

# Epidemiological Predictors of Financial Toxicity in Surgical Burn Injuries

## A Multicenter, Longitudinal, Cohort Study

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**Background:** Burns constitute a major global health challenge, causing over 11 million injuries and 300,000 deaths annually and surpassing the economic burden of cervical cancer and HIV combined. Despite this, patient-level financial consequences of burn injuries remain poorly quantified, with a significant gap in data from low- and middle-income countries. In this study, we evaluate financial toxicity in burn patients.

**Methods:** A prospective, multicenter cohort study was conducted across two tertiary care hospitals in India, assessing 123 adult surgical in-patients undergoing operative interventions for burn injuries. Patient sociodemographic, clinical, and financial data were collected through surveys and electronic records during hospitalization and at 1, 3, and 6 months postoperatively. Out-of-pocket costs (OOPCs) for surgical burn treatment were evaluated during hospitalization. Longitudinal changes in income, employment status, and affordability of basic subsistence needs were assessed at the 1-, 3-, and 6-month postoperative time point. Degree of financial toxicity was calculated using a combination of the metrics catastrophic health expenditure and financial hardship. Development of financial toxicity was compared by sociodemographic and clinical characteristics using logistic regression models.

**Results:** Of the cohort, 60% experienced financial toxicity. Median OOPCs were US\$555.32 with the majority of OOPCs stemming from direct nonmedical costs (US\$318.45). Cost of initial hospitalization exceeded monthly annual income by 80%. Following surgical burn care, income decreased by US\$318.18 within 6 months, accompanied by a 53% increase in unemployment rates. At least 40% of the cohort consistently reported inability to afford basic subsistence needs within the 6-month perioperative period. Significant predictors of developing financial toxicity included male gender (odds ratio, 4.17; 95% confidence interval, 1.25–14.29;  $P = 0.02$ ) and hospital stays exceeding 20 days (odds ratio, 11.17; 95% confidence interval, 2.11–59.22;  $P \leq 0.01$ ).

**Conclusions:** Surgical treatment for burn injuries is associated with substantial financial toxicity. National and local policies must expand their scope beyond direct medical costs to address direct nonmedical and indirect costs. These include burn care insurance, teleconsultation follow-ups, hospital-affiliated subsidized

lodging, and resources for occupational support and rehabilitation. These measures are crucial to alleviate the financial burden of burn care, particularly during the perioperative period.

**Key Words:** burn, injury, TBSA, health insurance, financial toxicity, LMICs, cost of care, surgery, rehabilitation

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Burns pose a major global health concern, with approximately 11 million injuries and over 300,000 deaths annually.<sup>1</sup> The economic impact of burn injuries surpasses the burden of both cervical cancer and HIV combined.<sup>1</sup> At a macroeconomic level, burn injuries lead to over 7.5 million disability-adjusted life years, costing an estimated 12 billion USD on burn care in low- and middle-income countries (LMICs) every year.<sup>2</sup> Notably, almost 95% of burn-related deaths occur in Southeast Asia, with 7 million burn injuries being reported on a yearly basis in India alone.<sup>3,4</sup>

Current understanding of the cost and economic impact of burn injuries is based heavily on modeling studies and does not account for individual patient-level data and health system level factors.<sup>5</sup> Burn patients are particularly high risk for financial challenges given the need for prolonged hospitalization, intensive care unit (ICU) admissions, and prolonged nature of disability and need for rehabilitation.<sup>6</sup> This, in turn, may impact a patient's ability to maintain employment and health-related quality of life after hospitalization.<sup>7</sup> Therefore, burn patients are predisposed to financial toxicity, defined as the negative consequences of the monetary burden of receiving health care on patients' overall health and financial stability. Despite the detrimental economic impact of burn injuries, patient-level financial consequences have been poorly quantified.<sup>8</sup> Furthermore, although low resource settings face a disproportionate burden of burn injuries, data on the true cost of burn care and postinjury outcomes are limited from LMICs.

The aim of this study is to granularly assess financial toxicity among patients undergoing surgical treatment for burn injuries. We quantify out-of-pocket costs (OOPCs), evaluate financial toxicity metrics, track longitudinal trends, and identify risk factors contributing to increased financial toxicity due to burn injuries. The study findings are designed to provide insights for healthcare providers and policymakers, offering a clearer understanding of the economic impact of burns at the patient level. This may guide targeted interventions and enhance care provision for this patient population.

## METHODS

### Study Design and Participants

A prospective, multicenter, longitudinal cohort study was conducted to evaluate financial toxicity in patients undergoing surgery after burn injuries across 2 tertiary care hospitals in India. The different hospitals were selected to account for regional differences and variations in

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payment models. This study was approved by the institutional review board and ethics committees of Harvard Medical School, All India Institute for Medical Science, and Saveetha Medical College Hospital. Informed consent was obtained from all patients.

Inpatients over 18 years of age undergoing operative interventions for burn injuries between October 2021 and March 2023 were included in the study. Patients were surveyed by trained personnel at each institute upon admission to reflect socioeconomic status and demographic factors prior to burn injury. Clinical and financial data were collected through a combination of surveys and electronic medical records at discharge. Clinical data collected included length of hospital stay, ICU admission, and total body surface area (TBSA) burned. Financial data collected included direct medical costs (eg, hospitalizations, pharmaceutical bills, laboratory, radiology related expenses), direct non-medical costs (eg, cost of transportation, food, lodging), individual income, household income, and patient-reported outcomes such as need to borrow money, sell land or possessions, take children out of school, job loss, or receipt of donations to afford care due to financial hardship.

The patients were surveyed at 1, 3, and 6 months postoperatively to identify changes in employment status, income, and ability to afford rent, mortgage, monthly bills, minimum credit card payments, and basic household items (eg, food, clothes). The survey instrument is attached in full as Appendix A, <http://links.lww.com/SAP/A936>. All the data was compiled on REDCap (Research Electronic Data Capture).

### Measurement of Financial Toxicity

Financial toxicity was evaluated comprehensively using 2 standardized economic metrics: catastrophic health expenditure and financial hardship. Patients reporting the presence of either metric were identified as experiencing financial toxicity.

Catastrophic health expenditure is an objective measure of financial toxicity defined as present when the combined total of healthcare utilization costs (including both direct medical and direct nonmedical costs) surpasses 10% of annual income.<sup>9</sup> This methodology was applied to calculate catastrophic health expenditure within our cohort.

Financial hardship is an example of a patient-reported outcome of financial toxicity and was assessed by examining whether patients needed to borrow money, sell assets, remove a child from school, rely on donations, or lost their job due to the healthcare encounter. In our cohort, the classification of financial hardship was determined if the response of one or more of the above criteria were affirmative.

This dual-metric approach was utilized as it provides a robust and nuanced understanding of the multifaceted dimensions of financial toxicity experienced by the patients in our study.

### Statistical Analysis

Sociodemographic, income, and clinical characteristics are presented as absolute numbers with concomitant percentages, stratified by presence of financial toxicity. An independent *t* test was used to assess differences in income by gender. Medians and the total cost to individual income ratio were calculated to compare the cost of care and income data.

Descriptive statistics were utilized to demonstrate longitudinal outcomes. Prevalence of unemployment was assessed at the time of admission and at 1, 3, and 6 months postoperatively. Median household income was also evaluated at these 4 time points. Percentages were provided to demonstrate prevalence of postoperative difficulty in ability to pay rent, mortgage, monthly bills, minimum credit card payments, and basic household items (eg, food, clothes). We categorized postoperative difficulty in ability to pay for basic needs as affirmative if any of the mentioned domains were answered in the affirmative.

We determined 6 baseline sociodemographic and clinical covariates that may be associated with financial toxicity, based on a priori background knowledge. These included age, gender, insurance status, length

of hospital stay, ICU admission, and TBSA burnt. We used a logistic regression model to evaluate the associations between the 6 covariates and financial toxicity. We first performed univariate analysis, followed by a multivariate adjustment, retaining all six covariates in the model.

All data were analyzed using R (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

A total of 126 patient were recruited upon admission. Of these, three patients passed away during the course of the study. Therefore, the analytic cohort included 123 patients; 107 (87%), 87 (71%), and 72 (59%) patients were retained for follow up at 1, 3, and 6 months after hospitalization.

Demographic and clinical characteristics of the patients at the time of hospitalization can be seen in Table 1, Appendix B. Most patients were men (71%, *n* = 87) and between 21–40 years of age (61%, *n* = 75). Prior to obtaining a burn injury, most patients were full or part-time employees (58%, *n* = 71). Baseline unemployment rate was 28% (*n* = 34). Just above half of the patients were in the lowest income tertile US\$0–318 (54%, *n* = 66). Governmental welfare was obtained by 36% (*n* = 44) of the cohort and only 21% of patients were insured (*n* = 25). Most patients had a length of hospitalization of more than 20 days (44%, *n* = 54) and 63% (*n* = 77) required ICU admission. Total body surface area injured as a result of burn injuries was commonly ≤25% (68%, *n* = 75).

There was greater prevalence of financial toxicity among those aged 21–40 years, those who had children, originated in the lowest income tertile, those educated up to the 9th–12th grade, and those with length of hospital stay greater than 20 days. There was also a greater prevalence of financial toxicity among men compared to women. Men earned a median US\$545.45 more income than their female counterparts (*P* < 0.01).

### Out-of-Pocket Costs of Burn Care and Financial Toxicity Evaluation

The median total OOPCs for burn care were US\$555.32. Total direct nonmedical costs (US\$318.45) made up the majority of these total costs followed by total direct medical costs (US\$62.69).

The costs of hospitalization at the time of burn injury led to catastrophic health expenditure for 25% (*n* = 29) and financial hardship for 55% (*n* = 67) of the cohort. In total, up to 60% (*n* = 76) of patients faced financial toxicity in the form of either catastrophic health expenditure or financial hardship (Table 2, Appendix B).

### Tracking Financial Impact of Burn Care Longitudinally

More than half the patients were retained up to the 6-month follow-up time point. Unemployment increased from 28% at time of admission to the hospital to 81%, 70%, and 61% at 1, 3, and 6 months after surgical burn injury respectively. Rates did not return to original levels in the 6-month perioperative period. Similarly, postoperative income remained worse than preinjury income, with median household income decreasing from US\$1000.00 at the time of admission to the hospital to US\$681.82, US\$727.27, and US\$818.18 at 1, 3, and 6 months, respectively (Appendix C, Fig. 1).

Patients consistently reported difficulty in paying for basic needs, with 42%, 48%, and 53% claiming inability to afford rent, bills, food, and other essential payments at the 1-, 3-, and 6-month time points.

### Risk Factors Associated With Likelihood of Financial Toxicity Development

#### Univariate Analyses

The univariate analyses in Table 3, Appendix B, examines the odds of financial toxicity by demographic and clinical factors. Patients

**TABLE 1.** Sociodemographic and Clinical Characters With Financial Toxicity<sup>2</sup>

Variable	Total, n (%)	Financial Toxicity		P
	Frequency (%)	Present, n (%)	Absent, n (%)	
Age, years				0.190
0–20	11 (9)	7 (9)	4 (8)	
21–40	75 (60)	49 (65)	26 (52)	
41–60	35 (28)	19 (25)	16 (32)	
61–85	5 (4)	1 (1)	4 (8)	
Gender				0.195
Male	90 (71)	58 (76)	32 (64)	
Female	36 (29)	18 (24)	18 (36)	
Relationship status				0.988
Single	44 (35)	26 (34)	18 (36)	
In a relationship	82 (65)	50 (66)	32 (64)	
Children				0.804
Do not have children	55 (44)	32 (42)	23 (46)	
Have children	71 (56)	44 (58)	27 (54)	
Monthly household income, US\$				0.001
0–318 (1st tertile)	68 (54)	51 (67)	17 (34)	
318–573 (2nd tertile)	42 (33)	20 (26)	22 (44)	
>573 (3rd tertile)	16 (13)	5 (7)	11 (22)	
Educational level				0.971
None	18 (14)	11 (15)	7 (14)	
1st–8th grade	32 (25)	20 (26)	12 (24)	
9th–12th grade	58 (46)	35 (46)	23 (46)	
University-level	18 (14)	10 (13)	8 (16)	
Employment status				0.121
Full/part-time employee	74 (59)	41 (54)	33 (66)	
Daily wage laborer	16 (13)	14 (18)	2 (4)	
Unemployed	34 (27)	20 (26)	14 (28)	
Retired	2 (2)	1 (1)	1 (2)	
Insurance status				0.23
None	99 (80)	63 (84)	36 (74)	
Present	25 (20)	12 (16)	13 (27)	
Welfare status				>0.999
None	82 (65)	49 (65)	33 (66)	
Receive welfare support	44 (35)	27 (36)	17 (34)	
Length of stay, days				0.002
1–5	26 (20)	11 (15)	15 (30)	
6–10	22 (17)	8 (11)	13 (26)	
11–20	27 (21)	15 (20)	10 (20)	
>20	54 (42)	42 (55)	12 (24)	
ICU admission				0.106
No	48 (38)	24 (32)	24 (48)	
Yes	80 (62)	51 (68)	26 (52)	
TBSA burnt, %				0.026
≤25	78 (67)	36 (82)	42 (60)	
>25	38 (33)	8 (18)	28 (40)	

with the length of hospital stay of over 20 days and TBSA burnt of over 25% were 4.77 [95% confidence interval (CI), 1.74–13.08;  $P \leq 0.01$ ] and 3.06 (95% CI, 1.24–7.59;  $P = 0.02$ ) times more likely to experience financial toxicity, respectively, compared to patients with lower length of hospital stay and TBSA burnt. Other demographic and clinical factors were not significantly associated with financial toxicity.

**Multivariate Analyses**

The multivariate logistic regression model identified that patients incurring financial toxicity were 4.17 (95% CI, 1.25–14.29;  $P = 0.02$ ) times more likely to be male as compared to female. In addition, similar to the univariate analysis, patients with length of hospital stay of over 20 days were 11.17 (95% CI, 2.11–59.22;  $P \leq 0.01$ ) times more likely to face financial toxicity, compared to patients with the length of hospital stay of  $\leq 20$  days (Table 3, Appendix B).

**DISCUSSION**

The present study examined the OOPCs, longitudinal trends, and epidemiological predictors of financial toxicity among 123 patients undergoing surgical treatment for burn injuries across three tertiary care centers in India. Notably, 60% of these patients experienced financial toxicity, with a median health expenditure of US\$555.32. After surgical burn care, households experienced a US\$318.18 decrease in income within 6 months, coupled with a 53% increase in unemployment rates. Significant predictors of financial toxicity included male gender and length of hospital stay exceeding 20 days. These findings underscore the need to identify and implement interventions to minimize the financial burden related to burn injuries.

Although burn injuries have been shown to contribute to substantial monetary burden, studies addressing financial toxicity based on patient-level data remain scarce. Existing studies typically focus solely on objective metrics like OOPCs and catastrophic health expenditure during hospitalization. For example, Prinja et al identified burns as incurring the highest out-of-pocket expenditure at US\$376, followed by road traffic injuries at US\$280, when studying catastrophic health expenditure among patients in North India public hospitals.<sup>10</sup> Similarly, Nguyen et al demonstrated that burn injuries in a major trauma hospital in Vietnam led to the highest overall healthcare costs compared to other injuries, at US\$427, due to extended hospital stays.<sup>11</sup> The current study adds to this narrative, identifying a total median cost of US\$555.32 for surgical burn care, with 60% of patients experiencing consequent financial toxicity. Moreover, this study is one of the first to highlight downstream financial impacts, showcasing a substantial decrease in income and employment rates within 6 months after surgical burn care. This contributes to longitudinal financial toxicity and consistent inability to afford basic subsistence needs for up to at least 40% of the cohort at any given time point during the six-month perioperative period.

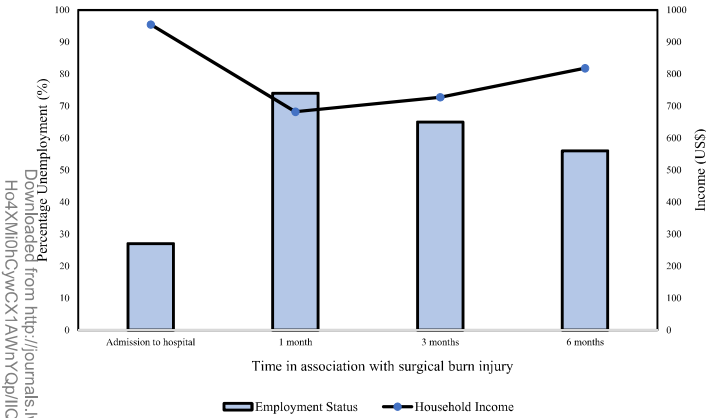
Previous studies have identified sociodemographic and clinical risk factors of financial toxicity, specifically catastrophic health expenditure, in LMICs. Studies in India and Nigeria assessing injury-related hospitalizations and emergency surgeries, respectively, identified age over 60 years, low socioeconomic status or income, unemployment, slum residents, lack of health insurance, treatment at a tertiary care center, and longer length of hospital stay as factors associated with increased likelihood of experiencing catastrophic health expenditure.<sup>10,12</sup> However, literature on risk factors specific to burn injuries remains limited. The present study focuses on burn injuries and adds that hospital

**TABLE 2.** Breakdown of Costs and Income of Patients<sup>3</sup>

Costs and Income	Median (IQR), US\$
Hospital bill	50.00 (17.05–522.73)
Total direct medical costs	64.46 (19.50–545.45)
Total direct nonmedical costs	324.10 (120.90–785.82)
Total costs of surgical burn care	570.45 (278.06–1501.13)
Total monthly individual income	454.55 (73.86–681.82)
Total monthly household income	954.55 (590.91–1590.91)
Total costs to individual income ratio	1.25

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**FIGURE 1.** Longitudinal Trends in Unemployment and Income in Association with Surgical Burn Injury.

length of stay of over 20 days was predictive of financial toxicity. In addition, males were more likely to have financial toxicity, possibly because their median prehospitalization income level was significantly higher than that of females. The loss of the higher income among males, thus, likely contributed to increased financial toxicity especially in the form of financial hardship.

The significant financial repercussions of burn injuries underscore the critical need for targeted interventions to mitigate the risk of financial toxicity. Global entities such as the World Bank, World Health Organization, and United Nations advocate for universal health coverage with protection against healthcare-related expenses.<sup>13–15</sup> India's Na-

tional Health Policy of 2017 aligns with this goal, aspiring to provide “universal access to good quality health care services without anyone having to face financial hardship as a consequence.<sup>16</sup>” The inclusion of burn care in the 2018 Pradhan Mantri Jan Arogya Yojana (PMJAY) is a significant step, but its coverage reaches only 40% of households with the lowest socioeconomic status, leaving gaps in access.<sup>17</sup> In tandem with national policies, localized initiatives embody the potential for state-level mandates to offer free treatment for burn injuries, thereby enhancing accessibility and reducing out-of-pocket costs.<sup>18</sup> A comprehensive strategy to address these gaps necessitates the development and implementation of both national and local policies. These policies should extend beyond minimizing direct medical costs, encompassing a targeted focus on nonmedical and indirect costs associated with burn injuries. Our findings underscore the persistence of financial challenges, especially in the perioperative period, even within the context of low direct medical costs. Potential mechanisms to reduce direct non-medical costs include subsidized lodging near burn centers or investment in teleconsultation facilities for remote long-term follow up. Addressing indirect costs involves prioritizing high-risk individuals, facilitating essential occupational support, and ensuring rehabilitation access during the perioperative period. Interdisciplinary collaboration remains vital for identifying and implementing cost-effective strategies, and regular evaluations are imperative to ensuring the sustained efficacy of these measures. Furthermore, exploring innovative public-private partnerships, such as tailored insurance coverage for burn patients, may offer promising novel avenues to further alleviate the persistent financial burden associated with burn injuries.

This study has important limitations to consider. First, the study was conducted across tertiary care hospitals in urban settings and does not represent the cost of burn care at the secondary level or at rural

**TABLE 3.** Predictors of Financial Toxicity<sup>4</sup>

	Financial Toxicity	
	Univariate OR (95% CI)	Multivariate OR (95% CI)
Age		
0–20	Reference	Reference
21–40	1.08 (0.29–4.02);0.91	4.19 (0.50–34.97);0.19
41–60	0.68 (0.17–2.74);0.59	2.77 (0.31–24.53);0.36
61–85	0.14 (0.01–1.76);0.13	0.61 (0.02–16.03);0.77
Gender		
Male	Reference	Reference
Female	0.55 (0.25–1.21);0.14	<b>0.25 (0.08–0.80);0.02*</b>
Insurance status		
No	Reference	Reference
Yes	0.53 (0.22–1.28);0.16	0.44 (0.13 to 1.42);0.17
Length of stay (days)		
1–5	Reference	Reference
6–10	0.84 (0.26–2.72);0.77	0.63 (0.15–2.59);0.52
11–20	2.05 (0.67–6.24);0.21	1.92 (0.47–7.87);0.36
>20	<b>4.77 (1.74–13.08);&lt;0.01*</b>	<b>10.88 (2.14–55.44);&lt;0.01*</b>
ICU admission		
No	Reference	Reference
Yes	1.96 (0.94–4.1);0.07	0.35 (0.10–1.20);0.52
TBSA burnt (%)		
≤25	Reference	Reference
>25	<b>3.00 (1.22–7.40);0.02*</b>	2.89 (0.80–10.43);0.10

\*P value <0.05 (statistically significant).

hospitals. However, the selected tertiary care centers represent high-quality institutions handling a spectrum of referral and complicated cases and therefore likely capture the highest echelon of the cost spectrum associated with burn injuries in India. Unfortunately, the study is unable to account for individuals who succumbed to burn injuries or were unable to reach these tertiary care facilities. Second, we did not stratify this study cohort by type of surgery or health system setting. Both health systems included in this study offer a similar level of expertise and assess patients from varying sociodemographic backgrounds. The general cost figure obtained from this study is, therefore, a good estimation of common costs in most settings in India. Nevertheless, we acknowledge that costs might differ, being lower in some public burn center settings and higher in certain private healthcare facilities. Lastly, the financial toxicity data in this study has been reported from patients directly and may be susceptible to reporting bias. To mitigate this, we utilized trained personnel to administer the surveys and had the same trained individual follow up with each respective patient. These steps were taken to enhance the reliability and accuracy of the reported financial data. Future studies should explore and compare more diverse healthcare settings and supplement data with qualitative components to gain a more nuanced understanding of the economic implications and possible solutions to mitigate financial toxicity in this population.

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## Appendix A – The survey instrument

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- One-, Three- and Six-month Follow-up Survey Instrument Page 18-26.

## Appendix B – Tables

- Table 1: Sociodemographic and clinical characters with financial toxicity<sup>2</sup>
- Table 2: Breakdown of costs and income of patients<sup>3</sup>
- Table 3: Predictors of financial toxicity<sup>4</sup>.

## Appendix C – Figure 1

Figure 1: Longitudinal Trends in Unemployment and Income in Association with Surgical Burn Injury<sup>2</sup>.