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**The South-South partnership to provide cardiac surgery: The Namibia Children Heart  
Project**

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This research is in partial fulfillment of the degree of M.Phil.

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## Table of Contents

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Declaration	3
Abstract	4
Acknowledgements	5
List of Tables and Figures	6
Abbreviations	7
Manuscript	8
Appendices	46

## Declaration

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## Abstract

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**Introduction :** Congenital and acquired heart diseases are highly prevalent in developing countries despite limited specialised care. Namibia established a paediatric cardiac service in 2009 with significant human resource and infrastructural constraints. Therefore, patients are referred for cardiac interventions to South Africa.

**Objectives :** To describe the diagnoses, clinical characteristics, interventions, post-operative morbidity and mortality and follow-up of patients referred for care.

**Methods:** Demographics, diagnoses, interventions, intra- and postoperative morbidity and mortality as well as longitudinal follow-up data of all patients referred to South Africa were recorded and analysed.

**Results:** The total cohort constituted 193 patients of which 179 (93%) had congenital and 7% acquired heart disease. The majority of patients (78.8%) travelled more than 400 km to Windhoek prior to transfer. There were 28 percutaneous interventions. Palliative and definitive surgery was performed in 27 and 129 patients respectively. Eighty (80/156, 51.3%) patients had postoperative complications, of which 15 (9.6%) were a direct complication of surgery. Surgical mortality was 8/156 (5.1%, 95% confidence interval 1.2-9.8), with a 30-day mortality of 3.2%. Prolonged ICU stay was associated with a 5% increased risk of death (Hazard Ratio 1.05, 95% confidence interval: 1.02-1.08,  $p=0.001$ ). Follow-up was complete in 151 (78%) patients over seven years.

**Conclusions :** Despite the challenges associated with a cardiac programme referring patients for intervention to a neighbouring country and the adverse characteristics of multiple lesions and complexity associated with late presentation, we report good surgical and interventional outcomes. Our goal remains to develop a comprehensive sustainable cardiac service in Namibia.

## Acknowledgements

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I would like to express my sincere thanks to the following:  
My supervisors for their guidance and wisdom throughout the study,  
My husband for his unending support and mentorship,  
Dr Susan Vosloo and Andre Brooks for the comprehensive reports that provided a big base for the study, and from which I drew so much work inspiration,  
And above all, the Almighty God for the gifts granted upon me.

## List of tables and figures

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Figure 1: Geographical distribution of referred patients.

Figure 2. Transcatheter interventions

Figure 3: Cardiac Surgery cases by procedure

Table 1. Primary diagnosis anatomical and physiological classification

Table 2. Surgical risk stratification

Table. 3 Patients not offered surgery

Table 4. Postoperative complications

Table 5. Mortality

## Abbreviations

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ARF	Acute rheumatic fever
ASAP	Awareness Surveillance Advocacy Prevention
CBMH	Chris Barnard Memorial Hospital
CCF	Congestive cardiac failure
CHD	Congenital Heart Disease
CI	Confidence interval
CRF	Case report forms
GAS	Group A Streptococcus
GDP	Gross Domestic Product
ICU	Intensive Care Unit
MDGs	Millennium Development Goals
MHSS	Ministry of Health and Social Services
NCHP	Namibia Children Heart Project
PASCAR	Pan African Society of Cardiology
PPP	Private Public Partnership
RCWMCH	Red Cross War Memorial Children's Hospital
REMEDY	The Global Rheumatic Heart Disease Registry
RHD	Rheumatic Heart Disease
RHDGen	RHD Genetic Consortium
SACH	Save a Child's Heart
UN	United Nations
WHF	World Heart Federation
WHO	World Health Organisation



## **PART A: Manuscript**



# **South-South partnership to provide cardiac surgery: The Namibia Children Heart Project**

Fenny Fiindje Shidhika

University of Cape Town student number: SHDFEN001

# Chapter 1

## 1.1. Context

Namibia is a sparsely populated country. There is currently no quantitative data to ascertain the high prevalence of congenital and acquired heart disease in the paediatric population. Due to the patients being referred with severe disease, Namibia has been funding for some patients to receive care in South Africa. However, sustainability is a major concern with this model in the face of declining governmental capital investment..

## 1.2. Ethical considerations

The study was performed in accordance with ethical standards described in the Declaration of Helsinki, with ethical approval from institutional review boards at the University of Cape Town (HREC REF: 762/2016) and the Ministry of Health and Social Services in Namibia (REF: 17/3/3). Parental consent had been obtained for surgery. We obtained a waiver of parental consent for this study.

## 1.3. Author guidelines for the *Cardiology in the Young* journal

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## Chapter 2

### 2.1. Publication-ready manuscript

#### **A South-South partnership to provide cardiac surgery and interventions: The Namibian Children's Heart Project.**

Fenny F Shidhika <sup>1,2</sup>, Christopher T Hugo-Hamman <sup>1,2,4</sup>, John B Lawrenson<sup>2,3</sup> Henning J Du Toit <sup>1</sup>, Susan M Vosloo <sup>4</sup>, Andre Brooks <sup>4,5</sup> Harold S Pribut <sup>4</sup>, Susan R Perkins <sup>2</sup>, Liesl J Zühlke <sup>2,6</sup>

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4. Christiaan Barnard Memorial Hospital, Cape Town, South Africa
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**Keywords:** Congenital heart disease, Namibia, Public-private partnerships, surgical outreach, sustainable cardiac service

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## **Abstract**

**Introduction :** Congenital and acquired heart diseases are highly prevalent in developing countries despite limited specialised care. Namibia established a paediatric cardiac service in 2009 with significant human resource and infrastructural constraints. Therefore, patients are referred for cardiac interventions to South Africa.

**Objectives :** To describe the diagnoses, clinical characteristics, interventions, post-operative morbidity and mortality and follow-up of patients referred for care.

**Methods:** Demographics, diagnoses, interventions, intra- and postoperative morbidity and mortality as well as longitudinal follow-up data of all patients referred to South Africa were recorded and analysed.

**Results:** The total cohort constituted 193 patients of which 179 (93%) had congenital and 7% acquired heart disease. The majority of patients (78.8%) travelled more than 400 km to Windhoek prior to transfer. There were 28 percutaneous interventions. Palliative and definitive surgery was performed in 27 and 129 patients respectively. Eighty (80/156, 51.3%) patients had postoperative complications, of which 15 (9.6%) were a direct complication of surgery. Surgical mortality was 8/156 (5.1%, 95% confidence interval 1.2-9.8), with a 30-day mortality of 3.2%. Prolonged ICU stay was associated with a 5% increased risk of death (Hazard Ratio 1.05, 95% confidence interval: 1.02-1.08,  $p=0.001$ ). Follow-up was complete in 151 (78%) patients over seven years.

**Conclusion :** Despite the challenges associated with a cardiac programme referring patients for intervention to a neighbouring country and the adverse characteristics of multiple lesions and complexity associated with late presentation, we report good surgical and interventional outcomes. Our goal remains to develop a comprehensive sustainable cardiac service in Namibia.



## **Introduction**

Congenital heart disease (CHD) is defined as the structural abnormalities of the heart or intra-thoracic vessels present at birth that have actual or potential functional significance. CHD are the most common birth defects and are associated with significant morbidity and mortality<sup>1,2</sup>. Rheumatic heart disease is the sequel to acute rheumatic fever following *Group A streptococcus* infection and is the most common acquired heart disease in developing countries<sup>3</sup>. This combination results in a high burden of childhood heart diseases in Africa<sup>4</sup>. Namibia gained independence from apartheid South Africa in 1990. It is a vast country (land area 824 268 km<sup>2</sup>) with a sparse population of 2.3 million people 44% of whom are children<sup>5</sup>. It is classified as an upper middle-income economy however, there is gross income inequality with a Gini co-efficient of 0,57<sup>6</sup>. Before 2007, there was no paediatric cardiac service in Namibia. Outpatient paediatric cardiac clinics were started by a visiting volunteer paediatric cardiologist in Windhoek and with increasing government commitment, a catheterisation laboratory was commissioned in 2010 and a limited local surgical programme (catering mostly for adults and older children), was commenced. With significant human resource constraints - no paediatric intensive care specialists, no paediatric critical care nurses, no paediatric cardiac anaesthetists or paediatric cardiac surgeons and no paediatric intensive care, a centre for cardiac surgery for babies and small children (under 20 kg) has not been established. In response, in 2009 a public private partnership was brokered between the Christian Barnard Memorial Hospital in Cape Town, South Africa and the Namibian Ministry of Health and Social Services. Whilst the goal is to develop a fully functional and sustainable paediatric cardiac service in Namibia, in the interim patients have been referred to South Africa for surgery. This study describes the diagnoses, clinical characteristics, interventions, post-operative morbidity and mortality and the follow-up of patients referred to Cape Town between 2009 and 2015.

## **Methods**

### *Study design and population*

We performed a retrospective data analysis of the 193 patients diagnosed with heart disease at Windhoek Central Hospital by a single paediatric cardiologist and referred to Christian Barnard Memorial Hospital in Cape Town, South Africa from the period between 2009 and 2015. Patient selection for surgery or intervention followed clinical and echocardiographic assessment and when relevant, cardiac catheterisation.



### *Ethics*

The study was performed in accordance with ethical standards described in the Declaration of Helsinki, with ethical approval from institutional review boards at the University of Cape Town and the Ministry of Health and Social Services in Namibia. Parental consent had been obtained for surgery. We obtained a waiver of parental consent for this study.

### *Data collection*

Data were captured from Windhoek Central Hospital and Christian Barnard Memorial Hospital registries using a standardised data collection form (Baseline Case Record Form – Appendix 1) and recorded in Research Electronic Data Capture (REDCap) database. Dependent and independent variables included demographic profile, primary diagnosis co-morbid and pre-operative data, echocardiography findings, cardiac catheterisation, surgery, post-operative morbidity and mortality and longitudinal follow-up outcomes. Patients were categorised using age and/or weight criteria and complexity estimated according to the presence of more than one lesion, associated pulmonary hypertension or complex CHD. The modified version of the hierarchy of heart defects developed by the CONgenital COR Vitia (CONCOR) registry was used for the primary diagnosis <sup>7</sup> and assigned codes according to the International Classification of Diseases and Related Health Problems 10<sup>th</sup> revision (ICD 10) coding system <sup>8</sup>. The Risk Adjustment for Congenital Heart Surgery (RACHS-1) model <sup>9, 10</sup> used here represents surgical complexity. Procedure nomenclature is assigned using the International Paediatric and Congenital Cardiac Code <sup>11</sup>.

### *Statistical analysis*

Data were analysed using STATA 14.0 (StataCorp, 4905 Lakeway Dr, College Station, TX 77845). Continuous variables were expressed as means with standard deviations or medians with interquartile ranges as appropriate. Categorical variables were expressed as absolute number frequencies and percentages. Linear regression models and Cox regression models were used to assess the relationship between and risk of appropriate variables with survival, respectively.

## **Results**

### *Demographics*

One hundred ninety-three patients were referred to the Cape Town centre for cardiac care. Patients originated from all regions of Namibia (Figure 1). Distances to the referral centre

ranged from 200 – 800 km with 107 people (55%) referred from villages over 700 km from Windhoek Central Hospital. The ratio of female to male was 1.3: 1. The median age for presentation with congenital and acquired heart disease categories were 12 months (Interquartile range 5.0- 60.0) and 210 months (Interquartile range 180- 276 months) respectively. The median age at referral to Christiaan Barnard Memorial Hospital was 32.8 months (Interquartile range 11.1-101.3).

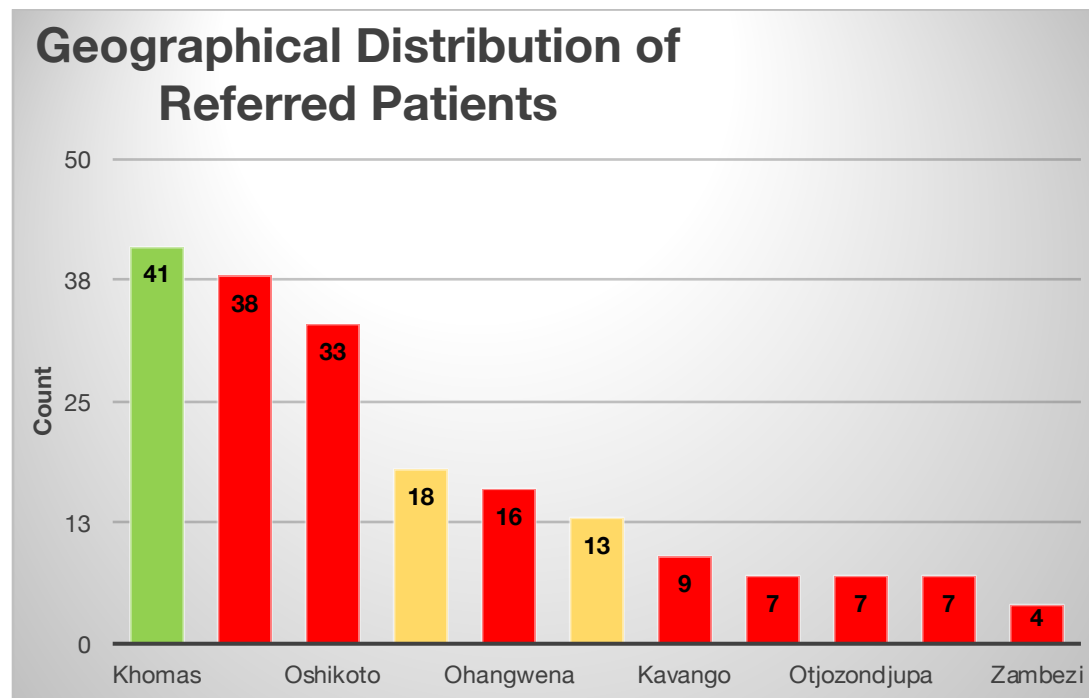


Figure 1: Geographical distribution of referred patients.  
(Green: referral centre, Orange: between 400-500 km, Red: further than 600 km)

### ***Baseline characteristics***

#### ***Primary diagnosis***

Congenital heart disease accounted for 179 (93 %) of patients. “Simple” left to right shunts were the largest group, n=77 (39.9%), 52 of which were ventricular septal defects. Partial and complete atrio-ventricular septal defects were found in 17 (8%) patients. complex cyanotic lesions, excluding tetralogy of Fallot, accounted for 29 (15%) patients. Obstructed left heart lesions were found in seven patients (see Table 1.) Only 14 (7.3%) patients had acquired heart diseases (Rheumatic Heart Disease n=11 and Takayasu arteritis n=3). The predominant lesion in the Rheumatic Heart Disease group was mitral stenosis (n=8, 73%). One patient had isolated mitral regurgitation, one mixed mitral valve disease, one severe mitral and aortic regurgitation.

**Table 1. Primary diagnosis anatomical and physiological classification**

<b>Congenital heart disease</b>	
<b>Diagnosis</b>	<b>N=193 %</b>
<i>Left to right shunts</i>	
Partial AVSD	(7) 3,6%
Complete AVSD	(6) 3,1%
VSD	(52) 26,9%
ASD	(8) 4,1%
PDA	(15) 7,7%
<i>Obstructive right heart lesions</i>	
Tetralogy of Fallot spectrum <i>Classic 20</i> <i>Pulmonary atresia 7</i> <i>DORV-Tetralogy 6</i>	(33) 17.1%
Isolated pulmonary valvar stenosis	(9) 4.7%
Double Chambered RV	(2) 1.0%
<i>Obstructive left heart lesions</i>	
Interrupted Aortic Arch	(2) 1.0%
Coarctation of Aorta	(3) 1.6%
Aortic stenosis <i>Valvar 3</i> <i>Sub- and supra-valvar 1</i>	(4) 2.1%
<i>Atrio-ventricular and ventriculo-arterial discordance</i>	
TGA (simple)	(2) 1.0%
ccTGA	(1) 0.5%
Ventricular inversion	(1) 0.5%
DORV <i>Taussig-Bing 1</i> <i>Non-committed VSD 1</i>	(2) 1.0%

Pulmonary atresia/IVS	(1) 0.5%
<b><i>Pulmonary vein abnormalities</i></b>	
TAPVD	(1) 0.5%
Isolated pulmonary vein stenosis	(1) 0.5%
<b><i>Single ventricle physiology</i></b>	
Tricuspid atresia	(9) 4.7%
Unbalanced AVSD <i>Isolated 1</i> <i>Unbalanced AVSD-Tetralogy 2</i>	(3) 1.6%
DILV	(3) 1.6%
HLH complex	(1) 0.5%
<b><i>Acquired heart disease</i></b>	
Rheumatic heart disease	(11) 5.7%
Takayasu arteritis	(3) 1.6%

***Abbreviations:***

AVSD: Atrio-ventricular Septal Defect, VSD; Ventricular Septa; Defect, ASD; Atrial Septal Defect, PDA; Patent Ductus Arteriosus, TGA; Transposition of the Great Arteries, CCTGA- Congenitally Corrected Transposition of the Great Arteries, DORV; Double Outlet Right Ventricle, RV; Right Ventricle, IVS: Intact Ventricular Septum, TAPVD; Total Anomalous Pulmonary Venous Drainage, DILV; Double Inlet Left Ventricle, HLH; Hypoplastic Left Heart

***Comorbidity***

The number of patients with Trisomy 21 was 13 (6.7%). The 22q11.3 microdeletion was isolated in five patients (2.6%) but not all patients with CHD were screened for this gene defect. Heterotaxy was discovered in four (2.1%), Noonan's syndrome was diagnosed in two patients (1,0%); Congenital diaphragmatic hernia in three patients (1.6%) and one patient had the VACTERL (Vertebral defects, Anal atresia, Cardiac defects, Tracheoesophageal fistula, Renal anomalies and Limb abnormalities) association. Significant failure to thrive (poor

somatic growth equal to or greater than three standard deviations below the mean for age and height) was found in 76 patients (39.4%). In our cohort, 80 (41.5%) had clinical features and echocardiographic evidence of pulmonary hypertension. Almost three-quarters of the patients had a delay to surgery due to an existing respiratory infection. Two patients were on respiratory support before surgery. There were two patients in the last trimester of pregnancy referred for percutaneous transcatheter mitral valve commissurotomy for RHD associated mitral valve stenosis.

### ***Catheterisation***

#### *Diagnostic cardiac catheterisation*

Cardiac catheterisation was performed in 89 patients (46.1%). The majority 62 (69.7%) were diagnostic/haemodynamic studies. Median age at catheterisation was 70.1 months (Interquartile range: 17.6 – 155.4). Catheterisation was performed in 30 (33.7%) patients with severe pulmonary hypertension to assess suitability for surgery. Of this group, three patients proved to have irreversible pulmonary hypertension secondary to pulmonary vascular disease and deemed inoperable. Catheterisation was done as routine inter-stage assessment in those undergoing staged single ventricle palliation or to delineate anatomy for biventricular repair in 32 (36.0%).

#### *Transcatheter interventions*

There were 28 (30.3%) transcatheter interventions (on 27 patients) including eight percutaneous mitral transcatheter commissurotomies and two radio-frequency ablations (see Figure 2). The remainder were for CHD interventions. There was one complication where an Amplatzer Patent Ductus Arteriosus occluder device (ADO 1) embolised into the left pulmonary artery. The device was removed, and the duct ligated surgically.

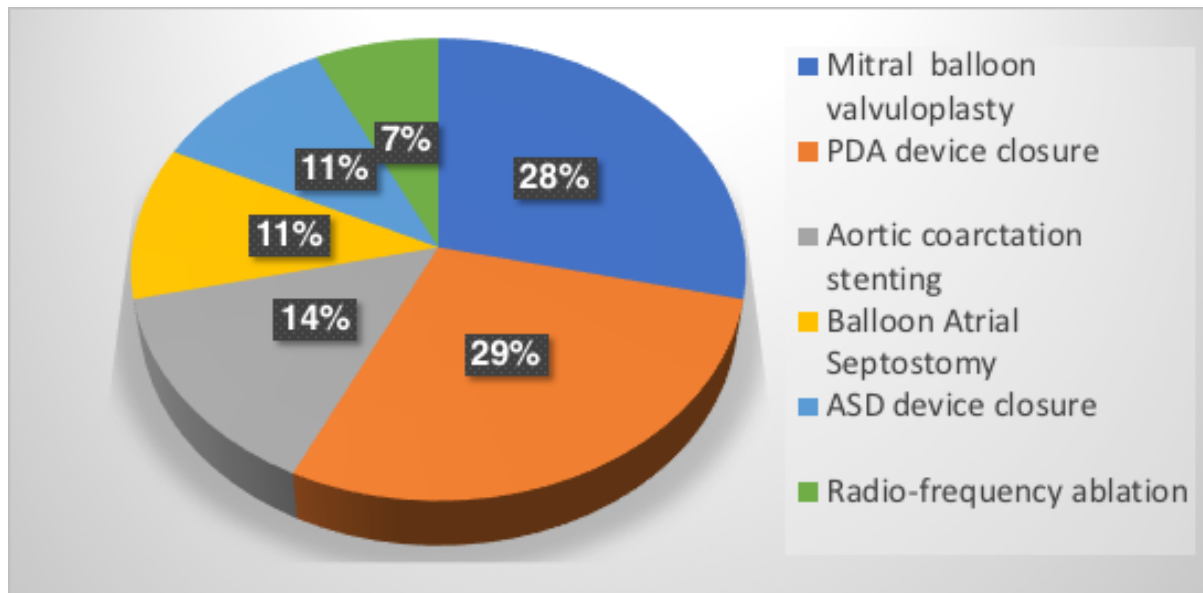


Figure 2. Transcatheter interventions

### ***Surgery***

The median age at presentation to Windhoek Central Hospital was 12 months (Interquartile range 5.0 - 47.5) however, the median age at time of surgery was 28.4 months (Interquartile range: 11.1-78.0). In total, 156 cases were performed; surgery was elective in 142/156 (91.0%) cases. Twenty-seven (17.3%) of all patients who underwent surgery had palliative procedures. Of these, 11 were for single ventricle palliation (10 Glenn shunts and one total cavopulmonary connection). Six patients had a right modified Blalock-Taussig shunt, nine had pulmonary artery bandings and one had a central shunt. One hundred twenty-nine (82.7%) patients had a full repair with 15 of these (11.6%) performed off cardiopulmonary bypass (See Figure 2). Those classified as “other” included three patients with double outlet right ventricle, five patients undergoing right ventricular outflow tract reconstruction and/or pulmonary valve replacement, two patients with divided right ventricle and ventricular septal defect repair and one each of left atrio-ventricular valve repair, tricuspid valve repair, divided right ventricle, ventricular septal defect and Sinus of Valsalva repair and ventricular septal defect /aortic valve repair. Risk stratification for surgical procedures (RACHS-1 categories) is illustrated in Table 2.

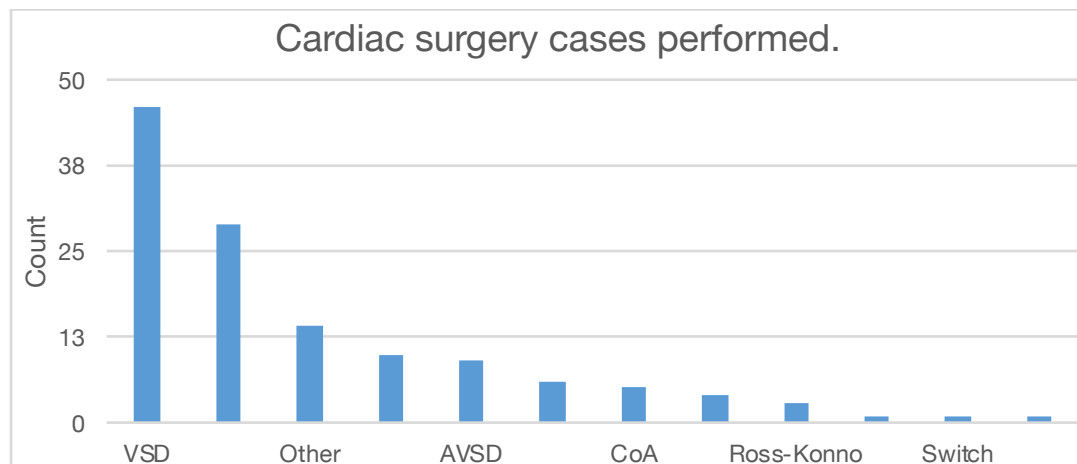
There were 11 re-operations (7.0%); four for haemodynamically significant residual defects, two in a child with pulmonary atresia, one with excessive pulmonary blood flow after systemic to pulmonary shunt, one with persistent ascites after right ventricular outflow tract reconstruction in tetralogy of Fallot (with hypoplastic branches) and one for a residual ventricular septal defect after atrio-ventricular septal defect repair. two patients needed

emergency revision; one for refractory bleeding and the other for systemic to pulmonary shunt thrombosis.

Two babies with congenital diaphragmatic hernia and one with tracheoesophageal fistula had those lesions repaired before cardiac surgery. Twelve patients with CHD were not offered surgery (Table 3).

**Table.2 Surgical risk classification**

RACHS-1 Category Score	Absolute frequency	Percentage
1	21	13.6
2	68	43.6
3	58	37.1
4	9	5.7
Total	156	100.00



**Figure 3: Cardiac Surgery cases by procedure**

Abbreviations: VSD: Ventricular Septal Defect, TOF: Tetralogy of Fallot, PDA: Patent Ductus Arteriosus, AVSD: Atrio-ventricular septal defect, ASD: Atrial Septal Defect, CoA: Coarctation of the Aorta, MVR: Mitral valve replacement, AVR: Aortic Valve replacement, IAA: Interrupted aortic arch.

**Table. 3 Patients not offered surgery**

	Age	Diagnosis	Investigation	Conclusion	Outcome
1	9y	Left isomerism Interrupted aortic arch, AVSD (common atrium) Left AV valve incompetence LV non-compaction	Cardiac catheterisation: PVRi 10 WU	Anatomy and haemodynamics not suitable for surgery	Unknown*
2	1m	AVSD Diaphragmatic hernia Trisomy 21	Cardiac catheterisation: PVRi 6 WU,	Poor respiratory capacity Advance pulmonary vascular disease	Eisenmenger syndrome
4	9m	Transposition of great arteries, Ventricular septal defect	Cardiac catheterisation PVRi > 6 WU	Irreversible pulmonary vascular disease,	Deceased
5	10m	Complete AVSD PDA	Cardiac catheterisation: PVRi 12 WU	Irreversible pulmonary vascular disease,	Unknown*
6	3m	Shone syndrome Sub-aortic stenosis Coarctation of aorta ASD, VSD	Cardiac catheterisation	Anatomy and haemodynamics not suitable for surgery	Unknown*
7	11y	Muscular VSD PDA	Echocardiogram	Haemodynamically insignificant	Alive
8	5m	Situs ambiguous Discordant AV connections Interrupted IVC VSD	Cardiac catheterisation	Complex and not suitable for surgery	Alive
9	3m	Tetralogy of Fallot with Pulmonary atresia and MAPCAS Pulmonary artery hypoplasia	Catheterisation	Inadequate pulmonary arteries not suitable for surgery	Unknown*
10	3d	Shone complex Interrupted aortic arch Sub-aortic stenosis	Catheterisation	Anatomy unsuitable for surgery	Unknown*



		Aorto-pulmonary window ASD, VSD			
11	15 y	Double inlet left ventricle AV valve regurgitation Previous Coarctation repair, Bi-directional Glenn shunt	TOE and catheterisation	Not suitable for univentricular palliation	Unknown*
12	1w	Pulmonary vein stenosis Severe pulmonary venous hypertension	Echocardiogram	Anatomy not suitable for correction	Unknown*

\*Lost to follow-up

Abbreviations: AVSD: Atrio-ventricular septal defect, AV: Atrio-ventricular, LV: Left Ventricle, PDA: Patent Ductus Arteriosus, ASD: Atrial Septal Defect, VSD: Ventricular Septal Defect, AV: Atrio-ventricular, IVC: Inferior Vena Cava, PVRi: Pulmonary Venous Resistance indexed, WU: Woods Units

## Outcome

### *Morbidity*

#### *Intra-operative morbidity*

One intra-operative complication was documented. This patient sustained left coronary injury during a single ventricle palliation with bilateral pulmonary artery augmentation. The coronary artery was repaired with successful re-vascularisation.

#### *Postoperative morbidity*

Eighty (80/156, 51.3%) patients had postoperative complications, of which 15 (9.6%) were a direct complication of cardiac surgery (Table 4). The median post-operative stay in intensive care was 5 days (Inter-quartile range: 3 - 7) with the maximum 106 days. Prolonged ICU stay, defined as 5 days after surgery, occurred in n=81 (51.9%).

**Table 4. Postoperative complications**

<b>Complication</b>	<b>Frequency</b>	<b>% n=156</b>
Pneumonia	41	26,28
Arrhythmia (tachyarrhythmia, AV dissociation)	9	5,77
Pulmonary hypertensive crisis	9	5,77
Persistent pleural drainage (transudate)	6	3,85
Pericardiotomy syndrome	4	2,56
Bleeding	2	1,28
Diaphragm paralysis	2	1,28
Pulmonary reperfusion injury	2	1,28
Wound sepsis	2	1,28
Myocardial ischaemia	1	0,64
Persistent pulmonary drainage (chylothorax)	1	0,64
Systemic to pulmonary shunt thrombosis	1	0,64
Total	80	51,28

***Mortality***

In total, there were eight surgical deaths with an overall mortality of 4.2%. Five of these were early (< 28 days) and three late deaths (Refer to Table 5). Two deaths occurred within 24-48 hours of surgery, two on day five and one each on days 20, 50 and 90, respectively. The 30-day mortality rate was 3.8 [95% Confidence interval 1.4-8.2]. Median age at death was 7.3 months (Interquartile range: 6.2-22.5).

**Table 5: Mortality**

	Age	Diagnoses	RACHS score	IPCCC procedures	Death	Cause of death
1	13m	Complete AVSD, PDA Trisomy 21	3	PA Band and PDA ligation	Early	Traumatic pericardiocentesis
2	6m	Pulmonary infundibular and valvar stenosis Dysplastic tricuspid valve	2	RVOTO relief with creation ASD	Early	Restrictive right ventricle and tachyarrhythmia
3	20m	Tetralogy of Fallot	2	Tetralogy repair and reoperation	Early	Restrictive right ventricle and tachyarrhythmia
4	11y	DORV with Tetralogy and MAPCAs	3	Bidirectional Glenn, atrial septectomy, PA Band, repair LAD	Early	Myocardial Infarction
5	20m	Complete unbalanced AVSD and pulmonary stenosis	3	RMBTS	Early	Unknown
6	3m	TGA with VSD VACTERL association Tracheoesophageal fistula	3	PA Band, PDA ligation, repair TOF	Late	Respiratory failure chronic lung disease
7	6m	Severe infundibular and valvar pulmonary stenosis	2	RVOT obstruction patch and creation ASD	Early	Restrictive right ventricle and tachyarrhythmia
8	8m	Complete unbalanced AVSD Right AV valve atresia, severe Left AV valve regurgitation	3	Left AV valve repair not suitable for bi-ventricular repair	Early	Cardiorespiratory failure

**Abbreviations:** AVSD: Atrio-ventricular septal defect, PDA: Patent Ductus Arteriosus, DORV: Double Outlet Right Ventricle, MAPCAs: Medium-sized Arterio-Pulmonary Collateral Arteries, TGA: Transposition of the Great Arteries, AV: Atrio-ventricular, RVOTO: Right ventricular outflow tract obstruction, ASD: Atrial Septal Defect, PA: Pulmonary artery, LAD: left anterior descending artery, TOF: Tetralogy of Fallot.

### **Longitudinal follow-up rates and overall survival**

Forty-two patients (21.8%) were lost to follow-up (failed to attend a scheduled visit for 24 months from the last visit) over the period 1 December 2009 to 31 December 2016.

### **DISCUSSION**

The major findings of this study from Africa are that despite the distance to the referral centre (more than half of all patients referred for cardiac surgery and intervention reside more than 700 km from the only referral centre in Namibia) and their late presentation and referral, surgical therapy could be offered to the patients with good outcomes with an acceptable overall mortality of 4.2 % despite complex disease, significant co-morbidity and protracted post-operative intensive care. A high number of these patients, 21.8%, are lost to follow-up within 24 months.

#### *Distance to care*

In poor countries, long distances to care represent an additional access challenge. The majority of our patients live in the northern regions of Namibia in mostly rural, agrarian communities surviving through subsistence farming. If they are recognised as having cardiac disease, they are sent to the regional centre for paediatric services at the Oshakati Intermediate Hospital. This hospital is located in excess of 700 km from the national referral centre in Windhoek. The Ministry of health and Social Services patient transport between Oshakati and Windhoek takes place by road once a week. Emergencies are transported by an air ambulance after lengthy procedural delays and at substantial extra direct cost. Poverty, distance to care and poor transport infrastructure represent significant barriers to all levels of health care and of course to responsible follow-up. Recognising these barriers to care, regular outreach visits to the north of Namibia were instituted in 2013 to provide patient care and upgrade local knowledge and cardiology skills.

#### *Late diagnosis and referral, complex disease and significant co-morbidity.*

The late presentation of patients with CHD to specialist care is primarily a consequence of poor early diagnosis and late recognition. This reflects poor knowledge of CHD in the peripheral referral regions of the country and the low penetrance of specialist paediatric services through the health system. Late detection has two significant results. Firstly, that those patients with

critical congenital heart disease (20% of all CHD) <sup>12</sup> who should have early surgery are never detected and die without treatment. The low numbers of babies with, for example, transposition of the great arteries or anomalous pulmonary venous connection in this cohort can be understood in this context. Secondly, by the time patients are diagnosed they have severe complications of their underlying disease. Pulmonary vascular disease secondary to severe pulmonary hypertension is the most common example and despite the pre-selection of patients by the cardiologist in Windhoek, a further three patients with pulmonary hypertension were deemed inoperable in Cape Town. The review does not reflect those many patients denied referral from Windhoek due to established pulmonary vascular disease. The problems posed by pulmonary hypertension are further reflected in the nine patients with post-operative pulmonary hypertensive crises. The higher age at presentation in the CHD group is also the reason for the high number of diagnostic cardiac catheterisations performed to assess the reversibility of pulmonary hypertension prior to surgery. Whilst failure to thrive is often multifactorial, especially in countries with high levels of unemployment, poverty and malnutrition, the high numbers with failure to thrive in the CHD cohort reflects the severity of their disease and a period of almost 22 months between presentation and referral for assessment. Pre-existing respiratory infection is a known risk factor for cardiac surgery <sup>13</sup>. A high number of children arrived for surgery with pre-existing respiratory disease, had in-hospital delay to operation and lengthy post-operative recovery.

The case-mix is diverse, predominantly CHD and predictable. The number of patients with Rheumatic Heart Disease (13) was low which does not reflect the high prevalence of this preventable disease in Namibia <sup>14, 15</sup>. Cardiac surgery was started at the Windhoek Central Hospital in October 2010 and through a similar period, most patients with Rheumatic Heart Disease needing valve surgery (200 reported cases) <sup>16</sup> had surgery at Windhoek Central Hospital. Those with rheumatic heart disease sent to Cape Town included children with body mass under 20kg and 8 patients needing percutaneous transcatheter mitral valve commissurotomy for mitral stenosis when the technology (Inoue percutaneous transcatheter mitral valve commissurotomy catheter) was not available at Windhoek Central Hospital.

#### *Surgical mortality and length of Intensive Care*

The low surgical mortality compares favourably with similar programs in developing countries and international standards established by the Society of Cardiothoracic Surgeons <sup>17-20</sup>. The likely causes of the post-operative deaths are revealing and suggest that in three patients the

risk associated with restrictive right ventricular pathophysiology was not fully appreciated pre-operatively. Two patients with complex atrio-ventricular septal defects also had abnormal right ventricle pathology. Pre-operative pulmonary hypertension was neither associated with mortality or length of time in ICU suggesting appropriate pre-selection. The length of post-operative intensive care correlates with mortality. Preoperative respiratory infection was common (75%) but neither this nor failure to thrive was a risk factor for death even though both factors were associated with the prolonged ICU stay after operation.

#### *Loss to follow-up and after-care*

Post-operative care and surveillance is a determinant of long-term outcome. The outreach paediatric cardiology service to the north of the country was started in 2013 partly to address this challenge. Although it has improved, patient “connection” with primary health facilities and with specialist cardiac care is poor. The lengthy distances to the referral centres, poor transport infrastructure and the fact that many of our families live in abject poverty further contribute to the problem. Many families simply cannot afford private transport to the hospitals or primary care services to sustain their follow-up care. There is no electronic medical record and no national database for patients within the system, so case finding and patient tracking remain problematic. Despite the health service challenges, the combination of a patient registry, outreach programme and the continuity of care provided by a single cardiologist have contributed to 80% of patients remaining within follow-up (which compares favourably with reports from elsewhere in Africa) <sup>15,21</sup>. However, the loss to follow-up rate of 20% is still high and suggests that our mortality statistics underestimate late post-operative deaths.

#### *Implications for health policy, practice and research*

The Namibian Children’s Heart Project is a humanitarian programme aimed to provide cardiac surgery and intervention for indigent Namibians who are unable to access such services in Namibia. It is South-South collaboration and a unique funding model on the African continent with national government purchasing services from private sector providers in a neighbouring country. Although the Namibian Children’s Heart Project has up to December 2015 brought relief to almost 200 patients with satisfactory results, these patients should be able to get the care they require in Namibia. There is an overwhelming general agreement evidence that the birth prevalence of CHD is 8 per 1000 live births <sup>2,22</sup>. Applying this to Namibia, with annual births per annum of 60 000, <sup>23</sup> there are 480 babies born every year with CHD. Of these 40% will need heart surgery and 20% who have critical CHD, require it in infancy <sup>1,12,24</sup> Without

addressing the backlog, 200 patients over six years is not enough, and the Ministry of health and Social Services should be planning heart surgery for at least 200 patients per year in the country.

It is our objective to develop a comprehensive, sustainable and self-sufficient paediatric cardiac surgical service in Namibia. The challenges are both human resources based and infrastructural. The minimum specialist requirements are a paediatric cardiac surgeon with sufficient training and recognised expertise in CHD, anaesthetists trained in paediatric cardiac care, a paediatric intensive care specialist and a well-trained cadre of paediatric cardiac intensive care nurses. In a country without a paediatric intensive care, construction of such a facility is a priority. Only with this facility, appropriate financial resources from government for heart surgery in children and a collective and cooperative effort to upgrade nurse ICU skills for babies and children will we be able to offer safe surgery within Namibia. Implementation requires strict adherence to established quality improvement protocols, with proposed participation in the International Quality Improvement Collaborative<sup>9,17</sup>.

### *Recommendations*

1. Continuous capacity building at all levels is mandatory.
2. Diagnostic services within the health department need to improve as without this, the sick newborn with critical CHD will remain invisible<sup>25 26</sup>.
3. The National Ministerial Outreach programme should be expanded at intermediate hospitals across the country.
4. Pulse oximetry screening should be considered in neonatal units to improve detection yields.
5. We strongly recommend a national database of heart disease in children.
6. Follow-up rates will be improved by calling the patients when they miss their scheduled appointments. Most families own cellular phones however the challenge is that patients are constantly changing their contact numbers and for those residing in remote areas, connectivity might be poor.

### **Conclusion**

We have demonstrated an effective model for humanitarian care through a South-South collaboration, which has achieved satisfactory outcomes for those fortunate to be referred and

funded by government. Despite health services constraints, adverse characteristics of multiple lesions and complexity associated with late presentation, the 30-day mortality rate is only 3.2%. The cohort reports only those who travelled to Cape Town and does not address the challenge of the many patients who were referred but died or became inoperable, whilst waiting. This study highlights health service deficiencies needing improvement and a commitment from the team to achieve safe surgery for babies and children within a sustainable national programme in Namibia.

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### **Conflicts of interest**

The authors declare no conflicts of interest.

### **Ethical standards**

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation (Human Research Ethics Committee University of Cape Town) and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the institutional committees (Human Research Ethics Committee Reference number 762/2016) and the Ministry of Health and Social Services in Namibia (17/3/3).

This work is in partial submission of the MPhil (Paediatric Cardiology) degree at the University



of Cape Town by Dr Shidhika.

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## **PART B: APPENDICES**



Addendum 1: Ethics Approvals

Addendum 2: CRF

Addendum 3: Protocol

Addendum 4: Diagnostic and procedure codes



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**OFFICE OF THE PERMANENT SECRETARY**

**Ref:** 17/3/3

**Enquiries:** Mr. M. Simasiku

**Date:** 08 April 2016

**Dr. Fenny Fiindje Shidhika**  
**P. O. Box 86629**  
**Eros, Windhoek**  
**Namibia**

**Re: Saving Children. The Namibian Children's Heart Project.**

1. Reference is made to your application to conduct the above-mentioned study.
2. The proposal has been evaluated and found to have merit.
3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**
  - 3.1 The data to be collected must only be used for academic purpose;
  - 3.2 No other data should be collected other than the data stated in the proposal;
  - 3.3 Stipulated ethical considerations in the protocol related to the protection of Human Subjects should be observed and adhered to, any violation thereof will lead to termination of the study at any stage;



UNIVERSITY OF CAPE TOWN  
Faculty of Health Sciences  
Human Research Ethics Committee



Room E53-46 Old Main Building  
Grootte Schuur Hospital  
Observatory 7925  
Telephone [021] 406 6492  
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24 October 2016

**HREC REF: 762/2016**

**Dr L Zuhlke**  
Paediatric Cardiology  
Room 2.17, ICH Building  
Red Cross War Memorial Children's Hospital  
Rondebosch

Dear Dr Zuhlke

**PROJECT TITLE: THE NAMIBIA HEART PROJECT: A 6- YEAR RETROSPECTIVE REVIEW  
(M.Phil candidate- Dr F Shidhika)**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

**Approval is granted for one year until the 30 October 2017.**

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: [www.health.uct.ac.za/fhs/research/humanethics/forms](http://www.health.uct.ac.za/fhs/research/humanethics/forms))

**Please quote the HREC REF in all your correspondence.**

***We acknowledge that the student, Dr F Shidhika will also be involved in this study.***

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate Institutional approval before the research may occur.

Yours sincerely

PP

T. Burgess

**PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE**

Federal Wide Assurance Number: FWA00001637.  
Institutional Review Board (IRB) number: IRB00001938

HREC 762/2016

**Addendum 2: Baseline CRF**

**APPENDIX 1**

**The Namibia children heart project; a 6-year retrospective review**

DATA COLLECTION FORM

**1. DEMOGRAPHICS**

Subject ID Number: (Sequential number plus patient initials): \_\_\_\_\_

Geographical Region:

1. Erongo
2. Hardap
3. Kavango
4. Khomas
5. Oshana

6. Omaheke
7. Oshana
8. Oshikoto
9. Otjozondjupa
10. Zambezi

Date of birth (DD /MM /YYYY): \_\_\_\_\_ (DD/MM/YYYY)

Date of initial presentation at Windhoek facility: \_\_\_\_\_ (DD/MM/YYYY)

Age at presentation (auto-calculated): \_\_\_\_\_ (MONTHS)

Cape Town facility Admission date: \_\_\_\_\_ (DD/MM/YYYY)

Cape Town facility Discharge date: \_\_\_\_\_ (DD/MM/YYYY)

Age at admission to Cape Town facility (auto-calculated): \_\_\_\_\_ (MONTHS)

Sex:

1. M
2. F
3. Other/Missing



**2. DIAGNOSIS** (According to the ICD.10 coding system Appendix 2.)

Primary Cardiac Dx Code: \_\_\_\_\_ (xxx.xx)

Type of Heart Disease

- 1. Acquired
  - 1. Takayasu’s Arteritis
  - 2. Rheumatic Heart Disease
  
- 2. Congenital
  - 1. Coarctation of Aorta
  - 2. Interrupted Aortic Arch
  - 3. Sub-aortic Stenosis
  - 4. Valvar Aortic stenosis
  - 5. Tricuspid Atresia
  - 6. Double Inlet Left Ventricle
  - 7. Double Outlet Right Ventricle
  - 8. Mitral Stenosis
  - 9. Double Orifice Mitral Valve
  - 10. Mitral Valve Prolapse
  - 11. Other. Pls describe \_\_\_\_\_

Additional lesions:

- 1. None
- 2. Total Anomalous Pulmonary Venous Drainage
- 3. Partial Anomalous Pulmonary Venous Drainage
- 4. Atrio-ventricular Disconcordance
- 5. Ventriculo-arterial Disconcordance
- 6. Isomeric atrial appendages
- 7. Other: Please describe \_\_\_\_\_

Other relevant diagnoses:

Diagnosis 2: \_\_\_\_\_ (xxx.xx)      Diagnosis 5: \_\_\_\_\_ (xxx.xx)  
Diagnosis 3: \_\_\_\_\_ (xxx.xx)      Diagnosis 6: \_\_\_\_\_ (xxx.xx)  
Diagnosis 4: \_\_\_\_\_ (xxx.xx)      Other/Missing: \_\_\_\_\_ (999)

Co-morbidities /Associations/Syndromes

- 1. HIV
- 2. Diaphragmatic hernia
- 3. Down syndrome
- 4. Noonan’s syndrome
- 5. Shone Complex
- 6. Pulmonary TB
- 7. Congenital Rubella
- 8. George’s Syndrome
- 9. Isolated midline defects
- 10. Skeletal abnormalities (e.g. kyphosis, scoliosis, radial)
- 11. VACTERL association
- 12. Congenital renal abnormalities
- 13. Other: Please describe \_\_\_\_\_

Pregnant at time of intervention?

- 1. Yes

- If yes, gestational age: \_\_\_\_\_ (weeks)
2. No
  3. Unknown/Missing

RACHS Category score:

1.            2.            3.            4.            5.            6.

Was patient returned to WCH because of contraindications for surgery?

1. Yes
2. No
3. Other

If yes, please describe the nature of the contraindication

\_\_\_\_\_

Outcome:

1. Patient was readmitted for intervention at a later date (within the review period)
2. Patient was deemed as an inappropriate candidate for surgery with no plans for further intervention

### 3. CATHETERISATION

1. Yes
2. No. If no, please proceed to Section.4 below.

If yes,

Date of catheterization: \_\_\_\_\_ (MM/ DD /YYYY)  
Age at catheterization: \_\_\_\_\_ (MONTHS)

Primary Indication for catheterization (tick one of the below):

1. Diagnostic
2. Haemodynamic
3. Interventional

**If Diagnostic**, please complete this section

1. Outcome
  1. Not amenable to surgery or other intervention
    1. Complex and inoperable anatomy
    2. Irreversible PHT
  2. Found to be suitable candidate for surgery
  3. Found to be suitable candidate for interventional catheterization
  4. Other. Please describe. -----

2. Catheterization Complications?

1. Yes
2. No

3. If yes, (can indicate more than one)

- |                   |                                  |
|-------------------|----------------------------------|
| 1. Arrhythmia     | 4. Pulmonary hypertensive crisis |
| 2. Bleeding       | 5. Death                         |
| 3. Cardiac arrest | 6. Other/Missing                 |

**If Haemodynamic**, please complete this section

Outcome

1. Irreversible pulmonary obstructive vascular disease
2. Reversible pulmonary obstructive vascular disease
3. Other. Please describe. -----

Baseline Pulmonary vascular resistance index: \_\_\_\_\_ (xx.xx)

Post O2 administration pulmonary vascular resistance index: \_\_\_\_\_ (xx.xx)

Catheterization Complications?

1. Yes
2. No
3. Unknown/Missing

If yes, (can indicate more than one)

- |                   |                                  |
|-------------------|----------------------------------|
| 1. Arrhythmia     | 5. Pulmonary hypertensive crisis |
| 2. Bleeding       | 6. Other/Missing                 |
| 3. Cardiac arrest |                                  |
| 4. Death          |                                  |

**If Interventional**, please complete this section

Outcome

1. ASD device closure  
Successful?  
1. Yes      2. No
  
2. PDA device closure  
Successful?  
1. Yes      2. No
  
3. Aortic stenting  
Successful?  
1. Yes      2. No  
Site of stenting: \_\_\_\_\_ (text)
  
4. RVOT/branch pulmonary arteries stenting  
Successful?

1. Yes      2. No

5. Percutaneous mitral valvuloplasty  
Successful?

1. Yes      2. No

3. Initial mean gradient:                      \_\_\_\_\_ mmHg

4. Post valvuloplasty mean gradient:        \_\_\_\_\_ mmHg

6. Percutaneous mitral valvuloplasty  
Successful?

1. Yes      2. No

Initial mean gradient:                      \_\_\_\_\_ mmHg

Post valvuloplasty mean gradient:        \_\_\_\_\_ mmHg

7. Radiofrequency ablation

Successful?

1. Yes      2. No

8. Other. Pls describe: \_\_\_\_\_

Successful?

1. Yes      2. No

Catheterization Complications?

1. Yes      2. No

If yes, (can indicate more than one)

1. Arrhythmia

2. Bleeding

3. Cardiac arrest

4. Death

5. Pulmonary hypertensive crisis

6. Other/Missing

#### **4. SURGERY**

1. Yes

2. No

If no, why not?

1. Deemed inoperable

2. Advanced pulmonary obstructive vascular disease

3. Complex anatomy

4. Unknown/Missing

If no, proceed to next section.

If yes,

Date of Surgery: \_\_\_\_\_ (DD/MM/YYYY)

Type:

1. Elective

2. Emergency

3. Re-operation

If re-operation, date of previous surgery: \_\_\_\_\_ (DD/MM/YYYY)

Palliative surgery?

1. Yes
2. No

If yes,

- |                  |  |
|------------------|--|
| 1. Central shunt | 5. RMBTS                                   |
| 2. Glenn shunt   | 6. TCPC                                    |
| 3. PA banding    | 7. Other. Please describe:<br>_____ (text) |
| 4. LMBTS         |  |

Definitive surgery?

1. Yes
2. No

If yes,

- |                                   |  |
|-----------------------------------|--|
| 1. Aortic valve replacement       | 8. PDA ligation                            |
| 2. Arterial switch procedure      | 9. Ross- Konno procedure                   |
| 3. ASD repair                     | 10. TAPVD Repair                           |
| 4. AVSD repair                    | 11. Tetralogy of Fallot repair             |
| 5. Coarctation repair             | 12. VSD repair                             |
| 6. Interrupted aortic arch repair | 13. Other. Please describe<br>_____ (text) |
| 7. Mitral valve replacement       |  |

Bypass time: \_\_\_\_\_ (Minutes)

Cross-clamp time: \_\_\_\_\_ (Minutes)

Other incidental surgeries?

1. None
2. Cleft palate repair
3. Diaphragmatic hernia repair
4. Diaphragm plication
5. Percutaneous gastrostomy
6. Other. Please describe. \_\_\_\_\_ (Text)
7. Unknown/Missing

## 5. COMPLICATIONS

Primary post-operative complications

- |                            |  |
|----------------------------|--|
| 1. None                    | 8. Pleural effusion                        |
| 2. Arrhythmia              | 9. Pericardial effusion                    |
| 3. Bleeding                | 10. Pulmonary hypertensive crisis          |
| 4. Cardiac failure         | 11. Seizures                               |
| 5. Chylothorax             | 12. Other: Please describe<br>_____ (text) |
| 6. Diaphragmatic Paralysis |  |
| 7. Infection               |  |

Residual defects

- 1. Yes
- 2. No

If yes

- 1. Requiring further intervention  
Describe \_\_\_\_\_ (text)
- 2. No further intervention required  
Describe \_\_\_\_\_ (text)

## 6. DEATH

- 1. Yes
- 2. No

If yes,

- 1. Intraoperative Death
- 2. Early postoperative mortality
- 3. \*Late postoperative mortality
- 4. Unknown/Missing

Date of death: \_\_\_\_\_ (DD/MM/YYYY)

Cause of Death:

- 1. Respiratory failure
- 2. Post-operative low cardiac output syndrome
- 3. Right heart failure
- 4. Myocardial infarction
- 5. Refractory ventricular tachyarrhythmia
- 6. Traumatic pericardiocentesis
- 7. Other: \_\_\_\_\_ (text)
- 8. Missing/Unknown

## 7. INPATIENT DAYS

Number of days in PICU/ICU post-surgery: \_\_\_\_\_ (0 to XX)  
Number of days in hospital: \_\_\_\_\_ (0 to XXX)  
Date of discharge back to Windhoek: \_\_\_\_\_ (DD/MM/YYYY)

## 8. FOLLOW-UP DETAILS

\*Has patient died since returning to Namibia (late mortality)?

1. Yes

If yes,

Date of death \_\_\_\_\_ (DD/MM/YYYY)

Cause of death if known \_\_\_\_\_ (text)

2. No

If no,

Most recent follow up appointment date: \_\_\_\_\_ (DD/MM/YYYY)

Number of kept follow up appointments since intervention: \_\_\_\_\_

Number of expected follow up appointments since intervention: \_\_\_\_\_

3. Unknown, lost to follow up

Number of attempts to trace patient:

1. <5

2. >5

Details: \_\_\_\_\_ (text)

The Namibia children heart project; a 6-year  
retrospective review  
Research proposal

---

Dr Fenny Shidhika  
MBChB (UCT), FC Paed (SA)



This research is in partial fulfillment of the degree of M.Phil.

Division of Paediatric Cardiology and Critical Care  
Department of Paediatrics  
School of Child and Adolescent Health  
Faculty of Health Sciences  
UNIVERSITY OF CAPE TOWN

June 2016

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## Table of Contents

Acronyms and Abbreviations .....	57
1 Purpose of this study.....	58
2 Literature review.....	60
1.1. Background .....	60
1.2 Initiating the service.....	60
1.3. Capacity building .....	63
1.4. Paediatric Cardiac Services in Africa.....	63
3 Aims and objectives .....	66
3.1 Aims .....	66
3.2. Study objectives .....	66
4 Methods .....	67
4.1 Study design.....	67
4.2 Inclusion criteria.....	67
4.3 Exclusion criteria .....	67
5 Data sources .....	67
6 Data management and statistical analysis .....	69
7 Ethics .....	69
8 Duration of the project.....	69
9 Funding budget .....	70
10 Outputs/Dissemination of results.....	70
11 Proposed graphs/Tables .....	71
12 References.....	75

## Acronyms and Abbreviations

ARF	Acute rheumatic fever
ASAP	Awareness Surveillance Advocacy Prevention
CBMH	Chris Barnard Memorial Hospital
CCF	Congestive cardiac failure
CHD	Congenital Heart Disease
CI	Confidence interval
CRF	Case report forms
GAS	Group A Streptococcus
GDP	Gross Domestic Product
ICU	Intensive Care Unit
MDGs	Millennium Development Goals
MHSS	Ministry of Health and Social Services
NCHP	Namibia Children Heart Project
PASCAR	Pan African Society of Cardiology
PPP	Private Public Partnership
RCWMCH	Red Cross War Memorial Children's Hospital
REMEDY	The Global Rheumatic Heart Disease Registry
RHD	Rheumatic Heart Disease
RHDGen	RHD Genetic Consortium
SACH	Save a Child's Heart
UN	United Nations

WHF	World Heart Federation
WHO	World Health Organisation

## **1 Purpose of the study**

Congenital heart disease (CHD) is the most common birth defect globally and is associated with significant morbidity and mortality<sup>1,2</sup>. Rheumatic heart disease (RHD), the sequel to acute rheumatic fever (ARF) and Group A streptococcus (GAS), is the most commonly acquired heart disease in developing countries<sup>3</sup>. This combination results in a high burden of childhood heart diseases in African countries such as Namibia<sup>4</sup>.

Namibia has a vast land area of 820 km<sup>2</sup> but a relatively sparse population of just over 2.3 million people. It is categorized as an upper- middle income country with a Gross Domestic Product (GDP) approximated at USD 12,99 billion and a GDP per capita of USD 4677 as reported by the World Bank in 2014. However there is an uneven income distribution as measured by a high Gini co-efficient of 0,67, just below South Africa and Brazil<sup>5</sup>. Prior to 2009 there were no dedicated paediatric cardiac services in Namibia and every child with a cardiac condition from an indigent family dependent on state health services suffered the inevitable consequences of their heart disease. The United Nations (UN) millennium development goals (MDGs) did not include heart disease in children. Resources were focused on combating infectious diseases even though CHD is a significant contributor to under-5 mortality globally. Namibia was no exception to this unfortunate reality and children with heart disease continued to suffer neglect. A paediatric cardiac service was thus established in Namibia in 2009 with a step-wise introduction of clinical services, a catheterisation laboratory and finally a limited surgical program. Between 2009 and 2015, over 200 patients were sent to South Africa for cardiac intervention and/or surgery.

This study aims to describe the clinical characteristics of the patients referred to South Africa for further intervention, to quantify morbidity and mortality and to identify

prognostic indicators for perioperative and postoperative morbidity and mortality. Finally, we will document and describe the follow-up patterns of these patients upon return to Namibia.

## **Literature review**

### **2.1. Background**

Prior to 2010, there was no dedicated cardiac service in Namibia. Without the ability to diagnose or treat heart disease, there was a general lack of awareness about the diseases. Care was provided as part of general paediatric practice with patients (mostly with rheumatic heart disease) occasionally referred for surgery to Kenyatta National Hospital in Kenya. Surgical outcomes of this programme were poor with little effective postoperative care. A visiting cardiothoracic surgeon from South Africa, who mostly catered to the adult population, also provided sporadic services. This was a period of uncertainty for children both with congenital and acquired heart disease.

The Ministry of Health and Social Services (MHSS) inaugurated the cardiac service at Windhoek Central Hospital on 5 August 2008. Professional and technical support was provided by cardiologists and surgeons from the Department of Cardiothoracic Surgery at the University of Cape Town (Red Cross War Memorial Children's Hospital and Groote Schuur Hospital). In one week, operations were performed on nine patients with rheumatic heart disease aged 9-28 years. However, despite considerable media attention, this programme was not sustained and with no resident paediatric or adult cardiologist in the country there followed a return to the status quo of non-delivery.

### **2.2 Initiating the service**

The first paediatric cardiologist started working in Namibia as a visiting specialist with monthly visits to Windhoek Central Hospital from 2007, eventually establishing a regular consultancy service but without any associated surgical services. The Namibia Children Heart Project (NCHP) was a collective effort of a cardio-thoracic surgeon and a paediatric cardiologist to develop a paediatric cardiac service and initiate cardiac surgery. Initially this only entailed a weekly outpatient clinic at Windhoek Central Hospital (WCH) but soon after, a weekly dedicated RHD clinic was introduced. Outreach clinics were introduced at Rundu and Oshakati state hospitals. The first paediatric cardiac catheterization was performed at Windhoek Central Hospital on 18

October 2010. In 2011 limited cardiac surgery was started at the hospital for children over 20 kgs. The NCHP was facilitated by a local paediatrician and supported by local services. A Namibian businessman and philanthropist who funded surgeries for nine children at the Panorama Mediclinic in Cape Town initially provided finance. Thereafter a public-private partnership (PPP) was brokered between MHSS and the Netcare Christiaan Barnard Memorial Hospital (CBMH) in Cape Town where the surgeries were performed.

Currently, patients are screened and on appropriate merits (weight over 20 kg and non-complex disease as defined using risk stratification scores) are referred for surgery in Windhoek. The patients remaining, primarily infants, children and those with complex disease are referred to CBMH for interventions. These patients are carefully selected based on urgency, prognosis and amenability to surgery. To date, more than 200 children have been referred to CBMH in Cape Town. The number of referrals is ultimately dependent on budgetary resources and space within the busy surgical programme at CBMH. Patients are evaluated further at CBMH and a final decision made regarding suitability for surgery or intervention.



Fig 1. Map of Namibia (taken from [www.places.co.za](http://www.places.co.za).) Windhoek Central Hospital is in the most central region, whereas Rundu and Oshakati Hospitals are situated far north.

### **2.3. Capacity building**

A comprehensive paediatric cardiac service requires a breadth of clinical and nursing skills as well as cardiac anaesthetists, intensivists and technologists. An anaesthetist and a technologist were recruited in 2010. The founding members of the team also conducted teaching modules for the cardiac unit and paediatricians. One nurse received training in paediatric cardiac intensive care at Red Cross War Memorial Children's Hospital (RCWMCH). Medical officers attached to paediatric cardiology service have been taught fundamentals of RHD and CHD with one attached to RCWMCH as a medical officer for 6 months before returning to the Namibian team in late 2009. Subsequently, this medical officer completed 4 years of paediatric training and obtained a fellowship (FC Paed) from the College of Medicine of South Africa and is now a post-graduate fellow in paediatric cardiology at the RCWMCH.

Continued growth and ensuring sustainability of the service however requires several elements to be in place. These include:

- Human resource development (e.g. there is currently no dedicated paediatric intensivists or paediatric cardiac surgeon in the country)
- Robust research programmes on congenital and acquired heart diseases
- Postgraduate training programme within the country.

Currently Namibia is a key site for several international research collaborations around RHD - the global rheumatic heart disease registry (REMEDY study) <sup>6</sup>, the Africa Rheumatic Heart Disease Genetic consortium (RHDGen) and INVICTUS trials.

### **2.4. Paediatric Cardiac Services in Africa**

The prevalence of CHD is 8 - 13 per 1000 live births with Asia reporting the highest prevalence <sup>7</sup>. This variability is explained in part by genetic, socio-economic and environmental/epigenetic factors. The high prevalence of ARF/RHD compounds the burden of heart disease in children in developing countries <sup>8</sup>. There are little robust data concerning the prevalence of CHD or acquired heart disease in Namibia.

There is increasing realisation that the lack of paediatric cardiac services results in a high number of preventable deaths and significant morbidity. In industrialized



countries, the need to create and fund paediatric units is related to national need. Less well-resourced countries however, struggle to create and fund paediatric units relative and children with heart disease continue to be neglected. A panel convened by the World Health Organisation (WHO) to advise on optimal resources for paediatric cardiac services recommended that a centre should be able to perform 300-500 operations annually for populations of 2 million people. Developing countries need at least one centre per 1 million people <sup>9</sup>. Africa faces significant challenges in addressing the needs of children with cardiac lesions amenable to operations or interventions because of the lack of resources in both specialized personnel and funding <sup>10</sup>. As a result, there is premature mortality and a higher rate of late presentation, rendering these patients as inoperable or at risk of substantial post-operative morbidity and mortality<sup>11</sup>.

South Africa, Egypt and Sudan were the first three countries to perform open-heart surgeries in adult and paediatric populations and still have the largest programmes on the continent <sup>4</sup>. These are also the only three countries offering paediatric training programmes for both paediatric cardiologists and cardiac surgeons <sup>12</sup>.

Many African countries have collaborations with centres in the United States, Europe and Asia <sup>11,13,14</sup> where visits are facilitated by humanitarian non-governmental organizations. In most cases these have not resulted in the development of local sustainable services. Cardiac operations are often conducted during planned surgical visits; local teams conduct screening operations in advance of the visit<sup>15</sup>. Capacity building in the form of training is encouraged during these visits to enable the development of local sustainable programmes.

In East Africa, Tanzania has strong collaborations with India and Israel. Recently a specialized cardiac team from Israel (through the Medical Centre's "Save a Child's Heart" organization) performed more than 20 operations on children with congenital heart disease in Tanzania. Kenya has a semi-independent service for children. They have facilities with resident cardiac surgeons performing open-heart surgery. Collateral agreements are in place with the UK, India and Israel. The latter have trained the bulk of the workforce in that country. Children's Heartlink, a non-governmental organization had previously worked with Nairobi Hospital in Nairobi, Kenya <sup>16</sup>.

In West and Central Africa, Nigeria, Ghana and Ivory Coast are performing limited heart surgery with the help of visiting foreign surgeons too. Sudan has the Salam Centre for Cardiac Surgery run by the Italian humanitarian organisation “Emergency.” Procedures are performed mostly on a pro bono basis. These programmes have largely replaced the previous method of sending individual patients abroad for surgery<sup>17,18</sup>.

In Southern Africa, Zambia has a similar programme where only complex patients requiring cardiopulmonary bypass are referred to South Africa or India. A local cardiologist provides follow-up. The local Zambian team can provide non-cardiopulmonary bypass surgery and transthoracic echocardiography. South Africa boasts a self-sufficient service in certain centres but still only offers care to 60% of children needing surgery in the public sector. The Walter Sisulu Heart Foundation in South Africa previously contributed to capacity building by training surgeons from other African countries with the intent of establishing centres in their own countries<sup>19</sup>. Two Namibian and one Zambian cardiothoracic surgeons successfully completed training through this initiative. Collaborations through the Pan-African Society of Cardiology (PASCAR) are currently underway to ensure that more African surgeons and cardiologists receive training<sup>20</sup>.

In 2002 Children’s HeartLink briefly supported a programme for training critical care nurses at RCWMCH in Cape Town, South Africa. This non-governmental organization supports partner hospitals with a more sustainable development model in six non-African countries: Brazil, China, India, Malaysia, Ukraine and Vietnam. The main goal of Children’s HeartLink’s program is to build upon the foundation and strengths of any pre-existing paediatric cardiac programmes. By delivering targeted, focused support to an existing program, Children’s HeartLink accelerates the learning and development curve. However, in Sub-Saharan Africa there are very few paediatric cardiac programmes with dedicated paediatric specialists who could benefit from their current delivery model<sup>21</sup>. Children’s HeartLink is aware of the tremendous need in Africa and the organisation is currently exploring some collaborative approaches with other organisations, as well as the possibility of developing their own alternative approaches, which may enable additional assistance in this region.

The ASAP (Advocacy, Surveillance, Awareness, Prevention) programme was developed for the prevention and control of rheumatic fever and rheumatic heart disease by African experts at the “All African” meeting on RHD in 2005 <sup>22</sup>. RHD is one of the top three aetiological factors of acute heart failure in the younger population of sub-Saharan Africa <sup>23</sup>. As with CHD, there are limited data on mortality related to RHD. In one study conducted in rural Ethiopia, the mortality rate related to untreated rheumatic heart disease reached 12,5 % <sup>24</sup>. The Global Registry of Rheumatic Heart Disease (REMEDY) is a collaboration between of 12 African countries, India and Yemen including Namibia that used a hospital-based registry aimed to prospectively describe demographic and patient characteristics, prevailing treatment patterns and major outcome patterns in order to provide information to respective governments for formulating policy and guidelines for the control and treatment of RHD <sup>25</sup>.

In general, these curative and preventative efforts for children with heart disease have little governmental commitment in developing countries in Africa. Considering the substantial support from the MHSS, Namibia presents a unique model with a funded national programme and budget to the NCHP.

### **3 Aims and objectives**

#### **3.1 Aims**

This study’s four major aims are:

- 1) To describe the clinical characteristics of the patients referred from Namibia to South Africa for surgery or intervention
- 2) To quantify morbidity and mortality
- 3) To identify prognostic indicators for perioperative morbidity and mortality.
- 4) To document the follow-up patterns of these patients upon return to Namibia.

#### **3.2. Study objectives**

- To describe baseline characteristics, diagnoses, interventions and outcomes of the patients who were referred to and received cardiac services at CBMH.

- To quantify morbidity and mortality in this cohort
- To assess how the age at presentation, age at surgery and complexity/high risk stratification scores affect the overall outcome as measured by morbidity and mortality
- To describe and quantify the number of patients who were deemed inappropriate candidates for surgery at CBMH because of late presentation and/or complexity.
- To document post-intervention, follow up patterns.

## **4 Methods**

### **4.1 Study design**

This is a retrospective study of a cohort of 200 patients with congenital and acquired heart disease recruited in Namibia and referred from WCH to CBMH for surgery and/or intervention between January 2009 and December 2015.

### **4.2 Inclusion criteria**

- All patients sent to CBMH in Cape Town for cardiac interventions between 1 January 2009 and 31 December 2015.

### **4.3 Exclusion criteria**

- Patients outside the said time frame
- Patients whose surgeries were performed at WCH in Windhoek.

## **5 Data sources**

The data sources will be the patients' registries at WCH and CBMH, the cardiologist's case notes and the cardiothoracic surgeons' surgical notes. Variables to be analysed include; demographics, diagnosis, catheterization and surgery details, morbidity and mortality as well as follow up details.

A standardised data collection form capturing all relevant demographic, clinical, catheterisation and surgery details, outcomes and follow- up patterns from medical records will be used (Appendix 1).

## **6 Data management and statistical analysis**

The data collected will be captured using Microsoft excel, coded accordingly and analysed using STATA 14.0. Continuous variables will be expressed as means with standard deviations, or medians with interquartile ranges as appropriate. Categorical variables will be expressed as frequencies and percentages. Linear regression models will assess the relationship between the variables. Cox regression models will be used to assess the risk of appropriate variables with survival.

## **7 Ethics**

Ethical approval has been obtained from the Ministry of Health and Social Services (MHSS) in Namibia with a waiver of consent for this study from patients. As this is a retrospective review, we are requesting a waiver of consent from the University of Cape Town Human Ethics Committee. Patients' identities will be fully protected by assigning a Subject ID number to be used on data collection forms in lieu of the patients' names. A key linking the names to the Subject IDs will be maintained in a secure manner by the trainee investigator. Raw data will not be shared beyond the research team members.

## **8 Duration of the project**

Data collection, analysis and consolidation will take an estimated 3-6 months. We anticipate completing the project within 6-9 months.

## 9 Funding budget

An operational budget of R9100 will be required. A cost breakdown is shown in Table 1.

Table 1. Budget

Calls to Namibia to ascertain follow-up status of patients	R1000
Photocopies of surgical records	R1000
HDD 2T	R1500
Printing	R1000
Stata 14.0 license	R2500 (for student license)
Open Access Journal Fees (CVJA)	R1500
Good Clinical Practice Course (Creede)	R600

## 10 Outputs/Dissemination of results

1. This research is in partial fulfilment of the degree of M.Phil. The final publication will be submitted both for the thesis and for publication in a peer-reviewed journal.
2. Information regarding the outcomes of the study will be shared with the Namibian Ministry of Health and Social Services, Christian Barnard Hospital, Harold and Ethel Pupkewitz Heart Foundation and all local intermediate/secondary hospitals in the referral regions.
3. Outcomes of the study as an abstract will also be presented at national and international cardiology congresses.

## 11 Proposed graphs/Tables

Table 1. Demographic data

Age at presentation	
Sex	
Region in Namibia	

Table 2. Diagnosis

Primary diagnosis	
Secondary diagnosis	
Additional associations	

Table 3. Left to right shunts

Atrial septal defect	
Atrio-ventricular septal defect	
Ventricular septal defect	
Patent ductus arteriosus	

Table 4. Right ventricular outflow tract obstructions

Tetralogy of Fallot	
Double outlet right ventricle- Tetralogy of Fallot type	
Tetralogy of Fallot with pulmonary atresia	
Pulmonary stenosis	
Double chambered right ventricle	

Table 5. Left ventricular outflow tract obstructions

Coarctation of Aorta	
Interrupted aortic arch	
Subaortic stenosis	
Valvar aortic stenosis	



Table 6. Univentricular pathology

Tricuspid atresia	
Double inlet left ventricle	
Double outlet right ventricle	

Table 7. Congenital mitral valve abnormalities

Mitral stenosis	
Double orifice mitral valve	
Mitral valve prolapse	

Table 8. Additional lesions

Total anomalous pulmonary venous drainage	
Partial anomalous pulmonary venous drainage	
Atrio-ventricular discordance	
Ventriculo-arterial discordance	
Isomeric atrial appendages	
Other	

Table 9. Acquired Heart Disease

Takayasu arteritis	
Rheumatic heart disease	

Table 10. Clinical findings

Pulmonary hypertension	
Cardiac failure	
Failure to thrive	
Hypercyanosis	

Table 11. Catheterisation

Diagnostic	
Haemodynamic	
Interventional	

Table 12. Findings at diagnostic/ haemodynamic catheterisation

Irreversible PHT	
Complex and inoperable anatomy	

Table 13. Interventional catheterisation

Stent	
Pulmonary balloon valvuloplasty	
Inoue balloon mitral valve commissurotomy	
PDA device closure	
Secundum ASD device closure	
Radio-frequency (RF) ablation	

Table 14. Surgical Intervention and details

Type of surgery	
Palliative	
Full repair	

Table 15. Complications

Arrhythmia	
Bleeding	
Low cardiac output syndrome	

Table 16. Mortality and details

Intraoperative mortality	
Early postoperative mortality	
Late postoperative mortality	

Table 17. Lost to follow-up (n=)

Diagnosis	
Age	
Region	

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## **Appendum 4: Diagnosis and procedures codes**

[Thesis submission\Diagnostic and procedure codes.xlsx](#)

