REMOTE PATIENT MONITORING OF GESTATIONAL DIABETES MELLITUS

A literature review

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This research’s objective was to know the benefits of remote patient monitoring of gestational diabetes mellitus (GDM) among gravid women, metabolic control and pregnancy outcomes. My research question was, what are the benefits of remote patient monitoring for GDM women, and the outcome of the pregnancy? This study was a literature review of some articles.

The methodology used in this thesis, was a literature review of 11 articles previously written on this topic. Publication from 2007 till 2017 was selected, limiting searches to 10 years. This is important to select up to date articles on remote monitoring systems. This research was written following the structure of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

1829 studies were found from the first database search through Scopus database. And 15 articles were identified from additional records through other sources, such as reference lists and PubMed search. 1619 articles were screened for eligibility. After excluding unwanted materials, 11 articles were identified for inclusion in the literature review.

Remote patient monitoring of women with GDM from the synthesis of many studies previously written, has tremendous impact in the life of the users, it helps pregnant women who are too busy with daily chores, those taking care of little children or those preoccupied with work to monitor their blood glucose level independently without the need for the usual outpatient clinic visit. They interact with their healthcare providers with the use of various telemedicine application systems they are utilizing. The use of remote monitoring system as a substitute to unplanned traditional outpatient visits did not predict the outcome of the pregnancy, outcome of delivery and neonatal outcomes.

Future research should concentrate on how the use of remote patient monitoring system (telemedicine system) will lead to the improvement of pregnancy outcomes and on how to reduce complications associated with GDM.
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ABBREVIATIONS

BG – Blood glucose
CCT – Clinical controlled trial
CIT – Cell-phone internet technology
CG – Control group
GCT – Glucose challenge test
GDM - Gestational diabetes mellitus
GDU – Gestational diabetes unit
GTT – Glucose tolerance test
HCP – Health care practitioners
IDDM – Insulin dependent diabetes mellitus
IS – Information system
IVR – Interactive voice response
LGA – Large for gestational age
NHS – National health service
NIDDM – Non-insulin dependent diabetes mellitus
OPD – Outpatient department
OGTT – Oral glucose tolerance test
OMDTSQ – Oxford maternity diabetes treatment satisfaction questionnaire
PIH – Pregnancy induced hypertension
PIN – Personal identification number

PRISMA – Preferred reporting items for Systematic reviews and Meta-Analyses

PROM – Premature rupture of the membranes

RCT – Randomized controlled trial

RPM – Remote patient monitoring

SD – Standard deviation

SMBG – Self-management of blood glucose

TMG – Telemedicine group
1 INTRODUCTION

There are various definitions of remote patient monitoring (RPM). Remote patient monitoring (RPM) is defined by the Center for connected health policy as a means of collecting medical and other forms of health data through digital technology from people at one place and transferring the information confidentially to the health care practitioners in another place for recommendations and assessment of data through electronical means. (Center for connected health policy, 2015). During monitoring programs, different ranges of health data can be collected from the point of care, and they include the vital signs. Hospitals, clinics and health centres received data which are transmitted to the health professionals in these facilities. These patients are remotely monitored by the health professionals and their treatment plan is acted upon through the information they received. Readmission, hospitalisations, and lengths of stay at the hospitals can be reduced using RPM, and the quality of life is improved using this RPM and it also safe costs. (Center for connected health policy, 2015.)

RPM is a technology to allows patients outside of standard clinical settings such as the home or offices to be monitored, this tend to increase the approach to health care and reduces the healthcare delivery costs. Individual’s quality of life can be improved tremendously when RPM is being incorporated in the chronic disease management. It gives the patients the liberty to be independent, prevent complications and minimize personal expenditures (Bayliss et al. 2003). These goals are being facilitated by RPM through the delivery of care to various houses. With this, those in need of medical attention and household are well furnished with the fact that are being taken care of through enormous support and monitoring in case of any arising issue (Cafazzo et al. 2009). Main features of RPM such as remote monitoring and physiological parameters analzyation trend, assist in early deterioration detection, which paved way to the reduction in hospitalisations, emergency department visits, and length of stay at the hospital. Wireless mobility in healthcare is needed because it eased the usage of RPM in an organisation and community. Efficiency is being increased because of the implementation of RPM which saves time, and gives the healthcare providers the privilege of utilizing more avenue and time to teach and interact with those in need of medical care remotely (Coye et al. 2009).
The World Health Organization (WHO) defined Gestational diabetes mellitus (GDM) as an intolerance of carbohydrate leading to hyperglycaemia of variable severity which start or was first detected during pregnancy (WHO, 1999).

Hyperglycaemia in pregnant women leads to the moving of excess glucose to the foetus which result in foetal hyperinsulinemia. Hyperinsulinemia whose consequence includes an overgrowth of insulin-sensitive tissues, causes a faster foetal growth and macrosomia babies, this leads to the increase in the risk of delivery complications such as shoulder dystocia, birth trauma, the need for assisted delivery such as caesarean section and increased risk of stillbirth (Hod et al. 1995.) Another common complication is foetal hypoxemia, which increases the risk foetal death inside the uterus, foetal polycythaemia, and hyperbilirubinemia (Mackillop et al. 2014). GDM manifests with increased levels of glucose in the higher part of the distributed population, which occurs during pregnancy (Buchanan et al. 2012).

GDM usually associated with risk of adverse perinatal outcomes which is a potential important risk to be cautious of, and a long-term risk of obesity and intolerance of glucose in the offspring. Women with GDM has an increased risk of hypertensive disorders during pregnancy, and they have a higher tendency of having diabetes mellitus postpartum. Perinatal complications can be reduced by diagnosing and treating GDM, though only few pregnancies benefit from this. (Buchanan et al. 2012.)

Strict blood glucose (BG) checking in women with GDM is important in the prevention of adverse maternal and foetal outcomes. Glycaemic control recommended method of assessment remains the finger-prick blood glucose monitoring method. The numbers of pregnant women with GDM is predicted to increase due to the changes in the screening and sociodemographic of GDM such as increased in the numbers of overweight and obese pregnant women. (Hirst et al. 2014.)

Women with GDM are exposed to lots of health hazards. There is a major need for intervention for those patients who cannot visit hospital regularly, this brings about the need for remote patient monitoring to reduce the complications associated with GDM. Most women who were not previously diabetic before the onset of pregnancy have high risk of being diabetic during post-partum period. This is the why there should be adequate monitoring of patients with GDM.
Recently there has been a great reduction in maternal mortality in diabetic pregnancies. Women at risks are those with an existing coronary artery disease. Generally, the maternal morbidity is associated with the severity of diabetic related disease before gestation. Pre-eclampsia risk is greatly increased in diabetic women. Those with co-existing renal disease have the risk of developing pre-eclampsia. Increased rate of infection, severe hypoglycaemia or hyperglycaemia, diabetic ketoacidosis are the other impediments associated with GDM and the impediments that may also occur from the increased caesarean delivery rate, which also include thromboembolic disease. (Baker et al. 2006.)

There are lots of health complications for foetus in utero and for the neonates after birth from women with GDM. Most of these complications are severe and are carried on as they grow. There is a lot of risk of miscarriage and congenital foetal abnormalities. Having a good diabetic control during pregnancy reduces these complications tremendously. Neural tube defects, congenital heart disease and other spinal anomalies, also a rare condition known as caudal regression syndrome are caused by high levels of glycosylated haemoglobin. In diabetic pregnancies, most of the mortality and morbidity are associated with congenital abnormality, and they are more rampant in normal pregnancies, two to four times. Aside the congenital malformations, another major obstetrical problem common with GDM is foetal macrosomia, which causes traumatic births complicated by possible hypoxic damage and shoulder dystocia. (Baker et al. 2006.)

Sudden, unexplained, late stillbirths occur in poorly controlled cases of GDM, and these occurs in 10 - 30 percent in pregnancies complicated by GDM. This incidence had reduced tremendously with the advent of remote patient monitoring systems and traditional hospital visits. (Baker et al. 2006.)

This research’s objective is to find out the benefits of remote patient monitoring of GDM among pregnant women, metabolic control and pregnancy outcomes.
2 REMOTE PATIENT MONITORING OF GESTATIONAL DIABETES MELLITUS

Under this chapter terminology used will be discussed and previous literatures that had already been written on this thesis topic will be reviewed, the conceptual framework of the study will be analysed, and methods used, results, own critical assessment will be discussed in this chapter and in subsequent chapters.

2.1 Diabetes

Diabetes mellitus is defined by the World Health Organization (WHO) as either an elevated fasting blood glucose level of > 7.8 mmol/L or a level of >11.1 mmol/L 2 hours following a 75g oral glucose load (Baker et al. 2006).

Management of GDM comprises of investigations and definitive obstetrics management (Saxena 2010). Performing a Glucose challenge test (GCT) which is an investigating test for gestational diabetes, in which plasma blood glucose levels are measured one hour after giving a 50g glucose load to the woman, irrespective of the time of the day or last meals. An abnormal result on glucose challenge test must be accompanied by a 100g oral glucose tolerance test (OGTT). This test involves measurement of blood glucose levels at fixed time intervals following the intake of prefixed quantities of glucose. While a 100g, 3-hour GTT (Glucose tolerance test) is a standard in the US, in the UK a 75g, 2-hour GTT is preferred. If the 100g, 3-hour GTT is used, the diagnosis can be made either using the Carpenter and Coustan criteria (table 1) or criteria defined by the National Diabetes Data Group (table 2). On the other hand, if they use the 75g oral glucose tolerance test in 2-hour, the diagnosis must be made using the criteria defined by the World Health Organization (table 3). (Saxena 2010.)
Table 1: 100g glucose load by O’Sullivan and Mahan: Adjusted criteria by Carpenter and Coustan (Carpenter & Coustan 1982; 768-73)

<table>
<thead>
<tr>
<th>Status</th>
<th>Plasma/serum glucose (mmol/litre)</th>
<th>Plasma/serum glucose levels (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting</td>
<td>≥ 5.8 mol/L</td>
<td>95</td>
</tr>
<tr>
<td>One hour</td>
<td>≥ 10.0</td>
<td>180</td>
</tr>
<tr>
<td>Two hours</td>
<td>≥ 9.1</td>
<td>155</td>
</tr>
<tr>
<td>Three hours</td>
<td>≥ 8.0</td>
<td>140</td>
</tr>
</tbody>
</table>

If only one value is abnormal, impaired glucose tolerance is diagnosed. If at least two values are abnormal, Gestational diabetes mellitus (GDM) is diagnosed. Overt diabetes is diagnosed if the fasting blood glucose level is ≥125, and they should not be given the 100g glucose load. (Sakala et al. 2011.)

Table 2: National Diabetes Data Group criteria for 100g OGTT (NDDG, 1979)

<table>
<thead>
<tr>
<th>Status</th>
<th>Plasma/serum glucose (mmol/litre)</th>
<th>Plasma/serum glucose levels (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting</td>
<td>≥ 5.3 mol/L</td>
<td>105</td>
</tr>
<tr>
<td>One hour</td>
<td>≥ 10.0</td>
<td>190</td>
</tr>
<tr>
<td>Two hours</td>
<td>≥ 8.6</td>
<td>165</td>
</tr>
<tr>
<td>Three hours</td>
<td>≥ 7.8</td>
<td>145</td>
</tr>
</tbody>
</table>
This is used for Oral glucose tolerance test (OGTT) using a 100g 3-hour standard test. This test is applicable in the US alongside the Carpenter and Coustan parameters as shown in Table 1.

Table 3: World Health Organization criteria for 75g OGTT (WHO, 2006)

<table>
<thead>
<tr>
<th></th>
<th>Whole blood venous</th>
<th>Whole blood capillary</th>
<th>Plasma venous</th>
<th>Plasma capillary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fasting</strong></td>
<td>≥ 6.1 mmol/L</td>
<td>≥ 6.1 mmol/L</td>
<td>≥ 7.0 mmol/L</td>
<td>≥ 7.0 mmol/L</td>
</tr>
<tr>
<td><strong>2 hours</strong></td>
<td>≥ 6.7 mmol/L</td>
<td>≥ 6.7 mmol/L</td>
<td>≥ 7.8 mmol/L</td>
<td>≥ 8.9 mmol/L</td>
</tr>
</tbody>
</table>

75 grams of OGTT is carried out in the morning after the patient has had up to three days of uncontrolled diet comprising of more than 150 grams of carbohydrates. The patient is diagnosed as having gestational diabetes, if two or more of the values on glucose tolerance test (GTT) are not normal. (Saxena 2010.)

**2.2 Gestational Diabetes Mellitus**

Gestational Diabetes Mellitus (GDM) is a habitual problem of pregnant woman disturbing approximately 150,000 pregnancies each year. GDM is associated with obstetrical complications such as shoulder dystocia and macrosomia during delivery etc. and to other upcoming perinatal morbidity. A major association with maternal glycaemic control and macrosomia or any other adverse outcomes of pregnancy has been well established. The backbone of therapy in these pregnancies is an intensive treatment regimen which focuses on the normalization of the blood glucose levels. (Homko et al. 2007.)

The understanding of women with GDM on diabetes, dietary intake, and blood glucose (BG) monitoring is very little, and there is a short duration from the diagnosis of GDM and delivery of the foetus which is usually eight to ten weeks. These patients combined with the changing
physiology of pregnancy require an antenatal outpatient setting with a thorough medication dosage as a means of managing any complication before delivery. (Hirst et al. 2014.)

It is difficult to accurately predict how GDM develops and progresses to therapy requirement in the physiology of pregnancy that changes rapidly. To maintain an optimal glycaemic control, further and rapid medication titration is required often once on treatment. There is a limited period to intervene in the enhancement of the glycaemic control because the diagnosis of GDM is often carried out in the third trimester of pregnancy around 10-16 weeks. (Mackillop et al. 2014.)

An increase in human placental lactogen and cortisol, which are also insulin antagonists are caused by hormonal changes which alter carbohydrate metabolism during pregnancy. Because of these two insulin antagonists (Lactogen and Cortisol), the mother develops relative insulin resistance to them. These usually occur during the third trimester. To balance these hormonal changes during normal pregnancy, increased amount of insulin is being secreted by the maternal pancreas to maintain carbohydrate metabolism. There will be a fall in the fasting level of glucose due to this. In contrast, the levels of glucose are more than in the non-gravid situation after a carbohydrate challenge. During facilitated diffusion, glucose crosses the placenta and the maternal blood glucose level is being closely followed by the foetal blood glucose level. (Baker et al. 2006.)

Pregnancy can be complicated by diabetes, when there is an already existing insulin-dependent diabetes mellitus (IDDM) or non-insulin dependent diabetes mellitus (NIDDM) pre-gravid or when there is a rapid development of a transient impaired glucose tolerance or diabetes in pregnancy. Approximately 1-2 percent of pregnancy women will develop gestational diabetes. (Baker et al, 2006.) White classification is usually used to classify diabetes in pregnancy (table 4).
Table 4: Diabetes in pregnancy as classified by White (White 1949, 1968)

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Gestational diabetes; glucose intolerance developing during pregnancy; fasting blood glucose normal</td>
<td>Diet alone</td>
</tr>
<tr>
<td>A2</td>
<td>Gestational diabetes with fasting plasma glucose &gt; 105mg/dL; or 2-hr postprandial plasma glucose &gt; 120mg/dL</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>B</td>
<td>Overt diabetes developing after age 20yr and duration &lt; 10yr</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>C</td>
<td>Overt diabetes developing before age 20yr or duration &gt; 10yr</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>D</td>
<td>Overt diabetes developing between the ages of 10 and 19yr, or duration 10-19yr, or background retinopathy</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>F</td>
<td>Overt diabetes at any age or duration with nephropathy</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>R</td>
<td>Overt diabetes at any age or duration with proliferative retinopathy</td>
<td>Diet and Insulin</td>
</tr>
<tr>
<td>H</td>
<td>Overt diabetes at any age or duration with arteriosclerotic heart disease</td>
<td>Diet and Insulin</td>
</tr>
</tbody>
</table>

Diabetes in pregnancy as classified by Priscilla White who initiated the study on the impact of diabetes types on pregnant outcome. This classification is used to evaluate maternal and foetal risk. It used to differentiate type A gestational diabetes from diabetes acquired before pregnancy.

There are two types of gestational diabetes:

1. Diet controlled Gestational diabetes mellitus (Type A1)

2. Medication controlled Gestational diabetes mellitus (Type A2)

This classification is still in use nowadays. (White Priscilla, 1949 & 1968)
2.3 Remote patient monitoring

This is a technology that allows a patient to be monitored outside a health facility; this allows increase access to healthcare and reduces healthcare delivery costs (Bayliss et al. 2003).

Patients with medical conditions often have the need to be monitored outside of a medical facility, example at home or in an ambulance (Baker et al. 2006).

Medical facilities, such as a hospital, usually have secure data networks, often including firewalls that protect against any unauthorized access. When the patient who is monitored outside of the medical facility need to transmit medical data to the medical facility, a secure connection typically needs to be established from a location where the patient is being monitored to the medical facility. (Baker et al. 2006)

Different equipment can be used as a tool in remote patient monitoring, such as web based telemedicine system, a smartphone, tablets and other electronic gadgets with internet facilities etc. A new means of providing health information to healthcare providers which has the tendency of helping in the control of blood sugar level in women with GDM is through the smartphone application (app). (Bayliss et al. 2003.)

The latest device for the control of type 1 and type 2 diabetes is the Smartphone apps which are used as a medical device. There are more informational needs that the women with GDM may have more than other diabetic patients. Though mobile technology is said to be more advantageous for the provision of health information, the needs of target groups must be carefully thought about notwithstanding its limitations. (Garnweidner-Holme et al, 2015.)

Patients’ health data is efficiently and effectively collected through the intervention of telemedicine, it is easier now to reach out to those with the difficulty of attending regular medical visits and there is an improvement in the management of chronic medical conditions (Trief et al. 2008).

Over the last decade remote patient monitoring systems have been used increasingly for the facilitation of the monitoring of diabetes (Montori et al. 2004).
In line with the new trend in technology and communications engineering, with diverse levels of complexity, different services have been designed (Bellazzi et al. 2004).

The system was designed to foster the interaction between the health care givers and their patients, the quality of care is tremendously improved through this. However, they try to bring out a more steady and fascinating dialogue with the women with GDM they are catering for and this makes the overseeing of the diseases coincide with the patients’ lifestyles. Frequent treatment changes and regular feedback from healthcare providers are required from women with GDM. Patients must be observant of their nutritional habits and physical activities, and changes to it is strongly advised during the pregnancy period till child birth. Personal checking of the capillary blood glucose is strictly advised and in rare cases, they can commence insulin treatment. (Perez-Ferre et al. 2010.)

Interventions based on internet technology improve the utilization of health care, self-efficacy and glycaemic control among women with GDM (Krishna & Borean, 2008). The usage of internet technology alongside mobile phone connectivity removes the potential accurate reporting of results by the patients. This technology is user friendly and thus improves patient satisfaction by increasing the easy usage among patients and decreasing the results reporting time. The potential benefits of this technology are the real-time exchanging of the read glucometer reading showing the glucose level between the patient and the doctors remotely. The patients get quick response from the doctor immediately. (Mackillop et al. 2014.)

With a web-based telemedicine system some patients are remotely monitored. Evaluation of the glucose control was conducted every 6-8 weeks at the Gestational Diabetes Unit (GDU), and every 2 weeks utilizing the web based telemedicine system. They conducted a telematic diabetes control through a webpage purposely structured for the observation of patients with diabetes. Patients send their glucometer reading via this website. Remote monitoring and two-way interaction between the health care providers and diabetic women was allowed through this website, giving them the privilege of sending their blood glucose read through a glucometer before and after every meal, insulin therapy received, carbohydrates portion ingested and other health parameters assessed remotely by the health practitioners in a professional way. Patients and their caregivers can exchange messages regarding their data, view and make a change to their insulin therapy, make a report on treatment or acquire metabolic control statistics, and they
can also download important documents from the website’s archive. Messages about treatment can either be communicated to the patients by the health care professionals through emails or phone message. (Carral et al. 2015.)

Monitoring using the smart phone based internet technology involves the collection and the sending of daily readings from a patient’s glucometer reading directly to another mobile smart using a wireless device. Information is being transferred by the patient and the medical professionals via a secured website with electronic interaction to and fro. (Bartholomew et al. 2015.)

2.4 Technology and gestational diabetes mellitus monitoring

Information technology for health has been acknowledged as a worthwhile device for overseeing of sick people with different medical demands (Homko et al. 2012).

Technology is playing a crucial role in the management and ease of health services in this present world. With the invention of internet, smartphones and other gadgets, more medical apps surfaces in the market and they are very helpful in the health care sectors. Home monitoring of blood glucose levels is a welcomed idea, measured data are sent swiftly to the health care providers. Telehealth is a technology whereby health care is being delivered at a distance with the aid of an electronic means of interaction. Nowadays it is known as digital health. (Figure 1 & 2). A broader range of technology is covered in this description. Another sub category of digital health is M-health, in this category, smartphones are being utilised for transferring data, a software application is consolidated to work alongside technology of health and health services. (Mackillop et al. 2014.)
Figure 1: The GD-m health Management System. (Mackillop et al. 2016)

Figure 2: The GD-m health management system (Mackillop et al. 2014)
Access to care is increased and efficient health care delivery can be achieved using health information technology which offers quality health care to women with pregnancies complicated by GDM (Homko et al. 2012).
3 DECLON AND MCLEAN MODEL

DeLone and McLean Information System (IS) Success Model is regarded as a structure and model used in the evaluation of complex variable that are dependent in IS research.

3.1 The D&M IS Success Model

According to the research of Shannon and Weaver, the technical level of communication was defined as the efficiency and accuracy of the information produced from the communication system. The semantic level is defined as the success of the information in conveying the intended meaning. The efficiency level is defined as the impact of the information conveyed on the receiver. (Shannon & Weaver, 1949).

Mason in 1978, made an extension to this theory, a well - structured, multidimensional model of IS success was suggested (Mason, 1978).

In the D&M IS success model, technical success is measured by the quality of the system, semantic success is measured by the quality of the information while effectiveness success is being measured by the use, the user satisfaction, the impact on an individual and impact on an organisation (DeLone and McLean, 1992).

Based on the consideration of process and causal, the six dimensions of success were suggested to be interrelated rather than independent. There are significant implications for the measurement, the analysis and the reporting of IS success in empirical studies. (DeLone and McLean, 1992).

A temporal process model suggests the creation of an IS which contains various features, that can be characterised as one that exhibits different levels of system and quality of an information. When the system is being used along with its information products had an impact or influences the conduct of an individual work which in turn leads to organisational impacts when the results manifest. Figure 3. (DeLone and McLean, 1992).
Causal or variance model studies the covariance of the success dimensions to determine if there is an existence of a cordial association between them, this distinguishes them from the process model. The more advanced a system quality the more satisfaction the users will benefits from the use, which will lead to a positive impact on the individual productivity and this will have a huge impact on the organisational productivity as well. (DeLone and McLean, 1992.)

3.2 Model adoption & Model validation

D&M IS success model had been adopted by various authors citation found in 285 journals and proceedings that had referenced the D&M IS success model from 1993 to mid-2002. This success model had been used as a common structure or template for reporting and making a comparison on research work that involves IS success or effectiveness. Many written articles measurement or their dependent variables development is positioned within the context of the D&M IS success structure or framework. (DeLone and McLean, 1992.)

To validate the D&M IS Success Model, the model empirical testing and validation is carried out. Research studies by Seddon & Kiew which was conducted on the accounting system of a university, outstanding associations between system quality, user satisfaction and individual impact was discovered. When there is a quality in a system, users will be satisfied and individual impact felt. (Seddon & Kiew, 1994). Rai et al (2002), conducted a goodness of fit test on all the D&M IS Success Model based on responses from 274 university- student IS users through a
conducted survey. From the study conducted, the goodness of fit indicators was outstanding while others were not outstanding. (Rai et al, 2002.)

3.3 The updated D&M IS Success Model

The model was updated based on the contributions from the research contributions and changes in the role and management of information systems. The updated model is presented on Figure 4.

Figure 4: Updated D&M IS Success Model (DeLone and McLean, 1992)

Three major dimensions of quality were discussed previously, these are, Information quality, Systems quality and Service quality. They are measured and controlled separately. They will have impact on use and user satisfaction. (DeLone and McLean, 1992.) As previously discussed, quality has
Use and user satisfaction are very interconnected. Use must come before user satisfaction in a process sense. A positive impact of use will lead to massive user satisfaction in a causal sense. Therefore, increased user satisfaction will yield an increased in the intention to use and eventually, it will increase use. With an increase in the intention to use and then use, this will be net benefits for all. Negative impact will lead to decrease use and withdrawal from the system or the IS department. (DeLone and McLean, 1992.)

The updated D&M IS Success Model has an arrow indication to show the relationships among the success dimensions in a process sense, but does not indicate any positive or negative signs for those relationships in a causal sense. For instance, a highly efficient-quality system will be welcomed with massive patronage, have more user satisfaction and lead to positive net benefits. All the associations to be proposed will then be positive. Likewise, a poor-quality system will lead to disappointment, nonsatisfaction and negative net benefits. All the associations to be proposed will be negative in this case. (DeLone and McLean, 1992.)

3.4 E-Commerce Success


The internet and the IS phenomenon that lends itself to a measurement framework (D&M IS success model) which is built on communication theory (Shannon and Weaver, 1949). The Internet and IS are powerful communications and commerce medium. Using the e-commerce context, the customers or the suppliers are the primary system, and not the internal users. They used the system to facilitate buying and selling decisions and executing business transactions. Individual users, organizations, industries, and national economies are being impacted by the electronic decisions and transactions. This communications and commerce process works perfectly with the updated D&M IS success model and its 6 success dimensions (System quality,
Information quality, Service quality, Usage, User satisfaction and Net benefits). (DeLone and McLean, 1992.)
4 RESEARCH AIM AND RESEARCH QUESTION

This research objective is to find out the benefits of remote patient monitoring of GDM among pregnant women, metabolic control and pregnancy outcomes.

I had always wanted to write and conduct more research in the field of Obstetrics and Gynaecology, since this is one of the medical conditions complicating pregnancy; I decided to write on Gestational diabetes mellitus. This is an interested aspect of medicine to be cautious about due to its predisposing factors and future consequences if not treated or managed efficiently. A woman who was not diabetic before the pregnancy have higher tendency of developing the type 2 diabetes which is the Non-insulin dependent diabetes mellitus (NIDDM) if she had GDM during her pregnancy, and foetus which was microsomic at birth can develop the type 1 diabetes mellitus, which is the Insulin dependent diabetes mellitus.

My research question is, what are the benefits of remote patient monitoring for GDM women, and the pregnancy outcome?

I will like to know the benefits of remote patient monitoring for GDM women and the pregnancy outcome (maternal and foetal outcome). This is very essential for the prevention of future reoccurrence of gestational diabetes mellitus in succeeding pregnancy and to prevent type 2 diabetes mellitus both for the child and the mother in real life. My studies will be a literature review of some articles, as many as possible articles will be reviewed and the details will be summarized in the subsequent chapters of this write up.
5 RESEARCH METHODS

This chapter focuses on the research methodological approach in this research, research data and the data collection methods. The methods of analysing those data, the process of the analysis and the evaluation of the methodology.

All these will be further discussed below.

5.1 Methodological approach in this research

This study is a literature review.

“A literature review surveys books, scholarly articles, and any other sources relevant to a chosen issue, area of research, or theory, and by so doing, provides a description, summary, and critical evaluation of these works in relation to the research problem being investigated” (Ridley Diana, 2012).

Literature reviews are designed to provide an overview of sources explored while researching a random topic and to demonstrate to your readers how your research fits within a larger field of study. (Ridley Diana, 2012)

The search strategy was conducted with the assistance of an experienced researcher, with searches performed in SCOPUS to identify all articles relevant to my topic. Publication from 2000 till 2017 was selected, limiting my searches to 17 years. This is important because I had to pick articles on remote monitoring systems with this modern-day technology.

This research was written following the structure of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). (Figure 5). The quality of selected articles which passed the eligibility stage was based on research carried out by these researchers, the performances of the patients, the healthcare team, patients’ satisfaction, maternal and neonatal outcomes.
Figure 5: PRISMA Flowchart
5.2 Inclusion criteria

The inclusion criteria for this study include:

- Pregnant woman diagnosed with GDM or those without pre-existing diabetes mellitus.
- Articles on telemedicine, telehealth.
- Articles published in English language.
- The telemedicine interventions included in the search are remote monitoring in the form of internet usage, mobile smartphone usage.
- Search was limited to year 2000 and after.

Databases were searched using the keywords diabetes AND gestational AND (remote OR mobile OR portable OR "cell phones" OR smartphone* OR digital OR mhealth OR ehealth OR telemedicine OR teleconsultation* OR telehealth OR distance.

5.3 Exclusion criteria

Exclusion criteria were:

- literatures on other forms of diabetes mellitus, other gestational complication other than GDM and articles on multiple gestation with GDM.
- articles published before 2000.
- articles written in other languages.

5.4 Study selection and data collection method

Screening method was used to eliminate duplicated articles and extracts important titles from the retrieved titles and abstracts. (Figure 5) Articles included were evaluated for quality work and extracted data. The quality of selected articles which passed the eligibility stage was based on research carried out by these researchers, the performances of the patients, the healthcare team, patients’ satisfaction, maternal and neonatal outcomes. Selection was based on potentially relevant articles to my research topic, with a big emphasis on gestational diabetes mellitus. A lot of articles found were on pregnant women with a history of diabetes mellitus type 1 and type 2.
prior before pregnancy. I had to limit the search by manually selecting the relevant articles on remote patient monitoring of GDM patients. These categories of women were those with the onset on diabetes mellitus because of their pregnancy and this is usually revealed towards the latter part of their pregnancy usually in the third trimester. The inclusion criteria were applied in the selection process. All extracted articles which are relevant to my studies were analysed under this topic, with their various research data and method of data collection.

Figure 5 shows the selection process (PRISMA flowchart). 1829 studies were selected from the first database search through Scopus database. 15 articles were identified from additional records through other sources, such as reference lists and PubMed search. Figure 6.

Figure 6: Screenshot of search result page.
1619 articles were screened for eligibility. After excluding 1342 articles did not meet the eligibility criteria based on the analysis of the word contents in their various titles and abstracts. In all, a total of 277 articles with full texts were extracted, reviewed, and selected based on their relevance to the research topic and their eligible attributes. From these, 250 articles were not considered due to the following: articles were written on other complications of gestation other than GDM, articles on type 1 and type 2 diabetes mellitus, GDM on multiple gestations, lack of self-monitoring components, not related to remote patient monitoring or other forms of telemedicine. 27 articles left were assessed for methodological quality and 16 were found to be weak or very weak after assessment. Finally, 11 articles were considered for inclusion in the literature review.

5.5 Method of analysis, process of analysis, evaluation of the methodology

The searched articles were read and each article’s methodology was summarised below and more information will be discussed under discussion chapter of this study.

All articles strictly follow the screening test criteria for testing women with GDM. The summary of included articles can be seen in appendix 1.
6 RESULTS OF THE STUDY

6.1 Study characteristics

The summary characteristics of reviewed articles are given in appendix 1, with 1110 participants conducted across 6 countries, which comprises of the United States of America (n= 4), Spain (n= 3), Northern Ireland & The republic of Ireland (n = 1), Norway (n = 1) and United Kingdom (n = 2). All the articles were published. All research was conducted between 2003 and 2016. The highest publications were published in 2015 (n= 4). 9 studies used RCT designs, 1 used CCT design and 1 used quantitative method.

The objective of the research of Hirst et al. (2015) was to know the satisfaction of women with the use of GDm-health system and their attitudes toward their diabetes care. This development service project was carried out within a designated hospital. They focused on women who had previous history of GDM, their motive is to encourage such women to commence monitoring of blood glucose from home from the second trimester of their pregnancy.

This research is targeted at women with GDM who do not need any treatment after BG monitoring for one week, they must be pregnant with singleton and they are usually diagnosed prior to 34 weeks gestation, with uncomplicated pregnancies and must be able to communicate in English. Participation was voluntary and volunteers will be instructed to measure all BG monitoring with communication with the rest of the team through clinic appointment using the GDm-health system to the midwife. 52 women was involved in this study.

Women measured their BG reading from home using a Bluetooth -enabled BG metre (Polymap Glucose meter accessory with Lifescan UltraEasy meter) which automatically transmit BG readings finger-pricked to a smartphone running a custom-written app. The reading is transmitted automatically to a secure website hosted by the NHS (National Health Service) through the 3G network. The caregivers (diabetes midwife or physician) review the website at least 3 times per week. In urgent situation, the women are contacted by the diabetes midwife through SMS (sent through the website) or a phone call. It was through 2 -way communication, with women having the chance to speak directly to their diabetes midwife.
The women completed a structured questionnaire within 4 weeks postpartum, satisfaction with the use of the system was assessed through it. The structured questionnaire is comprised of nine questions structured to analyse the patients’ general satisfaction with the care received from the diabetes care team, how acceptable and reliable the technology is, and their cordial relationship with the diabetes care team. They scored their responses on a scale of 7 points. (Hirst et al. 2015.)

The objective of the research of Homko et al. (2012) was to investigate the result of improved remote monitoring system on the control of glucose and outcome of pregnancy in women with GDM. This study consisted of 80 pregnant women with GDM. An interactive voice response phone communication was allowed through the internet based telemedicine system to ease communication between the health care providers and the patients to provide automated reminders for transmission of data. The study sample used are women in their reproductive age with a recorded diagnosis of GDM on a 3-hour OGTT, in line with the criteria of Carpenter and Coustan. The gravid patients are required to be in their 33rd weeks of pregnancy or even less when the study was initiated. Those with previous diabetic history without being pregnant or those with multiple births were eliminated from the study. (Homko et al. 2012.)

They randomized the women into two groups, 40 each into telemedicine or control (usual care). They trained the women in the telemedicine group on how to operate the computer and internet, and were given adequate instruction on the internet programme, and were given a full rundown on how to use the website at the clinic demonstration terminal. Alternatively, an automated telephone communication option was provided for those without internet access. They provided log in details to those in the remote monitoring group to ingress the secure website and a PIN and call free number to make use of the phone call system. When they use the interactive voice response (IVR) system, they were instructed to enter medical details such as read blood glucose values, changes in medication, and periods of hypoglycaemia, and indicate the period, utilizing keypad on the phone. After each transmission, the patients were given response, supported emotionally, and fortified for personal management of their diabetes.

Blood glucose levels is being monitored before breakfast in the morning, and 2 hours after every meal every day by women in the telemedicine group, and they count the foetal movements three times daily, record the insulin dosage used and episodes of hypoglycaemia. And transmits the
read data to their healthcare professionals weekly either through the phone or internet. Control group women performed likewise, and these women recorded their own information into a record book, evaluated by the health care practitioners at every antenatal visit. The two groups under study received a standard care. Every 2 weeks all study participants undergo clinical evaluation until week 36 of pregnancy, after this the visit will be every week. All the participants undergo therapy to achieve a metabolic results of a fasting plasma BG level of ≤ 95mg/ dl and 2-hour after meal glucose level of ≤ 120mg/ dl. (Homko et al. 2012.)

The aim of the research of Carral et al. (2015) was to investigate the influence of a web based remote monitoring system for monitoring the control of glucose in pregnant women with diabetes on healthcare visits, metabolic control, and pregnancy outcomes. The study consisted of two groups, telemedicine group (TMG) and control group (CG). Women with diabetes are 104 (77 women had GDM, 16 women had type 1 diabetes mellitus, and 11 women had type 2 diabetes mellitus). Participants were given the chance to choose which of the two groups they will like to join, because some of these participants had no internet access at home, and some are not pleased using the remote monitoring system based on web use to interact with the hospital. The telemedicine group were managed by the more structured outpatient visits and by a remote monitoring system based on web use while the control group were managed by regular hospital visits only (Gestational Diabetes Unit) and a nurse educator. They obtained written informed permission from the patients. The nurse educator gave an instruction to all participants to personally check their blood glucose values between 3 to 6 times daily, with pre-prandial goals of < 95 mg/dl and 2 h after meals of < 120 mg/dl, based on International recommendation and to follow a personal diet. (Carral et al. 2015.)

Pregnant women in the Control group individually evaluated their blood glucose control at the GDU every two or three weeks until delivery while those in the telemedicine group with the aid of a web based telemedicine system called DiabeTIC were evaluated every 2 weeks and individually every 6-8 weeks at the GDU. All the participants were re-examined in a one on one scheduled visit with the health care provider between 6 - 12 weeks postpartum.

With the aid of the telemedicine system called DiabeTIC, they performed a lot of telematic diabetes control. This is a website designed purposely for the monitoring diabetic patients.
The website permits distance and two-way interaction between the health care providers and the diabetic patients. (Carral et al. 2015.)

The objective of the research of Homko et al. (2007) was to show the viability of observing the control of glucose level in financially disadvantaged women with GDM through the internet. This study consisted of fifty-seven GDM women. They were categorised into two groups, the remote monitoring group which consists of thirty-two women with GDM and the control group which consists of 25 women with GDM. Women should be between age eighteen and forty-five years and should have a recorded diagnosis of GDM on a three-hour OGTT in line with the criteria of Carpenter and Coustan (Carpenter & Coustan 1982). Women with GDM should be at week 33 of gestation or less when they join the study. They excluded women with previous diabetic history before being pregnant or multiple gestations from the study. Participants from the study were told to observe the glucose level in their blood every day, perform the counting of the movement of their foetus three times daily and note down the dosage of insulin used and periods of hypoglycaemia. The health care providers received sent information from women in the internet group through the diabetes health network at least 3 times a week. Women in the other group women were told to write their read data in a record book and bring it along with them during their prenatal visits to be reviewed by the medical team. (Homko et al. 2007.)

All participants were equally assessed with the standard care, and were evaluated clinically every two weeks until the 36 weeks’ gestation, after which they visited every week until delivery. They all received standard clinical care from the team of subspecialists on maternal-foetal medicine, residents, a certified diabetes educator, and nutritionists as part of the management protocol. Glucose level monitoring is performed 4 times daily (before breakfast and 2 h after meals) as they were instructed. The aim is to maintain a metabolic goals of a fasting plasma blood glucose level ≤ 95 mg/dl and 2-hour after meal blood glucose level of ≤ 120 mg/dl. Patient who could not meet up with these criteria at least ninety percent of the time were treated with either glyburide or insulin. Women in the remote monitoring group without internet access were given a brand - new laptop and a free telephone with an internet access to be used during the study. (Homko et al. 2007.)
The objective of Mackillop et al. (2016) research was to study the efficacy of monitoring blood glucose in pregnancy using remote glucose monitoring (GDm-health) compared to standard care at the clinic. The secondary aim of this research is to compare the remote monitoring group and the control group for compliance to the allocated BG monitoring regime, maternal and neonatal outcomes, glycaemic control using glycated haemoglobin (HbA1c) and other BG readings, and patient attitudes to care received with the aid of a validated questionnaire and resources. This study comprises of 200 women with an abnormal oral glucose tolerance test (OGTT) in their present pregnancy. This is a randomised controlled trial. The women were randomised to the intervention group using the GDm-health management system and half the number of clinic visits or to normal clinic care. Recruited patients were in their 14 to 34 weeks of gestation until delivery. All women were told to measure their BG 6 times daily, 3 days weekly. This include a fasting sample, 1-hour post breakfast, pre-lunch, pre-dinner and 1-hour post dinner. The optimal BG is a fasting reading $\geq 3.5$ and $\leq 5.8$ mmol/L and 1-hour postprandial readings below 7.8 mmol/L. In case of persistently high BG readings, or a required medication, they were instructed to increase their blood glucose monitoring to every day of the week. (Mackillop et al. 2016.)

Participants in the control group individually record into a paper diary their BG values at home. They were scheduled to attend maternity diabetes clinic every two to four weeks where their BG readings will be reviewed by a midwife or specialist. If there is an abnormal reading, they are authorised to drop a voice message for the specialist diabetes midwife. The midwife will in turn return their call and give them medical and dietary advice within 72 hours. A smartphone with a preinstalled GDm-health application and Bluetooth - enabled BG meter is given to the participants in the intervention group. Every 4-8 weeks, they are instructed to attend the clinic (that is, half of the clinic visits of the standard care group). If there is a case of any pharmacological treatment, the participant will be directed to the clinic led by the consultant to commence treatment. (Mackillop et al. 2016.)

The research of Bartholomew et al. (2015) was carried out using a cell phone/ internet technology as a remote means of monitoring GDM. They carried out a randomized study comparing a regular voicemail system as a control group with a Cell-phone internet technology (CIT) system for management of hyperglycaemia during pregnancy. (Bartholomew et al. 2015.)
Inclusion criteria for the study include, women eighteen years and above with GDM or type 2 diabetes, recruited into the programme before they are in their week 30 and day 1 of gestation. Exclusion criteria were women with the age less than 18 and those in their week 30 and day 1 or longer, with type 1 diabetes and those unable to communicate in English. They diagnosed GDM with the criteria described by Carpenter and Coustan and supported by the American College of Obstetricians and Gynaecologists. (Carpenter & Coustan 1982, American College of Obstetricians and Gynaecologists) Diagnosis of type 2 diabetes mellitus was based on previous medical history of the women or their referring physicians. (Bartholomew et al. 2015.)

During the discussion with a maternal foetal medicine physician, participants were randomized into the cell-phone internet technology group or the control group when they were registered into the diabetes programme. They did their blood glucose monitoring for 3 weeks as indicated by the health care provider. Then they changed to another system of monitoring for the following three weeks. They completed a satisfaction survey after the second 3-week interval. Four tests per day were recommended to the participants, this include, fasting and 2 hours postprandial, according to the present standards of care. (Bartholomew et al. 2015.)

Randomization was performed using a random number generator. Tasks were placed in unrevealing sealed envelopes and labelled with numbers from 1 to 100. After signing their informed consent form, participants opened their envelopes. A 3-hour diabetes education class was organised and taught by the diabetes instructors who were certified in their field, after randomisation and before commencing their first 3-week interval on a monitoring system. Participants who required medication were provided personalised instruction regarding the right dosage. All participants also received equivalent education, training and consultation regarding a carbohydrate-controlled diet, exercise, SMBG (Self-management of blood glucose) and how to report SMBG results. They also received the same glucose meters and testing kits. They received an instruction to carry out SMBG four times daily (fasting and 2-hours postprandially). The control group participants record the values of their blood glucose in a log book and send the details to the programme nurse every week by sending the values over the voicemail system. Participants using the CIT method uploaded their blood glucose results at least every week; it could as well be uploaded after every test, every day or as it is more convenient to them within the period. Data extracted were analysed statistically. (Bartholomew et al. 2015.)
The objective of the research of Perez-Ferre et al. (2009) was to study the viability of a remote monitoring system based on internet use and text message service in observing patients with GDM compared to traditional face to face visits. A randomised interventional study was conducted with two groups formed. Participants were identified as having GDM according to Carpenter – Coustan criteria before week 28 of pregnancy were recruited to partake in the study. The written informed consent was signed by 100 women and the study was completed by 97 women. Women were advised on the kind of food they eat and personal checking of their glucose blood. Patients were randomised a week later into two equal groups (control and Telemedicine), according to their obstetric history and age. Patients that will require insulin therapy are allocated under Telemedicine group. Women were provided with a glucometer and a mobile phone for transmitting to the main station SMBG values through text message. Glucose values stored in the glucometer were transferred through infrared through an interface to the mobile phone in the application. Four visits were planned until delivery. Between planned visits, patients from either group had the chance of an unscheduled visits without prior appointment as authorised by the healthcare providers. (Perez-Ferre et al. 2009.)

Perez-Ferre et al. (2010) further goes on with their study with this new article and this time they were trying to assess the viability of a remote monitoring system based on Internet and a text message service in gestation and its effect on delivery and neonatal outcomes of women with GDM. This study was carried out in the same hospital in Madrid, Spain as their previous study. A prospective, randomised, clinic based study was designed and they carried out interventional study with two parallel groups. Women eligible for the study were diagnosed as having GDM before week 28 of pregnancy. Written consent was given by a total of 100 women and they were assigned to either group, 50 each into intervention group or control group respectively. Patients were monitored till delivery. The study was completed by 97 women, 48 women from the intervention group and 49 women from the control group.

They carried out this study in line with the guidance stated in the Declaration of Helsinki. This research was certified by the Ethical Committee of the hospital. 4 physical visits were scheduled throughout the study, once a month until delivery. Patients in the control group were granted the privilege to frequent the hospital without any given appointment and come along with their `record book with their blood glucose readings. Those with high level of glucose in their blood
above the given parameters should be cautioned about their food intake or insulin therapy. The telemedicine group each got a glucometer and a mobile phone with an installed application which allows transferring of blood glucose readings to the main database through a text message. They were strongly advised to send blood glucose readings to the terminal once a week. (Perez-Ferre et al. 2010.)

The aim of the research of Given et al. (2015) was to determine the feasibility and acceptability of using telemedicine in the diabetic care of women with GDM and the possibility of replacing alternative diabetes review appointments with telemedicine. A randomised controlled trial was carried out and women were placed into two separate groups, the telemedicine group and the control group after getting their informed consent. 50 participants participated in the study. 24 women were placed in the telemedicine group and 26 women were placed in the control group. Women recruited had been diagnosed with GDM or impaired glucose tolerance test following an oral glucose tolerance test, usually conducted at twenty-four to twenty-eight week of gestation. Those excluded from the study are those with previous diabetes history receiving oral steroid therapy. The study was carried out in two separate antenatal diabetes clinics in Northern Ireland and Republic of Ireland. (Given et al. 2015.)

Participants in the control group were instructed to check the glucose level in their blood seven times every day, before and after every meal and before bed. In every 2 weeks, they must visit a specialist diabetes clinic. They must perform all necessary test in every visit, which include, weight and blood pressure measurement, urinalysis test and glycaemia evaluation, using available SMBG records and glycated haemoglobin. Participants were reviewed weekly in the telemedicine group using the telemedicine system which includes a set of scales, blood pressure monitor, glucometer and a telemedicine hub. The telemedicine hub is a device which facilitates the collection and transmission of telemedicine data from the patient to the health care providers. The patients get a reminder for their telemedicine session once a week. (Given et al. 2015.)

Patient’s satisfaction was reviewed both quantitatively and qualitatively. Participants in the telemedicine group were asked to complete a questionnaire to indicate their satisfaction with the telemedicine device and its usefulness to them. A similar copy of the questionnaire was also given to the control group to measure blood glucose monitoring satisfaction and usefulness. They
must complete the questionnaires at week 36-38 of gestation. At week 36-38 of gestation participants in the telemedicine group were also invited for a recorded semi-structured interview with the permission from the patients to record. (Given et al. 2015.)

Kruger et al. (2003) studied the impact of dissemination of glucose in the blood through modem, and the satisfaction of patient with the service. 72 participants joined the study and they were randomised into two groups. They both tested for blood glucose levels with the Accu-Chek Complete metre. Blood glucose data was transmitted to the clinic by the modem group via the Acculink Modem and blood glucose data were directly transmitted to the clinic via telephone calls to the clinic personnel by the control group. The study participants included age was 18 years or older for all participating pregnant patients. The mean age of study participants was 31 years with a range of 19 to 41 years. When entering the study, the mean gestational age was 28 weeks with a range of 15 to 37 weeks. They were all instructed to test and record the blood glucose level 5 times a day. (Kruger et al. 2003.)

Hospital/clinic visit were scheduled for 1 week after the first visit, then every 2 weeks until 1 month before the proposed delivery, then weekly until delivery. During those visits, each participant’s blood glucose readings were reviewed and there is an adjustment or initiation of insulin therapy as required. After delivery, participant’s satisfaction questionnaires were mailed to each participant and each clinic health care provider who partook in the study. They were told to return filled questionnaire back to the Endocrinology and Metabolism Clinic. Statistical means was used in the analysis of data from the study. (Kruger et al. 2003.)

Borgen et al. (2017) developed a smartphone application (pregnant+ app) for women with GDM and they want to see if its usage alongside the standard care will result in a better blood glucose comparing this with regular care only, for patients with GDM. They performed a multicentre RCT (Randomized controlled trial), recruiting pregnant women attending the Outpatient department (OPD) at the Oslo University Hospital, Vestre Viken Hospital Trust and Akershus University Hospital. A total of 230 participants, 115 participants are in the control group and 115 participants are also in the intervention group. After the study questionnaires was given to access the participants satisfactory level. (Borgen et al. 2017.)
6.2 Maternal outcomes

All articles used will be accessed thoroughly to see the maternal outcomes after remote monitoring of the gravid women with GDM after delivery.

According to the research of Homko et al. (2012) women in both groups accomplished similar levels of glycaemic control as evaluated by the recorded blood glucose data in the logbook for the control group or through telemedicine transmission for the intervention group. There is variation of mean blood glucose, women from Tallahassee attained lower mean blood glucose levels than their Philadelphia counterpart (104.7 ± 9.3 mg/dL vs. 114.4 ± 19.7 mg/dL; \( P = 0.005 \))

Those that received treatment by medical nutrition therapy only attained lower mean blood glucose levels that those that requiring drug therapy, either glyburide or insulin (104.1 ± 13.2 mg/dL vs. 114.6 ± 15.1 mg/dL; \( P = 0.002 \)). Pre-eclampsia or gestational hypertension affected seven percent of women in the study which comprises of three women from the telemedicine group and two women from the control group. Premature rupture of the membranes (PROM) was experienced by two women in the study, and two other cases of chorioamnionitis was reported. (Table 5). Both groups reported increased caesarean delivery rate, though it was recorded more in the control group which had the highest rate. (Homko et al. 2012.)

Table 5: Maternal outcomes by treatment group (Homko et al. 2012)

<table>
<thead>
<tr>
<th></th>
<th>Controls % (n)</th>
<th>Telemedicine % (n)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caesarean delivery</td>
<td>50% (19)</td>
<td>36% (13)</td>
<td>0.3</td>
</tr>
<tr>
<td>Pre-eclampsia/gestational hypertension</td>
<td>5% (2)</td>
<td>8% (3)</td>
<td>0.7</td>
</tr>
<tr>
<td>Premature rupture of membranes</td>
<td>0% (0)</td>
<td>5.5% (2)</td>
<td>0.2</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>2.6% (1)</td>
<td>2.8% (1)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

In Carral et al. (2015) research, there was increased caesarean section rate in both groups but were higher among women in the control group. Insulin treatment was more rampant among participants in the control group in contrast to their counterparts in the telemedicine group. See Table 6 for more information. (Carral et al. 2015.)
Table 6: Maternal and Neonatal outcomes in patients of the study (N=104) (Carral et al. 2015)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Total (n=104)</th>
<th>TMG (N=40)</th>
<th>CG (N=64)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of delivery (gestational weeks)</td>
<td>38.2 ± 1.7</td>
<td>37.8 ± 2.1</td>
<td>38.4 ± 1.4</td>
<td>0.083</td>
</tr>
<tr>
<td>Delivery before 37 weeks (%)</td>
<td>8 (7.7%)</td>
<td>3 (7.5%)</td>
<td>5 (7.8%)</td>
<td>0.175</td>
</tr>
<tr>
<td>Caesarean delivery (%)</td>
<td>38 (36.5%)</td>
<td>12 (30.0%)</td>
<td>26 (40.6%)</td>
<td>0.164</td>
</tr>
<tr>
<td>Weight gain (kg)</td>
<td>8.8 ± 6.5</td>
<td>8.4 ± 6.5</td>
<td>9.0 ± 6.6</td>
<td>0.644</td>
</tr>
<tr>
<td>GDM with insulin treatment (%)</td>
<td>27 (25.9%)</td>
<td>6 (15.0%)</td>
<td>21 (32.8%)</td>
<td>0.023</td>
</tr>
<tr>
<td>Pregnancy induced HT (%)</td>
<td>5 (4.8%)</td>
<td>2 (5.0%)</td>
<td>3 (4.7%)</td>
<td>0.966</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>4.7 ± 3.6</td>
<td>4.8 ± 4.0</td>
<td>4.6 ± 3.4</td>
<td>0.879</td>
</tr>
<tr>
<td>Neonatal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscarriages (%)</td>
<td>2 (1.9%)</td>
<td>2 (5.0%)</td>
<td>0 (0.0%)</td>
<td>0.093</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3.159 ± 481</td>
<td>3.077 ± 570</td>
<td>3.213 ± 411</td>
<td>0.195</td>
</tr>
<tr>
<td>Large for gestational age (%)</td>
<td>11 (10.6%)</td>
<td>5 (12.5%)</td>
<td>6 (9.4%)</td>
<td>0.660</td>
</tr>
<tr>
<td>Small for gestational age (%)</td>
<td>6 (5.8%)</td>
<td>3 (7.5%)</td>
<td>3 (4.7%)</td>
<td>0.581</td>
</tr>
<tr>
<td>New-born males (%)</td>
<td>50 (48.1%)</td>
<td>18 (45.0%)</td>
<td>32 (50.0%)</td>
<td>0.695</td>
</tr>
<tr>
<td>Hypoglycaemia (%)</td>
<td>3 (2.9%)</td>
<td>1 (2.5%)</td>
<td>2 (3.1%)</td>
<td>0.646</td>
</tr>
<tr>
<td>Other neonatal complications (%)</td>
<td>3 (2.9%)</td>
<td>0 (0.0%)</td>
<td>3 (4.7%)</td>
<td>0.189</td>
</tr>
</tbody>
</table>

Results are expressed as mean ± SD values or numbers (%) as indicated. CG, control group; GDM, gestational diabetes mellitus; HT, hypertension; TMG, telemedicine group.

There were 5 cases of pregnancy induced hypertension among the participants. 2 cases from the TMG and 3 cases from the CG.
In Homko et al. (2007) research, insulin therapy was required by a greater proportion of women in the telemedicine group statistically significant to manage their diabetes. Similar levels of glycaemic control and haemoglobin A1C levels were achieved by both groups of women. Pre-eclampsia or gestational hypertension affected five women from the control group and nine women from the telemedicine group which amount to twenty percent of women in the control group and twenty eight percent of women in the telemedicine group. One woman from the intervention group had placenta abruptio at term and premature rupture of the membrane was experienced by four women. There was increased caesarean delivery rates among women in both groups but highest among those in the telemedicine group (69% vs. 40%). Although this did not reach statistical significance ($P = 0.53$). (Homko et al. 2007.)

In Perez-Ferre et al. (2010) research, maternal outcomes in this study was compared from the two groups. See table 7. Two women from the telemedicine group had pregnancy induced hypertension (PIH). There was more vaginal delivery in the control group than in the telemedicine group. There were 17 cases of caesarean delivery in the telemedicine group compared to 12 in the control group, also 10 instrumental vaginal delivery in the telemedicine group and 5 instrumental vaginal delivery in the control group. (Perez-Ferre et al. 2010.)

Table 7: Gestation, delivery and new born data. (Perez-Ferre et al. 2010)

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Telemedicine group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>48</td>
<td>49</td>
</tr>
<tr>
<td>Gestational weeks at delivery</td>
<td>$39.42 \pm 1.42$</td>
<td>$39.12 \pm 1.66$</td>
</tr>
<tr>
<td>Pregnancy induced hypertension</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Normal vaginal birth</td>
<td>26</td>
<td>20</td>
</tr>
<tr>
<td>Caesarean Section</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Condition</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Instrumental vaginal birth</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Large-for-gestational age</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Hypoglycaemia</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Preterm Birth (GA &lt; 37 weeks)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Loss of foetal wellbeing</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Shoulders dystocia</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

According to Given et al. (2015) research, there was no remarkable difference between the two groups under this study. There was a pre-eclampsia/ pregnancy induced hypertension case in the control group. There was similar number of caesarean deliveries in both groups. Intrauterine foetal death was experienced by one woman in the control group and none was recorded in the telemedicine group. Table 9, shows the statistical figures. (Given et al. 2015.)

### 6.3 Neonatal outcomes

The outcome of neonates where assessed from all articles under this study.

In Homko et al. (2012) research, there were no remarkable differences with regards to birth weight on univariate or multivariate analysis between the two groups. They admitted eleven infants to the neonatal intensive care unit, but there was no perinatal or neonatal death. One woman from the control group gave birth to a neonate with chromosomal abnormalities and multiple congenital abnormalities. Neonates born to women in the intervention group were least expected to be preterm, they also had lower respiratory disorders rates, and do not necessarily be admitted into the intensive care unit. Table 8 shows data in mean standard deviation. (Homko et al. 2012.)
Table 8: Neonatal outcomes by treatment group (Homko et al. 2012)

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>Telemedicine</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g)</td>
<td>3,249 ± 611</td>
<td>3,372 ± 469</td>
<td>0.3</td>
</tr>
<tr>
<td>GA at delivery (weeks)</td>
<td>37.9 ± 2.0</td>
<td>38.6 ± 1.3</td>
<td>0.08</td>
</tr>
<tr>
<td>Apgar score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 min</td>
<td>8.1 ± 1.0</td>
<td>7.6 ± 2.0</td>
<td>0.2</td>
</tr>
<tr>
<td>5 min</td>
<td>8.9 ± 0.3</td>
<td>8.9 ± 0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>LGA</td>
<td>18.4% (7)</td>
<td>25% (9)</td>
<td>0.7</td>
</tr>
<tr>
<td>Neonatal hypoglycaemia</td>
<td>10.5% (4)</td>
<td>11% (4)</td>
<td>1.0</td>
</tr>
<tr>
<td>ICU admissions</td>
<td>18.4% (7)</td>
<td>11% (4)</td>
<td>0.6</td>
</tr>
<tr>
<td>Preterm delivery</td>
<td>13.2% (5)</td>
<td>5.6% (2)</td>
<td>0.4</td>
</tr>
<tr>
<td>Jaundice /hyperbilirubinemia</td>
<td>5% (2)</td>
<td>2.8% (1)</td>
<td>1.0</td>
</tr>
<tr>
<td>RDS/respiratory</td>
<td>13.2% (5)</td>
<td>5.6% (2)</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Data are mean ± SD values or percentages (n) as indicated. GA, gestational age; ICU, intensive care unit; LGA, large for gestational age; RDS, respiratory distress syndrome.

In Carrat et al. (2015) research, there were little metabolic complications for neonates from women in the telemedicine group than for neonates from women in the control group, but none of these differences was of statistical importance. See Table 6. There were 11 cases of large for gestational age neonates, 5 cases from the TMG and 6 cases from the CG. 6 cases of small for gestational age neonates were also reported, 3 cases from both groups under this study. 2 miscarriages happened to 2 women in the TMG, and none was recorded in the CG. (Carral et al. 2015.)

In Homko et al. (2007) research, there was no significant differences among the two groups regarding weight at birth, gestational age at delivery, Apgar scores at 1 minute and 5 minutes, and rates of large for gestational age (LGA). There were no perinatal or neonatal death; however, eleven infants required a neonatal intensive care unit admission. Two infants had congenital anomalies at birth, one from each group (Intervention and control group). (Homko et al. 2007.)
In Perez-Ferre et al. (2010) research, LGA neonates birth were recorded in both groups under this study. More details on Table 7. Five foetal loss was recorded from women in the control group and three foetal loss recorded from women in the telemedicine group. (Perez-Ferre et al. 2010.)

Table 9: Clinical outcomes (Given et al. 2015)

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Control</th>
<th>Telemedicine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal HbA1c (mmol/mol) at 36 weeks of gestation</td>
<td>33.84 ± 2.88</td>
<td>34.04 ± 3.23</td>
</tr>
<tr>
<td>Appointments attended (%)</td>
<td>92.6 ± 18.2</td>
<td>97.8 ± 6.1</td>
</tr>
<tr>
<td>Pre-eclampsia/pregancy-induced hypertension</td>
<td>1 (3.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Caesarean delivery</td>
<td>10 (38.5%)</td>
<td>10 (47.6%)</td>
</tr>
<tr>
<td>Intrauterine death</td>
<td>1 (3.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Gestation (weeks) at delivery</td>
<td>38.7 ± 1.3</td>
<td>38.8 ± 0.8</td>
</tr>
<tr>
<td>Premature (&lt; 37 weeks of gestation)</td>
<td>2 (8%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3,272 ± 443</td>
<td>3,557 ± 599</td>
</tr>
<tr>
<td>Macrosomic (birth weight ≥4,000 g)</td>
<td>2 (8%)</td>
<td>6 (28.6%)</td>
</tr>
<tr>
<td>Admitted to NICU</td>
<td>9 (45%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>Neonatal hypoglycaemia (blood glucose &lt; 2.6 mmol/L)</td>
<td>6 (25%)</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>Jaundice</td>
<td>8 (47.1%)</td>
<td>10 (50%)</td>
</tr>
<tr>
<td>Respiratory distress or transient tachypnoea of the new-born</td>
<td>3 (15.0%)</td>
<td>1 (4.0%)</td>
</tr>
<tr>
<td>Shoulder dystocia</td>
<td>9 (0.0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Data are mean – SD values or n (%) as indicated. HbA1c, glycated haemoglobin; NICU, neonatal intensive care unit

In Given et al. (2015) research, after delivery 6 macrosomic neonates were given birth to by women from the telemedicine group as against 2 macrosomic deliveries from the control group, with weight at birth equal to or greater than 4,000 g. 9 cases of shoulder dystocia were reported from women in the control group and none was reported in the telemedicine group. More details are shown in Table 9. (Given et al. 2015.)
6.4 Patients’ satisfaction

The goal of this remote patient monitoring is to arrive at a positive end. Therefore, after each successive clinical trial, patients’ satisfaction evaluation is very important, so we can know how successful the different telemedicine method adopted performed. Under this subsection, we will discuss the Patients’ satisfaction from the previous studies evaluated one after the other.

The satisfaction scores in Bartholomew et al. (2015) research for the cell-phone internet technology (CIT) system were remarkably higher than for the voicemail method regarding preference, usability, management of time, motivation, self-efficacy, personalisation and recommendations to friends and family. (Bartholomew et al. 2015.)

They evaluated satisfaction with the use of the system through a designed questionnaire completed by women 4 weeks postpartum. It is known as Oxford Maternity Diabetes Treatment Satisfaction Questionnaire (OMDTSQ). Women scored their agreement on a scale of 7-point, ranging from +3 (strongly agree) to -3 (strongly disagree). Overall responses were favourable, which means, patients were highly satisfied with the care, with no woman scoring any question with the most negative scores (strongly disagree [-3]) or (disagree [-2]). Most patients commented about the technology, they were impressed because they don’t have to travel more often to the hospital for visits, especially when they have other commitment to cater for, some have little ones to look after. They reported that the system was convenient and reliable. They were well satisfied with their care and fully supported. (Hirst et al. 2015.)

In Given et al. (2015) research, the intervention group completed a questionnaire on the telemedicine satisfaction and usefulness at 36-38 weeks of gestation. The intervention group participants also participated in a semi-structured interview recorded with permission at thirty-six to thirty eight weeks of gestation. Four Healthcare practitioners (HCP) staff members who partook in the study were also interviewed. They consist of a consultant endocrinologist, a diabetes specialist midwife, and two diabetes specialist nurses. They conducted an interview which lasted between fifteen to thirty minutes and it was recorded.

The response rate to the satisfaction questionnaire was impressive. 91% (19 out of 21) of participants in the telemedicine group responded while 85% (22 out of 26) of participants in the
control group responded. Their response was positive, and 89.4% of participants agreed to use the telemedicine another time. Majority of the participants were impressed with the equipment and it was easy to use, though a few of them had issues with the blood pressure monitor. Positive response was also received from the control group, they were satisfied with the blood glucose metre. HCPs also found the equipment easy to use, they also have positive response. (Given et al. 2015.)

**6.5 Summary of the key results**

The initial database search through Scopus database produced 1829 studies with 15 articles identified from additional records from other sources, such as the reference lists and PubMed search. 11 articles were eventually identified for inclusion in the literature review after rigorous processes of eliminating weak, ineligible and unwanted articles.

From the 11 articles that met all required criteria. A total of 1110 participants conducted across 6 countries which included the USA, Spain, Northern Ireland, Republic of Ireland, Norway and UK. All research was conducted between 2003 and 2016, which had the highest number of publications. 9 studies used RCT designs, 1 used CCT design and 1 used quantitative method. Most articles used internet based internet based telemedicine system using cell-phones and computers.

Those excluded from the study were women with previous diabetic history before being pregnant and those with multiple births. Most of the studies were randomized into two groups, telemedicine and control group. All participants were equally assessed with the standard care. Standard care was provided from the highly skilled healthcare providers. They were instructed to check their glucose levels four times daily (before breakfast and 2-hour after meals). The aim is to maintain a metabolic goals of a fasting plasma blood glucose level ≤ 95mg/dl and 2-hour postprandial blood glucose level of ≤ 120 mg/dl. (Homko et al. 2007.)

Seven times daily blood glucose monitoring was used in one of the studies under review, participants in the control group examined the level of glucose in blood 7 times daily, before and after each meal and before bed. They visited the specialist diabetes clinic every 2 weeks. (Given et al. 2015.)
Another utilised the monitoring of blood glucose 6 times daily, on at least 3 days of the week. Consisting of a fasting sample, 1-hour post breakfast, pre-lunch, pre-dinner and 1-hour post dinner. The optimal blood glucose is a fasting reading $\geq 3.5$ and $\leq 5.8$ mmol/L and 1-hour postprandial readings below 7.8 mmol/L. In the case of women with a persistently high blood glucose reading, monitoring is increased to 7 days/week and for those that required or using medication. (Mackillop et al. 2016.)

If there is a case of any pharmacological treatment, participant will be referred to the clinic under the custody of the consultant to commence treatment. GDM was diagnosed with the criteria described by Carpenter and Coustan. (Carpenter and Coustan, 1982.)

Maternal outcome was described extensively in all articles under this study. Pre-eclampsia or gestational hypertension, premature rupture of the membranes (PROM), chorioamnionitis (Homko et al. 2012). Caesarean delivery rate was more common among women in the control group (Carral et. al. 2015) and among participants in the telemedicine group in some studies (Homko et al. 2007, Perez-Ferre et al. 2010).

Some birth defect was reported in some studies (Homko et al. 2007). Many large for gestational age neonates (macrosomia) were reported (Given et al. 2015).

Patients were highly satisfied with the telemedicine application and many says will utilise such method in their subsequent pregnancy.
7 DISCUSSION

Women with GDM is usually diagnose at approximately twenty four to twenty eight weeks of gestation, and they only have 12-16 weeks to get an appropriate control of the metabolism. Utilization of telemedicine to attain strict glycaemic control is an alternative means of lowering the number of outpatient clinic visits for women who have difficulty accessing healthcare centre for social and professional reasons other than the face to face assessments method. In this study, similar levels of glycaemic control, maternal and neonatal outcomes was achieved from participants in both groups. Significant lower outpatient visits to the GDU, nurse educator and general practitioners was recorded from women in the TMG compared to women in the CG. This study also confirmed that there was no impact of technology on the maternal and neonatal outcomes in women with GDM just like previous studies. Most of the studies used telephones, modems, or glucometers which has the capacity of transmitting information through the internet, and the telemedicine studies conducted with a special website created for diabetic patients. Information technology and the internet is having tremendous impact on business operations, just as seen in the updated D&M IS success model and its six success dimensions (DeLone and McLean, 1992). Studies reported that there is higher patient satisfaction and feeling of self-efficacy are significantly from pregnant women using telemedicine system support. Increased glucose control is predicted through enhanced patient satisfaction and keeping to the strict diabetes self-management regimen with the increased and persistent contact and feedback from the healthcare team through telemedicine systems. This results to reduce insulin treatment rate observed in the patients with GDM in the TMG in this study. They profited from supervised diabetes self-management and treatment for those requiring insulin therapy. There are several limitations to this study, they have a small sample size, and participants were not randomized and they have the liberty to choose between groups. All telemedicine system (Internet based, telephone calls, and glucometers capable of transmitting data) are all beneficial, however they all have their advantages and disadvantages Benefits of telemedicine system based on a diabetes-specific website include, it allows viewing or treatment schedule modification by the patient and caregivers, it allows the patients to receive metabolic control statistics or treatment reports, it allows patients to download documents of interest from the website.
archive, it also reminds patients who forgot to send their data as scheduled by sending them automatic reminders. (Carral et al. 2015.)

Homko et al. (2012) proposed a research to investigate the effect of an improved remote monitoring system with an IVR capabilities on pregnancy outcomes in women with GDM. This device assist women with feedback and encourages them in respect of diabetes self-management and improves communication between the women and their care providers. This system does not improve glucose control, however more than two-thirds of women achieved mean glucose level of < 110mg/dL. There is no difference in the pregnancy and neonatal outcome between the two groups (TMG and CG). But, infants from the telemedicine group were most unlikely to be admitted into the intensive care unit and if they are admitted, they will have shorter stays unlike those from the control group. There was no impact on pregnancy outcomes with the usage of the enhanced telemedicine monitoring system, however there was increased communication with the health care professionals and their patients. (Homko et al. 2012.)

Hirst et al. (2015) found out that technology use is a supplement to help control diabetes by women with GDM and the system was reported as reliable and convenient (Hirst et al. 2015). Homko et al. (2007) reported that the successful application of telemedicine system was potentially limited due to computer and internet access in underserved population (Homko et al. 2007).

Mackillop et al. (2015) reported that the trial protocol was to determine the efficacy of remote monitoring of pregnant women with GDM and compared to those using the usual care. They figured out that severe adverse clinical outcomes such as, shoulder dystocia or neonatal hypoglycemia that are common with GDM are usually not found in women under management. (Mackillop et al. 2015.)

Perez-Ferre et al. (2009) reported that the use of telemedicine system as a substitute to unscheduled traditional outpatient visits did not determine the pregnancy outcome, delivery outcome and neonatal outcomes despite the proportion of those using insulin in the telemedicine group. (Perez-Ferre et al. 2009.)

The patients’ and health professionals’ time is being saved by the reduction in the number of clinic visits. The telemedicine system also facilitates the accessibility of the patient to the professional team, at the patient’s convenience. It saves outpatient waiting times, reduces
transportation, reduces the interference of hospital visits with the patient’s regular work schedules, making live so easy for the patient. Those requiring insulin treatment benefit more from these, it paves way for easy access to their health care providers. (Perez-Ferre et al. 2010)

Borgen et al. (2017) reported that there is health recovery from most of the women with GDM after birth, studies indicated that there is a high chances of developing type 2 diabetes mellitus later in life. Studies further indicated that this is mostly common to women with the highest blood glucose levels during pregnancy. However, adequate intervention to reduce hyperglycaemia in women with GDM is being implemented to prevent the risk of type 2 diabetes mellitus. Healthy lifestyle adoption by women will positively influence their health and wellbeing during pregnancy and later in life. (Borgen et al. 2017.)

As previously discussed, quality has three dimensions: Information quality, System quality and Service quality. These represent remote patient monitoring system or telemedicine system in our study. The quality of the system is the quality of the information on telemedicine the health care providers gives to their patients as an alternative to the conventional outpatient hospital visits. Information quality is the value or the worth of the telemedicine information relayed to the women with GDM. The service quality is measured by the performance of the telemedicine system to the women in the TMG.

The quality of the system will further lure users to have the intension to use the telemedicine system, then the eventual use and when they are very pleased with the system, then user satisfaction sets in. This happens when the health care providers suggested telemedicine system application to women with GDM. The health care providers are aware of their patients’ health history and they are also aware of their tight schedule, work restriction or too busy with younger children. So, the health care provider recommended telemedicine system to their patients. They suggested the different telemedicine system available (Internet based or smartphone based) and the patient opted for any of the options available. Then, the intension to use sets in, and the patients finally gives in to use the system. The patient was happy to use the telemedicine system recommended by the health care provider, because it saves time, reduces cost, very efficient and convenient. Then the user satisfaction is being achieved, when the patients’ needs are met. This is a positive net benefits, because the patient finally observed an improvement in her glycaemic control, which brings about the reduction
in her daily blood glucose level monitoring using the recommended telemedicine system. This will prompt further influence and reinforce subsequent use and more user satisfaction will be achieved. This shows how an enhanced quality system is being associated with more use, more user satisfaction and positive net benefits. (DeLone & McLean, 1992.)
8 CONCLUSION

Remote patient monitoring of women with GDM from the synthesis of many studies previously written, has tremendous impact in the life of the users, it helps pregnant women who are too busy with daily chores, those taking care of little children or those preoccupied with work to monitor their blood glucose level independently without the need for the usual outpatient clinic visit. They interact with their healthcare providers with the use of their various telemedicine application systems they are utilizing.

Carral et al. (2015) concluded that a web-based telemedicine system is a facilitating tool for the management of pregnant diabetes patients that required strict glycaemic control as an addition to the regular outpatient clinic visits, mostly in cases where the medical centres are inaccessible. They will help in reducing the outpatient visits. (Carral et al. 2015.)

These present-day healthcare technologies’ real potential is their ability to increase how work is done while sustaining the care quality (Homko et al. 2012).

Pregnant women will hopefully understand how to control their diabetes better with this developed innovative patient-centred approaches to care. Therefore, scalability, sustainability and data security during the data collection need to be emphasized if digital care will be utilised for routine clinical care. (Hirst et al. 2014.)

Perez-Ferre et al. (2009, 2010) concluded that telemedicine is a useful device in the management of diabetic patients when it is combined with the traditional face-to-face outpatient monitoring, for patients requiring stricter glycaemic control or to those who had the difficulty in accessing the medical center (Perez-Ferre et al. 2009, 2010).

Future research should concentrate on how the use of remote patient monitoring system (telemedicine system) will lead to the improvement of pregnancy outcomes and on how to reduce complications associated with GDM using the remote patient monitoring system.
REFERENCES


48


Center for connected health policy California (CCHP), http://www.cchpca.org (2015)


National Diabetes Data Group criteria for 100g OGTT (NDDG, 1979)


Ridley Diana. 2012. The literature review – A step by step guide for student. SAGE.


## APPENDIX 1

Characteristics of the 11 selected studies (11 Publications)

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Setting /Country</th>
<th>Design</th>
<th>Population/gestation</th>
<th>Intervention</th>
<th>N</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirst et al. 2015</td>
<td>Oxford university Hospital, UK.</td>
<td>Structured questionnaire</td>
<td>34w</td>
<td>Mobile phone Internet technology (CIT)</td>
<td>I:49</td>
<td>C: It is accepted and convenient for most women.</td>
</tr>
<tr>
<td>Homko et al. 2012</td>
<td>Prenatal clinic Philadelphia, PA &amp; Diabetic hospital Tallahassee, FL</td>
<td>RCT</td>
<td>33w</td>
<td>Internet based using ITSMyHealthfile</td>
<td>I:40</td>
<td>C: Pre-eclampsia or gestational hypertension, premature rupture of the membrane, chorioamnionitis, neonatal hypoglycaemia, neonatal hypoglycaemia, increased birth weight</td>
</tr>
<tr>
<td>Carral et al. 2015</td>
<td>GDM unit in Cadiz, Spain</td>
<td>CCT</td>
<td>&lt; 30w</td>
<td>Web-based telemedicine system</td>
<td>I:40</td>
<td>C: HbA1c (%); weight gain, CS delivery rate, insulin treatment rate, neonatal hypoglycaemia, large for gestational age.</td>
</tr>
<tr>
<td>Study</td>
<td>Location</td>
<td>Intervention</td>
<td>Randomized Controlled Trial (RCT)</td>
<td>≤ 33w</td>
<td>≤ 34w</td>
<td>≤ 30w</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-----------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Homko et al. 2007</td>
<td>Prenatal clinic or one of its satellites in Philadelphia, PA</td>
<td>Internet-based telemedicine system using ITSMYHealthfile and Lassoweb</td>
<td>I:32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mackillop et al. 2015</td>
<td>Maternity diabetes service of National Health Service Hospital (NHS), UK</td>
<td>Smartphone based telemedicine system</td>
<td>I:100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bartholomew et al. 2015</td>
<td>Kapi‘olani Medical Center for Women and Children (KMCWC), Hawaii, USA</td>
<td>Cell-phone internet technology (CIT) telemedicine system</td>
<td>I:40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perez-Ferre et al. 2009</td>
<td>San Carlos University Hospital, Madrid, Spain</td>
<td>Internet and SMS telemedicine system</td>
<td>I:49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Location</td>
<td>Methodology</td>
<td>Duration</td>
<td>Technology</td>
<td>Randomization</td>
<td>Conditions</td>
</tr>
<tr>
<td>-------</td>
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<td>-------------</td>
<td>----------</td>
<td>------------</td>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td>Perez-Ferre et al. 2010</td>
<td>San Carlos University Hospital, Madrid, Spain</td>
<td>RCT</td>
<td>&lt; 28w</td>
<td>Cell-phone Internet technology (CIT), SMS telemedicine system</td>
<td>I:48 C:49</td>
<td>Large for gestational age, Hypoglycaemia, Pregnancy induced hypertension</td>
</tr>
<tr>
<td>Given et al. 2015</td>
<td>Prenatal diabetes clinics in Northern Ireland and Republic of Ireland</td>
<td>RCT</td>
<td>24-28w</td>
<td>Internet based telemedicine system</td>
<td>I:24 C:26</td>
<td>Pre-eclampsia/Pregnancy induced hypertension, neonatal hypoglycaemia, macrosomia, shoulder dystocia</td>
</tr>
<tr>
<td>Kruger et al. 2003</td>
<td>Endocrinology and metabolism clinic, USA</td>
<td>RCT</td>
<td>15-37w (Mean gestational age 28w)</td>
<td>Internet modem, telephone telemedicine system</td>
<td>I:36 C:36</td>
<td>Participants were satisfied with modem performance and the glucose meter.</td>
</tr>
<tr>
<td>Borgen et al. 2017</td>
<td>Diabetic OPD at the Oslo University Hospital, Vestre Viken Hospital Trust and Akershus University Hospital, Norway</td>
<td>RCT</td>
<td>&lt; 33w</td>
<td>Smartphone based telemedicine system</td>
<td>I:230</td>
<td>The primary outcome was the glucose level measured at the 2-hour OGTT 3 months postpartum. Changes in health behaviour and knowledge about GDM, quality of life, birth weight, mode of delivery and complications for mother and child.</td>
</tr>
</tbody>
</table>

w – week, I – Intervention, C - Control