NATIONAL QUALITY FORUM

National Voluntary Consensus Standards for
Pediatric Cardiac Surgery Measures

Measure Number: PCS-021-09

Measure Title: Standardized Mortality Ratio for Congenital Heart Surgery, Risk Adjustment for Congenital Heart Surgery (RACHS-1) Adjusted.

Description: Ratio of observed to expected rate of in-hospital mortality following surgical repair of congenital heart defect among patients <18 years of age, risk-adjusted using the Risk Adjustment for Congenital Heart Surgery (RACHS-1) method.

Numerator Statement: Cases of congenital heart surgery among patients <18 years of age resulting in in-hospital death.

Denominator Statement: Total cases of congenital heart surgery among patients <18 years of age.

Level of Analysis: Can be measured at all levels.

Data Source: Electronic Health/Medical Record, Electronic Clinical Database, Paper Medical Record, Data elements may be obtained from an administrative database (e.g., Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database (KID), Pediatric Health Information System (PHIS)); from a clinical database (e.g., Pediatric Cardiac Care Consortium (PCCC), Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database)*; from hospital-specific electronic medical records; or from paper medical records.
* The STS database does not currently include all variables, but there are plans to add them.

Measure Developer: Children's Hospital, Boston

Type of Endorsement: Recommended for Endorsement (Steering Committee Vote, Yes-8, No-1, Abstain-0)

Attachments: Assigning RACHS1 Risk Categories in ICD9 Coded Data, Assigning RACHS1 Risk Categories in PCCC Coded Data, Assigning RACHS1 Risk Categories in PCCC Coded Data, Decile Plots, Mortality Rates by RACHS1 Risk Category

PCS-021-09 Standardized Mortality Ratio for Congenital Heart Surgery, Risk Adjustment	**Recommendation:** Endorsement Yes-8; No-1; Abstain-0 **Final Measure Evaluation Ratings: I:** Y-9; N-0 **S:** H-7; M-1; L-1 **U:** H-5; M-2; L-1 **F:** H-6; M-2; L-1 **Discussion:** **I:** This is an important outcome measure in this at-risk surgical population. **S:** The Committee agreed this measure demonstrated scientific acceptability based on the submitted information. This measure uses the RACHS-1 system of risk analysis based on

for Congenital Heart Surgery (RACHS-1) method (Society of Thoracic Surgeons)	observed mortality (numerator) as related to expected mortality (denominator). The risk analysis takes into account all risk levels and condenses the programs performance on the basis of O/E. any score of 1.0 or over would indicate the observed mortality is greater than the expected mortality and therefore should indicate that the program is underachieving. Although there have been concerns expressed in the literature with the use of administrative datasets, particularly in areas in which the coding choices are limited. There was some concerned addressed about the conversion of the ICD-9-CM codes to ICD-10-CM, however the developer confirmed they have already began the mapping process for this measure. **U:** **F:** The data items required for this measure can be easily collected through manual chart abstraction for information to determine the RACHS-1 score and administrative data. Particularly with administrative data, the burden of gathering data items to calculate the measure is low.

THE NATIONAL QUALITY FORUM

MEASURE SUBMISSION FORM VERSION 3.1

March 2009

The measure information you submit will be shared with NQF's Steering Committees and Technical Advisory Panels to evaluate measures against the NQF criteria of importance to measure and report, scientific acceptability of measure properties, usability, and feasibility. Four conditions (as indicated below) must be met before proposed measures may be considered and evaluated for suitability as voluntary consensus standards. Not all acceptable measures will be strong—or equally strong—among each set of criteria. The assessment of each criterion is a matter of degree; however, all measures must be judged to have met the first criterion, *importance to measure and report*, in order to be evaluated against the remaining criteria. References to the specific measure evaluation criteria are provided in parentheses following the item numbers. Please refer to the *Measure Evaluation Criteria* for more information at *www.qualityforum.org* under Core Documents. Additional guidance is being developed and when available will be posted on the NQF website.

Use the tab or arrow (↓→) keys to move the cursor to the next field (or back ←↑). There are three types of response fields:

- drop-down menus - select one response;
- check boxes – check as many as apply; and
- text fields – you can copy and paste text into these fields or enter text; these fields are not limited in size, but in most cases, we ask that you summarize the requested information.

Please note that URL hyperlinks do not work in the form; you will need to type them into your web browser.

Be sure to answer all questions. Fields that are left blank will be interpreted as no or none. Information must be provided in this form. Attachments are not allowed except to provide additional detail or source documents for information that is summarized in this form. If you have important information that is not addressed by the questions, they can be entered into item #46 near the end of the form.

For questions about this form, please contact the NQF Project Director listed in the corresponding call for measures.

	CONDITIONS FOR CONSIDERATION BY NQF
	Four conditions must be met before proposed measures may be considered and evaluated for suitability as voluntary consensus standards.
A (A)	*Public domain or Measure Steward Agreement signed: Public domain - Agreement not required (If no, do not submit)* *Template for the Measure Steward Agreement is available at www.qualityforum.org under Core Documents.*
B (B)	*Measure steward/maintenance: Is there an identified responsible entity and process to maintain and update the measure on a schedule commensurate with clinical innovation, but at least every 3 years? Yes, information provided in contact section (If no, do not submit)*
C (C)	*Intended use: Does the intended use of the measure include BOTH public reporting AND quality improvement? Yes (If no, do not submit)*
D (D)	*Fully developed and tested: Is the measure fully developed AND tested? Yes, fully developed and tested (If not tested and no plans for testing within 24 months, do not submit)*

THE NATIONAL QUALITY FORUM

MEASURE SUBMISSION FORM VERSION 3.1

March 2009

	(for NQF staff use) NQF Review #: PCS-021-09 NQF Project: Pediatric Cardiac Surgery
	MEASURE SPECIFICATIONS & DESCRIPTIVE INFORMATION
1	*Information current as of (date- MM/DD/YY): 01/01/10*
2	*Title of Measure: Standardized Mortality Ratio for Congenital Heart Surgery, Risk Adjustment for Congenital Heart Surgery (RACHS-1) Adjusted.*
3	**Brief description of measure [1]:** Ratio of observed to expected rate of in-hospital mortality following surgical repair of congenital heart defect among patients <18 years of age, risk-adjusted using the Risk Adjustment for Congenital Heart Surgery (RACHS-1) method.
4 (2a)	**Numerator Statement:** Cases of congenital heart surgery among patients <18 years of age resulting in in-hospital death. **Time Window:** Not pre-specified, but a minimum of one year is recommended. **Numerator Details** (Definitions, codes with description): Number of cases of congenital heart surgery among patients <18 years of age able to be placed into a RACHS-1 risk category (see item 8 below) where patient disposition is death prior to hospital discharge.
5 (2a)	**Denominator Statement:** Total cases of congenital heart surgery among patients <18 years of age. **Time Window:** Not pre-specified, but a minimum of one year is recommended. **Denominator Details** (Definitions, codes with description): Pediatric cases <18 years of age undergoing surgical repair of a congenital heart defect and able to be placed into a RACHS-1 risk category (see item 8 below).
6 (2a, 2d)	**Denominator Exclusions:** Patients >=18 years of age, those undergoing heart transplantation, neonates or premature infants with patent ductus arteriosus repair as the only cardiac surgical procedure, transcatheter interventions, surgical cases unable to be assigned to a RACHS-1 risk category. **Denominator Exclusion Details** (Definitions, codes with description): Neonates are defined as patients <=30 days of age at surgery; premature infants are defined as <37 weeks gestation. See item 8 below for RACHS-1 risk categories.
7 (2a, 2h)	**Stratification** Do the measure specifications require the results to be stratified? No ► If "other" describe: N/A **Identification of stratification variable(s):** N/A **Stratification Details** (Definitions, codes with description): N/A
8 (2a, 2e)	**Risk Adjustment** Does the measure require risk adjustment to account for differences in patient severity before the onset of care? Yes ► **If yes,** Statistical Risk Model, see Variables ► Is there a separate proprietary owner of the risk model? No **Identify Risk Adjustment Variables:** RACHS-1 risk categories, age at surgery, prematurity, presence of major non-cardiac structural anomaly, combinations of cardiac procedures performed. **Detailed risk model:** attached ☒ **OR** Web page URL: N/A

[1] Example of measure description: Percentage of adult patients with diabetes aged 18-75 years receiving one or more A1c test(s) per year.

9 (2a) **Type of Score:** Ratio **Calculation Algorithm:** attached ☒ **OR** Web page URL: N/A

Interpretation of Score (*Classifies interpretation of score according to whether better quality is associated with a higher score, a lower score, a score falling within a defined interval, or a passing score*)
Better quality = Lower score ► If "Other", please describe: N/A

10 (2a. 4a, 4b) **Identify the required data elements**(e.g., primary diagnosis, lab values, vital signs)**:** In-hospital mortality, type of surgical procedure, age at surgery, prematurity, presence of major non-cardiac structural anomaly, combinations of cardiac procedures performed.
Data dictionary/code table attached ☒ **OR** Web page URL: N/A
Data Quality (2a) *Check all that apply*
☒ Data are captured from an authoritative/accurate source (e.g., lab values from laboratory personnel)
☒ Data are coded using recognized data standards
☒ Method of capturing data electronically fits the workflow of the authoritative source
☒ Data are available in EHRs
☒ Data are auditable

11 (2a, 4b) **Data Source and Data Collection Methods** *Identifies the data source(s) necessary to implement the measure specifications. Check all that apply*

☒ Electronic Health/Medical Record
☒ Electronic Clinical Database, Name: See other
☐ Electronic Clinical Registry, Name:
☐ Electronic Claims
☐ Electronic Pharmacy data
☐ Electronic Lab data
☐ Electronic source – other, Describe:
☒ Paper Medical Record
☐ Standardized clinical instrument, Name:
☐ Standardized patient survey, Name:
☐ Standardized clinician survey, Name:
☒ Other, Describe: Data elements may be obtained from an administrative database (e.g., Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database (KID), Pediatric Health Information System (PHIS)); from a clinical database (e.g., Pediatric Cardiac Care Consortium (PCCC), Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database)*; from hospital-specific electronic medical records; or from paper medical records.
* The STS database does not currently include all variables, but there are plans to add them.

Instrument/survey attached ☐ **OR** Web page URL: N/A

12 (2a) **Sampling** *If measure is based on a sample, provide instructions and guidance on sample size.*
Minimum sample size: Not pre-specified, although it is recommended that the sample size be large enough such that there is at least one death in each RACHS-1 risk category.

Instructions: N/A

13 (2a) **Type of Measure:** Outcome ► If "Other", please describe: N/A

► If part of a composite or paired with another measure, please identify composite or paired measure N/A

14 (2a) **Unit of Measurement/Analysis** (*Who or what is being measured*) *Check all that apply.*

☒ Can be measured at all levels
☐ Individual clinician (e.g., physician, nurse)
☐ Group of clinicians (e.g., facility department/unit, group practice)
☐ Facility (e.g., hospital, nursing home)
☐ Integrated delivery system
☐ Health plan
☐ Community/Population
☐ Other (*Please describe*):

15 (2a) **Applicable Care Settings** *Check all that apply*

☐ Can be used in all healthcare settings
☐ Ambulatory Care (office/clinic)
☐ Behavioral Healthcare
☐ Hospice
☒ Hospital
☐ Long term acute care hospital

	☐ Community Healthcare ☐ Dialysis Facility ☐ Emergency Department ☐ EMS emergency medical services ☐ Health Plan ☐ Home Health ☐ Nursing home/ Skilled Nursing Facility (SNF) ☐ Prescription Drug Plan ☐ Rehabilitation Facility ☐ Substance Use Treatment Program/Center ☐ Other (*Please describe*):
	IMPORTANCE TO MEASURE AND REPORT
	Note: This is a threshold criterion. If a measure is not judged to be sufficiently important to measure and report, it will not be evaluated against the remaining criteria.
16 (1a)	**Is measure related to a National Priority Partners priority area?** Safety reliability (for NQF staff use) **Does measure address a specific NPP goal?** (www.qualityforum.org/about/NPP/):
17 (1a)	**Does the measure address a high impact aspect of healthcare** leading cause of morbidity/mortality **Summary of Evidence:** Congenital heart defects engender major risks for death and lifelong disability. Despite recent advances, these conditions remain the most frequent type of birth defect, resulting in the highest mortality risk from birth defects in infancy, and are the leading medical cause of death in children until adolescence. **Citations[2] for Evidence:** Fyler DC. Nadas' Pediatric Cardiology. Philadelphia, PA: Hanley & Belfus, Inc; 1992. Yang Q, Khoury MJ, Mannino D. Trends and patterns of mortality associated with birth defects and genetic diseases in the United States, 1979-1992: an analysis of multiple-cause mortality data. Genetic Epidemiology 1997; 14(5):493-505. Zopf PE, Jr. Mortality Patterns and Trends in the United States. Westport, CT: Greenwood Press; 1992.
18 (1b)	**Opportunity for Improvement** *Provide evidence that demonstrates considerable variation, or overall poor performance, across providers.* **Summary of Evidence:** Despite advances leading to increased survival, analyses continue to demonstrate wide variation in mortality outcomes among institutions and practitioners. **Citations for Evidence:** Bazzani LG, Marcin JP. Case volume and mortality in pediatric cardiac surgery patients in California, 1998-2003. Circulation 2007; 115:2652-2659. Hannan EL, Racz M, Kavey RE, Quaegebeur JM, Williams R. Pediatric cardiac surgery: the effect of hospital and surgeon volume on in-hospital mortality. Pediatrics 1998; 101(6):963-969. Jenkins KJ, Newburger JW, Lock JE, Davis RB, Coffman GA, Iezzoni LI. In-hospital mortality for surgical repair of congenital heart defects: preliminary observations of variation by hospital caseload. Pediatrics 1995; 95:323-330. Lundstrom NR, Berggren H, Bjorkhem G, Jogi P, Sunnegardh J. Centralization of pediatric heart surgery in Sweden. Pediatric Cardiology 2000; 21(4):353-357. Sollano JA, Gelijns AC, Moskowitz AJ et al. Volume-outcome relationships in cardiovascular operations: New York State, 1990-1995. Journal of Thoracic and Cardiovascular Surgery 1999; 117(3):419-428.
19 (1b)	**Disparities** *Provide evidence that demonstrates disparity in care/outcomes related to the measure focus among populations.* **Summary of Evidence:** Variation in in-hospital mortality following repair of a congenital heart defect has been demonstrated across racial/ethnic groups and by type of insurance. **Citations for evidence:** Gonzalez PC, Gauvreau K, DeMone JA, Piercey GE, Jenkins KJ. Regional racial and ethnic differences in mortality for congenital heart surgery in children may reflect unequal access to care. Pediatric Cardiology

[2] Citations can include, but are not limited to journal articles, reports, web pages (URLs).

	2003; 24(2):103-108. DeMone JA, Gonzalez PC, Gauvreau K, Piercey GE, Jenkins KJ. Risk of death for Medicaid recipients undergoing congenital heart surgery. Pediatric Cardiology 2003; 24(2):97-102.
20 (1c)	**If measuring an Outcome** Describe relevance to the national health goal/priority, condition, population, and/or care being addressed: Congenital heart defects engender major risks for death and lifelong disability. Despite recent advances, these conditions remain the most frequent type of birth defect, resulting in the highest mortality risk from birth defects in infancy, and are the leading medical cause of death in children until adolescence. Despite advances leading to increased survival, analyses continue to demonstrate wide variation in mortality outcomes among institutions and practitioners. Variation in in-hospital mortality following repair of a congenital heart defect has been demonstrated across racial/ethnic groups and by type of insurance. NQF has endorsed less than 20 clinician-level performance measures in the areas of cardiac surgery and fewer in the pediatric surgical population. The RACHS-1 method adjusts for baseline risk differences and allows meaningful comparisions of in-patient mortality groups of children undergoing surgery for congenital heart disease. **If not measuring an outcome, provide evidence supporting this measure topic and grade the strength of the evidence** *Summarize the evidence (including citations to source) supporting the focus of the measure as follows:* • Intermediate outcome – evidence that the measured intermediate outcome (e.g., blood pressure, Hba1c) leads to improved health/avoidance of harm or cost/benefit. • Process – evidence that the measured clinical or administrative process leads to improved health/avoidance of harm and if the measure focus is on one step in a multi-step care process, it measures the step that has the greatest effect on improving the specified desired outcome(s). • Structure – evidence that the measured structure supports the consistent delivery of effective processes or access that lead to improved health/avoidance of harm or cost/benefit. • Patient experience – evidence that an association exists between the measure of patient experience of health care and the outcomes, values and preferences of individuals/ the public. • Access – evidence that an association exists between access to a health service and the outcomes of, or experience with, care. • Efficiency– demonstration of an association between the measured resource use and level of performance with respect to one or more of the other five IOM aims of quality. **Type of Evidence** *Check all that apply* ☐ Evidence-based guideline ☐ Quantitative research studies ☐ Meta-analysis ☐ Qualitative research studies ☐ Systematic synthesis of research ☐ Other (*Please describe*): N/A **Overall Grade for Strength of the Evidence**[3] (*Use the USPSTF system, or if different, also describe how it relates to the USPSTF system)*: N/A **Summary of Evidence** (*provide guideline information below*): N/A **Citations for Evidence:** N/A
21 (1c)	**Clinical Practice Guideline** *Cite the guideline reference; quote the specific guideline recommendation related to the measure and the guideline author's assessment of the strength of the evidence; and summarize the rationale for using this guideline over others.* **Guideline Citation:** N/A

[3]The strength of the body of evidence for the specific measure focus should be systematically assessed and rated, e.g., USPSTF grading system www.ahrq.gov/clinic/uspstmeth.htm: A - The USPSTF recommends the service. There is high certainty that the net benefit is substantial. B - The USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial. C - The USPSTF recommends against routinely providing the service. There may be considerations that support providing the service in an individual patient. There is at least moderate certainty that the net benefit is small. Offer or provide this service only if other considerations support the offering or providing the service in an individual patient. D - The USPSTF recommends against the service. There is moderate or high certainty that the service has no net benefit or that the harms outweigh the benefits. I - The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of the service. Evidence is lacking, of poor quality, or conflicting, and the balance of benefits and harms cannot be determined.

	Specific guideline recommendation: N/A **Guideline author's rating of strength of evidence** (*If different from USPSTF, also describe it and how it relates to USPSTF*)**:** N/A **Rationale for using this guideline over others:** N/A
22 (1c)	**Controversy/Contradictory Evidence** *Summarize any areas of controversy, contradictory evidence, or contradictory guidelines and provide citations.* **Summary:** N/A **Citations:** N/A
23 (1)	**Briefly describe how this measure (as specified) will facilitate significant gains in healthcare quality related to the specific priority goals and quality problems identified above:** Quality improvement efforts can be enhanced and stimulated by a clear understanding of how an entity (e.g., an institution) is performing in comparison to other entities. Information regarding overall performance can be difficult to obtain because of the extreme diversity of conditions that comprise congenital heart disease. Even the most common lesions make up only a small fraction of most surgical case loads. Measurement tools that can include all or most of a total surgical caseload provides a more precise and better reflection of overall performance.
	SCIENTIFIC ACCEPTABILITY OF MEASURE PROPERTIES
	Note: Testing and results should be summarized in this form. However, additional detail and reports may be submitted as supplemental information or provided as a web page URL. If a measure has not been tested, it is only potentially eligible for time-limited endorsement.
24	**Supplemental Testing Information:** attached ☒ **OR** Web page URL:
25 (2b)	**Reliability Testing** **Data/sample:** (1) Comparison of mortality rates by RACHS-1 risk category for all patients undergoing repair of congenital heart surgery at Children's Hospital Boston in 2003 for an internal database of all patients admitted to the cardiac intensive care unit in that year versus cases obtained from the administrative Pediatric Health Information System (PHIS) database for the same year. For the internal database, RACHS-1 risk categories were assigned manually by chart review. For PHIS, patient diagnoses and procedures were coded using ICD-9-CM codes and assigned to risk categories using a computer algorithm. (2) Comparison of standardized mortality ratios for all patients undergoing repair of congenital heart surgery calculated for Children's Hospital Boston in 2003 based on data in the PHIS database, and data captured in the internal database. (3) Comparison of institutional rankings based on standardized mortality ratio, RACHS-1 risk adjusted, for two large databases in 2003. Using the PHIS database, SMRs were generated for 35 free-standing children's hospitals performing more than 35 congenital heart repair procedures in 2003 (see item 30 below); similarly, SMRs were generated for 97 institutions in the KID 2003. The KID contains an 80% sample of pediatric discharges from all community hospitals in 36 participating states; PHIS contains 100% of inpatient cases from free-standing children's hospitals that pay a fee to participate. Fourteen institutions were identified as being included in both data sets in this year. (Note that some states do not identify institutions by name or location in the KID.) WIthin each data set, these 14 institutions were ranked from lowest SMR (lowest risk-adjusted mortality) to highest. **Analytic Method:** (1) Within each risk category, mortality rates from the two data sources were compared using Fisher's exact test. (2) Cases from the 35 children's hospitals performing congenital heart repair procedures in 2003 were used as the benchmark; these cases were used to calculate the expected mortality rates at Children's Hospital Boston given its distribution according to RACHS-1 risk category, age at surgery, prematurity, presence of a major non-cardiac structural anomaly, and multiple cardiac procedures performed simultaneously.

	(3) Spearman's rank correlation was used to quantify the association between institutional rankings generated from the PHIS database and those generated from KID. **Testing Results:** (1) Risk category 1 -- 0.0% (internal) vs 1.0% (PHIS), p=1.0; risk category 2 -- 1.1% vs 0.5%, p=0.63; risk category 3 -- 2.5% vs 2.0%, p=0.78; risk category 4 -- 1.7% versus 1.2%, p=1.0; risk category 6 -- 14.3% vs 11.9%, p=0.77. (2) SMR for Children's Hospital Boston calculated using data contained in the PHIS database: 0.44, 95% confidence interval (0.23, 0.78). SMR for Children's Hospital Boston calculated using data contained in the internal database: 0.60, 95% confidence interval (0.35, 0.94). (3) The Spearman rank correlation coefficient is 0.91, representing very high correlation between institutional rankings within the two different databases. Given the different sampling strategies, we would not expect perfect correlation between these SMRs.
26 (2c)	**Validity Testing** **Data/sample:** I -- Validation of Risk Adjustment Model Original derivation of RACHS-1: (1) Pediatric Cardiac Care Consortium (PCCC) database 1996; 4370 cases from 32 institutions. (2) Hospital discharge data from three states (Illinois 1994, Massachusetts 1995, California 1995); 3646 total cases. Subsequent validation: (3) 1996 hospital discharge data from six states (California, Illinois, Massachusetts, New York, Pennsylvania, Washington); 4318 total cases. (4) Retrospectively collected primary data from a newly created pediatric cardiac care program in Guatemala, 1997-2004; 1215 total cases. (5) Kids' Inpatient Database (KID) 2000; 12717 total cases. Other uses: (6) Kids' Inpatient Database (KID) 2003; 11395 total cases. (7) Pediatric Health Information System (PHIS) 2002-2006; 45621 total cases. II -- Ability of the Measure to Detect Meaningful Changes (1) Retrospectively collected primary data from a newly created pediatric cardiac care program in Guatemala, 1997-2004. (2) Retrospectively collected primary data from a single pediatric cardiology practice in the Midwest, 1992-2002. III -- Examination of Mortality Rates for Surgical Procedures within Risk Categories (1) Kids' Inpatient Database (KID) 2003. (2) Pediatric Health Information System (PHIS) 2002-2006. (3) European Asssociation for Cardio-Thoracic Surgery (EACTS) Congenital Database 2002-2006. (4) Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database 2002-2006. (5) Pediatric Cardiac Care Consortium (PCCC) Database 2002-2004. IV -- Inclusion of Clinical Factors in Risk Adjustment Method (1) Pediatric Cardiac Care Consortium (PCCC) database 1996. (2) Hospital discharge data from three states (Illinois 1994, Massachusetts 1995, California 1995). (3) Kids' Inpatient Database (KID) 2003. (4) Pediatric Health Information System (PHIS) 2002-2006. **Analytic Method:** I -- Validation of Risk Adjustment Model Discrimination of the risk adjustment method has been quantified using the area under the receiver-operator characteristic (ROC) curve (also called the c statistic); calibration was assessed using the Hosmer-Lemeshow test. II -- Ability of the Measure to Detect Meaningful Changes

	(1) In 1997, a new pediatric cardiac care program was established in Guatemala. Improvement of the program over time was explored by examining the reduction in SMR. Data were divided into 3 time periods (1997-1999, 2000-2002, 2003-2004) and compared to a US benchmark (KID 2000). (2) A small Midwestern practice began selectively referring congenital heart surgical patients to high volume surgical centers in August 1998. Changes in mortality over time were explored by examining SMRs. Data were divided into 3 time periods (August 1992-July 1995, August 1995-July 1998, August 1998-July 2002) and compared to contemporaneous US benchmarks (hospital discharge abstract data from California, Illinois, Massachusetts, Pennsylvania, and Washington in 1992, 1996, and 1998). III -- Examination of Mortality Rates for Surgical Procedures within Risk Categories For each of five data sets, in-hospital mortality rates were calculated for individual surgical procedures within each RACHS-1 risk category. Exact 95% confidence intervals were generated. IV -- Inclusion of Clinical Factors in Risk Adjustment Method Increases in discrimination of the risk adjustment method when clinical factors were added to the risk categories were quantified using the area under the ROC curve (c statistic). **Testing Results:** I -- Validation of Risk Adjustment Model (1) Area under the ROC curve for the full RACHS-1 model 0.811; p value for Hosmer-Lemeshow test 0.34. (2) Area under the ROC curve 0.814; p value for Hosmer-Lemeshow test 0.21. (3) Area under the ROC curve 0.818; p value for Hosmer-Lemeshow test 0.83. (4) Area under the ROC curve 0.854. (5) Area under the ROC curve 0.828; p value for Hosmer-Lemeshow test 0.66. (6) Area under the ROC curve 0.809; p value for Hosmer-Lemeshow test 0.18. (7) Area under the ROC curve 0.822; p value for Hosmer-Lemeshow test 0.08. II -- Ability of the Measure Detect Meaningful Changes (1) SMRs were 10.0 (95% confidence interval 7.2, 13.7) in 1997-1999, 7.8 (5.9, 10.0) in 2000-2002, and 5.7 (3.8, 8.3) in 2003-2004. There was a statistically significant decrease between 1997-1999 and 2003-2004 (p=0.008). Larrazabal LA, Jenkins KJ, Gauvreau K, Vida VL, Benavidez OJ, Gaitan GA, Garcia F, Castaneda AR. Improvement in congenital heart surgery in a developing country: the Guatemalan experience. Circulation 2007: 116:1882-1887. (2) SMRs relative to the US benchmark were 0.89 (p=0.75), 0.88 (p=0.72), and 0.24 (p=0.02) in the 3 respective time periods, indicating an improvement in performance. Allen SW, Gauvreau KG, Bloom BT, Jenkins KJ. Evidence-based referral results in significantly reduced mortality after congenital heart surgery. III -- Examination of Mortality Rates for Surgical Procedures within Risk Categories See attached spreadsheet (Item 26). In general, mortality rates of individual procedures within each RACHS-1 risk category are comparable. IV -- Inclusion of Clinical Factors in Risk Adjustment Method (1) Area under the ROC curve for risk category alone 0.784, adding age at surgery 0.807, adding major non-cardiac structural anomaly 0.814, adding prematurity 0.817. (2) Area under the ROC curve for risk category alone 0.749, adding age at surgery 0.813, adding prematurity 0.815, adding major non-cardiac structural anomaly 0.816. (3) Area under the ROC curve for risk category alone 0.747, adding age at surgery 0.806, adding prematurity 0.812, adding major non-cardiac structural anomaly 0.813. (4) Area under the ROC curve for risk category alone 0.742, adding age at surgery 0.807, adding prematurity 0.811, adding major non-cardiac structural anomaly 0.816.
27 (2d)	**Measure Exclusions** *Provide evidence to justify exclusion(s) and analysis of impact on measure results during testing.* **Summary of Evidence supporting exclusion(s):** See Analytic Method below.

	Citations for Evidence: Jenkins KJ, Gauvreau K, Newburger JW, Spray TL, Moller JH, Iezzoni LI. Consensus-based method for risk adjustment for surgery for congenital heart disease. Journal of Thoracic and Cardiovascular Surgery 2002; 123:110-118. **Data/sample:** N/A **Analytic Method:** The RACHS-1 risk adjustment method was developed with the clinical expertise of a nationally representative panel of experts, including both pediatric cardiologists and pediatric cardiac surgeons. A consensus based process was used to develop six distinct risk categories quantifying risk for in-hospital mortality. Congenital heart surgical procedures excluded were approved by all panel members. Performance of preliminary risk categories was examined using data from two large multi-institutional data sets. Final risk categories were approved by panel members. **Testing Results:** N/A
28 (2e)	**Risk Adjustment Testing** *Summarize the testing used to determine the need (or no need) for risk adjustment and the statistical performance of the risk adjustment method.* **Data/sample:** N/A **Analytic Method:** The RACHS-1 risk adjustment method was developed with the clinical expertise of a nationally representative panel of experts, including both pediatric cardiologists and pediatric cardiac surgeons. A consensus based process was used to develop six distinct risk categories quantifying risk for in-hospital mortality. Congenital heart surgical procedures excluded were approved by all panel members. Performance of preliminary risk categories was examined using data from two large multi-institutional data sets. Final risk categories were approved by panel members. **Testing Results:** N/A ►**If outcome or resource use measure not risk adjusted, provide rationale:** N/A
29 (2g)	**Testing comparability of results when more than 1 data method is specified** (*e.g., administrative claims or chart abstraction*) **Data/sample:** N/A **Analytic Method:** The RACHS-1 risk adjustment method was designed such that it could be implemented using a variety of different data sources. It has been successfully applied in administrative databases and using the clinical records of a single hospital or program. **Results:** N/A
30 (2f)	**Provide Measure Results from Testing or Current Use** Results from current use **Data/sample:** Pediatric Health Information System (PHIS) 2006-2008. **Methods to identify statistically significant and practically/meaningfully differences in performance:** A multivariable model (described in item 8) can be used to generate expected mortality rates based on case mix (described in item 9) for groups of patients within a single data set, such as those undergoing congenital heart surgery in specified institutions. These expected mortality rates, which are based on average performance within the data set, can be used to calculate standardized mortality ratios for each group. 95% confidence intervals for the SMRs can also be calculated. If the confidence interval for an SMR fails to contain the value 1, this suggests that group performance is either significantly better or significantly worse than average. In the Results below, information from the Children's Hospital Boston Comprehensive Quality Report is shown. This biannual report includes standardized mortality ratios for congenital heart surgery for 38 institutions contributing data to the PHIS database; Boston uses this information to benchmark its performance against other free-standing children's hospitals as a measure of effectiveness of care. Note that individual institutions would be able to benchmark themselves against an appropriate

comparison group as long as model coefficients for that group are provided.

Results:
Effectiveness – Cardiac Surgery Outcomes (from the Children's Hospital Boston Comprehensive Quality Report)

Measures: Standardized mortality ratio (SMR) for congenital heart surgery in children <18 years of age; also three-year rolling SMR.

The standardized mortality ratio for an institution is defined as its actual or observed in-hospital mortality rate divided by its expected in-hospital mortality rate; the expected rate is calculated based on the patient case mix at the institution relative to the case mix in the reference data set as a whole. An institution with a more complex case mix would have a higher expected mortality rate. The SMR for an institution will be equal to 1 if the observed mortality rate is equal to the expected rate. The SMR will be less than 1 if observed mortality is less than would be expected given the patient case mix.

Background: If Children's Hospital delivers effective cardiac care, death following congenital heart surgery should be infrequent, and the standardized mortality ratio will be low.

Data Source: Data were obtained from the Pediatric Health Information Systems (PHIS) database, which is compiled by the Child Health Corporation of America and contains clinical and financial information on patient admissions from 41 free-standing children's hospitals.

External Benchmark: Using the PHIS database, the SMR and 3-year rolling SMR can be calculated for member institutions performing >20 cases of congenital heart surgery per year over the time period CY02 to CY08, including most major pediatric cardiac centers.

Target: The target is to have the lowest SMR among institutions in the PHIS database.

Data Analysis: Congenital heart surgeries eligible for this measure are procedures that can be categorized using the RACHS-1 risk adjustment method. Procedures are placed into one of six categories based on anticipated risk of in-hospital mortality, with category 1 representing the lowest risk for death and category 6 the highest. In addition to risk category, the RACHS-1 method accounts for age at surgery (≤ 30 days, 31 days to 1 year, or ≥ 1 year), prematurity, presence of a major non-cardiac structural anomaly, and multiple cardiac procedures performed simultaneously. Together, risk category and these additional clinical factors describe the patient case mix of an institution; they are used to calculate its expected in-hospital mortality rate.

Ignoring the risk factors, the total number of in-hospital deaths in a calendar year divided by the total number of congenital heart surgeries performed is the observed mortality rate.

The SMR equals the observed mortality rate divided by the expected mortality rate. In addition to the SMR, a 95% confidence interval (CI) is calculated. This measure is generated for each calendar year separately, and also for aggregate 3-year periods.

Results:
Standardized mortality ratios are presented below for 38 institutions, ranked according to 3-year rolling SMR. Based on the 3-year rolling SMRs, institutions 1 through 5 all demonstrate risk-adjusted outcomes which are significantly better than average (upper bounds of the 95% confidence intervals lie below 1.0); institutions 34 through 38 have risk-adjusted outcomes which are significantly worse than average (lower bounds of confidence intervals are above 1.0).

Institution	CY08, Individual Year			CY08, 3-Year Rolling		
	SMR	95% CI	Rank	SMR	95% CI	Rank
1	0.71	(0.29, 1.47)	7	0.54	(0.31, 0.87)	1
2	0.45	(0.09, 1.32)	1	0.58	(0.32, 0.97)	2
3	0.59	(0.28, 1.09)	5	0.59	(0.39, 0.84)	3
4	0.91	(0.47, 1.59)	15	0.63	(0.43, 0.90)	4

	5	0.55	(0.27, 0.98)	4	0.65	(0.47, 0.89)	5
	6	0.66	(0.21, 1.55)	6	0.70	(0.41, 1.12)	6
	7	0.48	(0.22, 0.90)	2	0.75	(0.55, 1.00)	7
	8	0.83	(0.33, 1.71)	11	0.79	(0.49, 1.19)	8
	9	0.73	(0.29, 1.50)	9	0.79	(0.48, 1.22)	8
	10	1.00	(0.43, 1.97)	21	0.86	(0.51, 1.34)	10
	11	0.80	(0.22, 2.05)	10	0.86	(0.47, 1.45)	10
	12	0.95	(0.31, 2.22)	18	0.90	(0.54, 1.40)	12
	13	0.96	(0.50, 1.68)	19	0.90	(0.63, 1.24)	12
	14	1.36	(0.59, 2.68)	28	0.90	(0.51, 1.49)	12
	15	1.02	(0.41, 2.11)	23	0.92	(0.57, 1.41)	15
	16	1.30	(0.65, 2.33)	27	0.96	(0.62, 1.42)	16
	17	0.90	(0.51, 1.46)	14	0.96	(0.67, 1.33)	16
	18	0.53	(0.11, 1.56)	3	1.03	(0.60, 1.65)	18
	19	0.72	(0.29, 1.49)	8	1.05	(0.73, 1.47)	19
	20	0.93	(0.55, 1.48)	16	1.06	(0.81, 1.35)	20
	21	1.45	(0.62, 2.85)	30	1.07	(0.65, 1.65)	21
	22	0.98	(0.39, 2.01)	20	1.07	(0.66, 1.66)	21
	23	0.94	(0.34, 2.05)	17	1.08	(0.70, 1.59)	23
	24	1.12	(0.54, 2.06)	25	1.16	(0.78, 1.66)	24
	25	0.88	(0.28, 2.05)	13	1.20	(0.75, 1.82)	25
	26	1.70	(0.34, 4.96)	33	1.26	(0.54, 2.48)	26
	27	1.11	(0.51, 2.11)	24	1.28	(0.87, 1.81)	27
	28	2.33	(0.47, 6.81)	36	1.29	(0.52, 2.67)	28
	29	1.12	(0.56, 2.01)	25	1.30	(0.92, 1.78)	29
	30	1.52	(0.87, 2.47)	31	1.31	(0.94, 1.78)	30
	31	1.43	(0.68, 2.63)	29	1.32	(0.86, 1.94)	31
	32	1.01	(0.27, 2.59)	22	1.33	(0.76, 2.15)	32
	33	1.53	(0.73, 2.81)	32	1.34	(0.88, 1.95)	33
	34	2.20	(1.23, 3.62)	35	1.54	(1.10, 2.10)	34
	35	0.85	(0.27, 1.99)	12	1.59	(1.10, 2.24)	35
	36	2.38	(1.48, 3.65)	37	1.80	(1.33, 2.38)	36
	37	2.75	(0.89, 6.42)	38	2.71	(1.40, 4.73)	37
	38	1.82	(0.66, 3.95)	34	3.01	(1.93, 4.48)	38

31 (2h)

Identification of Disparities

►If measure is stratified by factors related to disparities (i.e. race/ethnicity, primary language, gender, SES, health literacy), **provide stratified results:** N/A

►If disparities have been reported/identified, but measure is not specified to detect disparities, provide rationale: N/A

USABILITY

32 (3)

Current Use *In use* *If in use, how widely used* *Other* ► *If "other," please describe:* *Nationally and internationally.*

☐ *Used in a public reporting initiative, name of initiative: N/A*
Sample report attached ☐ *OR Web page URL: N/A*

33 (3a)

Testing of Interpretability (*Testing that demonstrates the results are understood by the potential users for public reporting and quality improvement*)

Data/sample: N/A

Methods: Testing of interpretability not performed.

Results: N/A

34 (3b, 3c)	**Relation to other NQF-endorsed™ measures** ►Is this measure similar or related to measure(s) already endorsed by NQF (on the same topic or the same target population)? *Measures can be found at www.qualityforum.org under Core Documents.* *Check all that apply* ☐ Have not looked at other NQF measures ☒ Other measure(s) on same topic ☐ Other measure(s) for same target population ☐ No similar or related measures **Name and number of similar or related NQF-endorsed™ measure(s):** NQF # 0339 Pediatric Heart Surgery Mortality (PDI 6) **Are the measure specifications harmonized with existing NQF-endorsed™ measures?** Partially harmonized ►If not fully harmonized, provide rationale: NQF has endorsed less than 20 clinician-level performance measures in the areas of cardiac surgery and fewer in the pediatric surgical population. The RACHS-1 offers a more robust methodology for risk adjustment. **Describe the distinctive, improved, or additive value this measure provides to existing NQF-endorsed measures:** The RACHS-1 method adjusts for baseline risk differences and allows meaningful comparisions of in-patient mortality groups of children undergoing surgery for congenital heart disease.
	FEASIBILITY
35 (4a)	*How are the required data elements generated? Check all that apply* ☒ *Data elements are generated concurrent with and as a byproduct of care processes during care delivery (e.g., blood pressure or other assessment recorded by personnel conducting the assessment)* ☐ *Data elements are generated from a patient survey (e.g., CAHPS)* ☒ *Data elements are generated through coding performed by someone other than the person who obtained the original information (e.g., DRG or ICD-9 coding on claims)* ☒ *Other, Please describe: Data elements may be obtained from an administrative database (e.g., Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database (KID), Pediatric Health Information System (PHIS)); from a clinical database (e.g., Pediatric Cardiac Care Consortium (PCCC), Society of Thoracic Surgeons (STS) Congenital Heart Surgery Database)*; from hospital-specific electronic medical records; or from paper medical records.* **STS database does not currently include all variables but there are plans to add them.*
36 (4b)	*Electronic Sources All data elements* ►*If all data elements are not in electronic sources, specify the near-term path to electronic collection by most providers: N/A* ►*Specify the data elements for the electronic health record: In-hospital mortality, type of surgical procedure, age at surgery, prematurity, presence of major non-cardiac structural anomaly, combinations of cardiac procedures performed.*
37 (4c)	*Do the specified exclusions require additional data sources beyond what is required for the other specifications? No* ►*If yes, provide justification: N/A*
38 (4d)	*Identify susceptibility to inaccuracies, errors, or unintended consequences of the measure: Because this measure can be applied in administrative databases, it can be subject to the coding inaccuracies sometimes associated with these databases. This problem is minimized if prospectively collected data are used.* *Describe how could these potential problems be audited: Type of surgical procedure and other data elements can be easily audited.* *Did you audit for these potential problems during testing? No If yes, provide results: N/A*
39	*Testing feasibility Describe what have you learned/modified as a result of testing and/or operational*

(4e)	*use of the measure regarding data collection, availability of data/missing data, timing/frequency of data collection, patient confidentiality, time/cost of data collection, other feasibility/ implementation issues:* *While the measure has been shown to perform well in administrative and clinical databases, performance is even better in prospectively collected data sources.*
	CONTACT INFORMATION
40	*Web Page URL for Measure Information* *Describe where users (implementers) should go for more details on specifications of measures, or assistance in implementing the measure.* *Web page URL: Contact the Measure Steward*
41	**Measure Steward Point of Contact** **First Name:** Nina **MI:** A **Last Name:** Rauscher **Credentials (MD, MPH, etc.):** MS, RN, CPHQ **Organization:** Program for Patient Safety and Quality, Children's Hospital Boston **Street Address:** 300 Longwood Avenue **City:** Boston **State:** MA **ZIP:** 02115 **Email:** nina.rauscher@childrens.harvard.edu **Telephone:** 617-355-6567 ext: 0
42	**Measure Developer Point of Contact** **If different from Measure Steward** **First Name:** N/A **MI:** **Last Name:** N/A **Credentials (MD, MPH, etc.):** N/A **Organization:** N/A **Street Address:** N/A **City:** N/A **State:** **ZIP:** N/A **Email:** N/A **Telephone:** N/A ext: N/A
	ADDITIONAL INFORMATION
43	**Workgroup/Expert Panel involved in measure development** Workgroup/panel used ►If workgroup used, describe the members' role in measure development: An 11-member panel of pediatric cardiologists and cardiac surgeons used clinical judgment to place surgical procedures into six risk categories. Categories were refined after review of information from the Pediatric Cardiac Care Consortium and three statewide hospital discharge data sets. ►Provide a list of workgroup/panel members' names and organizations: Eugene H. Blackstone, MD, Cleveland Clinic Foundation David E. Fixler, MD, University of Texas Southwest Medical Center Howard P. Gutgesell, MD, University of Virginia Medical Center Frank L. Hanley, MD, University of California San Francisco Medical Center Thomas J. Kulik, MD, C.S. Mott Children's Hospital John E. Mayer, Jr, MD, Children's Hospital Boston James H. Moller, MD, University of Minneapolis Hospital Jane W. Newburger, MD, MPH, Children's Hospital Boston Jan M. Quaegebeur, MD, Columbia University Medical Center Thomas L. Spray, MD, Children's Hospital of Philadelphia Roberta G. Williams, MD, University of North Carolina at Chapel Hill School of Medicine
44	*Measure Developer/Steward Updates and Ongoing Maintenance* *Year the measure was first released: University 2002.* *Month and Year of most recent revision: Currently in progress (standardized mortality ratio for congenital heart surgery, RACHS-2 adjusted); anticipated release 2010.* *What is the frequency for review/update of this measure? Every three years.* *When is the next scheduled review/update for this measure? Currently in progress.*
45	**Copyright statement/disclaimers:** N/A
46	**Additional Information:** N/A
47	**I have checked that the submission is complete and any blank fields indicate that no information is provided.** ☒
48	**Date of Submission** (*MM/DD/YY*)**:** 01/04/10

RACHS-1 Algorithm
For Use With ICD-9-CM Codes

Identification of diagnoses for congenital heart disease

Any of the following:

745.0	Common truncus
745.10	Complete transposition of great vessels
745.11	Double outlet right ventricle
745.12	Corrected transposition of great vessels
745.19	Other transposition of great vessels
745.2	Tetralogy of Fallot
745.3	Common ventricle
745.4	Ventricular septal defect
745.5	Ostium secundum type atrial septal defect
745.60	Endocardial cushion defect, unspecified type
745.61	Ostium primum defect
745.69	Other endocardial cushion defect
745.7	Cor biloculare
745.8	Other bulbis cordis anomalies and anomalies of cardiac septal closure
745.9	Unspecified defect of septal closure
746.00	Pulmonary valve anomaly, unspecified
746.01	Pulmonary valve atresia, congenital
746.02	Pulmonary valve stenosis, congenital
746.09	Other anomaly of pulmonary valve
746.1	Tricuspid atresia and stenosis, congenital
746.2	Ebstein's anomaly
746.3	Congenital stenosis of aortic valve
746.4	Congenital insufficiency of aortic valve
746.5	Congenital mitral stenosis
746.6	Congenital mitral insufficiency
746.7	Hypoplastic left heart syndrome
746.81	Subaortic stenosis
746.82	Cor triatriatum
746.83	Infundibular pulmonic stenosis
746.84	Obstructive anomalies of heart, not elsewhere classified
746.85	Coronary artery anomaly
746.87	Malposition of heart and cardiac apex
746.89	Other specified anomaly of heart
746.9	Unspecified anomaly of heart
747.0	Patent ductus arteriosus
747.10	Coarctation of aorta (preductal) (postductal)
747.11	Interruption of aortic arch
747.20	Anomaly of aorta, unspecified
747.21	Anomalies of aortic arch
747.22	Atresia and stenosis of aorta
747.29	Other anomalies of aorta
747.3	Anomalies of pulmonary artery
747.40	Anomaly of great veins, unspecified
747.41	Total anomalous pulmonary venous connection
747.42	Partial anomalous pulmonary venous connection
747.49	Other anomalies of great veins

Identification of surgical procedures for congenital heart disease

Any of the following:

35.00	Closed heart valvotomy, unspecified valve
35.01	Closed heart valvotomy, aortic valve
35.02	Closed heart valvotomy, mitral valve
35.03	Closed heart valvotomy, pulmonary valve
35.04	Closed heart valvotomy, tricuspid valve
35.10	Open heart valvuloplasty without replacement, unspecified valve
35.11	Open heart valvuloplasty of aortic valve without replacement
35.12	Open heart valvuloplasty of mitral valve without replacement
35.13	Open heart valvuloplasty of pulmonary valve without replacement
35.14	Open heart valvuloplasty of tricuspid valve without replacement
35.20	Replacement of unspecified heart valve
35.21	Replacement of aortic valve with tissue graft
35.22	Other replacement of aortic valve
35.23	Replacement of mitral valve with tissue graft
35.24	Other replacement of mitral valve
35.25	Replacement of pulmonary valve with tissue graft
35.26	Other replacement of pulmonary valve
35.27	Replacement of tricuspid valve with tissue graft
35.28	Other replacement of tricuspid valve
35.31	Operations on papillary muscle
35.32	Operations on chordae tendineae
35.33	Annuloplasty
35.34	Infundibulectomy
35.35	Operations on trabeculae carnae cordis
35.39	Operations on other structures adjacent to valves of heart
35.41	Enlargement of existing atrial septal defect
35.42	Creation of septal defect in heart
35.50	Repair of unspecified septal defect of heart with prosthesis
35.51	Repair of atrial septal defect with prosthesis, open technique
35.52	Repair of atrial septal defect with prosthesis, closed technique
35.53	Repair of ventricular septal defect with prosthesis
35.54	Repair of endocardial cushion defect with prosthesis
35.60	Repair of unspecified septal defect of heart with tissue graft
35.61	Repair of atrial septal defect with tissue graft
35.62	Repair of ventricular septal defect with tissue graft
35.63	Repair of endocardial cushion defect with tissue graft
35.70	Other and unspecified repair of unspecified septal defect of heart
35.71	Other and unspecified repair of atrial septal defect
35.72	Other and unspecified repair of ventricular septal defect
35.73	Other and unspecified repair of endocardial cushion defect
35.81	Total repair of tetralogy of Fallot
35.82	Total repair of total anomalous pulmonary venous connection
35.83	Total repair of truncus arteriosus
35.84	Total correction of transposition of great vessels, not elsewhere classified
35.91	Interatrial transposition of venous return
35.92	Creation of conduit between right ventricle and pulmonary artery
35.93	Creation of conduit between left ventricle and aorta
35.94	Creation of conduit between atrium and pulmonary artery
35.95	Revision of corrective procedure on heart

35.98	Other operations on septa of heart
35.99	Other operations on valves of heart
36.99	Other operations on vessel of heart
37.33	Excision or destruction of other lesion or tissue of heart
37.5	Heart replacement procedures
37.51	Heart transplantation
37.52	Implantation of total replacement heart system
39.0	Systemic to pulmonary artery shunt
39.21	Caval-pulmonary artery anastomosis

Included only if a cardiac diagnosis code or one of the previous surgical procedure codes is present:

38.34	Resection of abdominal aorta with anastomosis
38.35	Resection of thoracic vessel with anastomosis
38.44	Resection of abdominal aorta with replacement
38.45	Resection of thoracic vessel with replacement
38.64	Other excision of abdominal aorta
38.65	Other excision of thoracic vessel
38.84	Other surgical occlusion of abdominal aorta
38.85	Other surgical occlusion of thoracic vessel
39.49	Other revision of vascular procedure
39.56	Repair of blood vessel with tissue patch graft
39.57	Repair of blood vessel with synthetic patch graft
39.58	Repair of blood vessel with unspecified type of patch graft
39.59	Other repair of vessel

** Case selection**

Keep all cases with ≥ 1 surgical procedure for congenital heart disease

Define:

Age group

- ≤ 30 days
- 31 days to 1 year
- ≥ 1 year

Major noncardiac structural anomalies

740.0	Anencephalus
740.1	Craniorachischisis
740.2	Iniencephaly
741.0	Spina bifida, with hydrocephalus
741.9	Spina bifida, without mention of hydrocephalus
742.0	Encephalocele
742.1	Microcephalus
742.2	Reduction deformities of brain
742.3	Congenital hydrocephalus
742.4	Other specified anomalies of brain
742.5x	Other specified anomalies of spinal cord
742.9	Unspecified anomaly of brain, spinal cord, and nervous system

748.0 Choanal atresia
748.2 Web of larynx
748.3 Other anomalies of larynx, trachea, and bronchus
748.4 Congenital cystic lung
749.0x Cleft palate
749.1x Cleft lip
749.2x Cleft palate with cleft lip
750.3 Tracheoesophageal fistula, esophageal atresia and stenosis
751.1 Atresia and stenosis of small intestine
751.2 Atresia and stenosis of large intestine, rectum, and anal canal
751.4 Anomalies of intestinal fixation
751.61 Biliary atresia
753.0 Renal agenesis and dysgenesis
753.15 Cystic kidney disease, renal dysplasia
753.2 Obstructive defects of renal pelvis and ureter
753.5 Exstrophy of urinary bladder
756.6 Anomalies of diaphragm
756.7 Anomalies of abdominal wall

Prematurity

765.0x Extreme immaturity
765.1x Other preterm infants
765.21-765.28 Gestational age ≤ 36 weeks

Identify and delete transcatheter interventions:

At least one catheterization code

37.21 Right heart cardiac catheterization
37.22 Left heart cardiac catheterization
37.23 Combined right and left heart cardiac catheterization
88.42 Aortography
88.43 Arteriography of pulmonary arteries
88.44 Arteriography of other intrathoracic vessels
88.5x Angiocardiography using contrast material

No code for cardiopulmonary bypass

39.61 Extracorporeal circulation auxiliary to open heart surgery

Only cardiac procedure is one of the following

PDA closure (diagnosis 747.0, procedure 38.85)
Atrial septectomy (procedure 35.41 *or* 35.42)
ASD closure (procedure 35.51 *or* 35.71)
VSD closure (procedure 35.53 *or* 35.72)
Vessel repair or occlusion (procedure 38.84, 38.85 *or* 39.59)
Unspecified valvotomy (procedure 35.00)
Aortic valvotomy (procedure 35.01)
Mitral valvotomy (procedure 35.02)
Pulmonary valvotomy (procedure 35.03)
Tricuspid valvotomy (procedure 35.04)

OR

No code for cardiopulmonary bypass and only cardiac procedure is one of the following

35.41 Enlargement of existing atrial septal defect
35.52 Repair of ASD with prosthesis, closed technique

Exclude cases not eligible for RACHS-1:

Unknown disposition/death

Age ≥ 18 years

Heart transplant
- 37.5 Heart replacement procedures
- 37.5x

Premature infants with PDA closure as only cardiac procedure
- Diagnosis 747.0 required; 745.4 and 745.5 allowed

Age ≤ 30 days and PDA closure as only cardiac procedure
- Diagnosis 747.0 required; 745.4 and 745.5 allowed

Define individual cardiac procedures assigned to a risk category

A case is considered to have a single surgical procedure for congenital heart disease if it matches to one of the descriptions below; it is assigned to the specified risk category

A case with additional cardiac procedures not explicitly allowed is considered to have multiple surgical procedures; it is assigned to the category of the highest risk procedure

Surgical procedures must be assigned in the order specified below; a case is eligible to match to a procedure only if it has not already been assigned to a previous procedure

- Repair of PAPVC — Risk category 1

Require:	Dx 747.42	Partial anomalous PV connection
	Proc 35.82	Total repair of TAPVC
	or 39.56, 39.57, 39.58	Repair of blood vessel
	or 39.59	
	or 36.99	Other operation on vessel of heart
	or 38.85	Other surg occlusion thoracic vessel
Allow:	PDA surgery	
	ASD2 repair	

- Repair of TAPVC, > 30 days — Risk category 2

Require:	Proc 35.82	Total repair of TAPVC
	Age > 30 days	
Cannot have:	Dx 747.42	Partial anomalous PV connection
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Repair of TAPVC, ≤ 30 days — Risk category 4

Require:	Proc 35.82	Total repair of TAPVC
	Age ≤ 30 days	
Cannot have:	Dx 747.42	Partial anomalous PV connection
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Systemic to PA shunt — Risk category 3

Require:	Proc 39.0	Systemic to PA shunt
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	PDA surgery	

- Glenn shunt — Risk category 2

Require:	Proc 39.21	Caval-pulmonary artery anastomosis
Cannot have:	Proc 35.94	Creation of conduit between atrium-PA
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	PDA surgery	

- Double switch — Risk category 4

Require:	Proc 35.84	Total correction of transposition of great vessels
	Proc 35.91	Interatrial transposition of venous return
Allow:	Proc 35.41 *or* 35.42	Creation of ASD
	PDA surgery	
	ASD2 repair	

- Arterial switch operation with VSD repair — Risk category 4

Require:	Proc 35.84	Total correction of transposition of great vessels
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 35.41 *or* 35.42	Creation of ASD
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Arterial switch operation — Risk category 3

Require:	Proc 35.84	Total correction of transposition of great vessels
Allow:	Proc 35.41 *or* 35.42	Creation of ASD
	PDA surgery	
	ASD2 repair	

- Atrial switch operation with VSD repair — Risk category 4

Require:	Proc 35.91	Interatrial transposition of venous return
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 35.41 *or* 35.42	Creation of ASD
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Atrial switch operation — Risk category 3

Require:	Proc 35.91	Interatrial transposition of venous return
Allow:	Proc 35.41 *or* 35.42	Creation of ASD
	PDA surgery	
	ASD2 repair	

- ASD primum repair — Risk category 2

Require:	Dx 745.61	Ostium primum defect
	Proc 35.54, 35.63 *or* 35.73	Repair of endocardial cushion defect
	or 35.51, 35.52, 35.61	Repair of ASD
	or 35.71	
Allow:	Proc 35.12	Mitral valvuloplasty
	Proc 35.02	Mitral valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	

- Repair of transitional or complete AVC with/without MVR — Risk category 3

Require:	Proc 35.54, 35.63 *or* 35.73	Repair of endocardial cushion defect
Cannot have:	Dx 745.61	Ostium primum defect
Allow:	Proc 35.12	Mitral valvuloplasty
	Proc 35.23 *or* 35.24	Mitral valve replacement
	Proc 35.14	Tricuspid valvuloplasty
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	Proc 35.51, 35.52, 35.61,	Repair of atrial septal defect
	or 35.71	

- Repair of TOF with pulmonary atresia — Risk category 3

Require:	Dx 746.01	Pulmonary valve atresia, congenital
	Proc 35.81	Total repair of tetralogy of Fallot
Allow:	Proc 35.92	Creation of conduit between RV and PA
	Proc 39.56, 39.57, 39.58	Repair of blood vessel
	or 39.59	
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	
OR		
Require:	Dx 746.01	Pulmonary valve atresia, congenital
	Dx 745.4	Ventricular septal defect
	Proc 35.92	Creation of conduit between RV and PA
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 39.56, 39.57, 39.58	Repair of blood vessel
	or 39.59	
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

OR

Require:	Dx 746.01	Pulmonary valve atresia, congenital
	Dx 745.4	Ventricular septal defect
	Proc 35.25 *or* 35.26	Pulmonary valve replacement
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 35.34	Infundibulectomy
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Repair of TOF with RV to PA conduit — Risk category 3

Require:	Proc 35.81	Total repair of tetralogy of Fallot
	Proc 35.92	Creation of conduit between RV and PA
Cannot have:	Dx 746.01	Pulmonary valve atresia, congenital
Allow:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Total repair of TOF — Risk category 2

Require:	Proc 35.81	Total repair of tetralogy of Fallot
Cannot have:	Dx 746.01	Pulmonary valve atresia, congenital
Allow:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.34	Infundibulectomy
	Proc 39.56, 39.57 *or* 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Konno procedure — Risk category 4

Require:	Proc 35.92	Creation of conduit between RV and PA
	Proc 35.11	Aortic valvuloplasty
	or 35.21 *or* 35.22	Aortic valve replacement
Allow:	Proc 35.01	Aortic valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 35.39	Operation on structure adjacent to valve
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- Rastelli procedure — Risk category 4

Require:	Dx 745.10	Complete transposition of great vessels
	or 745.11	Double outlet right ventricle
	Proc 35.92	Creation of conduit between RV and PA
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 37.33	Excision of other lesion/tissue of heart
	Proc 38.85	Other surg occlusion thoracic vessel
	PDA surgery	
	ASD2 repair	

- VSD closure and pulmonary valvotomy and/or infundibular resection — Risk category 2

Require:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.03	Pulmonary valvotomy
	or 35.13	Pulmonary valvuloplasty
	or 35.34	Infundibulectomy
Allow:	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Ross procedure — Risk category 3

Require:	Proc 35.21 *or* 35.22	Aortic valve replacement
	Proc 35.25 *or* 35.26	Pulmonary valve replacement
Allow:	Proc 35.01	Aortic valvotomy
	Proc 35.11	Aortic valvuloplasty
	Proc 35.03	Pulmonary valvotomy
	Proc 35.13	Pulmonary valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- TV reposition for Ebstein, > 30 days — Risk category 3

Require:	Dx 746.2	Ebstein's anomaly
	Proc 35.33 *or* 35.14	Annuloplasty Tricuspid valvuloplasty
	Age > 30 days	
Allow:	Proc 35.04	Tricuspid valvotomy
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- TV reposition for Ebstein, ≤ 30 days — Risk category 5

Require:	Dx 746.2	Ebstein's anomaly
	Proc 35.33 *or* 35.14	Annuloplasty Tricuspid valvuloplasty
	Age ≤ 30 days	
Allow:	Proc 35.04	Tricuspid valvotomy
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- RV infundibulectomy — Risk category 2

Require:	Proc 35.34	Infundibulectomy
Allow:	Proc 35.03	Pulmonary valvotomy
	Proc 35.13	Pulmonary valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Pulmonary valve replacement — Risk category 2

Require:	Proc 35.25 *or* 35.26	Pulmonary valve replacement
Allow:	Proc 35.03	Pulmonary valvotomy
	Proc 35.13	Pulmonary valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Pulmonary valvuloplasty — Risk category 2

Require:	Proc 35.13	Pulmonary valvuloplasty
Allow:	Proc 35.03	Pulmonary valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Pulmonary valvotomy — Risk category 2

Require:	Proc 35.03	Pulmonary valvotomy
Allow:	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	ASD2 repair	

- Aortic valve replacement — Risk category 3

Require:	Proc 35.21 *or* 35.22	Aortic valve replacement
Allow:	Proc 35.01	Aortic valvotomy
	Proc 35.11	Aortic valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Aortic valvuloplasty, > 30 days — Risk category 2

Require:	Proc 35.11	Aortic valvuloplasty
	Age > 30 days	
Allow:	Proc 35.01	Aortic valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Aortic valvuloplasty, ≤ 30 days — Risk category 4

Require:	Proc 35.11	Aortic valvuloplasty
	Age ≤ 30 days	
Allow:	Proc 35.01	Aortic valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Aortic valvotomy, > 30 days — Risk category 2

Require:	Proc 35.01	Aortic valvotomy
	Age > 30 days	
Allow:	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	ASD2 repair	

- Aortic valvotomy, ≤ 30 days — Risk category 4

Require:	Proc 35.01	Aortic valvotomy
	Age ≤ 30 days	
Allow:	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	ASD2 repair	

- Mitral valve replacement — Risk category 3

Require:	Proc 35.23 *or* 35.24	Mitral valve replacement
Allow:	Proc 35.02	Mitral valvotomy
	Proc 35.12	Mitral valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Mitral valvuloplasty — Risk category 3

Require:	Proc 35.12	Mitral valvuloplasty
Allow:	Proc 35.02	Mitral valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Mitral valvotomy — Risk category 3

Require:	Proc 35.02	Mitral valvotomy
Allow:	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	ASD2 repair	

- Tricuspid valve replacement — Risk category 3

Require:	Proc 35.27 *or* 35.28	Tricuspid valve replacement
Allow:	Proc 35.04	Tricuspid valvotomy
	Proc 35.14	Tricuspid valvuloplasty
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Tricuspid valvuloplasty — Risk category 3

Require:	Proc 35.14	Tricuspid valvuloplasty
Allow:	Proc 35.04	Tricuspid valvotomy
	Proc 35.33	Annuloplasty
	Proc 35.99	Other operation on valves of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Tricuspid valvotomy — Risk category 3

Require:	Proc 35.04	Tricuspid valvotomy
Allow:	Proc 35.99	Other operation on valves of heart
	PDA surgery	
	ASD2 repair	

- Annuloplasty — Risk category 3

Require:	Proc 35.33	Annuloplasty
Allow:	Proc 35.99	Other operation on valves of heart
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Sub AS resection — Risk category 2

Require:	Dx 746.81	Subaortic stenosis
	Proc 35.35	Operation on trabeculae carnae cordis
	or 35.39	Operation on structure adjacent to valve
	or 37.33	Excision of other lesion/tissue of heart
Allow:	PDA surgery	
	ASD2 repair	

- Repair of unspecified septal defect — Risk category 2

Require:	Proc 35.50, 35.60 *or* 35.70	Repair of unspecified septal defect
Allow:	PDA surgery	

- Repair of cor triatriatum — Risk category 3

Require:	Dx 746.82	Cor triatriatum
	Proc 35.98	Other operation on septa of heart
	or 37.33	Excision of other lesion/tissue of heart
Allow:	PDA surgery	
	ASD2 repair	

- Repair of truncus arteriosus and IAA — Risk category 5

Require:	Dx 747.11	Interruption of aortic arch
	Proc 35.83	Total repair of truncus arteriosus
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
Allow:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.92	Creation of conduit between RV and PA
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Repair of truncus arteriosus — Risk category 4

Require:	Proc 35.83	Total repair of truncus arteriosus
Allow:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.92	Creation of conduit between RV and PA
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Repair of hypo/IAA and VSD — Risk category 4

Require:	Dx 747.11	Interruption of aortic arch
	or 747.21	Anomalies of aortic arch
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	Proc 35.53 *or* 35.62 *or* 35.72	Repair of VSD
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Repair of hypo/IAA — Risk category 4

Require:	Dx 747.11	Interruption of aortic arch
	or 747.21	Anomalies of aortic arch
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
Allow:	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	PDA surgery	

- Repair of coarctation and VSD — Risk category 3

Require:	Dx 747.10	Coarctation of aorta
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Cannot have:	Dx 747.11	Interruption of aortic arch
Allow:	Proc 39.56 *or* 39.57 *or* 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 37.33	Excision of other lesion/tissue of heart
	PDA surgery	
	ASD2 repair	

- Coarctation repair, > 30 days — Risk category 1

Require:	Dx 747.10	Coarctation of aorta
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	Age > 30 days	
Cannot have:	Dx 747.11	Interruption of aortic arch
Allow:	Proc 39.56 *or* 39.57 *or* 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	PDA surgery	

- Coarctation repair, ≤ 30 days — Risk category 2

Require:	Dx 747.10	Coarctation of aorta
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	Age ≤ 30 days	
Cannot have:	Dx 747.11	Interruption of aortic arch
Allow:	Proc 39.56 *or* 39.57 *or* 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	PDA surgery	

- Repair of AP window — Risk category 2

Require:	Dx 745.0	Common truncus
	Proc 39.59	Other repair of vessel
	or 38.85	Other occlusion of thoracic vessel
Allow:	PDA surgery	

- ASD and VSD repair — Risk category 2

Require:	Proc 35.53, 35.62 *or* 35.72	Repair of ventricular septal defect
	Proc 35.51, 35.52, 35.61, *or* 35.71	Repair of atrial septal defect
Cannot have:	Dx 745.61	Ostium primum defect
Allow:	PDA surgery	

- VSD repair — Risk category 2

Require:	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
Allow:	PDA surgery	

- ASD secundum repair — Risk category 1

Require:	Proc 35.51, 35.52, 35.61 *or* 35.71	Repair of atrial septal defect
Cannot have:	Dx 745.60	Endocardial cushion defect, unspecified
	Dx 745.61	Ostium primum defect
	Dx 745.69	Other endocardial cushion defect
Allow:	Proc 35.98	Other operation on septa of heart
	PDA surgery	

- PDA surgery, > 30 days — Risk category 1

Require:	Dx 747.0	Patent ductus arteriosus
	Proc 38.85	Surgical occlusion of thoracic vessel
	Age > 30 days	
Cannot have:	Any other cardiac dx	
	Any other cardiac proc	

- Pulmonary artery band — Risk category 3

Require:	Dx 745.60	Endocardial cushion defect, unspecified
	or 745.69	Other endocardial cushion defect
	or 745.4	Ventricular septal defect
	Proc 38.85	Surgical occlusion of thoracic vessel
Cannot have:	Any other cardiac dx except 747.0	
	Any other cardiac proc	

- Fontan procedure — Risk category 3

Require:	Proc 35.94	Creation of conduit between atrium-PA
Cannot have:	Proc 35.81	Total repair of tetralogy of Fallot
	Proc 35.83	Total repair of truncus arteriosus
	Proc 35.84	Total correction of transposition of great vessels
	Proc 35.91	Interatrial transposition of venous return
	Proc 35.92	Creation of conduit between RV and PA
	Proc 35.93	Creation of conduit between LV-aorta
	Proc 39.0	Systemic to pulmonary artery shunt
	Proc 35.53, 35.62 *or* 35.72	Repair of VSD
	Proc 35.54, 35.63 *or* 35.73	Repair of endocardial cushion defect
Allow:	Proc 39.21	Caval-pulmonary artery anastomosis
	Proc 39.56, 39.57, 39.58 *or* 39.59	Repair of blood vessel
	Proc 36.99	Other operation on vessel of heart
	Proc 35.41 *or* 35.42	Enlargement of existing ASD Creation of septal defect in heart
	PDA surgery	

- Atrial septectomy — Risk category 4

Require:	Proc 35.41 *or* 35.42	Enlargement of existing ASD Creation of septal defect in heart
Allow:	PDA surgery	

- Stage 1 repair of HLHS — Risk category 6

Require:	Dx 746.7	Hypoplastic left heart syndrome
	Proc 35.41	Enlargement of existing ASD
	or 35.42	Creation of septal defect in heart
	Proc 39.0	Systemic to pulmonary artery shunt
	or 35.92	Creation of conduit between RV and PA
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	or 39.56, 39.57, 39.58	Repair of blood vessel
	or 39.59	
	or 36.99	Other operation on vessel of heart
Cannot have:	Proc 35.94	Creation of conduit between atrium-PA
	Proc 35.95	Revision corrective procedure on heart
	Proc 39.21	Caval-pulmonary artery anastomosis
Allow:	Dx 745.5	Ostium secundum atrial septal defect
	Dx 746.3	Congenital stenosis of aortic valve
	Dx 746.5	Congenital mitral stenosis
	Dx 747.0	Patent ductus arteriosus
	Dx 747.10	Coarctation of aorta
	Dx 747.22	Atresia and stenosis of aorta
	Dx 747.89	Other anomalies of great veins
	Proc 37.33	Excision of other lesion/tissue of heart
Cannot have:	Any other cardiac dx	

- Other Stage 1 repair — Risk category 6

Require:	Proc 35.41	Enlargement of existing ASD
	or 35.42	Creation of septal defect in heart
	Proc 39.0	Systemic to pulmonary artery shunt
	or 35.92	Creation of conduit between RV and PA
	Proc 38.35 *or* 38.45	Resection of thoracic vessel
	or 38.34 *or* 38.44	Resection of abdominal aorta
	or 38.64 *or* 38.65	Other excision of vessel/aorta
	or 38.84 *or* 38.85	Other surg occlusion of vessel/aorta
	or 39.56, 39.57, 39.58	Repair of blood vessel
	or 39.59	
	or 36.99	Other operation on vessel of heart
Cannot have:	Proc 35.94	Creation of conduit between atrium-PA
	Proc 35.95	Revision corrective procedure on heart
	Proc 39.21	Caval-pulmonary artery anastomosis
Allow:	Any cardiac dx	
	Proc 37.33	Excision of other lesion/tissue of heart

- RV to PA conduit — Risk category 3

Require:	Proc 35.92	Creation of conduit between RV and PA
Cannot have:	Proc 35.81	Total repair of tetralogy of Fallot
	Proc 35.83	Total repair of truncus arteriosus
	Proc 35.84	Total correction of transposition of great vessels
	Proc 35.94	Creation of conduit between atrium-PA
Allow:	Proc 35.95	Revision corrective procedure on heart
	Proc 39.49	Other revision of vascular procedure
	ASD2 repair	
	PDA surgery	

* Note that PDA surgery is allowed with any other procedure

Define cardiac procedures not assigned to a risk category

Cases with the following procedures – either alone or in combination with other procedures – are not assigned to a risk category:

Proc 35.00	Unspecified valvotomy
Proc 35.10	Unspecified valvuloplasty
Proc 35.20	Replacement of unspecified valve
Proc 35.31	Operation on papillary muscle
Proc 35.32	Operation on chordae tendineae
Proc 35.93	Creation of conduit between LV-aorta
Proc 35.95	Revision of corrective procedure on heart *Except with RV to PA conduit*
Proc 39.49	Other revision of vascular procedure *Except with RV to PA conduit*

Not assigned to a risk category if only cardiac procedure:

Proc 38.85 With dx 747.0 Also other cardiac diagnoses	Other surgical occlusion of thoracic vessel Patent ductus arteriosus

All other cases not yet assigned to a cardiac procedure are not assigned to a risk category

RACHS Algorithm
For Use with PCCC Codes

Identification of surgical procedures for congenital heart disease

Any of the following:

'11100','11130','11200','11210','11211','11212','11230','11231','11232','11300','11320',
'11330','11400','12100','12200','12300','12310','12320','12400','13100','13101',
'13102','13110','13111','13112','13120','13121','13122','13130','13131','13132','13140',
'13141','13142','13150','13151','13152','13160','13170','13172','13173','13180','13181',
'13300','13310','13320','13500','13510','13520','13530',
'13600','13610','13620','13800','13810','13820','14100','14110','14111','14112','14113',
'14114','14120','14121','14122','14123','14124','14125','14126','14127','14128','14130',
'14131','14132','14133','14134','14135','14136','14137','14138','14139','14140','14141',
'14142','14143','14144','14145','14200','14210','14220','14230','14240','14250','14260',
'14270','14290','14300','14310','14320','14330','14340','14350','14360','14370','14380',
'14400','14410','14420','14430','14440','14450','14451','14452','14460','15100','15120',
'15121','15122','15130','15140','15150','15200','15220','15221','15222','15230','15231',
'15232','15300',
'15400','15410','15420','15500','15510','15511','15512','15513','15514','15515','15520',
'15521','15522','15523','15524','15525','15530','15531','15532','15533','15534','15535',
'15540','15600','15700','16100','16110','16111','16112','16113','16114','16120','16121',
'16122','16123','16126','16127','16128','16130','16140','16141','16142','16143','16144',
'16145','16150','16151','16152','16153','16154','16180','16200','16210','16211','16212',
'16213','16220','16230','16240','16241','16250','16260','16270','16300','16310','16320',
'16340','16400','16410','16411','16412','16413','16420','16421','16422','16423','16430',
'16431','16432','16433','16440','16441','16442','16443','16444','16450','16500','16510',
'16511','16512',
'16520','16530','16531','16535','16540','16550','16560','16580','16581','16600','16610',
'16620','16700','16740','17100','17110','17111','17112','17113','17120','17121','17122',
'17123','17124','17130','17131','17140','17200','17210','17211','17220','17230','17300',
'17310','17311','17312','17313','17314','17320','17330','17340','17341','17342','17350',
'17351','17360',
'17400','17410','17411','17412','17420','17421','17422','17500','17510','17511','17512',
'17513','17514','17515','17517','17520','17521','17522','17523','17524','17530','17531',
'17532','17533','17534','17535','17550','17551','17552','17553','17560','17600','17610',
'17611','17612','17620','17621','17622','17630','17631','17632','17640','17641','17642',
'17700','17710','17711','17712','17713','17720','17721','17722','17723','17724','17725',
'17726','17740','17750','17760','17770','17790','17791','17792','17793','17800','17810',
'17811','17812','17813','17814','17820','17830','17831','17832','17833','17834','17835',
'17836','17840','17850','17851','17852','17853','17854','17860','17861','17862','17863',
'17865','17870','17900','17910','17911','17912','17913','17914','17920','17921','17922',
'17923','17924','17925','17926','17927','18100','18200','18210','18220','18230','18240',
'18250','18300'

**** Case selection****

Keep all cases with ≥ 1 surgical procedure for congenital heart disease

Define:

Age group
- ≤ 30 days
- 31 days to 1 year
- ≥ 1 year

Exclude cases not eligible:

Unknown disposition/death

Age ≥ 18 years

Heart and/or lung transplant

19520	Cardiac transplant
19521	"
19522	"
19530	Heart-lung transplant
23800	Lung transplant

Age ≤ 90 days and PDA closure as only cardiac procedure

or

Diagnosis of prematurity (00245) and PDA closure as only cardiac procedure

17610-17612	Right PDA surgery
17620-17622	Left PDA surgery

For all admissions, count the number of congenital heart surgical procedures.

All procedures allow PDA closure (17610, 17611, 17612, 17620, 17621, 17622). If PDA closure occurs with another procedure, treat the other code as a "single" procedure.

Many procedures also allow ASD2 repair {13100, 13101, 13102, 13120, 13121, 13122}.

***** Define individual cardiac procedures assigned to a risk category*****

- Norwood procedure, HLHS (norwhlhs) — Risk category 6

Require:	Proc 15230	Hypoplastic left ventricle surgery
	or 15232	Sano modification for Norwood surgery
	Diag 15210	HLHS
Allow:	PDA surgery	
	ASD2 repair	

- Norwood procedure, other (norwoth) — Risk category 6

Require:	Proc 15230	Hypoplastic left ventricle surgery
	or 15232	Sano modification for Norwood surgery
Cannot have:	Diag 15210	HLHS
Allow:	PDA surgery	
	ASD2 repair	

- Damus-Kaye-Stansel procedure (dks) — Risk category 6

Require:	Proc 17124	PA to aorta conduit for transposition
Allow:	PDA surgery	
	ASD2 repair	

- Truncus arteriosus repair and IAA repair (taiaa) — Risk category 5

Require:	Proc 17320	LV to aorta tunnel + conduit for truncus
	or 17330	RV to PA tunnel + valved conduit for truncus
	or 17350	RV to PA conduit for truncus
	Proc 17521	End-end repair hypoplastic aortic arch
	or 17522	Synthetic graft repair IAA
	or 17524	Subclavian flap repair IAA
Allow:	Proc 16114	Infundibular stenosis conduit
	Proc 17351	RV-PA conduit
	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
	PDA surgery	
	ASD2 repair	

- Truncus arteriosus repair (ta) — Risk category 4

Require:	Proc 17320	LV to aorta tunnel + conduit for truncus
	or 17330	RV to PA tunnel + valved conduit for truncus
	or 17350	RV to PA conduit for truncus

Cannot have:	Proc 17311	Truncal valve valveplasty
Allow:	Proc 16114	Infundibular stenosis conduit
	Proc 17351	RV-PA conduit
	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
	PDA surgery	
	ASD2 repair	

- Ebstein's repair, ≤ 30 days (ebstein30) — Risk category 5

Require:	Proc 14240	Tricuspid valve valveplasty
	or 14250	Tricuspid valve replacement
	or 14260	Tricuspid valve annuloplasty
	Diag 14250	Ebstein's anomaly
	Age ≤ 30 days	
Allow:	Proc 14210	Tricuspid valve valvotomy
	PDA surgery	
	ASD2 repair	

- Ebstein's repair, > 30 days (ebstein) — Risk category 3

Require:	Proc 14240	Tricuspid valve valveplasty
	or 14250	Tricuspid valve replacement
	or 14260	Tricuspid valve annuloplasty
	Diag 14250	Ebstein's anomaly
	Age < 30 days	
Allow:	Proc 14210	Tricuspid valve valvotomy
	PDA surgery	
	ASD2 repair	

- ASD creation/enlargement (asdce) — Risk category 4

Require:	Proc 13170	Creation of ASD
	or 13172	Blalock-Hanlon closed atrial septectomy
	or 13173	Open atrial septectomy
Allow:	PDA surgery	

- TAPVC repair, ≤ 30 days (tapvc30) — Risk category 4

Require:	Proc 12200	TAPVC surgery
	Age ≤ 30 days	
Cannot have:	Proc 17830	Blalock-Taussig shunt
	or 17831	Right Blalock-Taussig shunt
	or 17832	Left Blalock-Taussig shunt
	or 17833	Right B-T shunt + aortoplasty
	or 17834	Left B-T shunt + aortoplasty
Allow:	PDA surgery	
	ASD2 repair	

- TAPVC repair, > 30 days (tapvc) — Risk category 2

Require:	Proc 12200	TAPVC surgery
	Age > 30 days	
Cannot have:	Proc 17830	Blalock-Taussig shunt
	or 17831	Right Blalock-Taussig shunt
	or 17832	Left Blalock-Taussig shunt
	or 17833	Right B-T shunt + aortoplasty
	or 17834	Left B-T shunt + aortoplasty
Allow:	PDA surgery	
	ASD2 repair	

- Valvuloplasty/valvotomy, aortic, ≤ 30 days (avalv30) — Risk category 4

Require:	Proc 16510	Aortic valve valvotomy
	or 16511	Aortic valve valvotomy off-bypass
	or 16512	Transventricular aortic valve valvotomy
	or 16520	Aortic valve valveplasty
	Age ≤ 30 days	
Allow:	Proc 16530	Aortic valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valvuloplasty/valvotomy, aortic, > 30 days (avalv) — Risk category 2

Require:	Proc 16510	Aortic valve valvotomy
	or 16511	Aortic valve valvotomy off-bypass
	or 16512	Transventricular aortic valve valvotomy
	or 16520	Aortic valve valveplasty
	Age > 30 days	
Allow:	Proc 16530	Aortic valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve replacement, aortic (AVR) (avr) — Risk category 3

Require:	Proc 16540	Aortic valve replacement
Allow:	Proc 16510	Aortic valve valvotomy
	Proc 16511	Aortic valve valvotomy off-bypass
	Proc 16512	Transventricular aortic valve valvotomy
	Proc 16520	Aortic valve valveplasty
	PDA surgery	
	ASD2 repair	

- Valvuloplasty/valvotomy, tricuspid (tvalv) — Risk category 3

Require:	Proc 14210	Tricuspid valve valvotomy

	or 14240	Tricuspid valve valveplasty
Allow:	Proc 14260	Tricuspid valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve replacement, tricuspid (TVR) (tvr) — Risk category 3

Require:	Proc 14250	Tricuspid valve replacement
Allow:	Proc 14210	Tricuspid valve valvotomy
	Proc 14240	Tricuspid valve valveplasty
	Proc 14260	Tricuspid valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve surgery, other, tricuspid (tannulo) — Risk category 3

Require:	Proc 14260	Tricuspid valve annuloplasty
Allow:	PDA surgery	
	ASD2 repair	

- Valvuloplasty/valvotomy, mitral (mvalv) — Risk category 3

Require:	Proc 14310	Mitral valve valvotomy
	or 14340	Mitral valve valveplasty
Allow:	Proc 14360	Mitral valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve replacement, mitral (mvr) — Risk category 3

Require:	Proc 14350	Mitral valve replacement
Allow:	Proc 14310	Mitral valve valvotomy
	Proc 14340	Mitral valve valveplasty
	Proc 14360	Mitral valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve surgery, other, mitral (mannulo) — Risk category 3

Require:	Proc 14360	Mitral valve annuloplasty
Allow:	PDA surgery	
	ASD2 repair	

- Valvuloplasty/valvotomy, pulmonic (pvalv) — Risk category 2

Require:	Proc 16210	Pulmonary valve valvotomy
	or 16211	Pulmonary valve valvotomy off-bypass

	or 16212	Pulmonary valve valvotomy on-bypass
	or 16213	Closed pulmonary valvotomy
	or 16230	Pulmonary valve valveplasty
Allow:	Proc 16250	Pulmonary valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Valve replacement, pulmonic (pvr) — Risk category 2

Require:	Proc 16240	Pulmonary valve replacement
Allow:	Proc 16210	Pulmonary valve valvotomy
	Proc 16211	Pulmonary valve valvotomy off-bypass
	Proc 16212	Pulmonary valve valvotomy on-bypass
	Proc 16213	Closed pulmonary valvotomy
	Proc 16230	Pulmonary valve valveplasty
	Proc 16250	Pulmonary valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Konno procedure (konno) — Risk category 4

Require:	Proc 16531	LVOT enlargement (Konno)
Allow:	Proc 16530	Aortic valve annuloplasty
	Proc 16510	Aortic valve valvotomy
	or 16511	Aortic valve valvotomy off-bypass
	or 16512	Transventricular aortic valve valvotomy
	PDA surgery	
	ASD2 repair	

- Ross procedure (ross) — Risk category 3

Require:	Proc 16240	Pulmonary valve replacement
	Proc 16540	Aortic valve replacement
Cannot have:	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
Allow:	Proc 16510	Aortic valve valvotomy
	Proc 16511	Aortic valve valvotomy off-bypass
	Proc 16512	Transventricular aortic valve valvotomy
	Proc 16520	Aortic valve valveplasty
	Proc 16210	Pulmonary valve valvotomy
	Proc 16211	Pulmonary valve valvotomy off-bypass
	Proc 16212	Pulmonary valve valvotomy on-bypass
	Proc 16213	Closed pulmonary valvotomy
	Proc 16230	Pulmonary valve valveplasty
	Proc 16530	Aortic valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Congenitally corrected TGA repair, atrial — Risk category 4

switch and ASO (double)

Require:	Proc 17111	Mustard procedure
	or 17112	Senning procedure
	Proc 17130	Great vessel switch procedure for TGV
	or 17131	Jatene procedure for TGV
Allow:	Proc 13170	Creation of ASD
	Proc 13172	Blalock-Hanlon closed atrial septectomy
	Proc 13173	Open atrial septectomy
	PDA surgery	
	ASD2 repair	

- Arterial switch operation and VSD repair (asovsd) — Risk category 4

Require:	Proc 17130	Great vessel switch procedure for TGV
	or 17131	Jatene procedure for TGV
	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
Allow:	Proc 13170	Creation of ASD
	Proc 13172	Blalock-Hanlon closed atrial septectomy
	Proc 13173	Open atrial septectomy
	PDA surgery	
	ASD2 repair	

- Arterial switch operation and PA debanding (asopadb) — Risk category 4

Require:	Proc 17130	Great vessel switch procedure for TGV
	or 17131	Jatene procedure for TGV
	Proc 17713	Pulmonary artery debanding
Allow:	Proc 13170	Creation of ASD
	Proc 13172	Blalock-Hanlon closed atrial septectomy
	Proc 13173	Open atrial septectomy
	PDA surgery	
	ASD2 repair	

- Arterial switch operation (aso) — Risk category 3

Require:	Proc 17130	Great vessel switch procedure for TGV
	or 17131	Jatene procedure for TGV
Allow:	Proc 13170	Creation of ASD
	Proc 13172	Blalock-Hanlon closed atrial septectomy
	Proc 13173	Open atrial septectomy
	PDA surgery	
	ASD2 repair	

- Rastelli (rastelli) — Risk category 4

Require:	Proc 17121	Rastelli procedure for TGV
Allow:	PDA surgery	
	ASD2 repair	

- Interrupted aortic arch repair + VSD repair (iaavsd) — Risk category 4

Require:	Proc 17521	End-end repair hypoplastic aortic arch
	or 17522	Synthetic graft repair IAA
	or 17524	Subclavian flap repair IAA
	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
Allow:	PDA surgery	
	ASD2 repair	

- Interrupted aortic arch repair (iaa) — Risk category 4

Require:	Proc 17521	End-end repair hypoplastic aortic arch
	or 17522	Synthetic graft repair IAA
	or 17524	Subclavian flap repair IAA
Allow:	PDA surgery	

- AVC repair, complete (CAVSD) (cavc) — Risk category 3

Require:	Proc 14130	Repair complete AV canal (primum ASD)
	or 14131	Repair complete AV canal (ASD only)
	or 14132	Repair complete AV canal + mitral valveplasty
	or 14133	Repair complete AV canal + tricuspid valveplasty
	or 14134	Repair complete AV canal + MVR
	or 14136	Repair complete AV canal + VSD + mitral valveplasty
	or 14137	Repair complete AV canal + VSD + tricuspid valveplasty
	or 14138	Repair complete AV canal + VSD + MVR
	or 14140	Repair complete AV canal (without primum ASD)
	or 14141	Repair complete AV canal (VSD only)
	or 14142	Repair complete AV canal + VSD + mitral valveplasty
	or 14143	Repair complete AV canal + VSD + tricuspid valveplasty
	or 14144	Repair complete AV canal + VSD + MVR
Allow:	PDA surgery	
	ASD2 repair	

- AVC repair, partial (incomplete) (PAVSD) (pavc) — Risk category 2

Require:	Proc 14110	Repair partial AV canal (primum ASD)
	or 14111	Repair partial AV canal + mitral valveplasty
	or 14112	Repair partial AV canal + tricuspid valveplasty
	or 14113	Repair partial AV canal + MVR
	or 14120	Repair incomplete AV canal (primum ASD)
	or 14121	Repair incomplete AV canal + mitral valveplasty
	or 14122	Repair incomplete AV canal + tricuspid valveplasty
	or 14123	Repair incomplete AV canal + MVR
	or 14125	Repair incomplete AV canal + VSD + mitral valveplasty
	or 14126	Repair incomplete AV canal + VSD + tricuspid valveplasty
	or 14127	Repair incomplete AV canal + VSD + MVR
Allow:	PDA surgery	
	ASD2 repair	

- Cor triatriatum repair (cortria) — Risk category 3

Require:	Proc 12400	Cor triatriatum surgery
Allow:	PDA surgery	
	ASD2 repair	

- Pulmonary atresia – VSD (including TOF, PA) repair (pavsd) — Risk category 3

Require:	Proc 16141	Pulmonary outflow tract patch for pulmonary atresia
	or 16142	Pulmonary outflow tract conduit to MPA for pulmonary atresia
	or 16143	Pulmonary outflow tract conduit to RPA for pulmonary atresia
	or 16144	Pulmonary outflow tract conduit to LPA for pulmonary atresia
Allow:	PDA surgery	
	ASD2 repair	

- Conduit placement, RV to PA (condrvpa) — Risk category 3

Require:	Proc 16114	Infundibular stenosis conduit
	or 17351	RV-PA conduit
Cannot have:	Proc 17320	LV to aorta tunnel + conduit for truncus

	or 17330	RV to PA tunnel + valved conduit for truncus
	or 17350	RV to PA conduit for truncus
	Proc 17112	Senning procedure for TGV
	Proc 17111	Mustard procedure
	Proc 16120	Infundibular stenosis + VSD repair (tetralogy repair)
	or 16121	Infundibular resection for tetralogy
	or 16122	Infundibular patch for tetralogy
	or 16123	Transannular patch for tetralogy
	or 16126	Pulmonary valvotomy for tetralogy
	or 16127	Pulmonary valve resection for tetralogy
	Proc 16128	RV to PA conduit for tetralogy
Allow:	PDA surgery	
	ASD2 repair	

- Conduit placement, LV to PA (condlvpa) — Risk category 3

Require:	Proc 17123	LV to PA conduit for TGV
	or 17220	Corrected transposition LV to PA conduit
Allow:	PDA surgery	
	ASD2 repair	

- Aortic stenosis, supravalvar, repair (assup) — Risk category 3

Require:	Proc 16430	Supravalvar aortic stenosis surgery
	or 16431	Primary repair supravalvar aortic stenosis
	or 16432	Patch repair supravalvar aortic stenosis
	or 16433	Conduit repair supravalvar aortic stenosis
Allow:	PDA surgery	
	ASD2 repair	

- Aortic stenosis, subvalvar, repair (assub) — Risk category 2

Require:	Proc 16420	Subaortic stenosis surgery
	or 16421	Resection muscular subaortic stenosis
	or 16422	Resection membranous subaortic stenosis
	or 16423	LV to aorta conduit
Allow:	PDA surgery	
	ASD2 repair	

- Fontan (fontan) — Risk category 3

Require:	Proc 15410	Fontan procedure for univentricular heart
	or 17920-17927	Fontan shunt

Allow:	Proc 13170	Creation of ASD
	Proc 13172	Blalock-Hanlon closed atrial septectomy
	Proc 13173	Open atrial septectomy
	PDA surgery	
	ASD2 repair	

- Atrial switch operation and VSD repair (atrialvsd) — Risk category 4

Require:	Proc 17112	Senning procedure for TGV
	or 17111	Mustard procedure
	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
Allow:	PDA surgery	
	ASD2 repair	

- Senning (senning) — Risk category 3

Require:	Proc 17112	Senning procedure for TGV
Allow:	PDA surgery	
	ASD2 repair	

- Mustard (mustard) — Risk category 3

Require:	Proc 17111	Mustard procedure
Allow:	PDA surgery	
	ASD2 repair	

- DORV, intraventricular tunnel repair (dorv) — Risk category 3

Require:	Proc 16300	DORV surgery
	or 16310	LV to aorta tunnel + RVOT patch for DORV
	or 16320	LV to aorta tunnel + conduit (Rastelli) for DORV
	or 16340	LV to aorta tunnel + double conduit for DORV
Allow:	PDA surgery	
	ASD2 repair	

- Coarctation repair + VSD repair (coavsd) — Risk category 3

Require:	Proc 17511	End-end coarctation repair
	or 17512	Subclavian flap coarctation repair
	or 17513	Patch angioplasty coarctation repair
	or 17514	Interposition graft coarctation repair
	or 17515	Bypass graft coarctation repair

	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
Allow:	PDA surgery	
	ASD2 repair	

- Shunt, systemic to pulmonary, modified Blalock-Taussig shunt (mbts) — Risk category 3

Require:	Proc 17830	Blalock-Taussig shunt
	or 17831	Right Blalock-Taussig shunt
	or 17832	Left Blalock-Taussig shunt
	or 17833	Right B-T shunt + aortoplasty
	or 17834	Left B-T shunt + aortoplasty
Allow:	PDA surgery	

- Shunt, systemic to pulmonary, central (central) — Risk category 3

Require:	Proc 17810	Central shunt (aorta to MPA)
	or 17811	Aorta to MPA central shunt
	or 17812	Aorta to RPA central shunt
	or 17813	Aorta to LPA central shunt
Allow:	PDA surgery	

- Shunt, systemic to pulmonary, other (spshunt) — Risk category 3

Require:	Proc 17820	Waterston shunt
	or 17840	Potts shunt
	or 17850	Other systemic to PA shunt
	or 17851	Right SCA to RPA (prosthetic)
	or 17852	Left SCA to RPA (prosthetic)
	or 17853	Mee procedure
	or 17854	Band modified BT shunt
Allow:	PDA surgery	

- PA banding (pab) — Risk category 3

Require:	Proc 17710	Pulmonary artery banding
Allow:	PDA surgery	

- TOF repair (tof) — Risk category 2

Require:	Proc 16120	Infundibular stenosis + VSD repair (tetralogy repair)
	or 16121	Infundibular resection for tetralogy
	or 16122	Infundibular patch for tetralogy

	or 16123	Transannular patch for tetralogy
	or 16126	Pulmonary valvotomy for tetralogy
	or 16127	Pulmonary valve resection for tetralogy
Cannot have:	Dx 16240-16243	Pulmonary valve atresia + IVS
	or 16250-16256	Pumonary valve atresia + VSD
	or 16260-16263	Pulmonary valve atresia + Complex lesion
	Proc 16510	Aortic valve valvotomy
	or 16511	Aortic valve valvotomy off-bypass
	or 16512	Transventricular aortic valve valvotomy
	or 16520	Aortic valve valveplasty
	Proc 16540	Aortic valve replacement
Allow:	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
	PDA surgery	
	ASD2 repair	

- TOF repair, RV-PA conduit (tofrvpa) — Risk category 2

Require:	Proc 16128	RV to PA conduit for tetralogy
Cannot have:	Dx 16240-16243	Pulmonary valve atresia + IVS
	or 16250-16256	Pumonary valve atresia + VSD
	or 16260-16263	Pulmonary valve atresia + Complex lesion
	Proc 16510	Aortic valve valvotomy
	or 16511	Aortic valve valvotomy off-bypass
	or 16512	Transventricular aortic valve valvotomy
	or 16520	Aortic valve valveplasty
	Proc 16540	Aortic valve replacement
Allow:	Proc 15510-15515	VSD repair
	or 15520-15525	
	or 15530-15535	
	PDA surgery	
	ASD2 repair	

- RVOT procedure (rvot) — Risk category 2

Require:	Proc 16111	Infundibular stenosis resection
	Or 16112	Infundibular stenosis patch
	Or 16113	Infundibular stenosis transannular patch
Allow:	Proc 16210	Pulmonary valve valvotomy
	or 16211	Pulmonary valve valvotomy off-bypass
	or 16212	Pulmonary valve valvotomy on-bypass
	or 16213	Closed pulmonary valvotomy
	or 16230	Pulmonary valve valveplasty
	Proc 14260	Tricuspid valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Sinus of Valsalva, aneurysm repair — Risk category 2

(sinusval)

Require:	Proc 16610	Repair non-perf sinus of Valsalva aneurysm
	or 16620	Repair ruptured sinus of Valsalva aneurysm
Allow:	PDA surgery	
	ASD2 repair	

- Coarctation repair, end to end, ≤ 30 days (coaee30) — Risk category 2

Require:	Proc 17511	End-end coarctation repair
	Age ≤ 30 days	
Allow:	PDA surgery	

- Coarctation repair, end to end, > 30 days (coaee) — Risk category 1

Require:	Proc 17511	End-end coarctation repair
	Age > 30 days	
Allow:	PDA surgery	

- Coarctation repair, subclavian flap, ≤ 30 days (coasf30) — Risk category 2

Require:	Proc 17512	Subclavian flap coarctation repair
	Age ≤ 30 days	
Allow:	PDA surgery	

- Coarctation repair, subclavian flap, > 30 days (coasf) — Risk category 1

Require:	Proc 17512	Subclavian flap coarctation repair
	Age > 30 days	
Allow:	PDA surgery	

- Coarctation repair, patch aortoplasty, ≤ 30 days (coapa30) — Risk category 2

Require:	Proc 17513	Patch angioplasty coarctation repair
	Age ≤ 30 days	
Allow:	PDA surgery	

- Coarctation repair, patch aortoplasty, > 30 days (coapa) — Risk category 1

Require:	Proc 17513	Patch angioplasty coarctation repair
	Age > 30 days	
Allow:	PDA surgery	

- Coarctation repair, interposition graft, ≤ 30 days (coaig30) — Risk category 2

Require:	Proc 17514	Interposition graft coarctation repair
	Age ≤ 30 days	
Allow:	PDA surgery	

- Coarctation repair, interposition graft, > 30 days (coaig) — Risk category 1

Require:	Proc 17514	Interposition graft coarctation repair
	Age > 30 days	
Allow:	PDA surgery	

- Coarctation repair, other, ≤ 30 days (coaoth30) — Risk category 2

Require:	Proc 17515	Bypass graft coarctation repair
	Age ≤ 30 days	
Allow:	PDA surgery	

- Coarctation repair, other, > 30 days (coaoth) — Risk category 1

Require:	Proc 17515	Bypass graft coarctation repair
	Age > 30 days	
Allow:	PDA surgery	

- Coronary artery fistula ligation (cafist) — Risk category 2

Require:	Proc 18300	Coronary artery fistula surgery
Allow:	PDA surgery	

- Vascular ring repair (vascring) — Risk category 2

Require:	Proc 17550	Vascular ring surgery
	Or 17551	Ductus division for vascular ring
	Or 17552	Ligamentum division for vascular ring
	Or 17553	Division double aortic arch for vascular ring
Allow:	PDA surgery	

- Pulmonary artery sling repair (pasling) — Risk category 2

Require:	Proc 17740	Pulmonary artery sling surgery
Allow:	PDA surgery	
	ASD2 repair	

- Glenn (cavopulmonary anastomosis) (glenn) — Risk category 2

Require:	Proc 17910-17914	Glenn shunt
Allow:	PDA surgery	
	ASD2 repair	

- Aneurysm, ventricular, right, repair (anvr) — Risk category 2

Require:	Proc 15120	RV aneurysm surgery
	or 15121	RV aneurysm plication
	or 15122	RV aneurysm resection
Allow:	PDA surgery	
	ASD2 repair	

- ASD, common atrium, septation (common) — Risk category 2

Require:	Proc 13160	Common atrium closure
Allow:	PDA surgery	
	ASD2 repair	

- VSD repair + ASD repair (vsdasd) — Risk category 2

Require:	Proc 15510-15515	Closure muscular VSD
	or 15520-15525	Closure membranous VSD
	or 15530-15535	Closure supracrystal VSD
	Proc 13101	ASD suture closure
	or 13121	Secundum ASD suture closure
	or 13102	ASD patch closure
	or 13122	Secundum ASD patch closure
	or 13111	PFO suture closure
	or 13112	PFO patch closure
	or 13130-13132	Sinus venosus ASD closure
Allow:	PDA surgery	

- VSD repair + PA debanding (vsdpadb) — Risk category 2

Require:	Proc 15510-15515	Closure muscular VSD
	or 15520-15525	Closure membranous VSD
	or 15530-15535	Closure supracrystal VSD
	Proc 17713	Pulmonary artery debanding

Allow:	PDA surgery	
	ASD2 repair	

- VSD repair (vsd) — Risk category 2

Require:	Proc 15510-15515	Closure muscular VSD
	or 15520-15525	Closure membranous VSD
	or 15530-15535	Closure supracrystal VSD
Allow:	PDA surgery	

- AP window repair (apwin) — Risk category 2

Require:	Proc 17400	AP window surgery
	or 17410-17412	AP window suture repair
	or 17420-17422	AP window patch repair
Allow:	PDA surgery	

- VSD repair + pulmonary valvotomy or infundibular resection (vsdpv) — Risk category 2

Require:	Proc 16130	Infundibular stenosis resection + VSD repair
Allow:	Proc 16250	Pulmonary valve annuloplasty
	PDA surgery	
	ASD2 repair	

- Shunt, LV to RA (shuntlvra) — Risk category 2

Require:	Proc 15700	Shunt, LV to RA
Allow:	PDA surgery	
	ASD2 repair	

- PAPVC repair (papvc) — Risk category 1

Require:	Proc 12100	PAPVC surgery
Allow:	PDA surgery	
	ASD2 repair	

- PFO, primary closure (pfo) — Risk category 1

Require:	Proc 13110-13112	PFO closure
Allow:	PDA surgery	
	ASD2 repair	

- Sinus venosus ASD repair (asdsv) — Risk category 1

Require:	Proc 13130-13132	Sinus venosus ASD closure
Allow:	PDA surgery	

- ASD repair, primary closure (asd2pr) — Risk category 1

Require:	Proc 13101	ASD suture closure
	or 13121	Secundum ASD suture closure
Allow:	PDA surgery	

- ASD repair, patch (asd2pa) — Risk category 1

Require:	Proc 13102	ASD patch closure
	or 13122	Secundum ASD patch closure
Allow:	PDA surgery	

- ASD repair, other (asd2oth) — Risk category 1

Require:	Proc 13100	ASD closure
	or 13120	Secundum ASD closure
	or 13140-13142	Raghib ASD closure
	or 13150-13152	IVC type ASD closure
Allow:	PDA surgery	

- Aortopexy (apex) — Risk category 1

Require:	Proc 17560	Aortopexy
Allow:	PDA surgery	

- PDA closure, surgical, > 30 days (pda) — Risk category 1

Require:	Proc 17610-17612	Right PDA surgery
	or 17620-17622	Left PDA surgery
	Age > 90 days	

Coefficient for Risk Adjustment Models

(1) Original model validation data set; 4318 total cases. This data set consists of hospital discharge data from six states (California, Illinois, Massachusetts, New York, Pennsylvania, Washington) in 1996.

	Coefficient	Odds Ratio	95% Confidence Interval for OR	P Value
RACHS-1 Risk Category				
1	---	---	---	---
2	1.7477	5.74	(2.06, 16.0)	0.001
3	2.5860	13.3	(4.83, 36.5)	<0.001
4	2.8168	16.7	(5.73, 48.8)	<0.001
5	---	---	---	---
6	4.0022	54.7	(17.7, 169)	<0.001
Age at Surgery				
≥ 1 year	---	---	---	---
31 days to 1 year	0.9946	2.70	(1.89, 3.86)	<0.001
≤ 30 days	1.6509	5.21	(3.57, 7.60)	<0.001
Prematurity	1.2149	3.37	(1.93, 5.90)	<0.001
Presence of Major Non-Cardiac Structural Anomaly	0.7900	2.20	(1.30, 3.73)	0.003
Combinations of Cardiac Procedures	0.6149	1.85	(1.25, 2.74)	0.002
Intercept	-6.1226	---	---	---

(2) Kids' Inpatient Database 2006; 12463 total cases. This data set provides a United States population-based benchmark, and contains pediatric discharges from all community hospitals in 38 states.

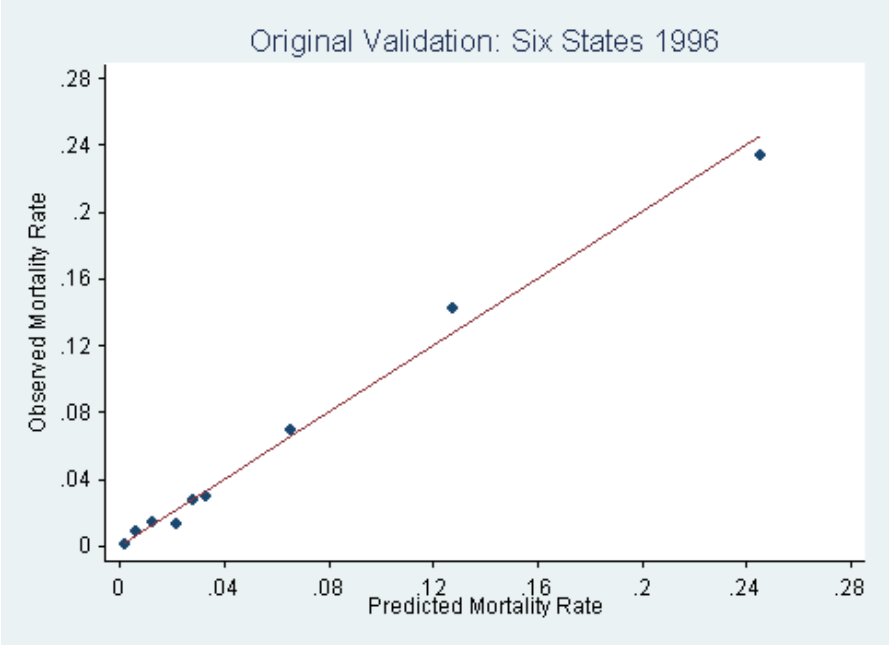
	Coefficient	Odds Ratio	95% Confidence Interval for OR	P Value
RACHS-1 Risk Category				
1	---	---	---	---
2	0.0202	1.02	(0.54, 1.92)	0.95
3	0.8624	2.37	(1.30, 4.32)	0.005
4	0.9422	2.57	(1.36, 4.48)	0.004
5	2.2793	9.77	(2.63, 36.3)	0.001
6	1.8726	6.51	(3.40, 12.4)	<0.001
Age at Surgery				
≥ 1 year	---	---	---	---
31 days to 1 year	0.7317	2.08	(1.41, 3.06)	<0.001
≤ 30 days	1.9963	7.36	(5.21, 10.4)	<0.001
< 1 year, days not specified	1.6726	5.33	(3.63, 7.81)	<0.001
Prematurity	0.6706	1.96	(1.42, 2.69)	<0.001
Presence of Major Non-Cardiac Structural Anomaly	0.2565	1.29	(0.90, 1.86)	0.17
Combinations of Cardiac Procedures	0.7687	2.16	(1.73, 2.69)	<0.001
Intercept	-5.4614	---	---	---

(3) Pediatric Health Information System 2002-2006; 45621 total cases. This data set provides a benchmark consisting of pediatric discharges from 40 free-standing children's hospitals in the United States.

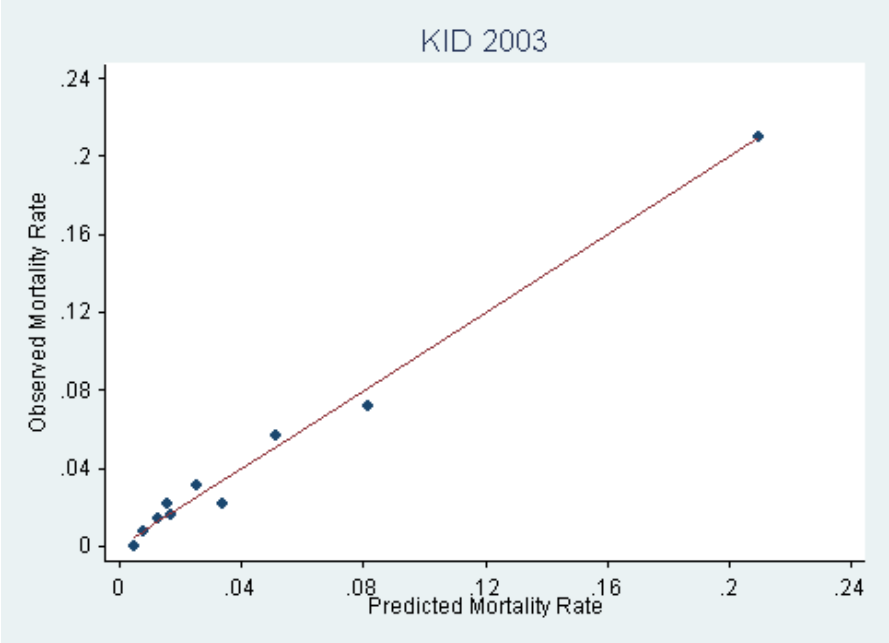
	Coefficient	Odds Ratio	95% Confidence Interval for OR	P Value
RACHS-1 Risk Category				
1	---	---	---	---
2	0.4081	1.50	(1.02, 2.22)	0.040
3	0.7918	2.21	(1.49, 3.26)	<0.001
4	1.4075	4.09	(2.76, 6.05)	<0.001
5	2.0026	7.41	(3.78, 14.5)	<0.001
6	2.2412	9.40	(6.29, 14.1)	<0.001
Age at Surgery				
≥ 1 year	---	---	---	---
31 days to 1 year	0.6323	1.88	(1.55, 2.29)	<0.001
≤ 30 days	1.6666	5.29	(4.37, 6.41)	<0.001
Prematurity	0.6985	2.01	(1.71, 2.37)	<0.001
Presence of Major Non-Cardiac Structural Anomaly	0.5291	1.70	(1.45, 1.98)	<0.001
Combinations of Cardiac Procedures	0.8130	2.25	(2.01, 2.53)	<0.001
Intercept	-5.5626	---	---	---

Decile Plots Illustrating Calibration According to the Hosmer-Lemeshow Test

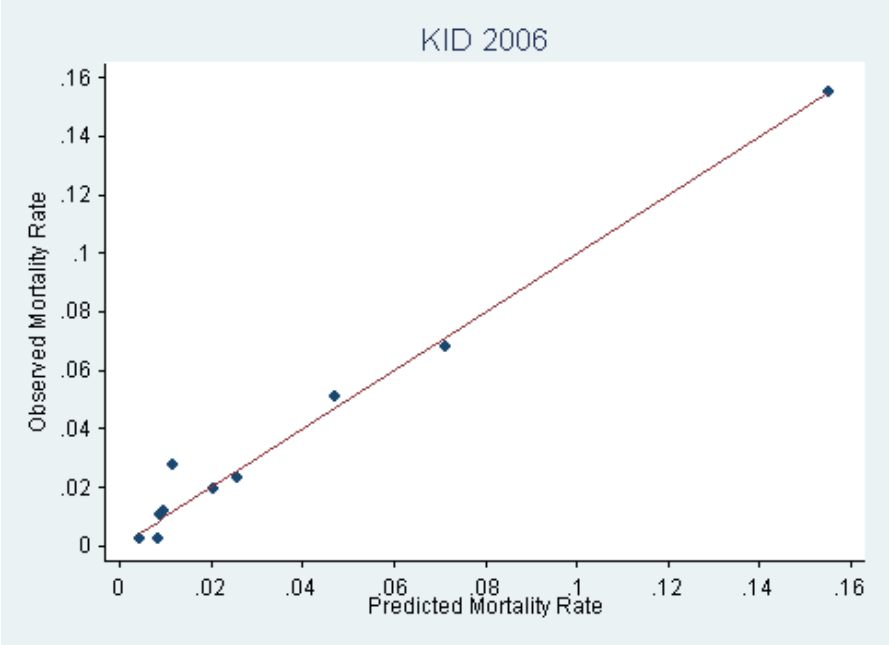
(1) Original validation data set: 1996 hospital discharge data from six states (California, Illinois, Massachusetts, New York, Pennsylvania, Washington); 4318 total cases.



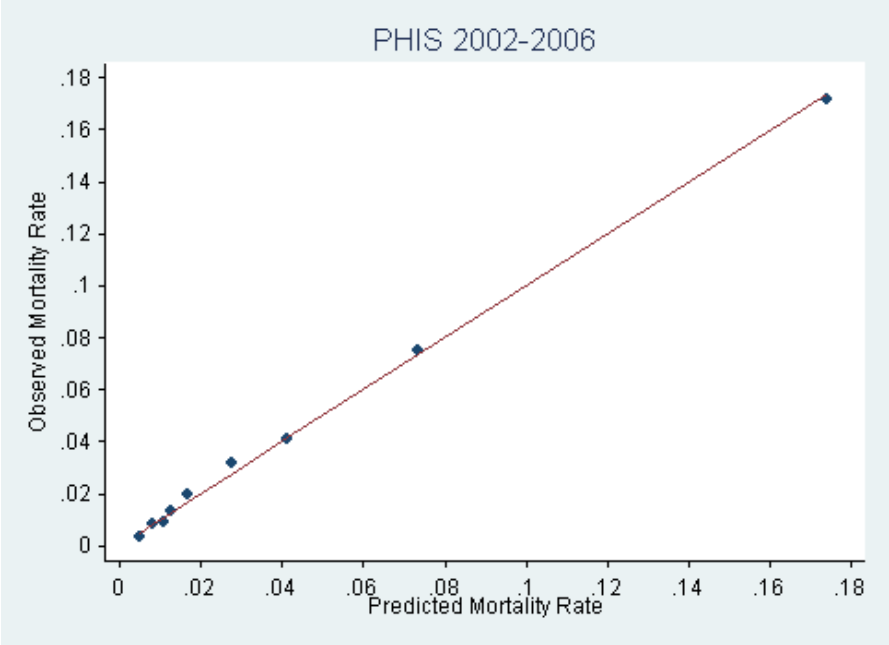
(2) Kids' Inpatient Database 2003; 11395 total cases. This is a United States population-based data set containing pediatric discharges from 36 states.



(3) Kids' Inpatient Database 2006; 12463 total cases. This is a United States population-based data set containing pediatric discharges from 38 states.



(4) Pediatric Health Information System 2002-2006; 45621 total cases. This data set consists of pediatric discharges from 40 free-standing children's hospitals.



Mortality Rates by Risk Category (RACHS-1)

Single Procedures (

	KID 2003			PHIS 2002-2006			EACTS 2002-2006			STS 2002-2006			PCCC 2002-2004		
	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI
Risk Category 1	1574	0.5	(0.2, 1.0)	5126	0.5	(0.4, 0.8)	4934	0.4	(0.3, 0.7)	5292	0.7	(0.5, 1.0)	1459	0.3	(0.1, 0.8)
Risk Category 2	3651	2.1	(1.7, 2.6)	14169	1.3	(1.1, 1.5)	7692	1.9	(1.6, 2.2)	8089	0.8	(0.7, 1.1)	3222	1.1	(0.8, 1.5)
Risk Category 3	2914	4.5	(3.8, 5.3)	11923	3.0	(2.7, 3.3)	6942	5.3	(4.8, 5.9)	6523	3.1	(2.7, 3.6)	2258	4.4	(3.6, 5.4)
Risk Category 4	644	6.7	(4.9, 8.9)	2919	5.6	(4.8, 6.5)	938	11.6	(9.6, 13.8)	966	6.9	(5.4, 8.7)	364	6.6	(4.3, 9.7)
Risk Category 5	7	42.9	(9.9, 81.6)	39	12.8	(4.3, 27.4)	14	57.1	(28.9, 82.3)	11	9.1	(0.2, 41.3)	3	0	---
Risk Category 6	352	26.1	(21.6, 31.1)	1806	17.3	(15.6, 19.1)	470	30.0	(25.9, 34.4)	777	19.6	(16.8, 22.5)	354	20.1	(16.0, 24.6)

Item 8 Risk Adjustment

The Risk Adjustment for Congenital Heart Surgery (RACHS-1) method incorporates five clinical characteristics: six predefined risk categories, age at surgery, prematurity, presence of a major non-cardiac structural anomaly, and combinations of cardiac procedures performed.

1) The six risk categories are based on surgical procedure performed and are defined below. Category 1 has the lowest risk of in-hospital death and category 6 the highest. Procedures not appearing in the list below are not eligible for this measure.

Risk Category 1

- Atrial septal defect surgery (including atrial septal defect secundum, sinus venosus atrial septal defect, patent foramen ovale closure)
- Aortopexy
- Patent ductus arteriosus surgery at age >30 days
- Coarctation repair at age >30 days
- Partially anomalous pulmonary venous connection surgery

Risk Category 2

- Aortic valvotomy or valvuloplasty at age >30 days
- Subaortic stenosis resection
- Pulmonary valvotomy or valvuloplasty
- Pulmonary valve replacement
- Right ventricular infundibulectomy
- Pulmonary outflow tract augmentation
- Repair of coronary artery fistula
- Atrial septal defect and ventricular septal repair
- Atrial septal defect primum repair
- Ventricular septal defect repair
- Ventricular septal defect closure and pulmonary valvotomy or infundibular resection
- Ventricular septal defect closure and pulmonary artery band removal
- Repair of unspecified septal defect
- Total repair of tetralogy of Fallot
- Repair of total anomalous pulmonary veins at age >30 days
- Glenn shunt
- Vascular ring surgery
- Repair of aorto-pulmonary window
- Coarctation repair at age $\leq$ 30 days
- Repair of pulmonary artery stenosis
- Transection of pulmonary artery
- Common atrium closure
- Left ventricular to right atrial shunt repair

Risk Category 3

- Aortic valve replacement
- Ross procedure
- Left ventricular outflow tract patch
- Ventriculomyotomy
- Aortoplasty
- Mitral valvotomy or valvuloplasty
- Mitral valve replacement
- Valvectomy of tricuspid valve
- Tricuspid valvotomy or valvuloplasty
- Tricuspid valve replacement
- Tricuspid valve repositioning for Ebstein anomaly at age >30 days
- Repair of anomalous coronary artery without intrapulmonary tunnel
- Repair of anomalous coronary artery with intrapulmonary tunnel (Takeuchi)
- Closure of semilunar valve, aortic or pulmonary
- Right ventricular to pulmonary artery conduit
- Left ventricular to pulmonary artery conduit
- Repair of double outlet right ventricle with or without repair of right ventricular obstruction
- Fontan procedure
- Repair of transitional or complete atrioventricular canal with or without valve replacement
- Pulmonary artery band
- Repair of tetralogy of Fallot with pulmonary atresia
- Repair of cor triatriatum
- Systemic to pulmonary artery shunt
- Atrial switch operation
- Arterial switch operation
- Reimplantation of anomalous pulmonary artery
- Annuloplasty
- Repair of coarctation and ventricular septal defect closure
- Excision of intracardiac tumor

Risk Category 4

- Aortic valvotomy or valvuloplasty at age $\leq$ 30 days
- Konno procedure
- Repair of complex anomaly (single ventricle) by ventricular septal defect enlargement
- Repair of total anomalous pulmonary veins at age $\leq$ 30 days
- Atrial septectomy
- Repair of transposition, ventricular septal defect, and subpulmonary stenosis (Rastelli)
- Atrial switch operation with ventricular septal defect closure
- Atrial switch operation with repair of subpulmonary stenosis
- Arterial switch operation with pulmonary artery band removal
- Arterial switch operation with ventricular septal defect closure
- Arterial switch operation with repair of subpulmonary stenosis
- Repair of truncus arteriosus
- Repair of hypoplastic or interrupted arch without ventricular septal defect closure
- Repair of hypoplastic or interrupted aortic arch with ventricular septal defect closure

- Transverse arch graft
- Unifocalization for tetralogy of Fallot and pulmonary atresia
- Double switch

Risk Category 5

- Tricuspid valve repositioning for neonatal Ebstein anomaly at age ≤ 30 days
- Repair of truncus arteriosus and interrupted arch

Risk Category 6

- Stage 1 repair of hypoplastic left heart syndrome (Norwood operation)
- Stage 1 repair of nonhypoplastic left heart syndrome conditions
- Damus-Kaye-Stansel procedure

2) Age at surgery is stratified as 30 days or less, 31 days to 1 year, greater than or equal to 1 year.

3) Prematurity defined as gestational age < 37 weeks.

4) Presence of a major non-cardiac structural anomaly in addition to the cardiac defect includes the following defects: anencephalus; craniorachischisis; ilniencephaly; spina bifida, with or without hydrocephalus; encephalocele; microcephalus; reduction deformities of brain; congenital hydrocephalus; choanal atresia; web of larynx; congenital cystic lung; cleft palate; cleft lip; tracheoesophageal fistula, esophageal atresia and stenosis; atresia and stenosis of small intestine; atresia and stenosis of large intestine, rectum, and anal canal; anomalies of intestinal fixation; biliary atresia; renal agenesis and dysgenesis; cystic kidney disease, renal dysplasia; obstructive defects of renal pelvis and ureter; exstrophy of urinary bladder; anomalies of diaphragm; and anomalies of abdominal wall.

5) Combinations of cardiac procedures performed specifies that two or more congenital heart surgical procedures from the list above were performed simultaneously. Cases with multiple cardiac procedures are placed into the risk category corresponding to the single highest-risk procedure.

The five clinical characteristics described above are incorporated as covariates in a multivariable logistic regression model with outcome in-hospital death. Risk categories 2, 3, 4, 5, and 6 are used as binary covariates, with category 1 as the reference group. Additional binary covariates included in the model are: age <=30 days, age 31 days to 1 year (reference group age >= 1 year), prematurity, presence of a major non-cardiac structural anomaly, and presence of combinations of cardiac surgical procedures.

Reference:
Jenkins KJ, Gauvreau K, Newburger JW, Spray TL, Moller JH, Iezzoni LI. Consensus-based method for risk adjustment for surgery for congenital heart disease. Journal of Thoracic and Cardiovascular Surgery 2002; 123:110-118.

Item 9 Type of Score

The measure is a standardized mortality ratio for congenital heart surgery, adjusted using the RACHS-1 method.

It is defined as the ratio of observed to expected in-hospital mortality rates following surgical repair of a congenital heart defect among patients <18 years of age. This technique allows computation of an overall risk-adjusted measure of performance for groups of patients.

To begin, the observed mortality rate is calculated for each group. This is defined as the number of pediatric cases of congenital heart surgery resulting in in-hospital death divided by the total number of pediatric cases of congenital heart surgery able to be placed into a RACHS-1 risk category.

Next, the expected mortality rate is calculated for each group. To do this, a multivariable logistic regression model with outcome in-hospital death is fitted. Five clinical characteristics are incorporated as covariates: risk categories 2, 3, 4, 5, and 6 as binary covariates, with category 1 as the reference group; age <=30 days and age 31 days to 1 year, with age >= 1 year as the reference group; prematurity; presence of a major non-cardiac structural anomaly; and presence of combinations of cardiac surgical procedures. This logistic model is used to calculate the predicted probability of death for each individual case in the data set. The average predicted probability of death for all cases, calculated by summing the predicted probabilities for each case and dividing by the total number of cases able to be placed into a RACHS-1 risk category, represents the expected mortality rate for the group, adjusting for case mix.

The standardized mortality ratio (SMR) is then calculated as the observed mortality rate divided by the expected mortality rate.

If the observed mortality rate for a group is higher than expected, meaning that the group performs worse than would be expected given its case mix, the SMR is greater than 1. If the observed mortality rate for a group is lower than would be expected, indicating better than anticipated performance, the SMR is less than 1.

Reference:

Jenkins KJ, Gauvreau K. Center-specific differences in mortality: preliminary analyses using the Risk Adjustment in Congenital Heart Surgery (RACHS-1) method. Journal of Thoracic and Cardiovascular Surgery 2002; 124:97-104.

Item 10 Data Dictionary

The Risk Adjustment for Congenital Heart Surgery (RACHS-1) method incorporates five clinical characteristics: six predefined risk categories, age at surgery, prematurity, presence of a major non-cardiac structural anomaly, and combinations of cardiac procedures performed.

1) The six risk categories are based on surgical procedure performed and are defined below. Category 1 has the lowest risk of in-hospital death and category 6 the highest. Procedures not appearing in the list below are not eligible for this measure.

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Risk Category 2

- Aortic valvotomy or valvuloplasty at age >30 days
- Subaortic stenosis resection
- Pulmonary valvotomy or valvuloplasty
- Pulmonary valve replacement
- Right ventricular infundibulectomy
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- Repair of total anomalous pulmonary veins at age >30 days
- Glenn shunt
- Vascular ring surgery
- Repair of aorto-pulmonary window
- Coarctation repair at age $\leq$ 30 days
- Repair of pulmonary artery stenosis
- Transection of pulmonary artery

- Common atrium closure
- Left ventricular to right atrial shunt repair

Risk Category 3

- Aortic valve replacement
- Ross procedure
- Left ventricular outflow tract patch
- Ventriculomyotomy
- Aortoplasty
- Mitral valvotomy or valvuloplasty
- Mitral valve replacement
- Valvectomy of tricuspid valve
- Tricuspid valvotomy or valvuloplasty
- Tricuspid valve replacement
- Tricuspid valve repositioning for Ebstein anomaly at age >30 days
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- Repair of cor triatriatum
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- Atrial switch operation
- Arterial switch operation
- Reimplantation of anomalous pulmonary artery
- Annuloplasty
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- Excision of intracardiac tumor

Risk Category 4

- Aortic valvotomy or valvuloplasty at age $\leq$ 30 days
- Konno procedure
- Repair of complex anomaly (single ventricle) by ventricular septal defect enlargement
- Repair of total anomalous pulmonary veins at age $\leq$ 30 days
- Atrial septectomy
- Repair of transposition, ventricular septal defect, and subpulmonary stenosis (Rastelli)
- Atrial switch operation with ventricular septal defect closure
- Atrial switch operation with repair of subpulmonary stenosis
- Arterial switch operation with pulmonary artery band removal
- Arterial switch operation with ventricular septal defect closure

- Arterial switch operation with repair of subpulmonary stenosis
- Repair of truncus arteriosus
- Repair of hypoplastic or interrupted arch without ventricular septal defect closure
- Repair of hypoplastic or interrupted aortic arch with ventricular septal defect closure
- Transverse arch graft
- Unifocalization for tetralogy of Fallot and pulmonary atresia
- Double switch

Risk Category 5

- Tricuspid valve repositioning for neonatal Ebstein anomaly at age ≤ 30 days
- Repair of truncus arteriosus and interrupted arch

Risk Category 6

- Stage 1 repair of hypoplastic left heart syndrome (Norwood operation)
- Stage 1 repair of nonhypoplastic left heart syndrome conditions
- Damus-Kaye-Stansel procedure

2) Age at surgery is stratified as 30 days or less, 31 days to 1 year, greater than or equal to 1 year.

3) Prematurity defined as gestational age < 37 weeks.

4) Presence of a major non-cardiac structural anomaly in addition to the cardiac defect includes the following defects: anencephalus; craniorachischisis; ilniencephaly; spina bifida, with or without hydrocephalus; encephalocele; microcephalus; reduction deformities of brain; congenital hydrocephalus; choanal atresia; web of larynx; congenital cystic lung; cleft palate; cleft lip; tracheoesophageal fistula, esophageal atresia and stenosis; atresia and stenosis of small intestine; atresia and stenosis of large intestine, rectum, and anal canal; anomalies of intestinal fixation; biliary atresia; renal agenesis and dysgenesis; cystic kidney disease, renal dysplasia; obstructive defects of renal pelvis and ureter; exstrophy of urinary bladder; anomalies of diaphragm; and anomalies of abdominal wall.

5) Combinations of cardiac procedures performed specifies that two or more congenital heart surgical procedures from the list above were performed simultaneously. Cases with multiple cardiac procedures are placed into the risk category corresponding to the single highest-risk procedure.

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