Experiences of a dedicated Heart and Maternal Health Service providing multidisciplinary care to pregnant women with cardiac disease in a tertiary centre in Namibia

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Abstract

Objectives: First, to describe the implementation process, benefits and challenges of a multidisciplinary service for pregnant women with cardiac disease in Namibia. Second, to assess pregnancy outcomes in this population.

Methods: In a tertiary hospital in Namibia, a multidisciplinary service was implemented by staff of obstetric and cardiology departments and included preconception counselling, provision of antenatal care and reliable contraception. Management guidelines developed for high-income settings were used, since no locally adapted guidelines were available. A cohort study was performed to assess cardiac, obstetric and fetal outcomes. Included were pregnant women with cardiac disease, referred to this service between 1 August 2016 and 31 July 2018.

Results: Important benefits of this service were the integrated approach, improved access to reliable contraception and insight into drivers of poor outcome. Several challenges with use of available guidelines were encountered, as contextual factors specific to lower-income settings were not taken into consideration, such as higher rates of infection or barriers to access care. The cohort consisted of 65 women. Cardiac disease was diagnosed for the first time in 16 (24.6%) women, of whom 11 had pre-existing cardiac disease. These women presented more often with heart failure than women with known heart disease (75.0\% vs. 6.1\%, RR 12.5, 95\% CI 3.9–38.0). Five women died. Cardiac events occurred in twenty-two women of whom eight developed thromboembolic events and two endocarditis. The majority had no indication for prophylaxis, based on available guidelines. Fetal events occurred in 36 pregnancies. After pregnancy more than half of women (35/65, 53.8\%) were using long-acting reversible contraception.

Conclusions: Despite several barriers, it was possible to implement a multidisciplinary service in a high-burden setting. Cardiac and fetal event rates in this cohort were high. To improve outcomes the focus should be on availability of context-specific guidelines and better detection of cardiac disease.

Keywords
cardiac disease in pregnancy, cardiomyopathy, maternal mortality, Namibia, pregnancy complications, rheumatic heart disease, sub-Saharan Africa

Sustainable Development Goal: Good health and wellbeing
INTRODUCTION

Cardiac disease in pregnancy is an important contributor to maternal deaths globally. In many high-income countries, cardiac disease is now the most common cause of maternal mortality, whilst in low- and middle-income countries (LMICs) its contribution to maternal mortality is increasing [1–4].

Risk prediction tools and management guidelines have been developed for women with cardiovascular disease, who are planning pregnancy or already pregnant [5–9]. These recommendations are based mainly on findings from high-income countries, as data from LMICs are scarce [7, 8, 10]. Recommendations are, therefore, not easily applied to low- and middle-income settings due to the limited availability, accessibility and affordability of diagnostic and therapeutic resources and differences in the epidemiology and severity of underlying cardiac disease [11–14]. In LMICs, there is still a high prevalence of rheumatic heart disease (RHD), whereas congenital heart disease is the most prevalent diagnosis in high-income countries [7, 8, 10, 11, 13–15]. Furthermore, more advanced disease is seen in LMICs [12, 14, 16]. The modified World Health Organisation (mWHO) risk classification, based on the underlying cardiac diagnosis, is considered the most accurate system for maternal cardiovascular risk assessment [9, 17–20]. However, it did not perform adequately in middle-income countries, as high rates of complications were seen in pregnancies classified as low risk [12].

In Namibia, a middle-income sub-Saharan African country, cardiac disease was one of the most common causes of maternal deaths in 2012–2015 [21]. In the national referral hospital in Windhoek, the capital city, staff noted a high rate of unintended pregnancies and a high rate of complications among pregnant women with cardiac disease. However, as no data were captured, the impact of cardiac disease on maternal and fetal outcome was unclear.

To address this, a dedicated Heart and Maternal Health Service (HMH) was established by staff of the cardiology and obstetrics and gynaecology departments of Windhoek Central Hospital in 2016. The aim was to implement a multidisciplinary service for women with cardiac disease in Namibia, providing care from preconception to postpartum. A 2-year prospective cohort study was performed to assess the spectrum of cardiac disease in pregnant women referred to this dedicated service and to assess cardiac, obstetric and fetal outcomes of these pregnancies.

The focus of this article is twofold: to describe the implementation process of this service, including the encountered benefits and challenges, and to present the findings of the cohort study.

METHODS

Setting

This study was performed at Windhoek Central Hospital, the tertiary public hospital of Namibia, serving a population of 2.3 million [22]. This facility has approximately 12,000 births per annum [22]. During the study period, the number of available obstetrician-gynaecologists ranged from three to six. This was the only public health facility in the country with availability of consultant cardiologists (2), cardiothoracic surgeons (2) and cardiac technologists (2) and where transcutaneous cardiac interventions and cardiac surgeries were performed. At one regional hospital in northern Namibia (Oshakati), about 700 km from Windhoek, two cardiologists employed in the private sector provided cardiac care for patients that were referred to them.

Patients presenting to any public health facility in Namibia pay a minimum fee (about US$ 0.65) for each healthcare visit and no additional costs are incurred for diagnostics or treatments including admissions, interventions or surgeries. Those living outside Windhoek in need of elective specialist care, such as a consultation at the cardiac outpatient department or admission for surgery, were transferred from district hospitals to Windhoek by a free bus service, once per week, provided by the Ministry of Health and Social Services.

Reproductive health services, including contraceptive services, are free of charge. Most facilities had combined oral contraceptives and progestogen-only injectables routinely available. The United Nations Population Fund made a once off donation of hormonal implants and intra-uterine devices to the Ministry of Health and Social Services of Namibia in 2016 so these contraceptive devices were available at the study site and some other hospitals for the duration of the study.

Design and inclusion criteria of cohort study

For this 2-year prospective observational cohort study, all pregnant and postpartum women with cardiac disease referred to the HMH Service were included between 1 August 2016 and 31 July 2018. We included both women with cardiac disease diagnosed prior to conception, as well as those newly diagnosed during pregnancy or within 42 days postpartum.

Implementation of the Heart and Maternal Health Service

The HMH Service was a comprehensive service for women of reproductive age with cardiac disease. A multidisciplinary team provided antenatal, intrapartum and postpartum care for women with cardiac disease. Every 2 weeks this team, consisting of one or more obstetricians, cardiologist, sonographers, echocardiographers and anaesthesiologists, was available at the antenatal clinic. Guidelines on the management of cardiovascular diseases during pregnancy of the European Society of Cardiology of 2011 were adhered to, as no local or LMICs-adapted guidelines were available at that time [17]. Based on clinical condition, severity of cardiac disease and obstetric history, each woman received an individualised management plan, which outlined the frequency
of follow-up visits, obstetric ultrasounds, maternal echocardiograms and birth plan. Information on postpartum contraception was provided during antenatal visits. Women who presented with newly diagnosed cardiac disease were scheduled for the earliest available clinic day if haemodynamically stable or assessed as inpatients if haemodynamically unstable. Maternal risk was assessed using the mWHO risk classification, which stratifies maternal cardiovascular risk into four classes: class I (no increased risk of maternal mortality and no/mild increase in morbidity) up to class IV (extremely high risk, pregnancy contraindicated) [17]. Risk stratification for cardiac disease not specifically mentioned in the classification was done by a consultant cardiologist (C. Hugo-Hammam) and a physician (T. Auula) with extensive experience in cardiology.

For women with an indication for anticoagulation, the vitamin K antagonist warfarin, unfractionated and low-molecular-weight heparin were available in the public health sector. If she presented early in the first trimester, a woman using warfarin was counselled about the option to change to low-molecular-weight heparins in the first trimester. However, dose adjustment with anti-Xa monitoring was not possible. The international normalised ratio was used to manage warfarin treatment.

In Namibia, termination of pregnancy up to 26 weeks of gestational age is legally permitted for significant maternal conditions and certain fetal conditions. Because reported cardiac event rates are 19%–27% for women classified as WHO III and 40%–100% for women in mWHO IV, compared to 2.5%–5% for mWHO I and 5.7%–10.5% for mWHO II, the option of termination of pregnancy was included in the counselling for all women classified as mWHO III and advised for women classified as mWHO IV (if they presented before 26 weeks of gestation) [6].

The HMH Service followed up all women at 6 weeks and at 6 months after the end of pregnancy. On clinical indication, the follow-up period was extended up to a year. Placement of long acting reversible family planning was offered directly after birth for women who had difficulties attending follow up visits and at 6 weeks after birth for all other women. If a HMH visit was not feasible for the woman, the 6-month follow-up was done by phone. At the last follow-up visit, all women were referred to the Cardiology service.

The HMH Service also provided preconception counseling at the cardiology outpatient department. All women of childbearing age were educated about their cardiac diagnosis, peripartum risk as determined by the mWHO risk classification and reliable contraception. A specifically designed patient information leaflet was provided to the women (Appendix S1). After counselling, the woman was seen by a doctor for her cardiac follow-up and any further concerns were addressed. Women who opted for long-acting reversible contraceptives (e.g., hormonal implant or intrauterine contraceptive devices) and who had no contra-indication for these methods, could have them placed on the same day. These women were referred to the gynaecology department, as only doctors from this department had the expertise and equipment for placement of these devices. When the HMH Service was introduced, it was planned that these contraceptive devices would be placed by nursing staff of the cardiac outpatient department. This turned out to be unattainable due to an already high workload of these nurses and lack of training resources.

Due to staff shortages across all departments the integrated HMH Service ended in June 2017 and cardiac and obstetric care was continued at the respective departments. Patient assessments and management were discussed in close communication between the departments and high-risk women were discussed during multidisciplinary meetings. The provision of preconception counselling continued and long-acting reversible contraceptives could be provided on the same day at the gynaecology department.

There was no specific budget available for the HMH Service. All members of the HMH Service were employed by the Ministry of Health and Social Services and the HMH Service was part of their clinical duties. The patient information leaflet was printed by the United Nations Population Fund.

Data collection and outcome

Structured forms were developed for the HMH Service to record the women’s antenatal visits and maternal and fetal outcomes. Data collected included socio-demographic characteristics, cardiac history, obstetric history, cardiac and obstetric outcome. All women were asked whether it was a planned or unplanned pregnancy and if continuation was desired.

Primary outcomes were underlying cardiac diagnoses of women referred to the HMH Service, severity of cardiac disease, risk assessment based on mWHO classification and condition at first presentation based on the New York Heart Association (NYHA) class. Secondary outcomes were the incidences of cardiac, obstetric and fetal events. Cardiac event was defined as heart failure requiring admission or modifications in medication, thromboembolic event, new onset or exacerbated arrhythmia, endocarditis or a cardiac intervention during pregnancy or within 6 months after the end of pregnancy. Obstetric events that were documented included postpartum haemorrhage more than 1000 ml, pre-eclampsia or eclampsia as defined by WHO [23]. Fetal event was defined as miscarriage or termination of pregnancy <26 weeks of gestation, stillbirth from 26 weeks of gestation or, if the gestational age was unknown, birthweight >1000 g and documented as either fresh or macerated in the medical file, premature birth <37 weeks gestation, small-for gestational age birthweight (<10th centile), born alive with congenital anomalies or neonatal death (within 28 days after birth). Maternal death was defined as death of a woman while pregnant or within 42 days of termination of pregnancy or birth, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes [24]. Late maternal death was defined as
the death of a woman from direct or indirect causes more than 42 days but less than 1 year after the end of pregnancy [24].

The association between events and several risk factors was assessed. Risk factors were selected when listed in the guidelines of the European Society of Cardiology or identified in studies from similar settings and present in at least 10% of our cohort [6, 16, 25].

Data analysis

Data analysis consisted of frequencies of demographic and clinical variables. Data were double entered and cross checked in Epidata version 3.1 and analysed with SPSS version 26. Continuous variables are presented as means with standard deviations and differences were assessed with student t-test. Missing data regarding medical history were assumed to be ‘no’, whereas complete case analysis was used to handle missing data regarding outcome measures of the current pregnancy. Categorical variables are presented as percentages. Differences were assessed using chi-square test or Fisher’s Exact test when indicated and risk ratio (RR) and 95% confidence interval (CI) are presented. Statistical significance was assumed at a two-sided value of $p < 0.05$. All results are presented in the tables and figures and therefore not published in a separate online database. We followed the STROBE reporting guidelines.

This study was reviewed and approved by the ethics research unit of the Namibian Ministry of Health and Social Services, Reference 17/3/3 SH. Women were informed about the purpose of the cohort and verbally offered to opt out of her anonymous data being used for research purposes.

RESULTS

Sixty-five pregnancies of women with cardiac disease were included in this cohort. Table 1 summarises baseline characteristics according to mWHO classes of the included women. Thirty-six women lived in Khomas region where the study site is located, 29 were from other regions representing nearly all 14 regions of Namibia and one woman

### Table 1 Baseline characteristics of 65 pregnant women with cardiac disease referred to the HMH service

| Variables                        | Overall (N = 65) | mWHO I (N = 6) | mWHO II (N = 12) | mWHO III (N = 26) | mWHO IV (N = 21) | p-value |
|----------------------------------|-----------------|----------------|------------------|-------------------|-----------------|---------|
| Age, years                       | 30.0 ± 7.6      | 23.8 ± 6.1     | 30.2 ± 7.7       | 30.9 ± 7.3        | 30.5 ± 8.1      | 0.22    |
| Nulliparous                      | 22 (33.8)       | 4 (66.7)       | 4 (33.3)         | 8 (30.8)          | 6 (28.6)        | 0.40    |
| Married/cohabiting               | 22 (33.8)       | 1 (16.7)       | 5 (41.7)         | 9 (34.6)          | 7 (33.3)        | 0.96    |
| Attitude towards pregnancy       |                 |                |                  |                   |                 |         |
| Desired and planned              | 22 (33.8)       | 2 (33.3)       | 3 (25.0)         | 10 (38.5)         | 7 (33.3)        | 0.69    |
| Desired and unplanned            | 20 (30.8)       | 3 (50.0)       | 6 (50.0)         | 6 (23.1)          | 5 (23.8)        |         |
| Undesired                        | 22 (33.8)       | 1 (16.7)       | 3 (25.0)         | 10 (38.5)         | 8 (38.1)        |         |
| BMI, kg/m²                       | 25.3 ± 6.9      | 21.1 ± 4.6     | 28.9 ± 8.2       | 24.9 ± 7.4        | 25.1 ± 5.3      | 0.15    |
| Pre-existing hypertension        | 10 (15.4)       | 1 (16.7)       | 2 (16.7)         | 2 (7.7)           | 5 (23.8)        | 0.43    |
| HIV                              | 7 (10.8)        | 0 (0.0)        | 2 (16.7)         | 3 (11.5)          | 2 (9.5)         | 0.83    |
| Tuberculosis                     | 4 (6.2)         | 0 (0.0)        | 0 (0.0)          | 3 (11.5)          | 1 (4.8)         | 0.68    |
| Cardiac disorder                 |                 |                |                  |                   |                 | 0.02    |
| Congenital                       | 12 (18.5)       | 3 (50.0)       | 4 (33.3)         | 3 (11.5)          | 2 (9.5)         |         |
| RHD                              | 31 (47.7)       | 2 (33.3)       | 7 (58.3)         | 15 (57.7)         | 7 (33.3)        |         |
| PPCM, current pregnancy          | 5 (7.7)         | 0 (0.0)        | 0 (0.0)          | 2 (7.7)           | 3 (14.3)        |         |
| PPCM, previous pregnancy         | 9 (13.8)        | 0 (0.0)        | 0 (0.0)          | 6 (23.1)          | 3 (14.3)        |         |
| Cardiomyopathy other             | 5 (7.7)         | 0 (0.0)        | 0 (0.0)          | 0 (0.0)           | 5 (23.8)        |         |
| Arrhythmia                       | 1 (1.5)         | 0 (0.0)        | 1 (8.3)          | 0 (0.0)           | 0 (0.0)         |         |
| Mixed                            | 1 (1.5)         | 1 (16.7)       | 0 (0.0)          | 0 (0.0)           | 0 (0.0)         |         |
| Pulmonary hypertension           | 1 (1.5)         | 0 (0.0)        | 0 (0.0)          | 0 (0.0)           | 1 (4.8)         |         |
| Previous cardiac surgery         | 14 (21.5)       | 2 (33.3)       | 3 (25.0)         | 9 (34.6)          | 0 (0.0)         | 0.01    |
| Previous cardiac event           | 27 (41.5)       | 0 (0.0)        | 5 (41.7)         | 16 (61.5)         | 6 (28.6)        | 0.03    |
| NYHA III–IV at presentation      | 15 (23.1)       | 0 (0.0)        | 0 (0.0)          | 3 (11.5)          | 12 (57.1)       | <0.001  |
| Newly diagnosed heart condition  | 16 (24.6)       | 2 (33.3)       | 0 (0.0)          | 3 (11.5)          | 11 (52.4)       | 0.001   |

Note: Values are mean ± standard deviation or n (%).
Abbreviations: BMI, body mass index; HIV, human immunodeficiency virus; HMH, Heart and Maternal Health Service; mWHO, modified World Health Organisation risk classification; NYHA, New York Heart Association functional classification; PPCM, peripartum cardiomyopathy; RHD, rheumatic heart disease.
lived in Angola. Figure 1 is a map of Namibia, indicating the study site and home regions of all women included in the cohort.

Pregnancy outcomes were available for all women. Follow-up data at 6 months was not available for six women and five babies, of whom two women already had cardiac events upon presentation to HMH Service. Incidence of cardiac events was therefore calculated based on data of 61 women. Five of the women died (5/59, 8.5%).

**Cardiac history and diagnosis**

RHD was the most common cardiac diagnosis (31/65, 47.7%), followed by congenital heart disease (12/65, 18.5%), Table 1. Nine women had previous valve replacements, four were mechanical and five bioprostheses. Appendix S2 contains baseline characteristics and outcomes of all women prosthetic valves. Eight women had an indication for anticoagulation, of whom only two presented early in the first trimester.

Sixteen (24.6%) women were diagnosed with cardiac disease for the first time during the current pregnancy, referred to as ‘newly diagnosed’. Five of these women developed peripartum cardiomyopathy and the remaining women had pre-existing cardiac disease: RHD (7), congenital heart disease (2), pulmonary hypertension (1) and cardiomyopathy (1). Women with newly diagnosed cardiac disease presented in failure with NYHA III or IV more often than women diagnosed with cardiac disease prior to pregnancy (75.0% vs. 6.1%, RR 12.5, 95% CI 3.9–38.0). Women living within Khomas region were less likely to be newly diagnosed compared to women from other regions (11.1% vs. 41.4%, RR 0.3, 95% CI 0.1–0.7). Over two thirds of the cohort had a high-risk cardiac condition as 47 women (72.3%) were classified as mWHO III or IV.

**Cardiac events**

The incidence of cardiac events was high (22/61, 36.1%), and threefold higher among women with newly diagnosed cardiac conditions than women with cardiac disease diagnosed before pregnancy, (13/16 vs. 9/45, RR 4.1 95% CI 2.2–7.6).

The most common event was new onset heart failure (18/61, 29.5%). This occurred in two women in the second trimester, five in the third trimester and eleven postpartum. One woman with heart failure secondary to peripartum cardiomyopathy survived a cardiac arrest. Eight
### TABLE 2  Details of all women using anticoagulation during pregnancy

| Diagnosis          | mWHO | Age | Parity | Attitude pregnancy | Indication warfarin | GA at presentation | 1st trimester | Mode of birth | Maternal outcome | Fetal outcome |
|--------------------|------|-----|--------|--------------------|---------------------|--------------------|---------------|---------------|----------------|---------------|
| RHD, MVR           | III  | 43  | 2      | Desired and unplanned | AF                  | 12 weeks           | Warfarin 5 mg | Caesarean section | Death          | Small-for-gestational age, alive at 6 months |
| RHD, MVR           | III  | 40  | 4      | Undesired          | Mechanical valve    | 12 weeks           | None         | Termination of pregnancy | Valve thrombosis | Medical abortion at 12 weeks |
| Cardiomyopathy     | IV   | 28  | 0      | Desired and planned | Previous DVT needing thrombectomy | 8 weeks           | None         | Caesarean section | CCF           | Hydrocephalus, alive at 6 months |
| RHD, AVR           | III  | 21  | 0      | Unwanted           | Mechanical valve    | Post miscarriage  | None         | Miscarriage | No events     | Miscarriage |
| DCMO, EF 38%       | IV   | 29  | 1      | Desired and unplanned | PE prior to onset pregnancy | 29 weeks           | None         | Assisted vaginal birth | No events     | Small-for-gestational age, alive at 6 months |
| Cardiomyopathy     | IV   | 36  | 3      | Undesired | Previous stroke    | 25 weeks           | Warfarin 5 mg | Caesarean section | No events     | Preterm birth at 35 weeks due to APH, alive at 6 months |
| RHD, AVR           | III  | 20  | 0      | Desired and planned | Mechanical valve    | 8 weeks           | LMWH         | Vaginal birth | No events     | Alive, no complications |
| RHD, AVR           | III  | 37  | 2      | Undesired          | Mechanical valve, previous stroke | 23 weeks           | Warfarin 7.5 mg | Vaginal birth | No events     | Alive, no complications |

**Abbreviations:** AF, atrial fibrillation; AVR, aortic valve replacement; CCF, congestive cardiac failure; DCMO, dilated cardiomyopathy; DVT, deep venous thrombosis; EF, ejection fraction; GA, gestational age; LMWH, low-molecular-weight heparin; m WHO, modified World Health Organisation risk classification; MVR, mitral valve replacement; PE, pulmonary embolism; RHD, rheumatic heart disease.

*Warfarin was stopped by doctor in referral hospital when woman presented with pregnancy.

*Woman was started at 16 weeks of gestation due to previous DVT.

*Warfarin stopped by woman when she realised she was pregnant.

*Woman had defaulted all medication, she was restarted at presentation to our hospital.
women had a thromboembolic event (thrombus in the left ventricle [4], stroke [2], pulmonary embolism [1] and mechanical valve thrombosis [1]). One stroke and the valve thrombosis occurred in the first trimester and the remaining six thromboembolic events occurred postpartum. Five women with a thromboembolic event had no indication for anticoagulation according to guidelines that were adhered to [17]. The remaining three women had an indication for anticoagulation, which was omitted in one case and inadequately monitored in the other two cases.

### Obstetric outcomes

Anecdotally, caesarean delivery was performed in 16 (24.6%) women, in the second trimester for 13 (35.9%). Of the 16 cases, five (31.2%) women had a spontaneous miscarriage. Thirty-three (57.3%) women had received preconception counselling and 30 (51.7%) had a planned pregnancy. Regarding pregnancy outcome, three women had a spontaneous miscarriage. Four women had their pregnancy terminated as they were classified as high risk.

### Fetal outcomes

There were 57 live births of whom two were born with congenital abnormalities (clubfoot and hydrocephalus). There were four neonatal deaths (one of which were due to complications of prematurity; all born before 28 weeks of gestation) and one born at 34 weeks of gestation, died at home due to unclear cause 15 days after birth.

### Table 3: Details of maternal deaths

| Diagnosis                | Timing presentation | mWHO | NYHA | Age (years) | Parity | Attitude pregnancy | When               | Cause of death                        | Fetal outcome               |
|--------------------------|---------------------|------|------|-------------|--------|--------------------|--------------------|---------------------------------------|-----------------------------|
| RHD, severe MS           | First trimester     | IV   | IV   | 21          | 1      | Undesired          | 16 days post abortion | Stroke                  | Medical abortion                   |
| RHD, bioMVR and AF on warfarin | First trimester     | III  | I    | 43          | 2      | Desired and unplanned | 56 days postpartum | Infective endocarditis                | Small-for-gestational age, alive at 6 months |
| RHD, severe MS           | Postpartum          | IV   | IV   | 35          | 4      | Unknown            | 16 days postpartum | Newly diagnosed RHD, CCF, infective endocarditis and septic shock | Alive at 6 months         |
| PPCM                     | Postpartum          | IV   | IV   | 17          | 0      | Undesired          | 3 months postpartum | Multi-organ embolism due to left ventricular thrombus | Preterm birth, alive at 6 months     |
| PPCM                     | Postpartum          | IV   | IV   | 18          | 0      | Desired and planned | 8 months postpartum | CCF                                    | Alive at 6 months             |

**Abbreviations:** AF, atrial fibrillation; CCF, congestive cardiac failure; mWHO, modified World Health Organisation risk classification; MS, mitral valve stenosis; MVR, mitral valve replacement; NYHA, New York Heart Association classification; PPCM, peripartum cardiomyopathy; RHD, rheumatic heart disease.
FIGURE 2   Events among mWHO classes. Two women classified as mWHO III had a twin pregnancy, so for fetal outcome the denominator in mWHO III was 28.

TABLE 4   Associated factors for events

| Risk factor                               | Present (%)          | Absent (%)          | RR    | 95% CI    | p-value |
|-------------------------------------------|----------------------|---------------------|-------|-----------|---------|
| **Cardiac events**                        |                      |                     |       |           |         |
| Prior cardiac event                       | 6/26 (23.1)          | 16/35 (45.7)        | 0.5   | 0.2–1.1   | 0.07    |
| Previous surgery                          | 2/13 (15.4)          | 20/48 (41.7)        | 0.4   | 0.1–1.4   | 0.11    |
| Pulmonary hypertension                    | 9/11 (81.8)          | 13/50 (26.0)        | 3.1   | 1.8–5.4   | 0.001   |
| Warfarin                                  | 3/8 (37.5)           | 19/53 (35.8)        | 1.0   | 0.4–2.7   | 1.00    |
| NYHA III–IV at presentation               | 15/15 (100)          | 7/46 (15.2)         | 6.6   | 3.3–13.0  | <0.001  |
| mWHO III–IV                              | 22/44 (50.0)         | 0/17 (0)            |       |           | <0.001  |
| Newly diagnosed                           | 13/16 (81.3)         | 9/45 (20.0)         | 4.1   | 2.2–7.6   | <0.001  |
| Unplanned pregnancy                       | 15/40 (37.5)         | 7/21 (33.3)         | 1.1   | 0.5–2.3   | 0.75    |
| **Fetal events**                          |                      |                     |       |           |         |
| Prior cardiac event                       | 18/27 (66.7)         | 18/38 (47.4)        | 1.4   | 0.9–2.2   | 0.12    |
| Previous surgery                          | 9/14 (64.3)          | 27/51 (52.9)        | 1.2   | 0.8–1.9   | 0.45    |
| Pulmonary hypertension                    | 4/11 (36.4)          | 32/54 (59.3)        | 0.6   | 0.3–1.4   | 0.20    |
| Warfarin                                  | 5/8 (62.5)           | 31/57 (54.4)        | 1.1   | 0.6–2.1   | 0.72    |
| NYHA III–IV at presentation               | 10/15 (66.7)         | 26/50 (52.0)        | 1.3   | 0.8–2.0   | 0.32    |
| mWHO III–IV                              | 28/47 (59.6)         | 8/18 (44.4)         | 1.3   | 0.8–2.4   | 0.27    |
| Newly diagnosed                           | 8/16 (50.0)          | 28/49 (57.1)        | 0.9   | 0.5–1.5   | 0.62    |
| Unplanned pregnancy                       | 24/42 (57.1)         | 12/23 (52.2)        | 1.1   | 0.7–1.8   | 0.70    |
| **Obstetric events**                      |                      |                     |       |           |         |
| Prior cardiac event                       | 6/27 (22.2)          | 6/37 (16.2)         | 1.4   | 0.5–3.8   | 0.54    |
| Previous surgery                          | 3/14 (21.4)          | 9/50 (18.0)         | 1.2   | 0.4–3.8   | 0.72    |
| Pulmonary hypertension                    | 2/9 (18.2)           | 10/53 (18.9)        | 1.0   | 0.2–3.8   | 1.00    |
| Warfarin                                  | 0/8 (0)              | 12/56 (21.4)        |       |           | 0.33    |
| NYHA III–IV at presentation               | 5/14 (35.7)          | 7/50 (14.0)         | 2.6   | 1.0–6.8   | 0.12    |
| mWHO III–IV                              | 8/46 (17.4)          | 4/18 (22.2)         | 0.8   | 0.3–2.3   | 0.73    |
| Newly diagnosed                           | 4/15 (26.7)          | 8/49 (16.3)         | 1.6   | 0.6–4.7   | 0.45    |
| Unplanned pregnancy                       | 6/42 (14.3)          | 6/22 (27.3)         | 0.5   | 0.2–1.4   | 0.31    |

Note: The incidence of cardiac, fetal and obstetric events presented as events/risk factor present or absent. Furthermore, risk ratio and 95% confidence interval for each risk factor.

Abbreviations: CI, confidence interval; mWHO, modified World Health Organisation risk classification; NYHA, New York Heart Association classification; RR, risk ratio.
There were two twin pregnancies, one resulted in two macerated stillbirths. Born prematurely were 22 babies, six were born at less than 32 weeks’ gestation due to pre-eclampsia (2), spontaneous preterm birth (2), placental abruption (1) and bleeding placenta praevia (1). Seven babies had a low birthweight.

Risk factors and mWHO risk prediction

Figure 2 presents the cardiac, obstetric and fetal events according to mWHO classes. There were cardiac events in 71.4% of women in mWHO IV, 26.9% in mWHO III and none in mWHO I and II. There was a high rate of fetal and obstetric events in all classes. Table 4 presents known potential risk factors for adverse events. NYHA III–IV at presentation, mWHO III–IV, pulmonary hypertension and newly diagnosed cardiac diseases were associated with cardiac events, but not with obstetric or fetal events.

Postpartum contraception

After pregnancy more than half of the women (35/65, 53.8%) were using long-acting reversible contraception, the majority were implants (26). After counselling, five women opted for sterilisation. All five had an obstetric indication for caesarean section. Eight women were not on contraceptives for the following reasons: opted for a long-acting reversible contraceptive method but did not have funds to return to the hospital (4), were not sexually active (3) or wanted another child soon (1).

DISCUSSION

The HMH Service was introduced at Windhoek Central Hospital in Namibia to provide multidisciplinary care to women with cardiac disease referred to this tertiary centre. It was the first of its kind in the country and provided valuable insight into the spectrum and severity of cardiac disease in pregnant women in our setting, as well as the drivers of poor outcome. Several barriers to the provision of care were identified. In this section, we discuss these insights and barriers.

RHD, cardiomyopathies and congenital heart disease were the most frequent cardiac diagnosis in this cohort, which is similar to findings from other LMICs [26–29]. A high proportion of women had pre-existing cardiac disease that was only diagnosed in the current pregnancy, despite these women having been symptomatic in previous pregnancies. This indicates that cardiac disease is insufficiently recognised during antenatal care. This is a missed opportunity to intervene as nearly all these women presented in poor clinical condition having already developed cardiac complications. These complications may have been prevented by initiation of treatment or cardiac intervention at an earlier stage. Late diagnosis of cardiac disease is still a common problem in LMICs [13, 14, 26, 30, 31]. Our findings suggest that women and health workers need to be made aware of symptoms and signs of cardiac disease and the importance of timeous detection and management of cardiac illness. To improve diagnosis of cardiac disease and prevent complications, targeted screening programs should be implemented at healthcare service such as antenatal care or primary healthcare clinics, as recommended by the Pan-African Society of Cardiology [11]. This requires that health workers are trained and equipped to recognise, initiate management and refer women with suspected cardiac disease accordingly. In Uganda and Eritrea, countries with a similar high RHD prevalence as Namibia, screening with an echocardiogram of asymptomatic pregnant women revealed a prevalence of subclinical cardiac disease of 1.7% and 2.3% respectively, mainly RHD [28, 29].

We identified a high mortality rate of 8.5% and over a third of the women had cardiac events. Similarly high rates were identified in other LMICs such as Kenya (9.3%) and South Africa (3.7%), and much lower mortality rates were identified in high-income settings (0.3%–0.6%) [7, 10, 26, 32]. More than two thirds of the women in our cohort had high-risk conditions (mWHO III/IV), which was also the case in the Kenyan and South African cohort [26, 32]. In two large cohorts, reporting on women from mainly high-income settings, only 15.0% and 17.4% of the cases were classified as high risk [7, 10]. The difference in outcome between high-income countries and LMICs could be due to differences in availability of resources, but another explanation could be that more advanced disease is seen in middle-income settings, as diagnosis of mild cardiac disease is often missed.

Although the definition of maternal death only includes deaths within 42 days after the end of pregnancy, many women die from medical conditions, including cardiac disease, between 6 weeks and 1 year after the end of pregnancy [24, 33]. In this study, three out of five maternal deaths occurred more than 42 days after birth. In a South African cohort nine of the ten maternal deaths were late maternal deaths and in a large Canadian cohort three out of six [7, 32]. These findings indicate that a longer follow-up period and monitoring and registration of late maternal deaths are essential to obtain more accurate data on outcome and further improve care after the end of pregnancy.

Fetal outcome in our cohort was poor, but more data are needed to identify pregnancies at risk for poor fetal outcome in the Namibian setting. Similar rates of poor fetal outcome were found in other LMICs such as Uganda, Kenya and Egypt among women with cardiac disease [26–28]. Facilities that provided multidisciplinary care for pregnant women with cardiac disease reported much lower rates, suggesting that joint care could improve fetal outcome [10, 16]. The overall poor fetal outcome in this cohort could also be explained by the high rate of obstetric events, such as placenta praevia and pre-eclampsia, which caused premature birth for several women. The high rates of obstetric events...
were not reported in the other cohorts [7, 10, 26, 32]. Considering our small cohort this finding might be due to chance.

The HMH Service quantified maternal risk using the mWHO risk classification and adopted the guidelines of the European Society of Cardiology. Several challenges with its use were encountered as neither consider barriers to the provision of care to pregnant women with cardiac disease that are specific to LMICs. For example, accurate risk classification requires access to comprehensive cardiac care and echocardiography as a bare minimum, which is not uniformly available at healthcare facilities in Namibia (Figure 1) [6]. As a result, several recommendations by mWHO and guidelines of the European Society of Cardiology on the level of care or frequency of follow up visits appeared not to be appropriate or feasible in our setting. The mWHO classification has a heavy focus on congenital cardiac diseases, the most prevalent lesion in high-income settings. However, some RHD lesions are not specifically mentioned, which may make it less fit for use by doctors with limited cardiac expertise.

The guidelines of the European Society of Cardiology did not recommend routine endocarditis prophylaxis during birth and it was therefore not given to our study population [34]. However, in LMICs there are considerably higher rates of maternal infections and the Pan-African Society of Cardiology recently recommended antibiotic prophylaxis during birth for all women with RHD [11, 35]. We had two cases of infective endocarditis after birth in women with RHD and both women died.

Eight women had a thromboembolic event, of whom two died. Only less than half of these eight women had an indication for anticoagulation according to the adopted guidelines [17]. Among the women using anticoagulation, there was a high rate of cardiac and fetal events. These results reiterate that for all women with cardiac disease the need for anticoagulation should be assessed, taking into account both the risks and benefits of this treatment, as well as the possibilities and challenges of our setting.

Given all these considerations, context-specific guidelines, a risk stratification tool and referral algorithms are needed, based on local evidence and available expertise and resources in Namibia. An adaptation of mWHO, incorporating other recognised risk factors, such as NYHA status, cardiac history or medication use and taking into account the aforementioned local considerations, could form the base of a Namibian referral algorithm, such as the one implemented in a South African setting [16].

Even though almost half of the women live far from our referral centre and despite limited resources, the HMH Service was able to increase access to care for women with cardiac disease in Namibia, including improved access to long-term reliable contraception. The importance of access to preconception counselling and family planning for women with cardiac disease is recognised in many reports, as it can reduce high-risk pregnancies [6, 36]. Reported barriers are lack of integrated approach and misconceptions about side effects and contra-indications for contraceptive methods among women with cardiac disease and healthcare providers [36–39]. The HMH Service sought to address some of these barriers through the integrated approach, training of health workers and counselling of women. Access to care still needs to improve as most women presented after the first trimester, two thirds of the pregnancies were unplanned and several women had to travel long distances (some greater than 700 km) to receive long acting reversible contraception.

Due to staff shortages, the joint cardiac obstetric service was suspended after June 2017. Lack of staff is a common issue in LMICs and not easily solved [40–42]. Task shifting and sharing is a frequently used solution and could be considered [43]. In two studies performed in Uganda and Eritrea, echocardiograms were performed by nurses and medical students respectively and supervised by a cardiologist [28, 29]. The Namibian Ministry of Health and Social Services has an active programme of training health workers including specialists, nurses, technologists, pharmacists, and it is anticipated that the number of staff with special expertise will increase over the next few years. At last, findings of this study have been used for advocacy to ensure all stakeholders, including policy makers, prioritise cardiovascular health in women and commit to mobilise financial, technical and human resources.

Limitations

This study had several limitations. First, we did not include women’s perspectives in the evaluation of the HMH Service. Second, the severity of cardiac disease of this cohort may partially be a result of referral bias, as asymptomatic women or those with mild disease may have been undiagnosed or managed in district or regional hospitals. Third, there were no Namibian data available/colllected to compare the identified maternal and fetal outcomes, such as thromboembolic events or low birth weight. Considering Namibia’s high maternal and neonatal mortality rates, these rates may be high in the general pregnant population as well [44, 45]. Fourth, due to the small cohort it was not possible to perform a multivariable analysis identifying risk factors for poor outcome. Lastly, no data were collected to evaluate the impact of the provision of preconception counselling for women with cardiac disease at the cardiology outpatient department.

CONCLUSION

A collaborative approach is essential to ensure improved care of women with cardiac disease. Despite many barriers, it was possible to implement such an approach in a high burden setting like Namibia. A high rate of maternal and fetal events was identified. Important benefit of this service was insight into spectrum and severity of cardiac disease and local drivers of these poor outcomes such as late
diagnosis of pre-existing cardiac disease. To improve outcomes, studies are needed to identify effective strategies for improved diagnosis of cardiac disease, as well as for the development of context-specific guidelines for a middle-income setting like Namibia. We encourage national and regional organisations to collaborate and initiate large prospective studies to collect high quality data that will inform these interventions.

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DATA AVAILABILITY STATEMENT

Data supporting the findings are available upon reasonable request.

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