Review

ANNALS OF MEDICINE & SURGERY

OPEN

Current status and future of cardio-obstetrics-review

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Abstract

Cardio-obstetrics refers to an approach to maternal care that is based upon teamwork with specialists from maternal-foetal medicine, cardiology, anaesthesiology, neonatology, nursing, social work, and pharmacy that work together to achieve appropriate outcomes for the pregnant patient. The aim of this paper is to highlight and provide a narrative review on the currently published research on the current status and future of cardio-obstetrics. A short review on the hemodynamic physiology in pregnancy has also been described in this paper. The authors have discussed the major risk factors associated with exacerbation of pregnancy and the possible remedies that are currently available in this paper in accordance to the updated research. The cardio-obstetrics team provides advice about healthy pregnancy planning before conception. Proper cardio-obstetric care is associated with better outcomes in women with a high cardiovascular risk with decreased adverse maternal and foetal outcomes. Such care should be given to underserved and marginalized communities with great care as they have largely lacked such care in the past. The authors conclude the paper by recommendations to advance this newly emerging field by way of further scientific research and public awareness. This review can serve helpful to any physician working in the healthcare as well as the public that are interested in awareness about the multidisciplinary needs of pregnant women with cardiovascular disease.

Keywords: Cardiology, cardiovascular diseases, delivery of healthcare, female, humans, obstetrics, pregnancy, pregnant women

Introduction

Cardio-obstetrics refers to an approach to maternal care that is based upon teamwork with specialists from maternal-foetal medicine, cardiology, anaesthesiology, neonatology, nursing, social work, and pharmacy wore together to achieve appropriate outcomes for the pregnant patient[1]. A cardio-obstetrics care team is dedicated to caring for this cohort of patients. This is similar to multidisciplinary teams of providers for advanced and chronic diseases with high morbidity like advanced heart failure and transplant cardiology, oncologic cardiology and valvular cardiology. The main focus of this team is to focus on patient's progress throughout pregnancy as well as have a detailed plan for safe delivery with no complications in the ideal sense.

HIGHLIGHTS

- Cardio-obstetrics refers to an approach to maternal care that is based upon teamwork of different specialists.
- The aim of this paper is to provide a narrative review on the current status and future of cardio-obstetrics. A short review on the hemodynamic physiology in pregnancy has also been described in this paper.
- Cardio-obstetrics is a newly emerging field.
- Public awareness and further research is required to advance this field.

The team also provides advice about healthy pregnancy planning before conception. The team also gives advice women with cardiovascular (CV) disease about the complication recurrence is they experienced any complications during past pregnancies. It is though that such planning allows patients as well as providers to be part of a shared decision-making regarding conception planning and future pregnancies[2]. A study by Magun *et al*[3]. Highlights that proper cardio-obstetric care is associated with better outcomes in women with a high CV risk with decreased adverse maternal and foetal outcomes. This effect is even more pronounced in underserved populations where the study derived its study cohort[3]. According to a recent study by Creanga *et al*[4]. Cardiovascular disease takes the lead in being the top cause of mortality in pregnancies. Worldwide trends in maternal mortality have been on a steady decline in the recent decades, but cardiovascular disease (CVD) is on the rise and has a detrimental effect on maternal mortality, be it directly or in an indirect fashion due to increase in risk factors[5].

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Annals of Medicine & Surgery (2023) 85:2774–2780

Received 14 February 2023; Accepted 24 April 2023

Published online 3 May 2023

http://dx.doi.org/10.1097/MS9.0000000000000773

The most concerning part is not just the rising trend seen in CV-disease-related deaths in pregnancy but that the deaths are mainly caused by factors which can be easily prevented were the preventive strategies implemented in the first place[6]. The duration of pregnancy is an especially stressful time for maternal physiology as it has to undergo tremendously challenging modifications to help in growth, nourishment and birth of the baby. The aim of this paper is to highlight and provide a comprehensive review of the currently published research on the current status and future of cardio-obstetrics. All patient's CV hazard is thoroughly reviewed by the cardio-obstetric specialists, who also keep an eye on any pre-existing heart issues and spot and address any CV abnormalities that may happen during pregnancy or postpartum. Cardiologists and specialists in maternal-foetal care, foetal treatment, and maternal and foetal outcomes collaborate at Johns Hopkins to promote pregnant CV health. Our paper is unique in the sense that it attempts to address the entire gamut of cardio-obstetrics in a concise fashion. This article provides an overview of cardio-obstetrics and its role in managing CVD in pregnant women. It discusses the differences between vaginal delivery and caesarean section for women with CVD and their respective maternal and foetal outcomes. The article also addresses the impact of chronic hypertension, diabetes, hyperlipidemia, maternal obesity, and smoking on maternal and foetal outcomes during pregnancy, as well as the potential management strategies for these conditions. It emphasizes the importance of preconception counselling and early CV follow-upto mitigate these risks. In terms of the article's structure, it begins by defining cardio-obstetrics and its purpose. The challenges associated with managing CVD in pregnant women and how cardio-obstetrics can help overcome these challenges are also discussed. The article then delves into a comparison of delivery methods and their impact on maternal and foetal outcomes.

Finally, the article concludes by emphasizing the need for trained physicians with a special focus on cardio-obstetrics to provide exceptional CV care to pregnant women. Overall, the article provides a comprehensive overview of the challenges faced in managing CVD in pregnant women and the importance of cardio-obstetrics in addressing these challenges.

Methods

A comprehensive examination of the literature was conducted to uncover all reports in the English language found in the literature databases of PubMed, Scopus, and Google Scholar from January of 2019 to February 2023. The use of search terms, such as "pre-eclampsia," "gestational hypertension," "hypertension during pregnancy," "hypertensive disorders of pregnancy," "cardio-obstetrics," "heart teams," "CV health," and "CVD," was employed in this examination. Abstracts of oral communications and posters presented at congresses were excluded, even if accessible through Medline, and the bibliographies of the selected papers were thoroughly analyzed in order to further locate pertinent studies. The full text of the published papers was then analyzed to extract the relevant data.

Review

Every organ in the body has to undergo stress during this time with the heart being one of them. It has been estimated that the amount of blood (stroke volume) the heart has to push through during pregnancy is up to 50% more than it pushes under non-pregnant physiologic conditions which compels the heart to work harder. Such circumstances almost invariably have residual effects on the maternal body postpartum. Women who already had significant CV risk factors before pregnancy do not easily battle this stress and experience a worsening of their risk factors making them more prone to CV mortality in the future[7–9]. Over the recent years, there is a trend for women to become pregnant later in life. On top of that, traditional CV risk factors such as smoking, hypertension, obesity and diabetes mellitus are on the rise further intensifying risk of maternal mortality[10,11].

Cardiac output increasing during pregnancy by multiple mechanisms. Plasma volume expands by upto 50% during pregnancy. During labour, cardiac output further jumps up by upto 50% due to anxiety, pain of labour and constant pumping action of uterine contraction pushing blood to mother's vasculature. The vena cava compression which is present through pregnancy, most significantly during the third trimester also experiences decompression after birth further increasing the cardiac output. This increases the volume of blood circulated in the mother's vascular system by approximately half a liter. All these changes in hemodynamics including changes in systemic vascular resistance and blood pressure promote a state in which there is increased cardiac output in the maternal physiology[12–14].

Pregnant patients who suffer from a pre-existing CVD experience multiple complications during pregnancy. The most common complication due to pregnancy in these patients is arrythmia. This is followed by heart failure and thromboembolic events[15]. The placenta is a vital connection between the maternal and foetal circulatory systems. Its primary function is to transfer oxygen and nutrients from the mother to the developing foetus while also removing metabolic wastes and carbon dioxide from the foetus through the umbilical cord's blood vessels. The umbilical cord, which attaches to the foetus, is formed from the placenta. Oxygen-rich blood from the mother's placenta flows through the umbilical vein, which partly enters the foetal hepatic circulation and mostly goes into the inferior vena cava. This path bypasses the liver through the ductus venosus, resulting in an estimated oxygen saturation level of 70–80%[16]. Uteroplacental blood flow is crucial for foetal development and maternal well-being. As pregnancy progresses, hormonal regulation and remodelling of spiral arteries contribute to uterine vascular adaptation. In pre-eclampsia, dysfunction of the uteroplacental vasculature due to hormonal imbalance, proinflammatory cytokines, and autoantibodies leads to decreased blood flow and increased vascular resistance. The maternal CV status can have a significant impact on uteroplacental blood flow, which in turn affects foetal oxygenation and nutrient supply, ultimately influencing foetal circulation[17]. The effects of maternal CVD on foetal circulation have been studied extensively in the literature. In addition to the references above, other studies have found that maternal pulmonary hypertension is associated with increased foetal mortality and morbidity[18], while maternal heart failure can lead to foetal distress and preterm birth[19]. Maternal hypertension has been shown to cause decreased foetal aortic blood flow, which has been linked to an increased risk of foetal growth restriction and neonatal morbidity and mortality[20]. By comprehending the natural alterations in the CV system during pregnancy and recognizing the diverse issues that can arise with

cardiac diseases, doctors can personalize the patient's medical treatment to maximize monitoring of her pregnancy and plan for the anticipated delivery method and timing. This knowledge also allows for the possibility of transferring high-risk patients to a medical facility that can offer essential cardiac care, CV surgery, and care for the newborn[21].

Pregnant women with congenital heart disease face significant rates of maternal cardiac and neonatal complications. Those who have impaired sub-pulmonary ventricular systolic function and-/or severe pulmonary regurgitation are at even higher risk for adverse cardiac outcomes. It is important to closely monitor and provide specialized care for these patients to reduce the risk of complications during pregnancy and childbirth[22]. Recent progress in paediatric cardiology and cardiac surgery has made it possible for a growing number of women with congenital heart disease to enjoy better health and successfully bear children. While it is uncommon to hear of maternal fatalities in pregnant women with congenital heart disease, this vulnerable population still requires careful monitoring and specialized care throughout their pregnancy to ensure a safe and successful delivery[23,24]. Maternal CVD can adversely affect foetal circulation in a number of ways. For example, hypertension in pregnancy can reduce uteroplacental blood flow, which in turn can lead to foetal growth restriction, intrauterine foetal death, and premature birth[25]. Cardiac arrhythmias can cause variations in foetal heart rate and rhythm[26], while valvular heart disease can lead to impaired cardiac output, reduced uteroplacental blood flow, and foetal hypoxaemia[27].

In a study by Ruys *et al*[28]. The Registry Of Pregnancy And Cardiac disease (ROPAC) cohort was used to comment on maternal and foetal benefits of caesarean section. Authors reported that planned caesarean delivery not only lacked maternal benefit but on the contrary proved detrimental to foetal outcomes resulting in low birthweight as well as decreased gestational age of infants born to mothers with CV disease[28]. This is one of the reasons vaginal deliveries is preferred in these select cases. Vaginal delivery has decreased risk of bleeding, developing an infection and events of thromboembolism compared to caesarean delivery[29].

To prevent further CV deterioration, the American College of Gynecology (ACOG) recommends that women who have CVD have an appointment with either a primary care physician or a cardiologist no later than a week or two after they give birth[30].

Women who suffer from chronic hypertension before pregnancy tend to have poor maternal and foetal outcomes. In a study by Bateman *et al*[31]. Women who had chronic hypertension had increased risk of pre-eclampsia, pulmonary oedema, poor foetal growth and still birth. Another meta-analysis revealed that pregnant women with chronic hypertension had a high risk of preterm delivery and neonatal admission. Women who suffer from chronic hypertension have different treatment blood pressure targets that are more liberal than the pre-pregnancy conservative blood pressure values. This is due to the fear that highly aggressive blood pressure control may further decrease placental perfusion leading to poor outcomes. It is recommended to stop using all angiotensin-converting enzyme inhibitors and angiotensin receptor blockers at least a month before conception. Beta blockers are safe to use drugs during pregnancy[32,33]. Melchiorre, *et al*[34] state that an increased risk of CVDs in later life has been linked to Hypertensive Disorders of Pregnancy (HDP). This correlation is not unexpected, as research has indicated that women with pulmonary embolism exhibit signs of cardiac dysfunction, ventricular hypertrophy, and evidence of localized myocardial ischaemia and fibrosis based on indirect echocardiographic findings. The CV changes, which have been found to have strong prognostic significance for future CV morbidity and mortality in non-pregnant individuals, do not fully revert to their original state even 1 year after giving birth. The correlation is even stronger in the case of severe or early-onset HDP, the presence of foetal growth disorders, the requirement for preterm delivery, and repeated HDP. Confounders such as family history of CVDs, high body mass index, hypertension, diabetes, and dyslipidemia can reduce, but not eliminate, this relationship. The exact mechanisms behind this excess CV morbidity and mortality in women who experienced pulmonary embolism and gestational hypertension in pregnancy are not yet fully understood, but a combination of pre-pregnancy predisposition to increased CV risk and the direct impact of pregnancy on the CV system may be involved. Despite the lack of guidelines regarding the timing and extent of CV follow-up and preventive strategies after HDP, it is advisable for screening to commence as early as 1 year after delivery and to include informing women of their increased future CV risk, as well as promoting lifestyle modifications such as weight control, quitting smoking, adopting a healthy diet, and engaging in daily exercise. Further studies are necessary to address the issue of structured screening for CVD and the impact of timely preventive interventions in enhancing CV health in this demographic of young women[34]. Infants who are born to diabetic mothers are at an increased risk of developing diabetes further in life. Pregnancy also intensifies diabetic kidney and retinal disease in diabetic mothers. Women with diabetic nephropathy and retinopathy also suffer from an increased risk of symptomatic acute myocardial infarctions throughout the course of their pregnancy, hence diabetes proves detrimental to both the mother and the infant[33,35]. Tight glycated haemoglobin levels of less than 6.5% are associated with the lowest incidence of congenital and foetal outcomes during pregnancy[33]. All plasma lipids tend to increase in quantity during pregnancy but this increase is postulated to be non-detrimental. The detrimental effects of hyperlipidemia are most evident on the foetus and leads to premature birth and low birthweight, which in turn proves to be a risk factor for atherogenesis as the age of the child increases further in life. Maternal obesity and weight gain out of the normal limits has a positive association with pre-eclampsia and gestational diabetes. It is also reported to increase neonatal mortality as well as the incidence of congenital heart disease in infants. This is the effect seen in the immediate period during and after pregnancy. It has also been associated with long-term increased risk of death, myocardial infarction and peripheral artery disease compared with pregnant women with a normal body mass index. Pregnant women who smoke tend to give birth to children who are preterm and have a low birthweight. These children are also at an increased risk of asthma further in life[33].

The main goal of cardio-obstetrics is to provide exceptional CV care. This means that care starts even before conception in the form of preconception counselling for women who have pre-existing chronic diseases. Once issues of concern are identified and patients are properly educated, only then should be referral and management options considered[36]. As it is well-known that pregnancy acts as a stress test and unmasks CVDs which previously remained benign and asymptomatic, there is a dire need for training competent physicians with a special focus on care of

pregnant women with CVD under the name of cardio-obstetrics. Building such a team can help in risk stratification of these patients even before pregnancy has been conceived. This will also provide ample time to perform optimization of the health condition prior to pregnancy. Moreover, personalized care can be provided to these patients as they progress through the pregnancy. Any complications that may arise during or after pregnancy can be promptly treated by this team[37].

Sharma *et al*[37]. Propose the establishment of pregnancy heart teams. These teams must include cardiologists who have ample expertise in cardio-obstetrics, maternal-foetal medicine specialists, primary healthcare providers obstetric anesthesiologists, neonatologists, geneticists, pharmacists, social workers, nurses, and other care team members as depicted in Fig. 1. It reported that well-run teams like these help in reducing the adverse CV outcomes in pregnant woman who are at high risk of pregnancy-related complications. The team can review patient medications and perform all sorts of health-optimization that works in the benefit of the patient. These teams can also train future trainees in cardio-obstetrics further increasing the number of care providers in this niche field. Furthermore, a large registry should be formed that tracks maternal and postpartum morbidity and mortality to better champion best-practices in care of this cohort of patients. Social media can serve as a powerful tool in worldwide dissemination of best-practices and awareness in this field. It has already served to connect physicians and other stakeholders from medical societies, policy-makers and public alike. Social media can also serve to spark the interest of researchers to pursue further research in this field and advance to new horizons[37].

In a recent study by Florio *et al*[38]. The perceptions and experiences of patients in a cardio-obstetrics clinic were thoroughly assessed among pregnant individuals with CVD. It was noted from a quality improvement standpoint that the majority of patients were referred by their general obstetricians, but this does not reach women with known cardiac disease who are planning a future pregnancy or young women with congenital or structural disease managed by paediatric cardiologists. Collaboration between cardio-obstetric clinicians, primary care, and paediatric groups is needed to encourage contraceptive use and prevent unplanned pregnancies. The importance of coordination between cardiologists and obstetricians for better assessment and outcomes during pregnancy was emphasized by a joint presidential advisory from the American Heart Association and American College of Obstetrics and Gynecology (ACOG). The effectiveness of multidisciplinary collaboration has been proven in other areas of medicine, including diabetes, cancer, and neurologic conditions, leading to improved outcomes, enhanced patient knowledge, and increased patient satisfaction. The implementation of a multidisciplinary approach in cardio-obstetric clinics could potentially result in decreased mortality in critical non-obstetric cardiac patients and enhanced provider satisfaction. However, the impact of cardio-obstetric teams on pregnancy outcomes and satisfaction in patients with CVD has yet to be determined and further multicenter studies are needed to compare the benefits of multidisciplinary team approaches and usual care, and determine the optimal approach for best outcomes. A study this year by[39] Quiñones, *et al*. reported good pregnancy and neonatal outcomes were experienced by most women with pre-existing CVD when managed in a specialized and a multidisciplinary program. They also reported that the highest risk for pregnancy complications, such as pre-eclampsia and preterm birth, was among women with acquired heart disease[39].

Underserved and marginalized communities also require a dedicated cardio-obstetrics service. Tamirisa *et al*[40]. Argue that the Association of Black Cardiologists, Inc. responded to the persistent crisis of Black maternal health by organizing a Black Maternal Heart Health Roundtable in June 2020, which produced a publication with unified solutions to improve the health outcomes for Black women of all ages. Multidisciplinary collaborations among specialists in obstetrics, maternal-foetal medicine, cardiology, primary care, midwives, doulas, and paediatricians were discussed and considered crucial in recognizing the impact of unique risk factors on disparities in maternal care and outcomes and ensuring continuous care throughout the maternal health continuum, from preconception to postpartum. The inclusion of community leaders in the maternal care team was also suggested as a means of improving communication and reducing distrust in marginalized communities, as this novel

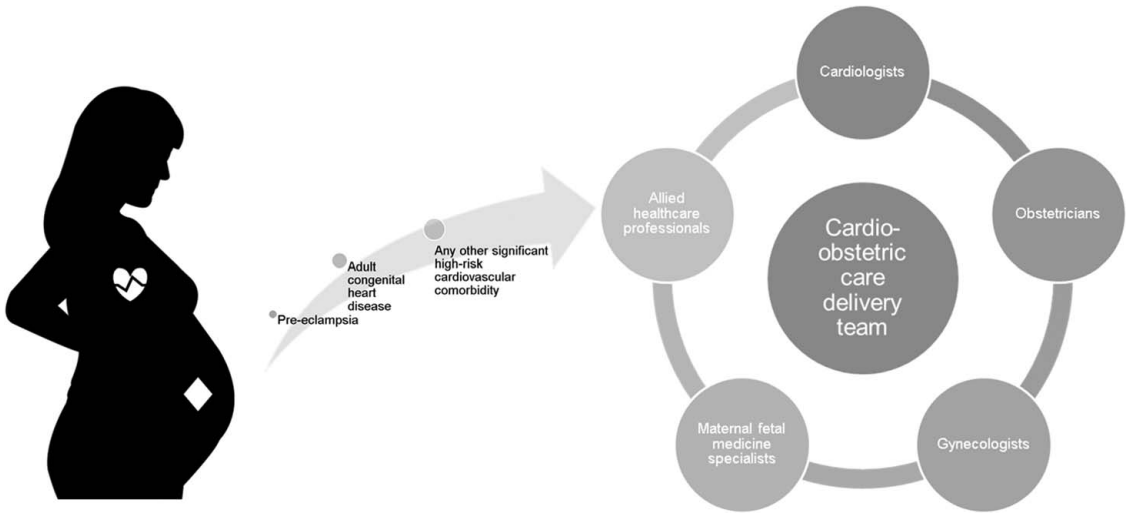

Figure 1. The cardio-obstetrics team provides care to any pregnant patient with significant cardiovascular comorbidities.

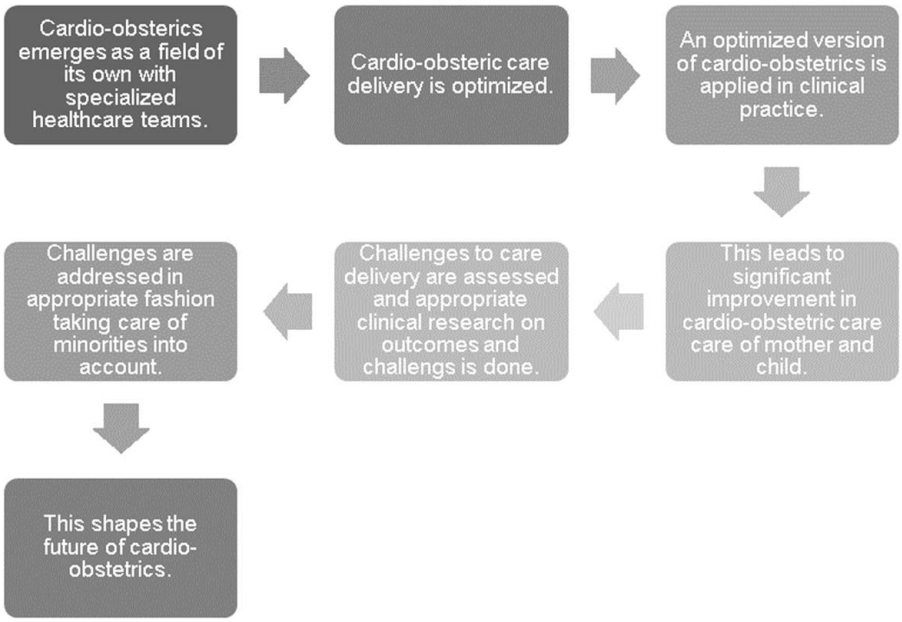

Figure 2. Way forward for cardio-obstetrics research and delivery of patient care.

approach has been proven effective in other areas of CVD management and care. A cardio-obstetrics team, consisting of various medical specialists including cardio-obstetrics, CV medicine, maternal-foetal medicine, obstetrics, primary care, genetics, nursing, pharmacy, social work, and other experts such as anesthesiologists, cardiologists specializing in heart failure, electrophysiologists, and allied professionals, is required throughout the preconception phase, pregnancy, and postpartum phase, particularly in women with heart failure and arrhythmias. Coordinated cardio-obstetrics clinics have been shown to reduce adverse cardiac complications during and after pregnancy. The specific members of the cardio-obstetrics team, also referred to as the pregnancy heart team, may vary based on the patient's needs, but a neonatologist is typically included to address foetal and neonatal risks in cases where preterm delivery may be necessary. They also argue that the increased risk for the gravida with CVD, particularly heart failure, must be taken into consideration. Peripartum cardiomyopathy is identified as the leading cause of late postpartum death related to CVD. For the ongoing safety of the patient, the development of a coordinated and interdisciplinary plan for discharge and subsequent postpartum assessment and management is considered crucial. Such plans should be tailored to address patient-specific warning signs of CVD worsening, early postpartum follow-up, considerations regarding breastfeeding, emotional support, future pregnancy intentions, contraceptive needs, and long-term CV follow-up. As advised by the ACOG, a postpartum follow-up visit is recommended within 7–10 days of delivery for women with hypertensive disorders and 7-14 days for women with CVD, to be conducted with either the primary care provider or cardiologist. Optimizing cardio-obstetric care is faced with various barriers, including delays in identification and diagnosis of women with acquired CVD, difficulties in accessing high-quality care, and limited insurance coverage. Data from maternal mortality review committees suggest that nearly 70% of CV and coronary deaths are preventable, with provider-related factors, including delayed diagnosis and treatment, being a significant contributor. Education about pregnancy and heart disease for multidisciplinary healthcare providers is deemed important for optimal care. Systemic discrimination and implicit racial bias pose as significant barriers to high-quality care for Black women, the highest risk group, and the staggering rates of poor outcomes are not protected against by factors such as educational attainment, income, and employment. Other barriers include transportation, childcare, and rurality. Addressing racism and the social drivers of health through policy reform at the local, state, and federal levels is necessary. The lack of insurance coverage and bundled payment models disincentivizing multiple postpartum visits also hinder optimized cardio-obstetric care. Medicaid expansion in states without coverage and extensions to 12 months postpartum are considered solutions for optimizing healthcare during the critical preconception and postpartum periods. Illinois became the first state to provide full Medicaid benefit coverage for mothers during the postpartum period for a full year, with several states following suit[40]. The strengths include the comprehensive coverage of the topic and inclusion of recent studies and meta-analyses, while the limitations include the lack of original research and possible bias in the selection of studies. Figure 2 depicts the way forward for cardio-obstetrics research and delivery of patient care.

Conclusion

Cardio-obstetrics is a newly emerging field. Pregnancy has a tremendously stressful effect on hemodynamic physiology of women, especially those with CVD. Chronic hypertension, smoking and obesity all have detrimental effects on both maternal and foetal outcomes. There is scarcity of specialists currently who are experts in dealing with pregnant women who have CVD necessitating a need for multidisciplinary teams targeted at this

cohort of patients to target and optimize maternal health and subsequent foetal health before any decompensation of health can occur. Public awareness and further research are required to advance this field.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Source of funding

None.

Author contribution

All authors significantly contributed to data curation, formal analysis, investigation, conceptualization, supervision, visualization, writing—original draft and writing—review and editing. All authors reviewed the final version of the paper and approved it for submission and publication.

Conflicts of interest disclosure

The authors declare that they have no conflicts of interest.

Research registration unique identifying number (UIN)

Not applicable.

Guarantor

Hassan Mumtaz.

Availability of data and materials

All data used in this paper have been taken from publicly available resources.

Provenance and peer-review

Not commissioned, externally peer-reviewed.

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