Delivering on Digital: A Review of Virtual Health Literature in Perinatal Care

by

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Abstract

Virtual health aims to transform the delivery of healthcare and improve overall patient experiences and health outcomes. Women of reproductive age are frequent users of digital technologies, and the perinatal period presents an opportunity to improve both child and maternal health outcomes. Healthcare professionals recognize the importance of leveraging digital technologies to strengthen the delivery of patient-centred care during the perinatal period. This report reviews the current literature on digital health technologies targeted at pregnancy to assess the success factors, limitations and considerations necessary for implementation. Identified success factors include convenience, extended interactions between patient and provider and anonymity. Identified limitations include the digital divide, provider pushback and privacy concerns. The decision to implement digital health interventions also requires consideration of the potential for victim blaming, increases in social equity and complexity in health behaviour change.

Keywords: perinatal care, digital health, virtual health, telemedicine, digital messaging, remote monitoring, online treatment and resources
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Introduction

The digital age has profoundly changed the way we live our lives. Increasing numbers of individuals are making use of personal computing devices such as laptops and mobile phones to access the internet. According to the Canadian Radio-television and Telecommunications Commission (CRTC), 93% of households in British Columbia (BC) have internet access (1). Canadians generally perceive technology as a positive asset that improves their ability to communicate with others, to work more efficiently, to make more informed decisions and to be more creative (2).

In the health field, the digital transformation promises to improve patient experiences, communications between patients and families and providers and overall health outcomes (3). Within the last decade, research on telemedicine, telehealth, mobile health (mHealth) and electronic health (eHealth) has increased dramatically (4). Thus, the concept of digital doctors or nurses, the explosion of digital health applications and advances in electronic medical records are emerging as critical components for the future of healthcare globally. Within the past year, the World Health Organization (WHO) released its first set of recommendations on digital health interventions (5). The document includes ten recommendations to strengthen the role of digital health technology to improve access to information and essential healthcare services. Moreover, WHO developed a classification system for digital health interventions to unify broad definitions such as mHealth and eHealth.

In BC, the Provincial Health Services Authority’s (PHSA) Office of Virtual Health (OVH) was the first authority to develop a clinically designed policy for virtual health. Outlined in this policy is the expectation that patients will receive as good or better care virtually than they would receive in person. As defined by PHSA, virtual health “refers to a patient centred model
focused on connecting patients, families and providers, using technology to optimize wellness, speciality care and outcomes (6)”. It encompasses telemedicine, mHealth, eHealth and opportunities across the patient care continuum to enhance healthcare delivery. In this report, the terms *virtual health* and *digital health* will be used interchangeably.

A survey of Canadians in 2018 revealed that seven out of ten Canadians would take advantage of virtual health visits; however, less than one of ten Canadians have had a virtual health visit (7). Evidently, a gap exists between Canadians’ expectations of healthcare delivery and what they receive. While the interest for virtual health is high, the progress is slow. Challenges related to dated and fragmented technological infrastructure, siloed operations, geographic barriers and lack of financial commitment towards public health prevention continues to hinder progress towards disruptive digital innovation (8). In response to both public and private sector demands, the PHSA OVA has established the following priorities to advance virtual health across BC (9):

I. *Virtual Health Visits* – the use of secure audio, video and chat to connect patients with their healthcare providers from any location;

II. *Clinical Digital Messaging* – the use of text, email, instant messaging and voice-to-text to facilitate messaging between patients and providers;

III. *Remote Patient Monitoring* – the use of both connected and unconnected devices, such as wearables or glucometers, to monitor patients from any location;

IV. *Online Treatment and Resources* – the use of online platforms and mobile applications to provide individual and group treatments for patients.
While digital innovation across health services may improve health outcomes by improving access to care, the perinatal period presents an opportunity to improve both child and maternal health outcomes. Moreover, the low-risk perinatal population would likely be receptive to increased access to healthcare information and support networks. Women of reproductive age are frequent users of digital technologies, such as the internet and hand-held mobile devices. Pregnant women spend on average six hours per month online researching pregnancy and child-health-related information (10). However, the quality of perinatal information available online may not be sufficient to inform action (11). Inaccurate, non-evidence-based digital information presents major public health concerns, but care providers can help women access information from reputable websites (12). Therefore, it is critical for physicians, nurses, midwives and other healthcare professionals to understand the health-seeking behaviours of their patients and align their efforts to strengthen perinatal care.

Interest in virtual health across BC is high. Earlier this year, Telus Health launched Babylon, a new health application that aims to fill the gap in primary healthcare. Its launch was met with both praise and skepticism. Concerns exist that the virtual platform will undermine effective primary care, resulting in higher costs for the public system and widening gaps in social inequities (13). It is therefore timely to identify the potential positive and negative impacts of virtual health interventions for the perinatal population.

**Review Purpose**

In this report, I present a review of the current literature on digital health technologies targeted at pregnancy to assess the success factors, limitations and considerations necessary for implementation.
What this study adds?

While reviews of mHealth, eHealth and telemedicine interventions aimed at strengthening perinatal care exist, the primary focus has been in the context of low- and middle-income countries (14–16). There are limited reviews exploring the landscape of virtual health in perinatal care in high-income countries. Therefore, this report will review digital health interventions implemented in these countries, as defined by the World Bank (17), because these studies are more relevant to the BC context.

Methods

Cooper’s Guide for literature reviews

I followed Cooper’s guide to literature reviews (18) by focusing on six characteristics: focus, goal, perspective, coverage, organization and audience. The focus refers to the type of literature to be included. Due to the paucity of research in this area, I included uncontrolled, non-randomized and randomized controlled studies as well as pilot studies and program evaluations. I excluded case studies on single patients because of their limited generalizability to the wider population. My goal was to integrate various bodies of literature, providing a sufficient overview of programs that would also allow for the identification of central issues and gaps. I employed a neutral perspective and included both supportive and unsupportive publications. The coverage refers to the amount of literature to be included: comprehensive, comprehensive with selective citation, representative, and central. I followed a representative approach in which I retrieved and evaluated literature against inclusion and exclusion criteria. I organised the report into key themes that emerged from my analysis. Finally, I prepared the report for an academic audience.
Search strategy

The initial search strategy was broad in scope to provide a comprehensive review of available literature. I conducted searches in Ovid Medline and CINAHL in February 2020 (see Appendix A1/A2 for the search strategy). I included studies that reported on the use of virtual health during prenatal, perinatal and postnatal care. The interventions had to have been implemented during pregnancy or during the first 3-6 weeks of the postpartum period. Table 1 provides a summary of inclusion and exclusion criteria. I also excluded studies that were not relevant for a universal healthcare system, such as, studies on uninsured pregnant women or private out-of-pocket remuneration models. Additional sources were identified by hand selection of reference lists and snowball searching from Google Scholar.

Table 1. Inclusion and exclusion criteria

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
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<tr>
<td>- Published in English</td>
<td>- Commentaries, letter to editors or case studies</td>
</tr>
<tr>
<td>- Peer-reviewed</td>
<td>- Technology for physicians or care providers (e.g. clinical screening interventions, decision-making tools, virtual training programs)</td>
</tr>
<tr>
<td>- Published between January 2010 to February 2020 (under the assumption that previous interventions from earlier publications would be included in later publications)</td>
<td>- Implemented in middle- or low- income countries</td>
</tr>
<tr>
<td></td>
<td>- Content related to abortion, preconception or fertility</td>
</tr>
<tr>
<td></td>
<td>- Focus was on private or out-of-pocket services</td>
</tr>
</tbody>
</table>

Screening and reviewing

The search returned 623 and 837 articles from Ovid Medline and CINAHL, respectively (see Figure 1 for the flow diagram of the selection of studies). First, article titles were scanned to determine relevance. After duplicates were removed, abstracts were reviewed against inclusion
and exclusion criteria (see Table 1). For articles in which the title and abstract did not provide sufficient detail, the full articles were evaluated. Following this process, a total of twenty-six studies were deemed relevant.

Figure 1. Search and article screening
**Qualitative analysis**

I followed Braun and Clarke’s six phases of thematic analysis (19): familiarizing [self] with the data, generating initial codes, generating themes, reviewing themes, defining and naming themes, and producing the report. The six phases describe an iterative, non-linear process to explore the key themes in the data. I reviewed the full text of all selected articles and generated both semantic and latent codes. Subsequently, I clustered the initial codes into major themes. I generated themes according to the following key characteristics including success factors, limitations and key considerations for implementing digital health interventions.

**Critical Review of Relevant Literature**

**Study selection**

The literature search identified 26 studies that met inclusion/exclusion criteria. I divided the studies into four domains for virtual health: virtual health visits, digital messaging, remote patient monitoring, and online treatment and resources. Appendix B-E provides a detailed overview of the selected studies. Sixteen of the 26 were randomized controlled trials (20–35), six were qualitative studies (36–41), two were retrospective studies (42,43), one was a non-randomized controlled trial (44) and one was an observational study (45).

**Virtual health interventions**

1. **Virtual health visits**

Virtual health visits, also known as telemedicine, describes the use of secure audio, video and chat from any location to allow patients to connect with their care providers (9). The traditional model of telemedicine describes patient care in the comfort of their home or local community. Most notable is the application of telemedicine to provide clinical support to rural or
underserved communities that lack healthcare specialists or healthcare facilities (46).

Telemedicine allows for benefits such as reductions in time lost from work, lower transportation costs, increased efficiency for healthcare providers and the healthcare system (46). While telemedicine has been discussed in the literature since 1950 and videoconferencing is well-integrated into most healthcare practices, my analysis extends our understanding of telemedicine to new uses. Three articles discussed innovative telemedicine use in the context of obstetric care (43–45).

In BC, the standard of care for low-risk prenatal women is approximately 14 prenatal examinations that increase in frequency as the pregnancy progresses into the third trimester (47). However, studies have demonstrated that reduced visit schedules can be as safe as standard care (48). One study provided one-third of antenatal visits by virtual care, where a digital sphygmomanometer and a handheld fetal Doppler monitor collected and monitored vital health data from the patient during virtual visits (49). Participants from both the virtual care and standard care groups were highly satisfied, but the virtual care model reported significantly higher mean scores for satisfaction with scheduling, provider, personal, general and overall care (49). More virtual care patients reported visits starting on time and experienced greater convenience of visit dates and times (49). Women who had experienced a previous childbirth were more likely to select the virtual care cohort, while nulliparous women are more likely to select standard care (49).

Telemedicine in prenatal genetic counselling is a well-established service to serve geographically isolated communities (50). While telemedicine typically delivers care to remote patients, my search revealed one study that leveraged telemedicine to address a workforce shortage of genetic counsellors across urban and remote clinics (45). Genetic counsellors were
employed to worked remotely from their home office to provide virtual genetic counselling services to patients visiting clinics in-person (45). This model allowed genetic counsellors to provide care to understaffed regions. However the following challenges were noted: limited provider experience with telemedicine, technical glitches and some patients reporting that the virtual health approach as less personal, especially when discussing sensitive or bad news (45).

A virtual format may also expedite patient referrals and decrease wait times. Canada has on average the second longest wait times for specialist care compared to other high-income countries (51). In gynecological care, the average wait time to see a specialist is 8.7 weeks, while the wait time between specialist consultation and treatment is an additional 7.4 weeks (51). Evidently, there is an urgent need to improve access to care for the subset of pregnant women that require specialized care. A secure, web-based electronic consultation (eConsult) service, allows primary care providers to submit a consultation to a specialist electronically for advice, without the requirement to meet via a face-to-face consultation (43). Through a retrospective chart review, 34.3% (135 of 394) of eConsults avoided a referral to the specialist, while 18.5% (73 of 394) required a referral to a specialist. For cases that required an in-person visit, the eConsult ensured that the necessary preliminary tests and examinations were completed in advance. Overall, the eConsult service reduced wait times and provided more timely care to prenatal patients who required specialist care.

II. Digital messaging

Nine studies explored the use of digital messaging (Table 2). Digital messaging refers to the use of text, email, instant messaging and voice-to-text to facilitate messaging between patients and providers (9). These platforms can provide one- or two-way messaging.
Digital messages are a powerful tool for breastfeeding support among new mothers. While breastfeeding initiation rates in BC are considered high (96%), a suboptimal number of infants (42%) are breastfed exclusively for six months (52). The use of innovative communication technology has the potential to strengthen the existing programs that offer breastfeeding support, such as breastfeeding clinics and services offered through the Vancouver Breastfeeding Centre and the Nurse-Family Partnership (53–55). For example, a two-way pilot texting support program between breastfeeding peer counsellors and new mothers provided an automated set of targeted educational information to mothers and allowed for women to text back to their peer counsellor specific concerns related to the information received (20). The total number and intensity of engagement with the two-way short message service (SMS) messages was significantly associated with exclusive breastfeeding at two weeks postpartum (20). Moreover, 97% (n=27) of participants would recommend this program to a friend (20).

Digital messaging is also used in the care of gestational diabetes mellitus (GDM). In Canada, 54.5 (95% CI: 53.6–55.4) per 1,000 deliveries are complicated by GDM (56). GDM presents important short- and long-term health consequences for both the mother and the newborn. It is associated with multiple complications such as increased incidences of gestational hypertension, caesarean delivery, still birth, preeclampsia and macrosomia (36). Generally, care for mothers with GDM includes education related to lifestyle change, along with nutrition and physical activity counselling. However, compliance with gestational diabetes care plans are often low due to a number of barriers related to self-efficacy, perception of risk and level of social support (57).

Patient empowerment is an important approach for those living with diabetes (58). Two studies described the use of digital messaging in the context of GDM that leverage the patient
empowerment through education and information that may inform necessary lifestyle changes (21,36). In one, women received daily text messages with educational information related to testing blood glucose levels, keeping to their treatment plans, medication adherence and exercise (36). Overall, 66% of participants felt that the messages helped remind them to check their blood glucose levels, and 63% would recommend the program to a friend. However, some women noted some dissatisfaction related to the automated nature of the messages and the lack of personal interaction with a care provider. Another approach was an SMS reminder at three weeks, three months and six months to remind women to obtain an oral glucose tolerance test (OGTT) after they give birth (21). While the implementation of the reminder system was feasible, no significant increase in OGTT rates was observed between the different reminder groups. Thus, the intervention likely did not address additional barriers for obtaining an OGTT in this population.

The Text4baby is a free mobile health service offered in the United States that provides health and safety information about pregnancy and the newborn’s first year of life (59). Since its launch in 2010, there have been some pivotal evaluations that inform the utility and feasibility of the program (22,23). The intervention was significantly associated with increased agreement with the statement I am prepared to be a new mother. Additionally, it was significantly associated with negative attitudes towards alcohol consumption when compared to the baseline values. Overall, digital messaging is a feasible platform to deliver prenatal education information to pregnant women.

Two studies explored the use of online interventions targeted towards pregnant smokers (24,37). Both programs involved information on how to quit smoking and the harms of smoking for fetal and infant development, along with social support and advice from ex-smokers. Overall,
the anti-smoking programs were acceptable and feasible. However, there were no significant differences in smoking-related outcomes and change in self-efficacy between the groups. Additionally, both studies described recruitment challenges in this specific population. The use of commercial online advertisements was demonstrated as a feasible, anonymous and likely cost-effective method to engage pregnant smokers in digital cessation support (60). This method has large reach potential and can offer support to a hard-to-reach population of smokers that does not require disclosure of smoking status to in-person care providers (60).

Two studies explored the use of texting to improve vaccination rates (25,26). In one, the intervention group received five weekly text messages regarding influenza vaccination and two text message appointment reminders (25). The intervention group was 30% more likely to be vaccinated, but the values were not statistically significant. The second evaluated whether text messages sent to ambulatory pregnant women could improve influenza vaccine uptake (26). However, the text messaging prompts were not effective at increasing influenza vaccination rates among a low-income, urban, ambulatory obstetric population (26).

III. Remote patient monitoring

Remote patient monitoring is a form of telemedicine wherein patient care is delivered at a distance; vital parameters are live-monitored or data is recorded from a patients’ local environment and sent virtually to the healthcare provider (61). For this project, I define remote patient monitoring as the ability to monitor patients from any location utilizing both connected or unconnected devices, such as blood pressure and activity monitors (9). Three publications explored remote monitoring (Table 3). The interventions included monitoring for mental health, gestational hypertensive disorders and induced labour (27,38,39). These studies involved
Table 2. Overview of digital messaging interventions

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Description</th>
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<tr>
<td>Lactation Advice thru Texting Can Help (LATCH)</td>
<td>(20): a two-way texting platform used as an adjunct tool for WIC breastfeeding PCs to provide timely peri-partum breastfeeding support.</td>
</tr>
<tr>
<td>Johnson et al.</td>
<td>(36): a total of 30 text messages that included a welcome message, a daily message as either a direct reminder to test their blood glucose levels and keep up with their treatment plan or an educational message and a final message. Educational messages included four areas: blood glucose goals, healthy eating, medication adherence, and exercise.</td>
</tr>
<tr>
<td>DIAMIND Study</td>
<td>(21): a SMS reminder for an oral glucose tolerance test was sent at six weeks, three months and six months postpartum.</td>
</tr>
<tr>
<td>Text4baby</td>
<td>(22,23): text messages provide information on a variety of topics critical to maternal and child health, such as prenatal care, influenza, immunization, developmental milestones, breastfeeding, safe infant sleep, injury prevention, mental health, and tobacco use.</td>
</tr>
<tr>
<td>SmokefreeMom</td>
<td>(24): an automated, text-messaging program designed to help pregnant smokers quit smoking. Messages provided advice and tips about how to quit smoking, social support, encouragement for quitting, information about the harms of smoking on a baby's development and advice from ex-smokers.</td>
</tr>
<tr>
<td>MiQuit</td>
<td>(37): an automated 12-week advice and support programme for quitting smoking in pregnancy delivered by SMS text message. Tailoring characteristics include gestation, motivation to quit, the hardest situation to avoid smoking, cessation self-efficacy, cigarette dependence and partner's smoking status.</td>
</tr>
<tr>
<td>Stockwell et al.</td>
<td>(25): received five weekly text messages regarding influenza vaccination starting mid-September 2011 and two text message appointment reminders.</td>
</tr>
<tr>
<td>Moniz et al.</td>
<td>(26): received 12 text messages regarding general preventive health in pregnancy plus the importance of influenza vaccination during pregnancy.</td>
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automatic recording or manual input of patient data, along with a platform in which this information was relayed to both the patient and the provider. A triage nurse monitored the live data (38,39) or an automated alert would notify clinical staff when indicators were above or below expected values (27).

Remote monitoring of mental health status has been widely explored and evaluated in the context of the general population (62–64). However, few studies have explored its feasibility in the prenatal population. One study explored the use of a mood tracking and alert (MTA) application among a group of high-risk pregnant women (27). The application provided a notification to clinical providers when patients’ mood symptoms worsened. Overall, the use of the application improved both service delivery and patient engagement for individuals experiencing perinatal depressive symptoms (27). Moreover, women utilizing the MTA application reported a significantly better ability to manage their own health relative to the control group (27).

In the context of gestational hypertensive disorder (GHD), a wireless blood-pressure monitor, digital weight scale and activity tracker provided obstetric surveillance (65). Study participants made one blood-pressure measurement in the morning and evening, one weight measurement per week and wore the activity tracker during the day and night. The first study examined the value of remote monitoring in the context of GHD (38). Remote monitoring resulted in a lower relative number of prenatal admissions in the remote monitoring group relative to the usual care group (38). A follow-up qualitative study examined the perceptions of patients, midwives and obstetricians on the delivery of the program and found that 87% (n=41/47) of patients did not report any negative concerns related to their privacy in utilizing the
monitoring devices (38). Moreover, 80% of women (n=28/35) reported that they felt that remote monitoring was an important intervention that added value to their pregnancy (38).

Finally, remote monitoring was used in the context of induced labour, allowing the patient to experience the earlier stages of labour within the comfort of their home (39). The use of slow-release prostaglandin along with a remote monitoring device allowed for an improved induction and labour experienced by participating women (39). The program received positive feedback; however, patients emphasized the importance of a virtual presence of the healthcare provider that reassured patients that they were being monitored.

Table 3. Overview of remote monitoring interventions

<table>
<thead>
<tr>
<th>Intervention</th>
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<tr>
<td><strong>Mood tracking and alert (MTA) mobile application</strong> (27): application alerted providers when participant mood symptoms worsened, prompting the provider to contact the participant.</td>
</tr>
<tr>
<td><strong>PREMOM Study</strong> (38): surveillance using a blood pressure monitor, an activity tracker, and a weight scale. Women were asked to measure blood pressure twice a day, measure their weight once a week, and wear an activity tracker for 24 hours/day. Data were automatically sent by Wi-Fi or Bluetooth to an online platform. A midwife reviewed the data every workday.</td>
</tr>
<tr>
<td><strong>Labour induction</strong> (39): the combination of slow-release prostaglandin along with fetal ECG and uterine activity was monitored in the hospital via the wireless technology</td>
</tr>
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</table>

IV. **Online treatment and resources**

Online treatment and resources describe the use of online platforms and mobile applications to provide individual and group treatments for patients (9), for example, the use of web-based platforms for treatment delivery or applications for educational information. Ten
publications related to studies of online treatment and resources were retrieved (Table 4). The interventions included online resources and treatments for alcohol use during pregnancy, diabetes, mental health, gestational weight gain, GDM and smoking cessation.

Provision of online information for alcohol use during pregnancy was common. Prenatal exposure to alcohol causes fetal alcohol syndrome (FAS), with the child experiencing intellectual disabilities and resultant challenges related to neurocognitive, behavioural and social functioning (66). Due to the severity of risks, there are widespread public health efforts to prevent alcohol consumption during pregnancy. Two studies explored online treatment for reported alcohol use during pregnancy (28,29). One evaluated the feasibility and acceptability of a computer-delivery screening and brief intervention (28), and a second tested the effectiveness of a health-counselling combined with computer-tailored intervention (29). The computer-based interventions were effective in alcohol use in both studies, but only one study reached statistical significance (29).

Internet-based interventions for mental health allowed for participant anonymity about a sensitive health topic. One study utilized a mobile device to deliver a stress coping app targeted to reduce stress in a sample of hospitalized women (40). The intervention reduced immediate stress and also provided respite from a stress response (39).

Web-based support programs are also available for individuals with Type 1 diabetes (30). One program delivered evidence-based information, along with a digital platform that supported a self-care diary and provided peer support in a discussion forum (29). However, the program did not result in differences between the control and experimental groups in terms of well-being and diabetes management (29).
Three studies explored the use of online technologies for gestational weight gain (31–33). The studies used a mobile app to encourage increased physical activity, along with lifestyle change advice and information, but had different outcome measures. One compared lifestyle advise only with lifestyle advice plus the use of a mobile app (31). Another compared the use of a mobile phone app (which included daily messages, mobile phone activity diary with automated feedback and self-monitoring, along with tracking with a Fitbit) with the use of a Fitbit alone (32). The third provided dietary and exercise advice to address behaviour change and exercise advice compared to usual care (33). No study demonstrated a significant benefit between intervention and standard care groups.

Finally, three studies explored the use of online treatment for smoking cessation (34,35,41). One designed a phone-based postpartum continuing care (PPCC) protocol (34). Another attempted to determine whether a behavioural intervention in pregnancy using online information would improve smoking cessation rates (35). The third study explored the use of an interactive and personalized quit plan that emulated the support from an expert smoking cessation advisor (41). All studies had low engagement with the intervention and there were no significant differences in the use of tobacco. The researchers concluded that women who had not stopped smoking before presenting to hospital care showed little interest in participating in interventions that would help them quit.
Table 4. Overview of *Online Treatment and Resources*

<table>
<thead>
<tr>
<th>Application</th>
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<tr>
<td><strong>Computer delivered screening and brief intervention (e-SBI)</strong> (28)</td>
<td>A 20-minute interactive session, using techniques such as brief education regarding alcohol-related pregnancy risks; helping the participant evaluate the pros and cons of change to avoid alcohol; feedback regarding how many women drink during pregnancy; eliciting a specific, participant-selected goal regarding drinking during the rest of pregnancy.</td>
</tr>
<tr>
<td><strong>Van der Wulp et al.</strong> (29)</td>
<td>An intervention in which alcohol cessation advice is delivered via a computer. The content is based on the answers of respondents to questions and is generated by a computer program. Consequently, the feedback is adapted to the specific characteristics of a particular individual, yielding the potential to provide messages highly tailored to the individuals' situation.</td>
</tr>
<tr>
<td><strong>MODIAB-Web Study</strong> (30)</td>
<td>Web-based support consisted of evidence-based information, a self-care diary for monitoring of daily activities, and peer support in a discussion forum.</td>
</tr>
<tr>
<td><strong>Stress Coping App</strong> (40)</td>
<td>The app included study measures, educational overview of concepts, four guided imagery audio files to be listened to daily, and a stress self-assessment scale to be used before and after each use.</td>
</tr>
<tr>
<td><strong>SNAPP Trial</strong> (31)</td>
<td>Received a comprehensive dietary, physical activity, and behavioural intervention and access to a specifically developed interactive smartphone application to reinforce the key information presented in both the face-to-face sessions and telephone calls. The app was designed to encourage women to set dietary and physical activity goals and monitor their progress.</td>
</tr>
<tr>
<td><strong>Trial App with Fitbit</strong> (32)</td>
<td>A daily message, either as a text message or short video script, was available between 10 am and 7 pm, and the activity diary was available after 7 pm to midnight every day. Daily messages were prompts to support physical activity or to reinforce the topics of the initial in-person session.</td>
</tr>
<tr>
<td><strong>Kennelly et al.</strong> (33)</td>
<td>Smartphone app has a comprehensive database of low glycemic index recipes, an exercise advice section, and a homepage comprising daily nutritional and exercise tips and an encouraging thought of the day.</td>
</tr>
<tr>
<td><strong>Phone-based Postpartum Continuing Care (PPCC)</strong> (34)</td>
<td>An individualized approach that encourages abstinence foremost, and also stresses the importance of harm reduction for women who are in the contemplation stage of change and find it more difficult to quit smoking.</td>
</tr>
<tr>
<td><strong>MumsQuit</strong> (41)</td>
<td>An interactive and personalized quit plan that emulates the support from an expert smoking cessation advisor. The intervention delivers 33 evidence- or theory-based behavior change techniques and provides up to 4 weeks of pre-quit date support and up to 4 weeks of post-quit date support, with e-mail reminders sent to notify users when new intervention sessions are being released.</td>
</tr>
</tbody>
</table>
Success Factors for Digital Health Interventions

Overall, the trends and lessons learned from the studies above can be informative for the design and implementation of new virtual health interventions for the PHSA. My analysis revealed the following themes as success factors: convenience, extended interactions between patient and providers, and anonymity.

Convenience

Qualitative, interview-based studies examined women’s experiences and level of satisfaction with virtual health interventions (22,37,39–41). Women viewed interventions positively if they allowed some or all of the following: shorter wait times (20,39,43,45), less travel time (44,49), or care in the comfort of their home (22,36–39,44,49). For example, women described the convenient delivery of SMS as “having access to additional information without having to bring anything additional with them” as a critical component of their participation in health information messaging programs (37). Moreover, convenience came from the ability to have fewer in-person visits, while perceiving similar quality of care as for standard care (44). Increased convenience not only improved care for patients but was also supported by providers. Providers reported less travel time between sites and the use of platforms shortened wait times between referrals (43,45).

Extended interactions between patient and provider

The virtual presence of healthcare providers, beyond traditional care, was associated with improved health outcomes for patients (20,27,39). For example, the two-way SMS intervention between breastfeeding peer counsellors and patients was significantly associated with higher
exclusive breastfeed rates and patient satisfaction (20). Moreover, the women within the labour induction cohorts also identified the importance of a virtual presence from their care providers, which provided a greater sense of reassurance and trust in their provider (39). These studies suggest that virtual health interventions should not replace standard care but rather, should be provided in conjunction with standard care to offer more flexibility and comfort for the patient.

Anonymity

Challenges related to pregnancy and childbirth, such as postpartum depression, continue to be highly stigmatized (67). Therefore, patients may be reluctant to disclose their challenges related to mental health during pregnancy, including smoking and alcohol use, due to fears of discomfort, guilt or even legal repercussions (67). While digital health is not intended to replace standard in-person care, the delivery of health education and resources on virtual platforms may help to provide care to difficult to reach populations. Several interventions described in this report required minimal personal information for registration (28,29,34,41), which participants reported as a lower-barrier way to access online treatment. While most of these platforms did not report a significant difference in behavioural outcomes, anonymity was noted by participants as a facilitating characteristic and is an important consideration for the delivery of treatment for stigmatized patient populations.

Limitations of Digital Health Interventions

My analysis identified the following limitations or challenges in the implementation of digital interventions: digital divide, privacy, and compensation models.
**Digital divide**

All identified studies were offered to patients at no additional financial cost; however, participation was generally restricted to patients who had access to a smartphone utilizing an iOS or Android operating system (20–22,25,26,36,37). Therefore, most studies stated that the requirement for a personal device, necessary to fully engage in virtual health opportunities, was a major limitation. This raises the issue of the digital divide.

The *digital divide* describes the unequal access to the internet and technologies such as mobile phones (68). Typically, differences in access is determined by income level, but also by age, with older individuals tending to have fewer interactions with digital technologies. The *secondary digital divide* describes the knowledge gap that exists between users (69). Thus, even if an individual has access to the internet, health literacy dictates an individual’s ability to interpret and use health information. A *tertiary digital divide* may result from other barriers to the utilization of technologies (69), such the availability of appropriate and relevant health content for the individual. Therefore, aspects such as language, cultural sensitivity and gender roles are also relevant (69). While the BC Government is taking active steps to bridge the gap in digital readiness through programs such as the Connected Communities, it is unlikely that these programs will address all three levels of the digital divide (70).

**Provider pushback**

The fee-for-service model of financial compensation for physicians presents a unique challenge in the context of Canadian healthcare (71). Currently, the model incentivizes physicians to see more patients and bill for more services within a certain time frame (71). With the integration of new models and platforms for care, billing for patients’ interactions through
email or SMS presents novel challenges for the healthcare system (72). Furthermore, a subset of providers may perceive technologies as a threat to their profession. For example, integrating technology and automation into healthcare may replace the middle-skilled workers that typically fill these roles (3). This trend is known as job polarization and describes an increased demand for high-skilled and low-skilled workers with fewer opportunities for middle-skilled workers (3).

Privacy concerns

Finally, concerns exist over the threat of data privacy violations (73,74). The utilization of web-based and electronic methods for health communication pose challenges related to privacy, ethics and the safety and security of storing and managing data (73). Moreover, there are concerns related to the ownership of health data and the extent to which this health information is shared among the public and academic sectors and with private enterprises for corporate gain (75). The occurrence of any digital security incidents may compromise both the safety and trust of digital health consumers (3).

Key Considerations for Implementing Digital Health Interventions

My analysis of the literature suggests key considerations for the design and implementation digital health interventions targeted at the perinatal period.

Victim blaming

Most interventions outlined in this report focused on altering behavioural outcomes in pregnant women (i.e. physical inactivity, smoking and alcohol use during pregnancy, dietary considerations). While the delivery of non-judgemental, supportive health information is an important component of patient-centred and patient-empowered care, such interventions may
raise concerns related to victim blaming. The term *victim blaming* describes the concept in which patients are blamed for their health problems because of their choices and actions (76). This emphasizes the expectation that with adequate digital health information, patients will make the healthier choice because they know that it is the ‘right’ choice. However, it is critical to consider the socioeconomic factors that contributes to individual’s health choices. For example, low-income women are more likely to reside in ‘food deserts’ or areas with limited access to healthy foods, resulting in an overreliance on high-processed convenience foods (77). Meanwhile, fresh produce may be more physically and financially accessible for higher-income individuals. As a result, lower-income women may continue to consume greater quantities of low-cost and low-nutritional-value convenience goods, despite receiving the appropriate health education information on the importance of prenatal nutrition (77). Therefore, the implementation of educational resources alone should not be expected to change patient health behaviours and outcomes. Additional supports are necessary to address barriers such as socioeconomic, gender, social status, physical environment and culture (78).

*Social equity*

Digital health information is typically generalized with the intention to be applicable to a wider audience. However, generalizations and assumptions about the demographics and characteristics of a ‘standard’ patient creates issues of social equity. Information is typically targeted towards English-speaking women, aged 25-35, who are partnered in a marriage or marriage-like relationship with a male partner (79). This standard defines the language, imagery and content of health education resources (79). Further, information is typically targeted towards *heteronormative* ideals, without providing appropriate representation for the Lesbian, Gay,
Bisexual, Trans, Queer and/or Questioning, Intersex and Ally + (LGBTQIA+) communities. As a result, information may result in further oppression of marginalized and underserved groups (79). Thus, it is critical to advocate for greater inclusivity, diversity and representation along the continuum of planning, developing and implementation of digital health education initiatives. A participatory approach to the design of programs and interventions will lead to more representative and relevant health content and the ability to build capacity among patient populations as partners in their own health (80).

*Complexity in health behaviour change*

While pregnancy is often considered a time when women are receptive to positive health behaviour change, it is important to acknowledge the complexity of behaviour change (81). Literature has demonstrated that capability and opportunity are key determinants of behaviour change during pregnancy (82). For example, the physiological side effects of pregnancy, such as morning sickness, may impact a women’s perceived capability to engage in health behaviour change (82). A women’s lack of knowledge or low sense of self-efficacy may impact her psychological capability for behaviour change (82). Additionally, it is important to distinguish between pregnancy and the postpartum period. The loss of physical connection between the mother and infant after childbirth may alter a women’s perceived consequences of her health behaviours (83). For example, a mother may revert to her previous smoking behaviors without considering the health implications of second-hand smoke to her newborn (83). Additionally, the women may prioritize care for their newborn over their own health in the postpartum period. Isolation experienced by women in the postpartum period may contribute to a lack of social support and social opportunity to engage in health promoting activities (82). Thus, a women’s
perceived capability and opportunity for behaviour change must be considered as a key determinant for health behaviour change in pregnancy.

**Conclusion**

Overall, this report provides a representative overview of virtual perinatal care interventions. Most studies included in this report were published after 2015, reflecting recent interest in digital health. Despite available technologies, integration into practice is slow. In this report, I evaluated the strength of evidence from existing virtual health interventions to inform recommendations for PHSA and its priorities for advancing virtual health across BC.

*Virtual health visits* are gradually being integrated into most healthcare practices. Beyond this traditional model, strong evidence exists in support of *virtual health visits* for perinatal care. Telemedicine provided more-timely, patient-centred care through expedited patient referrals, decreased patient wait times and greater patient satisfaction.

My analysis of *digital messaging* demonstrated moderate strength of evidence, depending on the topic of the intervention. For example, two-way SMS communications between breastfeeding peer counsellors and postpartum women was significantly associated with exclusive breastfeeding status at two weeks postpartum. However, no significant differences in health outcomes was measured for most SMS programs that targeted gestational diabetes, smoking cessation and vaccination rates among mothers. Thus, the implementation of digital messaging is recommended for general prenatal health information, including breastfeeding support, rather than more complex health behaviours.

Studies explored the application of *remote monitoring* in the context of mental health, hypertensive disorders and labour induction. Overall, strong evidence exists in support of *remote*
monitoring and the use of connect and unconnected devices to monitor obstetric patients from any location. The use of mood trackers, blood pressure monitors and labour monitoring devices that were connected to provider alert systems were all significantly associated with improved health outcomes or patient satisfaction, while ensuring care provider time was allocated appropriately.

The literature on online treatment and resources revealed a limited body of evidence to support implementation in the perinatal population. Only one of the two programs targeted at alcohol abstinence demonstrated a significant association with abstinence at six weeks from baseline measurements. One program that involved the use of a stress and coping application for pregnant women experiencing complications of preterm labour was significantly associated with decreased stress scores. However, the other programs that targeted type II diabetes, gestational weight gain, gestation diabetes mellitus and smoking cessation did not lead to any significant differences in measured health outcomes. Thus, the current state of online treatment and resources does not adequately address complex behaviour change among perinatal populations. The current evidence does not support resources being dedicated to these types of interventions.

Based on the strength of evidence summarized in this report, I recommend that the PHSA OVA prioritize, in rank order, the implementation of the following virtual health technologies:

1. Virtual health visits (strong evidence)
2. Remote patient monitoring (strong evidence)
3. Clinical digital messaging (moderate evidence)
4. Online treatment and resources (limited evidence)
While virtual health is not intended to replace standard care, its application can supplement existing care practices, strengthen communications between patients, families and providers and better deliver patient-centred care. In advancing virtual health, PHSA might consider *patient and provider convenience, extended patient and provider interactions* and *anonymity* as key strengths of existing interventions that will likely act as facilitators for patient participation and engagement. Furthermore, PHSA might consider how its virtual health policy can be adapted to better address the *digital divide, provider pushback* and *privacy concerns*. Moreover, program planners should reflect on whether existing digital health program exacerbate *victim blaming* and *social health inequities* and the role of participatory approaches for the future design and implementation of interventions.

By identifying evidence-based recommendations and analysing positive and negative impacts of virtual health interventions, PHSA is better informed to implement digital health interventions. It is essential for care providers to leverage the available technological innovation to strengthen the delivery of patient-centred perinatal care and ultimately improve health outcomes for mothers and newborns across BC.

*Study Limitations*

My review has a number of limitations. Publication bias is a well-known phenomenon in academic literature. Researchers and academic journals tend to publish significant over non-significant or negative results. Therefore, the available literature readily provides examples of significant results, which may be over-represented in this report. Second, it is important to consider the *halo effect*, in which women who experienced a healthy birth and healthy baby may experience a cognitive bias or positive perception of their experience with the intervention because of their healthy baby (39,84). Because individuals who experience miscarriages are
typically excluded from study results, the reported results may overrepresent positive feedback. Third, this report was not intended to provide comprehensive overview of virtual health in perinatal care because it was conducted and completed by one author under time and resource constraints. Therefore, individual biases and interpretations, along with the narrow scope of this review, limits the strength of the findings from this report. Fourth, the report did not provide any articles specific to the needs of Indigenous perinatal patients within BC. Therefore, it would be important to consider the feasibility of virtual health initiatives within the context of Indigenous birthing practices. Finally, my qualitative data analysis and thematic analysis was potentially subject to bias. Without self-reflexivity, such analyses can lead to inconsistencies and a lack of coherence, which may impact the overall themes that are reported (85). I provide a critical reflection below.
Critical Reflection

The completion of my capstone project symbolizes the culmination of my journey as a graduate student in the Master of Public Health Program. Given the relatively short duration of this program, along with its fast paced and comprehensive nature, this capstone project allowed me the opportunity to reflect on my experiences in the program.

It was important that this project demonstrate my learnings from the program and highlight my readiness as a public health practitioner. Moreover, this capstone project allowed me to reflect and expand upon on my practicum experiences at Perinatal Services BC (PSBC), with PHSA. I intend to share my capstone project with my former supervisor and mentors at Perinatal Services BC: Ms. Tatiana Popovitskaia, Ms. Christina Tonella and Dr. Ann Pedersen. This report may help inform the future direction of virtual health at PSBC and PHSA.

Throughout the course of my capstone, I connected with key individuals deeply engaged in the field of digital health and digital innovation, such as the Research Manager for the Digital Lab at BC Children’s and Women’s Hospital. I recognized that the field of digital health and innovation is rapidly evolving. Moreover, I realized that digital innovation is typically implemented in clinic specific settings with unique patient considerations and technological infrastructure. I acknowledge that these innovative projects are likely not presented in the academic literature and may present a gap in my report. Therefore, if given the chance to reattempt this project, I would be sure to incorporate both academic literature along with engagement from local researchers to obtain a more realistic and timely understanding of digital innovation in BC.

Overall, my capstone project was an extremely rewarding experience. I am grateful to be exposed to this work and to work closely with Dr. Tania Bubela and Dr. Charlotte Waddell. I
take great pride in applying my knowledge from this project to my future career as a public health practitioner that strives to improve child and maternal health outcomes across BC.
References


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70. Province of British Columbia. Connected Communities [Internet]. [cited 2020 Mar 2]. Available from: https://www2.gov.bc.ca/gov/content/governments/connectivity-in-bc/connected-communities


72. Canadian Medical Association. Virtual Care In Canada: Discussion paper [Internet]. Available from: https://www.cma.ca/sites/default/files/pdf/News/Virtual_Care_discussionpaper_v2EN.pdf


Appendix A1: Ovid Medline Search Strategy

1. Computers/ or Electronic Mail/ (53171)
2. Mobile Applications/ (5271)
3. Cell Phone/ (8239)
4. Text Messaging/ (2642)
5. Telemedicine/ or Text Messaging/ or Cell Phone/ or Remote Consultation/ or "Delivery of Healthcare"/ or Communication/ (199966)
6. Remote Consultation/ or Monitoring, Physiologic/ (58487)
7. Internet/ (71223)
8. Telephone/ (11551)
9. Remote Consultation/ or Videoconferencing/ or Telemedicine/ or Telecommunications/ (30011)
10. ("virtual health" or "digital health" or "virtual care" or "digital care").mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (1859)
11. ("mobile health" or mhealth or "electronic health" or ehealth).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (38980)
12. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (412999)
13. Perinatal Care/ (4400)
14. Prenatal Care/ or Prenatal Education/ (27002)
15. Maternal Health/ or Maternal Behavior/ or Maternal Health Services/ (25721)

16. Pregnancy/ (863699)

17. 13 or 14 or 15 or 16 (878212)

18. 12 and 17 (9519)

19. limit 18 to (english language and full text and humans and yr="2010 -Current") (623)
### Appendix A2: CINAHL Complete Search Strategy

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SU pregnancy or pregnant

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Database - CINAHL Complete

SU maternal

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

Interface - EBSCOhost 38,610
Research Databases
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Database - CINAHL Complete

SU prenatal OR SU prenatal care

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

Interface - EBSCOhost 36,505
Research Databases
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SU perinatal care

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

Interface - EBSCOhost 3,839
Research Databases
Search Screen - Advanced Search
Database - CINAHL Complete

SU perinatal

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

Interface - EBSCOhost 13,290
Research Databases
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Database - CINAHL Complete

S1 OR S2 OR S3
OR S4 OR S5 OR
S6 OR S7 OR S8
OR S9 OR S10
OR S11

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

Interface - EBSCOhost 221,222
Research Databases
Search Screen - Advanced Search
Database - CINAHL Complete

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or "electronic health" or ehealth

Expanders - Apply equivalent subjects
Search modes - Boolean/Phrase

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| S9   SU videoconferencing | **Expanders** - Apply equivalent subjects  
**Search modes** - Boolean/Phrase | **Interface** - EBSCOhost 1,432 Research Databases  
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| S8   SU text messaging or texting or sms messaging | **Expanders** - Apply equivalent subjects  
**Search modes** - Boolean/Phrase | **Interface** - EBSCOhost 2,503 Research Databases  
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| S7   SU internet | **Expanders** - Apply equivalent subjects  
**Search modes** - Boolean/Phrase | **Interface** - EBSCOhost 46,313 Research Databases  
**Search Screen** - Advanced Search  
**Database** - CINAHL Complete |
| S6   SU telephone | **Expanders** - Apply equivalent subjects  
**Search modes** - Boolean/Phrase | **Interface** - EBSCOhost 18,595 Research Databases  
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| S5   SU mobile applications or apps or mobile apps or mhealth or ehealth | **Expanders** - Apply equivalent subjects  
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## Appendix B: Summary of literature for Virtual Health Visits

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<th>Topic</th>
<th>Findings</th>
<th>Limitations</th>
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</thead>
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<td>Pflugeisen et al., 2016 (44)</td>
<td>United States</td>
<td>Non-randomized controlled trial</td>
<td>Prenatal care</td>
<td>No significant differences in pregnancy, health or birth outcomes among groups; virtual visits feasible among low-risk pregnant women</td>
<td>Lack of information regarding provider productivity, patient satisfaction and cost reduction; unequal size of cohorts; self-selection by participants</td>
</tr>
<tr>
<td>Weissman et al., 2017 (45)</td>
<td>United States</td>
<td>Implementation study</td>
<td>Clinical genetics</td>
<td>Alternate care model in which local patient connected with distant provider virtual decreased wait times; allowed patients to be seen in a clinic closer to their homes,</td>
<td>Provider education and acceptance is a barrier; technical glitches; some patients find the approach less personal (especially when discussing sensitive or bad news)</td>
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<tr>
<td>Shehata et al., 2016 (43)</td>
<td>Canada</td>
<td>Retrospective electronic chart review</td>
<td>Electronic consultation</td>
<td>Traditional consultation was avoided in 34.3% of eConsults; demonstrated potential to reduce wait times for traditional consultations; process was feasible/well-received by primary care providers</td>
<td>Consults completed by one gynecologist, therefore feedback might not be generalizable for service provided by multiple; retrospective chart review provides surrogate data rather than actual number of consultations avoided</td>
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</table>
### Appendix C: Summary of literature for Digital Messaging

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<th>Methods</th>
<th>Topic</th>
<th>Findings</th>
<th>Limitations</th>
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<td>Harari et al., 2018 (20) n=52</td>
<td>Pregnant women, ages 18 or older, from one of four WIC breastfeeding peer counselling programmes</td>
<td>United States</td>
<td>Single-blind RCT2; participants randomized to intervention (standard care with two-way SMS3 with BFPC4) or control (standard care)</td>
<td>Breastfeeding</td>
<td>Total number and intensity of engagement with postpartum two-way SMS exchanges was significantly associated with exclusive breastfeeding status at 2 weeks</td>
<td>Small sample size; self-reported breastfeeding status; limited generalizability due to homogeneity of sample (from WIC program); no data to determine if standard care (# of phone calls and visits) impacted intensity of engagement or breastfeeding behavior</td>
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<tr>
<td>Johnson et al., 2018 (36) n=19</td>
<td>Pregnant women, ages 18 or older and diagnosed with GDM5, receiving prenatal care at the University of North Carolina clinics</td>
<td>United States</td>
<td>Feasibility study with pre- and post- intervention questionnaires; all participants received intervention (standard care along with one-way SMS)</td>
<td>GDM</td>
<td>Participants found daily SMS messages be acceptable and feasible. 50% and 66% of participants felt that the messages helped them eat healthier and remember to check their blood glucose levels, respectively</td>
<td>Small sample size; self-reported behavioural outcomes; limited generalizability; clinical improvements were not assessed</td>
</tr>
<tr>
<td>Van Ryswky et al., 2018 (21) n= 267</td>
<td>Pregnant women diagnosed with GDM receiving prenatal care from Women's and Children's Hospital</td>
<td>Australia</td>
<td>RCT; participants randomized to intervention (SMS reminder to attend an OGTT6 at six weeks, three months and six months postpartum) or control (SMS reminder at six months postpartum)</td>
<td>GDM</td>
<td>No significant differences in OGTT rates within six months postpartum between groups</td>
<td>Sample from South Australia, findings may not generalize; participation in research may bias behavioural outcomes</td>
</tr>
<tr>
<td>Evans et al., 2012 (22) n=90</td>
<td>Pregnant women receiving prenatal care at the Fairfax County, Virginia Health Department</td>
<td>United States</td>
<td>RCT with pre- and post- intervention interviews; participants randomized to intervention (standard care with text4baby program) or control (standard care)</td>
<td>Pregnancy health</td>
<td>Intervention significantly associated with increased agreement with feelings of being prepared to be a new mother and attitudes against alcohol consumption during pregnancy</td>
<td>Small sample size; self-reported behavioural outcomes; selection bias, study participants may be motivated to receive resources; differences between intervention and control groups due to attrition (more economically disadvantaged at follow-up)</td>
</tr>
</tbody>
</table>

1 WIC: Women, Infant and Children breastfeeding program  
2 RCT: randomized controlled trial  
3 SMS: short message service  
4 BFPC: breastfeeding peer counsellor  
5 GDM: gestational diabetes mellitus  
6 OGTT: oral glucose tolerance test
<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Intervention</th>
<th>Main Findings</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evans et al., 2014</td>
<td>n=943</td>
<td>Pregnant women receiving prenatal care at Madigan Army Medical Centre in Tacoma, WA</td>
<td>RCT; participants randomized to intervention (standard care with text4baby program) or control (standard care)</td>
<td>Pregnancy health</td>
<td>Intervention significantly associated with increased agreement with belief in important of taking prenatal vitamins, importance of visiting healthcare provider and risk associated with alcohol consumption. Self-reported behavioural outcomes; differences between baseline and follow-up samples due to attrition (more unmarried, unemployed at follow-up); high attrition rate limits statistical power of findings.</td>
</tr>
<tr>
<td>Abroms et al., 2017</td>
<td>n=99</td>
<td>Pregnant women receiving prenatal care at 11 obstetrics-gynecology clinics in Washington, DC</td>
<td>RCT; participants randomized to intervention (SmokefreeMOM SMS program) or control (quitline referral)</td>
<td>Smoking cessation</td>
<td>Participants assessed intervention as acceptable and feasible; no significant differences in smoking related outcomes and change in self-efficacy between groups. Small sample size due to recruitment challenges; sample had disclosed their smoking status to care provider, findings may not generalize to non-disclosing smokers.</td>
</tr>
<tr>
<td>Naughton et al., 2013</td>
<td>n=33</td>
<td>Pregnant women accessing prenatal care from midwives in two primary care clinics in Cambridgeshire and Suffolk</td>
<td>Semi-structured interviews with participants receiving MiQuit SMS messages and participants who did not receive any texts</td>
<td>Smoking cessation</td>
<td>Following themes emerged: convenience of SMS was advantageous, timing of message (earlier in the day) was critical to provide deterrent, automated SMS felt less personal. Small sample size; self-selection bias, eligible women asked to contact researchers; limited generalizability due to homogeneity of sample; brief nature of the texting intervention (five texts) provides limited insight into final intervention.</td>
</tr>
<tr>
<td>Stockwell et al., 2014</td>
<td>n=1187</td>
<td>Pregnant women receiving prenatal care from five community-based clinics</td>
<td>RCT; participants randomized to intervention (telephone appointment reminder and SMS vaccine reminders) or control (telephone appointment reminder only)</td>
<td>Vaccination</td>
<td>Intervention was significantly associated with higher influenza vaccination rates. Limited generalizability due to homogeneity of sample (from a single primarily low-income urban population); vaccination rates may be underreported if women were vaccinated at outside site; low response rate of satisfaction survey.</td>
</tr>
<tr>
<td>Moniz et al., 2013</td>
<td>n=204</td>
<td>Pregnant women receiving prenatal care from an academic center's outpatient clinic</td>
<td>RCT with pre- and post-intervention questionnaires; participants randomized to intervention (SMS texts for general pregnancy health plus influenza vaccination) or control (SMS texts for general pregnancy health)</td>
<td>Vaccination</td>
<td>No significant difference in influenza vaccination rate among groups. Limited generalizability due to homogeneity of sample (from a single urban, tertiary care facility); SMS platform verifies messages sent, but not necessarily received by participants; vaccination rates may be underreported if women were vaccinated at outside site.</td>
</tr>
</tbody>
</table>
### Appendix D: Summary of literature for Remote Monitoring

<table>
<thead>
<tr>
<th>Study/n</th>
<th>Participants</th>
<th>Country</th>
<th>Methods</th>
<th>Intervention</th>
<th>Findings</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hantsoo et al., 2018 (27) n=72</td>
<td>Pregnant women, with depressive symptomatology, receiving prenatal care from urban ambulatory prenatal clinic</td>
<td>United States</td>
<td>RCT; participants randomized to intervention group with incentive (MTA7 app with incentive for use) or intervention only group (MTA app) or control (standard care)</td>
<td>Mental Health</td>
<td>Intervention groups were significantly associated with higher self-reported ability to manage their own health and more telephone encounters with providers.</td>
<td>Self-reported information on depressive symptoms; small sample size, sampling bias from convenience sample; limited generalizability due to homogeneity of sample (from low-income, racial-ethnic minority population); no measure of clinical outcomes for participants; unable to casual claims because patients with depressive symptoms tend to improve overtime</td>
</tr>
<tr>
<td>Lanssens et al., 2019 (38) n=91</td>
<td>Pregnant women at high-risk of hypertensive disorders of pregnancy</td>
<td>Belgium</td>
<td>Post-intervention questionnaire with participants who received RM (blood pressure monitor, activity tracker and weight scale)</td>
<td>Hypertensive disorders</td>
<td>87% (41/47) did not report any negative concerns about their privacy; 89% (42/47) reported positive response to importance of RM in pregnancy follow-up; 80% (28/35) reported added value to pregnancy</td>
<td>Small sample size; limited generalizability due to homogeneity of sample (from local Dutch hospital); uncontrolled survey environment (cannot eliminate external environmental influences)</td>
</tr>
<tr>
<td>O’Brien et al., 2013 (39) n=15</td>
<td>Pregnant women accessing prenatal care from the maternity hospital in North West of England</td>
<td>United Kingdom</td>
<td>Semi-structured interviews with participants that received RM (slow-release prostaglandin and remote monitoring device)</td>
<td>Labour induction</td>
<td>Following themes emerged: need for women to experience labour within their comfort zone, desire to achieve next best thing to normal labour, importance for virtual presence by care provider</td>
<td>Small sample size; RM only be offered to individuals with easy access to the hospital due to safety concerns; individuals were interviewed in postnatal period with healthy babies ‘halo effect’</td>
</tr>
</tbody>
</table>

7 MTA: mood tracking and alert
8 RM: remote monitoring
## Appendix E: Summary of literature for *Online Treatment and Resources*

<table>
<thead>
<tr>
<th>Study/n</th>
<th>Participants</th>
<th>Country</th>
<th>Methods</th>
<th>Intervention</th>
<th>Findings</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ondersma et al, 2015 (28) n= 48</td>
<td>Pregnant women, who screened positive for alcohol risk, receiving prenatal care at Henry Ford Health System</td>
<td>United States</td>
<td>RCT; participants randomized to intervention (computer delivered SBI9) or control (information on infant nutrition)</td>
<td>Alcohol use</td>
<td>Participants assessed intervention as acceptable and feasible; no significant differences in abstinence and healthy pregnancy outcomes between groups</td>
<td>Small sample size; self-reported abstinence; limited generalizability due to homogeneity of sample (from low-income African American population)</td>
</tr>
<tr>
<td>van der Wulp et al., 2014 (29) n=393</td>
<td>Pregnant women, screened positive for alcohol risk, receiving prenatal care from 60 midwifery practices</td>
<td>Netherlands</td>
<td>RCT with pre- and post-intervention questionnaire; participants randomized to intervention with online treatment (health counselling with computer tailoring), health counselling only, or standard care</td>
<td>Alcohol use</td>
<td>Computer tailoring was significantly associated with higher alcohol abstinence and reduced alcohol use at six months after baseline compared to standard care</td>
<td>Self-reported alcohol use; high dropout rates among participants; sample had disclosed their alcohol use status to care provider, findings may not generalize to non-disclosing women</td>
</tr>
<tr>
<td>Linden et al., 2018 (30) n=174</td>
<td>Pregnant women, with Type 1 diabetes, receiving prenatal care from one of six participating study centres</td>
<td>Sweden</td>
<td>RCT; participants randomized to intervention (web-based information, self-care diary and peer support) or control (standard care)</td>
<td>Diabetes</td>
<td>No significant difference in general well-being and self-efficacy of diabetes management among groups</td>
<td>Self-reported psychosocial variables; small-sample size; higher number of women declined to participate, no analysis of non-respondents; high dropout rates among participants</td>
</tr>
<tr>
<td>Jallo et al., 2017 (40) n=15</td>
<td>Pregnant women, with complications of preterm labour, receiving prenatal care from a hospital obstetrical unit</td>
<td>United States</td>
<td>Post-intervention semi-structured interview with participants that utilizes the stress coping app</td>
<td>Mental health</td>
<td>Use of stress coping app was significantly associated with decreased VASS10 scores when compared to scores before, demonstrated immediate effect on decreasing stress</td>
<td>Self-reported stress rating; small sample size; short retention rate within study; limited generalizability due to homogeneity of sample (from single, African American population)</td>
</tr>
</tbody>
</table>

9 SBI: screening and brief intervention  
10 VASS: visual analog stress scale
<table>
<thead>
<tr>
<th>Authors, Year</th>
<th>Sample Size</th>
<th>Study Design</th>
<th>Country</th>
<th>Interventions</th>
<th>Outcomes</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodd et al., 2017 (31)</td>
<td>n=162</td>
<td>RCT with post-intervention questionnaire; participants randomized to intervention (lifestyle advice plus smartphone app) or control (lifestyle advice only)</td>
<td>Australia</td>
<td>Gestational weight gain</td>
<td>No significant difference in healthy eating index and macronutrient and food group intake among groups; low uptake of smartphone app (31%)</td>
<td>Self-reported questionnaires, potential for recall bias; small sample size; low-response rates from women</td>
</tr>
<tr>
<td>Choi et al., 2016 (32)</td>
<td>n=30</td>
<td>RCT; participants randomized to intervention (mobile phone app plus Fitbit) or control (Fitbit only)</td>
<td>United States</td>
<td>Gestational weight gain</td>
<td>No significant difference in mean steps per day among groups; intervention group reported lower perceived barrier to being active</td>
<td>Small sample size; limited control whether Fitbit was always worn; study focused on short-term behavior change; findings may not be generalizable to non-English speakers or women who are not motivated to use those technologies</td>
</tr>
<tr>
<td>Kennelly et al., 2018 (33)</td>
<td>n=498</td>
<td>RCT; participants randomized to intervention (mobile phone app with dietary and exercise advice or control (standard care)</td>
<td>Ireland</td>
<td>No significant difference in incidence of GDM among groups; intervention reported lower dietary glycemic load and increased exercise participation</td>
<td>Self-reported dietary intake and exercise behaviors (subject to underreporting or overreporting)</td>
<td></td>
</tr>
<tr>
<td>Coleman-Cowger et al., 2018 (34)</td>
<td>n=130</td>
<td>RCT; participants randomized to intervention (standard care with PPCC) or control (standard care)</td>
<td>United States</td>
<td>No significant difference in tobacco products per day and cessation rate among groups</td>
<td>Small sample size; significant drop out rate; limited generalizability due to homogeneity of sample (from low income, African American population); findings may not generalize to non-disclosing women</td>
<td></td>
</tr>
<tr>
<td>Reynolds et al., 2019 (35)</td>
<td>n=22</td>
<td>RCT; participants randomized to intervention (standard care with behavioral smoking cessation intervention with online support) or control (standard care)</td>
<td>Ireland</td>
<td>Smoking cessation</td>
<td>Study was unable to report findings due to low enrollment</td>
<td>Challenges related to recruitment in this population; small sample size; low dose of the intervention</td>
</tr>
<tr>
<td>Herbec et al., 2014 (41)</td>
<td>n=13</td>
<td>Semi-structured interviews with participants that received MumsQuit intervention</td>
<td>United Kingdom</td>
<td>Smoking cessation</td>
<td>Following themes emerged: preference for accessible, targeted program, tailored to individuals, comprehensive and novel information, ongoing support related to craving management</td>
<td>Small sample size; limited generalizability due to homogeneity of sample (from white, married women; reporting and selection bias of women that agreed to participate in interviews</td>
</tr>
</tbody>
</table>

11 GDM: gestational diabetes mellitus  
12 PPCC: phone-based postpartum continuing care
Appendix F: Capstone Presentation

Delivering on Digital:
A Review of Virtual Health Literature in Perinatal Care

Stephanie Liu, MPH Candidate, Simon Fraser University
Capstone Presentation - April 6, 2020
I respectfully acknowledge that Simon Fraser University is located on the traditional and unceded territories of the Tsleil-Waututh (səˈɪl̓ɪlwətaʔ), Kwikwetlem (kw̓ik̓wəƛ̓əm), Squamish (Sḵwx̱wú7mesh Úxwumixw) and Musqueam (x�亏损əθk̓ʷəy̓əm) Nations.
Virtual Health

“Refers to patient centred model focused on connecting patients, families and providers, using technology to optimize wellness, speciality care and outcomes.” (1)
“...ensure the standard of care for delivery of virtual health services is equivalent to, or better than, the standard of care for in-person services.”

- PHSA Virtual Health Policy (1)
PHSA Virtual Health Priorities

Virtual Health Visits  Digital Messaging  Remote Monitoring  Online Treatment and Resources
Opportunities for Perinatal Care

- Women of reproductive age use digital technologies for perinatal information
- Poor quality of perinatal information online
- Inaccurate, non-evidence based digital information is a major public health concern
- Role for care providers to align efforts with health-seeking behaviours of patients

Source: Shutterstock (2)
Purpose:

To review current literature on digital health technologies targeted at pregnancy to assess the success factors, limitations and consideration necessary for implementation.
Methods

- **Literature review:** *Cooper's Guide for literature reviews*
- **Search strategy:** in Ovid Medline and CINAHL
- **Screening & reviewing:** inclusion and exclusion criteria
- **Full article review:** 26 articles
- **Qualitative analysis:** *Braun & Clarke's Thematic Analysis*
- **Report writing**
Search and article screening
Findings

- 26 studies included in report
- Study designs: randomized controlled trials (16 studies), qualitative studies (6 studies), retrospective studies (2 studies), non-randomized controlled trial (1 study) and observational study (1 study)
- Divided into four domains:
  - Virtual health visits
  - Digital messaging
  - Remote patient monitoring
  - Online treatment and resources
- Strength of evidence varied depending on the type of intervention
Virtual Health Visits

Use of secure audio, video and chat from any location to allow patients to connect with their care providers, also known as “telemedicine”
Examples of Virtual Health Visits

Virtual prenatal visits (4)  Remote clinical genetic services (5)  Electronic consultation (6)

Strong evidence: provided more timely, patient-centred care through expedited patient referrals, decreased patient wait times and greater patient satisfaction.
Digital Messaging

Use of text, email, instant messaging and voice-to-text to facilitate messaging between patients and providers.

Source: Shutterstock (7)
Examples of Digital Messaging

- Text4baby (8)
- Lactation Advice thru Texting Can Help (LATCH) (9)
- DIAMIND Study (10)

Moderate evidence: varied depending on intervention topic; implementation is recommended for general prenatal health information, including breastfeeding support, rather than more complex health behaviours.
Remote Monitoring

Use of both connected and unconnected devices, such as wearables or glucometers, to monitor patients from any location.

Source: Shutterstock (11)
Examples of Remote Monitoring

- Mood tracking and alert (MTA) mobile application (12)
- PREMOM Study (13)
- Labour induction (14)

Strong evidence: supports the use of remote monitoring and the use of connected and unconnected devices to monitor obstetric patients from any location.
Online Treatment and Resources

Use of online platforms and mobile applications to provide individual and in group treatments for patients.

Source: Shutterstock (15)
Examples of Online Treatment and Resources

- Alcohol Cessation (16)
- Trial App with Fitbit (17)
- MumsQuit (18)

Limited evidence: current state of online treatment and resources does not adequately address complex behaviour change among the perinatal population.
Success Factors

- Convenience
- Extended interactions between patient and provider
- Anonymity
Limitations

- Digital divide
- Provider pushback
- Privacy concerns
Key Considerations

- Victim blaming
- Social equity
- Complexity in health behavior change
### PHSA Virtual Health Priorities

<table>
<thead>
<tr>
<th>Service</th>
<th>Evidence Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Health Visits</td>
<td>Strong evidence</td>
</tr>
<tr>
<td>Digital Messaging</td>
<td>Moderate evidence</td>
</tr>
<tr>
<td>Remote Monitoring</td>
<td>Strong evidence</td>
</tr>
<tr>
<td>Online Treatment and Resources</td>
<td>Limited evidence</td>
</tr>
</tbody>
</table>
Study Limitations

- **Publication bias**
- **Halo effect** → women who experienced a healthy birth may have a more positive perception of their experience
- **Representative coverage**, rather comprehensive
- Missing needs of **Indigenous perinatal patients** within BC
- **Qualitative data analysis** and **thematic analysis**
It is essential to leverage appropriate technological innovations to strengthen the delivery of patient-centred perinatal care.

Thank you.
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