hospital costs in this subgroup. The influence of burn size and severity as well as rural living situation was likely attributable to the factors discussed above. We also explored the impact of anatomic location of burn injury on hospital cost. However, we did not find burns to any specific anatomic location of any depth (including full thickness burns requiring grafting) to be independently associated with increased hospital costs.

The principal limitation of this study is that charge data were not available on all pediatric patients admitted to the burn center during the study period. This is likely due to the fact that charge data are not easily obtainable by our data entry staff at time of discharge and requires follow-up with the hospital billing department weeks to months after discharge. However, we did examine the patient and injury characteristics of the pediatric burn patients on whom we did not have charge data and found that they did not differ significantly from the group that was subject to analysis. In addition, there is a limitation to using charge data even after conversion to cost using the CCR. Charges tend to grossly overestimate costs and while the CCR deflates the charge to an amount more representative to actual hospital costs. The CCR is a hospital wide measure and might not be reflective of the actual ratio in the emergency department, intensive care unit, and operating rooms where these patients were treated.¹⁵

This study provides an initial step in defining the costs associated with pediatric burn injury. There are few studies examining the costs related to pediatric burn injury. Corpron recently performed an analysis of costs related to acute care at the pediatric burn center in Columbus, Ohio and found that the burn center was profitable for the hospital.¹⁶ However, estimating the lifetime costs associated with burn injury clearly extends far beyond costs associated with the initial hospitalization. Costs can be broadly divided into direct costs—those medical and nonmedical (eg, travel costs) due to the injury, and indirect productivity costs—those that take into account losses in work and leisure time of both the child and the parents who may need to miss work in order to care for their child.⁶ If one were to evaluate the problem from a societal perspective the costs associated with parents missing work to visit their children in the hospital and also to help their children at home following discharge would need to be considered. If the child were permanently disabled as a result of their injury this would result in lost productivity during adult life and increased governmental costs for disability income.

Finally, if one were to comprehensively analyze the costs of burn injury to children then the impact of injury on quality of life years must also be considered. Quality of life is a critical consideration in evaluating the long-term impact of burn injury. Although there is a lack of quality of life survey tools that have been validated for burn injury, studies that have evaluated distress, functional independence, satisfaction with life, and satisfaction with appearance all demonstrate a potential tremendous and persistent impact of burn injury.¹⁷

In conclusion, this study demonstrated that injury severity (TBSA and TBSA grafted) was the single most significant factor impacting index hospitalization costs following pediatric burn injury. Further studies defining the longitudinal societal cost impact of burn injury are needed as are studies that evaluate the impact of burn injury on quality of life.

Acknowledgments

This work was supported by funds from the National Institute on Disability and Rehabilitation Research in the Office of Special Education and Rehabilitative Services in the U.S. Department of Education and the National Institutes of Health/National Center for Research Resources 8K12RR023265-02.

References

1. Akobundu E, Ju J, Blatt L, Mullins C. Cost-of-illness Studies: a review of current methods. *Pharmacoeconomics* 2006;24:869–90. [PubMed: 16942122]
2. Vijgen S, Hoogendoorn M, Baan C, et al. Cost effectiveness of preventitive interventions in type 2 diabetes mellitus: a systemic literature review. *Pharmacoeconomics* 2006;24:425–41. [PubMed: 16706569]
3. D'Souza A, Smith M, Miller L, Kavookjian J. An appraisal of pharmacoeconomic evidence of maintenance therapy for COPD. *Chest* 2006;129:1693–708. [PubMed: 16778291]
4. Halpin D. Health economics of chronic obstructive pulmonary disease. *Proc Am Thorac Soc* 2006;3:227–33. [PubMed: 16636090]
5. Priebe M, Chiodo A, Scelza W, Krirshblum S, Wuermser L, Ho C. Spinal cord injury medicine. 6. Economic and societal issues in spinal cord injury. *Arch Phys Med Rehabil* 2007;88:S84–S88. [PubMed: 17321854]
6. Miller TR, Romano EO, Spicer RS. The cost of childhood unintentional injuries and the value of prevention. *The future of children* 2000;10:137–63. [PubMed: 10911691]
7. Hart LG, Larson E, Lishner DM. Rural definitions for health policy and research. *Am J Public Health* 2005;95:1149–55. [PubMed: 15983270]
8. Bird JL, Tyler JA. Tumour necrosis factor alpha, interferon gamma and dexamethasone regulate IGF-I-maintained collagen production in cultured human fibroblasts. *J Endocrinol* 1995;147:167–76. [PubMed: 7490531]
9. Blackmore C, Zelman W, Glick N. Resource cost analysis of cervical spine trauma radiography. *Radiology* 2001;220:581–7. [PubMed: 11526251]
10. Finkelstein, E. The incidence and economic burden of injuries in the United States. New York: Oxord University Press; 2000.
11. Haas JLG. Acutely injured patients with trauma in Massachusetts: differences in care and mortality, by insurance status. *Am J Public Health* 1994;84:1605–8. [PubMed: 7943478]
12. Rhee P, Grossman D, Rivara F, et al. The effect of payer status on utilization of hospital resources in trauma care. *Arch Surg* 1997;132:399–404. [PubMed: 9108761]
13. Roberts I. Smoke alarm use: prevalence and household predictors. *Inj Prev* 1996;2:263–5. [PubMed: 9346105]
14. DiGuseppi C, Roberts I. Individual-level injury prevention strategies in the clinical setting. *The future of children* 2000;10:53–82. [PubMed: 10911688]
15. Gold, M.; Siegel, J.; Russel, L.; Weinstein, M. Cost-effectiveness in health and medicine. New York: Oxford University Press; 1996.
16. Corpron CA, Martin AE, Roberts G, Besner GE. The pediatric burn unit: a profit center. *J Pediatr Surg* 2004;39:961–3. [PubMed: 15185234]
17. Sheridan RL, Hinson MI, Liang MH, et al. Long-term outcome of children surviving massive burns. *JAMA* 2000;283:69–73. [PubMed: 10632282]

Table 1

Baseline patient and injury characteristics

Baseline/Injury/Hospital Course Variable	Mean (SD) or %
Total patients	654
Age (years)	5.4 (5.1)
Gender (% male)	69.1
Etiology	
Scald	44.0%
Fire/flame	27.8%
Contact	13.6%
Flash	6.9%
Grease	5.1%
Electrical	1.4%
Other	1.2%
Payer status	
Commercial	48.1%
HMO	13.6%
Medicaid	27.6%
Uninsured	5.1%
Other/unknown	5.6%
Rural-urban code *	
1	71%
2	11%
3	6.4%
4	11%
Mean % TBSA (total)	8.2 (9.3)
Mean % TBSA (grafted)	2.1 (6.8)
Inhalation injury	1.2%
Total costs	\$9026 (\$25,483)
LOS (days) [†]	8.0 (13.4)
Number of operations	0.4 (1.1)
Inpatient mortality	1.0%

* 1–4 = Increasing rural situation.

[†] Survivors only.

Table 2

Univariate regression analysis of factors associated with hospital cost

Variable	Coefficient	95% CI	P
Age, years	128.5	−2867, 3124	.09
Sex	−123.4	−4386, 4140	.96
Noncommercial payer status	4774	846.4, 8703	.02
RUCA code			
1	Reference		
2	−1986	−8048, 4076	.52
3	−694.9	−8560, 7170	.86
4	6464	286.6, 12642	.04
TBSA total	2098	1962, 2335	<.001
Anatomic location			
Head and neck	1268	−2634, 5170	.64
Arm	−122.5	−4026, 3781	.95
Hand	−128.9	−4097, 3840	.95
Leg	−373.4	−4073, 3327	.52
TBSA grafted	2923	2773, 3074	<.001
Inhalation injury	4906	−1836, 11678	.15
Year of injury	266.7	−1159, 1692	.71

Table 3

Multivariate regression analysis

Variable	Coefficient	95% CI	P
Age	26.4	−975, 1028	.96
Noncommercial payer status	−4074	−14,879, 6731	.44
RUCA code			
1	Reference		
2	−1439	−27,998, 25,120	.91
3	13,006	−6042, 32,055	.17
4	−4261	−4261, 6004	.49
TBSA total	232.5	−421, 886	.46
TBSA grafted	2639	1833, 3445	<.001

Table 4

Severely injured subgroup

Baseline/Injury/Hospital Course Variable	Mean (SD) or %
Total patients	54
Commercial insurance	29.6%
RUCA group	
1	70.4%
2	9.1%
3	11.4%
4	9.1%
Mean % TBSA (total)	32.7 (12.5)
Mean % TBSA (grafted)	16.9 (16.6)
Inhalation injury	3.7%
LOS (days)*	42.0 (28.5)
Number of operations	2.3 (2.6)
Total costs	\$63,806 (62,850)

* Survivors only.

Table 5

Univariate regression analysis of severely injured subgroup

Variable	Coefficient	95% CI	P
Age	-1679	-121,469, 87,992	.65
Sex	18,029	-20,334, 56,391	.35
Noncommercial payer status	4659	-33,269, 42,587	.81
RUCA Code			
1	Reference		
2	-10,935	-73,858, 51,987	.73
3	-54,468	-111,546, 2610	.06
4	75538	12,615, 138,460	.02
TBSA total	3617	2643, 4590	<.001
Anatomic location			
Head and neck	-15,078	-42,124, 11,967	.27
Arm	-23,538	-56,485, 9409	.16
Hand	-25,281	-53,432, 2870	.08
Leg	-24,343	-54,632, 5945	.11
TBSA grafted	2699	2015, 3383	<.001
Inhalation injury	-512	-18,424, 17,400	.95