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ORIGINAL ARTICLE

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Impact of standardized clinical assessment and management plans on resource utilization and costs in children after the arterial switch operation

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Abstract

Background: Standardized Clinical Assessment and Management Plans (SCAMPs) are a quality improvement initiative designed to reduce unnecessary utilization, decrease practice variation, and improve patient outcomes. We created a novel methodology, the SCAMP managed episode of care (SMEOC), which encompasses multiple encounters to assess the impact of the arterial switch operation (ASO) SCAMP on total costs.

Methods: All ASO SCAMP patients (dates March 2009 to July 2015) were compared to a control group of ASO patients (January 2001 to February 2009). Patients were divided into "younger" (<2 years) and "older" (2–18 years) subgroups. Utilization included all cardiology visits, tests, and procedures. Standardized costs were applied to each unit of utilization.

Results: There were 100 historical and 63 SCAMP patients in the younger subgroup, and 163 historical and 165 SCAMP patients in the older subgroup. In the younger subgroup, the SCAMP had a 28% reduction in outpatient clinic visits ($P < .001$), a 52% reduction in chest radiographs ($P < .001$), a 21% reduction in electrocardiograms ($P < .001$), and a 30% total reduction in costs. In the older subgroup, the SCAMP had a 21% reduction in outpatient clinic visits ($P < .001$), a 20% reduction in chest radiographs ($P = .05$), a 10% reduction in echocardiograms ($P = .05$), a 25% reduction in exercise stress tests ($P = .01$), and a 14% total reduction in costs. The total cost savings of the ASO SCAMP was $216 649 in the first 6 years of the SCAMP. There was no difference in clinical outcomes between the historical and SCAMP cohorts.

Conclusion: SCAMPs can improve resource utilization and reduce costs after the ASO operation while maintaining quality of care.

KEYWORDS
congenital heart disease, cost reduction, resource utilization, standardization

1 | INTRODUCTION

The arterial switch operation (ASO) is the preferred surgical repair for children born with D-looped transposition of the great arteries. It has excellent long-term survival and cardiovascular outcomes.[1] However, there are significant long-term complications including main and branch pulmonary artery stenosis, valve dysfunction, coronary artery obstruction, and ventricular dysfunction. Consequently, following the ASO, patients require lifelong cardiology follow-up, primarily on an outpatient basis. "Best" practices for outpatient care in this population remain unclear, and there is significant variation among clinicians and institutions. Moreover, the total cost of outpatient management and the optimal resource utilization for this patient population are unknown.

We have implemented a standardized approach to treating ASO patients in our outpatient cardiology clinic as part of a broader effort termed Standardized Clinical Assessment and Management Plans (SCAMPs). SCAMPs are a quality improvement initiative designed to eliminate unnecessary resource utilization, decrease practice variation, and improve patient outcomes. The SCAMPs methodology has been described in detail.[2–5] In brief, the ASO SCAMP development process included a background position paper, targeted data statements, a consensus based management algorithm, and targeted data collection. The ASO SCAMP was introduced in 2009 and is currently on its fourth iteration. The major changes to the SCAMP involved creation of a low and high-risk stratification score (January 2011) with less frequent follow-up and testing for low-risk patients (January 2011 and January 2012). An overview of the ASO SCAMP has been previously described.[6] The goal of this study was to measure the impact of the ASO SCAMP on total resource utilization.

2 | METHODS

2.1 | Inclusion and exclusion criteria for the ASO SCAMP

Patients were eligible for inclusion in the ASO SCAMP if they had a diagnosis of D-looped transposition of the great arteries or double outlet right ventricle and underwent an ASO in the first 3 weeks of life. Patients > 18 years old were excluded. Only patients exclusively managed at Boston Children's Hospital were included in the analysis to accurately capture all resource utilization. Patients were enrolled in the ASO SCAMP during outpatient clinic visits. The time period of data collection for the ASO SCAMP was from March 2009 to July 2015.

2.2 | SCAMP managed episode of care

Estimates of health care costs often rely on a single encounter, ignoring deferred care that may increase utilization. To address this deficiency, we defined a SCAMP managed episode of care (SMEOC) to encompass multiple encounters to assess the impact of SCAMPs on total costs after the ASO. The SMEOC window is a length of time and should be defined in advance. The SMEOC length is influenced on the disease processes, expected intervals of follow-up, and projected frequency of outcome events. The SMEOC should be broad enough to encompass variations in care and clinical course yet small enough so that studies can be practically performed.

Creating a SMEOC is a multi-step process that can easily be applied to any SCAMP. Step one is the identification of all unique cohorts or subgroups that are likely to have an impact on utilization (e.g., age, risk-severity score). Step two involves describing the duration of or boundaries for the episode of care for the SCAMP. For example, a SMEOC can be a fixed time in years, or defined by the timing around a cardiac event or procedure. Step three is the identification of which resource utilization units are relevant for the specific SCAMP (e.g., outpatient visits, echocardiograms, and exercise stress tests). Once all resource utilization units are identified, an average fixed dollar cost is assigned to each unit type and is kept constant throughout analysis.

2.3 | The ASO SMEOC

This SMEOC methodology was applied to the ASO SCAMP. Step one was the identification of all clinically important subgroups within the ASO SCAMP that a priori were thought to influence resource utilization. Younger patients were expected to be followed more closely, and, therefore, were likely to have increased resource utilization. Accordingly, patients were divided into "younger" (age < 2 years) and "older" (age 2–18 years) subgroups. In the ASO SCAMP, patients were classified as being "low-risk" or "high-risk" based on having any of the criteria in Table 1. As risk factors can develop over time, the risk assignment was based on the predominant risk category that was present during most of the SMEOC duration. As high-risk patients were expected to have increased resource utilization due to greater clinical concerns, they were also identified as an important subgroup.

Step two was to define the unique episode of care. Based on the recommended ASO SCAMP outpatient follow-up intervals, the SMEOC duration was defined as 2 years for the younger subgroup and 3 years for the older subgroup. Patients < 2 years of age at their first clinic visit who continued to be followed beyond 2 years of age were included in both the younger and older cohorts. Patients remained in the younger cohort for a total duration of 2 years. Two years plus 1 day was calculated from the first clinic visit for each patient in the younger subgroup and used as the first date in the older subgroup. A

TABLE 1 High-risk criteria for the arterial switch operation SCAMP

Risk factor
Coronary artery stenosis
RVOT/MPA stenosis ≥ moderate
Branch PA stenosis ≥ moderate
Tricuspid or pulmonary valve regurgitation ≥moderate
Mitral or aortic valve regurgitation ≥ moderate
Tricuspid, mitral, or aortic valve stenosis ≥ moderate
LV dysfunction ≥ moderate
RV dysfunction ≥ moderate
Ventricular arrhythmia
Atrial arrhythmia
Aortic root/ascending aorta dilation (*z*-score ≥ 5)
ICD/PM placement

Abbreviations: ICD, implantable cardioverter defibrillator; LV, left ventricle; MPA, main pulmonary artery; PM, pacemaker; PA, pulmonary artery; RV, right ventricle; RVOT, right ventricular outflow tract; SCAMP, Standardized Clinical Assessment and Management Plan.

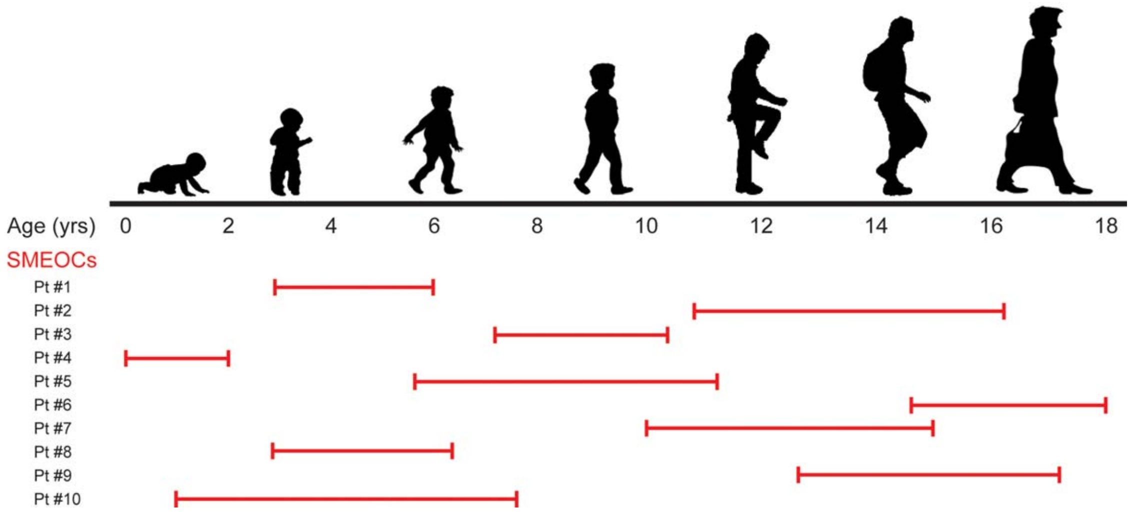

FIGURE 1 Longitudinal episodes of care for the arterial switch operation SCAMP. The red bars designate relative durations of the SCAMP managed episode of care (SMEOCs). Each bar represents one typical patient. SMEOCs can vary in length, but at a minimum were defined as 2 years for younger patients and 3 years for older patients. Patients can enter and exit the SCAMP at different time points, but with enough patients there is sufficient overlap to adequately characterize the care delivery during the first 18 years of life

patient's 18th birthday was taken as their last day of follow-up and all subsequent events were excluded. Patients with at least one full SMEOC of follow-up were included in the analysis. For patients with follow-up longer than one SMEOC, mean utilization was reported per SMEOC. Figure 1 depicts the longitudinal infant to adulthood framework encompassed by the ASO SCAMP.

Step three was the identification of all cardiology resource utilization units relevant to the ASO SCAMP. This included all cardiology clinic visits, echocardiograms, chest radiographs, exercise stress tests, electrocardiograms, Holter and event monitors, lung perfusion scans, and cardiac magnetic resonance examinations (CMR). In addition, the number of cardiac catheterizations, electrophysiology procedures, cardiac surgeries, and all inpatient admissions (to a cardiology or cardiac surgical service) were counted for all patients. Resource utilization by general pediatricians or other specialists was not captured in this analysis. Events per SMEOC were then calculated at the patient level. Patients were enrolled in the ASO SCAMP at the time of the first completed outpatient SCAMP data form. Resource utilization performed at this first ASO SCAMP visit was attributed to the historical period as those management decisions were usually made at the prior visit, and therefore reflected pre-SCAMP treatment. Any subsequent testing, evaluation, events, or follow-up were attributed to the SCAMP.

2.4 | Event cost assignment

The cost of each utilization event was calculated as 60% of charges for the calendar year 2015. Both professional and technical fees were included in cost estimates. The unit costs were kept fixed throughout the analysis to control for the impact of inflation and contractual insurance adjustments. Due to variable cost of inpatient admissions, catheterizations, and cardiac surgeries, more accurate patient specific costs were calculated based on global charge bundles as previously reported.[7,8] These global charge bundles provide more accurate charges based on procedure complexity. Overhead costs were not included in charge calculations, as these were not expected to change due to the implementation of SCAMPS. Total costs were then calculated on a per patient level, allowing aggregated analysis per SMEOC.

2.5 | Historical cohort

To measure the impact of the ASO SCAMP, a historical cohort of consecutive patients was identified using identical inclusion and exclusion criteria, age-based subgroups, risk category, SMEOC durations, and capture of resource utilization. Data for this cohort was analyzed between January 2001 and 2009 or date of the first SCAMP visit. Cost was calculated using the same methodology as the SCAMP cohort and also expressed in 2015 US dollars.

As patients were often followed and managed as both an infant and older child, the same patient could cross over from one subgroup to another subgroup (eg, younger subgroup to older subgroup). In the same way, a patient could also cross over from the historical cohort to the SCAMP cohort). All subgroups and cohorts were analyzed separately.

2.6 | Statistical analysis

Counts and percentages were calculated for categorical demographic and clinical characteristics; median, minimum, and maximum values were calculated for all continuous demographic and clinical characteristics. Demographic and clinical characteristics were compared between cohorts using the chi-square or Fisher exact test for categorical variables, and Wilcoxon rank-sum test for continuous variables. The mean number of each resource utilization event type per SMEOC and the corresponding 95% confidence interval using the Poisson distribution was calculated. Also using the Poisson distribution, we determined the difference in means by chi-square across the historical and SCAMP cohorts stratified age subgroups and within risk categories. Bootstrap sampling (random sampling with replacement), which makes no assumptions regarding the distributional shape of each cost, was performed 2000 times for each cost. The mean and 95% CI for each cost or cohort difference in cost were derived from the distributions of the replicates obtained from the bootstrapping. All analyses were done in SAS Enterprise Guide 5.1.

2.7 | Statement of responsibility

The Boston Children's Hospital Committee on Clinical Investigation approved this retrospective study and waived the requirement for informed consent. The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

3 | RESULTS

3.1 | Patient characteristics

A total of 281 unique ASO patients met the study inclusion criteria over the historical cohort and SCAMP cohort time periods. In the younger subgroup, there were 100 historical and 63 SCAMP patients. In the older subgroup, there were 163 historical and 165 SCAMP patients. The demographic and clinical characteristics are summarized by age subgroup in Tables 2 and 3. In the younger subgroup, SCAMP patients were slightly older at first visit, but otherwise similar on all other demographic and clinical characteristics, including risk category. In the older subgroup, SCAMP patients were older at first visit, had shorter follow-up duration, and had fewer SMEOCs per patient.

3.2 | Resource utilization

Resource utilization was compared between the historical and SCAMP cohorts by age subgroup (Tables 4 and 5). In the younger subgroup, compared to the historical cohort, the SCAMP cohort had a 28% reduction in outpatient clinic visits ($P < .001$), a 52% reduction in chest radiographs ($P < .001$), and a 21% reduction in electrocardiograms ($P < .001$). In the older subgroup, compared to the historical cohort, the SCAMP cohort had a 21% reduction in outpatient clinic visits ($P < .001$), a 20% reduction in chest radiographs ($P = .05$), a 10% reduction in echocardiograms ($P = .05$), and a 25% reduction in exercise stress tests ($P = .01$). There was no category in which utilization for the SCAMP cohort was higher than that for the historical cohort.

3.3 | Cost savings

Total cost savings for the ASO SCAMP was calculated based on the total reduction in costs per patient SMEOC in the SCAMP cohort for all statistically significantly changed resource utilization events multiplied by the number of SMEOCs in the SCAMP cohort. In the younger subgroup, cost reduction analyses included outpatient clinic visits, chest radiographs, and electrocardiograms. Including only the cost of significantly changed events, there was a savings of $798 (95% CI—$395 to $1,197) per patient SMEOC in the SCAMP cohort, which represents 30% total cost reduction in those resources. Across the 63 patient SMEOCs in the SCAMP cohort, there was a cost savings of $50 274 during the SCAMP period.

In the older subgroup, cost reduction analyses included outpatient clinic visits, chest radiographs, echocardiograms, and exercise stress tests. Including only the cost of those significantly changed events, there was a savings of $605 (95% CI—$188 to $1041) per patient SMEOC in the SCAMP cohort, with a 15% total cost reduction in those

TABLE 2 Demographic and clinical characteristics for the younger (age < 2 years) patients

	All	Historic	SCAMP	*P* value
Number of patients	163	100	63	
Male	96 (59%)	56 (56%)	40 (63%)	.34
Age at first visit (years)	0.08 (0.03, 1.8)	0.08 (0.04, 1.4)	0.11 (0.03, 1.6)	< .01
Duration of follow-up (years)	2.0 (2.0, 2.0)	2.0 (2.0, 2.0)	2.0 (2.0, 2.0)	1.0
SMEOCs per patient	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)	1.0
High-risk patients	39 (24%)	20 (20%)	19 (30%)	.14
Cardiac diagnosis				.53
D-TGA	154 (94%)	95 (95%)	59 (94%)	
D-TGA + pulmonary stenosis	5 (3%)	2 (2%)	3 (5%)	
Double outlet right ventricle	4 (2%)	3 (3%)	1 (1%)	
History of VSD	67 (41%)	41 (41%)	26 (41%)	.97
History of coarctation	23 (14%)	12 (12%)	11 (17%)	.33
Death	1 (0.6%)	0 (%)	1 (2%)	.21

Values are expressed as n (%) or median (minimum, maximum).
Abbreviations: D-TGA, D-looped transposition of the great arteries; SCAMP, Standardized Clinical Assessment and Management Plan; SMEOC, SCAMP managed episode of care; VSD, ventricular septal defect.

TABLE 3 Demographic and clinical characteristics for the older (age 2–18 years) patients

	All	Historic	SCAMP	*P* value
Number of patients	328	163	165	
Male	199 (61%)	102 (63%)	97 (59%)	.48
Age at first visit (y)	5.4 (2.0, 15.3)	3.8 (2.0, 14.7)	6.1 (2.1, 15.3)	<.01
Duration of follow-up (y)	5.6 (3.0, 11.9)	6.9 (3.0, 11.9)	5.4 (3.0, 6.3)	<.01
SMEOCs per patient	1.9 (1.0, 4.0)	2.3 (1.0, 4.0)	1.8 (1.0, 2.1)	<.01
High-risk patients	66 (20%)	31 (19%)	35 (21%)	.62
Cardiac diagnosis				.51
D-TGA	319 (97%)	157 (96%)	162 (98%)	
D-TGA + pulmonary stenosis	2 (1%)	1 (1%)	1 (1%)	
Double outlet right ventricle	7 (2%)	5 (3%)	2 (1%)	
History of VSD	120 (37%)	60 (37%)	60 (36%)	.93
History of coarctation	31 (9%)	14 (9%)	18 (11%)	.48
Death	1 (0.3%)	1 (0.6%)	0 (0%)	.31

Values are expressed as n (%) or median (minimum, maximum).
Abbreviations: D-TGA, D-looped transposition of the great arteries; SCAMP, Standardized Clinical Assessment and Management Plan; SMEOC, SCAMP managed episode of care; VSD, ventricular septal defect.

resources. Across all 275 SCAMP SMEOCs, this amounted to a $166 375 cost savings during the SCAMP period. Combining both subgroups together, the total cost savings of the ASO SCAMP was $216 649 in the first 6 years of the SCAMP.

Considering all costs for all events, for the younger subgroup, the average cost per SMEOC was $12 099 for the historical cohort and $8865 for the SCAMP cohort. Although the average number of catheterizations and surgeries per SMEOC was similar between the historical and SCAMP cohorts, there was a difference in the complexity of the procedures, accounting for the differences in costs for the younger subgroup. Figure 2 shows the difference in average cost per SMEOC for some of the resource utilization types. For the older subgroup, the historical average cost per SMEOC was $7880 compared to $7648 for the SCAMP cohort. The estimated total costs of cardiac care from neonatal discharge to 18 years of age are shown in Table 6.

3.4 | Clinical outcomes

There was no significant difference between the historical and SCAMP cohorts in the number of cardiac catheterizations or electrophysiology procedures, inpatient hospital days, cardiac surgeries, or deaths. There was one death in the younger SCAMP cohort and one late death in the

TABLE 4 Resource utilization per SMEOC for the younger (age < 2 years) patients

Utilization type	Historical (SMEOCs = 100)	SCAMP (SMEOCs = 63)	*P* value	% Reduction
Cardiac magnetic resonance imaging	0.0 (0.0–0.1)	0.0 (0.0–0.1)	.85	
Cardiac surgeries	0.0 (0.0–0.1)	0.0 (0.0–0.1)	.41	
Catheterizations/electrophysiology procedure	0.2 (0.1–0.3)	0.1 (0.1–0.2)	.28	
Chest radiographs	2.1 (1.8–2.4)	1.0 (0.8–1.3)	<.001	52
Echocardiograms	2.0 (1.8–2.3)	1.8 (1.5–2.2)	.33	
Electrocardiograms	4.3 (3.9–4.7)	3.4 (3.0–3.9)	<.001	21
Exercise stress tests	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.00	
Holter/event monitors	0.1 (0.1–0.2)	0.2 (0.1–0.3)	.40	
Inpatient admission days (floor)	0.0 (0.0–0.0)	0.0 (0.0–0.1)	1.00	
Inpatient admission days (floor)	0.2 (0.2–0.3)	0.2 (0.1–0.3)	.45	
Lung perfusion scans	0.3 (0.2–0.4)	0.3 (0.2–0.5)	.93	
Outpatient clinic visits	4.7 (4.3–5.1)	3.4 (2.9–3.8)	<.001	28

Values expressed are Poisson mean (95% confidence interval).
Abbreviations: SCAMP, Standardized Clinical Assessment and Management Plan; SMEOC, SCAMP managed episode of care.

TABLE 5 Resource utilization per SMEOC for the older (age 2–18 years) patients

Utilization type	Historical (SMEOCs = 362)	SCAMP (SMEOCs = 275)	*P* value	% Reduction
Cardiac magnetic resonance imaging	0.2 (0.2–0.3)	0.2 (0.2–0.3)	.49	
Cardiac surgeries	0.0 (0.0–0.0)	0.0 (0.0–0.0)	.37	
Catheterizations/electrophysiology procedure	0.1 (0.0–0.1)	0.1 (0.0–0.1)	.54	
Chest radiographs	0.5 (0.4–0.5)	0.4 (0.3–0.4)	.05	20
Echocardiograms	2.1 (1.9–2.2)	1.9 (1.7–2.0)	.05	10
Electrocardiograms	2.2 (2.0–2.3)	2.0 (1.9–2.2)	.20	
Exercise stress tests	0.4 (0.3–0.4)	0.3 (0.2–0.3)	.01	25
Holter/event monitors	0.2 (0.2–0.3)	0.2 (0.1–0.2)	.32	
Inpatient days (intensive care)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	.85	
Inpatient days (floor)	0.1 (0.0–0.1)	0.1 (0.1–0.1)	.29	
Lung perfusion scans	0.2 (0.2–0.3)	0.2 (0.2–0.3)	.98	
Outpatient clinic visits	2.4 (2.3–2.6)	1.9 (1.8–2.1)	<.001	21

Values expressed are Poisson mean (95% confidence interval).
Abbreviations: SCAMP, Standardized Clinical Assessment and Management Plan; SMEOC, SCAMP managed episode of care.

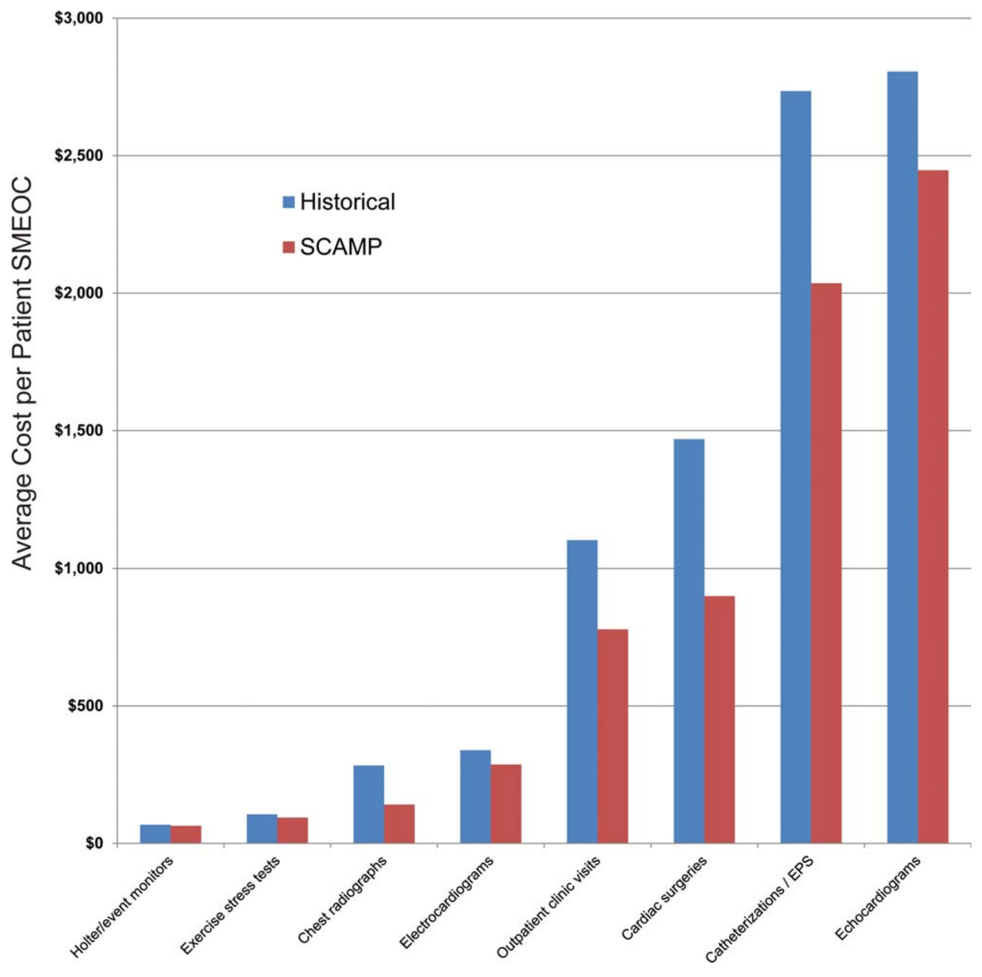

FIGURE 2 Specific resource utilization costs between the historical and SCAMP cohorts. The bars designate the average cost per patient SCAMP managed episode of care for various resource utilization types. Blue bars represent the historical cohort and red bars represent the SCAMP cohort

TABLE 6 Total costs (2015 US dollars) of pediatric cardiac care after the arterial switch operation

Patient population	Estimated total costs of care (from neonatal discharge to 18 years of age)
Historical cohort (low-risk)	$31 600
SCAMP cohort (low-risk)	$25 600
Historical cohort (high-risk)	$149 600
SCAMP cohort (high-risk)	$134 100
Historical cohort (all patients)	$54 100
SCAMP cohort (all patients)	$49 700

older historical cohort. The one death in the younger SCAMP cohort was noncardiac and likely related to a metabolic disorder. From a cardiac standpoint, he had no significant hemodynamic lesions or concerns. The one death in the older historical cohort was in a 24-year-old male who died of a presumed arrhythmogenic cardiac arrest, outside the follow-up/analysis period. This was a high-risk patient with a history of complete heart block and pacemaker implantation in 1986.

3.5 | Risk category

There was no significant difference in the percentage of high-risk patients between the historical and SCAMP cohorts in either of the age subgroups (Tables 2 and 3). High-risk patients in both the historical and SCAMP cohorts had generally greater resource utilization than low-risk patients. Specifically, in both cohorts and age subgroups, compared to low-risk patients, high-risk patients had more outpatient clinic visits, chest radiographs, echocardiograms, electrocardiograms, inpatient floor days, and lung perfusion scans. In addition, for the older subgroup, both the historical and SCAMP high-risk patients had more exercise tests and CMRs compared to low-risk patients.

The impact of risk stratification on resource utilization between the historical and SCAMP cohorts was also analyzed. In examination of the younger subgroup, the impact of the SCAMP on resource utilization was generally similar across low and high-risk patients. There were similar reductions in outpatient clinic visits, chest radiographs, and electrocardiograms in both low and high-risk patients. In examination of the older subgroup, the SCAMP reduced utilization for outpatient clinic visits, chest radiographs, echocardiograms, electrocardiograms, and exercise tests in low-risk patients only (Table 7). There were no significant differences in utilization for any of the high-risk patients in the older subgroup.

4 | DISCUSSION

This is the first study to analyze the utilization and cost impact of a SCAMP using the SMEOC methodology to capture total relevant medical costs. Compared to a historical cohort, the ASO SCAMP cohort had fewer outpatient clinic visits, chest radiographs, and echocardiograms in all patients. In older patients, utilization of stress exercise tests was also reduced. Moreover, there was no item with increased utilization in the SCAMP cohort. There was a total costs savings of $216 649 during the 6-year SCAMP period compared to the historical control. Despite the reduction of testing, outpatient follow-up, and costs, there was no difference in adverse clinical outcomes or number of procedures, suggesting that the SCAMP did not adversely affect clinical outcomes.

TABLE 7 Resource utilization per SMEOC by risk category for the older (age 2–18 years) patients

	Low-risk			High-risk		
	Historical (SMEOCs = 294)	SCAMP (SMEOCs = 218)	*P* value	Historical (SMEOCs = 68)	SCAMP (SMEOCs = 58)	*P* value
Cardiac MRI	0.2 (0.1–0.2)	0.2 (0.1–0.2)	.66	0.5 (0.3–0.7)	0.5 (0.4–0.7)	.78
Cardiac surgeries	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.00	0.1 (0.1–0.3)	0.1 (0.0–0.2)	.29
Catheterizations and EP procedures	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.00	0.3 (0.2–0.4)	0.4 (0.2–0.6)	.39
Chest radiographs	0.2 (0.2–0.3)	0.1 (0.1–0.1)	<.001	1.5 (1.2–1.8)	1.4 (1.1–1.7)	.66
Echocardiograms	1.9 (1.7–2.0)	1.5 (1.4–1.7)	<.001	3.0 (2.7–3.5)	3.2 (2.7–3.7)	.69
Electrocardiograms	1.9 (1.7–2.1)	1.6 (1.4–1.8)	.01	3.5 (3.0–3.9)	3.7 (3.3–4.3)	.42
Exercise stress tests	0.3 (0.3–0.4)	0.2 (0.2–0.3)	.01	0.5 (0.4–0.7)	0.4 (0.3–0.6)	.43
Holter and event monitors	0.2 (0.1–0.2)	0.1 (0.1–0.2)	.18	0.4 (0.2–0.5)	0.3 (0.2–0.5)	.97
Inpatient days (intensive care)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.00	0.0 (0.0–0.1)	0.0 (0.0–0.1)	.90
Inpatient days (floor)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	.46	0.2 (0.1–0.4)	0.3 (0.2–0.5)	.24
Lung perfusion scans	0.1 (0.1–0.2)	0.1 (0.1–0.2)	.66	0.6 (0.4–0.8)	0.5 (0.4–0.7)	.47
Outpatient clinic visits	2.2 (2.1–2.4)	1.6 (1.4–1.7)	<.001	3.3 (2.9–3.8)	3.3 (2.8–3.8)	.85

Values expressed are Poisson mean (95% confidence interval).
Abbreviations: EP, electrophysiology; MRI, magnetic resonance imaging; SCAMP, Standardized Clinical Assessment and Management Plan; SMEOC, SCAMP managed episode of care.

4.1 | Medical costs

This study attempted to define and measure the effect of a unique treatment plan across a disease specific longitudinal episode of care. Estimations of total medical expenditures often capture resource utilization occurring within a narrow time frame, typically 30 days or 1 year, without accounting for differences in the length of follow-up at the patient level.[9–11] This can result in cost shifting, where the system can be "gamed" to defer testing or costs to make the metric of interest appear improved. Total medical expenditures are not decreased and only delayed to occur outside the measurement window. Some studies have defined an episode of care as the period beginning with increased resource utilization and ending when utilization returns to baseline.[11,12] Other studies have attempted to define and capture total medical costs for broadly defined disease populations or for common diseases, including diabetes and coronary artery disease.[13,14] However, the associated comorbidities make it difficult to attribute the resource utilization and costs to the disease of interest. In contrast, the noncardiac comorbidities in patients with transposition of the great arteries after the ASO are rare. Some studies attempt to capture longitudinal costs using claims data, but often do so assessing the impact of one simple intervention (e.g., drug A versus drug B) and focus less on the disease process as a whole.[15] The SMEOC therefore successfully captures all resource utilization associated with the disease and describes the total medical costs to manage the unique condition.

When examining all costs for all events in the younger subgroup, there was a significant savings in the younger SCAMP cohort. Although there was a similar number of cardiac catheterizations and surgeries per SMEOC in the SCAMP versus historical cohorts, in the SCAMP cohort, the procedures were less complicated procedures resulting in lower charges. This could be due to (1) improved technical outcomes of the neonatal ASO during the SCAMPs era, (2) improved efficiencies in inpatient care, or (3) the SCAMP detected problems before they worsened. There was no significant difference between the older SCAMP and historical cohorts with regard to the catheterization and surgical complexity. We hypothesize that era effect may have had the greater impact, but the data are insufficient to suggest which is more likely.

Patients with transposition of the great arteries represent an uncommon diagnosis, but rank much higher in terms of standardized resource utilization compared to other pediatric conditions.[16] An understanding of the costs, especially as it pertains to the outpatient management, is important. This methodology has provided us accurate cost data for longitudinal care across a relatively large population of patients after the ASO operation at a single center. These data can be used to inform contractual negotiations with payors and to set realistic goals for further cost reductions. Too often payors apply arbitrary rules in an attempt to control costs, typically in the form of reduced payment or reduced access to care. With the SCAMPs and SMEOC methodology, providers can now lead the effort for cost reduction. With these data in hand, the cost savings can be shared between payors and providers to create further incentive for appropriate cost reduction.

4.2 | Risk stratification

The greatest reduction in resource utilization and costs was in older, low-risk patients. The SCAMP did not significantly reduce utilization for younger patients and older high-risk patients. This result is not surprising as the authors of the ASO SCAMP intentionally targeted the healthiest patients who they felt were being over tested and followed too frequently. These results highlight the importance of risk stratification which allows more health care dollars to be spent on the patients who truly need greater resources and closer surveillance.

5 | LIMITATIONS

An important limitation of the current study is the use of a single center design, limiting the generalizability of the results to other institutions and patient populations. Although we have shown that SCAMPs can be deployed across multiple institutions in a network,[17,18] each center will need to validate the impact of a SCAMP on their practice. The costs required to create, execute, and analyze the ASO SCAMP were not measured. The ASO SCAMP was the first SCAMP created, and significant process improvements allow us to create and implement new SCAMPs with less effort. In addition, this type of pre/post analysis suffers from an inability to definitively assign causality due to temporal trends or time related confounding. Ideally an interrupted time series analysis could have been used, but there were not enough pre and post-outpatient clinic visits/observations.[19] The ASO SCAMP was modified three times during its 6-year implementation. Because of the rapid cycle of SCAMP iterations, there were not enough follow-up events for each SCAMP iteration to conduct this broad SMEOC-type analysis. Because the latest version of the SCAMP recommends less follow-up for healthier patients than the prior version, the above cost savings data may be an underestimate of the current costs savings. Finally, because historical controls were used for the comparison, we cannot completely exclude the possibility that differences in the patient populations or other secular trends in resource utilization confound our results. Nevertheless, our analysis found that the two populations had minimal identifiable differences.

6 | CONCLUSION

Compared to a historical cohort, the ASO SCAMP reduced total costs without adversely impacting care. The SMEOC methodology ensures that all relevant medical costs are being captured. The SCAMP and SMEOC methodology can be exported to other institutions, and may provide a way to reduce costs on a national level.

CONFLICT OF INTEREST

The authors have no financial or other conflicts of interest relevant to this article to disclose.

AUTHOR CONTRIBUTIONS

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Rathod conceptualized and designed the study, participated in the data collection, and drafted and approved the final manuscript.

Jurgen participated in the data collection, drafted the manuscript, and approved the final manuscript version.

Hamershock and Graham performed the data analyses, revised and edited the manuscript, and approved the final manuscript version.

Friedman, Marshall, Samnaliev, and Jenkins interpreted the data, revised and edited the manuscript, and approved the final manuscript version.

Lock and Powell conceptualized and designed the study, supervised the study, interpreted the data, revised and edited the manuscript, and approved the final manuscript version.

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