Maternal Overweight, Obesity and Excess Gestational Weight Gain:

Identification of Maternal and Perinatal Implications and Primary Maternity Care Providers' Opportunities for Interventions to Improve Health Outcomes

BC Perinatal Health Program

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III. Executive Summary

The obesity epidemic has become a major public health concern in both industrialized and developing countries. Women of reproductive age are also experiencing the obesity epidemic. In 2005/6, thirty percent of British Columbian women had a pre-pregnancy body mass index (BMI) within overweight (19.9%) or obese (11.4%) categories.

This report reviews: i) the association of maternal overweight and obesity with both adverse pregnancy outcomes and long-term adverse outcomes for mothers and babies; ii) the association of excess gestational weight with both adverse pregnancy outcomes and long-term adverse outcomes for mothers and babies; iii) approaches that can be taken in primary obstetrical care to promote healthy weight among women who are either planning pregnancy, pregnant, or postpartum.

There is a dose-response relationship between maternal weight and adverse pregnancy outcomes, such that risk is: increased with excessive gestational weight gain; greater with pre-pregnancy overweight; and greatest with pre-pregnancy obesity. Women who are overweight or obese are at increased risk for a range of pregnancy complications, including gestational diabetes mellitus, pre-eclampsia, Caesarean section, maternal mortality, and labour induction. Women who are overweight or obese also experience greater risk of infertility compared to women of a lower weight. Women who are obese are at higher risk of complications than women who are overweight, but women who are overweight are still at higher risk than women of normal pre-pregnancy weight. The pregnancy-related risks of obesity are comparable in magnitude to other well- recognized antenatal risk factors, such as smoking or alcohol.

Risks such as stillbirth, fetal death, macrosomia and large for gestational age, neural tube defects, meconium aspiration, and shoulder dystocia are associated with overweight and obesity during pregnancy. Maternal obesity is also a risk factor for childhood obesity and obesity in early adult life.

Pregnancy weight gain within the U.S. Institute of Medicine guidelines (on which the Health Canada guidelines are based) is associated with the best pregnancy outcome for mother and child. However, weight gain alone is not a good predictor of poor pregnancy outcome since the amount of gestational weight gained by women with good pregnancy outcomes is widely variable. Women who are overweight or obese are more likely to exceed IOM guidelines. Risk factors for excessive gestational weight gain include: younger age, being single, ethnicity, current eating habits, self-report of low numbers of

supportive individuals in women's lives, and receiving incorrect advice (or no advice) from health care provider(s).

Postpartum weight retention is most strongly associated with excessive weight gain in pregnancy, particularly excessive first trimester weight gain. There is mixed evidence regarding whether postpartum weight retention is associated with pre-pregnancy overweight or obesity. Other risk factors for postpartum weight retention include: unhealthy eating habits, low physical activity, low socioeconomic status/education, low affect/ depression, ethnicity, and self-report of low numbers of supportive individuals in women's lives.

While there is evidence that moderate weight loss will improve fertility, it is assumed that weight reduction before pregnancy will improve future pregnancy outcomes. Outside of pregnancy, recommendations for the achievement of a healthy weight involve lifestyle interventions which include healthy eating, physical activity, and behavioural therapy. However, best practices have yet to be determined as few interventions have succeeded in promoting sustained weight loss, and drop-out rates are high. Lifestyle interventions during pregnancy are aimed at curbing gestational weight gain, not weight loss. Interventions during pregnancy have had mixed results and better practices have yet to be determined. The mixed results of existing intervention studies promoting healthy weights for women pre-pregnancy, during pregnancy and postpartum, emphasize that there are no simple solutions. These findings should serve to motivate the development of better women-centred interventions based on published successes and failures and based on women's motivations and barriers to adopting lifestyles that promote a healthy weight. Because of barriers present when planning a pregnancy and the recognized non-pregnancy related health benefits of achieving a healthy weight, steps should be taken to achieve this healthy weight outside of pregnancy (by promoting weight gain within the IOM guidelines). There should also be postpartum follow-up.

Herein is a checklist of better/ promising practices for primary obstetrical healthcare practitioners to support women who are overweight or obese pre-pregnancy, during pregnancy and postpartum, with a goal to improve maternal and perinatal outcomes.

IV. Introduction

The obesity epidemic has become a major public health concern in both industrialized and developing countries[1,2,3,4,5,6,7,8,9,10.] In the general population in Canada, the prevalence of overweight has stayed relatively constant while the rate of obesity has risen substantially. In 1970-1971 overweight and obesity rates were 40.0% and 9.7% (respectively)[11]. In 2004 the rates were 36.1% and 23.1% (respectively)[12].

Women of reproductive age are also experiencing the obesity epidemic. Data from antenatal records in 2005/6 reveal that 30% of British Columbian women had a pre-pregnancy body mass index (BMI) within overweight (19.9%) or obese (11.4%) categories[13].

This report reviews: i) the association of maternal overweight and obesity with both adverse pregnancy outcomes and long-term adverse outcomes for mothers and babies; and ii) approaches that can be taken within primary obstetrical care to promote healthy weights among women who are either planning pregnancy, pregnant, or postpartum.

V. Overweight and Obesity Related to Childbearing

DEFINITIONS

Canadian Guidelines for the management and prevention of obesity in adults and children recommend measurement of both body mass index (BMI) and waist circumference to assess the level and distribution of adiposity in adults[14]. BMI is calculated as weight in kilograms divided by height in metres squared. Health Canada defines underweight as a BMI less than 18.5 kg/m^2, normal weight as a BMI of 18.5-24.9 kg/m^2, overweight as a BMI of 25.0-29.9 kg/m^2, class I obesity as a BMI of 30.0 - 34.9 kg/m^2, class II obesity as a BMI of 35.0 -39.9 kg/m^2, and class III obesity as a BMI ≥ 40.0 kg/m^2[2,15]. The other accepted measure of excessive body fat is waist circumference, based on the association between this measure of central adiposity and an increased risk of morbidity and mortality[16,17,18].

Waist circumference has replaced the waist-to-hip ratio since it is easier to perform. In adults with a BMI of 25 to 34.9 kg/m^2 (i.e. overweight or obese), a waist circumference greater than 88 cm (35 in) for women is associated with a greater risk of hypertension, type 2 diabetes, dyslipidemia, and coronary heart disease[16].

There is ethnic variability in the BMI and waist circumference values that are associated with increased risk of adverse cardiovascular outcomes. The most appropriate cut-off values continue to be debated. The definitions discussed above apply to Caucasian, Hispanic and Black women. Lower cut-off values have been proposed for Asian women who have proportionately more truncal and visceral adiposity. BMI values of >23 kg/m^2 (overweight) and >30kg/m^2 (obese), and waist circumferences of >80 cm have been proposed to define overweight among Asian women[19].

These definitions of overweight and obese have not been rigorously applied in the relevant pregnancy literature. Definitions have included arbitrary weight cut-offs (e.g. obesity defined as ≥90 kg and normal weight as <75 kg[20]). But when accepted thresholds have been applied, pre-pregnancy BMI categories have been used. The association between increased pre-pregnancy waist circumference and pregnancy complications has not been studied.

RISKS OF OVERWEIGHT AND OBESITY RELATED TO CHILDBEARING
A Medline search was performed from January 1980 to March 2008 using the following search terms: {'overweight' OR 'obesity' OR 'BMI' OR 'body mass index' OR 'weight gain'} AND {'pregnancy' OR 'pre-pregnancy'} AND {'risks' OR 'effects' OR 'complications' OR 'pregnancy outcomes'}. This search was limited to English language articles involving human subjects. We identified 2,993 articles of which 28 were included in this review, based on the following inclusion criteria: maternal weight was defined using BMI (rather than weight in kg), maternal and fetal outcomes were reported separately for overweight and obese categories, and measures of risk of overweight and obesity were relative to women of normal BMI.

Definitions of overweight and obesity in the included studies varied slightly but in general conformed to those which are currently accepted. There were 28 original studies[7,9,21,22,23,24,25,26,27, 28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44].

Fertility

Overweight and obesity have negative effects on fertility. Ovulatory disorders are more prevalent and frank anovulatory infertility increases in prevalence with increasing BMI[45]. A common cause of anovulatory infertility is polycystic ovarian syndrome (PCOS)[46]; obese women with PCOS have lower success rates with ovulation induction by pharmacological means[47].

Women who are overweight and obese have lower success rates with assisted reproduction. Specifically, being overweight or obese is associated in some (but not all studies) with longer periods of ovarian stimulation, higher doses of gonadotropins, lower oocyte retrieval, poorer oocyte quality, a lower incidence of embryo transfer, and lower rates of pregnancy[48,49,50,51]

During Pregnancy

Maternal

The risk of experiencing many complications in pregnancy increases as BMI increases above 24.9kg/m^2. However, the risk of experiencing some complications increases only as BMI increases above 29.9kg/m^2 (i.e. into the obese categories). In other words, women who are obese are at higher risk of experiencing complications than women who are overweight, but women who are overweight are still at higher risk than women of normal pre-pregnancy weight.

Gestational Diabetes (GDM)

Large observation studies have identified that the risk of gestational diabetes (GDM) is higher among overweight and obese women than women with a normal BMI[7, 8,9,21,25,28,29,30]. The magnitude of this risk increases progressively with increasing BMIs above 24.9. The association remains significant after adjusting for confounders such as maternal age, race, marital status, education, and parity[52].

In a meta-analysis of 20 cohort studies[53], the unadjusted odds ratio (OR) for GDM was 2.14 (95% CI 1.82-2.53) for women who were overweight, 3.56 (95% CI 3.05-4.21) for class I obese, and 8.56 (95% CI 5.07-16.04) for class II/III obese, compared with women of normal weight pre-pregnancy. The associations were similar, albeit slightly lower, in a

separate meta-analysis which adjusted for confounders: OR of 1.86, 3.34 and 5.77 for GDM among overweight, class I obese, and class II/III obese women, respectively. British Columbian data are consistent with these findings. In 2005/6, the GDM rate was 6.8% of all pregnancies; however, 8.7% of overweight women and 14.4% of obese women had GDM[13].

GDM is a pregnancy complication of importance because it is independently associated with a variety of complications for the mother, fetus, and baby in the index pregnancy[54,55,56,57], an increased risk of GDM in subsequent pregnancies, and an increased risk of type 2 diabetes for the mother and child[21,55,56 ,58,59,60]. Estimates of the absolute risk of type 2 diabetes long-term have varied depending on the duration of follow-up and diagnostic criteria used. Fifty percent of women with a history of GDM will have developed diabetes after 10 years[58].

Hypertensive Disorders of Pregnancy (HDP)

As with GDM, the HDP are more common among women who are overweight and obese, with the risk increasing with increasing BMI. This excess of HDP includes both pre-existing hypertension and pre-eclampsia[36].

Pre-existing hypertension is more common among women who are overweight (OR 2.60; 95% CI 1.49-4.55) or obese (OR 7.93; 95% 4.74-13.27) compared with women of normal pre-pregnancy BMI (BMI 18.5-25kg/m^2) (2,827 women)[25]. Antenatal data from British Columbia showed that in 2005/6, hypertension occurred in 2.3% of women overall, but among 3.1% of overweight women and 5.8% of obese women[13]. These figures are similar to large studies from Europe (e.g. 3% and 5.3% for overweight and obese women, respectively; 25,601 women)[36].

Non-proteinuric gestational hypertension has been less well studied, but two recent cohort studies involving 24,241 women estimated that gestational hypertension risk was increased among overweight (OR 1.5, 95% CI 1.4-1.7), obese (OR 2.2, 95% CI 2.1-2.6), and class II/ III obese women (OR 3.1, 95% CI 2.0-4.3)[28,31]. It developed in 19.7%, 28.5%, 37.2% and 42.2% of normal weight, overweight, obese and class II/III obese women respectively[31].

Pre-eclampsia risk increases among women who are overweight (OR 1.4- 2.3) or obese (OR 2.1-5.6)[7,9,20,22 ,21,61,62,. Systematic review of observational literature (13 cohort studies, almost 1.4 million women) has estimated that pre-eclampsia risk doubles with each 5-to-7 kg/m^2 increase in pre-pregnancy BMI, even when women with confounding medical conditions (e.g. pre-existing hypertension or diabetes mellitus) or multiple gestations were excluded[63]. In British Columbia (2005/6 data), the HDP are present among 7.3% of overweight and 11.6% of obese women, compared with 5.3% of women overall[13].

Thromboembolism

Obesity is a well-recognized risk factor for thromboembolism[20,64,65,66], which is a leading cause of maternal mortality in Canada and worldwide[67]. However, most studies addressing maternal weight-related pregnancy complications[9,21,22, 25,26,29] have not included thromboembolism as an outcome. When studied, risk increased with obesity (387 women, 129 cases and 258 controls[66], but also progressively with increasing weight. For example, the risk of antenatal thromboembolism doubled for women weighing 90-120 kg

and quadrupled for those who weighed more than 120kg in a Canadian population-based cohort study (142,404 women)[20].

Labour

Higher BMI is associated with prolonged gestation at term. In a study of 9,336 births, delivery at 42 weeks or more was more common among women who were overweight (OR 1.5; 95% CI 1.2-2.0) or obese (OR 1.7; 95% CI 1.2-2.3), compared with women of normal pre-pregnancy BMI[34].

Labour induction is more common among women who are overweight (OR 1.2-2.1) or obese (OR 1.6-3.2)[7,22,25,28,31]. Failed labour induction is also more common[28,68]. In a study of 126,080 deliveries, after excluding women with diabetes or HDP, obesity was associated with more failure to progress in the first stage relative to women with normal BMI (OR 3.1; 95% CI 2.5-3.8)[69]. Labour duration is not affected by maternal weight[25].

Operative vaginal deliveries, third and fourth degree lacerations and shoulder dystocia are more common with increasing maternal BMI[68]. Overweight and obese women are more prone to infections such as endometritis, urinary tract infections, wound infections and post operative pneumonia[7]. In one of the largest observational studies addressing pregnancy complications[7], the risk of wound infection was increased among women who were overweight (OR 1.3; 95% CI 1.1-1.5) or obese (OR 2.2; 95% CI 1.9-2.6), compared with women of normal pre-pregnancy BMI. Similar figures were seen for urinary tract infection for overweight (OR 1.2, 95% CI 1.04-1.3) and obese women (OR 1.4, 95% CI 1.2-1.6), and genital tract infection among overweight (OR 1.24; 95% CI 1.09-1.41) and obese (OR 1.30; 95% CI 1.07-1.56) women.

Caesarean Section

BMI is positively associated with rates of both elective and emergency Caesarean delivery[7,70,71,72,73] and inversely associated with the success of vaginal birth after prior caesarean delivery (VBAC) [74].

In a meta-analysis of 33 cohort studies involving 995, 069 women, Caesarean delivery was more common among women who were overweight (OR 1.5; 95% CI 1.3-1.6), obese (OR 2.1; 95% CI 1.9-2.3), or who had class II/III obesity (OR 2.9; 95% CI 2.3-3.8)[75]. Similar increases have been reported in other studies that adjusted for potential confounders such as pre-eclampsia, diabetes, and macrosomia[21,28,29,30].

Successful VBAC is inversely related to maternal weight. In a study of 510 women attempting a trial of labour, women who were underweight (BMI<19.8 kg/m^2) had the highest success rate (85%), compared with women who were overweight [from between pregnancies (74%) or from prior to the first pregnancy (71%)] and those women who were obese [from between pregnancies (56%) or from prior to the first pregnancy (55%)][74].

The frequency of caesarean delivery among women who are overweight and obese is of concern due to increased rates of postoperative wound infection, endometritis, excessive blood loss, and thromboembolism[7,21,70,76,77,78].

Anaesthetic Complications

Anaesthetic risks among women who are overweight or obese are significant[20,79]. The need for emergency anaesthesia is particularly hazardous. An anaesthetic review prior to labour should be considered. Women with class II/III obesity have the highest rate of complications, which include poor peripheral access, difficult placement of epidural or spinal anaesthesia, difficult intubation, more frequent pulmonary aspiration during anaesthesia, and more frequent sleep apnoea post partum (adjusted OR 2.0, 95% CI 1.3-3.1)[20].

Postpartum Haemorrhage

Studies have reported increased risk of post partum haemorrhage for women who are overweight (OR 1.1- 1.6) or obese (OR 1.2-1.7)[7,25,28,31] , or who have class II/III obesity (OR 3.14)[28], compared with women with normal BMIs. However, the literature on this outcome is conflicting[80] possibly because the measurement of blood loss is subjective and the definition of postpartum haemorrhage variable. Women who are obese are at increased risk for post partum anaemia[81] although no difference in the rates of blood transfusion has been demonstrated[20].

Breastfeeding

Several epidemiological studies have found an inverse association between maternal overweight and obesity and breastfeeding[35,82,83,84,85]. In a large retrospective study, the likelihood of breastfeeding at discharge was significantly lower among mothers who were overweight (OR 0.86; 95% CI 0.84-0.88) or obese (0.58; 95% CI 0.56-0.60) compared to those with normal BMIs[7]. A systematic review of 22 observational studies found that after adjusting for confounders, women who were overweight or obese planned to breastfeed for a shorter period, were less likely to initiate breastfeeding, had delayed lactogenesis, and breastfed for shorter durations compared with women with normal BMIs[86].

Fetal and Perinatal Issues

Miscarriage

Women who are overweight or obese have an increased risk of miscarriage, following either natural conception or assisted reproduction[49,87,88,89]. Following natural conception, women who are obese have a recurrent miscarriage rate that is more than three times higher than that for women of normal weight (OR 3.5, 95% CI 1.1-12.0)[88]. A meta-analysis of 12 observational studies showed that women who were overweight or obese (vs. women of normal weight) were also more likely to miscarry (OR 1.3, 95% CI: 1.1-1.7) following in vitro fertilization (IVF).

Perinatal Mortality

Although between-study comparisons are hampered by different definitions of perinatal mortality, there appears to be an association between increasing maternal BMI and higher

perinatal mortality rates. For example, a Finnish study involving 25,601 singleton pregnancies demonstrated that perinatal mortality was higher among overweight (OR 1.5, 95% CI 1.0-2.4) or obese women (OR 2.2, 95% CI 1.3-3.6) compared with those of normal BMI[36]. The association is strongest for stillbirth.

Stillbirth is more common among women who are overweight (OR 1.5, 95% CI 1.1-1.9) or obese (OR 2.1, 95% CI 1.6-2.7), compared with women with normal BMI (meta-analysis of 9 observational studies of primarily nulliparous women)[90]. Although risk estimates were unadjusted, several cohort studies have demonstrated a significant positive association between maternal obesity and stillbirth after adjusting for factors such as maternal age, parity, diabetes, hypertensive disorders, smoking, alcohol, and chronic disease[36,37,38,91].

Neonatal death is more common among obese women. In a Danish cohort study involving 24,505 women with singleton pregnancies, obesity (vs. normal BMI) was associated with more neonatal death (adjusted OR 2.7; 95% CI 1.2-6.1)[38]; similar rates were seen in a second study involving women with class II/III obesity[32]. In neither study was maternal overweight associated with neonatal death.

Congenital Malformations

There is a strong positive association between pre-pregnancy BMI and birth defects, particularly those involving the neural tube[23,92,93,94,95,96]. A case-control study using data from the Atlanta Birth Defects Risk Factor Surveillance Study[23] demonstrated a 7% increase in the risk of fetal anomaly for each 1-unit incremental increase in BMI above a value of 25 kg/m^2(i.e. any degree of overweight or obesity).

The National Birth Defects Prevention Study (NBDPS), the largest population-based study to date (with 10,249 cases and 4,065 controls) demonstrated an association between pre-pregnancy BMI and 16 categories of structural birth defects[39]. Excluded from analyses were mothers with important confounders (e.g., pre-gestational diabetes) and adjustment was made for preconceptual folic acid consumption.

In the NBDPS, maternal obesity was most strongly associated with spina bifida (OR 2.1, 95% CI 1.6-2.7), as well as more severe forms of neural tube defect (i.e., anencephaly and hydrocephaly)[92,94,96,97,98]. These data are consistent with older studies[92,93,94,96,97,99,100]. No relationship has been demonstrated between maternal overweight and neural tube defects.

In the NBDPS study, maternal obesity was also positively associated with heart defects (OR 1.4, 95% CI 1.2-1.6) and diaphragmatic hernia (OR 1.4, 95% CI 1.03-2.0), and inversely associated with gastroschisis (adjusted OR 0.2; 95% CI 0.1-0.3). Maternal overweight was positively associated with heart defects (OR 1.1, 95 % CI 1.01-1.3), omphalocoeles (OR 1.5, 95% CI 1.-4-2.2), and hypospadias (OR 1.3, 95% CI 1.01-1.5).

The reasons for an association between maternal obesity and a spectrum of structural birth defects of different pathogenesis are unknown. For example, maternal overweight is associated with a higher risk of omphalocoeles (which result from a failure of reduction of mid-gut herniation), whereas obesity is associated with more gastroschisis (which results from a vascular event). It must also be recognized that some associations have reached only borderline statistical significance and may be spurious. Regardless, undiagnosed maternal diabetes has been suggested in the pathogenesis of maternal weight-related fetal anomalies[39]. Also, although folic acid supplementation was adjusted

for in the aforementioned studies, there is some evidence that obese women do not experience the typical reduction in neural tube defect risk associated with folic acid supplementation at the recommended 400 mcg/day[93].

Pre-term Delivery

The association between maternal BMI and pre-term delivery remains controversial with some studies showing an increased risk[21,22,28,30,31,32,33] and others demonstrating a reduced risk or no change[20,26,69]. When subtypes of pre-term birth are examined, however, infants of women who are overweight or obese have a higher risk of iatrogenic preterm delivery because of maternal complications, such as preeclampsia. The risk of preterm delivery due to spontaneous preterm labour appears to be reduced. This was demonstrated in a recent study which reported an increase in elective pre-term deliveries for women who were overweight (OR 1.2, 95% CI 1.03-1.3), obese (OR 1.5, 95% CI 1.3-1.8) or who had class II or III obesity (OR 2.1, 95% CI 1.8-2.6), but a lower risk for spontaneous preterm labour for women who were overweight (OR 0.9, 95% CI 0.8-0.98), class I obese (OR 0.9, 95% CI 0.7-0.99), and class II/III obese (OR 0.8, 95% CI 0.6-1.03)[32]. A large Danish study reported similar findings but in addition, noted a higher risk of preterm birth due to pre-term, premature rupture of membranes (PPROM) which has been associated with infections in the urogenital region[33].

Neonatal Morbidity

Infants of women who are obese are more likely to have low APGAR scores, hypoglycaemia, to require resuscitation, and to be admitted to a neonatal intensive care unit. In a retrospective cohort study, after adjusting for maternal age, smoking, parity and preexisting diabetes, the risk of an APGAR score ≤ 3 at five minutes was significantly higher for women who were overweight (OR 1.7; 95% CI 1.3-2.7), class I/II obese (OR 3.2; 95% CI 2.1-4.8), or class III obese (OR 6.0; 95% CI 2.7-13.4), compared with women of normal BMI[28]. An Australian study reported that neonatal resuscitation was more common among women who were overweight (OR 1.3, 95% CI 1.0-1.7) or obese (OR 1.8; 95% CI 1.3-2.4), compared with infants born to women of normal weight[25]. In addition, women who were obese were twice as likely to deliver an infant with neonatal hypoglycaemia (OR 1.9; 95% CI 1.2-3.1)[25]. In a Canadian cohort study involving 18,643 women, the risk of NICU admission was higher among infants born to women who were overweight (OR 1.2; 95% CI 1.1-1.4), class I/II obese (OR 1.6; 95% CI 1.4-1.9), or class III obese (OR 2.9; 95% CI 1.9-4.4)[28].

Infant Birthweight

Maternal BMI has an important independent influence on infant birth weight. Several studies have demonstrated a protective effect of maternal overweight on delivery of small for gestational age (SGA) infants[26,30,36]. Macrosomia or a large for gestational age (LGA) infant are also more common among women who are overweight (OR 1.3- 2.1) or obese; this effect persists after adjustment for maternal diabetes (OR 1.9-3.5)[7,21,22,28,29,30,31]. Macrosomia is a powerful predictor of shoulder dystocia and through this, third and fourth degree perineal lacerations, blood loss, and neurological injury to the infant[27,101]. Macrosomic infants face an increased obesity later in life[102].

The Risks in Perspective

It is clear that there are substantial pregnancy-associated risks of a BMI above 25 kg/m^2. The attributable risks are also high given the prevalence of overweight and obesity in the general obstetric population (i.e. 30% in British Columbia)[13].

The pregnancy-related risks of obesity are comparable in magnitude to other well-recognized antenatal risk factors. For example, the risk of preterm delivery at <33 weeks among women who are obese (OR 1.5 - 2.0 compared with women of normal weight)[21,30,31] is equivalent to that associated with maternal smoking of up to 10 cigarettes daily (OR 1.4-1.5 compared with non-smokers)[30,103]. An alcohol intake of more than 5 standard drinks per day triples the risk of stillbirth (OR 3.65 compared with non-drinkers)[104], as does a maternal BMI over 30 kg/m^2 [(26,91)]. Neural tube defects are three times more common among women who are obese compared with those with a normal BMI[23]. This amounts to an absolute risk increase of about 1%, similar to early pregnancy exposure to carbamazepine or folic acid antagonists(OR 2.8)[105]. As such, reducing women's weight pre-pregnancy should be given similar priority to that of maternal smoking cessation, alcohol cessation, adequate folic acid supplementation, and avoidance of teratogenic drugs.

MEDICAL ASSESSMENT CONSIDERATIONS/ CHALLENGES

Several practical difficulties can arise in managing care for women who are overweight or obese. Blood pressure is overestimated when standard cuffs are used[106]. Abdominal palpation to assess fetal growth, lie or presentation may be difficult due to increased adiposity. Prenatal sonographic diagnosis is difficult, particularly if BMI is >36kg/m^2 [(107)]. Ultrasound visualization of fetal anatomy declines with increasing maternal size, with the most marked reductions in visualization for fetal heart, umbilical cord, and spine[107]. Ten percent of women who are obese have suboptimal 4-chamber views at 22-24 weeks gestation despite the use of advanced ultrasound equipment[108]. Fetal monitoring by intermittent auscultation or continuous cardiotocography (CTG) using external abdominal transducers can be technically difficult. The depth of maternal adipose tissue can interfere with the doppler signal which may compromise CTG quality and contribute to poor neonatal outcomes[109].

LONG-TERM MATERNAL AND PAEDIATRIC IMPLICATIONS

Obesity is associated with increased all-cause mortality for women[110, 111,112,113]. The risks for a number of health conditions increase with increasing BMI. Several factors related to cardiovascular disease increase with increasing BMI[114], including stroke[110], coronary heart disease[110,112], hypertension [110,112], and hyperlipidemia[112]. Type 2 diabetes increases with increasing BMI [110,112], as does kidney disease[115,116]. The risk for a number of cancers increases, including endometrial cancer, breast cancer, gallbladder cancer, oesophageal cancer, renal cancer, leukemia, multiple myeloma, and non-Hodgkin lymphoma[110,117]. Rates of asthma[118] and arthritis[119,120] are higher among women who are obese. The risk of dementia may increase with increasing BMI[121].

Maternal obesity, both independently and through association with diabetes, is a risk factor for childhood obesity[122] and obesity in early adult life[57,123,124,125,126,127,128,129,130,131]. Children of women who were obese during early pregnancy are twice as likely to be obese at ages 2, 3 and 4[132], and almost 3 times as likely at age 7[122] compared with children whose mothers had a normal pre-pregnancy BMI. A dose-response relationship was

shown in a longitudinal study of 6,280 participants in which increasing maternal BMI was associated with increasing BMI of the offspring at ages 1, 14 and 31 years[123].

These effects may be due to more than genetics or postnatal environment[133]. Fetal programming may occur whereby *in utero* exposure to overnutrition (secondary to overweight/obesity) and/or hyperinsulinaemia (secondary to maternal diabetes), results in long-lasting changes to fetal metabolism and this 'thrifty' (i.e. energy-saving) phenotype increases the risk of obesity or diabetes in later life[57,134]. For example, maternal diabetes increases the offspring's risk of type 2 diabetes more than would be predicted from genetics alone[133]. In a recent American study involving nearly 10,000 multiethnic mother-child pairs, increasing degrees of hyperglycaemia in pregnancy were associated with higher rates of obesity in their children at age 5-7 years[135]. Importantly, treatment of GDM attenuated these risks[135].

COST IMPLICATIONS

There has been limited research into the cost implications of overweight and obesity as related to childbearing. During pregnancy, two studies from France have shown that the cost of prenatal care is 5.4- to 16.2-fold higher for women with a BMI of 25-34 kg/m^2, compared with that for women with normal BMI[136,137]. When both prenatal and postnatal care were considered, cost was even higher, due in large part to more prolonged hospitalization (by an average of 4.4 days), compared with women of normal BMI. In an Australian obstetric population, prolonged hospitalization (exceeding 5 days) was also more common among women who were overweight (OR 1.4, 95% CI 1.1-1.6), class I/II obese (OR 1.5, 95% CI 1.2-1.9), and class III obese (OR 3.2, 95% CI 2.2-4.6), compared with women of normal weight[9]. Hospitalization was also longer in an American study of 13,442 pregnancies; after adjustment for age, ethnicity, level of education and parity, the mean (+/-SE) hospital stay for delivery was greater among women who were overweight (3.7±0.1 days), obese (4.0±0.1 days), class II obese (4.1±0.1 days), or class III obese (4.4±0.1 days), compared with women of normal BMI (3.6±0.1 days). Most of the increase in length of stay associated with higher BMI was related to increased rates of Caesarean delivery, maternal weight-related anaesthetic risks and postpartum complications[138].

Although longer maternal length of stay is a major contributor to cost, other contributors include: extra pregnancy screening at maternity clinics, anaesthetic risks, and postpartum complications for the mother, and costs relating to increased neonatal intensive care unit admission for the baby.

In the same American study quoted above[138], overweight and obesity were also associated with more prenatal fetal tests, obstetrical ultrasonographic examinations, medications dispensed from the outpatient pharmacy, telephone calls to the department of obstetrics and gynaecology, and prenatal visits with physicians, but fewer prenatal visits with nurse practitioners and physician assistants.

VI. Gestational Weight Gain

GUIDELINES

Weight gain in pregnancy is generally considered to be the difference between a woman's weight at the last antenatal visit and either her pre-gravid weight or her weight at the first antenatal visit.

The 1999 Canadian guidelines by Health Canada were adapted from the 1990 Institute of Medicine (IOM) guidelines [139] developed to reduce the risk of fetal growth restriction. Gestational weight gain goals are adjusted based on pre-pregnancy BMI. Table 1 presents the guidelines for singleton pregnancies; for women with multiple gestations, weight gain goals are slightly higher[140]. According to these guidelines, healthy weight pregnant women with twins should gain a total of 16.0-20.5 kg (35-45 lb.) and aim for a rate of gain equal to 0.7 kg (1.5 lb.) each week during the second and third trimesters.

Several studies have confirmed that pregnancy weight gain within the IOM ranges optimizes term deliveries of babies of birthweight between 3,000 and 4,000 g[141,142,143]. However, there is concern that IOM guidelines for gestational weight gain are too high, especially for women who are overweight or obese[144,145]. The IOM is currently reviewing their guidelines with the revised guidelines expected in June 2009. Health Canada is observing the IOM review with the intention to revisit the Canadian guidelines.

RISKS OF EXCESSIVE GESTATIONAL WEIGHT GAIN

Gestational weight gain in excess of the guidelines is associated with an increase in both maternal complications (such as GDM[68]), pre-eclampsia[146,147], failed induction of labour, or Caesarean section[68,148,149], and perinatal complications (such as fetal macrosomia or LGA infants and fetal distress[142,146,147,148,149,150,151]), after adjusting for confounders such as maternal age, race, parity, and smoking. The magnitude of increased risk is smaller than that seen among women who are either overweight or obese pre-pregnancy, with OR of about 1.5 for all but LGA infants with an OR of over 2. As such, one sees a dose-response relationship between maternal weight and adverse pregnancy outcomes, such that risk is: increased with excessive gestational weight gain; greater with pre-pregnancy overweight; and greatest with pre-pregnancy obesity. As with maternal overweight and obesity, excessive gestational weight gain is also a risk factor for childhood obesity[152].

Pregnancy weight gain in excess of the IOM guidelines is common. The range of weight gain among women with normal pregnancy outcome is so variable that gestational weight gain *alone* is not a good predictor of pregnancy outcome[153]. Although obese women tend to gain less weight overall[154,155,156,157], they are more likely to gain weight in excess of guidelines, compared with women of normal weight[158]. In British Columbia (2005/6 data), the mean weight gain (±SD) in pregnancy was similar among women of normal weight (15.7± 5.5 kg), overweight (14.8 ± 6.4 kg), and obese (11.7 ± 7.2 kg). However, women of normal pre-pregnancy weight were less likely to have excessive weight gain (39.3%) compared with women who were overweight (60.4%) or obese (65.7%)[13].

Risk markers for excessive weight gain include: younger age, being single, Black, or Hispanic[159], or self-report of low numbers of supportive individuals in women's lives[160]. Excessive weight gain is associated with either a lack of provider advice about recommended weight gain, or, advice to gain more than the IOM guidelines for women who are overweight or obese[161].

All of the following dietary patterns have been associated with excessive weight gain, particularly for women who are overweight pre-pregnancy: a diet that is high in energy [162], fat or glycaemia[163,164], and consumption of sweets[161]. However, a change in eating habits during pregnancy may be more closely related to weight gain than the actual macronutrient ratio of the foods chosen[162].

Pre-pregnancy dieting or restrained eating are also risk factors for excessive gestational weight gain [165,166], possibly because they may impair an individual's ability to respond to hunger and fullness cues[166]. Pre-pregnancy dieting is of particular concern because it is so common. In the 1999 BC Nutrition Survey, 46.4% of women aged 19 – 30 and 42.5% of women aged 31-50 reported trying to lose weight; 72.9% of them by changing their eating habits[12]. During pregnancy, women with a history of dieting report the perception of being "allowed" to eat more food, and "allowed" to eat "fattening" foods that were previously perceived to be off-limits[165].

VII. Supporting Women and Health Care Providers to Reduce Risks

The 2003-2005 Confidential Enquiry into Maternal and Child Health (CEMACH) included in their list of top 10 recommendations the urgent development of national guidelines for management of obese pregnant women in the United Kingdom. A key finding of the Enquiry was that more than half of all the women who died from direct or indirect causes (and for whom information was available) were overweight or obese, and more than 15% were class III obese[67]. There are no published guidelines on managing pregnancy among overweight and obese women from the Society of Obstetricians and Gynaecologists of Canada (SOGC).

While an increased risk of many complications has been identified in association with overweight or obesity during pregnancy, there is insufficient evidence to identify best practices to reduce these risks.

Incorporate Behaviour Change Theory & Practices

Women and their behaviors do not exist within a vacuum. The contexts of women's lives provide both motivations and barriers to adopting behavior change. As stated in the World Health Organization's Ottawa Charter for Health Promotion: "health is created and lived by people within the settings of their everyday life; where they learn, work, play and love"[167]. Therefore, women-centred practice is recommended to promote health[167]. A women-centred approach to maternity care is one in which services are located in the context of primary care with the recognition that for the majority of women, pregnancy and childbirth are normal life events[168]. In this approach, maternity services place the mother and her baby at the centre of care, and plan and provide services to meet their needs[168]. Developing women-centred care relies, in part, on understanding women's preferences and needs with respect to care[168]. It also involves engaging women and their families (as defined by the woman) in the processes of planning and delivering services[168].

Behaviour change requires both recognition of the problem to be addressed, and adoption of new behaviours. Motivational interviewing is emerging as a promising practice for promoting healthy weight among several populations; however, it has not yet been established among women during the perinatal period[169,170,171,172,173,174,175,176].

A foundational tenet of motivational interviewing is that people vary in their readiness for change and can be influenced to increase their motivation for making changes[177]. Motivational interviewing is often used along with Prochaska and DiClemente's transtheoretical model of change (also known as the stages of change theory[177]. While the specific delineation of the stages has been questioned, the transtheoretical model of

change identifies that some people are not even thinking about changing a behaviour (known as precontemplation) while others are thinking about and taking steps towards making a behaviour change[169]. The model states that practitioners should use different techniques to assist individuals with making a behaviour change depending on whether they are precontemplators or women thinking about/taking steps towards change[178].

CHECKLIST

Table II outlines a checklist of reasonable practices to support women who are overweight or obese (in order to improve maternal and perinatal outcomes) and to support practitioners to initiate appropriate consultations and investigations; it has been modified from two sources[179,180]. The checklist includes issues to address when women are planning pregnancy, are pregnant, or are postpartum.

PRE-PREGNANCY

Healthy Eating, Physical Activity, Substance Reduction and Avoidance

Health Canada recommends that all women of childbearing age follow the healthy eating recommendations in Canada's Food Guide [181] and be physically active every day following Canada's Physical Activity Guide[182].

To promote tobacco reduction and cessation, the British Columbia Perinatal Health Program Guideline: Tobacco Use in the Perinatal Period recommends that physicians: ask women of childbearing age about their smoking status; advise those who smoke how important it is to stop and avoid exposure to second hand smoke; and, offer assistance in quitting to those who smoke[183].

To promote alcohol and other substance use reduction and cessation, the British Columbia Perinatal Health Program Guideline: Alcohol Use in the Perinatal Period and Fetal Alcohol Spectrum Disorder recommends that physicians: talk about substance use with all women; identify those who need help with reducing drinking and other substance use; and support women to reduce or stop use of alcohol and other substances[184].

Weight Loss

The American College of Obstetricians and Gynecologists (ACOG) recommends preconception counselling about potential complications of maternal overweight and obesity, and participation in weight loss programs pre-pregnancy[185].

Weight loss may improve fertility. A loss of 5-10% of body weight may restore ovulation within six months for more than half of obese women with polycystic ovarian syndrome (PCOS)[186,187,188,189]. If conception is not yet desired, contraception should be advised, even for women with demonstrated subfertility. Several studies have shown that following bariatric surgery, fertility is improved[190].

It is assumed that weight reduction before pregnancy will improve future pregnancy outcomes, but there are no randomized controlled trials that have established that this assumption is correct. A cohort study involving 150, 000 Swedish women with two births examined changes in BMI between pregnancies in relation to perinatal morbidity. Women with a BMI decrease of more than one unit had significantly lower rates of pre-

eclampsia and LGA infants in their second pregnancy. However, as only 5.4% of women in this study were obese and 19% were overweight, it is unclear whether such modest weight loss in overweight or obese women would result in similar benefits[191]. Several studies have shown that following bariatric surgery, adverse maternal (e.g. pre-eclampsia, GDM) and fetal outcomes (e.g. macrosomia) are reduced in a subsequent pregnancy[190]. If a woman has undergone bariatric surgery prior to conception, she may need supplementation with vitamin B12, iron, calcium, and folic acid[192,193,194].

Regardless of proven benefit on subsequent pregnancy outcomes, there are recognized health benefits for women for moderate weight reduction (on glycaemic control, BP, lipids, and the risk of stroke, coronary artery disease and death) that make a convincing argument for advocating for taking steps towards the achievement of a healthy weight outside of pregnancy.

Outside of pregnancy, better practices for the achievement of a healthy weight involve lifestyle interventions including calorie reduction, physical activity, and behavioural therapy. Pharmacotherapy and bariatric surgery may also have a role. Canadian clinical practice guidelines recommend consideration of pharmacotherapy for individuals with BMI≥ 27 kg/m^2 in the presence of cardiovascular risk factors or BMI≥ 30 kg/m^2 if 3-6 months of lifestyle modification has been unsuccessful. Bariatric surgery could be considered for individuals with BMI ≥ 35 kg/m^2 and cardiovascular risk factors, or BMI≥ 40 kg/m^2 if other weight loss strategies have failed[14].

There are potential barriers to achieving weight loss among women who are overweight or obese and planning a pregnancy. First, 50% of pregnancies are unplanned. Second, as the most successfully maintained weight loss involves lifestyle change resulting in slow progressive weight loss, it is possible that women who are planning pregnancy may not be willing to wait for such a long time prior to conceiving. In the setting of advanced maternal age, it may even be *inappropriate* to suggest that conception be delayed to achieve weight loss. There appears to be a consensus, however, that pregnancy should be delayed for two years following bariatric surgery, during which time one sees the majority of the weight loss and postoperative complications.

As we believe that either the postpartum period or the period before women are planning a pregnancy may be the times to target weight loss, barriers to success and strategies to achieve weight loss are discussed under '*Supporting Women and Health Care Providers to Reduce Risks/ Postpartum'*.

Folic Acid Supplementation

For all women of childbearing age (including during pregnancy), a multivitamin and mineral supplement containing 0.4 mg daily of folic acid is recommended to reduce the risk of NTDs and possibly, other congenital anomalies[181]. Women with a BMI > 30 kg/m^2 may need higher doses of folic acid to achieve the same folate levels as women with a BMI <20 kg/m^2[195]. Although the mechanisms for the obesity-associated risk of NTDs are poorly understood, the 2007 guidelines of the Society of Obstetricians and Gynaecologists of Canada (SOGC) recommend that women with class II/III obesity take 5 mg daily of folic acid for at least three months before conception, and continue this dose until 10-12 weeks post-conception[195].

Optimize Treatment of Co-morbidities

Chronic diseases such as type 2 diabetes, hypertension, and obstructive sleep apnea are more common among women who are overweight or obese[196]. Treatment of these co-morbidities should be optimized prior to conception. In addition, early assessment of glycaemic control, liver enzymes, renal function, and proteinuria should be considered as this may help to later distinguish pre-pregnancy morbidity (such as type 2 diabetes, macrohepatic steatosis, or pre-existing renal disease) from pregnancy-induced complications [such as gestational diabetes, HELLP syndrome (hemolysis, elevated liver enzymes, low platelets), or gestational proteinuria of pre-eclampsia]. Both pre-pregnancy morbidity and pregnancy complications occur more commonly in association with overweight and obesity[197].

DURING PREGNANCY

Multidisciplinary Support

Given the array of maternal and fetal complications that may occur for women who are overweight or obese, involvement of a multidisciplinary team should be considered, similar to that which is commonly available for women with diabetes.

Screen for GDM

Screen women for GDM following the British Columbia Perinatal Health Program Obstetric Guideline 10A: Gestational Diabetes[198]. This guideline recommends that women with identified risk factors be screened in the first or second trimesters.

Set an Appropriate Weight Gain Goal

Height, weight and BMI should be recorded on the first antenatal visit. At present, height and weight are each recorded on 80% of antenatal records in British Columbia (2005/6 data), allowing for calculation of BMI in 70% of women[13].

An appropriate gestational weight gain goal should be set based on current Canadian Guidelines (based on the IOM guidelines), and risks associated with excessive weight gain should be discussed in early pregnancy. Based on results of questionnaire-based studies, prenatal care providers are not following IOM guidelines when advising patients about gestational weight gain. In two recent studies[199,200], a third of women reported having received no advice from their health providers about how much weight to gain during pregnancy. And, among women who did receive advice, 50% of women who were overweight were advised to gain more than recommended by guidelines[200].

Weight loss is not recommended during pregnancy for all women, including women who are overweight or obese, because of concerns about the impact of maternal ketosis on fetal brain development[201].

Encourage Healthy Eating and Physical Activity (to achieve weight gain goal)

Healthy Eating

There are limited data on actual nutritional intake because pregnant women are usually excluded from analyses. Available information suggests that women do not meet nutrition recommendations for pregnancy. American data from 1988-94 reported that women consumed insufficient grains, vegetables, fruit, milk and meat, and consumed excessive fat, saturated fat, and sodium[202].This finding is in contrast to the fact that women report wanting to eat well to support their fetus' health[203], and appear to have adequate nutrition knowledge, regardless of socioeconomic status [204].

Physical Activity

Physical activity during pregnancy is advisable, not just acceptable, for all pregnant women.

In small studies, physical activity in pregnancy was not associated with adverse maternal or perinatal outcomes[205,206,207,208,209,210,211,212,213,214]. In fact, lack of physical activity is associated with loss of muscular and cardiovascular fitness, excessive maternal weight gain, higher risk of gestational diabetes, higher risk of pregnancy-induced hypertension, development of varicose veins and deep vein thrombosis, and more physical complaints such as dyspnea or low back pain[215].

Physical activity also has the potential to positively influence body image satisfaction[216]. Among 74 Caucasian women of high socioeconomic status, the perceived benefits of exercise in pregnancy were (in order of importance): improved mood, increased energy/stamina, and assistance with fitness and weight control [217]. Reported barriers to physical activity during pregnancy were feeling too big and physical limitations, such as nausea, vomiting and fatigue[211].

The SOGC guideline (2003) recommends maintenance of a good fitness level throughout pregnancy without trying to reach peak fitness or train for an athletic competition[215]. Suggested activities include brisk walking, stationary cycling, cross-country skiing and swimming as they are associated with minimal risk of loss of balance or fetal trauma.

Barriers to Healthy Eating and Physical Activity

Related to Health Care Providers

Conversations about healthy eating and activity during pregnancy may not be taking place, or incorrect information may be communicated[203]. As such, women may not know the recommended weight gain for their pre-pregnancy BMI and/or that it is both safe and advisable to exercise during pregnancy. Most studies suggest that women value having conversations with their health care providers about healthy weight, healthy eating, and physical activity[199,164, 203,218].

There is opportunity for health care providers to better communicate the physical activity recommendations for pregnancy, as many women believe that physical activity in

pregnancy is unsafe. Women may be discouraged by family and friends or be discouraged by what they perceive as mixed advice from health care providers[219].

In a survey of members of the American College of Obstetricians and Gynecologists, most members were aware of obesity-related pregnancy risks and felt that weight management fell within their clinical practice but did not feel adequately trained in weight management[218]. We could not identify relevant Canadian data. Other barriers to weight management included both practice-related factors (e.g. support services, visit time) and patient-related factors (e.g. patient motivation and compliance with dietary and activity advice) [218]. Of interest is the fact that when health care providers did not influence women's lifestyle, their spouse/ partner often did[217].

Related to Women

There are limited data on barriers to meeting nutrition recommendations in pregnancy. However, as discussed above (under '*Encourage healthy eating and physical activity*'), barriers to healthy eating do NOT appear to include lack of nutrition knowledge[204].

A barrier to healthy lifestyle in pregnancy may be the interaction between how women feel about their bodies and their eating and physical activity habits, of which one investigation identified four patterns based on attitudes during but also before and after pregnancy[220]:

1. **Relaxed maintenance**: Women in this category are well educated. They have stable weight and are content with their weight pre-pregnancy. During pregnancy these women "watch" what they eat, eat a "healthy" diet, and are physically active in their daily lives (but do not intentionally plan exercise). They are not concerned about their weight during pregnancy. Postpartum weight is not of much concern and they return to a healthy eating pattern similar to their pre-pregnancy habits. They continue to include physical activity in daily life but do not plan exercise. Their postpartum weight returns to close to pre-pregnancy weight but they may maintain some extra weight.

2. **Exercise**: Women in this category are well educated. Pre-pregnancy exercise and fitness are priorities for these women. They have healthy eating habits pre-pregnancy and are happy with their weight. They maintain healthy eating during pregnancy and continue to include exercise while pregnant, but less frequently and intensely than pre-pregnancy. Exercisers return to exercising postpartum, some after a non-active transition time. Their motivation for loss of their pregnancy weight is related to both health and body image. They don't retain weight postpartum but those who take a non-active transition time take longer to return to their pre-pregnancy weight.

3. **Determined***:* Women in this category have a variety of educational levels. They perceive themselves as overweight pre-pregnancy, but they may or may not have tried losing weight. These women are somewhat uncomfortable with gaining weight during pregnancy. They are determined to lose weight postpartum and achieve a lower weight than pre-pregnancy. Postpartum, they go on diets and exercise to lose weight. They are frustrated at the slow rate of weight lost postpartum but they do reach their pre-pregnancy weight by approximately one year.

4. **Unhurried***:* These women have the lowest education. They are unhappy with their weight pre-pregnancy but most do not take action to lose weight. They do not plan physical activity during pregnancy and have unhealthy eating habits (e.g. consume more high-fat and high-sugar sweets and snacks than women in the other three groups). They are unhappy with their weight postpartum but do not make weight loss a priority and take no action (eating habits or physical activity).

In order to plan effective interventions, it is important to understand how women respond and adjust to the changes in eating, body weight/ shape, and physical activity that are associated with pregnancy and the period following delivery[221].

Effectiveness of Lifestyle Interventions

Lifestyle interventions during pregnancy are aimed at curbing gestational weight gain; they are NOT aimed at weight loss. Interventions aimed at curbing excessive gestational weight gain have had mixed results in a variety of settings and with women of variable socioeconomic status and pre-pregnancy weight[222,223,224].

No effect was seen on gestational weight gain, eating habits (except for caffeine intake), or physical activity levels following individual dietary counselling and physical activity sessions among aboriginal Cree women[225]. Gestational weight gain and physical activity were unaltered, although there were some dietary improvements (increased fibre, fruit and vegetable intake) following dietary and physical activity counselling from early pregnancy, provided by public health nurses at antenatal visits, for primiparous women in Finland[224].

In contrast, excessive weight gain was curbed among women who were normal weight (but not overweight) by a behavioural intervention (vs. usual care) in a randomized controlled trial involving low-income women[216]. Weight gain was curbed among normal and overweight low-income (but not high-income) women by providing education on weight gain, diet, and exercise by mail, as well as guidance about and monitoring of gestational weight gain by health care providers[217]. Gestational weight gain was reduced by weekly motivational talks and regular physical activity among obese women in Sweden[224]; modes of delivery and neonatal outcomes were not changed.

The mixed results of existing intervention studies emphasize that there are no simple solutions to supporting women to curb excessive gestational weight gain. These data should serve to motivate the development of better interventions based on published successes and failures. For example, there may be a role for education and/or involvement of spouses and partners, because when health care providers did not influence women's lifestyle, their spouse/ partner often did[217]. There may also be a role for novel approaches that take into account women's barriers to healthy lifestyle adoption, as well as their motivation (i.e. readiness for change). For example, one could consider focussing on women who demonstrate a 'determined' pattern of eating/ lifestyle, rather than on those who are 'unhurried' and who may, therefore, be less receptive to interventions.

POSTPARTUM
Prevention of Weight Retention

The pattern of postpartum weight loss, and the amount of weight ultimately retained postpartum, is variable. In general, women lose weight gradually, reach their lowest BMI (which usually includes some weight retention) at approximately 12 months[226,227], and then gain weight slowly thereafter[160,226].

Postpartum weight retention is of concern because of its potential impact on subsequent pregnancy weight gain[228] and long-term overweight and obesity. Even if a woman's weight is higher than pre-pregnancy but remains within the normal range, there is an increased risk of excessive gestational weight gain and adverse pregnancy outcomes in a subsequent pregnancy[191].

Postpartum weight retention is most strongly associated with excessive weight gain in pregnancy, particularly excessive first trimester weight gain[52,154,159,160,227,229,230,231,232,233,234,235,236,237]. In fact, excessive weight gain in pregnancy may explain some of the association between postpartum weight retention and both overweight and obesity[238].There is mixed evidence regarding whether postpartum weight retention is associated with pre-pregnancy overweight or obesity[228,229,238,239]. It may be that pre-pregnancy overweight or obesity indirectly increases the risk of postpartum weight retention because women who are overweight or obese are at higher risk of gaining more than the IOM guidelines[238]. And, gaining more than the IOM guidelines, in turn, increases risk for postpartum weight retention[238].

There are many other risk factors for postpartum weight retention, including: unhealthy eating habits[240], low physical activity[160,241], inadequate sleep[242], low socioeconomic status/education[229,240], low affect/ depression[229], ethnicity[159,227], and self-report of low numbers of supportive individuals in women's lives[160]. In the United States, Black women retain more weight than Caucasian women, and both Black and Caucasian women retain more weight than Asian women[159,227]. There is a lack of evidence regarding weight retention among women of other ethnic backgrounds.

As risk factors for postpartum weight retention, inadequate sleep and mood are worthy of specific mention because each is so prevalent, and because each is potentially modifiable. A study involving 940 Caucasian women with higher socio-economic status found that women who reported less than five hours of sleep per night at six months postpartum were more likely to retain 5kg or more at one year postpartum[242]. Postpartum, low affect (or "the blues") occurs among 70-80% of women and frank depression in 12-16%[243]. It appears that overweight and obesity may cluster with depression and disordered eating (preoccupation with body shape and pathological avoidance of "fattening" foods) postpartum[244].

Any effect of breastfeeding on postpartum weight retention is small, but there are, of course, many other reasons to breastfeed. Breastfeeding (especially exclusively without supplementing with formula) may promote a small amount of postpartum weight loss[245], and women who choose to breastfeed have better diet quality[238,246].

Weight Loss Strategies

Outside Pregnancy

The Canadian Medical Association 2006 Canadian clinical practice guidelines on the management of obesity in adults and children recommend a comprehensive healthy lifestyle intervention for people who are overweight and obese that includes an energy-reduced diet, regular physical activity, and education and support in behaviour modification techniques[14]. Health care providers are also encouraged to create a non-judgemental atmosphere when discussing weight, and to consider an individual's barriers to weight loss[14].

Among the adult population in general, the weight loss industry is large, and many lessons can be learned from it. The variety of approaches that have been tried is detailed under '*During pregnancy*. Most interventions are still only moderately successful in promoting sustained, small amounts of weight loss[247]. The evidence is weak for determining best practice regarding weight management for overweight and obese individuals[248] and there is insufficient evidence to determine the effectiveness of commercial weight loss programs[249].

The following weight loss delivery methods have been identified as warranting future investigation:

- Reminder systems for physicians to perform specific actions[248],
- Brief training interventions for health care providers[248],
- Shared care between a hospital program and GP[248],
- In-patient care, and dietitian-led treatments[248],
- On-going monitoring and support[250], and
- Long-term follow-up[250] particularly personal contact (vs. internet-based follow-up or no follow-up at all)[251].

The following weight loss program content has shown promise:

- Setting realistic weight loss goals[250],
- Teaching eating behaviour control techniques (cognitive-behaviour therapy)[252,253],
- Promoting healthy eating *and* physical activity[254],
- Teaching self-esteem[255].

The evidence is weak regarding the optimal diet composition for weight loss and maintenance, especially considering high drop-out rates and poor diet adherence[256]. Low glycemic index diets may promote weight loss and weight maintenance[257,258]. Lower carbohydrate diets may promote greater short-term weight loss without superior long-term effectiveness [259,260]. As such, there may not be one 'optimal' diet for everyone. Considering the high drop-out rates, an 'optimal' diet may be an eating pattern that an individual is able to follow long-term and so there may be as many 'optimal' diets as there are individuals[259].

Tailoring Weight Loss Programs to Women Who are Postpartum

The American College of Obstetricians and Gynecologists recommends participation in nutrition counselling and exercise programs postpartum[185]. A Cochrane review (as well as the National Research Council and Institute of Medicine[161]) concluded that there is insufficient evidence to identify best practices for the promotion of postpartum weight loss and prevention of weight retention[261]. Study drop-out rates are high and can exceed 40%.

A dietary component of postpartum weight loss programs appears to be important. In fact, diet and exercise are not more effective than diet alone[261]. On average, postpartum weight loss interventions have resulted in a weight loss of 4.8-7.8kg[262]. Greater weight loss is seen with programs of longer duration.

There is mixed evidence regarding whether women change their eating habits postpartum compared to pre-pregnancy[238,263]. Even if they do improve their eating habits, women during the postpartum period do not consume the recommended amount of grain products, vegetables and fruit, or milk and alternatives[238,263].

Women who are overweight or obese report different eating patterns than women with normal BMIs. A study involving 340 low-income women found that those who were obese one year postpartum reported more barriers to healthy eating, more emotional eating, and more food insecurity (i.e. a lack of access to safe, affordable, healthy food) than women who had normal BMIs[240]. Women who had normal BMIs one year postpartum reported eating in response to taste, hunger, and cravings more than women who were overweight or obese[240].

Physical activity alone has not been successful in achieving postpartum weight loss, although physical activity may have other benefits. Group physical activity may decrease postpartum depression, but it is not clear whether the physical activity or the opportunity to interact with other new mothers was responsible for the improved mood (2 RCTs, 39 women)[264]. Unfortunately, studies show that most women decrease strenuous, moderate, and mild physical activity during pregnancy and postpartum versus pre-pregnancy[160,217,241].

Being physically active postpartum is related to self-efficacy (i.e. believing that you can do it[265]), and being physically active pre-pregnancy[241]. In a study involving 74 Caucasian, high socioeconomic status women who were physically active during pregnancy, the perceived benefits of physical activity *postpartum* were, in order of importance: weight control, staying fit, and improving mood[217]. The importance that women placed on weight loss postpartum is in contrast to the priority that they placed on management of mood as a motivator for exercise in pregnancy[217].

Women have reported all of the following barriers to physical activity postpartum: lack of time[160], hours worked outside of the home[241], finding childcare[241,266], presence of other children in the home[241], lack of opportunity[160], other household responsibilities[261], and fatigue[160]. Again, these responses are different from those in pregnancy when physical limitations are the major barrier.

In terms of additional approaches, a promising intervention was studied among 85 Finnish women who received dietary and physical activity counselling by public health nurses at baby clinics[267]. Participants kept a food and physical activity record during the

eight-month intervention. Although 50% of the intervention group (compared with 30% of controls) returned to their pre-pregnancy weight, the difference did not reach statistical significance.

It is important to note that none of the interventions studied has had a negative impact on breastfeeding[261].

Motivations and Barriers to Change

In designing an effective intervention it is important to understand women's motivations and barriers to healthy eating and physical activity postpartum. As women adjust to the role of mother, self-care may become less of a priority than caring for children. As such, even when women have adopted or continue to practice healthy eating and physical activity during pregnancy, these practices may not continue postpartum[220].

During the early postpartum period, women may be particularly vulnerable to body-dissatisfaction. In a study of 90 primarily Caucasian women (mean±SD BMI four months postpartum of 25.7±4.8), the proportion of women who reported dieting because they were unhappy with their weight increased from 53% pre-pregnancy to 70% postpartum[221]. Also, dieting pre-pregnancy was associated with greater body dissatisfaction postpartum[221].

In a small study of 22 Black women who were postpartum, the following were identified by them as desirable in a postpartum weight loss intervention: low cost (free), easily accessible geographically, structured, group- or mentor-oriented, including learning good cooking habits, involving the whole family, including child-care, and being staffed by people knowledgeable about the stressors of new motherhood and postpartum depression[266].

Screening for Cardiovascular Risk Factors

The 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children recommend for all adults, measurement of BMI and waist circumference[14]. For individuals with a BMI>25 kg/m^2 or a waist circumference above the ethnic specific waist circumference cut-off, the following are also recommended: blood pressure, heart rate, fasting glucose, and fasting lipid profile measurement at regular intervals. Additional investigations, such as liver enzyme tests, urinalysis, and sleep studies are suggested when appropriate.

VIII. Role Modelling to Prevent Childhood Obesity

Children with at least one parent who is obese are at increased risk of becoming obese themselves[268]. This is intuitive when one considers that parents determine food availability in the home, how the food is eaten in the home, what sort of recreational opportunities are available, children's allowances; and countless other rules and policies that influence the extent to which various members of the family engage in healthful eating and physical activity[268].

For infants, toddlers, and young children, the mothers' child-feeding practices relate to children's food preferences, energy intake, and ability to sense hunger and fullness[269,270,271]. Breastfeeding may have a small protective effect for preventing childhood obesity[272]. Children who are encouraged to eat in response to hunger, and to stop eating when full, are better able to regulate their eating when presented with large amounts of favourite foods in an unsupervised environment[269,270]. Maternal restriction of high-fat, -salt, or -sugar foods may actually lead to increased BMI and adiposity[265,266,273] by reinforcing the preference for these 'forbidden foods' [265,267,274].

Parents are also important role models for healthy eating[269,270,274]. Children eat what they see their parents eat and they prefer foods that are offered in positive environments, such as pleasant family meals[274]. Children who are exposed at an earlier age to vegetables and fruit *enjoy* vegetables and fruit more, and *eat more* vegetables and fruit[274,275].

Parents and other care-givers are also important role models for physical activity. The Framingham Children's study found that children of physically active mothers were twice as likely to be active, and those with two active parents were almost six times more likely to be physically active, compared with children of two sedentary parents[276].

It follows logically that many groups recommend family-based interventions for prevention (and treatment) of childhood obesity[14,268,272,277,278,279,280,281,282,283,284].

In summary, supporting healthy lifestyles amongst postpartum women may support healthy lifestyles for children. Doing so may reinforce for mothers (and fathers) their critical role as role models for healthy eating and lifestyle, and may aid them in supporting their children in developing healthy relationships with food and physical activity.

IX. Conclusions

Obstetric care providers have an important role to play in promoting healthy weight for women in pregnancy and beyond. Women who are overweight or obese pre-pregnancy and those who gain excessive weight during pregnancy, are at increased risk of complications both for themselves and for their fetus/ infant, in a dose-response fashion. The risks associated with maternal weight are comparable to those of other antenatal risk factors, including moderate smoking. Therefore, pregnant women who are overweight or obese should be regarded as higher risk.

There are recognized non-pregnancy related health benefits to having a healthy weight (for example reduced risk of type 2 diabetes). Also, there are barriers present when planning a pregnancy (for example, 50% of pregnancies are unplanned). It is unrealistic to think that this multifaceted health concern will be solved by pre-pregnancy counselling and weight reduction alone. Therefore, it is recommended that steps be taken to achieve a healthy weight outside of pregnancy in addition to targeting women during pregnancy (by promoting weight gain within the IOM guidelines) followed by postpartum interventions to promote the achievement of healthy weights.

Women who are overweight, obese, and/or have had excessive gestational weight gain should be 'flagged' for health care providers who will be assuming or resuming care. These women are at increased risk of complications in the next pregnancy, as well as long-term maternal and paediatric health problems.

Given the central role of eating habits in weight loss programs, active involvement of a dietitian should be sought. Consideration could be given to targeting those women who are at greatest risk of postpartum weight retention (i.e. those who are obese, or who gained an excessive amount of weight in pregnancy), and to factoring in their motivations and barriers to healthy lifestyle adoption (i.e. readiness for change).

The findings presented in this paper should serve to motivate the development of better health promotion focussed, women-centred interventions based on published successes and failures with respect to supporting women to experience healthy weights during the childbearing years. Such interventions should also be based on evidence that explores women's motivations and barriers to adopting lifestyles that promote a healthy weight.

Herein is a checklist of better/ promising practices for primary obstetrical healthcare practitioners to support women who are overweight or obese pre-pregnancy, during pregnancy and postpartum, with a goal to improve maternal and perinatal outcomes.

Appendix A: Gestational Weight Gain Recommendations

Table 1: Recommended gestational weight gain relative to pre-pregnancy body mass index (BMI), for singleton pregnancies[285]

	***TOTAL* Weight Gain**		***RATE* of Weight Gain**
Pre-Pregnancy BMI (kg/m^2)	**(kg)**	**(lb)**	
<20	12.5-18	28-40	First trimester gain 1.0 – 3.5 kg (2 – 8 lb). Second and third trimesters gain approximately 0.5kg (1.0lb) per week.
20-27	11.5-16	25-35	First trimester gain 1.0 – 3.5 kg (2 – 8 lb). Second and third trimesters gain approximately 0.4kg (0.75lb) per week.
>27	7-11.5	15-25	First trimester gain 1.0 – 3.5 kg (2 – 8 lb). Second and third trimesters gain approximately 0.3kg (0.5lb) per week.

Appendix B: Pregnancy Care Checklist

Table 2: Pregnancy Care Checklist for Women who are Overweight and Obese

PRE-PREGNANCY
Encourage moderate weight loss prior to conception by physical activity and healthy eating following Eating Well with Canada's Food Guide[181] and Canada's Physical Activity Guide to Healthy Active Living[182]
Recommend contraception while aiming for target weight
Counsel about risks associated with maternal overweight and obesity
Optimize glycemic control prior to conception for women with pre-gestational diabetes
Initiate folic acid supplementation 3 months prior to conception among women who are obese
If the woman has undergone bariatric surgery prior to conception, supplementation with vitamin B12, folate, iron and calcium may be indicated
IN PREGNANCY
At initial antenatal visit: • Record height, weight and BMI (kg/m^2) • Discuss Health Canada weight gain guidelines, set weight gain GOAL and RATE • Counsel about maternal and fetal risks of overweight/obesity • Counsel about maternal and fetal risks of excessive gestational weight gain during pregnancy • Test early glucose tolerance to screen for pre-existing, undiagnosed Type 2 diabetes, especially in the presence of risk factors such as: family history of diabetes, previous GDM, and/or a previous macrosomic infant • Promote and support breastfeeding
In early pregnancy: • Confirm dating with early ultrasound • Conduct detailed anomaly scan at 18 weeks • Conduct early assessment of liver function, renal function, degree of proteinuria, and ECG to screen for other medical problems • Promote and support breastfeeding
Throughout or later in pregnancy: • Measure blood pressure with an appropriately sized cuff • Monitor weight gain and rate of gain throughout pregnancy, relative to GOAL • Encourage healthy eating following Eating Well with Canada's Food Guide[181] • Encourage moderate physical activity unless there is a (are) contraindication(s) • Screen for GDM at 24-28 weeks • Promote and support breastfeeding

In preparation for labour and delivery:

- Involve a multidisciplinary team
- Arrange an anaesthetic consult prior to the onset of labour†
- Do complex care planning to ensure appropriate equipment is available (e.g. operating room bed, commodes) and prepare for potential labour complications (including failed induction, slow progress, shoulder dystocia, fetal distress, emergency Caesarean section, thromboembolism postpartum, and post-operative wound infection)
    - Prescribe antibiotic prophylaxis for caesarean section: 2g cephalothin iv if weight is >70kg
    - Administer uterotonics in a timely fashion given increased risk of PPH
- Consider postoperative DVT prophylaxis
- Promote and support breastfeeding

FOLLOWING PREGNANCY

- Counsel regarding healthy eating and physical activity following Eating Well with Canada's Food Guide[181] and Canada's Physical Activity Guide to Healthy Active Living[182], promotion of a healthy weight, and other health concerns prior to attempting future pregnancies
- Screen periodically for diabetes and other cardiovascular risk factors according to published guidelines
- Advise on long-term risks of obesity, hypertension and diabetes
- Refer to community support services for the promotion of a healthy lifestyle
- Promote and support breastfeeding

** Based on expert opinion[180,286]*

† A reasonable criterion would be a BMI >35kg/m^2 but different centres will establish different cut-offs based on logistics.

GDM (gestational diabetes), DVT (deep vein thrombosis), PPH (postpartum haemorrhage)

Appendix C: References

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