

ONLINE SUPPLEMENTAL MATERIAL

Methods

Patient level characteristics included sex, race (white, black, or other), prematurity (< 37 weeks), birth weight (in grams), presence of any extracardiac malformation (anomalies searched include cleft palate, cleft lip, choanal atresia, diaphragmatic hernia, biliary atresia, intestinal malrotation, gastroschisis, omphalocele, esophageal atresia, tracheoesophageal fistula, duodenal atresia, anal atresia, other anomalies of the gastrointestinal system, spine, vertebral anomalies, presence of a genetic syndrome (syndromes searched include: Alagille, CHARGE association (represented by coloboma, renal and ear anomalies), DiGeorge, Goldenhar, Kabuki, Noonan, Williams syndrome, Turner, Trisomy 21, Edwards, Patau, and Cri du chat), year of admission in PHIS, type of health insurance (private, public, other), preoperative intensive care (defined by use of prostaglandin, and/ or mechanical ventilation), preoperative acuity (defined by preoperative use of oxygen, use of prostaglandin, propranolol, total parenteral nutrition, and/or use of arterial blood gas), and age at surgery (days: <=5 days; 6-8 days; 9-15 days; and 16-30 days).

PHIS does not allow for accurate identification of pulmonary valve anatomy and therefore we could not determine the number of patients with pulmonary valve stenosis, atresia, or absent leaflets.

In order to identify a metric for hospital cardiothoracic surgery performance, we chose a commonly performed procedure as a proxy for hospital quality metric. Using the PHIS patients who had a ventricular septal defect (VSD) closure, a commonly performed pediatric cardiovascular surgical procedure, performed between 31 days and 2 years of

life, we calculated average hospital length of stay by year and by hospital, and then created quartiles using the hospital-year distribution of length of stay. The covariates included in the model are the hospital-level percentage of patients discharged after VSD closure with LOS: ≤ 5 days; 6-7 days; 8-15 days; and > 15 days.

Hospital preference for complete surgery was calculated as the percentage of patients at each hospital (across all years) who received a complete surgery out of the total patients that year that received complete or staged procedure between 0 and 30 days. Each hospital was classified by the quintile of hospital preference for complete surgery. To control for hospital volume and cardiac case volume, we ranked each hospital into highest and lowest quintiles for average number of staffed beds/year and average number of cardiac cases/year using an average across PHIS years 2004-2015.

Results

The C-statistic for the propensity score model was 0.81. The propensity score had a similar distribution across the two groups: ranging from 0.02 to 0.91 in the staged group and 0.03 to 0.93 in the complete repair group. The mean of the stabilized inverse probability weights was 1 in each group. We did not trim the weights because our analytic results consistently yielded the same conclusions using unstabilized and stabilized inverse probability weights (with or without bootstrapping), and we wanted to retain the full sample for generalizability purposes.

Online Table 1. Unweighted Patient Characteristics by Surgical Treatment Group

	Complete Neonatal Repair (N=1032)	Staged Repair (N=1331)
Male	593 (57.5%)	725 (54.5%)
Race		
White or Caucasian	645 (62.5%)	873 (65.6%)
Black or African American	101 (9.8%)	207 (15.6%)
Other	286 (27.7%)	251 (18.9%)
Insurance Payer		
Private	445 (43.1%)	511 (38.4%)
Public	493 (47.8%)	694 (52.1%)
Other	94 (9.1%)	126 (9.5%)
Genetic Syndrome	292 (28.3%)	454 (34.1%)
Extra-cardiac Anomalies	121 (11.7%)	214 (16.1%)
Prematurity (< 37 weeks)	137 (13.3%)	212 (15.9%)
Mean Birth Weight (kg) [†]	2.70 ± 0.99	2.73 ± 0.81
High Preoperative Acuity	892 (86.4%)	1206 (90.6%)
Age at First Procedure		

0-5 days	268 (26.0%)	455 (34.2%)
6-8 days	229 (22.2%)	293 (22.0%)
9-15 days	256 (24.8%)	290 (21.8%)
16-30 days	279 (27.0%)	293 (22.0%)

*Values represented as count (percentage) or †mean ± standard deviation.

Online Table 2. Unweighted and Weighted Hospital Characteristics by Surgical Treatment Group

	Unweighted		Weighted			
	Complete Neonatal Repair (N=1032)	Staged Repair (N=1331)	Complete Neonatal Repair (N=1032)	Staged Repair (N=1331)	Standard Difference	P-value
Hospital Preference for Complete Repair						
5-18% (prefers staged)	45 (4.4%)	384 (28.9%)	14.4%	18.3%	-10.6%	0.095
19-29%	100 (9.7%)	349 (26.2%)	21.1%	19.4%	4.3%	0.42
30-47%	181 (17.5%)	285 (21.4%)	20.4%	19.8%	1.7%	0.75
48-67%	215 (20.8%)	168 (12.6%)	16.5%	16.5%	0.2%	0.97
69-88% (prefers complete)	491 (47.6%)	145 (10.9%)	27.5%	26.0%	3.5%	0.50
Number of Hospital Beds						
145-264	228 (22.1%)	339 (25.5%)	23.8%	23.8%	0.1%	0.98
271-296	143 (13.9%)	290 (21.8%)	17.8%	18.3%	-1.4%	0.80

303-353	242 (23.5%)	248 (18.6%)	20.8%	19.5%	3.3%	0.54
377- 442	198 (19.2%)	214 (16.1%)	16.2%	17.7%	3.9%	0.46
493-592	221 (21.4%)	240 (18.0%)	21.4%	20.7%	1.5%	0.76

Number of Cardiac Surgery Cases Per Year

27-408	215 (20.8%)	266 (20.0%)	20.9%	19.4%	3.9%	0.45
411-522	149 (14.4%)	316 (23.7%)	18.9%	19.6%	-1.8%	0.72
523-641	184 (17.8%)	292 (21.9%)	18.0%	19.1%	-2.6%	0.60
642-910	232 (22.5%)	241 (18.1%)	20.9%	20.6%	0.7%	0.90
921-1743	252 (24.4%)	216 (16.2%)	21.3%	21.4%	-0.2%	0.96

Proportion of Patients with Length of Stay[†]

1-5 days	0.31 (0.10)	0.32 (0.12)	0.32 (0.13)	0.32 (0.093)	0.47%	0.93
6-7 days	0.20 (0.049)	0.20 (0.058)	0.20 (0.071)	0.20 (0.060)	-0.73%	0.86

8-15 days	0.24 (0.048)	0.23 (0.067)	0.24 (0.093)	0.24 (0.078)	-0.67%	0.87
> 15 days	0.26 (0.043)	0.25 (0.044)	0.25 (0.086)	0.25 (0.080)	0.62%	0.82

* Values represented as count (percentage) or † mean (standard deviation).

Online Table 3. Cardiac Complications

	Any Cardiac Complication Within Days # 1-7		Any Cardiac Complication Within Days # 2-7		Any Cardiac Complication Within Days # 1-30		Any Cardiac Complication Within Days # 2-30	
	Palliative	Complete	Palliative	Complete	Palliative	Complete	Palliative	Complete
	ECMO	29 (19.9%)	38 (21.7%)	29 (26.6%)	36 (23.7%)	61 (20.8%)	59 (13.9%)	62 (23.7%)
Chest Closure	21 (14.4%)	41 (23.4%)	20 (18.4%)	43 (28.3%)	71 (24.2%)	158 (37.1%)	71 (27.1%)	166 (40.2%)
Pleural Effusion with CT Placement	24 (16.4%)	23 (13.1%)	20 (18.4%)	19 (12.5%)	53 (18.1%)	77 (18.1%)	50 (19.1%)	73 (17.7%)
CPR*	44 (30.1%)	33 (18.9%)	14 (12.8%)	16 (10.5%)	58 (19.8%)	48 (11.3%)	30 (11.5%)	32 (7.8%)
CPR NOS*	27 (18.5%)	9 (5.1%)	23 (21.1%)	6 (4.0%)	54 (18.4%)	21 (4.9%)	51 (19.5%)	18 (4.4%)
Other Shock of Heart**	5 (3.4%)		5 (4.6%)	0	8 (2.7%)	7 (1.6%)	8 (3.1%)	7 (1.7%)
Pacemaker Insertion/Revision	8 (5.5%)	9 (5.1%)	7 (6.4%)	8 (5.3%)	9 (3.1%)	18 (4.2%)	8 (3.1%)	18 (4.4%)
Pacing of Heart	5 (3.4%)	41 (23.4%)	5 (4.6%)	38 (25.0%)	11 (3.8%)	70 (16.4%)	11 (4.2%)	67 (16.2%)

Cardioversion***	30 (20.6%)	13 (7.4%)	27 (24.8%)	10 (6.6%)	64 (21.8%)	40 (9.4%)	62 (23.7%)	37 (9.0%)
Cardioversion/def ***	0	0	0	0	0	2 (0.5%)	0	2 (0.5%)
Only 1 Complication on This Day	112 (76.7%)	149 (85.1%)	79 (72.5%)	133 (87.5%)	226 (77.1%)	368 (86.4%)	198 (75.6%)	361 (87.4%)

Extracorporeal membrane oxygenation, ECMO; Chest tube, CT; Cardiopulmonary resuscitation, CPR; Not otherwise specified, NOS. CPR NOS indicates CPR events that were identified with ICD-9 code 99.60, and CPR indicates CPR events captured using PHIS CTC code. ** Other shock of heart corresponds to ICD-9 code 99.62 (Other electric countershock of heart), comprised of cardioversion: NOS/ external/ conversion to sinus rhythm, defibrillation, external electrode stimulation. Cardioversion values refer to cardioversion identified with ICD-9 code. Cardioversion/def refers to defibrillation (PHIS CTC code).

Online Table 4. Characteristics of Patients that Died

	Staged Repair, Alive (N=1184)	Staged Repair, Died (N=147)	Complete Repair, Alive (N=940)	Complete Repair, Died (N=92)
Male	53.64%	61.23%	57.77%	54.35%
Race				
White or Caucasian	65.96%	62.59%	62.55%	61.96%
Black or African American	15.11%	19.05%	9.68%	10.87%
Other	18.91%	18.37%	27.77%	27.17%
Insurance Payer				
Private	39.27%	31.29%	44.26%	31.52%
Public	51.60%	56.46%	46.81%	57.61%
Other	9.12%	12.24%	8.94%	10.87%
Genetic Syndrome	32.94%	43.54%	26.38%	47.83%
Extra-cardiac Anomalies	14.61%	27.89%	10.53%	23.91%
Prematurity (< 37 weeks)	15.46%	19.73%	12.55%	20.65%
Mean Birth Weight (kg) [†]	2.74 (0.81)	2.62 (0.73)	2.71 (1.0)	2.58 (0.87)
High Preoperative Acuity	90.88%	88.44%	86.06%	90.22%
Age at First Procedure				

0-5 days	34.04%	35.37%	26.60%	19.57%
6-8 days	22.97%	14.29%	22.45%	19.57%
9-15 days	21.62%	23.13%	24.15%	31.52%
16-30 days	21.37%	27.21%	26.81%	29.35%

*Values represented as count (percentage) or †mean ± standard deviation.

Online Table 5: Codes

Description	ICD-9 Code
Prematurity	
Prematurity unspecified	765.20
Prematurity <24 weeks	765.21
Prematurity 24 completed	765.22
Prematurity 25-26 weeks	765.23
Prematurity 27-28	765.24
Prematurity 29-30	765.25
Prematurity 31-32	765.26
Prematurity 33-34	765.27
Prematurity 35-36	765.28
Prematurity >=37 weeks	765.29
Extracardiac malformations	
Cleft palate	749.00
Cleft lip	749.1x
Cleft lip + cleft palate	749.2x
Choanal atresia	748.0
Diaphragmatic hernia	756.6
Biliary atresia	751.61
Intestinal malrotation	751.4
Gastroschisis	756.73
Omphalocele	756.72
Esophageal atresia, tracheoesophageal fistula	750.3
Duodenal atresia	751.1

Anal atresia	751.2
Anomalies of the digestive system	751.0, 751.5, 751.6x, 751.7-751.9
Anomalies of the spine/vertebrae	756.19
Genetic Diagnoses	
Alagille syndrome	759.89
<u>CHARGE syndrome/association:</u>	
Coloboma	377.23
Renal anomalies	753.0, 753.1x, 753.2x, 753.3 to 753.6
Ear anomalies	744.0x, 744.1, 744.2x, 744.3, 744.4x, 744.5, 744.8x, 744.9
Di George syndrome	279.11
Goldenhar syndrome	756.0 (non-specific code)
Kabuki syndrome	759.89 (non-specific code)
Noonan syndrome	759.89 (non-specific code)
Williams syndrome	759.89
Turner syndrome	758.6
Trisomy 21	758.0
Trisomy 18	758.2
Trisomy 13	758.1
Other major extra-cardiac anomalies	
Anencephaly	740.0
Craniorachischisis	740.1
Iniencephaly	740.2
Spina bifida, with hydrocephalus	741.0x
Spina bifida, without hydrocephalus	741.9x
Encephalocele	742.0

Microcephalus	742.1
Reduction deformities of brain	742.2
Congenital hydrocephalus	742.3
Unspecified anomaly of brain, spinal cord, and nervous system	742.9
Laryngeal web	748.2
Congenital cystic lung	748.4
Heart block	426.10
Heart block 1 st degree	426.11
Heart block 2nd degree Mobitz II	426.12
Heart block Wenckebach	426.13
Cardiac arrest	427.5
Shock	785.50
Cardiogenic shock	785.51
Circulatory or septic shock	785.59
Mediastinitis	519.2
Septic shock	785.52
Laryngomalacia	748.3
Tracheomalacia	519.19
Diaphragm paralysis	519.4
Vocal cord paralysis	478.30
Necrotizing enterocolitis	777.50
Urinary tract infection	599.0
Sepsis	995.91
PROCEDURES	
ICD-9 Procedure Codes for Complete TOF repair	

Total repair of tetralogy of Fallot	35.81
Open heart valvuloplasty of pulmonary valve without replacement	35.13
Open and other replacement of pulmonary valve with tissue graft	35.25
Open and other replacement of pulmonary valve	35.26
Repair of ventricular septal defect with prosthesis	35.53
Repair of endocardial cushion defect with prosthesis	35.54
Repair of unspecified septal defect of heart with tissue graft	35.60
Repair of ventricular septal defect with tissue graft	35.62
Other and unspecified repair of unspecified septal defect of heart	35.70
Other and unspecified repair of ventricular septal defect	35.72
Other and unspecified repair of endocardial cushion defect	35.73
Creation of conduit between right ventricle and pulmonary artery	35.92
Other operations on valves of heart	35.99
ICD-9 Codes for palliative TOF procedures	
Closed heart valvotomy, pulmonary valve	35.03
Percutaneous valvuloplasty	35.96
Systemic to pulmonary artery shunt	39.0
Other intrathoracic vascular shunt or bypass	39.23
Angioplasty or atherectomy of other non-coronary vessels	39.50
Daily events/complications	

Cardiopulmonary bypass for heart surgery	39.61
Deep hypothermic cardiopulmonary arrest	39.62
ECMO	39.65, 39.66
Measurement of systemic arterial blood gases	89.65
Packed blood cells	99.04
Platelet transfusion	99.05
Fresh frozen plasma	99.06, 99.07
Insertion of endotracheal tube	96.04
Cardiac catheterization	37.21, 37.22, 37.23
Angioplasty	39.50
TOF reoperation (CPT codes)	33692, 33694 and 33697
Pericardial effusion/ pericardiocentesis	37.0
Pleural effusion with chest tube	34.04
CPR-not otherwise specified	99.60
Other shock of heart	99.62
Packed blood cells	99.04
Platelet transfusion	99.05
Fresh frozen plasma	99.06, 99.07
Peritoneal dialysis	39.95
Exploratory thoracotomy	34.02
Pacemaker insertion/ revision	37.7x
Pacing of the heart	39.64
Cardioversion	99.6x
Chest closure (repair of chest wall)	34.7x
Operations in the diaphragm	34.8x

Mechanical ventilation	96.70
Mechanical ventilation less than 96 hours	96.71
Mechanical ventilation over 96 hours	96.72
Tracheostomy	31.2x
G-tube placement	46.3x, 46.39
Bronchoscopy	33.22
Tracheoesophageal fistula repair	31.73
Fixation of intestine	46.6x
Incision of intestine	45.0x