Received: 22 February 2022 | Revised: 1 April 2022 | Accepted: 25 April 2022

DOI: 10.1111/ctr.14692

Clinical TRANSPLANTATION
The Journal of Clinical and Translational Research

WILEY

ORIGINAL ARTICLE

Impact of the heart transplant allocation policy change on inpatient cost of index hospitalization

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[Correction added on 12 June 2022, after first online publication: reference number 2 has been updated in the reference list.]

Abstract

Background: We sought to determine the financial impact of the United Network for Organ Sharing heart transplant (HT) allocation policy change of October 2018.

Methods: Using the Nationwide Inpatient Sample we retrospectively analyzed hospital discharge data between January 1, 2016 and December 31, 2019. ICD-10-CM procedure codes were used to identify hospitalizations of patients undergoing HT as well as the use of temporary mechanical circulatory support (MCS) during the HT hospitalization. Patients $<$ 18 years old and those with missing data on costs were excluded. The primary outcome was inflation-adjusted costs. Total costs were inflated to 2019 US dollars.

Results: During the course of the study, temporary MCS increased significantly among 11 380 weighted patients transplanted while mean length of stay (LOS) did not. Mean inflation-adjusted costs rose about $40k per HT. On univariate analysis, transplantation year, use of temporary MCS and LOS were all significantly associated with increased cost while on multivariate analysis only temporary MCS and LOS were.

Conclusions: The 2018 allocation change has resulted in more expensive inpatient costs for HT correlating with an increase in temporary MCS.

KEYWORDS
health care cost, heart transplant, UNOS allocation policy

1 | INTRODUCTION

Heart transplantation (HT) is associated with significant financial costs.[1,2] Due to financial pressures across the healthcare system, value-driven care is receiving increased scrutiny. In October 2018, the United Network for Organ Sharing updated the HT allocation policy to address important limitations in the former 3-tiered system that included discrepancies in listing priority relative to patient risk characteristics and allocation of donor organs based on strict geographic location. A major driver of the new allocation system was to improve equitable access to donor organs and reduce waitlist times while maintaining or improving transplant outcomes. Previous studies have confirmed improved waitlist outcomes and increased transplantation rates in the new allocation system[3] with variable effects on post-transplant outcomes.[4,5] To further understand the effect of the allocation policy change on the value of care, we sought to determine its impact on the inpatient cost associated with HT in the United States.

2 | METHODS

We performed a retrospective analysis of discharge data from the National Inpatient Sample (NIS) between January 1, 2016 and December 31, 2019. The NIS contains discharge data from a 20% stratified sample of community hospitals in the United States and is a part of the Healthcare Quality and Utilization Project (HCUP). Each discharge information includes de-identified elements such as patient demographics, principal diagnosis, secondary diagnoses, procedural codes, and costs. Our Institutional Review Board waived approval due to lack of private individually identifiable information and direct intervention or interaction. We acknowledge participation in the Transplant Peer Review Network and complied with the journal's author guidelines and policies.

We used the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) procedure code 02YAxxxx to identify all hospitalizations of patients who underwent HT. Temporary mechanical circulatory support (MCS) use was identified using ICD-10-CM procedure codes 5A02xxx, 02HA0Rx,02HA0Yx, 02HA3Rx, 02HA3Yx, 02HA4Rx, 02HA4Yx, and 5A15223. Durable mechanical support such as implantable ventricular assist devices were counted as MCS and were not otherwise analyzed. We excluded patients < 18 years of age and those with missing data on cost. To calculate total inpatient cost of HT of all the patients, we replaced missing values of the cost with mean inflation adjusted costs for the respective years. The primary outcome of interest was inflation-adjusted costs.

All statistical analyses were done using discharge weights provided by the NIS to obtain national estimates. Continuous variables were described as mean and standard error (SE) and categorial variables as frequencies and percentages. Trends in baseline characteristics and outcomes were examined using logistic regression for categorical variables and linear regression for continuous variables, using year as sole predictor. Hospital total charges were converted to cost estimates using hospital-specific cost-to-charge ratios provided by the HCUP. Briefly, cost-to-charge ratios (CCRs) are distributed by the HCUP as supplemental files that can be linked to HCUP State and nationwide databases. The CCRs, when combined with total charges found on inpatient discharge or emergency department visit records are used to estimate hospital delivery costs. Service delivery costs are those associated with treating a patient, including labor, supplies, and overhead.[6] Total costs were inflated to 2019 US dollars.[7] We examined the predictors of inflation-adjusted cost of care using a linear regression model with year, length of stay (LOS) and MCS as univariate and subsequently multivariate predictors. Using Stata 16.1 (StataCorp, College Station, TX, USA), our analyses took into account survey design complexity by incorporating sampling weights, primary sampling units, and strata. Standard errors were computed using Taylor series linearization. P-values < .05 were considered statistically significant.

3 | RESULTS

Of 11 380 weighted hospital patients that met inclusion criteria, .18% were excluded for missing cost data. Baseline characteristics are shown in Table 1. Temporary MCS increased significantly during the course of the study from 19.13% in 2016 to 47.15% in 2019 (P < .001), with the most prominent increase occurring between 2018 and 2019. Neither LOS nor insurance status changed significantly over time. Mean inflation-adjusted cost per HT rose from \$232 897±13 769 (SE) and \$235 030±14 192 in 2016 and 2017, respectively, to \$255 243±12 219 and \$271 973±12 022 in 2018 and 2019, respectively (P = .017). Total inflation adjusted cost for all transplants performed were \$640 467 338 and \$616 953 395 in 2016 and 2017, respectively, and \$773 389 159 and \$814 558 928 in 2018 and 2019, respectively. On univariate analysis, transplantation year, use of temporary MCS, and LOS were all statistically significant predictors of cost (Table 2), while on multivariate analysis only temporary MCS and LOS remained significant predictors (Table 3).

3.1 | Comment

Here, we demonstrate several important findings; namely, that the costs associated with index HT hospitalization increased following the 2018 allocation system change primarily due to increased use of temporary MCS. Previous studies support our results. Using game-theory probability Saltzberg predicted reduced cost effectiveness (cost for year of post-transplant life expectancy) of HT after the 2018 allocation change due to increased short-term MCS, increased procurement radius and ischemic times and reduced post-transplant survival.[8] Rogers and colleagues, using regional data of 759 transplants, showed a significant increase in total hospital charges (un-adjusted for inflation) after the allocation change without changes in LOS.[9] We extend these results using national data with amplified statistical power and inflation-adjusted hospital costs to demonstrate an increase in expense. Our study shows similar mean costs per HT in 2016 and 2017 prior to the allocation change with an increase in the year 2018, midway through which the allocation policy change was implemented, and a continued increase in 2019, the first full year of the policy change. It cost on average \$38 009 more per transplant in 2019 than the average cost per transplant from 2016 to 2017. This will result in \$100–\$120 million more per year (15-18% increase in cost) to deliver the current volume of transplants performed annually in the United States. Our data correlate the increased expense with an increase in use of temporary MCS, which has become more common since the allocation change due to association with higher listing status and faster transplant times.[3,10] Despite higher use of temporary MCS, which often requires inpatient wait for HT, LOS did not change over time likely because of significantly reduced waitlist times under the new allocation system.

Limitations of our study include those inherent to the NIS itself and several other considerations. The NIS is an administrative database that lacks granularity and for which there is potential for inaccurate data collection and classification which may have affected results. Also, the NIS heart transplant data that we report is about 10–15% lower than the UNOS data likely due to the extrapolation of the 20% stratified sample that is used and it is possible this difference in volume confounded our results. In addition, there are other factors leading to costs to the transplant system, including those associated with wait

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The Journal of Clinical and Translational Research
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TABLE 1 Baseline characteristics and trends in hospitalizations of patients undergoing heart transplant age ≥ 18 years in the United States, 2016–2019

Variables, weighted *n* (%)	2016 (Weighted *n* = 2745)	2017 (Weighted *n* = 2625)	2018 (Weighted *n* = 3030)	2019 (Weighted *n* = 2980)	Total (Weighted *n* = 11380)	*P* value
Age (mean [S.E]) years	54.05 (.66)	53.86 (.56)	54.34 (.56)	53.31 (.54)	53.89 (.29)	.516
Female	700 (25.5)	670 (25.52)	915 (30.2)	935 (31.38)	3220 (28.3)	.01
Race						.454
White	1565 (60.42)	1525 (61.49)	1790 (60.78)	1755 (60.31)	6635 (60.73)	
Black	570 (22.01)	550 (22.18)	625 (21.22)	710 (24.4)	2455 (22.47)	
Hispanic	230 (8.88)	245 (9.88)	350 (11.88)	270 (9.28)	1095 (10.02)	
Other	225 (8.69)	160 (6.45)	180 (6.11)	175 (6.01)	740 (6.77)	
Comorbidities						
Chronic pulmonary disease	355 (12.93)	290 (11.05)	425 (14.03)	400 (13.42)	1470 (12.92)	.461
Atrial fibrillation	1085 (39.53)	1040 (39.62)	1210 (39.93)	1100 (36.91)	4435 (38.97)	.453
Diabetes mellitus	845 (30.78)	830 (31.62)	1050 (34.65)	900 (30.2)	3625 (31.85)	.909
Hypertension	1805 (65.76)	1925 (73.33)	2415 (79.7)	2260 (75.84)	8405 (73.86)	.001
Valvular disease	625 (22.77)	580 (22.1)	705 (23.27)	605 (20.3)	2515 (22.1)	.432
Obesity	280 (10.2)	380 (14.48)	370 (12.21)	345 (11.58)	1375 (12.08)	.768
Renal failure	1285 (46.81)	1210 (46.1)	1425 (47.03)	1195 (40.1)	5115 (44.95)	.072
Peripheral vascular disease	1370 (49.91)	1135 (43.24)	1480 (48.84)	1245 (41.78)	5230 (45.96)	.086
Liver disease	305 (11.11)	240 (9.14)	440 (14.52)	385 (12.92)	1370 (12.04)	.129
Neurological disorders	250 (9.11)	325 (12.38)	415 (13.7)	420 (14.09)	1410 (12.39)	.011
Hypothyroidism	425 (15.48)	365 (13.9)	385 (12.71)	470 (15.77)	1645 (14.46)	.977
Carotid artery disease	15 (.55)	35 (1.33)	30 (.99)	15 (.5)	95 (.83)	.729
Dyslipidemia	1100 (40.07)	970 (36.95)	1025 (33.83)	1025 (34.4)	4120 (36.2)	.082
Smoking	635 (23.13)	575 (21.9)	590 (19.47)	525 (17.62)	2325 (20.43)	.043
Alcohol abuse	65 (2.37)	30 (1.14)	45 (1.49)	50 (1.68)	190 (1.67)	.496
Drug abuse	40 (1.46)	60 (2.29)	45 (1.49)	20 (.67)	165 (1.45)	.089
Coronary artery disease	1260 (45.9)	1050 (40)	1330 (43.89)	1145 (38.42)	4785 (42.05)	.062
Previous myocardial infarction	425 (15.48)	355 (13.52)	345 (11.39)	350 (11.74)	1475 (12.96)	.057
Previous CABG	220 (8.01)	160 (6.1)	210 (6.93)	155 (5.2)	745 (6.55)	.129
Previous PCI	195 (7.1)	165 (6.29)	230 (7.59)	160 (5.37)	750 (6.59)	.406
Prior cerebrovascular disease	335 (12.2)	375 (14.29)	285 (9.41)	310 (10.4)	1305 (11.47)	.089
Prior PPM or ICD	985 (35.88)	925 (35.24)	1075 (35.48)	935 (31.38)	3920 (34.45)	.222
Hospital location						.608
Rural/urban non-teaching	15 (.55)	35 (1.33)	25 (.83)	<11 cell count	85 (.75)	
Urban teaching	2730 (99.45)	2590 (98.67)	3005 (99.17)	2970 (99.66)	11295 (99.25)	
Bed size of the hospital						.562
Small	25 (.91)	25 (.95)	35 (1.16)	65 (2.18)	150 (1.32)	
Medium	260 (9.47)	255 (9.71)	300 (9.9)	180 (6.04)	995 (8.74)	
Large	2460 (89.62)	2345 (89.33)	2695 (88.94)	2735 (91.78)	10235 (89.94)	
Region						.865
Northeast	455 (16.58)	455 (17.33)	580 (19.14)	580 (19.46)	2070 (18.19)	
Midwest	580 (21.13)	545 (20.76)	670 (22.11)	715 (23.99)	2510 (22.06)	
South	1110 (40.44)	1055 (40.19)	1095 (36.14)	1090 (36.58)	4350 (38.22)	
West	600 (21.86)	570 (21.71)	685 (22.61)	595 (19.97)	2450 (21.53)	

(Continues)

TABLE 1 (Continued)

Variables, weighted *n* (%)	2016 (Weighted *n* = 2745)	2017 (Weighted *n* = 2625)	2018 (Weighted *n* = 3030)	2019 (Weighted *n* = 2980)	Total (Weighted *n* = 11380)	*P* value
Primary expected payer						.057
Medicare	1085 (40.04)	1025 (39.42)	1135 (37.52)	965 (32.44)	4210 (37.22)	
Medicaid	330 (12.18)	295 (11.35)	345 (11.4)	395 (13.28)	1365 (12.07)	
Private insurance	1165 (42.99)	1150 (44.23)	1360 (44.96)	1505 (50.59)	5180 (45.8)	
Self-pay, no charge, or other	130 (4.8)	130 (5)	185 (6.12)	110 (3.7)	555 (4.91)	
Elixhauser comorbidity index						.061
0–4	325 (11.84)	345 (13.14)	305 (10.07)	245 (8.22)	1220 (10.72)	
5–8	1945 (70.86)	1890 (72)	2100 (69.31)	2285 (76.68)	8220 (72.23)	
> = 9	475 (17.3)	390 (14.86)	625 (20.63)	450 (15.1)	1940 (17.05)	
Mechanical circulatory support	525 (19.13)	545 (20.76)	665 (21.95)	1405 (47.15)	3005 (26.41)	<.001
LOS (mean [S.E]) days	39.01 (2.48)	36.36 (2.07)	39.51 (1.81)	40.18 (1.55)	38.84 (.99)	.46
Inflation-adjusted cost, US $ (mean [S.E])	232897.1 (13769.4)	235029.78 (14191.61)	255243.86 (12219.01)	271972.85 (12021.76)	249571.5 (6591.61)	.017

Abbreviations: CABG, Coronary Artery Bypass Graft; ICD, Implantable Cardioverter Defibrillator; LOS, Length of stay; PCI, Percutaneous Coronary Intervention; PPM, Permanent Pacemaker; SE, Standard Error.

TABLE 2 Univariate analysis of predictors of inflation-adjusted cost in hospitalizations of patients undergoing heart transplant age ≥ 18 years in the United States, 2016–2019

Variables	Beta-coefficient	95% CI (Lower, Upper)	*P* value
Year	13770.07	2444.99, 25095.16	.017
Mechanical circulatory support	112944.5	89490.83, 136398.1	<.001
Length of stay (days)	3924.615	3537.59, 4311.64	<.001

TABLE 3 Multivariate analysis of predictors of inflation-adjusted cost in hospitalizations of patients undergoing heart transplant age ≥ 18 years in the United States, 2016–2019

Variables	Beta-coefficient	Lower, Upper	*P* value
Year	7311.19	−1758.20, 16380.58	.114
Mechanical circulatory support	48913.17	32647.79, 65178.54	<.001
Length of stay (days)	3793.31	3408.24, 4178.37	<.001

time outside the hospital (which are overall shorter under the new allocation system), amplified use of normothermic ex-vivo perfusion and donation after cardiac death as well as increased travel costs (which have been noted to be higher since 2018 due to greater donor distance[11]) that were not evaluated in the current analysis, but are likely to be low relative to inpatient costs. While average cost per transplant increased there was also an increase in transplant volume after the allocation change which may be beneficial from a patient and society standpoint. There was also a reduction in durable LVADs after the allocation change, since durable LVADs are typically implanted on a prior admission the cost is not captured in our analysis and may confound results. Finally, only the first full year post the 2018 allocation system change was analyzed due to data availability. In conclusion, the 2018 allocation policy change has substantially increased inpatient HT expense due to increased use of temporary MCS. Future iterations of the UNOS allocation system will need to account for rising costs in addition to outcomes in order to optimize delivery of value-driven care.

ACKNOWLEDGMENT

We have no relevant disclosures or funding sources to report.

CONFLICT OF INTEREST

None.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in National Inpatient Sample at https://www.hcup-us.ahrq.gov/nisoverview.jsp.

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How to cite this article: Abramov D, Minhas AMK, Fudim M, Chung JS, Patel JN, Rabkin DG. Impact of the heart transplant allocation policy change on inpatient cost of index hospitalization. *Clin Transplant*. 2022;36:e14692. https://doi.org/10.1111/ctr.14692