Outcomes Associated with Gestational Diabetes: A Literature Review

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Introduction

Bringing another human into this world is seen as a right of passage for most women. Creating a child of your very own usually brings joy and bliss to a new mother. There are many reasons to be excited about pregnancy such as finding out the gender of the baby, picking out new baby clothes, and extending the family tree. Considering pregnancy is viewed as one of life's happiest moments, mothers are often unaware of substantial negative health risks and problems it may have on the body and potentially, the rest of their lives. One of the most common problems is gestational diabetes mellitus, which affects approximately 5-7% of all pregnant women (Moncrieff, 2018). It is common that most women with GDM return to normal blood glucose levels after giving birth. However, healthy interventions should still be implemented throughout the woman and child's lifetime to ensure other problems do not develop due to the initial diagnosis of gestational diabetes (Bone, 2015).

Gestational diabetes mellitus (GDM) is defined as "any degree of glucose intolerance with onset or first recognition during pregnancy, is characterized by underlying maternal defects in the B-cell response to insulin during pregnancy" (Moon, Kwak, & Jang, 2016, p. 26). Gestational diabetes is most commonly found during the third trimester and is thought to be a result of the combination between normal metabolic changes during pregnancy, as well as the predisposition of GDM (Moncrieff, 2018). As a result of gestational diabetes, prenatal and maternal complications can occur which include preeclampsia, cesarean delivery, and increased risk of type 2 diabetes in the future (Sugiyama et al., 2017). This lifetime risk of type 2 diabetes is determined to be approximately 60% (Noctor & Dunne, 2015). Gestational diabetes can also lead to cardiovascular disease for the mother and obesity and Type 2 diabetes for the child (Moncrieff, 2018).

Risk Factors

Weight gain, including waist circumference and body fat, are the most influential risk factors for GDM (Noctor & Dunne, 2015). Generally, mothers with body mass indexes over $30kg/m^2$ are at risk for getting gestational diabetes (Moncrieff, 2018). It is said that, "BMI during pregnancy may be associated with abnormal glucose tolerance at this stage" (Noctor & Dunne, 2015, p. 240). Even though weight loss is not recommended in regular pregnancies, women with gestational diabetes and who are overweight or obese may be encouraged to decrease their weight and reduce their energy intake by no more than 30% (Bone, 2015). This weight loss under primary care instruction is not linked to ketosis and most of all, does not cause harm (Bone, 2015). Weight loss can aid in decreasing blood glucose levels, as well as providing a healthier pregnancy for both mother and child.

Age is another very important consideration when it comes to GDM. Pregnant women who are over the age of 25 have an increased risk of gestational diabetes (CDC, 2019a). For instance, only 1.9% of mothers twenty years old or younger had gestational diabetes in the United States in 2016 (Deputy, Kim, Conrey, & Bullard, 2018). As maternal age increases, there is an increase in percentage of gestational diabetes as well. For example, 7% of mothers from 30-34 had GDM and 12.8% of mothers age 40 and beyond had GDM in the United States in 2016 (Deputy, Kim, Conrey, & Bullard, 2018). Therefore, there is a positive correlation between gestational diabetes and age. Nonetheless, gestational diabetes is more concerning to women who are over the age of thirty.

Race can also be a risk factor towards gestational diabetes. Generally, women with non-white European ethnicities have higher chances of acquiring GDM (Noctor & Dunne, 2015). 5.3% of non-Hispanic whites had gestational diabetes in the U.S. in 2016, compared to 11.1%

Asians, 9.2% American Indian/ Alaskan Native, and 8.4% Native Hawaiian/Pacific Islander (Deputy, Kim, Conrey, & Bullard, 2018). Specifically, American Indians and Alaskan Natives have higher rates of being overweight, obese, and having gestational diabetes when compared to non-Hispanic whites (Anderson, Spicer, & Peercy, 2016). Furthermore, because American Indians and Alaskan Natives have higher rates of gestational diabetes, they are also more likely to have preterm babies and high birth weight babies (Anderson, Spicer, & Peercy, 2016). This portrays that there is a higher prevalence of gestational diabetes in non-white European ethnicities; however, this prevalence may be due to social determinants rather than race. For instance, American Indians and Alaskan Natives have less access to prenatal care, which may be the actual reason why certain races having higher incidences of gestational diabetes (Anderson, Spicer, & Peercy, 2016). Additionally, non-Hispanic whites may also have less access to overall health care and education on maintenance of their bodies, which can lead to being overweight or obese, and as a result, gestational diabetes is more likely to occur during their pregnancy.

It is also well known that "women with a single gestational diabetes pregnancy are at risk for gestational diabetes in their future pregnancies" (Kim, 2014, p. 294). Mothers with GDM in their first pregnancy had a 41% risk of acquiring it in their second pregnancy (Kim, 2014). On the other hand, women who did not have gestational diabetes in their first pregnancy only had a 4% chance of obtaining gestational diabetes in their second pregnancy (Kim, 2014). Furthermore, mothers with GDM in their first two pregnancies had a 57% chance of getting it in their third pregnancy (Kim, 2014). This shows that there is an increased risk for future gestational diabetes with subsequent pregnancies.

Significance in Nursing

This is a critical topic because there is an increase of gestational diabetes in women globally, and not just in the United States. For example, in Korea the prevalence of GDM has risen to 10.5% of all Korean women in 2011 (Moon, Kwak, & Jang, 2017). This thesis will focus on the outcomes that are associated with gestational diabetes to both mother and child. For instance, "Women with a history of GDM have a sevenfold life time risk of developing type 2 diabetes mellitus (T2DM) compared to those with euglycemic pregnancies" (Tawfik, 2016, p. 500). Furthermore, there is an increase in family history of gestational diabetes considering there is a known cycle in which "the daughter of GDM mother becomes obese, gets pregnant, develops GDM, has a daughter, who becomes obese" (Bone, 2015, p. 42). It is important to stop this cycle from occurring, and in return there will be a decrease in short-term and long-term effects for both mother and neonate.

Gestational diabetes is estimated to affect approximately 5-7% of all pregnancies, depending on the population being studied; however, its prevalence continues to increase (Moncrieff, 2018). This is important because care before, during, and after these pregnancies must be altered for expecting mothers. This primarily affects nurses in obstetrics and gynecology. However, it can also affect pediatric nurses for when the neonate is starting to show affects from the gestational diabetes. Children who were born from mothers with GDM may seek care for obesity and Type 2 diabetes in the future (Moncrieff, 2018). Additionally, gestational diabetes may be associated with neonatal death, but results are different in various studies (Sugiyama et al., 2017). In undeveloped nations such as Palau, diagnosis and treatment is not as advanced and therefore may be linked to more neonatal deaths (Sugiyama et al., 2017). Further education as well as "development of evidence-based, culturally-appropriate interventions for

weight loss and management," will aid other countries in decreasing GDM rates and neonatal mortality (Sugiyama et al., 2017, p. 1965). In addition, gestational diabetes can affect geriatric nurses for when the mother is older and showing comorbidities such as type 2 diabetes or cardiovascular disease. Therefore, it is absolutely crucial that nurses are able to educate mothers with gestational diabetes on related outcomes on both mother and child. Several steps must be taken in order to decrease the likelihood of adverse outcomes from occurring, and in that case affects the health system as a whole.

Rationale

This literature review is being conducted because the writer's mother had gestational diabetes with her second child. The writer was interested in knowing the likelihood of her mother developing Type 2 diabetes in the future, as well any other unknown outcomes that might occur. Furthermore, the writer wanted to know the short term and long-term effects on the child, specifically the chances of the child developing Type 2 diabetes in the future. All mothers who have a history of gestational diabetes should be aware of the outcomes associated with it, but most of all should be educated on what they can do to decrease the likelihood of developing these outcomes.

Research Questions

1) What are the effects of gestational diabetes on subsequent pregnancies in adult women?
2) What are the long-term effects for the mother that can occur after gestational diabetes?
3) Do women who have gestational diabetes have a higher risk of developing Type 2 diabetes? When does this risk occur?
4) What are the short-term and-long term effects of gestational diabetes on the child who is born?

5) Does gestational diabetes have a genetic component?

Purpose

The purpose of this thesis is to conduct a review of the literature in order to examine and describe the current state of evidence surrounding the outcomes associated with gestational diabetes mellitus for both the mother and child.

Background

Diabetes

Diabetes can negatively alter the lives of those who are affected, whether it is Type 1, Type 2, or gestational. There are an estimated 30.3 million people, which is 9.4% of adults in the United States who are affected with diabetes mellitus (Waysham, 2018). Diabetes is a result of insufficient insulin production or insufficient response of insulin leading to hyperglycemia (Moncrieff, 2018). Insulin is made by pancreatic B cells in response to an increase in blood glucose levels and lowers blood glucose by stimulating the uptake of glucose into cells promoting storage (Moncrieff, 2018). A decrease in insulin, a lack of response to insulin, or a combination of both results in hyperglycemia (Moncrieff, 2018). There are 387 million people diagnosed with diabetes globally today, another estimated 179 million that are undiagnosed, and this alarmingly high number is expected to increase by 53% by the year 2035 (Bone, 2015).

There are several less-known types and syndromes of diabetes. This includes Maturity Onset Diabetes of the Young. This is a rare form of diabetes caused by a genetic mutation, which runs strongly in families (The British Diabetic Association). Any child of a parent who has this genetic mutation has a 50% chance of inheriting it and therefore they will develop this type of diabetes before the age of 25 regardless of modifiable risk factors such as weight and lifestyle (The British Diabetic Association). Another form of diabetes is neonatal diabetes, which is

diagnosed before six months of age (The British Diabetic Association). Furthermore, Wolfram Syndrome is a rare genetic disorder that is a combination of four common features, which include diabetes insipidus, diabetes mellitus, optic atrophy, and deafness (The British Diabetic Association). Additionally, another rare, genetically inherited diabetic syndrome is Alström Syndrome. Some key features included in this syndrome are retinal degeneration, hearing loss, cardiomyopathy, obesity, type 2 diabetes, kidney failure, orthopedic and rheumatology problems (The British Diabetic Association). There is also Latent Autoimmune Diabetes in Adults, which has similarities between both Type 1 and Type 2 Diabetes, which is why some people even call it Type 1.5 Diabetes (The British Diabetic Association). On the contrary, it is not classified as it's own separate type yet but has medical research surrounding it to pinpoint the differences (The British Diabetic Association). Lastly, there is Type 3c Diabetes, which is when another disease damages the pancreas, such as pancreatic cancer, pancreatitis, cystic fibrosis, haemochromatosis, or even if someone had part or the entire pancreas removed (The British Diabetic Association). However, there are three most common types of diabetes: Type 1, Type 2, and gestational. Although there are many different types and syndromes of diabetes, this thesis will primarily focus on gestational.

Type 1 Diabetes

Type 1 commonly occurs at an earlier age in which there is an elimination of B cells, therefore the need of an outside source of insulin (Moncrieff, 2018). It affects approximately 1.25 million people in the United States (Beyond Type 1). It is the most common metabolic disorder in children and adolescents, and the incidence is rising by 3-4% each year (Ziegler & Neu, 2018). By the year 2050, it is expected that 5 million people in the United States will be diagnosed with type 1 diabetes (Beyond Type 1). A child with a sibling who has a diagnosis of

type 1 has a 5% risk of developing the disease, while children with a parent of type 1 has a risk between 5-7% of developing the disease (Ziegler & Neu, 2018). Diagnosis of type 1 diabetes is based off of typical symptoms including polydipsia, polyuria, weight loss, and blood sugar measurements (Ziegler & Neu, 2018). Other signs may include decreased general health, shortness of breath, abdominal pain, and vomiting (Ziegler & Neu, 2018). Treatment for this disease is insulin therapy; but individual self-monitoring of blood sugar as well as education for the patient and family are also important aspects (Ziegler & Neu, 2018). The goal for the HbA1c value is under 7.5% (Ziegler & Neu, 2018). Insulin pump therapy is most useful for preschool children, which is also known as a continuous subcutaneous infusion and mimics the body's function the most (Ziegler & Neu, 2018). After the diagnosis of type 1 diabetes, it is imperative to provide screening practices during well visits due to the many complications associated with the disease. These screenings include checking for retinopathy, nephropathy, neuropathy, hypertension, and hyperlipidemia; if therapies to fix the complications are unsuccessful then further interventions and medications are administered to the patient such as use of intravitreous injections, ACE inhibitors, AT-I blockers, or administrations of statins (Ziegler & Neu, 2018).

Type 2 Diabetes

Type 2 diabetes usually occurs later on in life due to insulin resistance or faulty insulin production and is linked to obesity as well as a sedentary lifestyle (Moncrieff, 2018). The majority of diabetes cases are type 2 diabetes, accounting for 90-95% of the total 34 million diabetes cases in the United States (CDC, 2019b). 25% of people over the age of 65 have type 2 diabetes, and there is an alarming increase in the rate of younger patients and even teenagers that have been diagnosed (Wysham, 2018). By the time patients are diagnosed with this disease, 35 to 40% of B-cell function had already been lost (Wysham, 2018). Good glycemic control is the

answer to decreasing the long-term micro and macrovascular complications by 37% (Wysham, 2018). Long-term complications of type 2 diabetes include retinopathy, nephropathy, stroke, myocardial infarction, heart failure, and neuropathy (Wysham, 2018). Diet, exercise, diabetes education, and metformin are recommended guidelines to manage the disease (Wysham, 2018). Weight loss is especially important because it improves insulin sensitivity, reduces hepatic glucose production, decreases li-polysis, and decreases fat in the liver (Wysham, 2018). Weight loss as small as 5% has been proven beneficial in improving glycemic control (Wysham, 2018). However, due to the progressive nature of the disease diet and exercise without medications are not enough to live complication-free (Wysham, 2018). Different medications along with healthy life-style choices are essential to living with type 2 diabetes without complications (Wysham, 2018).

Comparing Diabetes

The onset of gestational diabetes differs from type 1 and 2 in which hyperglycemia is first diagnosed during pregnancy, commonly the third trimester, and is thought to be a result of metabolic changes as well as predisposition to GDM (Moncrieff, 2018). The long-term effects of gestational diabetes differs from type 1 and 2, in which it can lead to Type 2 diabetes and cardiovascular disease to the mother; and obesity and type 2 diabetes for the child (Moncrieff, 2018). Both type 1 and 2 can lead to vascular disease, which can result in kidney failure, blindness, stroke, or death (Moncrieff, 2018). However, some women who are diagnosed with GDM do not realize the lifelong impact that it may have, such as the potential for acquiring type 2 diabetes in the future. For instance, a woman described GDM stating, “It is like a cold, but it lasts a little bit longer because of the baby, but you stay on the diet or take the medication and you will be fine afterwards” (Tang et al, 2014, p. 1530). This statement is not always the case,

for women who were diagnosed with gestational diabetes are recommended to have a healthy balance between diet and weight for the rest of their lives to avoid unfavorable outcomes.

Pregnancy

During the first half of pregnancy there is actually an improvement in insulin sensitivity, which promotes the storage of energy substrates for their use later on in the pregnancy and therefore supports the action of insulin (Moncrieff, 2018). However, during the second and third trimester there is an increase in insulin resistance (Moncrieff, 2018). This increase is to allow mobilization of glucose and amino acids to be transferred to the fetus, which is why the second half of pregnancy is considered "diabetogenic" (Moncrieff, 2018). In return, there is a reduced uptake of glucose to compensate for the increase in insulin secretion by pancreatic B cells and normalize blood glucose levels (Moncrieff, 2018). The reason why 9.2% of pregnant woman develop gestational diabetes is due to body's inability to counter glucose utilization and insulin production (Bone, 2015).

Gestational Diabetes

Dr. J.P. Hoet described the first written record of the obstetrical risk associated with diabetes in pregnancy (Knopp, 2002). Dr. Hoet had written it in French and it was then translated into English in 1954 to be included in the journal *Diabetes* (Knopp, 2002). As a part of the epidemiology of chronic diseases team in Boston, Massachussetts, Dr. John B. O'Sullivan and his colleagues were unsure of methods to diagnose pregnant women with gestational diabetes (Knopp, 2002). In the mid-1950s, Dr. O'Sullivan performed 100-g oral glucose tests mainly in the second and third trimester, which became the standard for gestational diabetes detection for the next 40 years (Knopp, 2002).

In the United States, 2%-10% of pregnancies are affected by gestational diabetes (CDC, 2019a). Risk factors include having had gestational diabetes in a previous pregnancy, having had given birth to a baby who weighed more than nine pounds, being overweight, being more than 25 years old, having a familial history of type 2 diabetes, having polycystic ovary syndrome, and are from the following ethnicities: African American, Hispanic, American Indian, Alaskan native, Hawaiian native, or Pacific Islander (CDC, 2019c).

Gestational diabetes happens when there is a deficiency in the compensatory insulin secretion and the woman's body cannot meet the level of insulin resistance, which leads to glucose intolerance and hyperglycemia (Moncrieff, 2018). This may be due to a decrease in pancreatic B cell activity, an increase in insulin resistance, or a combination of the two factors (Moncrieff, 2018). Gestational diabetes also may be due to an underlying metabolic vulnerability and as a result, the body cannot withstand the additional metabolic stress that the "diabetogenic" state of pregnancy (Moncrieff, 2018). This underlying vulnerability is most likely due from genetic predisposition or familial genetic influences, such as having a familial history of type 2 diabetes or gestational diabetes. This vulnerability can also be linked to one single factor or a combination of factors such as being obese or overweight and pregnancy may tip this very delicate metabolic balance (Moncrieff, 2018). Genetic influences in gestational diabetes include insulin signaling and biochemical mediators; which can predispose women with type 2 diabetes in future (Moncrieff, 2018).

Determinants of health may also play a role. For instance, prevention of gestational diabetes includes eating healthy foods and watching portion sizes (Mayo Clinic, 2017). However, low socioeconomic neighborhoods have less healthy options, but instead, more fast food options. Furthermore, staying active before and during pregnancy, with at least 30 minutes

of moderate activity on most days, can help prevent gestational diabetes (Mayo Clinic, 2017). It is also recommended to start pregnancy at a healthy weight and to not gain more weight than recommended (Mayo Clinic, 2017). On the other hand some women do not have access to safe neighborhoods to walk or bike in, as well as cannot afford or make the time to go to the gym due to other priorities such as watching other children. Women in lower socioeconomic classes may have more trouble trying to prevent gestational diabetes because of lack of access to healthy choices and safe exercise environments, but also may be due to lack of access to prenatal care.

Testing

During the first prenatal visit, it is common that strategies for detecting and diagnosing hyperglycemic disorders will be discussed and that values for fasting plasma glucose, A1c, or random plasma glucose will be completed on high-risk women (Bone, 2015). High-risk would include women with family history of diabetes or women who are overweight or obese. GDM is usually diagnosed during 24 to 28 weeks of gestation with a two-step approach that is composed first of a 50-g challenge test followed by a 75-g oral glucose tolerance test and the value is then measured one hour after (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Glycemia is considered 92mg/dl at baseline, 180mg/dl at the one-hour mark, and 153mg/dl at the two-hour mark (Capula et al., 2013). If the one-hour glucose level during the challenge test is more than 180mg/dl, then they are classified with gestational diabetes (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Women who receive a value ranging between 140mg/dl and 180mg/dl are to continue on to the second step of the 75-g oral glucose tolerance test (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). If the fasting glucose level is greater than or equal to 110mg/dl or the two-hour glucose concentration is more than or equal to 140mg/dl, they were diagnosed with GDM (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). However, there is an argument

regarding the timing of diagnostic screening methods considering that it may be too late for interventions to be implemented and that the impact may not be accomplished in its full extent (Moncrieff, 2018). Diagnosis should be completed earlier on in the pregnancy so a treatment plan can be in place, which would include strategies to decrease the risk of adverse outcomes, such as diet and exercise.

Diet

With the diagnosis of gestational diabetes, it is important to implement weight control through a healthy diet. Although dieting will not cure gestational diabetes, it can considerably help in decreasing obstetric complications, which include gestational hypertension, pre-eclampsia, and shoulder dystocia (Bone, 2015). Even though it is not often recommended for pregnant woman to be on a weight loss diet, women who are overweight and suffering from GDM can reduce their caloric intake to up to 30% without causing harm or ketosis (Bone, 2015). A balanced diet composed of carbohydrates, proteins, and fats should be considered for dietary interventions (Bone, 2015). Diets such as the Mediterranean diet, Dietary Approaches to Stop Hypertension diet, and alternate Healthy Eating Index diet were correlated with a lower risk of developing type 2 diabetes as a long-term outcome (Moon, Kwak, & Jang, 2016). Therefore it is important to note that compliance will not only aid with their current state, but also decrease their risk of type 2 diabetes in the future (Rayanagoudar et al, 2016). On the other hand, women do report diet being the most bothersome aspect of gestational diabetes management (Kopec, Ogonowski, Rahman, & Miazgowski, 2014).

Exercise

It is common that woman feel that needing to take care of older children take away the time to get in exercise throughout the day, saying that they feel “selfish” (Tang et al, 2014).

However, a minimum of thirty minutes of exercise on most days of the week is recommended during pregnancy; which include walking, weight-bearing exercises, and light-intensity resistance training, but does not include abdominal contraction exercises (Bone, 2015). Women who followed this recommendation were less likely to have a large infant for gestational age (Bone, 2015). Furthermore, implementing exercise into their lifestyle after pregnancy would decrease their lifetime risk of getting type 2 diabetes, cardiovascular disease, and other unwanted long-term effects of gestational diabetes.

Insulin

Insulin and hypoglycemic agents have also been used throughout pregnancy to manage GDM. Nonetheless, insulin therapy is not for everyone. Gestational diabetes is divided up into two subcategories; those who can reach a normal glycemic levels with a change of diet and those who need insulin in order to achieve the same levels (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). All women with GDM, regardless of whether or not they are using insulin, should know how to use a glucometer in order to what their blood glucose levels are at (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Monitoring blood glucose is a great way for women to know if their plan of care is working. Most women on insulin reported injecting it themselves, receiving these injections ranging anywhere from once to four times or more daily (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). The downside of treating GDM with insulin is that it has shown to have higher risk of perinatal mortality, when compared to diet-treated GDM (Billionnet et al, 2017). Furthermore, women being treated with insulin report having lower well being compared to those being treated with diet (Kopec, Ogonowski, Rahman, & Miazgowski, 2014).

Final Thoughts

Screening and diagnosing gestational diabetes are imperative in order to implement interventions needed to have a safer and happier pregnancy experience. Women who are diagnosed should be educated thoroughly on a diet and exercise plan that can work for their individualized lifestyle. Women with GDM should also know the importance of using a glucometer throughout their pregnancy, therefore they can see for themselves whether what they are implementing is enough to keep their glycemic levels normal. If they cannot keep their glycemic levels normal with diet and exercise, then insulin is to be used; however, education is still needed on the risks that can be associated with this.

Furthermore, thinking that gestational diabetes is simply a temporary disease will not help with compliance, however if patients are also educated on the significant impact that GDM can have on their future, such as the risk of having Type 2 diabetes, then maybe they will be more willing to comply to their treatment regimen. After reviewing the current state of evidence surrounding the outcomes associated with gestational diabetes mellitus for both mother and baby, educating upon the research questions of this literature review: What are the effects of gestational diabetes on subsequent pregnancies in adult women, what are the long-term effects for the mother that can occur after gestational diabetes, do women who have gestational diabetes have a higher risk of developing Type 2 diabetes and when does this risk occur, what are the short term and long term effects of gestational diabetes on the child who is born and lastly does gestational diabetes run in families; may help patients understand why treating themselves now may aid in their future health as well as their infant's future health.

Methods

A literature review was performed to identify current outcomes associated with gestational diabetes. Databases used were CINAHL and Medline. These databases were searched

for peer-reviewed articles, as well as articles published ranging from the year 2014-2018. Key terms were used throughout the databases in order to extract the most applicable articles for this literature review. Key terms included gestational *diabetes, pregnancy, type 2 diabetes, maternal outcomes, and neonatal outcomes.*

The inclusion criteria for articles that will be discussed in this systematic review is as follows:

a) Articles must be peer-reviewed.
b) Articles must be either research studies or literature reviews.
c) Articles that are research studies must be IRB approved.
d) Articles must be focused on risk factors of gestational diabetes.
e) Articles must be focused on gestational diabetes outcomes.

Exclusion criteria are as follows:

a) Articles that concentrate on breastfeeding as prevention of type 2 diabetes.
b) Articles that focus on pros and cons of screening techniques for gestational diabetes.
c) Articles that solely describe dieting and exercise practices for women who have gestational diabetes.
d) Articles that focus on relationships of genes in gestational diabetes.
e) Articles that describe pregnancy with type 2 diabetes, rather than pregnancy with gestational diabetes.

A total of 31 articles used in this literature review. 24 of those articles were primary research and used for the findings. 23 of those research studies were quantitative, while only 1 was qualitative. 7 literature reviews were retrieved for this thesis. However, information obtained from those reviews was only used to provide contextual data and information for the

introduction and background, therefore they were not evaluated as part of the article used in the analysis. Most of the articles are from the United States of America, however there were other articles that were included from France, Italy, Korea, Palau, and Saudi Arabia. Refer to the table on page 28.

Findings

Subsequent Pregnancies

One single gestational diabetes pregnancy increases the risk for gestational diabetes in future pregnancies (Getahun, Nath, Ananth, & Smulian, 2008). Gestational diabetes recurrence across subsequent pregnancies was found to be fairly consistent across approaches, ranging from 38.4% to 47.7% (England et al, 2015). For instance, there is a 41% risk in the second pregnancy of gestational diabetes if a woman had it in the first pregnancy (Getahun, Nath, Ananth, & Smulian, 2008). This can be compared to the 4% risk of gestational diabetes of women who did not have it in their first pregnancy (Getahun, Nath, Ananth, & Smulian, 2008). For the third pregnancy, there is a 57% chance of gestational diabetes if a woman had gestational diabetes in the first two pregnancies (Getahun, Nath, Ananth, & Smulian, 2008). However, the women who were found to have recurrent GDM were found to be older and more likely to be foreign born, which are already risk factors of gestational diabetes (England et al, 2015).

It is determined that high maternal pre-pregnancy BMI is the main factor of gestational diabetes reoccurrence (Wong, Chong, Chenn, & Jalaludin, 2019). With that being said, limiting weight gain in between pregnancies would decrease the risk of developing gestational diabetes in their subsequent pregnancies (Wong, Chong, Chenn, & Jalaludin, 2019). Women who had gestational diabetes with previous pregnancies should be made aware that there is a higher chance of them getting it again with each pregnancy from then on. Modification of lifestyle

between pregnancies which result in weight loss and less weight gain during pregnancy, along with improved nutrition or increased physical activity are most likely the reason why mothers with a history of GDM did not get it again in their next pregnancy (England et al, 2015). Mothers who had gestational diabetes describe the risk of type 2 diabetes as a motivator for behavior change; however they did not describe the prevention of GDM in subsequent pregnancies to be a motivator (Tang et al, 2014). While only a few research studies suggested that gestational diabetes in future pregnancies was important, discussing subsequent pregnancies should be part of the education portion of the gestational diabetes diagnosis. This would help motivate mothers with GDM to implement lifestyle changes that would help in decreasing the likelihood of getting it again with future pregnancies.

Long-term Effects on Mothers

There are multiple long-term influences that may affect mothers who have experienced gestational diabetes. For instance, there is 2.5-fold increase in developing metabolic syndrome (Gunderson et al, 2009). Gestational diabetes can cause unfavorable changes in HDL and triglyceride levels (Cho, Jan, Park, & Cho, 2014). There is also a predicted 1.7-fold increase in developing cardiovascular disease (Shah, Retnakaran, & Booth, 2008). Greater vascular resistance, lower stroke volume, lower cardiac output, and higher intimal medial thickness are noted when compared to women without gestational diabetes (Heitritter, Solomon, Mitchell, Skali-Ounis, & Seely, 2005). Usually being female is a protective factor against developing cardiovascular disease, however women with history of gestational diabetes and later the development of type 2 diabetes, negates the protective effect of being female, and therefore the risk increases to that of a male (Carr et al, 2006). Furthermore, women who had gestational diabetes have more cardiovascular events and at earlier ages (Carr et al, 2006). Heart disease is

the leasing cause of death with women who are affected by cardiovascular disease due to the root cause of gestational diabetes (Carr et al, 2006). The inflammatory markers that are correlated with cardiovascular disease include C-reactive protein, IL-6, and plasminogen activator inhibitor-1 (Heitritter, Solomon, Mitchell, Skali-Ounis, & Seely, 2005). Women with gestational diabetes had higher levels of these inflammatory markers which puts this population ar isk for developing cardiovascular disease (Heitritter, Solomon, Mitchell, Skali-Ounis, & Seely, 2005). Metabolic and cardiovascular changes combined ultimately causes metabolic syndrome, which is defined as central body adiposity, dyslipidemia, hypertension, and elevated fasting glucose (Carr et al, 2006). Women with family history of type 2 diabetes have an increased risk for developing metabolic syndrome (Carr et al, 2006). It is imperative that providers address all of these long-term affects on mothers and discuss a plan of care regarding primary prevention of cardiovascular disease and metabolic syndrome due to mother's increased risk stemming from their history of gestational diabetes.

Risk of Type 2 Diabetes

It is known that mothers with a history of gestational diabetes have an increased risk of developing type 2 diabetes in the future. 50% of the research articles supported this correlation. Immediately following pregnancy, 5-10% of mothers with gestational diabetes were found to have type 2 diabetes in the United States (Sugiyama et al., 2017). Furthermore, 35-60% of women with previous gestational diabetes will develop diabetes within the next 10-20 years (Sugiyama et al., 2017). Although type 2 diabetes is a risk factor for women who have had gestational diabetes, other factors can increase that risk even more. There are multiple unmodifiable factors such as family history of type 2 diabetes and personal history of gestational diabetes, and modifiable factors such as weight and current and future health behaviors (Tang et

al, 2014). For instance, preterm deliveries from gestational diabetes were further associated with future onset of type 2 diabetes (Rayanagoudar et al, 2016). There is also a greater risk of progression of type 2 diabetes in non-white women; which is seen in blacks and Asians when compared to white women (Rayanagoudar et al, 2016). Family history and weight status play a pivotal role in the development of type 2 diabetes (Twafik, 2016). For example, an obese woman with a positive family history of type 2 diabetes has an increased risk and therefore should have take more control of their postpartum weight (Twafik, 2016).

For that reason, it is recommended to receive testing for type 2 diabetes 4-12 weeks postpartum as well as lifelong monitoring; even for women with normal results (Deputy, Kim, Conrey, & Bullard, 2018). Structured lifestyle change programs that are CDC-recognized can help promote a healthy diet and lifestyle for mothers with history of gestational diabetes and therefore reduce the risk of type 2 diabetes (Deputy, Kim, Conrey, & Bullard, 2018). Women who had a history of gestational diabetes but did not develop type 2 diabetes in the future implemented lifestyle interventions that reduced weight retention and improved markers of insulin resistance (Deputy, Kim, Conrey, & Bullard, 2018). There are several perceived barriers that mothers reported to engaging in healthy behaviors such as lack of time and lack of childcare, emotional barriers, and lack of motivation (Tang et al, 2014). Mothers reported that motivators for improving health behaviors included to avoid type 2 diabetes, to stay healthy to take care of their children, and to be a role model for their children (Tang et al, 2014). It is important to target women with gestational diabetes who have additional risks such as non-white women and women with family history of diabetes. By doing so, nurses can teach higher risk women the significance of controlling their postpartum weights and maintain healthy lifestyles. Furthermore,

healthcare providers can pinpoint barriers and motivators to help develop an individualized plan to decrease the risk of type 2 diabetes.

Effects on Child

There are several short-term effects of the children from mothers who had gestational diabetes. Macrosomia of the infant, otherwise known as birth weight more than the 90th percentile is one of the most common effects on the child (Billionnet et al, 2017). Women with gestational diabetes have a significant increase in macrosomia when compared to women without gestational diabetes (Lu, Huang, Yan, & Wang, 2016). For instance there is a twofold-increased risk for offspring of mothers with GDM to have macrosomia (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb, 2017). 7 out of 24 articles mentioned macrosomia as a neonatal outcome. Other short-term effects included erb'spalsy, clavicle fracture, congenital malformations, perinatal death, birth asphyxia (Billionnet et al, 2017). However, prenatal mortality is more common in less develop nations than developed nations (Sugiyama et al., 2017). There is also a threefold increased risk of stillbirths was noted in these children (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb, 2017). A 30% increase in the operating room for perinatal death was noted in the gestational diabetes group when compared to the group without GDM (Billionnet et al, 2017). Admission to the neonatal intensive unit increases for this population, especially with higher glucose levels (Lu, Huang, Yan, & Wang, 2016). There is a fourfold increase in APGAR scores lower than 7 for a full term newborn, which leads to a twofold increase in NICU admission. The newborn's increased rate of NICU admissions suggests that extensive medical interventions needed to be performed (Capula et al, 2013). Respiratory distress syndrome is also a concern for there is an increased incidence in assisted ventilation, surfactant use, and antibiotic use (Vilchez et al, 2015). (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb. 2017). When compared

to neonates who were born from mothers without gestational diabetes, neonatal seizures are more common (Vilchez et al, 2015). Factors that are associated with neonatal seizures are due to the hypocalcaemia, hypoglycemia, and polycythemia related to gestational diabetes (Vilchez et al, 2015).

In addition to the short-term effects on the child, there are quite significant long-term effects on adult offspring of mothers with GDM. At the 6-month follow-up appointment, mothers with gestational diabetes had children with significantly higher body mass indexes when compared to mothers with normal glucose levels during pregnancy (König, Junginger, Reusch, Louwen, & Badenhoop, 2014). Excessive body mass of these children can be a risk factor for pre-diabetes and type 2 diabetes in the future. It appears that a hyperglycemic intrauterine environment may be involved in the pathogenesis of pre-diabetes and type 2 diabetes once the children become adults (Clausen et al, 2008). On the other hand, the presence of pre-diabetes and type 2 diabetes are more often in the offspring of a Caucasian woman with GDM (Clausen et al, 2008). Identification of high-risk groups of pregnant women should have education of implementing lifestyle interventions to decrease the risk of getting GDM. Therefore, they will have the goal of a normoglycemic intrauterine environment and will decrease the risk of type 2 diabetes in the future generations (Clausen et al, 2008).

Familial Implication

Mothers reported that gestational diabetes ran in their families (König, Junginger, Reusch, Louwen, & Badenhoop, 2014). Gestational diabetes can become a vicious cycle, affecting multiple mothers in one family tree. For example, the daughter of a mother who has gestational diabetes becomes obese and gets pregnant, therefore developing gestational diabetes herself, and the cycle goes on and on (König, Junginger, Reusch, Louwen, & Badenhoop, 2014).

GDM has found to be twice as common among daughters of diabetic mothers, which includes gestational diabetes, type 1 diabetes, and type 2 diabetes (McLean, Chipps, & Cheung, 2006). On the other hand, a daughter with a diabetic mother and a diabetic father were not more likely to have gestational diabetes than a daughter with just a diabetic mother (McLean, Chipps, & Cheung, 2006). Therefore, this shows that there is a genetic predisposition to gestational diabetes and that hyperglycemia in pregnancy in addition to genetic factors can produce gestational diabetes in following generations (McLean, Chipps, & Cheung, 2006).

Furthermore, there is a positive association between fetal exposure to heavy maternal smoking on top of having gestational diabetes during pregnancy and the risk of daughters developing gestational diabetes themselves in the future (Bao et al, 2016). It was found that maternal smoking equal to or more than 25 cigarettes per day was associated with a 98% higher risk of gestational diabetes in the daughter (Bao et al, 2016). This correlation may be due to the environmental insult in utero, which can lead to metabolic changes in the fetus and therefore result in impaired glucose metabolism and metabolic disease in the future, such as gestational diabetes, in the future (Bao et al, 2016). These metabolic changes along with familial history of gestational diabetes would increase the risk of getting GDM even more for the daughter. On the other hand, if appropriate education about smoking and decreasing the overall risk for gestational diabetes is implemented for women who are deemed a higher risk, the gestational diabetes cycle may come to an end. For instance, by teaching the child of the mother with gestational diabetes that GDM is a risk and that diet, exercise, and a healthy weight are needed to decrease that risk, then it is less likely for this cycle to occur. Additionally, the earlier this association is taught to the daughter, the more time the daughter has to conduct healthy behaviors.

Thoughts on Disease

Literature on the topic of gestational diabetes support that women felt varying degrees of distress and some of the major concerns included anxiety, fear and despair, loss of control, failure, guilt, worries about own health and babies' health (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Support and education regarding gestational diabetes would help ease common stressors. It was found that the women who measured their blood glucose levels more frequently had increased levels of stress (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Even though it is important to check blood glucoses regularly, it should not be done more than the recommended amount due to increased stress levels. Furthermore, women who were neutral or unsatisfied with their treatment and care were more stressed (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Additionally, women who had less knowledge on gestational diabetes also had an increase in stress (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). 26% of women felt that gestational diabetes had an affect on their social life during the beginning of pregnancy and this percentage rose to 35% by the end of pregnancy (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). In addition, 14% of women reported that gestational diabetes interfered with their families in the beginning of their pregnancy, which increased to 26% by the end of pregnancy (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Main factors that contributed towards no postpartum follow up included time pressure, emotional stress to adjust to baby, and fear of being diagnosed with diabetes (Nielsen, Kapur, Damm, Courten, & Bygbjerg, 2014). These factors need to be addressed by providers and nurses before hospital discharge in order to make sure that women will be able to take care of themselves after the pregnancy.

Education for Pregnant Women

Many of the articles supported an increase in education on gestational diabetes. This is especially important for women with lower levels of education because they may have less

assess to resources as well as different perspectives about their diagnoses and future health risks (Tang et al, 2014). Women who are in the reproductive age group should receive health education concerning the serious adverse effects of diabetes and obesity on their reproductive life (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb, 2017). For example, information on this topic should be integrated into schools and universities (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb, 2017). Comprehensive educational programs specifically on gestational diabetes are needed in order to increase patient awareness (Twafik, 2016). Theory-based educational programs are recommended to apply cognitive frameworks, such as those used in primary care (Twafik, 2016). There also should be an emphasis on nurses providing education and support individually tailored to each patient's needs regarding gestational diabetes (Kopec, Ogonowski, Rahman, & Miazgowski, 2014). Education should be individualized because every woman has different medical history such as familial events of diabetes as well as different diets, weights, and exercise regimens that need to be considered to properly set up a plan.

Table I. *Summary of findings: gestational diabetes outcomes*

Authors/Article Title	**Purpose**	**Type of Study (review or research study)/ sample size**	**Methods**	**Main Outcomes**
Anderson, Spicer, & Peercy. (2016) Obesity, Diabetes, and Birth Outcomes Among American Indians and Alaska Natives	To compare statistics between American Indian and Alaskan Native women with white, African American, and Hispanic women.	Research study 5,193,386 U.S. first births	Quantitative descriptive study	American Indian and Alaskan Natives have higher rates of being overweight and obese. There is a higher percentage of American Indian/Alaska Native rates of gestational diabetes.
Bao et al. (2016) Parental smoking during pregnancy and the risk of gestational diabetes in the daughter	To determine if fetal exposure to smoking increases risk of GDM in the daughter.	Research study 15,665 singleton pregnancies	Quantitative descriptive study	There is an observed positive association between heavy maternal smoking during pregnancy and risk of GDM in the daughter.
Billionnet et al. (2017) Gestational diabetes and adverse perinatal outcomes from 716,152 births in France in 2012	GDM expressed risks of preterm birth, pre-eclampsia/eclampsia, macrosomia, respiratory distress, birth trauma, and cardiac malformations. The researchers found that there were more risks in women with GDM who were treated with insulin rather than women who were treated with a change of diet.	Research study 716,152 births in France	Quantitative descriptive study	The researchers found that there were more risks in women with GDM who were treated with insulin rather than women who were treated with a change of diet.

Bone. (2015) Big Babies: An Exploration of Gestational Diabetes	To summarize maternal and neonatal risks of gestational diabetes.	Literature review 26 articles	Online search retrieval	Women with gestational diabetes are at risk for Type 2 diabetes and metabolic syndrome. Neonates are at risk for Type 2 diabetes in the future due to in-utero exposure of hyperglycemia.
Capula et al. (2013) Gestational Diabetes Mellitus: Screening and Outcomes in Southern Italian Pregnant Women	To promote GDM screening practices and determines neonatal outcomes.	Research study 2,448 pregnant women in Italy	Quantitative descriptive study	Screening is important to determine whether or not a woman has gestational diabetes. GDM was not found to be associated with stillbirths, neonatal deaths, or nerve palsy. However, GDM was strongly associated with admission to the NICU, mostly from respiratory problems.
Carr et al. (2006) Gestational diabetes mellitus increases the risk of cardiovascular disease in women with a family history of type 2 diabetes	To determine whether past gestational diabetes increases cardiovascular disease in women with a familial history of type 2 diabetes.	Research study 332 women with history of gestational diabetes and 663 women without a history of gestational diabetes	Quantitative descriptive study	Women with familial history of type 2 diabetes and experience gestational diabetes during their pregnancy have an increased risk of cardiovascular disease, including metabolic syndrome and type 2 diabetes, and experienced these at younger ages.
Cho, Jan, Park, & Cho. (2006) Waist circumference is the key risk factor for diabetes in Korean women with history of gestational diabetes	To investigate relationships between obesity and the onset of type 2 diabetes in Korean women.	Research study 909 women with a history of gestational diabetes	Quantitative descriptive study	Diabetes incidence within 6 years of having gestational diabetes was 12.8% and increased significantly with obese women.
Clausen et al. (2008).	To determine the role of intrauterine hyperglycemia	Research Study 597 women, aged 18-27	Quantitative descriptive	Hyperglycemic intrauterine environments may be involved in

High Prevelance of type 2 diabetes and pre-diabetes in adult offspring of women with gestational diabetes mellitus or type 1 diabetes: the rold of intrauterine hyperglycemia	and future risk of type 2 diabetes in human offspring from women with gestational diabetes or type 1 diabetes.	years	study	type 2 diabetes and pre-diabetes of adult offspring.
Deputy, Kim, Conrey, & Bullard. (2018) Prevalence and Changes in Preexisting Diabetes and Gestational Diabetes Among Women Who Had a Live Birth- United States 2012-2016	To evaluate the correlation between age and GDM, as well as weight and GDM.	Research study 3,942,094 women; 6% with GDM	Quantitative descriptive study	There is a positive correlation between age and developing gestational diabetes. There is also a positive correlation between weight and developing GDM.
England et al. (2015) Estimating the recurrence rate of gestational diabetes mellitus (GDM) in Massachusetts 1998-2007: Methods and findings	To identify if women with GDM have an increased risk of developing recurrent GDM in future pregnancies.	Research Study 134,670 women with two sequential deliveries	Quantitative descriptive study	GDM recurrence was fairly consistent; nearly half of the women with GDM in one pregnancy developed it again with subsequent pregnancy.
Getahun, Nath, Ananth, Chavez, & Smulian. (2008) Gestational diabetes in the United States: temporal trends 1989 through 2004.	To characterize trends in gestational diabetes by maternal age, race, and geographic region within the United States.	Research Study Births in the United States between 1989 and 2004; n= 58.922,266	Quantitative descriptive study	Rates of gestational diabetes have increased in the United States significantly between 1989 and 2004.
Gundersen et al. (2009)	To examine whether childbearing has a higher	Research study 1452 multiparas aged	Quantitative descriptive	An increase in parity is associated with an increase risk of developing

Childbearing is associated with higher incidence of the metabolic syndrome among women of reproductive age controlling for measurements before pregnancy: the CARDIA study	incidence of metabolic syndrome post-delivery.	18-30 years	study	metabolic syndrome, regardless of obesity and weight gain during pregnancy.
Heitritter, Solomon, Mitchell Skali-Ounis, & Seely. (2005) Subclinical inflammation and vascular dysfunction in women with previous gestational diabetes mellitus	To compare biochemical and hemodynamic markers of cardiovascular disease in nondiabetc women with history of gestational diabetes.	Research study 25 premenopausal healthy women with a history of gestational diabetes and 23 premenopausal healthy women with a history of normal pregnancy	Cross sectional study	Women with a history of gestational diabetes had higher mean levels of cardiovascular disease markers and increased peripheral vascular resistance as well as decreased cardiac output when compared to the control group.
Lu, Huang, Yan, & Wang. (2016) Use of the National Diabetes Data Group and the Carpenter-Coustan criteria for assessing gestational diabetes mellitus and risk of adverse pregnancy outcome	To evaluate neonatal outcomes in women with GDM.	Research study 11,486 Taiwanese pregnancies	Retrospective cohort study	Neonates born from a woman with GDM have a greater risk of macrosomia, low-birth weight, and admission to the NICU.
Kim. (2014) Maternal outcomes and follow-up gestational diabetes mellitus	To summarize the risk factors of developing gestational diabetes in the future.	Literature review 86 articles	Online search retrieval	Women with gestational diabetes in their first pregnancy have a 41% risk of GDM in their second pregnancy, while there is only a 4% chance of women without GDM in their first pregnancy. Women

				increased their chances of gestational diabetes with each unit of BMI gained between pregnancies. Women who were overweight or obese are able to decrease their risk of gestational diabetes by losing weight.
Köing, Junginger, Reusch, Louwen, & Badenhoop (2014) Gestational diabetes outcome in a single center study: Higher BMI in children after six months	To examine obstetric outcomes and metabolic disorders in patients with gestational diabetes and their offspring.	Research study 130 mothers with gestational diabetes and 77 mothers with normal glucose tolerance	Retrospective single center cohort study	Treatment of GDM could decrease the frequency of obstetric and neonatal complications.
Kopec, Ogonowski, Rahman, & Miazgowski. (2014) Patient-Reported Outcomes in Women with Gestational Diabetes: a Longitudinal Study	To evaluate if gestational diabetes affected women's social life.	Research study 205 women with GDM	Longitudinal study	Women who did not have proper information and social support surrounding GDM exhibited distress. Insulin treatment and frequency of blood glucose measurements were also associated with distress during pregnancy.
McLean, Chipps, & Cheung. (2006) Mother to child transmission of diabetes mellitus: does gestational diabetes program Type 2 diabetes in the next	To determine if gestational diabetes programs type 2 diabetes in following generations.	Research study 535 mothers with a family history of diabetes	Quantitative descriptive study	Gestational diabetes is twice as common in daughters of diabetic mothers.

generation?				
Moncrieff. (2018) Gestational Diabetes	To summarize maternal and neonatal short-term and long-term risks.	Literature review 36 articles	Online search retrieval	Short-term maternal risk includes hypertensive disorders, pre-eclampsia, caesarean delivery, birth trauma, and perineal tears. Short-term neonatal risks include macrosomia, shoulder dystocia, birth injury, neonatal hypoglycemia, polycythemia, hyperibilirubinaemia, and respiratory distress syndrome. Long-term maternal risks include Type-2 diabetes and cardiovascular disease. In-utero exposure predisposes offspring to obesity and Type-2 diabetes. Female offspring are predisposed to future gestational diabetes.
Moon, Kwak, & Jang. (2016) Prevention of type 2 diabetes mellitus in women with previous gestational diabetes mellitus	To summarize the risk gestational diabetes has on developing postpartum diabetes in the future.	Literature review	Online search retrieval	Women who have had GDM have a 7-fold higher risk of developing postpartum diabetes. 50% of women with GDM have an incidence of postpartum diabetes within the first 2 years postpartum.
Noctor & Dunne. (2015) Type 2 diabetes after gestational diabetes: The	To summarize prevention of Type 2 diabetes in women with gestational diabetes.	Literature review 107 articles	Online search retrieval	Increased follow up criteria Is needed to detect Type 2 diabetes in women who had previously been diagnosed with gestational diabetes.

influence of changing diagnostic criteria				
Rayanagoudar et al. (2016) Quantification of the type 2 diabetes risk in women with gestational diabetes: a systematic review and meta-analysis of 95,750 women	To summarize the risk factors that women with GDM had that could predispose them to future diabetes.	Research study 39 studies with a total of 95,750 women	Meta analysis	BMI, family history, non-white ethnicity, and advanced maternal age were risk factors associated with Type 2 diabetes. The earlier the diagnosis of GDM, raised fasting glucose, increased HbA1c and use of insulin all increased risk of GDM. Multiparty, hypertensive disorders during pregnancy, and preterm delivery contribute risks towards future diabetes.
Shah, Retnakaren, &Booth. (2008) Increased risk of cardiovascular disease in young women following gestational diabetes mellitus	To determine if women with gestational diabetes have an increased risk of cardiovascular disease.	Research study 8,191 women with GDM and 81,262 women without GDM	Quantitative descriptive study	Women with GDM have an increased risk for cardiovascular disease when compared to women without GDM.
Sugiyama et al. (2017) Assessment of Gestational Diabetes and Associated Risk Factors and Outcomes in the Pacific Island Nation of Palau	To determine both maternal and neonatal outcomes associated with gestational diabetes.	Research study 1,730 women with a single live birth in Palau	Retrospective cohort study	Women with GDM had a higher prevalence of high birth weight infants, cesarean sections, and neonatal deaths. Decreasing obesity rates in Palau would aid in reducing gestational diabetes in the women.
Tang et al. (2014) Perspectives on Prevention of	To determine whether or not women with gestational diabetes were taking proper	Research study 23 women; 8 Hispanics,	Qualitative program research	6 of the women were unaware of how GDM increases the risk of Type 2 diabetes. It is imperative

Type 2 Diabetes: A Qualitative Study of Hispanic, African-American and White Women	steps in order to prevent Type 2 diabetes in the future.	8 African-Americans, 7 Non Hispanic Whites		that health care workers educate their patients on potential outcomes. 11 women reported that they had no time, and/or lack of childcare in order to engage in a healthy lifestyle. 10 women reported lack of motivation in order to decrease their chance of Type 2 diabetes in the long run.
Twafik. (2016) The Impact of Health Education Intervention for Prevention and Early Detection of Type 2 Diabetes in Women with Gestational Diabetes	To delay and minimize the risk of developing Type 2 diabetes with health education.	Research study 201 participants	Quantitative descriptive study	Health education improves knowledge, beliefs, practices, and weight control at the end of pregnancy.
Vilchez et al. (2015) Labor and neonatal outcomes after term induction of labor in gestational diabetes	To compare outcomes of women with gestational diabetes versus women without gestational diabetes throughout their pregnancy.	Research study 273,043 cases; 176,079 non-GDM cases, 96,964 GDM cases	Quantitative descriptive study	Mothers with GDM have a higher chance of cesarean delivery and macrosomia >4500 grams. Women with GDM had higher rates of neonatal complications, assisted ventilation, NICU admission, antibiotic use, low apgar scores and neonatal seizures.
Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb. (2017)	To evaluate how age and BMI affect getting GDM.	Research study 9,723 women;	Quantitative descriptive	Prevalence of GDM and pre-GDM increases with age peaking at 40-44

Prevalence and Complications of Pregestational and Gestational Diabetes in Saudi Women: Analysis from Riyadh Mother and Baby Cohort Study (RAHMA)		2,354 women with GDM, 418 with pre-GDM, and 6,951 non-diabetic women	study	years old with GDM and 45+ with pre-GDM. As BMI increased, prevalence of GDM and pre-GDM also increased.
Wong, Chong, Chenn, & Jalaludin (2019) Factors predicting recurrence of gestational diabetes in a high-risk multi-ethnic population	To examine predictors for GDM reoccurrence in amulti-ethnic population.	Research study 3587 pregnancies complicated with GDM	Quantitative descriptive study	Women who have had GDM in a previous pregnancy have a high risk of recurrence in their next pregnancy. The strongest predictor of this is inter-pregnancy weight gain.
Wysham. (2018) What's New in the Evolving Management of Type 2 Diabetes: Individualizing Therapy with Novel Treatment Options	To compare treatment options for type 2 diabetes	Literature review 21 articles	Online search retrieval	Personalized therapy using a patient's phenotype should be used for the most effective and safe treatment. Medications should be chosen according to patient's attributes, genetics, and comorbities.
Ziegler & Neu. (2018) Diabetes in Childhood and Adolescence	To correctly diagnose type 1 diabetes in children and adolescents along with treatments and complications.	Literature review 40 articles	Online search retrieval	Presenting symptoms of children with diabetes includes polydipsia, polyuria, and weight loss. The goal of treatment is to reach normalcy for glucose metabolism, but children need individualized treatment so that goals can be met.

Discussion

This literature review attempted to summarize the current information on gestational diabetes while answering various research questions in order to understand the gaps in literature and in which areas further research should occur using a total of 31 articles. The first research question regarding the effects of gestational diabetes on subsequent pregnancies was determined as an increased risk of having gestational diabetes in subsequent pregnancies. The percentage of risk continues to increase with each pregnancy. For instance, there is a 41% risk of getting GDM again a second pregnancy, which increases to 57% for the third pregnancy (Getahun, Nath, Ananth, & Smulian, 2008). However, pre-pregnancy BMI is the main factor towards this increase in risk in subsequent pregnancies, therefore balancing a healthy BMI between pregnancies would actually help decrease the risk of having GDM again in another pregnancy (Wong, Chong, Chenn, & Jalaludin, 2019).

The research question regarding the long-term effects for mothers due to gestational diabetes were found to be metabolic syndrome and cardiovascular disorders. For example, there is a 2.5-fold increased risk of mothers with GDM to develop metabolic syndrome (Gunderson et al, 2009). This is due to the unfavorable changes in HDL and triglyceride level stemming from the main problem of gestational diabetes (Cho, Jan, Park, & Cho, 2014). Furthermore, there is a 1.7-increased risk of developing cardiovascular disorders (Shah, Retnakaran, & Booth, 2008). Gestational diabetes can cause greater vascular resistance, lower stroke volume, lower cardiac output, and higher intimal medial thickness (Heitritter, Solomon, Mitchell, Skali-Ounis, & Seely, 2005).

The third research question inquires about the risk of type 2 diabetes in mothers with GDM. It was found that immediately following pregnancy, 5-10% of mothers with gestational

diabetes had type 2 diabetes and 35-60% of women with previous gestational diabetes will develop type 2 diabetes within the next 10-20 years (Sugiyama et al., 2017). In addition to the increased risk, it was found that women with a preterm delivery or a non-white background had additional risk to type 2 diabetes (Rayanagoudar et al, 2016). Lastly, family history and weight status play the most important role in the development of type 2 diabetes with previous history of gestational diabetes; for an obese woman with a positive family history of type 2 diabetes has more risk than a woman with no family history and maintains a normal weight (Twafik, 2016).

The next research question examines the effects on the children with mothers who have GDM. The most common short term effect was found to be macrosomia. There is a twofold-increased risk for offspring of mothers with GDM to have macrosomia (Wahabi, Fayed, Esmaeil, Mamdouh, & Kotb, 2017). A lot of these newborns may also be sent to the neonatal intensive unit, especially with higher glucose levels and other varying problems that they may have (Lu, Huang, Yan, & Wang, 2016). The offspring of mothers with GDM may also experience pre-diabetes or type 2 diabetes as adults, due to the hypeglycemic intrauterine environment that they endured (Clausen et al, 2008).

The last research question asks about the genetic component or familial implication that gestational diabetes may have on future generations. It was found that a genetic predisposition to gestational diabetes is present and that hyperglycemia in pregnancy in addition to genetic factors such as familial history can produce gestational diabetes in following generations (McLean, Chipps, & Cheung, 2006). It is twice as common for daughters of diabetic mothers to have gestational diabetes in their own pregnancies (McLean, Chipps, & Cheung, 2006). In addition to the increased risk of female offspring to get GDM, it was found that maternal smoking equal to or more than 25 cigarettes per day was associated with a 98% higher risk of gestational diabetes

in the daughter (Bao et al, 2016).

Implications for further research

Future studies should examine lifestyle changes that mothers endure after the diagnosis of gestational diabetes to see if behavior alterations are able to adequately aid in decreasing adverse effects, such as diet and exercise. Additionally, following the mother's offspring throughout their lives and documenting their exercise and eating habits could determine whether or not type 2 diabetes or gestational diabetes in females are correlated with having a mother with gestational diabetes or if they would have gotten these co-morbidities due to their lifestyle would also be a substantial step taken in regards to this research. This review was unsuccessful in finding sufficient data regarding the entirety of the children's life. Furthermore, different educational approaches should be studied to summarize which one brings in the most mothers for follow up appointments as well as decide to make those lifestyle changes that will aid in decreasing future risks. This literature failed to find adequate educational programs on gestational diabetes and their effectiveness on mothers with gestational diabetes.

Implications for nursing practice

This literature review impacts the healthcare system because it stresses the importance of education for mothers with gestational diabetes on what to expect for themselves as well as their children. As a nurse, it is imperative to educate pregnant women on what risk factors they may have that could possibly predispose them to gestational diabetes, such as increased age and non-white race. By helping new mothers understand their risk factors, they may be better suited when and if they end up with gestational diabetes because they would already have some knowledge regarding the topic. Education on gestational diabetes should be implemented into each visit, especially if they have those risk factors. Education should also be carried out during follow up

appointments and well visits with their primary care physician. Enforcing this would allow mothers to recall upon information they already know and serve as a reminder to maintain healthy lifestyle choices to decrease long-term effects from gestational diabetes.

Implications for policy

In addition to increased education, it is imperative to advocate for better access to prenatal care in populations that have more rick factors and less resources (Anderson, Spicer, & Peercy, 2016). This would include non-Hispanic white populations such as American Indians and Alaskan Natives. If certain populations had better access to health care, then there would be reduced cases of gestational diabetes within that population and within generations. This reduction may cause a decrease in gestational diabetes overall. Considering gestational diabetes is estimated to affect approximately 5-7% of all pregnancies and that this percentage continues to increase worldwide, increasing education and access to better prenatal care may aid in the reduction of those affected (Moncrieff, 2018, p. 506).

Limitations

Limitations on this literature review include the timing of some of the research articles. Some of the research studies used in the findings section were more than 10 years old. This may be a potential limitation because information regarding gestational diabetes may have changed since then. Another potential limitation of this study is the sample profile. The research studies used were not only conducted in the United States of America, but rather other countries were used as well. Other countries may not have the same medical standards or standardized testing for gestational diabetes, which may be why they are experiencing more troubles with the disease.

Conclusion

All of the research questions have been answered through this literature review. The main component from this literature review is that pregnant women who have higher risk factors should be educated on how to implement lifestyle changes to decrease their risk of getting gestational diabetes. Even if they still end up having gestational diabetes, there are many ways that they can reduce their chances of having GDM again, or decrease the adverse outcomes through education. This way, women with previous history of GDM can reduce their chances of having metabolic syndrome, cardiovascular disorders, or type 2 diabetes in the future. Education can be done by a nurse or primary care provider, and should be done throughout their lifetime and continuing onto their children. This would hopefully decrease the amount of gestational diabetes in female offspring and stop the cycle of gestational diabetes that may continue on throughout generations.

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