


Holistic View of Autografting Patients by Percentage of Total Body Surface Area Burned: Medical Record Abstraction Integrated with Administrative Claims

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Aim: This retrospective observational study provides a holistic view of the clinical and economic characteristics of inpatient treatment of patients with thermal burns undergoing autografting, by integrating real-world data (RWD) from medical records from healthcare providers (HCPs) and administrative claims.

Methods: We identified eligible patients between July 1, 2010, and November 30, 2019, from the HealthCore Integrated Research Database[®] (HIRD[®]) and obtained their medical records from HCPs. We abstracted data from medical records to describe patient demographics and clinical characteristics and obtained costs of treatment from claims.

Results: Two hundred patients were stratified into cohorts based on the percentage of total body surface area (%TBSA) burned: minor (< 10%), moderate (10%–24%), and major (≥ 25%). Data obtained from medical records and administrative claims were comparable to previous findings from administrative claims data. This privately insured study cohort predominantly consisted of White men. Diabetes mellitus and hypertension were frequently reported in a relatively young population. Key clinical characteristics that could influence burn treatment decisions and long-term outcomes, such as body mass index, size of autograft donor site, and mesh ratio, were frequently underdocumented in patients' medical records.

Conclusion: Evidence generated from 2 orthogonal RWD sources confirmed that patients with larger %TBSA burned required more intensive care, thereby incurring higher costs. This study highlights considerable incompleteness in many critical fields in medical records, which limits the ability to generate broader insights. More comprehensive documentation of clinical characteristics and outcomes of autografts and donor sites in the operative and medical notes is critical to appropriately evaluate their impact on outcomes of burn treatments in future research using RWD.

Keywords: burn injury, healthcare resource utilization, treatment patterns, real-world data

Introduction

Burn injuries are a serious global public health concern. The Healthcare Cost and Utilization Project reported about 16.8 burn-related hospital stays per 100,000 population in the United States (US) alone in 2013.¹ Most burn-related injuries occur at home and in the workplace.² Fire and flames and scalding are the most common causes of thermal burns.³

Burn injuries may be classified as superficial, superficial partial-thickness, deep partial-thickness (DPT), full-thickness (FT), or fourth-degree burns, based on burn depth, which influences treatment during the acute injury phase, as well as the patient's long-term functional and cosmetic outcomes.^{4,5} In the acute-injury phase (0 to 48 hours), the clinical severity of a burn can range from a superficial (first-degree) burn with red, dry, painful skin, to a FT (third-degree) burn with waxy-white to leathery dry skin and no pain sensation in the burned area.⁵

Patients with DPT and FT burns often require hospitalization for surgical excision and skin-grafting. Skin-grafting, such as autografts, allografts, xenografts, and other skin substitutes, is the most common procedure used in burn-related inpatient treatment.¹ A recent retrospective analysis using administrative claims data from 2 large US private insurance health plan databases—HealthCore Integrated Research Database[®] (HIRD[®]) and IBM[®] MarketScan[®]—estimated that about a quarter of the patients admitted to hospitals with thermal burns underwent autografting, the gold standard in burn treatment,⁶ during their hospital stay.⁷ Burn treatments often require specialized care, surgery, prolonged hospitalization, and rehabilitation, which result in a substantial economic burden. The retrospective analysis revealed that the inpatient treatment of burns with autografting had an average daily total medical cost per patient of approximately \$9000.⁷ The average total hospitalization cost of burn treatment with autografting was around \$157,000, which accounted for 85% of the mean total all-cause cost of care in the first year of burn treatment. Healthcare costs and length of hospital stay increased with the increase in percentage of total body surface area (%TBSA) burned.

Although data from administrative claims provide valuable informative trends of costs and healthcare resource utilization (HCRU) over time, such data lack detailed clinical information (eg, body mass index [BMI], size of autograft donor site) about patients. Such information could provide a more robust picture of inpatient burn treatment than administrative data alone. The objective of this study was to provide a holistic view of the clinical and economic characteristics of the inpatient care of patients with thermal burns undergoing autografting, by integrating data from 2 sources—inpatient medical records and administrative claims data.

Materials and Methods

Data Source and Study Design

In this retrospective observational study, we linked longitudinal pharmacy and medical claims data with medical records. The HIRD consists of de-identified patient-level longitudinal pharmacy and medical-claims data associated with large US commercial health plans (including Medicare Advantage) for more than 50 million individuals at the time of the study.^{7,8} Patients with thermal burns undergoing inpatient autografting between July 1, 2010, and November 30, 2019 were identified in the HIRD (Figure 1). The list of codes used to identify procedures, medications, and burn-related clinical characteristics can be found in Yu et al.⁷ The first observed hospitalization for thermal burns with autografting was regarded as the index event, and the admission date was designated as the index date. The preindex (baseline) period was defined as the 6-month period prior to and not inclusive of the index date. The follow-up period was the 6-month period after the index date.

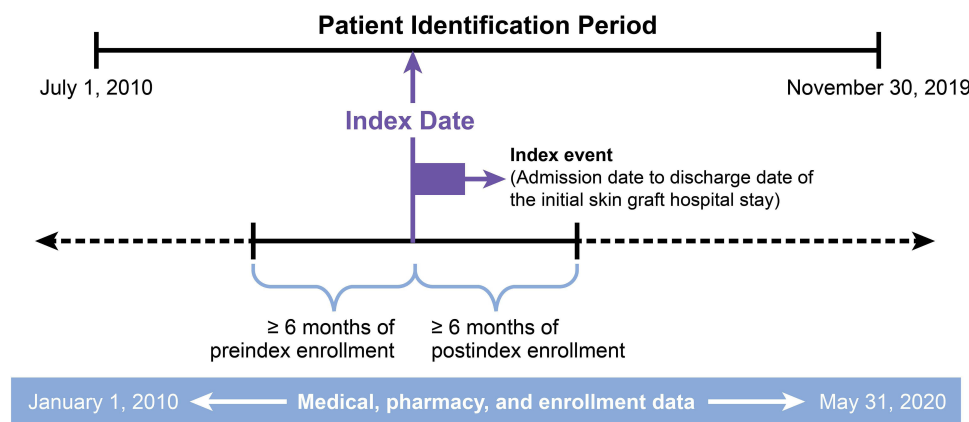


Figure 1 Timeline describing the study period.

A list of patients and their healthcare providers (HCPs) at inpatient facilities on the index date was generated from the HIRD for eligible patients who met all the inclusion and exclusion criteria outlined in Figure 2. The study protocol, medical record abstraction methodology, and a standardized clinical data abstraction form were reviewed and approved by a central institutional review board (WCG Institutional Review Board (IRB), study number 1292435, granted on September 11, 2020). The acquisition and handling of study data complied with

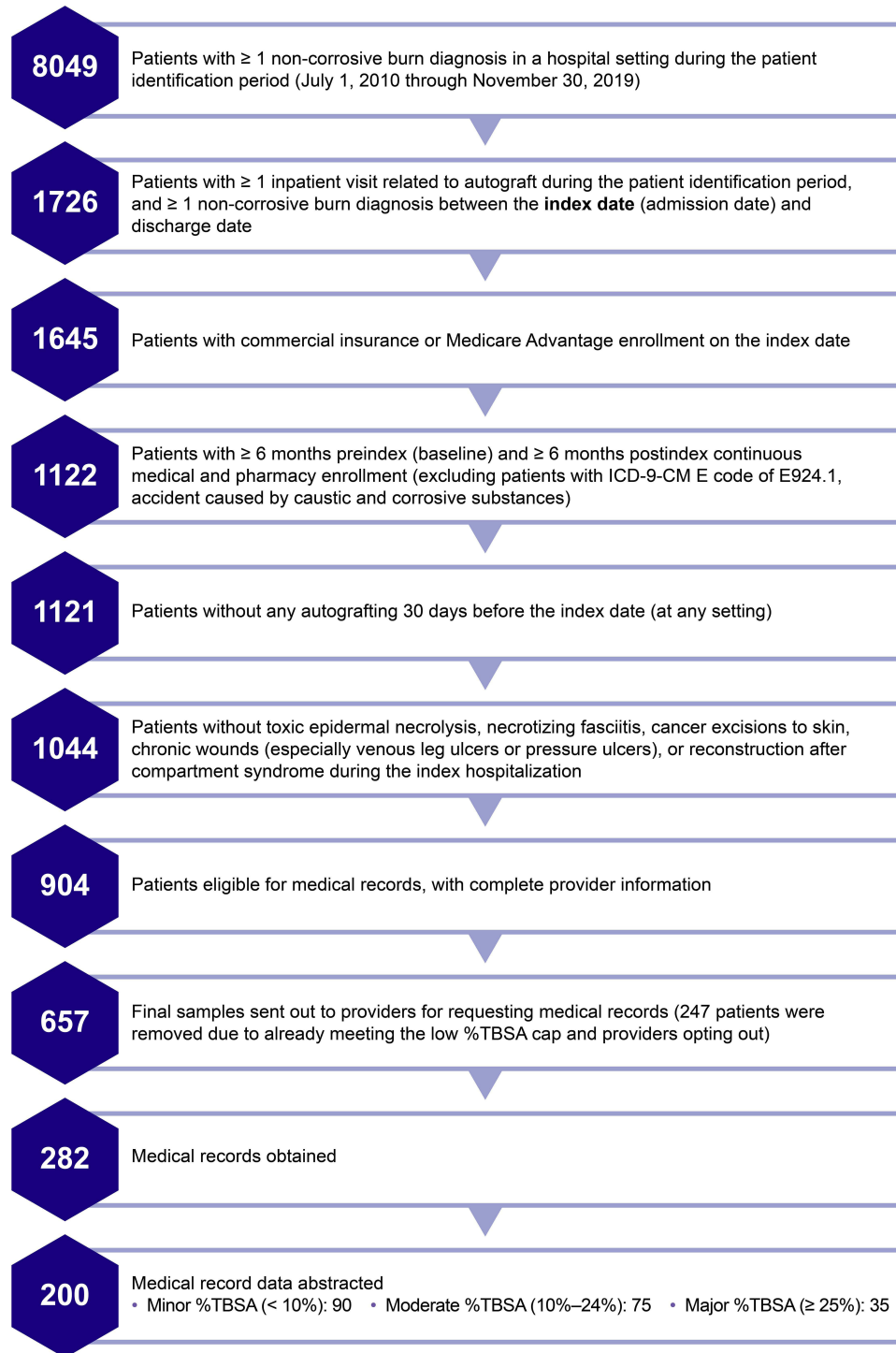


Figure 2 Inclusion/exclusion criteria to determine the study cohort (blue hexagons indicate number of patients at each step).

Abbreviations: %TBSA, percentage of total body surface area; ICD-9-CM, International Classification of Diseases-Ninth Revision-Clinical Modification.

applicable state and federal privacy regulations, including the Health Insurance Portability and Accountability Act (HIPAA). Requests for patients' full medical records, along with the institutional review board approval letter, were sent to multiple facilities. We aimed to abstract data on patient demographics, burn sites, %TBSA, autograft donor and recipient sites and sizes, treatment procedures, and medications, from a total of 200 medical records provided by HCPs.

We categorized patients according to %TBSA burned as minor (< 10%), moderate (10%–24%), and major (\geq 25%) %TBSA cohorts based on expert opinion. In the real world, there is a higher prevalence of patients in the minor (< 10%) %TBSA cohort.^{7,9} To gain insight into treatment patterns among patients with severe burns, we therefore prioritized and oversampled major/moderate %TBSA groups by obtaining as many records as possible. When patients with major/moderate %TBSA were exhausted, we used the medical records for patients with low %TBSA to achieve our target of 200 records.

Prior to data abstraction, the patients in our study cohorts were screened to confirm that they had a record of autografting procedures in their medical charts. For those patients whose %TBSA burned were not documented in their medical records, this was estimated by dividing area covered by autograft by TBSA. The TBSA was estimated using the formula:¹⁰

$$\text{TBSA} = 0.20247 \times (\text{height in meters})^{0.725} \times (\text{weight in kilograms})^{0.425}$$

If data on the heights and weights of patients were unavailable, the TBSA was estimated based on age and sex.¹⁰ Data on the area covered by the autograft were missing for 3 patients, who were then included in the minor (< 10%) %TBSA cohort. Data abstraction was carried out between 30 days before and 60 days after the index date to account for the possibility of a staged autografting approach (ie, if the length of stay of index hospitalization was longer than 60 days, data were included until the discharge date).

Statistical Analyses

Patient demographics, comorbidities, and medication use during the baseline period and index burn-related clinical characteristics were summarized with descriptive statistics, such as frequency, mean, standard deviation (SD), and median. Univariate analyses were performed with regard to patient baseline characteristics, including demographics, clinical characteristics, and comorbidities, by %TBSA cohort. All baseline and index hospitalization measures were also described with univariate statistics by %TBSA cohort. In subgroup analyses by %TBSA cohorts, Chi-squared tests were used for categorical variables, Fisher exact tests were used for binary variables, and *t*-tests or Wilcoxon rank-sum tests were used for continuous variables to explore trends in the data. A Bonferroni-corrected alpha of 0.017 was used to account for post hoc multiple comparisons.

Data on costs were adjusted to 2019 US dollars, given the most recent medical care price index information provided by the Bureau of Labor Statistics at the time of this study.¹¹ Healthcare costs by %TBSA cohort were analyzed as continuous variables with mean, SD, and median. All analyses were conducted with Statistical Analysis System, version 9.3 (SAS Institute Inc., Cary, NC, USA). To protect the confidentiality of health-plan members and minimize the risk of re-identification, all data values for which the number of patients was in the range of 1 to 10 were reported as \leq 10.

Results

Study Cohort

Using administrative claims data, 8049 patients hospitalized for thermal burns during the patient identification period (July 1, 2010, through November 30, 2019) were identified. [Figure 2](#) shows the attrition of the 8049 patients to the prespecified target of 200 patients, whose hospital clinical records and associated administrative data were included in this study. Regarding %TBSA burned, we observed some differences between the data from administrative claims and medical records ([Supplemental Table S1](#)). %TBSA as documented in the medical records was more inclusive of different

burn-depth categories. Therefore, patients were stratified based on %TBSA burned, as determined from their medical records, as follows:

90 patients with minor (< 10%) %TBSA

75 patients with moderate (10%–24%) %TBSA

35 patients with major ($\geq 25\%$) %TBSA (Figure 2).

Of 200 medical records, 15 did not have %TBSA burned documented. Those missing %TBSA burned were estimated using the method described earlier in the Data Source and Study Design section.

Baseline Demographic and Clinical Characteristics

Nearly two-thirds of patients across the 3 %TBSA cohorts were male (Table 1). Of those in the moderate and major %TBSA cohorts, 65% and 74%, respectively, were White patients. The major %TBSA cohort (median age: 36 years) appeared to be younger than the minor (median age: 46 years) and moderate (median age: 46 years) %TBSA cohorts. Of the entire study cohort, 31% of the patients did not have their BMI reported in their medical records (Figure 3). Administrative claims data indicated that nearly two-thirds of patients across all cohorts had preferred provider organization (PPO) health insurance coverage.

The general comorbidity burden was low based on the Quan-Charlson Comorbidity Index across all cohorts.¹² Chronic obstructive pulmonary disease (COPD) and anxiety were common comorbidities in the minor %TBSA cohort, reported in 18% and 17% of patients, respectively. Hypertension (> 23%) and diabetes mellitus (> 11%) were frequently reported comorbidities in the minor and moderate %TBSA cohorts. Opioid analgesics, antibiotics, and antidepressants were commonly used medications in the minor and moderate %TBSA cohorts. Thirty-one percent of patients in the minor and 37% of patients in the moderate %TBSA cohorts, respectively, were documented as current smokers. Smoking status at index was not documented in the medical records for 14% of the minor, 31% of the moderate, and 40% of the major %TBSA cohorts, respectively.

Burn-Related Clinical Characteristics

Medical records revealed that fire and flames were the most common cause of burn injuries in the moderate (75%) and major %TBSA (74%) cohorts, whereas the category of hot substance or object, caustic material, and steam (48%) was the most common cause of burn injuries in the minor %TBSA cohort (Table 2). Primary locations of burn sites, as noted in the medical records, were sensitive burn sites in the minor (58%), upper limb in the moderate (84%), and trunk in the major %TBSA cohorts. Fractures were also reported in 13% of patients in the minor (97%) %TBSA cohort. Fewer than 10 patients in each cohort were hospitalized in the 30 days leading up to the index date.

Index Hospitalization Characteristics and Healthcare Resource Utilization

Data from medical records indicated that larger %TBSA coincided with longer length of hospital stay (including intensive care), more autograft operations, and longer time period between index date and date of first autograft procedure (Table 3). Patients in the major %TBSA cohort spent a mean (SD) of 46.5 (25.16) days in the hospital and had 2.8 (1.92) autografting procedures; whereas patients in the minor and moderate %TBSA cohorts spent 10.6 (11.28) and 16.4 (9.35) days in the hospital, respectively, and most patients (100% in minor and 91% in moderate %TBSA cohorts) only had 1 autografting procedure.

The time period between admission and first autograft procedure increased with increase in %TBSA: mean (SD) for the cohorts was 5.7 (8.03) days in the minor, 7.2 (4.87) days in the moderate, and 13.3 (10.8) days in the major %TBSA cohorts. Of the patients in the major %TBSA cohort, 77% spent a mean (SD) of 30.4 (20.75) days in the intensive care unit (ICU), and 51% required a ventilator. Fewer patients in the other 2 cohorts required intensive care and spent less time in the ICU. Across all cohorts, most patients received opioid and non-narcotic analgesics.

Nearly all patients underwent debridement during their inpatient stay (Table 3). In the major %TBSA cohort, 54% of autograft procedures were performed alongside additional skin graft procedures (eg, allograft and cultured epithelial autograft) during the surgery. Among the entire study cohort, autograft details, such as size of donor sites and mesh ratio,

Table I Baseline Characteristics of %TBSA Cohorts Obtained From Medical Records and Administrative Claims

Characteristics		%TBSA Cohorts			P value ^a		
Burn cohort		Minor ($< 10\%$)	Moderate ($10\%–24\%$)	Major ($\geq 25\%$)	Minor vs Moderate	Minor vs Major	Moderate vs Major
Total number of records, n		90	75	35			
From Medical Records							
Sex and age on index date	Male, n (%)	57 (63.3)	54 (72.0)	27 (77.1)	0.249	0.203	0.647
	Age on index date (years), mean (SD), median	43.4 (19.50), 46	42.4 (20.03), 46	36.3 (17.26), 36	0.800	0.062	0.107
BMI	Underweight/normal: BMI < 25 , n (%)	26 (28.9)	21 (28.0)	≤ 10 (*)	0.118	0.509	0.537
	Overweight: $25 \leq$ BMI < 30 , n (%)	17 (18.9)	11 (14.7)	≤ 10 (*)			
	Obese: BMI ≥ 30 , n (%)	14 (15.6)	23 (30.7)	≤ 10 (*)			
	Mean, SD, median	26.6 (7.08), 26.3	28.6 (8.37), 28	27.3 (6.18), 26.9	0.175	0.637	0.506
	Unknown, n (%)	33 (36.7)	20 (26.7)	≤ 10 (*)			
Race	White, n (%)	36 (40.0)	49 (65.3)	26 (74.3)	0.005	0.002	0.323
	Others (not undocumented), n (%)	≤ 10 (*)	≤ 10 (*)	0 (0.0)			
	Unknown, n (%)	46 (51.1)	22 (29.3)	≤ 10 (*)			
Smoking status closest to index date	Current smoker, n (%)	28 (31.1)	28 (37.3)	≤ 10 (*)	0.018	0.015	0.179
	Former smoker, n (%)	12 (13.3)	≤ 10 (*)	≤ 10 (*)			
	Never smoker, n (%)	37 (41.1)	> 10 (*)	≤ 10 (*)			
	Unknown, n (%)	13 (14.4)	23 (30.7)	14 (40.0)			
From Administrative Claims							
Plan type	HMO, n (%)	19 (21.1)	> 10 (*)	≤ 10 (*)	0.240	0.730	0.842
	PPO, n (%)	56 (62.2)	53 (70.7)	24 (68.6)			
	CDHP, n (%)	15 (16.7)	≤ 10 (*)	≤ 10 (*)			

Quan-Charlson comorbidity index	Mean (SD), median	0.74 (1.36), 0	0.45 (1.23), 0	0.23 (0.77), 0	0.091	0.011	0.138
	0, n (%)	61 (67.8)	59 (78.7)	32 (91.4)	0.121	0.018	0.065
	1–2, n (%)	> 10 (*)	> 10 (*)	≤ 10 (*)			
	3+, n (%)	≤ 10 (*)	≤ 10 (*)	≤ 10 (*)			
Individual comorbidity ^b	COPD, n (%)	16 (17.8)	≤ 10 (*)	≤ 10 (*)	0.175	0.097	0.716
	Anxiety, n (%)	15 (16.7)	≤ 10 (*)	≤ 10 (*)	0.507	0.149	0.497
	Diabetes mellitus, n (%)	10 (11.1)	12 (16.0)	≤ 10 (*)	0.369	0.180	0.058
	Hypertension, n (%)	21 (23.3)	22 (29.3)	≤ 10 (*)	0.477	0.212	0.053
Medication use	Opioid analgesics, n (%)	44 (48.9)	23 (30.7)	≤ 10 (*)	0.026	0.001	0.167
	Antibiotics, n (%)	29 (32.2)	17 (22.7)	≤ 10 (*)	0.222	0.830	0.635
	Antidepressants, n (%)	16 (17.8)	15 (20.0)	≤ 10 (*)	0.842	0.800	1.000

Notes: *Percentage and standard deviation are not reported for groups containing ≤ 10 patients. ^aP values were calculated from Chi-squared tests for categorical variables, Fisher exact tests for flag variables, and t-tests or Wilcoxon tests for continuous variables; Bonferroni corrected alpha = 0.017. ^bThe presence of each clinical condition was identified as ≥ 1 medical claim with a diagnosis code for the condition of interest during the baseline period.

Abbreviations: %TBSA, percentage of total body surface area; BMI, body mass index; CDHP, consumer directed health plans; COPD, chronic obstructive pulmonary disease; HMO, health maintenance organization; PPO, preferred provider organization; SD, standard deviation.

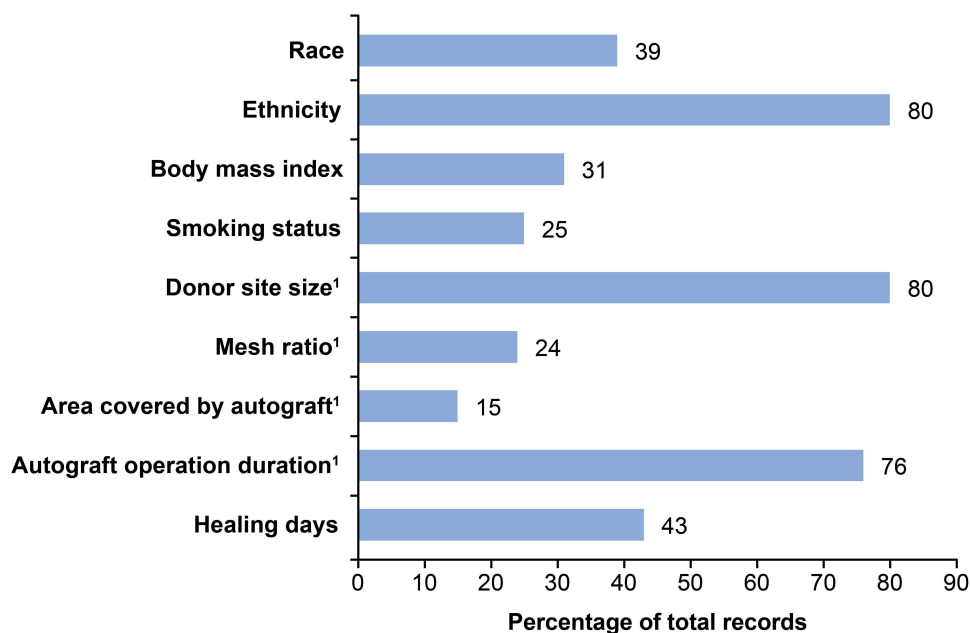


Figure 3 Extent of missing critical information in patient medical records. ¹Reported at autografting operation level.

were frequently not documented in the patient charts, with 80% and 24% missing, respectively (Figure 3). Time to wound healing was also not documented in 43% of patient charts.

Patients with larger %TBSA also received more physical and occupational therapy. Medical records indicated that 69% of patients with minor %TBSA, 77% of patients with moderate %TBSA, and 83% of patients with major %TBSA burned received physical or occupational therapy during their index hospital stay. In the 6-month follow-up period, administrative claims data indicated that 80% of patients in the major %TBSA cohort received physical therapy, and 74% received occupational therapy in outpatient visits. In comparison, 54% and 59% of patients in the minor and moderate %TBSA cohorts, respectively, received outpatient physical therapy. Of the patients in the minor and moderate %TBSA cohorts, 37% and 47%, respectively, received outpatient occupational therapy (Supplemental Table S2).

All-Cause and Burn-Related Healthcare Costs from Claims Data

The mean total medical costs increased with increase in %TBSA burned (Figure 4). Administrative claims data revealed mean (SD) total costs of index hospitalization were \$75,025 (\$78,900) in the minor %TBSA cohort, \$173,532 (\$161,563)

Table 2 Index Burn-Related Clinical Characteristics Obtained From Medical Records by %TBSA Cohorts

Characteristics		%TBSA Cohorts			P value ^a		
		Minor (< 10%)	Moderate (10%–24%)	Major (≥ 25%)	Minor vs Moderate	Minor vs Major	Moderate vs Major
Burn cohort							
Total number of records, n		90	75	35			
Burn agent ^b	Hot substance or object, caustic material, and steam, n (%)	43 (47.8)	24 (32.0)	11 (31.4)	0.056	0.111	1.000
	Fire and flames, n (%)	42 (46.7)	56 (74.7)	26 (74.3)	< 0.001	0.009	1.000
	Other causes, n (%)	≤ 10 (*)	≤ 10 (*)	≤ 10 (*)	0.592	1.000	0.498
	Unknown, n (%)	≤ 10 (*)	0 (0.0)	0 (0.0)	0.252	0.559	—

(Continued)

Table 2 (Continued).

Characteristics		%TBSA Cohorts			P value ^a		
		Minor (< 10%)	Moderate (10%–24%)	Major (≥ 25%)	Minor vs Moderate	Minor vs Major	Moderate vs Major
Burn cohort							
Total number of records, n		90	75	35			
Burn site ^b	Head and neck, n (%)	15 (16.7)	36 (48.0)	28 (80.0)	< 0.001	< 0.001	0.002
	Trunk, n (%)	31 (34.4)	51 (68.0)	34 (97.1)	< 0.001	< 0.001	< 0.001
	Upper limb, n (%)	48 (53.3)	63 (84.0)	31 (88.6)	< 0.001	< 0.001	0.772
	Upper limb except wrist and hand, n (%)	39 (43.3)	55 (73.3)	31 (88.6)	< 0.001	< 0.001	0.086
	Wrist and hand, n (%)	29 (32.2)	41 (54.7)	23 (65.7)	0.004	0.001	0.306
	Lower limb, n (%)	48 (53.3)	50 (66.7)	30 (85.7)	0.111	0.001	0.041
	Lower limb except foot and ankle, n (%)	42 (46.7)	47 (62.7)	30 (85.7)	0.043	< 0.001	0.015
	Foot and ankle, n (%)	15 (16.7)	18 (24.0)	11 (31.4)	0.249	0.086	0.487
	Unspecified, n (%)	≤ 10 (*)	0 (0.0)	0 (0.0)	1.000	1.000	—
	Sensitive burn sites (head, neck, wrist, hand, foot, or ankle), n (%)	52 (57.8)	59 (78.7)	33 (94.3)	0.005	< 0.001	0.052
Fractures along with the burn injury, n (%)		12 (13.3)	≤10 (*)	≤ 10 (*)	0.202	0.346	1.000

Notes: *Percentage and standard deviation are not reported for groups containing ≤ 10 patients. ^aP values were calculated from Chi-squared tests for categorical variables, Fisher exact tests for flag variables, and t-tests or Wilcoxon tests for continuous variables; Bonferroni corrected alpha = 0.017. ^bThe sum across burn agents or sites may be larger than the total number of patients because a patient could have more than 1 burn agent or site identified during the index event.

Abbreviation: %TBSA, percentage of total body surface area.

in the moderate %TBSA cohort, and \$561,433 (\$605,183) in the major %TBSA cohort, with burn-related inpatient treatment and pharmacy costs accounting for over 99% of these amounts in each cohort (Table 4).

Discussion

This study confirms the previous finding by Yu et al⁷ that patients with larger %TBSA burned require more intensive care, thereby incurring higher costs. In the present analysis, the number of autograft procedures, length of hospital stay, number of physical and occupational therapy sessions, and overall treatment costs of burn injuries positively correlated with %TBSA burned. Further, among various %TBSA cohorts, the mean cost of treatment and mean length of hospital stay were comparable to those reported earlier.⁷

In the previous analysis of HCRU,⁷ Yu et al had only used data from administrative claims, and we expanded upon those findings in this study. Administrative claims data alone lacked detailed critical clinical information (eg, BMI, size of autograft donor site) on patients as they are primarily generated for billing and reimbursement purposes and may be subject to International Classification of Diseases-Ninth or Tenth Revision-Clinical Modification (ICD-9/10-CM) code availability and coding practices. This may result in inconsistencies and/or undercoded/missing data on several patient characteristics, such as patient BMI, which may often not directly relate to reimbursement, but are still important for providers to consider when making burn-treatment decisions. Therefore, medical records are important real-world data (RWD) sources to complement administrative claims data for observational studies because they often provide routine, HCP-collected clinical data, important patient characteristics, and detailed treatment patterns that are not always available and/or reliable from claims.¹³ As the objective of this study was to corroborate and bolster real-world evidence (RWE) to assess patient outcomes and inform treatment guidelines in burn care, it was essential to integrate data from

Table 3 Index Hospitalization and Treatment Characteristics Obtained From Medical Records by %TBSA Cohorts

Characteristics		%TBSA Cohorts			P value ^a		
		Minor (< 10%)	Moderate (10%–24%)	Major (≥ 25%)	Minor vs Moderate	Minor vs Major	Moderate vs Major
Burn cohort							
Total number of records, n		90	75	35			
From Medical Records							
Length of stay of index hospitalization in days, mean (SD), median		10.6 (11.28), 9	16.4 (9.35), 14	46.5 (25.16), 40	< 0.001	< 0.001	< 0.001
Number of autografting operations	1, n (%)	90 (100.0)	68 (90.7)	≤ 10 (*)	0.012	< 0.001	< 0.001
	2, n (%)	0 (0.0)	≤ 10 (*)	> 10 (*)			
	≥ 3, n (%)	0 (0.0)	≤ 10 (*)	13 (37.1)			
	Mean (SD), median	1.0 (0.00), 1	1.1 (0.35), 1	2.8 (1.92), 2	0.003	< 0.001	< 0.001
Time to first autografting from index admission date in days, mean (SD), median		5.7 (8.03), 4	7.2 (4.87), 6	13.3 (10.80), 12	< 0.001	< 0.001	0.001
Donor site size in cm ² , n, %	≤ 300	16 (17.8)	≤ 10 (*)	≤ 10 (*)	0.006	0.011	0.741
	301–1000	≤ 10 (*)	≤ 10 (*)	≤ 10 (*)			
	> 1000	≤ 10 (*)	≤ 10 (*)	≤ 10 (*)			
	Mean (SD), median	263.9 (323.96), 140	1135.2 (1208.05), 900	2728.4 (3437.43), 1022	0.005	< 0.001	0.342
	Unknown	68 (75.6)	64 (85.3)	27 (77.1)			
Mesh ratio, ^b n, %	0.25:1	≤ 10 (*)	0 (0.0)	0 (0.0)	1.000	1.000	–
	0.5:1	≤ 10 (*)	0 (0.0)	≤ 10 (*)	1.000	0.483	0.318
	1:1	14 (15.6)	≤ 10 (*)	≤ 10 (*)	0.825	0.597	0.403
	1.5:1	12 (13.3)	≤ 10 (*)	≤ 10 (*)	0.202	1.000	0.462
	2:1	30 (33.3)	41 (54.7)	12 (34.3)	0.007	1.000	0.065
	3:1	≤ 10 (*)	≤ 10 (*)	14 (40.0)	0.047	< 0.001	< 0.001
	4:1	0 (0.0)	0 (0.0)	≤ 10 (*)	–	0.021	0.030
	Unknown	31 (34.4)	16 (21.3)	12 (34.3)	0.083	1.000	0.164

Medication received	NSAIDs, n (%)	30 (33.3)	27 (36.0)	21 (60.0)	0.745	0.008	0.023
	Opioid analgesics, n (%)	76 (84.4)	70 (93.3)	33 (94.3)	0.089	0.232	1.000
	Non-narcotic analgesics, n (%)	44 (48.9)	48 (64.0)	26 (74.3)	0.060	0.015	0.383
	Glucocorticoid steroids, n (%)	≤ 10 (*)	≤ 10 (*)	≤ 10 (*)	0.772	0.094	0.192
	Antibiotics, n (%)	63 (70.0)	64 (85.3)	34 (97.1)	0.026	0.001	0.099
	Topical pain medication, n (%)	0 (0.0)	≤ 10 (*)	≤ 10 (*)	0.205	0.077	0.591
Excision or debridement procedure, n (%)		85 (94.4)	72 (96.0)	35 (100.0)	0.729	0.321	0.550
Physical or occupational therapy sessions, n (%)		62 (68.9)	58 (77.3)	29 (82.9)	0.292	0.178	0.619
ICU use during index hospitalization	Number of patients, n (%)	34 (37.8)	26 (34.7)	27 (77.1)	0.746	< 0.001	< 0.001
	Total ICU days, mean (SD), median	6.5 (8.02), 4	13.0 (12.34), 10.5	30.4 (20.75), 29	0.030	< 0.001	0.001
	Patients with ventilator use, n (%)	≤ 10 (*)	≤ 10 (*)	18 (51.4)	0.087	< 0.001	< 0.001
Skin graft procedure other than autografting during this autografting procedure ^c , n (%)		≤10 (*)	15 (20.0)	19 (54.3)	0.045	< 0.001	0.001
Other skin graft procedure, n, %	Allograft (cadaver skin or homograft)	≤10 (*)	≤10 (*)	14 (40.0)	0.178	< 0.001	< 0.001
	Others (cultured epithelial autograft, autologous skin cell suspension etc.)	0 (0.0)	≤ 10 (*)	≤ 10 (*)	0.455	0.280	0.537
	Unknown	≤10 (*)	10 (13.3)	≤ 10 (*)	0.306	0.063	0.403
Negative pressure wound therapy after autograft in the operation, n (%)		17 (18.9)	≤ 10 (*)	≤ 10 (*)	0.285	1.000	0.384

Notes: *Percentage and standard deviation are not reported for groups containing ≤ 10 patients. ^aP values were calculated from Chi-squared tests for categorical variables, Fisher exact tests for flag variables, and t-tests or Wilcoxon tests for continuous variables; Bonferroni corrected alpha = 0.017. ^bThe smallest mesh ratio was captured if there were multiple mesh ratios in 1 autografting procedure. ^cThe sum across skin graft procedures may be larger than the total number of other skin graft procedures documented because a patient could have more than 1 skin graft identified during 1 autografting procedure.

Abbreviations: %TBSA, percentage of total body surface area; ICU, intensive care unit; NSAID, nonsteroidal anti-inflammatory drug; SD, standard deviation.

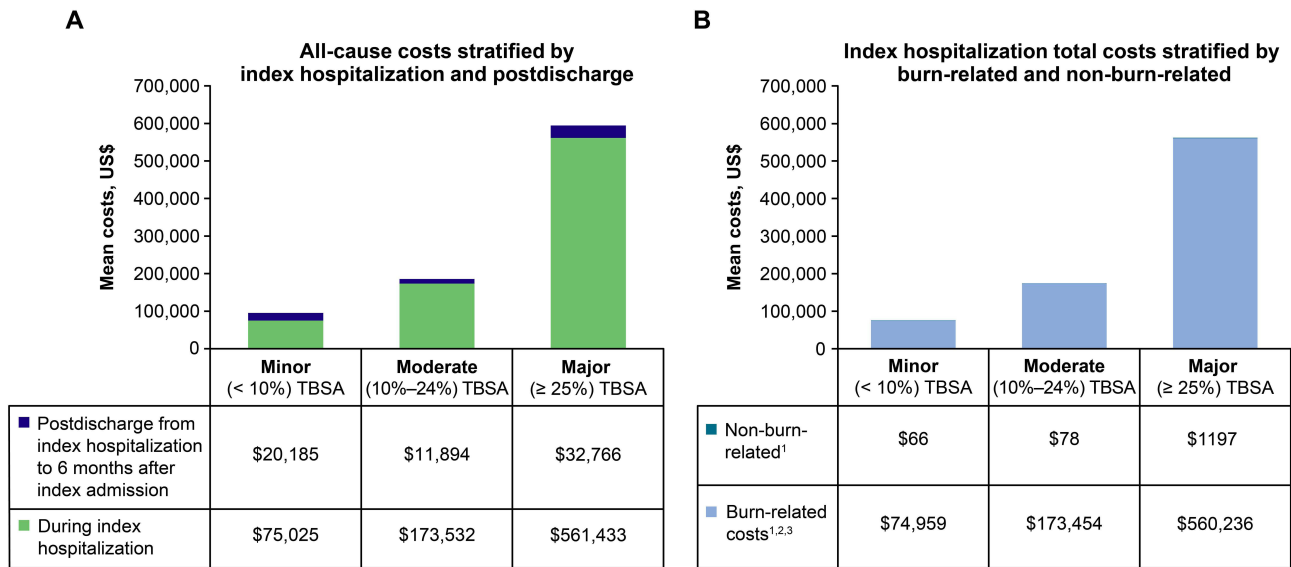


Figure 4 All-cause costs stratified by (A) index hospitalization and postdischarge costs, and (B) burn-related and non-burn-related costs during index hospitalization. ¹Includes medical (inpatient, emergency room, other outpatient, and skilled nursing facility) and pharmacy costs. ²Burn-related medical claims were limited to claims with ICD-9/10-CM codes for burns (including all sequelae of burns) or any of ICD-9/10-CM/procedure coding system procedure or current procedural terminology codes for skin grafts/skin substitutes (HCUP clinical classifications software procedure categories 172) on the medical claims associated with that service. ³Burn-related pharmacy claims were: (a) medications for pain, mental conditions, and depression (non-opioid analgesics, opioid analgesics, hypnotics, anxiolytics, and antidepressants), (b) medication for infection (antibiotics), (c) medication for itching (naltrexone, gabapentin/pregabalin, H₁ receptor antagonist). **Abbreviations:** H₁, histamine receptor; HCUP, healthcare cost and utilization project; ICD-9/10-CM, International Classification of Diseases-Ninth or Tenth Revision-Clinical Modification; TBSA, total body surface area.

medical records from HCPs and administrative claims to obtain comprehensive and complete documentation on patient characteristics, autografting and burn-related treatment patterns, accompanied by corresponding costs of treatment.

There were some differences in the %TBSA burned data between administrative claims and medical records. As mentioned earlier, claims are filed using codes, which, owing to code availability and coding practices, might represent a simplification of the complexities seen in clinical practice. The differences we observed in this study could, in part, be explained by the fact that the required diagnosis codes that accompany autografting for billing purposes used in administrative claims were third-degree burns or higher, whereas the %TBSA burned that was documented in medical records was more detailed and inclusive of varying burn-depth categories. In this study, patients were stratified into cohorts for analysis based on the %TBSA burned recorded in their medical charts by HCPs.

The complementary information we hoped to obtain from patient medical records was frequently not well documented. We found that even %TBSA burned, a critical piece of clinical information for burn treatment, was not documented in 15 out of the 200 medical records in our study. In the 200 records abstracted, incomplete documentation of key patient characteristics, such as BMI (31% undocumented), and autograft procedure details, such as size of autograft donor site (80% undocumented) and mesh ratio (24% undocumented), limited our ability to generate broader insights. BMI is a measure of obesity, which may present significant challenges to burn treatment management and wound healing.¹⁴ Metabolically and endocrinologically active adipose tissue, which is abundant in obese patients, releases proinflammatory mediators following severe burns.¹⁴ This release may lead to adverse events and obesity-related complications, thereby influencing the outcomes of acute and continuing burn care. Studies have shown that patients who have burn injuries and severe obesity have a longer overall length of hospital stay, as well as a higher mortality rate compared with normal-weight burn patients. Obesity is usually undercoded in administrative claims data, which emphasizes the need to obtain accurate documentation of BMI in patient medical records.¹⁵ Additionally, autograft harvesting creates a donor-site wound that is susceptible to fluid loss, infection, permanent scarring, and other morbidities.^{16–19} A higher skin graft mesh ratio allows a skin graft to stretch, and although this increases the area covered by the graft and improves adherence to convoluted wounds, it also increases healing times for the wound and causes a scar with a checkerboard appearance.^{20,21} The size of the burn wound excised/autografted is typically

Table 4 Costs of Burn Treatment by %TBSA Cohort

Costs	Minor (< 10%) %TBSA				Moderate (10%–24%) %TBSA				Major (≥ 25%) %TBSA				P value ^a		
	n	Mean	SD	Median	n	Mean	SD	Median	n	Mean	SD	Median	Minor vs Moderate	Minor vs Major	Moderate vs Major
From Administrative Claims															
All-cause															
Total cost ^b	90	\$75,025	\$78,900	\$53,129	75	\$173,532	\$161,563	\$129,240	35	\$561,433	\$605,183	\$364,666	< 0.001	< 0.001	< 0.001
Total medical cost ^c	90	\$74,943	\$78,867	\$53,107	75	\$173,381	\$161,547	\$129,235	35	\$560,192	\$604,132	\$364,595	< 0.001	< 0.001	< 0.001
Inpatient	90	\$74,926	\$78,864	\$53,107	75	\$173,367	\$161,535	\$129,011	35	\$560,166	\$604,124	\$364,595	< 0.001	< 0.001	< 0.001
ER visits	90	\$0	\$0	\$0	75	\$0	\$0	\$0	35	\$0	\$0	\$0	–	–	–
Physician office visits	90	\$17	\$83	\$0	75	\$15	\$79	\$0	35	\$25	\$119	\$0	0.477	0.882	0.696
Other outpatient services	90	\$0	\$0	\$0	75	\$0	\$0	\$0	35	\$1	\$7	\$0	–	0.113	0.149
Pharmacy cost	90	\$82	\$215	\$13	75	\$151	\$366	\$42	35	\$1241	\$5926	\$74	0.003	0.001	0.092
Patients with ≥1 prescription fills	58	\$127	\$258	\$31	56	\$202	\$412	\$68	27	\$1609	\$6731	\$97	0.002	< 0.001	0.026
Burn-related															
Total cost ^b	90	\$74,959	\$78,872	\$53,129	75	\$173,454	\$161,540	\$129,240	35	\$560,236	\$604,126	\$364,627	< 0.001	< 0.001	< 0.001
Total medical cost ^{c,d}	90	\$74,942	\$78,868	\$53,107	75	\$173,381	\$161,547	\$129,235	35	\$560,191	\$604,133	\$364,595	< 0.001	< 0.001	< 0.001
Inpatient	90	\$74,926	\$78,864	\$53,107	75	\$173,367	\$161,535	\$129,011	35	\$560,166	\$604,124	\$364,595	< 0.001	< 0.001	< 0.001
ER visits	90	\$0	\$0	\$0	75	\$0	\$0	\$0	35	\$0	\$0	\$0	–	–	–
Physician office visits	90	\$16	\$82	\$0	75	\$15	\$79	\$0	35	\$25	\$119	\$0	0.663	0.956	0.696
Other outpatient services	90	\$0	\$0	\$0	75	\$0	\$0	\$0	35	\$0	\$0	\$0	–	–	–

(Continued)

Table 4 (Continued).

Costs	Minor (< 10%) %TBSA				Moderate (10%–24%) %TBSA				Major (≥ 25%) %TBSA				P value ^a		
	n	Mean	SD	Median	n	Mean	SD	Median	n	Mean	SD	Median	Minor vs Moderate	Minor vs Major	Moderate vs Major
Pharmacy cost ^e	90	\$17	\$47	\$8	75	\$72	\$298	\$17	35	\$46	\$65	\$20	0.006	0.006	0.565
Patients with ≥1 prescription fills	54	\$29	\$58	\$18	55	\$99	\$345	\$27	27	\$59	\$69	\$32	0.013	0.023	0.719

Notes: ^aP values were calculated from Chi-squared tests for categorical variables, Fisher exact tests for flag variables, and t-tests or Wilcoxon tests for continuous variables; Bonferroni corrected alpha = 0.017. ^bSum of medical and pharmacy costs. ^cSum of inpatient, ER, physician office visits, and other outpatient services. ^dBurn-related medical claims were limited to claims with ICD-9/10-CM codes for burns (including all sequelae of burns) or any of ICD-9/10-CM /PCS procedure or CPT codes for skin grafts/skin substitutes (HCUP CCS procedure categories 172) on the medical claims associated with that service. ^eBurn-related pharmacy claims were: (a) medications for pain, mental conditions, and depression (non-opioid analgesics, opioid analgesics, hypnotics, anxiolytics, and antidepressants), (b) medication for infection (antibiotics), (c) medication for itching (naltrexone, gabapentin/pregabalin, H₁ receptor antagonist).

Abbreviations: %TBSA, percentage of total body surface area; CCS, clinical classifications software; CPT, current procedural terminology; ER, emergency room; H₁, histamine receptor; HCUP, healthcare cost and utilization project; ICD-9/10-CM, International Classification of Diseases-Ninth or Tenth Revision-Clinical Modification; PCS, procedure coding system; SD, standard deviation.

documented and used for reimbursement; however, it may not reflect the area of skin harvested (size of autograft donor site) to provide those autografts. The autograft donor area can vary greatly based on the mesh ratios chosen to stretch the skin to fit the excised area. Despite the importance of clinical information such as BMI, size of autograft donor site, and mesh ratio on inpatient burn care decision-making, a substantial number of medical records we obtained for this study had no documentation of such data. The burn community could establish a standard way to record the calculated area or %TBSA that was autografted and the autograft donor sites, as well as the mesh ratios for each area autografted. This approach might facilitate the documentation by building a module with those required data fields in electronic medical records systems. Additionally, notes on the healing progress (eg, percentage of wound re-epithelialized or still open) at discharge should be standardized. It is critical for providers to accurately record these key parameters in the patients' medical records to provide a more robust picture of burn care.

Ideally, RWD from multiple sources should provide a more comprehensive view to generate RWE and, hence, better inform treatment decisions, as well as support the development of treatment guidelines and regulatory filings.²² Our study highlights that, in reality, the lack of consistent documentation on essential clinical characteristics of patients with burn injuries in their medical records limits our ability to better understand the relationship between burn treatment and patient outcomes, even after we integrated 2 important RWD sources of medical records and administrative claims. Similarly, a recent study examining the role of RWE in oncology product approvals by the US Food and Drug Administration found that incomplete data on important prognostic factors have rendered real-world studies and controlled clinical trials incomparable for certain cancer therapies.²³ These findings emphasize the importance of comprehensive documentation of clinical characteristics and outcomes in the operative and medical notes for patients, which are critical to appropriately evaluate the impact of the treatment on outcomes in future research using RWD.

Our study, linking HCP-provided medical records on patients with administrative claims from the HIRD, had several limitations. Abstracted medical records data are only available for a subset of the patients identified in the administrative claims analysis; therefore, these data may not uniformly represent entire populations identified in the claims analysis. All patients included in the study were enrolled in commercial or Medicare Advantage health insurance plans in the US and satisfied all inclusion/exclusion criteria. The results may not be generalizable to patients with other types of health insurance (eg, Medicaid), those who are uninsured, or to those outside the US.

Abstracted medical records were limited by what the HCPs documented in the patients' medical charts and to what was supplied by the facilities even though we requested full medical records (eg, the HCP may have a "working copy" of a record that has pertinent information but not complete clinical data). Despite our best efforts to oversample patients with severe burn injuries, the final sample size in the major %TBSA group was small, somewhat limiting the statistical inference. The length of the follow-up period (6 months postindex date) required to estimate HCRU and treatment costs could potentially have excluded patients with severe complications who died during or right after initial autografting hospitalization, thus introducing survival bias into costs and HCRU examination.

Conclusion

This study, leveraging RWD from 2 independent sources, confirmed that length of hospital stay and overall cost of care positively correlated with %TBSA burned in patients who underwent inpatient burn care and autografting. In this privately insured burn patient cohort undergoing inpatient autografting, we found a predominance of White men, and prevalence of diabetes mellitus and hypertension in a relatively young population. There was considerable incompleteness in many critical fields in the medical records, which limited the ability to generate broader insights. In future studies investigating outcomes in patients with burns, researchers should be aware of these limitations, and consider combining data from multiple real-world sources. More detailed documentation of the clinical characteristics and outcomes (eg, size of autograft donor site, mesh ratio, failure to heal, healing times, etc.) of autografts and donor sites in the operative and medical notes are critical to facilitate the correct evaluation of their impact on the outcomes of burn treatments in future research using RWD.

Abbreviations

%TBSA, percentage of total body surface area; BMI, body mass index; COPD; chronic obstructive pulmonary disease; DPT, deep partial-thickness; FT, full-thickness; HCP, healthcare provider; HCRU, healthcare resource utilization;

HIPAA, Health Insurance Portability and Accountability Act; HIRD[®], HealthCore Integrated Research Database[®]; ICD-9/10-CM, International Classification of Diseases-Ninth or Tenth Revision-Clinical Modification; ICU, intensive care unit; IRB, institutional review board; PPO, provider preferred organization; RWD, real-world data; RWE, real-world evidence; SD, standard deviation; TBSA, total body surface area; US, United States.

Data Sharing Statement

Restrictions apply to the availability of the HIRD, and the data used in analysis are not available to the public.

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Author Contributions

All authors (HH, T-CY, C-CT, and HT) made a significant contribution to the conception, study design, and analysis and interpretation of data. All authors contributed to the drafting, revision, and critical review of the article. The authors have agreed on the submission of the article to *ClinicoEconomics and Outcomes Research*. The authors reviewed and agreed on the different versions of this article. They approved the final version for submission and any changes introduced at the proofing stage. All authors accept responsibility for the content of the article.

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Disclosure

HH and T-CY are employees of Mallinckrodt Pharmaceuticals, Hampton, NJ, USA. Authors C-CT and HT are employees of HealthCore, Inc., Wilmington, DE, USA, whose activities on research projects are funded by various pharmaceutical/biotechnology/medical device companies. The authors report no other conflicts of interest in this work.

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