CREATING A "VALUE INDEX":
A METHOD TO COMPARE REGIONAL PROGRAMS PERFORMING CONGENITAL HEART SURGERY

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ABSTRACT

Resource allocation challenges persist among surgical programs in the U.S. As healthcare policy moves increasingly toward value-based approaches, models to assist in comparing and evaluating programs become increasingly important. We used the Texas Hospital Inpatient Discharge Database to develop such a model. We included all patients under one year old, with primary surgical procedural codes for Total Anomalous Pulmonary Venous Connection, Transposition of the Great Arteries, and Tetralogy of Fallot (a congenital heart defect where not enough blood is able to reach the lungs to get oxygen). We examined mortality, length of stay, and total hospital charges data from January 2005 to June 2010. We used scatter plots to place programs into value quartiles. Three of the 11 surgical programs we identified appeared within the quartile of high-survival with low-charges and were identified as having high value. We performed additional risk-adjustment modeling and treatment pattern evaluation, and such information will have great importance for regional care planning.

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Economic and resource allocation challenges exist regarding the surgical care of children diagnosed with congenital heart disease. Overall, this subset of birth defects affects 1% of all live births. The healthcare burden is profound, with upwards of $6 billion spent annually in acute care costs alone.[1] In fact, of all birth defects, congenital heart defects are associated with the highest average hospital charges, length of stay, and mortality.[2] The abundance of congenital heart surgical programs within geographical regions raises questions of how resource allocation is determined and whether society is acting in the most efficient manner regarding such programs.

Previous studies have investigated factors associated with increased resource utilization in this patient population. They have found that States varied greatly in the frequency of high resource utilization. In addition, they have noted that institutions of various types did not differ in high-cost admissions, regardless of children's hospital or teaching status. Such studies have also identified individual patient-related factors which contribute to high resource utilization including variables such as, Risks Adjustment for Congenital Heart Surgery (RACHS-1) classification, age, prematurity, diagnosis of associated anomalies, and Medicaid coverage.[3] Other groups have focused on specific disease entities and employed administrative databases to explore whether various centers had significant differences, with the primary outcome measure being hospital cost. In particular, they have found that total costs varied significantly by center and were actually most prominent for lower complexity procedures.[4] Specifically regarding outcomes analysis, several groups have also explored the relationship between programmatic surgical volumes and mortality rates.[5-10] These studies have revealed that lower center volume is significantly associated with higher in-hospital mortality. More specifically, they have revealed no association of center volume with the rate of postoperative complications. However, the lower center volume is significantly associated with higher mortality in those patients who have post-operative complications.[5] Studies have also been performed which looked at programs within specific States of interest in validating an inverse association between institutional surgical volumes and hospital mortality.[8-10]

In spite of these studies, the issues regarding both metrics of outcome (such as mortality rates), and resource allocation, have not been jointly addressed. These variables in combination form integral sets of data to determine how a program may be "valued." The concept of value has become increasingly critical in the analysis of programs overall, and in particular, when comparing programs occupying and serving a common geographical region. Such discussions will become even more significant as our society adopts the new paradigms of value-based healthcare finance and we shift towards a potential strategy of regionalized care.

In the State of Texas, several congenital heart surgical programs have historically existed, all competing to provide services for a geographically similar patient population. In other regions of the country, a paucity of programs creates the need for difficult transportation scenarios. This creates not only medical challenges for the patient, but also significant social challenges for the parents and families. The fiscal issues surrounding these challenges are compelling, yet difficult to quantify. As healthcare policy changes, models to assist in the process of evaluating geographically similar programs are required. Outcome metrics have often focused predominantly on morbidity and mortality figures. Health service researchers have moved from a focus on cost containment alone toward overall value or performance as key areas of investigation. More specifically, answering the question "what are we getting for what we spend?" is of increasing importance. This paradigm shift focuses on the importance of performance value.[11] Developing a true model of value, with clear definitions that can be employed to evaluate programs in a fair and quantifiable manner, is required. We sought to develop such a model by evaluating all Texas programs pursuing surgical intervention for three specific cyanotic lesions using the concept of a "value index."

Patients and Methods
Data Source

The Texas Hospital Inpatient Discharge Public Use Data File (THIDPUDF) is an administrative database kept by the Texas Department of State Health Services. It requires all hospitals within the State to report quarterly data on their respective patient discharges. This database includes more than 550 Texas hospitals and, on average, more than 725,000 overall discharges per year. Both pediatric and adult data is collected, with more specific regulations regarding pediatric data collection being defined in 2004. Data from both free standing and non-free standing children's hospitals are included within the pediatric data.

Study Population

Our study population was obtained from the THIDPUDF for all patients under the age of one year, with a principal surgical procedure code for Total Anomalous Pulmonary Venous Connection (TAPVC), Transposition of the Great Arteries (TGA) or Tetralogy of Fallot (TOF; a congenital heart defect where not enough blood is able to reach the lungs to get oxygen) from January 2005 – June 2010. The principal surgical procedure code is defined as the code associated with the principal surgical or obstetrical procedure performed during the period covered by a specific hospital admission and associated set of hospital charges. It is the product of coding entities including the International Classification of Diseases (ICD-9), Current Procedural Terminology (CPT) and Healthcare Common Procedure Coding System (HCPCS). In 1949, the World Health Organization created the ICD coding system to better track mortality rates as well as causes of disease on a global basis. It undergoes a formal revision process every 10 years thus leading to the numeric component (ICD-9 represent the 9th revision). CPT codes were initially created in 1966 and are maintained by the American Medical Association. They describe medical, surgical and diagnostic services in a uniform informational manner designed to assist administrative, financial and analytical parties. The HCPCS was established in 1978 as a set of standardized codes for healthcare procedures and services in order to process insurance claims.

For all patients within our study cohort, the database was further queried for mortality, length of stay and hospital charges for each respective program performing surgical procedures for TAPVC, TGA or TOF. In this manner, data was collected to identify not only the number of programs performing surgical procedures for these three diagnoses, but also outcomes and financial data regarding their respective performance.

Data Analysis

Program characteristics for the combined three surgical procedures were evaluated by outcomes variables of mortality (30-day, or in-hospital), length of stay (admission to discharge) and overall total hospital charges. Averages for each outcome variable, denoted as population (p), were determined using the entire cohort independent of program. Subsequently, outcome variables were studied for each program submitting data and compared to the overall averages. Linear Regression Analysis was employed to determine whether program size as a function of case volume impacted any of the studied outcome variables. Finally, a "value index" was created for each program, which consisted of survival rates relative to hospital charges. A scatter plot technique was employed to create "value quartiles" where population (p) appears at the center of the quartiles. For example, programs with both higher than the average survival rates as well as lower than the average hospital charges were thus categorized in the most valued quartile.

Results

A total of 1,352 patients under one year of age were identified during the study period as having undergone surgical intervention for TAPVC, TGA or TOF. Eleven congenital cardiac surgical programs were identified as having performed these operative interventions, and these programs varied widely in regard to volume of cases performed for these specific disease entities, with a range of 26 – 364 cases (see Figure 1). When evaluating the cohort as a whole, average mortality rate was 3.0% with a range 0.9% to 12.9% per program, $p \leq 0.001$ (Figure 2). For the entire study cohort, average length of stay was 17.4 days, with a range of 12.7 days to 28.4 days per program, $p \leq 0.001$ (Figure 3). Finally, the average total hospital charges per patient for the entire study cohort was $250,388, with a range of $162,920 to $404,167 per program, $p \leq 0.001$ (Figure 4).

A statistical analysis was also performed to determine whether programmatic volume impacted mortality, length of stay or total hospital charges. This analysis revealed an association between programmatic volumes and mortality, which approached statistical significance ($p \leq 0.65$). Neither length of stay nor total hospital charges were found to be associated with programmatic volumes ($p \leq 0.998$ and $p \leq 0.893$).

A value index based upon hospital survival relative to hospital charges per patient was developed with a scatter plot technique used to place programs into "value quartiles". Programs of "high value" were defined as appearing within the quartile of higher than average survival rates and lower than average total hospital charges. Of the 11 programs within the study, three appeared within the quartile of high survival with low charges and thus were identified as having "high values" (Figure 5).

Number of TAPVC, TGA, TOF Patients per Texas Hospital (2005 - 2010)

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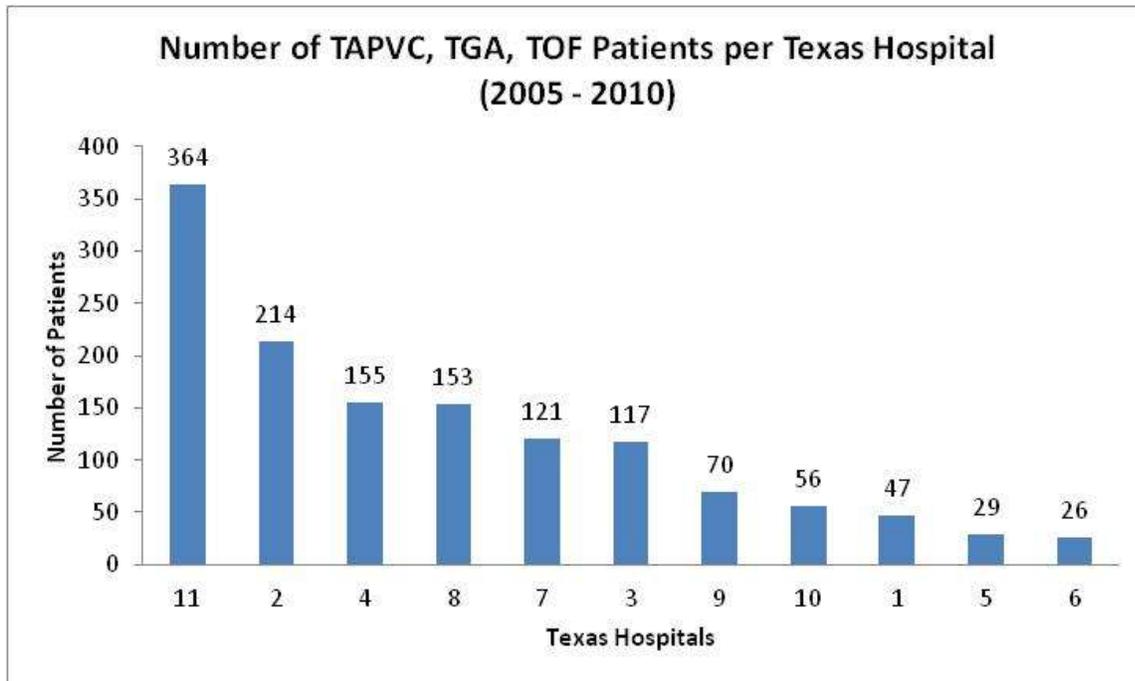
* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
 TOF = Tetralogy of Fallot.

Risk Adjustment

The THIDPUDF also provided the ability to employ risk-adjusted stratification based on defined illness severity scores. These data points were used to determine the number of patients per program within each severity score classification (Figure 6). By employing the database defined illness severity scores, risk adjusted mortality was also evaluated to compare programs (Figure 7). Finally, our risk-adjusted value index was developed for each program, and is represented by a scatter plot technique to define programs of "high value" (Figure 8). Using risk-adjusted data, five of the 11 programs were identified as having "high value."

The results of this administrative database driven project to evaluate multiple congenital cardiac surgical programs within a single State reveals useful data to begin the process of placing a "value" on each program. We desired to develop a model for "value" and employ this model to evaluate the many congenital cardiac surgical programs within the State of Texas. We chose three congenital heart disease lesions, which commonly require surgical intervention within the first year of life, and are within a spectrum of moderate surgical severity based on Risk Adjusted Classification for Congenital Heart Surgery (RACHS-1) criteria, which has 6 categories for risk stratification.[12] The lesions chosen were all within RACHS-1 categories 2–4.

Our data analysis reveals wide variation in both outcome metrics often associated with surgical programmatic evaluation, such as mortality rates and length of stay, but also within the area of hospital charges as a surrogate for resource utilization. This variation was somewhat surprising and led us to ask whether previously described associations between programmatic size might impact our study outcome variables. This analysis only revealed that programmatic size approached statistical significance as a correlate to mortality rates, but not in regard to length of stay, nor total hospital charges. When defining "value" as a product of high survival rates relative to low total hospital charges, the model revealed only three of 11 programs provided "high value". When subsequently

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employing our risk-adjusted model strategy based upon illness severity scores, five programs were found to deliver "high value." Such a model may be employed in other regions of the country where a large number of programs occupy a similar geographic area. The use of such models may serve to not only allow programs to self-evaluate their "value" and search for methods to improve upon it, but also for healthcare providers and insurance plan leaders within regional communities to employ data and evidence-based analyses to inform policy decisions regarding regionalization of care.

FIGURE 2
COMPARISON OF HOSPITAL MORTALITY RATES
(Average = 3.0%)
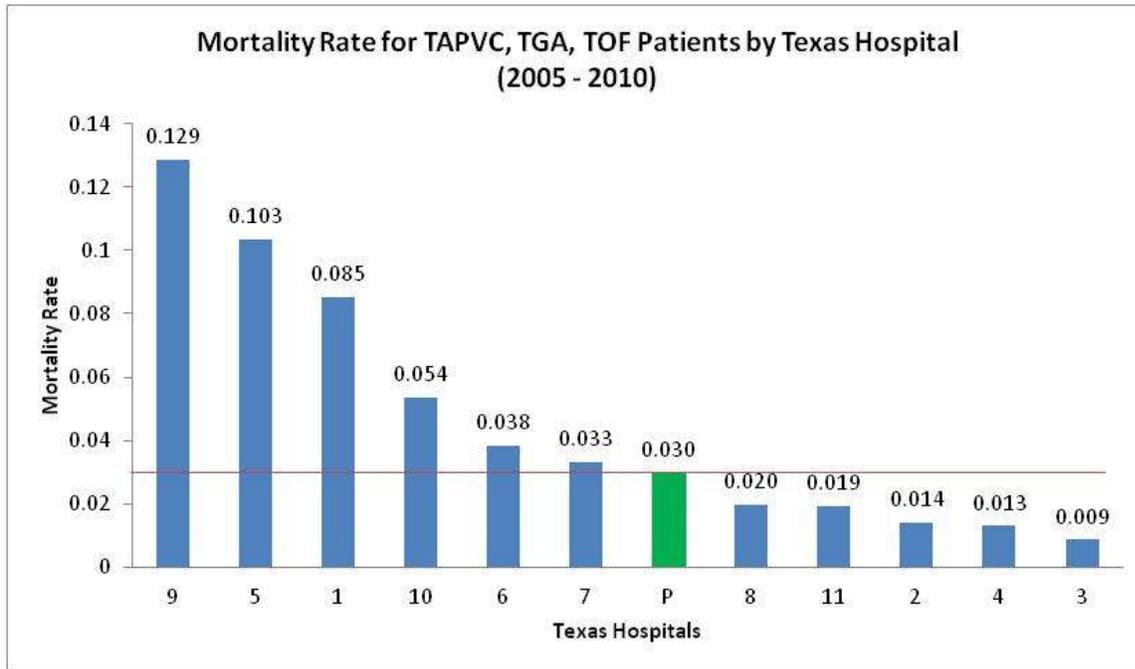
Mortality Rate for TAPVC, TGA, TOF Patients by Texas Hospital
(2005 - 2010)

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* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
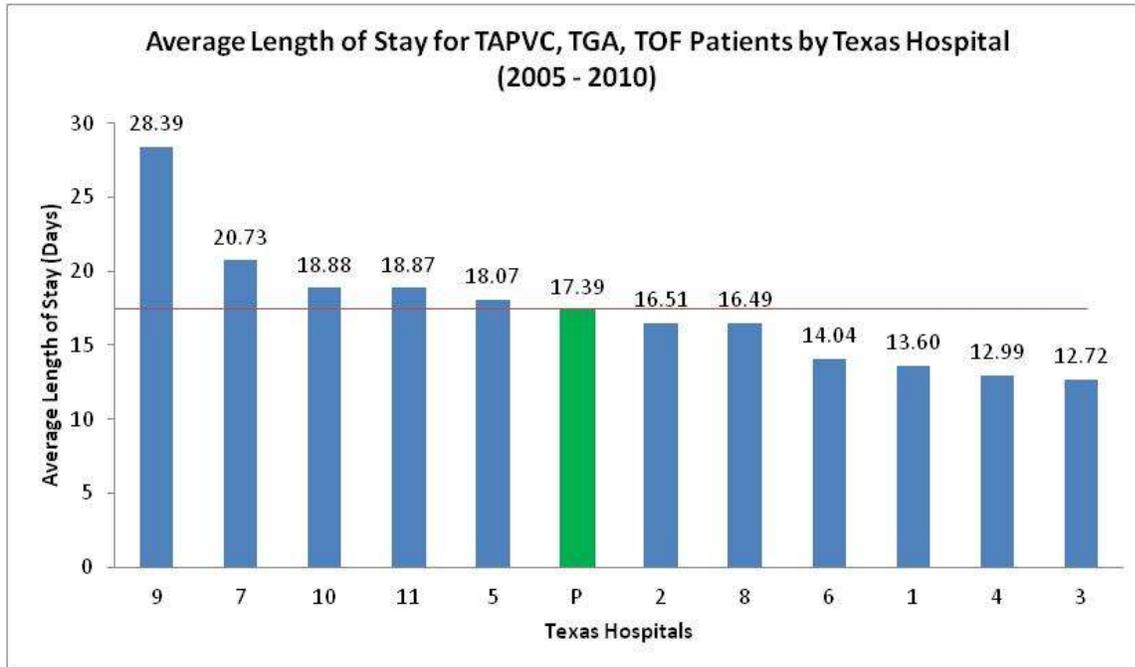   TOF = Tetralogy of Fallot.

Limitations

Several limitations exist in our analysis. We employed a large administrative database to which all hospitals within the State of Texas are mandated to report. Although such databases contain valuable information regarding both outcome and resource utilization information, they lack detailed clinical data. This challenge has been previously well described.[13] As national clinical registries and statistical clearinghouses gain prominence through wide dissemination of electronic health record (EHR) systems, administrative databases should become even more valuable for analysis. Although the THIDPUDF mandates State-wide reporting, there is no auditing mechanism within the State to ensure the accuracy of the data collected. This lack of formal site-visit auditing, such as is performed by clinical registries like the Society of Thoracic Surgeons (STS) Database, highlights the inability to monitor issues of possible missing data and coding errors.[14]

The use of principal surgical codes to select patients undergoing surgical intervention for TAPVC, TGA and TOF ensures that a corrective surgical procedure was performed on these patients within the first year of life. This coding mechanism employs ICD-9, CPT as well as HCPCS codes. The inherent limitations of ensuring the manner by which these multiple coding mechanisms were employed to produce a principal surgical code is challenging to quantify. In addition, this coding scheme does not delineate whether a staged-approach was performed prior to complete repair, as may be the case with TOF patients initially receiving a Blalock-Tausig Shunt followed by complete repair. As such, there may be an unknown number of cases where a complete repair had yet to be

performed, and this may be more significant when comparing programs if a programmatic bias exists within an institution to initially pursue a palliative intervention within a staged-approach model. The relatively small number of patients and procedures in certain groups, such as for TGA, may also have limited our ability to detect differences within a particular group.

FIGURE 3
COMPARISON OF HOSPITAL LENGTHS OF STAY
(Average = 17.4 days)

Average Length of Stay for TAPVC, TGA, TOF Patients by Texas Hospital (2005 - 2010)
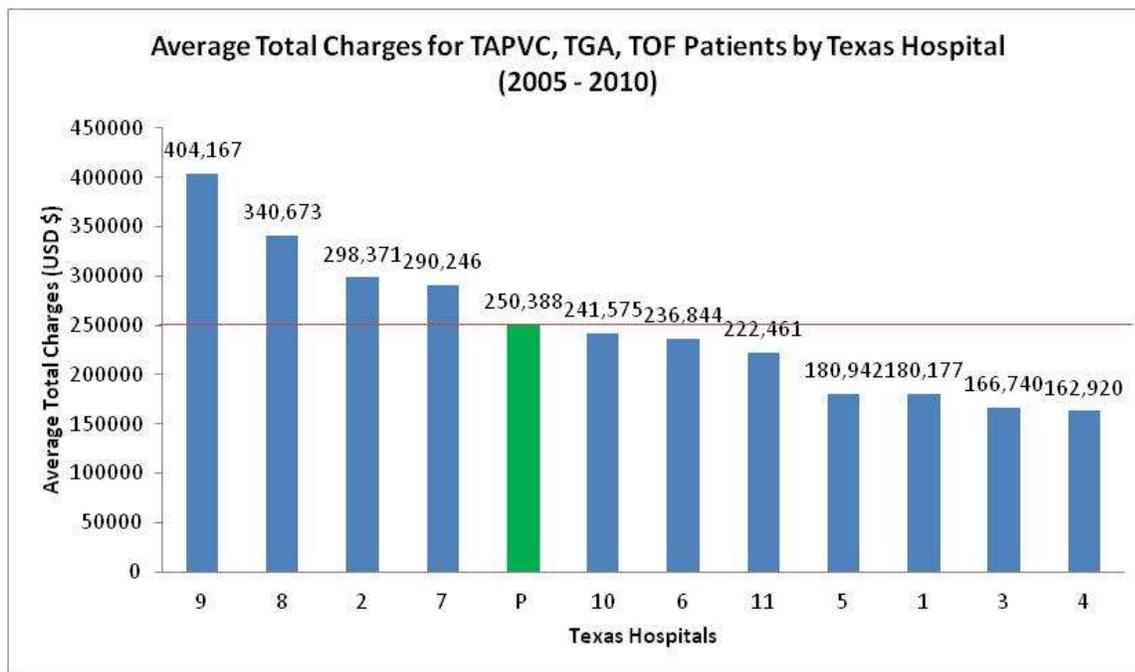
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* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
    TOF = Tetralogy of Fallot.

When discussing economic variables regarding hospital programs, delineating between hospital costs and hospital charges is of paramount importance. This study is also limited by the use of total hospital charges as a surrogate for resource allocation. Actual cost measures are difficult to ascertain and are not available in the THIDPUDF. An assumption is made that cases with high total hospital charges also had high resource utilization. However, because charging structures are complex and do not accurately reflect costs, only cases of high resource use may be adequate when using such a surrogate for resource allocation. Conner and her group employed this methodology and it has been adopted previously by other groups, using total hospital charges as a surrogate to study resource allocation.[3]

In spite of these limitations, the recent work of Pasquali and colleagues linking clinical registry data with administrative data in the congenital heart surgical population will allow groups to better analyze cost data with outcomes data of morbidity and mortality.[15] In this manner, quality improvement initiatives may be better directed towards the overall goal of creating better "value." The importance of including financial and cost data within clinical registries such as the STS database has also been a recent source of much discussion.

FIGURE 4
COMPARISON OF TOTAL HOSPITAL CHARGES
(Average = $250,388)

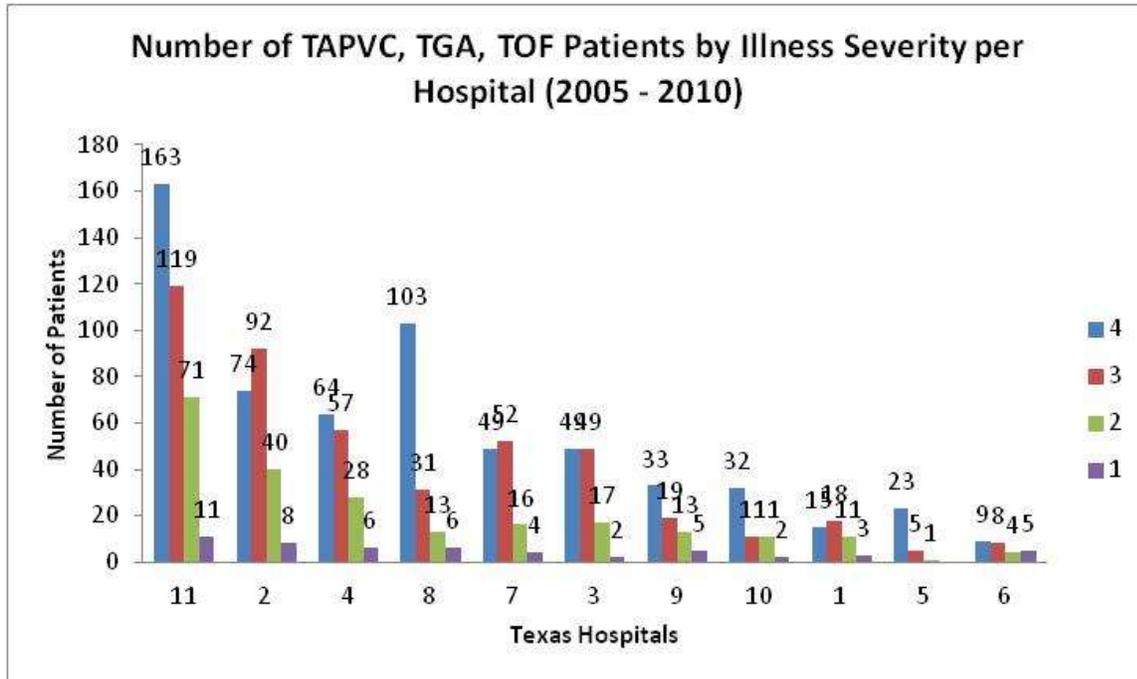Average Total Charges for TAPVC, TGA, TOF Patients by Texas Hospital (2005 - 2010)

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* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
TOF = Tetralogy of Fallot.

Average Total Charges per TAPVC, TGA, TOF Case vs. Survival Rate
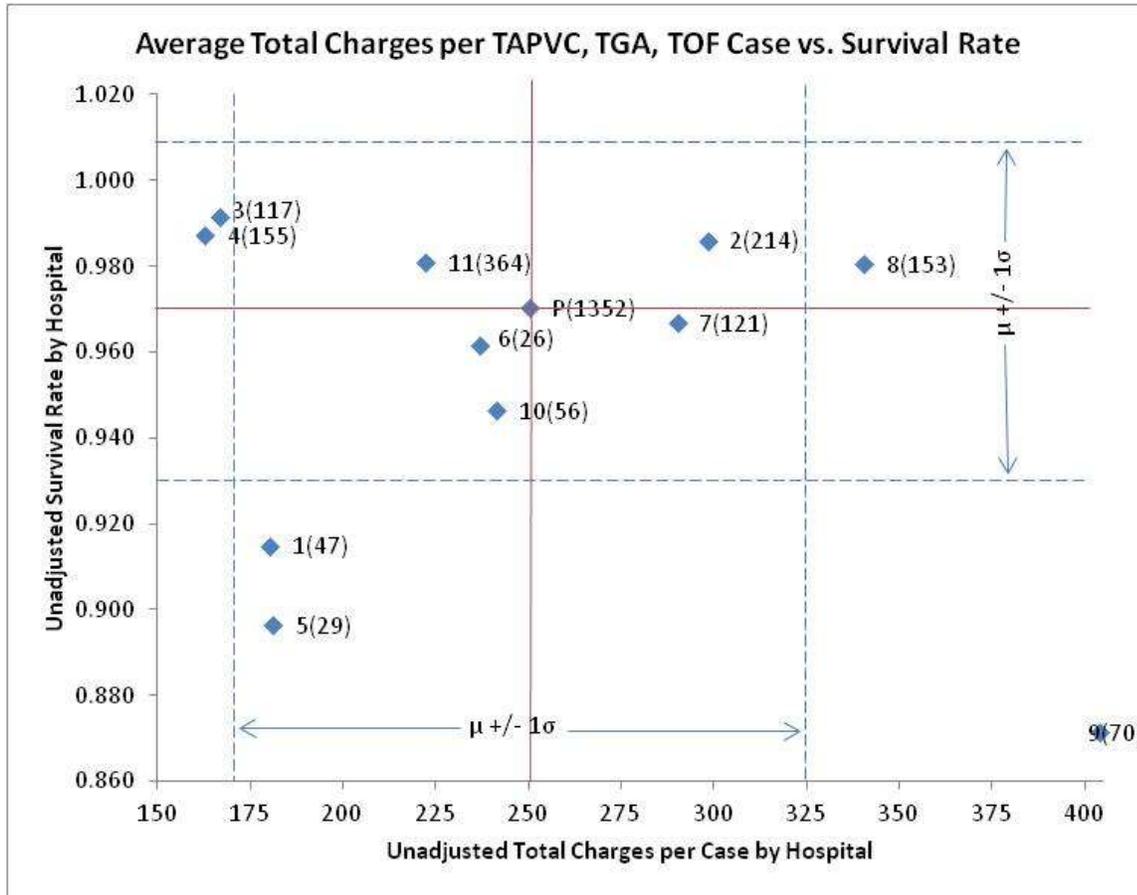
* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
TOF = Tetralogy of Fallot.

FIGURE 6
**SEVERITY SCORES AS DEFINED BY THIDPUDF*:**
PROGRAMMATIC BREAKDOWN OF CASES BY SEVERITY SCORE

Number of TAPVC, TGA, TOF Patients by Illness Severity per Hospital (2005 - 2010)

Illness Severity	Number of Patients
4: Extreme	614
3: Major	461
2: Moderate	225
1: Minor	52
Grand Total	**1,352**

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* Note: THIDPUDF = Texas Hospital Inpatient Discharge Public Use Data File; TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries; TOF = Tetralogy of Fallot.
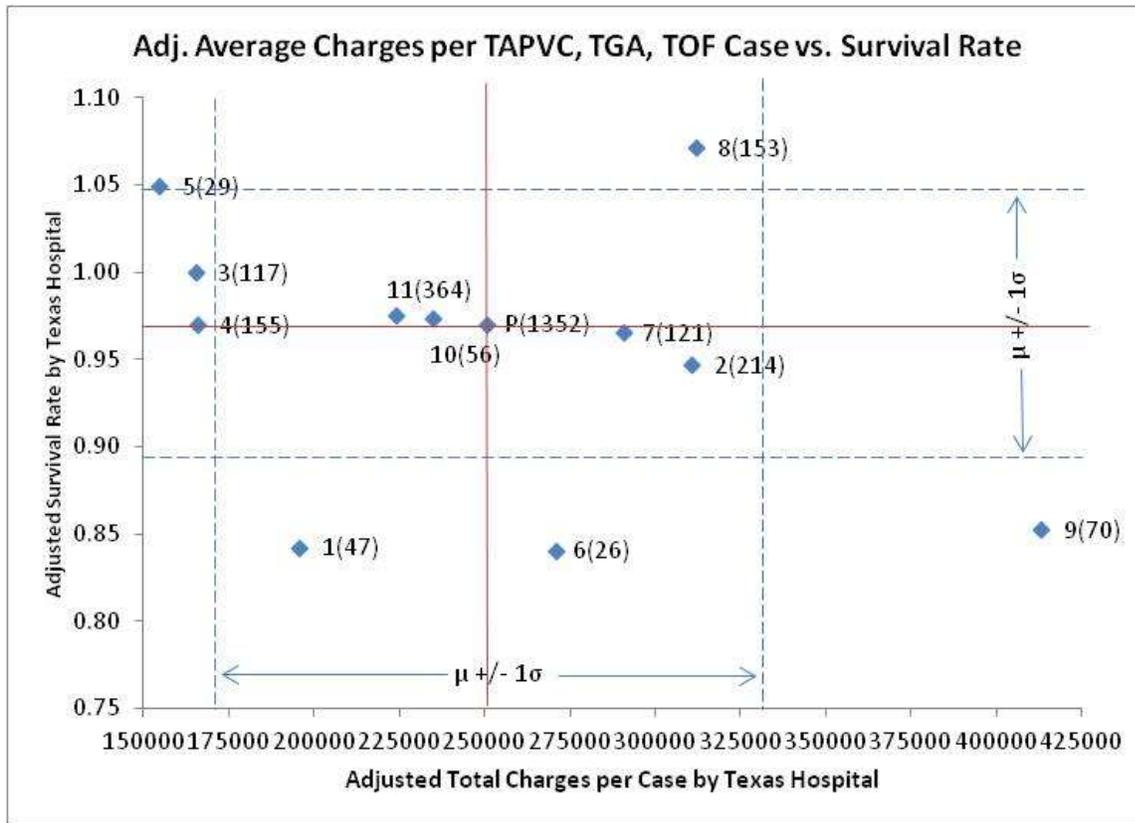
FIGURE 7
SEVERITY SCORE ADJUSTED COMPARISON OF HOSPITAL MORTALITY RATES
(Average = 3.0%)
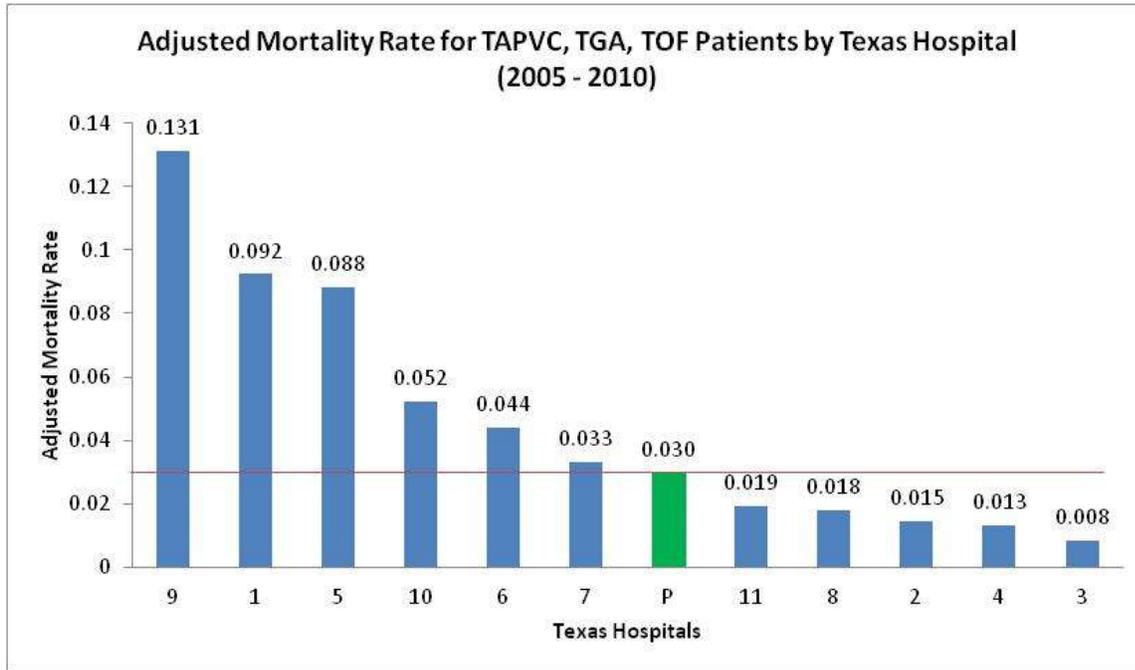
Adjusted Mortality Rate for TAPVC, TGA, TOF Patients by Texas Hospital
(2005 - 2010)

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* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
   TOF = Tetralogy of Fallot.

Adj. Average Charges per TAPVC, TGA, TOF Case vs. Survival Rate

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* Note: TAPVC = Total Anomalous Pulmonary Venous Connection; TGA = Transposition of the Great Arteries;
    TOF = Tetralogy of Fallot.

Conclusions

Our analysis includes all programs within the State of Texas, over a 5.5 year time period and captures patients undergoing surgical intervention for three commonly treated cyanotic lesions. In a society focused upon data driven, evidence-based decision making, and one where such information is becoming more readily accessible, such an analysis becomes more compelling within our professional community. This understanding, compounded by the impact of ongoing paradigm shifts as to how economics drive the methods by which we not only deliver care, but allocate our resources to ensure its delivery, become significant points of discussion. We must move from a focus solely on outcomes as a surrogate of quality, toward an acceptance that "value" is what must be defined and pursued. Creating accepted definitions of concepts such as "value" become important within our community so that we may pursue these discussions in a thoughtful and transparent fashion.

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