Hypertensive disorders of pregnancy and the risk of future cardiovascular disease in women

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Abstract

Background: Cardiovascular disease (CVD) continues to be the leading cause of mortality in women globally. In addition to the traditional CVD risk factors, some sex-specific conditions increase the burden of CVD in women. This study aims to review evidence on associations between hypertensive disorders in pregnancy (HDP) and risk of CVD in later life.

Methods: A database search was carried out using predetermined search terms in MEDLINE and CINAHL. The search was limited to literature published in English between January 2000 and November 2016. Following the application of study inclusion and exclusion criteria and critical appraisal of the evidence, 12 studies were included in the review.

Results: The findings of this review suggest that the risk of future CVD events and mortality is significantly higher in women with a history of hypertensive disorders in pregnancy. The results indicate that a history of preeclampsia, gestational hypertension, or elevated systolic blood pressure alone during pregnancy is consistently associated with increased risk of developing and death from myocardial infarction, heart failure, hypertension, and stroke in later life.

Conclusion: Nurses and other health care providers should be aware of the CVD risk associated with hypertensive disorders in pregnancy and engage these high-risk women in discussions about health promotion strategies and interventions to address modifiable CVD risk factors.

Keywords: Cardiovascular disease, nursing, hypertensive disorders in pregnancy, preeclampsia, and gestational hypertension

Précis Statement: Women with history of hypertensive disorders in pregnancy should be supported to reduce their future risk of CVD.

Clinical Implications

- Nurses and other health care providers should be aware of CVD risk factors, including those specific to women.

- Nurses and other health care professionals should effectively engage in risk communication to inform and educate women about CVD risk factors and risk management strategies.

- Women at increased risk of CVD, including those with history of hypertensive disorders during pregnancy, need to be identified, their CVD risk profile be assessed, and be supported to reduce their future risk through targeting modifiable risk factors.

Introduction

Cardiovascular disease (CVD) is the leading cause of death; every year, 17.9 million people die from CVD worldwide. Deaths from CVD increased by 14.5% between 2006 and 2016 globally (Benjamin et al., 2019). According to the World Heat Federation, CVD accounts for one-third of all deaths among women. Women who develop CVD are more likely to die from it if they live in low- and middle-income countries (Federation, 2017). It is estimated that more than 130 million adults in the US will have some form of CVD by 2035. Thus, CVD continues to impose significant financial burdens on the health care systems; the total costs and direct medical costs of CVD are expected to reach $1.1 trillion and $748.7 billion in 2023, respectively (Benjamin et al., 2019). CVD generally refers to any disease that affects the cardiovascular system, and includes but not limited to coronary heart disease (CHD) and cerebrovascular disease (stroke). Coronary heart disease/ ischemic heart disease/coronary artery disease refers to narrowing or blockage of coronary arteries, usually caused by atherosclerosis (Mosca et al., 2011). CHD is the leading cause of deaths from CVD; in the US 43.8% of all CVD-related deaths are attributable to CHD alone (Benjamin et al., 2019).

In addition to the traditional CVD risk factors that contribute to development of CVD in both genders, a number of risk factors affect CVD risk in women only (Leening et al., 2014). Some conditions, such as a history of polycystic ovary syndrome (Mahendru & Morris, 2013) gestational diabetes, intrauterine growth restrictions (Rich-Edwards, Fraser, Lawlor, & Catov, 2013), preterm birth, gestational hypertension, and miscarriages (Cusimano, Pudwell, Roddy, Cho, & Smith, 2014) have been found to be associated with increased risk of CVD in women.

This literature review aimed to collect and review evidence on associations between hypertensive disorders of pregnancy and the risk of developing CVD in women in later life. Hypertensive disorders of pregnancy (HDP) include chronic hypertension, preeclampsia, chronic hypertension with superimposed preeclampsia, gestational hypertension, eclampsia,

and postpartum hypertension. In 2013, the American College of Obstetrics and Gynaecology (ACOG) updated the definitions of the different types of HDP (American College of Obstetricians and Gynecologists: Task Force on Hypertension in Pregnancy, 2013). According to ACOG, chronic hypertension is blood pressure ≥ 140/90 detected after conception or before 20 weeks of pregnancy; gestational hypertension is new onset elevation of blood pressure ≥ 140/90, closer to term, in the absence of proteinuria; preeclampsia is defined as blood pressure ≥140/90 in two separate measurements, at least 4 hours apart, after 20 weeks of pregnancy, in those pregnant women whom their blood pressure was previously normal; and superimposed preeclampsia is chronic hypertension in association with preeclampsia (American College of Obstetricians and Gynecologists: Task Force on Hypertension in Pregnancy, 2013). Preeclampsia itself is responsible for up to 15% of maternity-related deaths (Funai et al., 2005), and occurs in 7.5% of all pregnancies; however, the incidence rate is lower in developed countries (2-5%) (Brown et al., 2013).

Methods

Search strategy

The literature on the associations between HDP and CVD was accessed using predetermined search terms in MEDLINE and CINAHL. The search terms for exposure included: 'hypertensive pregnancy disorders*', 'hypertension*', 'pregnancy-induced hypertension*', 'gestational hypertension*', 'hypertensive disorders of pregnancy*', 'preeclampsia*', 'pre-eclampsia', 'postpartum hypertension*', 'eclampsia', and 'pregnancy complications*'. The search terms for outcome included: 'cardiovascular disease*', 'heart disease*', 'coronary heart disease*', 'coronary artery disease', 'myocardial infarction', 'acute coronary syndrome', 'ischaemic heart disease*, and 'ischemic heart disease*'. All primary studies that examined associations between HDP and the risk of developing CVD in later life were included. The search was limited to publication years between January 2000 and December

2016. There was no limitation on follow-up period. Non-English literature and review studies were excluded. Conference abstracts, letters to the editor and editorial articles were also excluded. However, the reference lists of the included studies and excluded previous review studies were checked for possible additional studies.

Study selection

A total of 314 publications were retrieved from the initial search. After limiting to English language and the defined years of publication, search yielded 248 citations. Review articles and duplications were removed, leaving 165 papers for further assessment. Initial screening of the article titles and abstracts resulted in exclusion of 55 articles. The full texts of the remaining studies were reviewed for relevancy, resulting in exclusion of further 99 papers (Figure 1).

Quality assessment

The remaining 11 papers were assessed for quality using the Critical Appraisal Skills Program (Critical appraisal skills programms, 2016). The quality of none of the studies was assessed as poor (Table 1), therefore, all the 11 studies were included in the review. Table 2 provides a brief summary of the included studies.

Results

The reviewed studies were mostly large population-based cohort studies that examined the risk of CVD events and/or mortality in women with a history of HDP (n=3,564,442). There was one case-control study (n=629) and one cross sectional population-based study (n=403,550). Out of the included articles, 10 studies were conducted in Europe (three in Finland, two in Norway, and one each in Iceland, Sweden, Scotland, the Netherlands and

Denmark), one in Israel, and one in Taiwan. The findings of this review are presented under following four themes.

Preeclampsia and risk of CVD

The association between history of preeclampsia and risk of CVD in women was examined in five studies (Arnadottir, Geirsson, Arngrimsson, Jonsdottir, & Olafsson, 2005; Irgens, Roberts, Reisæter, Irgens, & Lie, 2001; Lin et al., 2011; Männistö et al., 2013; Smith, Pell, & Walsh, 2001). A population-based prospective cohort study recruited 12,055 multiparous women, who had given birth in year 1966 in Finland and followed up the women for 40 years (Männistö et al., 2013). The study found that any form of HDP was associated with increased risk of cardiac events and diabetes in later life. According to this study, women with a history of preeclampsia/eclampsia in comparison with women with normal blood pressure during pregnancy were more likely to develop CVD (hazard ratio 1.4, 95% CI 1.1- 1.7), ischemic heart disease (hazard ratio 1.36, 95% CI 1.01-1.83), heart failure (hazard ratio 1.6, 95% CI 1.1-2.5), and arterial hypertension (hazard ratio 2.33, 95% CI 1.88-2.88). The risks of developing myocardial infarction (hazard ratio 1.2, 95% CI 0.73 - 2.0), death from and myocardial infarction (hazard ratio, 95% CI 0.51-4.08), and developing ischemic cerebrovascular disease (hazard ratio 1.19, 95% CI 0.68–2.09) also increased although did not reach a statistically significant level. These risks were particularly greater if women had superimposed preeclampsia/eclampsia that is they had chronic arterial hypertension and then developed preeclampsia/eclampsia (Männistö et al., 2013).

Likewise, a population-based cohort study in Israeli analysed death rates among 37,061 women who delivered in Jerusalem between 1964 and 1976, with a median 30 (24-36) years follow up (Funai et al., 2005). The study concluded that the relative death rate was 2.13 (95% CI 1.8-2.5, p<0.001) higher in women who were diagnosed with preeclampsia compared with

women who had normal blood pressures during their pregnancy, and deaths from CVD contributed most strongly to this increase (Funai et al., 2005).

A large population-based cohort study in Taiwan recruited 1,132,064 women, who had given birth between 1999 and 2003, through the linkage between birth certificates and national health insurance hospital discharge data (Lin et al., 2011). The study aimed to investigate the risk of major CVD events and mortality during pregnancy and within 3 years postpartum. After adjusting for known CVD risk factors, the risk of major cardiac events and mortality was significantly higher in women with a history of preeclampsia/eclampsia. Women with a history of preeclampsia/eclampsia had 13.0 times higher risk of developing myocardial infarction (95% CI 4.6-6.3, p<0.0001) and 8.3 times greater chance of developing heart failure (95% CI 4.2-16.4, p<0.0001) in their later life. The risk of stroke was 14.5 times higher in these women (95% CI 1.3-165.1, p<0.03), and the participants had 6.4 higher incidence of overall death (95% CI 3.8-10.9, p<0.0001) and 2.3 times higher incidence of CVD-related deaths (95% CI 1.6-3.1, p<0.0001) compared to those without this condition (Lin et al., 2011). These results correspond with the findings of Funai et al.'s (2005) study, which reported significantly higher death from CVD in women with a history of preeclampsia.

In addition, a retrospective population based cohort study in Scotland recruited 129,290 women from the Scottish Morbidity Record, who had their first live child between 1981 and 1985, to closely examine the associations between preeclampsia and risk of future fatal and non-fatal CHD (Smith et al., 2001). Out of the cohort, 22,781 women had developed preeclampsia during their pregnancies while 107,139 women had not. Following up the women for 15 to 19 years, the study found that the rate of CHD events doubled (95% CI 1.5-2.5) in women who had a history of preeclampsia when compared to the control group (Smith et al., 2001). A similar population-based cohort study in Norway recruited 626,272 women

through the Norwegian Medical Birth Registry, who had given birth from 1967 to 1992 with the median follow up of 13 years (Irgens et al., 2001). The study found that preeclampsia was associated with a 8.12-fold (95% CI 4.3-15.3) increased risk of death from CVD (Irgens et al., 2001).

Gestational hypertension and risk of CVD

The relationships between gestational hypertension and the risk of CVD in later life was examined in five studies (Arnadottir et al., 2005; Lykke et al., 2009; Männistö et al., 2013; Wikström, Haglund, Olovsson, & Lindeberg, 2005). The results of these studies were consistent in finding positive associations between the experience of gestational hypertension and CVD in later life.

A registry-based cohort study in Denmark recruited 782,287 women from 15 to 50 years old, who had their first delivery, with median follow-up of 14.60 years (Lykke et al., 2009). The study found that the risk of developing CHD increased in women with history of gestational hypertension by 1.5 times (95% CI 1.25-1.76, p<0.001). These women were also at greater risk of developing subsequent hypertension (5.3 times, 95% CI 4.90 to 5.75, p<0.001) in the future (Lykke et al., 2009).

Similarly, a cohort study of 4,782 women from 2,443 sibships, or offspring who share same two parents, participating in the Family Blood Pressure Program study (FBPP) between 2000 and 2004 in Finland, reported that women with a history of gestational hypertension compared with their normotensive counterparts were at greater risk for developing hypertension in the future (Garovic et al., 2010). The increased risk remained significant after controlling for the known CVD risk factors including race, family history, smoking, dyslipidaemia, and diabetes mellitus (adjusted hazard ratio 1.8, 95% CI 1.4–2.3, *p*<0.001). In addition, hypertension developed at earlier ages in these women (50% hypertensive at the age

of 53 vs. 60, respectively, *p*<0.001) (Garovic et al., 2010). The relatively greater risk of future hypertension observed in the Lykke et al.'s (2009) study may be due to the lack of complete adjustments for CVD risk factors, such as obesity (Lykke et al., 2009).

A cross-sectional population-based study in Sweden analysed the risk of fatal or non-fatal CHD events in 403,550 women who had given birth between 1973 and 1982, with follow up of 15 years (Wikström et al., 2005). The study revealed that compared to women with normotensive pregnancies, women with a history of gestational hypertension in their first pregnancy had an increased risk of developing CHD in later life (relative risk 1.6, 95% CI 1.3-2.0) (Wikström et al., 2005). A similar study was conducted in Iceland by Arnadottir et.al. (2005). This particular study recruited participants (n= 325 cases and n= 650 controls) who had given birth in the University Hospital in Reykjavik, Iceland between 1931 and 1947, and followed them until 1996. The study found that the risk of mortality from CHD among women with a history of HPD was 24.3% compared to 14.6% in women without the condition (relative risk 1.66, 95% CI 1.27 - 2.17) (Arnadottir et al., 2005). These results are consistent with the findings of Wikström et al. (2005) and Garovic et al. (2010). Arnadottir et al. (2005) reported that overall, women with gestational hypertension survived 3-9 years less than women without this condition. Männistö et al. (2013) also found that women with gestational hypertension were at increased risk for CHD (hazard ratio 1.44, 95% CI, 1.24–1.68), myocardial infarction (hazard ratio 1.75, 95% CI, 1.40–2.19), death from myocardial infarction (hazard ratio 3.00, 95% CI, 1.18–3.09), and ischemic stroke (hazard ratio 1.59, 95% CI, 1.24–2.04).

Is the severity of hypertensive disorders during pregnancy of significance?

Hypertensive disorders of pregnancy

The relationship between the severity of HDP and risk of future CVD was assessed in three studies (Luoto et al., 2008; Lykke et al., 2009; Wikström et al., 2005), and these studies found that severity of HDP was a factor in increasing the risk.

The study by Lykke et al. (2009) found the risk of CHD increased by 1.57 times (95% CI 1.44-1.72,) and 1.61 times (95% CI 1.34-1.94,) in women with mild preeclampsia and severe preeclampsia respectively, indicating no significant difference in future CHD risk according to the severity of preeclampsia after a median of 14.60 years follow up. However, compared to women with mild preeclampsia (relative risk 3.61, 95% CI 3.43-3.80), those with severe preeclampsia were at greater risk for developing hypertension in later life (relative risk 6.07, 95% CI 5.45-6.77) (Lykke et al., 2009).

The impact of increased systolic blood pressure during pregnancy, without specifying the type of HDP, on future CVD risk was evaluated in a study which derived data from a cohort of 4,090 women delivered between 1954 and 1963 in Finland, with a follow up period of approximately 44 years (Luoto et al., 2008). Mortality data were gathered from the Finnish Cause-of-Death Registry. Results demonstrated that CVD mortality rate was considerably higher in women who had a history of systolic hypertension during pregnancy whether developed in early or late stage of pregnancy. For each 13 ± 1 mmHg rise in systolic blood pressure during early pregnancy, CVD mortality raised by 20% and for one standard deviation increase in systolic blood pressure in late pregnancy, the mortality rate increased by 14% (Luoto et al., 2008). The study concluded that an increase in systolic blood pressure alone during pregnancy could be considered as an important predictor of future CVD risk and mortality in women (Luoto et al., 2008). In another study, compared to women without the condition, the risk of future ischemic heart disease increased by 1.9 times (95% CI 1.6-2.2) in women with mild preeclampsia, but with greater increase in women with severe preeclampsia (relative risk 2.8, 95% CI 2.2-3.7) (Wikström et al., 2005).

Hypertensive disorders of pregnancy

CVD risk according to the order of pregnancy, number, and time of diagnosis of HDP

A prospective population-based cohort study conducted in Norway investigated the relationship between the order of the pregnancy, time of onset of preeclampsia (preterm or term) and mortality from CVD (Skjaerven et al., 2012). The researchers recruited 836,147 women from the Medical Birth Registry of Norway between 1967 and 2002, and followed them up until 2009. Of these women, 34,824 developed preeclampsia during their pregnancy. The study found that women who developed term preeclampsia in their first pregnancy were more likely to die from CVD than those without the condition in their first pregnancy (adjusted hazard ratio 1.6, 95% CI 1.4-2.0) (Skjaerven et al., 2012). This risk was even higher for women who developed preterm preeclampsia (adjusted hazard ratio 3.7, 95% CI 2.7-4.8). In addition, women who had developed preterm preeclampsia in their first pregnancy (<37 weeks) and did not have additional children, were at greater risk of CVD death compared to women who had subsequent children (9.2% vs. 1.1%) (Skjaerven et al., 2012). While in women who had term preeclampsia, if they had only one child, the risk of death from CVD was 2.8%, which fell to 1.1% for those who had two or more children (Skjaerven et al., 2012). However, all-cause mortality for women with two or more lifetime births, who had preterm preeclampsia in first pregnancy did not increase (adjusted hazard ratio 1.1, 95% CI 0.87-1.14), even if they had preterm preeclampsia (Skjaerven et al., 2012). The results indicated that mortality from CVD was particularly higher in women with early preeclampsia in first pregnancy who did not have subsequent children (Skjaerven et al., 2012).

Including more than 20,000 primigravida and 2000 women with recurrent HDP, Wikstrom et al. (2005) found that women with hypertensive disease in both pregnancies had an increased hazard ratio of 2.8 (95% CI 2.0–3.9) compared with women with two normal pregnancies (Wikström et al., 2005).

Hypertensive disorders during pregnancy and the risk of future stroke

Several studies examined the relationship between HDP and stroke, and these studies consistently found positive relationships between experience of HDP and increased risk of stroke in later life (Arnadottir et al., 2005; Garovic et al., 2010; Lin et al., 2011; Lykke et al., 2009; Männistö et al., 2013). In their population-based prospective cohort study in Finland, Männistö et al. (2013) found that gestational hypertension increased the risk of future ischemic stroke (hazard ratio 1.59, 95% CI 1.24-2.04) (Männistö et al., 2013). Another population-based cohort study in Taiwan found that women with a history of preeclampsia or eclampsia had 14.5 times (95% CI 1.3-165.1) greater adjusted risk of developing stroke in the future , 7.3 times (95% CI 5.5-9.7) greater chance of developing major adverse cardiovascular events without stroke, and 2.3 times greater (95% CI 1.6-3.1) chance of death from major adverse cardiovascular events, compared with women without preeclampsia or eclampsia (Lin et al., 2011).

In addition, Lykke et al. (2009) found that the risk of stroke was elevated 1.51 times (95% CI 1.26-1.81, p<0.001) in women with history of gestational hypertension, 1.4 times (CI 1.30 to 1.58) in women with mild preeclampsia, and 1.58 times (CI 1.23 to 2.03, p<0.001) in women with sever preeclampsia, again indicating that the severity of HDP is a concern (Lykke et al., 2009). Consistent with the above studies, Arnadottir et al. (2005) found that the rate of death from cerebrovascular event including stroke was 9.5% in women with history of HDP compared to 6.5% in women without the condition (relative risk 1.46, 95% CI 0.94-2.28) (Arnadottir et al., 2005).

Discussion

The findings of this review consistently suggest that any type of history of HDP is associated with increased risk of future CVD events and mortality in women. The findings indicate that women with a history of preeclampsia, gestational hypertension and/or elevated systolic blood pressure alone during pregnancy are at greater risk for developing and death from myocardial infarction, heart failure, hypertension, and stroke in their later life (Luoto et al., 2008; Lykke et al., 2009; Männistö et al., 2013). The evidence suggests that HDP adds to the burden of CVD in women, however, due to the heterogeneity across the reviewed studies in terms of population, exposure variables, outcome variables, and follow-up periods, it was difficult to combine the results statistically in a meta-analysis to derive a pooled estimate of the impact of HDP conditions on CVD risk.

Although the underlying mechanisms linking HDP to increased risk of CVD are not very well understood (Aykas et al., 2015; Garovic et al., 2010; Lykke et al., 2009; Valdiviezo, Garovic, & Ouyang, 2012), this association might be due to some shared risk factors between the two conditions. Women who experience HDP are more likely to have hypertension, high serum uric acid levels, high microalbuminuria, and high serum triglycerides levels, factors that escalate the risk of CVD (Aykas et al., 2015; Valdiviezo, Garovic, & Ouyang, 2012). In addition, women with a history of gestational hypertension or severe preeclampsia are more likely to develop type 2 diabetes, which is a strong risk factor for developing CVD in women (Lykke et al., 2009).

Some studies have found that the damaging effects of HDP on the vascular system remain for many years, which can dispose women to subsequent CVD (Valdiviezo et al., 2012). Ehrental et al. (2015) found that women with a history of preeclampsia had higher blood pressures at 3 months and 1 year after the index complicated pregnancy in comparison with women without the complication (Ehrenthal, Rogers, Goldstein, Edwards, & Weintraub,

2015). If the increased blood pressure associated with preeclampsia or gestational hypertension remains uncontrolled for years, the risk of coronary heart disease increases by two-fold (95% 1.86 to 2.52) (Bellamy, Casas, Hingorani, & Williams, 2007). Also, women with a history of gestational hypertension or preeclampsia (mild or severe) are at greater risk for developing hypertension in later life (Garovic et al., 2010; Lykke et al., 2009). This can partially explain the increased risk of stroke among these women (Ehrenthal, Rogers, Goldstein, Edwards, & Weintraub, 2015; Garovic et al., 2010; Lykke et al., 2009). Women who develop HDP early in pregnancy have poorer CVD risk factor profile than women who experience these conditions later in their pregnancy (Veerbeek et al., 2015). It seems that the increased vascular resistance seen in early preeclampsia can lead to systolic and diastolic dysfunction and could be the possible mechanism in the development of chronic hypertension (Sibai et al., 1998; Veerbeek et al., 2015).

Furthermore, Canti et al. (2010) found that women with preeclampsia had significantly higher body mass index ($p= 0.019$) and abdominal circumference measurements ($p= 0.026$) in comparison with normotensive pregnant women (Canti et al., 2010). It is well known that obesity, particularly increased waist circumference, can escalate the risk of CVD (Klein et al., 2007). Apart from the significant synergistic effects between HDP conditions and the known CVD risk factors, HDP has been shown to contribute to the risk of CVD in women independently (Garovic et al., 2010; Lin et al., 2011; Männistö et al., 2013; Skjaerven et al., 2012; Wikström et al., 2005)

The available evidence supports the view that pregnancy should be considered as a cardiovascular stress test, and the experience of HDP indicates greater susceptibility to CVD in the future (Hermes et al., 2013; Veerbeek et al., 2015). This knowledge provides an opportunity for early identification of these high-risk women. It is equally important to raise

the awareness of the affected women of the risk and to support them in creating a healthy lifestyle as a risk reducing strategy.

Limitations

The findings of this review should be interpreted with some caution. This review is limited by our ability to review the relevant literature in the specific time period of the research. However, we believe that our systematic search in Medline and CINAHL retrieved the most recent large population-based cohort studies. We also systematically appraised the quality of the included studies (Table 1), and ensured that the included studies were high-quality research, increasing the validity of the findings. It should also be noted that hypertensive disorders in pregnancy may have been differently defined or misclassified in the included studies. For example, while Männistö et al. (2013) considered BP≥ 145/95 mmHg with proteinuria as the definition of preeclampsia, in Funai et al.'s (2005) study, BP≥140/90 mmHg and 1+ protein in urine on dipstick were considered as diagnostic criteria.

Implications for practice

The findings of this review have several implications for practice. The evidence highlights the importance of consideration of pregnancy history in assessment of CVD risk in women. The exiting CVD risk assessment tools, such as Framingham risk score, the SCORE score and the Reynolds risk score enable health providers to identify high risk population subgroups for close monitoring, early diagnosis, and therapy (Lloyd-Jones, 2010). It has been shown that the effects of HDP on the cardiovascular system are reflected in the existing CVD risk estimation tools. For example, in a longitudinal follow-up study in Netherlands (Hermes et al., 2013), using the Framingham Risk Score, the estimated 10-year and 30- year CVD risks of 300 women with a history of HDP were compared with the estimated CVD risks of 94 women with normotensive pregnancies. After a mean follow-up of 2.5 years, the estimated

10-year CVD risk of women with HDP was significantly higher than the risk of women who did not have the condition (7.2% vs. 4.4%, respectively, $p<0.001$, incident rate ratio 5.8, 95% CI 1.9-19). The estimated 30-year CVD risk was also greater in women with HDP than women without the condition (11% vs. 7.3%, respectively, $p<0.001$, incident rate ratio 2.7, 95% CI 1.6-4.5). The results were consistent when the SCORE score and the Reynolds Risk Score were applied (Hermes et al., 2013). Likewise, comparing the estimated risk of CHD and stroke between women with and without history of HDP, Garovic et al. (2010) found that women who had a history of hypertension during their pregnancy showed an increased estimated risk for CHD (14% vs. 11% at 70 years, respectively, $p= 0.009$) and stroke (8% vs. 5% at 70 years, respectively $p=0.009$) compared to women without the condition (Garovic et al., 2010).

Considering that women at reproductive age are younger and may not manifest the symptoms of CVD for many years, using appropriate CVD risk estimation tools is a pragmatic approach to identify high risk women who can benefit from risk modification interventions (Lloyd-Jones, 2010). However, it should be noted that the ability of the available tools to predict CVD risk is poorer in women compared to men, particularly among younger women (Hermes et al., 2013; Wenger, 2017). It is suggested that future research evaluates the possibility of improving the accuracy of the existing CVD assessment tools for women by inclusion of women-specific risk factors, such as history of HDP. The ACC/AHA Pooled Cohort Equation, endorsed by the American College of Cardiology and American Heart Association, aims to improve the CVD risk estimation for women by considering their higher lifetime CVD risk, however, overestimation of CVD risk with advanced age is a concern with this tool (Wenger, 2017).

Efforts should also be made to increase the awareness of the link between HDP and CVD among health care providers as well as women suffering from these conditions. Nurses can play an important role in increasing women's awareness of cardiovascular health and risk factors and encourage women with a history of HDP to discuss their cardiovascular health with a general practitioner or cardiologist (Berra, 2011). The Association of Women's Health, Obstetric and Neonatal Nurses (AWHONN) advises that nurses should provide women with regular cardiovascular health screening and education during health care visits to foster their awareness of CVD risk factors (AWHONN, 2011). Increasing women's knowledge of CVD risk factors and helping them to develop a reasonable risk perception is important to facilitate active engagement in risk reducing behaviours to mitigate the risk (Gholizadeh, Davidson, Salamonson, & Worrall-Carter, 2010). To achieve this goal, health care providers should themselves be well- knowledgeable about the traditional as well as the gender-specific CVD risk factors.

Globally, primary care providers give first line of care to people with increased CVD risk by identifying high risk population groups, initiating risk management, and providing suitable care plans and follow ups. Effective assessment and management of individuals with increased risk of CVD needs appropriate amount of time to clearly communicate the risk with the person, understand the existing barriers and facilitators, engage individuals in risk reducing behaviours, initiate and evaluate treatments to modify risk factors such as hypertension, diabetes, and high blood cholesterol levels. In busy primary care practices, this responsibility can be shared between physicians, nurse practitioners, nurses, physician assistants, and midwives (Voogdt-Pruis, Beusmans, Gorgels, Kester, & Van Ree, 2010). In addition, CVD risk management can be effective if health professionals work collaboratively and in partnership with individuals. Women should be actively engaged in risk prevention programs, including adapting a healthy lifestyle and adhering to evidence-based

recommendations about diet, alcohol consumption, exercise, medications, and regular check-ups for blood pressure, blood sugar and blood cholesterol (Erhardt, Moller, Puig, & management, 2007).

Future research should focus on assessing the knowledge and awareness of health care providers and women of the CVD risk associated with HDP as well as identifying, implementing and evaluating strategies to close any knowledge gap and improve the cardiovascular health outcomes for women with a history of HDP.

Conclusion

Women with a history of HDP are at significantly greater risk for developing CVD in their later life. This knowledge should encourage health care providers to identify this high-risk subgroup of women and offer them appropriate screening and counselling. These women should be encouraged to discuss their cardiovascular health with health care providers and be supported to reduce their future CVD risk through adoption of a healthy lifestyle and recognition and improvement of modifiable risk factors.

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