Universiteit Leiden
The Netherlands

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

Heemelaar, S.; Agapitus, N.; Akker, T. van den; Stekelenburg, J.; Mackenzie, S.; Hugo-Hamman, C.; Auala, T.

RESEARCH ARTICLE

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Steffie Heemelaar[1,2] | Ndatiyaroo Agapitus[3] | Thomas van den Akker[2,4] |
Jelle Stekelenburg[5,6] | Shonag Mackenzie[1] | Christopher Hugo-Hamman[3] |
Tangeni Auala[3]

[1]Department of Obstetrics & Gynaecology, Windhoek Central Hospital, Windhoek, Namibia

[2]Department of Obstetrics and Gynaecology, Leiden, The Netherlands

[3]Department of Cardiology, Windhoek Central Hospital, Windhoek, Namibia

[4]Athena Institute, VU University, Amsterdam, The Netherlands

[5]Department of Health Sciences, University Medical Center Groningen, Groningen, The Netherlands

[6]Department of Obstetrics and Gynaecology, Medical Center Leeuwarden, Leeuwarden, The Netherlands

Correspondence
Steffie Heemelaar, Department of Obstetrics and Gynaecology, Leiden University Medical Center, Postbus 9600, Leiden 2300 RC, The Netherlands.
Email: s.heemelaar@lumc.nl

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

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 contra-indicated) [17]. Risk stratification for cardiac disease not specifically mentioned in the classification was done by a consultant cardiologist (C. Hugo-Hamman) and a physician (T. Auala) 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 counselling at the cardiac 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.
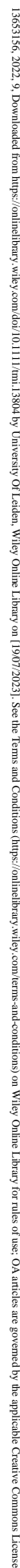
RESULTS

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						0.69
Desired and planned	22 (33.8)	2 (33.3)	3 (25.0)	10 (38.5)	7 (33.3)	
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/m^2	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)	
Arrhytmia	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.

FIGURE 1 Map of Namibia with its 14 regions. Number of live births annually, home region of women of the cohort and distribution of cardiologists are shown. One woman lived in Angola and is not indicated on the map. Distance from the district hospital in Zambezi region to the capital, which is in Khomas region, is 1227 km. LB, live births

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[a]	Termination of pregnancy	Valve thrombosis	Medical abortion at 12 weeks
Cardiomyopathy	IV	28	0	Desired and planned	Previous DVT needing thrombectomy	8 weeks	None[b]	Caesarean section	CCF	Hydrocephalus, alive at 6 months
RHD, AVR	III	21	0	Unwanted	Mechanical valve	Post miscarriage	None[c]	Miscarriage	No events	Miscarriage
DCMO, EF 38%	IV	29	1	Desired and unplanned	PE prior to onset pregnancy	29 weeks	None[d]	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; mWHO, modified World Health Organisation risk classification; MVR, mitral valve replacement; PE, pulmonary embolism; RHD, rheumatic heart disease.

[a]Warfarin was stopped by doctor in referral hospital when woman presented with pregnancy.

[b]Woman was started at 16 weeks of gestation due to previous DVT.

[c]Warfarin stopped by woman when she realised she was pregnant.

[d]Woman had defaulted all medication, she was restarted at presentation to our hospital.

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.

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. Table 2 summarises the characteristics and outcomes of women using anticoagulation during pregnancy. Three of these women developed cardiac events and there were fetal events for six of these pregnancies. Two women who had RHD developed infective endocarditis postpartum; both died.

In this cohort five women died: two had developed peripartum cardiomyopathy and three had RHD. Three of the five deaths occurred more than 42 days after the end of pregnancy. Table 3 summarises details of these five maternal deaths.

Obstetric outcomes

Antenatal care commenced in the first trimester for 16 (24.6%) women, in the second trimester for 38 (58.5%), in the third trimester for five (7.7%). Three (3.1%) women did not attend antenatal care and attendance was unknown for three women.

Of the 49 women with cardiac disease diagnosed before current pregnancy, only 30 (61.2%) women had received preconception counselling and only 15 (30.6%) 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: their mWHO classification was III (2) or IV (2). Of the 58 women who gave birth, 28 (43.1%) had a spontaneous vaginal birth and two (3.3%) women had an assisted vaginal birth. Twenty-eight women gave birth by caesarean section (43.1%). Two women had a cardiac indication for caesarean section as they were haemodynamically unstable, and all other women had an obstetric indication.

Obstetric events occurred among 12 women: postpartum haemorrhage (6), eclampsia (2), pre-eclampsia (5), of which one woman also had postpartum haemorrhage.

Fetal outcomes

There were 57 live births of whom two were born with congenital abnormalities (clubfoot and hydrocephalus). There were four neonatal deaths of which three 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.
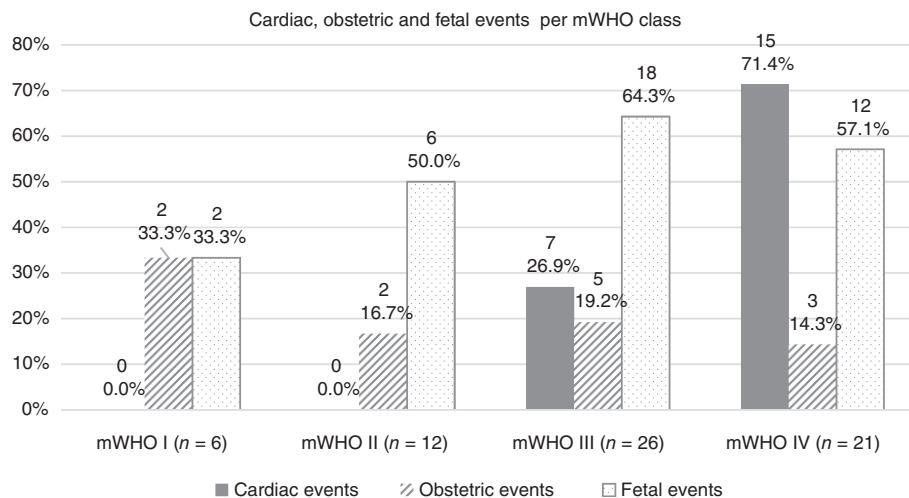
FIGURE 2 Events among mWHO classes. Two women classified as mWHO III had a twin pregnancy, so for fetal outcome the denominator in mWHO III was 28

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/collected 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.

DATA AVAILABILITY STATEMENT
Data supporting the findings are available upon reasonable request.

REFERENCES

1. Knight M, Bunch K, Tuffnell D, Jayakody H, Shakespeare J, Kotnis R, et al. Saving lives, improving mothers' care—lessons learned to inform maternity care from the UK and Ireland confidential enquiries into maternal deaths and morbidity 2014–16. Oxford: National Perinatal Epidemiology Unit. Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2018.
2. Vangen S, Bodker B, Ellingsen L, Saltvedt S, Gissler M, Geirsson RT, et al. Maternal deaths in the Nordic countries. Acta Obstet Gynecol Scand. 2017;96:1112–9.
3. Creanga AA, Syverson C, Seed K, Callaghan WM. Pregnancy-related mortality in the United States, 2011–2013. Obstet Gynecol. 2017;130: 366–73.
4. Heemelaar S, Petrus A, Knight M, van den Akker T. Maternal mortality due to cardiac disease in low- and middle-income countries. Trop Med Int Health. 2020;25:673–86.
5. Drenthen W, Boersma E, Balci A, Moons P, Roos-Hesselink JW, Mulder BJM, et al. Predictors of pregnancy complications in women with congenital heart disease. Eur Heart J. 2010;31:2124–32.
6. Regitz-Zagrosek V, Roos-Hesselink JW, Bauersachs J, Blomström-Lundqvist C, Cífková R, de Bonis M, et al. 2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy. Eur Heart J. 2018;39:3165–241.
7. Silversides CK, Grewal J, Mason J, Sermer M, Kiess M, Rychel V, et al. Pregnancy outcomes in women with heart disease: the CARPREG II Study. J Am Coll Cardiol. 2018;71:2419–30.
8. Siu SC, Sermer M, Colman JM, Alvarez AN, Mercier LA, Morton BC, et al. Prospective multicenter study of pregnancy outcomes in women with heart disease. Circulation. 2001;104:515–21.
9. Thorne S, MacGregor A, Nelson-Piercy C. Risks of contraception and pregnancy in heart disease. Heart. 2006;92:1520–5.
10. Roos-Hesselink J, Baris L, Johnson M, de Backer J, Otto C, Marelli A, et al. Pregnancy outcomes in women with cardiovascular disease: evolving trends over 10 years in the ESC Registry Of Pregnancy And Cardiac disease (ROPAC). Eur Heart J. 2019;40: 3848–55.
11. Mocumbi AO, Jamal KK, Mbakwem A, Shung-King M, Sliwa K. The Pan-African Society of Cardiology position paper on reproductive healthcare for women with rheumatic heart disease. Cardiovasc J Afr. 2018;29:394–403.
12. van Hagen IM, Boersma E, Johnson MR, Thorne SA, Parsonage WA, Escribano Subías P, et al. Global cardiac risk assessment in the Registry Of Pregnancy And Cardiac disease: results of a registry from the European Society of Cardiology. Eur J Heart Fail. 2016;18:523–33.
13. Watkins DA, Sebitloane M, Engel ME, Mayosi BM. The burden of antenatal heart disease in South Africa: a systematic review. BMC Cardiovasc Disord. 2012;12:23.
14. Zuhlke L, Engel ME, Karthikeyan G, Rangarajan S, Mackie P, Cupido B, et al. Characteristics, complications, and gaps in evidence-based interventions in rheumatic heart disease: the Global Rheumatic Heart Disease Registry (the REMEDY study). Eur Heart J. 2015;36: 1115–22a.
15. Bauersachs J, Konig T, van der Meer P, Petrie MC, Hilfiker-Kleiner D, Mbakwem A, et al. Pathophysiology, diagnosis and management of peripartum cardiomyopathy: a position statement from the Heart Failure Association of the European Society of Cardiology Study Group on peripartum cardiomyopathy. Eur J Heart Fail. 2019;21:827–43.
16. Sliwa K, Libhaber E, Elliott C, Momberg Z, Osman A, Zühlke L, et al. Spectrum of cardiac disease in maternity in a low-resource cohort in South Africa. Heart. 2014;100:1967–74.
17. European Society of Gynecology (ESG), Association for European Paediatric Cardiology (AEPC), German Society for Gender Medicine (DGesGM), Regitz-Zagrosek V, Lundqvist CB, Borghi C, et al. ESC Guidelines on the management of cardiovascular diseases during pregnancy: the Task Force on the management of cardiovascular diseases during pregnancy of the European Society of Cardiology (ESC). Eur Heart J. 2011;32:3147–97.
18. Balci A, Sollie-Szarynska KM, van der Bijl AG, Ruys TP, Mulder BJ, Roos-Hesselink JW, et al. Prospective validation and assessment of cardiovascular and offspring risk models for pregnant women with congenital heart disease. Heart. 2014;100:1373–81.
19. Lu CW, Shih JC, Chen SY, Chiu HH, Wang JK, Chen CA, et al. Comparison of 3 risk estimation methods for predicting cardiac outcomes in pregnant women with congenital heart disease. Circ J. 2015;79:1609–17.
20. Pijuan-Domenech A, Galian L, Goya M, Casellas M, Merced C, Ferreira-Gonzalez I, et al. Cardiac complications during pregnancy are better predicted with the modified WHO risk score. Int J Cardiol. 2015;195:149–54.
21. National Maternal Death, Stillbirth and Neonatal Death Review Committee. Report on the Confidential Enquiry into Maternal Deaths 1 April 2018 to 31 March 2019 and Near Miss 1 October 2018 to 31 March 2019. Windhoek: Ministry of Health and Social Services; 2020.
22. Namibia Statistics Agency. Namibia Inter-censal Demographic Survey 2016 Report (NSA Website). https://cms.my.na/assets/documents/ NIDS_2016.pdf (2017) Accessed 19 Jan 2020.
23. World Health Organisation. Managing complications in pregnancy and childbirth: a guide for midwives and doctors. Geneva: World Health Organisation; 2017.
24. World Health Organization. The WHO application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM. Geneva: World Health Organization; 2012.
25. Diao M, Kane A, Ndiaye MB, Mbaye A, Bodian M, Dia MM, et al. Pregnancy in women with heart disease in sub-Saharan Africa. Arch Cardiovasc Dis. 2011;104:370–4.
26. Lumsden R, Barasa F, Park LP, Ochieng CB, Alera JM, Millar HC, et al. High burden of cardiac disease in pregnancy at a National Referral Hospital in Western Kenya. Glob Heart. 2020;15:10.
27. Rezk M, Elkilani O, Shaheen A, Gamal A, Badr H. Maternal hemodynamic changes and predictors of poor obstetric outcome in women with rheumatic heart disease: a five-year observational study. J Matern Fetal Neonatal Med. 2018;31:1542–7.
28. Beaton A, Okello E, Scheel A, DeWyer A, Ssembatya R, Baaka O, et al. Impact of heart disease on maternal, fetal and neonatal outcomes in a low-resource setting. Heart. 2018;105:755–60.
29. Otto H, Saether SG, Banteyrga L, Haugen BO, Skjaerpe T. High prevalence of subclinical rheumatic heart disease in pregnant women in a developing country: an echocardiographic study. Echocardiography. 2011;28:1049–53.

30. Bhatla N, Lal S, Behera G, Kriplani A, Mittal S, Agarwal N, et al. Cardiac disease in pregnancy. Int J Gynaecol Obstet. 2003;82: 153–9.

31. Zuhlke L, Mirabel M, Marijon E. Congenital heart disease and rheumatic heart disease in Africa: recent advances and current priorities. Heart. 2013;99:1554–61.

32. Sliwa K, Azibani F, Baard J, Osman A, Zühlke L, Lachmann A, et al. Reducing late maternal death due to cardiovascular disease—a pragmatic pilot study. Int J Cardiol. 2018;272:70–6.

33. Nair M, Nelson-Piercy C, Knight M. Indirect maternal deaths: UK and global perspectives. Obstet Med. 2017;10:10–5.

34. Habib G, Lancellotti P, Antunes MJ, Bongiorni MG, Casalta JP, del Zotti F, et al. 2015 ESC Guidelines for the management of infective endocarditis: The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC). Endorsed by: European Association for Cardio-Thoracic Surgery (EACTS), the European Association of Nuclear Medicine (EANM). Eur Heart J. 2015;36:3075–128.

35. The WHO Global Maternal Sepsis Study (GLOSS) Research Group. Frequency and management of maternal infection in health facilities in 52 countries (GLOSS): a 1-week inception cohort study. Lancet Glob Health. 2020;8:e661–71.

36. Zuhlke L, Acquah L. Pre-conception counselling for key cardiovascular conditions in Africa: optimising pregnancy outcomes. Cardiovasc J Afr. 2016;27:79–83.

37. Chang AY, Nabbaale J, Nalubwama H, Okello E, Ssinabulya I, Longenecker CT, et al. Motivations of women in Uganda living with rheumatic heart disease: a mixed methods study of experiences in stigma, childbearing, anticoagulation, and contraception. PLoS One. 2018;13:e0194030.

38. Dawson AJ, Krastev Y, Parsonage WA, Peek M, Lust K, Sullivan EA. Experiences of women with cardiac disease in pregnancy: a systematic review and metasynthesis. BMJ Open. 2018;8: e022755.

39. Sobhani NC, Schultz H, Kheiwa A, Killion M, Parikh NI, Harris IS, et al. Contraceptive choices in the immediate postpartum period in women with cardiac disease. Am J Cardiol. 2019; 123:1364–9.

40. Koblinsky M, Moyer CA, Calvert C, Campbell J, Campbell OMR, Feigl AB, et al. Quality maternity care for every woman, everywhere: a call to action. Lancet. 2016;388:2307–20.

41. Miller S, Abalos E, Chamillard M, Ciapponi A, Colaci D, Comandé D, et al. Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide. Lancet. 2016;388:2176–92.

42. Mahlathi P, Dlamini J. Minimum data sets for human resources for health and the surgical workforce in South Africa's Health System. A rapid analysis of stock and migration. Nairobi: African Institute for Health and Leadership Development; 2015.

43. Joshi R, Alim M, Kengne AP, Jan S, Maulik PK, Peiris D, et al. Task shifting for non-communicable disease management in low and middle income countries—a systematic review. PLoS One. 2014;9:e103754.

44. Heemelaar S, Josef M, Diener Z, Chipeio M, Stekelenburg J, van den Akker T, et al. Maternal near-miss surveillance, Namibia. Bull World Health Organ. 2020;98:548–57.

45. Ministry of Health and Social Services. Demographic and Health Survey Namibia; 2013. Windhoek: Ministry of Health and Social Services; 2014.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.