Updated PRAiS logistic regression risk model: April 2014

Probability of death within 30 days following paediatric cardiac surgery $= \frac{1}{1+e^{-Z}}$ where

$$Z = -5.638 + 0.362 * age - 0.170 * weight + \sum_{i=1}^{40} B_i X_i \ .$$

Parameters $i = 1-40$ are tabulated below along with their corresponding regression coefficients, B_i, and the condition that must be satisfied for $X_i = 1$ ($X_i = 0$ otherwise). Note that patient age must be in units of years and patient weight in units of kilograms. The model was developed using records for patients **under 16 years old**.

i	$X_i = 1$ if condition satisfied ($X_i = 0$ otherwise)	B_i
1	Specific Procedure = Anomalous coronary artery repair	-14.434
2	Specific Procedure = Aortic valvotomy	-14.734
3	Specific Procedure = Aortic valvoplasty	3.264
4	Specific Procedure = Arterial switch (for isolated transposition)	1.799
5	Specific Procedure = Arterial shunt	3.635
6	Specific Procedure = Arterial switch + VSD closure	1.940
7	Specific Procedure = ASD repair	-12.942
8	Specific Procedure = Atrioventricular septal defect (partial) repair	1.644
9	Specific Procedure = Aortic Valve Replacement - non Ross	-13.694
10	Specific Procedure = Aortic valve replacement - Ross	-13.361
11	Specific Procedure = Atrioventricular septal defect (complete) repair	2.498
12	Specific Procedure = Bidirectional cavopulmonary shunt	1.741
13	Specific Procedure = Fontan procedure	1.802
14	Specific Procedure = Heart Transplant	3.768
15	Specific Procedure = Interrupted aortic arch repair	2.740
16	Specific Procedure = Isolated coarctation repair	1.948
17	Specific Procedure = Isolated Pulmonary artery band	3.501
18	Specific Procedure = Low volume group	3.652
19	Specific Procedure = Mitral valve replacement	3.151
20	Specific Procedure = No specific procedure	2.877
21	Specific Procedure = Norwood procedure (Stage 1)	2.602
22	Specific Procedure = PDA ligation (surgical)	2.935
23	Specific Procedure = Pulmonary atresia VSD repair	3.498
24	Specific Procedure = Pulmonary valve replacement	3.899
25	Specific Procedure = Rastelli procedure	2.909
26	Specific Procedure = Repair of total anomalous pulmonary venous drainage	2.773
27	Specific Procedure = Subvalvar aortic stenosis repair	2.416
28	Specific Procedure = Supravalvar aortic stenosis repair	3.428
29	Specific Procedure = Tetralogy repair	1.884
30	Specific Procedure = Truncus arteriosus repair	2.275
31	Specific Procedure = VSD Repair	0.586
32	Not identified as univentricular heart	-0.615
33	Diagnosis Group = Low Risk	-0.887
34	Diagnosis Group = Medium Risk	0.162
35	Diagnosis Group = High Risk	0.725
36	Age Group = Neonate	0.529
37	Age Group = Infant	-0.062
38	Age Group = Child	-0.467
39	No recorded non-Down's comorbidities	-0.611
40	Procedure Type = Bypass	0.772

We note that caution is needed when interpreting individual coefficients as these are not clinically meaningful when taken in isolation of the other risk factors. The predicted risk comes from the *combination* of procedure, age, weight, severity of diagnosis and co-morbidity information.

The original PRAiS risk model was developed on a subset of national CCAD data from 2000-2010 and then tested on a pristine validation set. It was developed using the 2010 CCAD specific procedure algorithm. The original risk model was published in: Crowe, S, Brown, K, Pagel, C, Muthialu, N, Cunningham, D, Gibbs, J, Bull, C, Franklin, R, Utley, M, Tsang, V (2013). "Development of a diagnosis and procedure based risk model for 30-day outcome following paediatric cardiac surgery", Journal of the Thoracic and Cardiovascular Surgery, 145:1270-8.

Version 1.0 of the PRAiS software used an updated version of the PRAiS risk model developed by recalibrating the model parameters on the full 2007-2010 CCAD data set and using the 2012 CCAD specific procedure algorithm.

In response to a step change in the completeness of reporting of comorbidity and diagnosis and an apparent improvement in outcomes, and at the request of the NICOR congenital steering group, we have now updated the PRAiS risk model again by recalibrating the model on the 2009-2012 CCAD dataset (version 2.0). We have not changed the risk factors included in the model, but the membership of the Low, Medium and High Diagnosis Risk Groups has changed slightly (detailed in the Important Mappings Used For PRAiS spreadsheet). After recalibrating in June 2013, it was realised that there were some errors in the national dataset which have since been corrected. We recalibrated the PRAiS risk model on the revised 2009-2012 dataset in April 2014 and have incorporated this calibration into the PRAiS software (version 2.2). (NOTE: there is no version 2.1 of the PRAiS model calibration, but there is a version 2.1 of the software used to implement PRAiS.)

We performed some cross-validation of the model to estimate its accuracy in data not used for calibration. We calibrated the model on ten random 70% subsets of the 2009-2012 CCAD dataset and tested each calibration in the remained 30% of the data not used for calibration. Each 30% subset contained 3640 episodes on average. The performance of the risk model in each of ten 30% subsets is given below.

Subset (N~3640 in each 30% subset)	**ROC Areas under the curve**	**Observed number of deaths in 30% test subset**	**Predicted number deaths in 30% test subset**
1	0.78	99	86.8
2	0.76	87	97.5
3	0.80	85	94.1
4	0.78	86	96.4
5	0.77	92	91.9
6	0.78	83	78.9
7	0.78	91	92.1
8	0.76	91	91.5
9	0.79	86	94.0
10	0.76	81	103.3

The final recalibrated version (developed on the whole of the 2009-2012 data set) has an ROC area under of the curve of 0.82. We note that the final recalibrated version has not been tested in a pristine data set. As with any risk model, its performance in prospective data cannot be guaranteed.

We consider this version of the PRAiS risk model to be fit for the purpose of local routine monitoring of outcomes. Its use in national comparison needs to be interpreted with caution.

NOTE: In our implementation of the risk model we set the minimum risk for an episode to be 0.1% (0.0001). This is because there were no deaths for some combinations of risk factors in the historical data from 2009-2012 leading to an estimated risk of 0%. We do not consider this to have clinical face validity and so have specified a minimum risk of 0.1% for such episodes (in the long run, 1 death expected in 1000 episodes). There were no recorded deaths within 30 days for the following specific procedures: Anomalous coronary artery repair, ASD repair, Aortic valvotomy, Aortic Valve Replacement - non Ross and Aortic Valve Replacement – Ross.

Age Band Classification:

Neonate is defined as less than or equal to 30 days old.
Infant is defined as between 31 days and one year old inclusive.
Child is defined as older than a year and less than 16 years old.