

Article

Characteristics shifting of heart disease in pregnancy: A report from low middle-income country

Cyntia Puspa Pitaloka,¹ Absa Secka,¹ Ernawati Ernawati,^{2,3} Agus Sulistyono,²
Hermanto Tri Juwono,² Erry Gumilar Dachlan,² Aditiawarman²

¹Master Program of Public Health, Faculty of Public Health, Universitas Airlangga, Surabaya

²Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Airlangga, Surabaya / Dr. Soetomo General Hospital

³Department of Obstetrics and Gynaecology, Airlangga University Academic Hospital, Surabaya, Indonesia

Abstract

Background: Heart disease in pregnancy is one of the leading causes of maternal mortality and morbidity in developing countries. However, the characteristics of the disease vary between countries and regions. This study aimed to present the characteristics of pregnant women with heart disease in an economically advantageous region of a developing country.

Design and methods: A cross-sectional study was conducted using data from the Weekly Report of Obstetrics and Gynaecology Department to assess pregnant women with heart disease characteristics and pregnancy outcomes. A total sample of 69 pregnant women with heart disease regarding their gestational age was included in the study. Variables observed were maternal characteristics, heart disease's clinical parameter, and maternal and neonatal outcomes. Chi-square test was used to examine the different characteristics of congenital and acquired heart disease groups.

Results: The prevalence of cardiac disease in pregnancy was 5.19%. Fifty-three point six percent of pregnant women with heart disease were suffered from congenital heart disease (CHD), while 46.4% were acquired heart disease (AHD). Most labor methods were Cesarean delivery, and 69.6% of women experienced cardiac complications. Maternal death was reported in 8.69% of cases. Four cases were CHD complicated by pulmonary hypertension, which leads to Eisenmenger syndrome. Two other cases were AHD complicated by Peripartum Cardiomyopathies. Although statistically insignificant, complications are more common in the AHD group than CHD.

Conclusion: Cardiac disease prevalence in pregnancy is considered high, with CHD as the most common case, which significantly differs from other developing countries.

Introduction

Currently, the presence of heart disease among pregnant women is more common. In western countries, the prevalence increases from about 0.2-0.4% to 1-4% during the last few

years.^{1,2} However, data on Asia are varied and limited, ranging from 0.3-5.2%, including Indonesia.³⁻⁶

The burden caused by heart disease in pregnancy is enormous. Heart disease is the leading cause of maternal mortality in developed countries. It starts to emerge in developing ones as the number of cardiac diseases in low and middle-income countries increases.⁷ The significant difference in pregnancy with heart disease between developed and developing countries lies in access to prenatal care.⁸ While it is easier to obtain in developed countries, some developing countries still struggle in providing accessible antenatal care.⁹ Some countries, including Indonesia, do not give the minimum antenatal care recommended by the 2016 WHO ANC model.¹⁰⁻¹² Thus, the early detection of diseases may not be done, and the characteristics of the conditions may also vary.

Studies show that Rheumatic Heart Disease (RHD) is the most common heart disease detected during pregnancy in developing countries.^{8,1} The high prevalence of infection and the delay of giving antibiotic prophylaxis for Streptococcal infections is the reason behind its high burden.⁸ In contrast, congenital heart disease (CHD) is the leading cause of heart disease in pregnancy in developed countries as the advance of treatment, and perioperative care could save more babies with congenital anomalies.^{1,14,15} Thus, the number of women of reproductive age living with CHD increases. Nevertheless, those figures are not necessarily the same between regions in the countries. Studies conducted in Australia and New Zealand among the low-economy community shows that RHD is more prevalent despite their high-economy country status.¹⁶ Thus, we suggest that there could be a possibility of an increased number of CHD in developing countries in regions where the economy is better than the rest of the country.

Surabaya is the second-largest city in Indonesia with a fairly advanced technology and economy. During 2015-2017, preeclampsia/eclampsia is the leading cause of maternal mortality in Surabaya,¹⁷ inconsistent with Indonesia's general situation in which postpartum hemorrhage is the leading cause of death.¹ Understanding the different conditions Surabaya may have, in this study, we aim to examine the causes of heart disease in pregnant women and any difference in characteristics with previous studies. The second is to investigate any correlation between heart disease

Significance for public health

This study will be valuable as a reference in managing heart disease in pregnancy, particularly in a low middle-income country. Through understanding the detailed characteristics of heart disease in pregnant women, the clinicians, stakeholders, and policymakers can take the best approach to solve heart disease in their countries.

type with maternal and child outcomes. We believe that any difference in characteristics of pregnancy with heart disease will lead to different approaches in preventing its complication. Hence, we hope that our study results will provide new insight into pregnancy with heart disease in the context of a developing country.

Design and methods

This cross-sectional study was conducted in Dr. Soetomo General Academic Hospital Surabaya, the largest referral hospital in the eastern part of Indonesia. The data reported were emergency cases admitted to the delivery room from January to December 2019 from the Weekly Report of Obstetrics and Gynecology Department, Dr. Soetomo General Academic Hospital. The study population was all pregnant women with heart disease either coming alone or referred from other clinics and hospitals. Patients who were planned for conservative management were excluded. Hence, we included 69 deliveries with heart disease of a total of 1328 emergency deliveries.

The study variables were maternal characteristics, including maternal age, gravidity, number of antenatal care visits, gestational age, and referral source which has been taken by random sampling technique. The clinical parameter observed was heart disease type. Maternal and neonatal outcomes examined were the mode of delivery, cardiac complications, postpartum contraception, postpartum maternal outcomes, birth weight, and Apgar score. All data variables were extracted and collected using a case report form anonymously. We used SPSS version 20.0 software to detect the potential association between heart diseases and maternal-neonatal outcomes. Some variables are adjusted to fit with the chi-square test; *p*-values <0.05 were considered to be statistically significant.

Results

There were 69 pregnant women with heart disease out of a total of 1328 deliveries (5.19 %). The average age of pregnant women with heart disease was 29.2±6.4 years, with the lowest age being 16 years and the highest being 44 years. The average gestational age at delivery was 32.2±7.4 weeks, with the youngest was eight weeks, and the oldest was 40 weeks. Most frequent deliveries took place at 37 and 38 weeks, but most of the deliveries were preterm. Other characteristics of pregnant women can be seen in Table 1.

Table 2 shows the characteristics of heart diseases. The most common heart pathologies were CHD, with atrial septal defect (ASD) and ventricular septal defect (VSD) being the most common subtype. AHD only accounts for 46.4% of the lesion, with RHD as the leading cause, followed by hypertensive heart disease and peripartum cardiomyopathy.

The most significant delivery method was the elective caesarean section (CS) (44.9%). Seven mothers were not given contraception after deliveries. Most mothers did not experience cardiac complications, but four mothers had multiple cardiac complications. Six maternal death were recorded in this study. Of these, four cases were caused by CHD and two AHD. The CHD case includes two cases of ASD, one case of VSD, and one case of tetralogy of Fallot. In comparison, those with AHD were peripartum cardiomyopathy cases. Five of these deaths occurred during postpartum periods. Only one case was reported prior to delivery due to ASD complicated by severe pulmonary hypertension, which then falls

into Eisenmenger syndrome.

The most prominent obstetric complication was preterm delivery (34.8%). Spontaneous abortion was experienced by nine mothers, leaving only 60 infants alive after deliveries. Most of the babies (58.3%) had low birth weight, but 81.7 % of babies had an Apgar score ≥7 5 min *post-partum* (Table 3). We did not find any significant association between type of heart diseases with maternal and neonatal outcomes (Table 4).

Discussion

This study aimed to examine heart disease characteristics in pregnant women with acquired and congenital heart disease in developing countries. Our significant finding is the increasing prevalence of congenital heart disease despite developing countries' status, which will be discussed later in this study.

Compared to similar studies in Indonesia among pregnant women, heart disease prevalence in this study is considered high.^{6,1} The causes of this phenomenon could be two things. First, the high rate of pregnant women with heart disease in Dr. Soetomo General Academic Hospital was due to a tertiary hospital's status and top referral hospital in East Indonesia, which received referral

Table 1. Characteristics of pregnant women with heart disease.

Variables	n	%
Age		
<20 years old	3	4.3
20-34 years old	51	73.9
>35 years old	15	21.7
Gravidity		
Primigravida	25	36.2
Multigravida	44	63.8
Gestational age		
<32 weeks	21	30.4
32 - <37 weeks	20	29
>37 weeks	28	40.6
Antenatal care visits		
<8 times	36	47.8
>8 times	33	52.2
Source of referral		
Outpatient Clinic of Dr. Soetomo Hospital	22	36.2
Other hospitals	37	53.6
Others*	10	1.5

IUD, intra-uterine device; *referred by family obstetrician and come by herself.

Table 2. Clinical characteristics of heart disease.

Variable	n (%)	Subtype	n	%
Type of heart disease				
Congenital heart disease	37 (53.6)	TOF	4	5.8
		ASD	18	26.1
		VSD	12	17.4
		PDA	2	2.9
		Ebstein	1	1.4
Acquired heart disease	32 (46.4)	RHD	20	29.0
		Hypertensive	6	8.7
		PPCM	5	7.2
		Conduction problem	1	1.4

TOF, tetralogy of Fallot; ASD, atrial septal defect; VSD, ventricular septal defect; PDA, patent ductus arteriosus; RHD, rheumatic heart disease; PPCM, peripartum cardiomyopathy

cases from the surrounding area and eastern part of Indonesia. Recommendations from the European Society of Cardiology (ESC) states that pregnant women with high-risk heart disease must undergo treatment in a central hospital with the expertise to manage pregnancy with heart disease.¹⁴ Second, this increase was consistent with trends occurring globally. The rise in prevalence was due to an increased number of women with congenital heart defects who attain reproductive age.²

Heart disease in pregnancy is a high-risk condition and associated with an increase in maternal mortality. However, these poor outcomes can be limited if early detection and quality antenatal care can be provided.^{14,20} The 2016 WHO ANC model recommends ANC contacts at least eight times to reduce morbidity and mortality rates and enhance positive pregnancy experiences. WHO added three more contacts in the third semester to monitor high-risk pregnancy and other asymptomatic complications.¹¹ In this study, only half of the pregnant women whose number of ANC contacts adhere to WHO recommendation despite the previous finding, which correlates ANC and potential risk factors for maternal mortality.²¹ Indonesia still practices the previous Focused ANC model recommendations, stating that the number of ANC visits during pregnancy should not be less than four.²² The difference practice in Indonesia could be the results of political, logistic, infrastructural, and resources, which was acknowledged by WHO to be the problem of countries in low resource settings.¹¹

We found that the mean age and parity of pregnant women with heart disease in this study were consistent with other developing countries. Our study showed that most cases were in reproductive ages and multigravida dominated. A study in Vietnam in 2014 - 2016 showed that most pregnant women with cardiac disease were 18-44 years.⁸ Another study in Africa reported that most pregnant women with cardiac disease were <24 years old and multigravida.²³ Multigravida cases are mostly found in AHD.

The most significant finding in this study was the clinical characteristics of heart disease. As we observed in this study, CHD, instead of AHD, was the most common disorder among pregnant women. This finding is not in-line with other studies within many developing worlds, most of which have reported RHD to be the most prevalent form of heart disease in pregnancy.^{3,6,8,19} The increased prevalence of CHD in our study could result from an increasing number of successful surgical repair on CHD for the last decades, which may have potentially increased the life expectancy of women with cardiac diseases. Quality of life increases, and social interactions are basically normal in this sub-group of patients, and then pregnancy obviously becomes a relevant issue. Data from one referral hospital in Indonesia showed that surgical procedures in CHD had a high success rate with low morbidity and mortality.²⁴ Another journal revealed that successful Tetralogy of Fallot repair was more than 95 % and positively impacted pregnancy outcome.²⁵

The number of adults with CHD who reach reproduction age and become pregnant is increasing. The risk of developing complications of CHD women during pregnancy varies on the type of underlying defects and the presence of comorbidities.²⁶ In our study, ASD was the most common form of CHD, which lies in line with the literature. Generally, ASD during pregnancy is well-tolerated, but hemodynamic changes during pregnancy may increase mortality and morbidity risk. Moreover, although both repaired and unrepaired ASD are well-tolerated, the repaired one has better pregnancy outcomes.²⁷ Among our CHD patients, two maternal mortality had unrepaired ASD as their underlying heart disease, which falls into Eisenmenger syndrome. This condition could indicate the importance of heart disease screening during pregnancy to

detect pulmonary arterial hypertension and manage it before the condition worsens.

The most optimal mode of delivery in women with heart disease is debatable since each method has its advantage and disadvantage.^{8,28} In the ESC guidelines, vaginal delivery is generally preferred, but CS rates in women with heart disease are usually

Table 3. Maternal and neonatal outcomes.

Variables	n	%
Mode of delivery		
Elective caesarean section	31	44.9
Emergency caesarean section	13	18.8
Vaginal birth	25	36.2
Postpartum contraception		
Without contraception	7	10.1
IUD	23	33.3
Permanent	39	56.5
Maternal cardiac complications		
Without cardiac complications	43	62.3
Eisenmenger syndrome	5	7.2
Lung edema	5	7.2
Heart failure	6	8.7
Arrhythmia	5	7.2
Cardiac arrest	1	1.4
More than one complication	4	5.8
Obstetric complications		
Without obstetric complications	19	27.5
Abortion	9	13.0
Preterm delivery	24	34.8
Severe preeclampsia	3	4.3
Premature rupture of the membrane	3	4.3
Gestational diabetes mellitus	2	2.9
Placenta previa	1	1.4
More than one complication	8	11.6
Postpartum maternal outcomes		
Alive	63	91.3
Death	6	8.7
Birth weight*		
Low birth weight	35	58.3
Normal weight	25	41.7
5 Minutes Apgar score*		
>7	49	81.7
<7	11	18.3

IUD, intra-uterine device; *Only count for 60 neonates.

Table 4. Maternal and neonatal outcomes related type of heart diseases.

Variables	Congenital (37)	Acquired (32)	p
Mode of delivery			
Caesarean section	19	12	0.375
Emergency caesarean section	5	8	
Vaginal birth	13	12	
Maternal cardiac complications	11	15	0.143
Maternal obstetric complications	25	25	0.328
Maternal death	4	2	0.503
Birth weight*			
Low birth weight	22	13	0.148
Normal weight	11	14	
5 minutes Apgar score*			
>7	28	21	0.520
<7	5	6	

*Only count for 60 neonates.

more remarkable than the average population.²⁸ In this study, elective and emergency CS is more prevalent in the congenital than acquired groups, but there is no statistical difference. In both groups, CS is more prevalent than vaginal birth. The high prevalence of cardiac complications in this study could explain this condition, with CS aimed to perform a safer delivery method for mothers and babies.

The puerperium is a golden opportunity to provide various contraceptive choices for women to lower an unexpected pregnancy risk. It also provides a window for recovery from a previous pregnancy, especially in Peripartum Cardiomyopathy²⁹. Our findings indicate that some women in this study did not choose modern contraception methods to prevent unplanned pregnancy. This is a concern as it can be detrimental to their health if they have an unplanned pregnancy. Women with congenital heart disease should know if their offspring are at increased CHD risk. Thereby preconception counseling, family planning, and contraception play an essential role.

The rates of cardiac complications among women with heart disease in this study are higher than in the literature. It showed around 37.7% cardiac complications compared to 16% of other study complications.^{30,31} In this study, CHD patients had a higher cardiac complication rate than AHD patients. Heart failure was the most cardiac complication recorded, followed by lung edema, Eisenmenger syndrome, and arrhythmia, respectively. This study also showed that maternal death recorded were higher in the CHD group, although statistically insignificant. Undiagnosed heart disease, delay in management, and unrepaired congenital heart disease could lead to complications and worsen maternal outcomes.³² Thus, early diagnosis of the newborn's asymptomatic congenital heart disease will significantly benefit this condition.

More than 50% of our patients were experiencing obstetric complications. As reported in many studies, preterm delivery was the most common obstetric complication recorded.^{23,33} Many studies revealed that preterm delivery on cardiac disease in pregnancy could be explained in two ways, spontaneous and indicated preterm delivery. Furthermore, spontaneous is higher than indicated preterm delivery.³⁴ This present study showed the same result. The spontaneous and indicated preterm delivery ratio was approximately 0.4 (10/24 cases). The worsening maternal condition was the most common reason for delivery indication.

CHD is the most frequent underlying maternal heart disease in the Western world. Our study showed the same situation that four of our maternal death indicated cardiogenic shock secondary to pulmonary hypertension and Eisenmenger syndrome in CHD cases. Pregnant women with Eisenmenger syndrome from emerging countries and uncorrected congenital heart disease are reported to have a high risk of maternal mortality.³² Due to insufficient adaptation of the right ventricle to increase cardiac output, pulmonary hypertension is poorly tolerated during pregnancy. This condition can be pushed into failure by increased cardiac output and potential intravascular volume injections during labor. Shifting of postpartum intravascular volume resulting from hemorrhage or diuresis is poorly tolerated. Most of our maternal death reported was on the peripartum period, a period known as the most significant risk, and most deaths occur between 2 and 9 days *post-partum*. Pre-pregnancy evaluation in women with these conditions may influence pre-pregnancy advice and management, while current guidelines still advise against pregnancy in women with pulmonary hypertension because of high maternal mortality and morbidity rates. This is a big problem in our setting because of some delay in heart disease detection and inadequate antenatal visit.⁶ Good antenatal care management, early detection of cardiac dis-

ease in pregnancy, early referral to specialist centers where appropriate, and multidisciplinary expertise should be involved in the pregnancy management system.

We acknowledged that the short data range due to the cross-sectional study was our study's limitation. There was no information regarding the time of heart disease diagnosis; hence, it was no data about the time of onset of heart disease. In this regard, data from this study also did not provide information on whether pregnant women with a history of heart disease had previously received counseling about the risk of getting pregnant with heart disease. To our knowledge, this is the first epidemiological study that reveals CHD as the leading cause of cardiac disease in pregnancy in a developing country. Therefore, further research should be considered.

Conclusion

Cardiac disease prevalence in pregnancy is considered high, with CHD as the most common case, showing a significant difference compared to other developing countries. Cardiac and maternal complications are more common in the AHD group than CHD, and maternal death is more common in CHD than AHD, but the results are statistically insignificant.

Correspondence: Ernawati, Department of Obstetrics and Gynaecology, Faculty of Medicine, Universitas Airlangga/ Dr. Soetomo General Hospital. Jl. Mayjen Prof. Dr. Moestopo No.47, Surabaya East Java, Indonesia 60132.
E-mail: ernawati@fk.unair.ac.id

Key words: heart disease; pregnancy; developing countries; pregnancy complications.

Acknowledgments: The authors would like to thank all staffs at Department of Obstetrics and Gynecology Dr. Soetomo General Academic Hospital staff and Dr. Soetomo Surabaya's ethics committees.

Contributions: CPP, AS, study design, analysis and interpretation of data, manuscript writing; CPP, data collection; EE, manuscript writing, critical revision for intellectual content, and final approval.

Conflict of interest: The authors declare no potential conflict of interests.

Ethical approval: The study has been reviewed by the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital and received an exempt review as defined by federal regulation 45 CFR 46 with number 0130/LOE/301.4.2/X/2020.

Received for publication: 25 January 2021.

Accepted for publication: 13 May 2021.

©Copyright: the Author(s), 2021

Licensee PAGEPress, Italy

Journal of Public Health Research 2021;10:2137

doi:10.4081/jphr.2021.2137

This work is licensed under a Creative Commons Attribution NonCommercial 4.0 License (CC BY-NC 4.0).

References

- Regitz-Zagrosek V, Blomstrom Lundqvist C, 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.
- Elkayam U, Goland S, Pieper PG, Silversides CK. High-risk cardiac disease in pregnancy: part I. *J Am Coll Cardiol* 2016;68:396–410.
- Chhetri S, Shrestha NR, Pilgrim T. Pregnancy complicated by heart disease in Nepal. *Heart Asia* 2014;6:26–9.
- Özlem Bozkaya V, Kaplan ZAO, Özgü E, Engin-Üstün Y. Screening and evaluation of newly diagnosed cardiovascular diseases in first-trimester asymptomatic pregnant women in a tertiary antenatal care center in Turkey. *Anatol J Cardiol* 2020;23:99–104.
- Yang L, Yamamoto-Hanada K, Ishitsuka K, et al. Medical and surgical complications in pregnancy and obstetric labour complications in the Japan Environment and Children's Study (JECS) cohort: a birth cohort study. *J Obstet Gynaecol* 2020;40:918–24.
- Muninggar L, Yusuf M, Prasetyo B. Maternal mortality risk factor in pregnancy with heart disease at Dr. Soetomo General Hospital, Surabaya, Indonesia. *Majalah Obstetri dan Ginekologi* 2019; 27:17–23.
- Mocumbi A, Sliwa K, Soma-Pillay P. Medical disease as a cause of maternal mortality: the pre-imminence of cardiovascular pathology. *Cardiovasc J Afr* 2016;27:84–8.
- Nguyen Manh T, Bui Van N, Le Thi H, et al. Pregnancy with heart disease: Maternal outcomes and risk factors for fetal growth restriction. *Int J Environ Res Public Health* 2019;16:2075.
- Moller A-B, Petzold M, Chou D, Say L. Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. *The Lancet Global Health* 2017;5:e977–83.
- Laksono AD, Rukmini R, Wulandari RD. Regional disparities in antenatal care utilization in Indonesia. *PLOS One* 2020;15:e0224006.
- World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. 2016. Available from: <https://apps.who.int/iris/bitstream/handle/10665/250796/9789241549912-eng.pdf?sequence=1>
- Benova L, Tunçalp Ö, Moran AC, Campbell OMR. Not just a number: examining coverage and content of antenatal care in low-income and middle-income countries. *BMJ Global Health* 2018;3:e000779.
- French Katharine A., Poppas Athena. Rheumatic heart disease in pregnancy. *Circulation* 2018;137:817–9.
- Regitz-Zagrosek V, Roos-Hesselink JW, Bauersachs J, et al. 2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy. *Eur Heart J* 2018;39:3165–241.
- Cauldwell M, Gatzoulis M, Steer P. Congenital heart disease and pregnancy: A contemporary approach to counselling, pre-pregnancy investigations and the impact of pregnancy on heart function. *Obstet Med* 2017;10:53–7.
- Sullivan EA, Vaughan G, Li Z, et al. The high prevalence and impact of rheumatic heart disease in pregnancy in First Nations populations in a high-income setting: a prospective cohort study. *BJOG* 2020;127:47–56.
- Rochmatin H. [Determinants of Maternal Mortality in the City of Surabaya in 2015-2017]. [Article in Indonesian]. *JBK* 2019;7:178.
- Soedarmono YSM. The Indonesian approach to reduce maternal mortality. *ISBT Sci Ser* 2017;12:272–80.
- Warsita IGN, Negara KS, Wiradnyana AAGP, Aryana MBD. [Characteristics of pregnant patients with heart disease at Sanglah General Hospital Denpasar]. [Article in Indonesian]. *Medicina* 2019;50.
- Iftikhar SF, Biswas M. Cardiac disease in pregnancy. *StatPearls* [Internet]: Treasure Island; 2020.
- Diana S, Wahyuni CU, Prasetyo B. Maternal complications and risk factors for mortality. *J Public Health Res* 2020;9:1842.
- Ministry of Health Republic of Indonesia. Indonesia Health Profile 2018. Accessed: 2020 Jul 24. Jakarta: Ministry of Health Republic of Indonesia; 2019. Available from: https://pusdatin.kemkes.go.id/resources/download/pusdatin/profil-kesehatan-indonesia/PROFIL_KESEHATAN_2018_1.pdf
- Nqayana T, Moodley J, Naidoo D. Cardiac disease in pregnancy. *Cardiovasc J Afr* 2008;19:145–51.
- Kurniawaty J, Widyastuti Y. Outcome of adult congenital heart disease patients undergoing cardiac surgery: clinical experience of dr. Sardjito hospital. *BMC Proceedings* 2019;13:16.
- Pedersen LM, Pedersen TAL, Ravn HB, Hjortdal VE. Outcomes of pregnancy in women with tetralogy of Fallot. *Cardiol Young* 2008;18:423–9.
- Greutmann M, Pieper PG. Pregnancy in women with congenital heart disease. *Eur Heart J* 2015;36:2491–9.
- Bredy C, Mongeon F-P, Leduc L, et al. Pregnancy in adults with repaired/unrepaired atrial septal defect. *J Thorac Dis* 2018;10:S2945–52.
- Petrus AHJ, Jongert BL, Kiès P, et al. Evaluation of mode of birth in pregnant women with heart disease. *Eur J Obstet Gynecol Reprod Biol* 2020;248:150–5.
- Ashrafi R, Curtis SL. Heart disease and pregnancy. *Cardiol Ther* 2017;6:157–73.
- Owens A, Yang J, Nie L, et al. Neonatal and maternal outcomes in pregnant women with cardiac disease. *J Am Heart Assoc* 2018;7:e009395.
- Silversides CK, Grewal J, Mason J, et al. Pregnancy outcomes in women with heart disease: The CARPREG II Study. *J Am Coll Cardiol* 2018;71:2419–30.
- Sliwa K, Baris L, Sinning C, et al. Pregnant women with uncorrected congenital heart disease. *JACC: Heart Fail* 2020;8:100–10.
- Goya M, Casellas M, Merced C, et al. Predictors of obstetric complications in women with heart disease. *J Matern Fetal Neonatal Med* 2016;29:2306-11.
- Makino Y, Matsuda Y, Mitani M, et al. Risk factors associated with preterm delivery in women with cardiac disease. *J Cardiol* 2012;59:291–8.