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Gestational Weight Gain - Its Importance To Pregnant Women And Their Children

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ABSTRACT

INTRODUCTION

The amount of weight that women gain during pregnancy has an impact on their health and the health of their babies. However, most women experience gestational weight gain in excess of the recommended amounts.

OBJECTIVES

To gain a deeper understanding of women's perspectives regarding gestational weight gain, to examine how they experience the advice that they receive pertaining to gestational weight gain, and to explore the association between gestational weight gain and their child's weight status.

METHODS

Three studies of different research designs were conducted. The first was a systematic review of qualitative, quantitative, and mixed methods studies to gain a broad understanding of pregnant women's perceptions of gestational weight gain. This was followed by a qualitative study to explore the experience of women living in an urban area in Nova Scotia pertaining to the gestational weight gain advice that they receive. The third study used a retrospective cohort design to examine the association between gestational weight gain and offspring weight status.

RESULTS

Although pregnant women realized that gestational weight gain played a role in the health of their unborn child, which was their top priority, they were not certain about how much weight they should gain, partly because they did not report receiving much gestational weight-related advice from their prenatal care providers. Many women gained excess weight during pregnancy, which was associated with a higher body mass index trajectory observed in their children from birth to approximately five years of age.

CONCLUSION

Based on their perceptions of gestational weight gain and their experience of the gestational weight gain-related advice that they receive from their prenatal care providers, pregnant women reported that they could benefit from having more explicit and focused discussions pertaining to gestational weight gain with these providers. Such an approach could have downstream weight-related implications for their children and perhaps help to curb the childhood obesity epidemic.

KEYWORDS

(in alphabetical order): advice, body mass index, childhood obesity, gestational weight gain, guidelines, primary care.

SUMMARY FOR LAY AUDIENCE

There are guidelines for how much weight women should gain during their pregnancies, and weight gain that falls above or below those recommendations is associated with adverse outcomes for mothers and their children. This PhD thesis aimed to first explore pregnant women's perceptions of their pregnancy weight gain. Next, a qualitative study was undertaken locally, in Nova Scotia, to understand pregnant women's experience of the advice that they received from a number of sources about their pregnancy weight gain. These studies showed that women's top priority was the health of their baby. They were unsure about how much weight they should gain and they reported that their prenatal care providers did not often provide advice about weight gain.

Finally, a quantitative study was conducted to explore the relationship between pregnant women's weight gain and the body mass index paths of their children from birth to approximately five years of age. This work showed that women who gained excess weight during pregnancy had children whose body mass index paths were significantly higher than children whose mothers had not gained excess pregnancy weight.

DEDICATION

To my late mother, Maria Nair da Silva Damato Piccinini, who would have wanted me to undertake this challenge and who would have unfailingly supported me in person had she been here. However, she accompanied me on this journey in spirit and I am so thankful for that…I never felt alone.

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CHAPTER ONE

INTRODUCTION

1. OVERVIEW

This thesis is about women with low risk pregnancies who in Canada receive prenatal care by family physicians, midwives, and obstetricians. As with all pregnancies, the key issues are maternal and fetal well-being and outcomes. Weight gain is a matter of interest to both pregnant women and prenatal care providers during pregnancy and in addition is a harbinger of the baby's health. How these constructs intersect is the topic of the thesis.

The first part of this Introduction will consider the discrepancy between pregnant women's desire for a healthy baby and their guideline-discordant gestational weight gain. The background of this discrepancy and the relevant literature was the justification for a new study that undertook a mixed-methods systematic review of that literature which included a variety of study types.

The second part of this Introduction will address the background literature pertaining to the provision of reportedly inconsistent messages to pregnant women over the years about gestational weight gain, the perception by prenatal care providers that they are providing gestational weight gain advice, and pregnant women's affirmation that they are not receiving such advice. This conflicting literature led to the design of an in-depth study of women's experience of the weight gain advice they receive during pregnancy.

The third part of this Introduction examines the inconsistent literature on the association between gestational weight gain and offspring outcomes, some due to research design issues. This material constituted justification for a quantitative study exploring the association between pregnant women's gestational weight gain relative to the guideline recommendations and their children's body mass index over time.

2. PERCEPTIONS OF GESTATIONAL WEIGHT GAIN

There is a discrepancy between pregnant women's desire for a healthy pregnancy and their guideline-discordant gestational weight gain, as a substantial body of evidence shows that the amount of weight that women gain during pregnancy is significantly associated with the overall health of the pregnancy. The current recommendations for

optimal gestational weight gain were published by the Institute of Medicine in 2009 [1], and weight gain outside the recommended amounts is associated with adverse maternal and fetal outcomes, both in the short term and the long term [2-33]. Gestational weight gain concordance with these guidelines is thus an important clinical issue, particularly when considering that the majority of women in North America experience excess gestational weight gain [14,34-36], with some recent studies showing excess gestational weight gain in as many as 60% to 70% of pregnant women [24,27].

Due to the discrepancy between women's desire to ensure a healthy pregnancy and their guideline-discordant pregnancy weight gain, it is important to give consideration to pregnant women's perspectives of gestational weight gain, especially given that most women perceive the health of their unborn child to be their top priority during pregnancy [37-43].

A number of studies showed that women's knowledge of targets for personal gestational weight gain and their awareness of the risks associated with excess gestational weight gain in general were limited [44,45]. Further, while some studies showed that women considered pregnancy weight gain as a normal process and were not perturbed by it [39,46], other studies found that women expressed frustration, self-consciousness and shame towards their weight gain [47,48]. Finally, although a woman's health beliefs, health behaviours, and awareness of the recommendations can influence gestational weight gain [26,49-57], there is uncertainty as to whether pregnant women who are aware of the recommendations value them enough to alter their health beliefs and health behaviours [48].

There is some historic evolution which may explain women's perceptions of gestational weight gain that is found in the literature. Many studies were conducted at a time when women typically entered pregnancy at a lower BMI, and the prevailing worry pertained to insufficient weight gain [58]. In addition, several studies explored women's perceptions of gestational weight gain in the postpartum period [39,46,58,59], which although important to understand, provided a retrospective lens that is potentially very different from the real-time perspectives of women who are experiencing a pregnancy. Finally, a substantial number of relevant studies were quantitative, specifically cross-sectional. Although this approach has advantages, it is perhaps less suited to an area that is not well understood.

Therefore, in order to address the dissonance between women's desire to ensure the health of the pregnancy and the guideline-discordance of their gestational weight gain, the first study in this thesis (Chapter Two), "*Women's perceptions of gestational weight gain: a systematic review and thematic synthesis"*, aimed to gain a deeper understanding of pregnant women's perceptions of gestational weight gain through a systematic review of the literature that included qualitative, quantitative, and mixed methods studies.

Pregnancy has been described as a "teachable moment" [60], as women are very motivated to make positive health changes. Therefore, for pregnant women and their families, knowledge gained from this work could potentially influence their efforts to manage their gestational weight gain in order to approximate the recommended amounts as closely as possible and increase the chances of providing their unborn children with a healthy start in life.

3. PERCEPTIONS OF GESTATIONAL WEIGHT GAIN ADVICE

Pregnant women's knowledge pertaining to gestational weight gain, derived from information and understanding gained through education or previous experience [61], is a modifiable factor that can influence gestational weight gain [50-55]. There is evidence that pregnant women obtain conflicting information and advice about gestational weight gain from a number of sources that results in considerable confusion [62-64].

This confusion is possibly a reflection of a number of factors, including the shifting of guidelines for optimal gestational weight gain that occurred over a few decades. Formal recommendations dating back to more than a century ago simply advised pregnant women to restrict weight gain [65,66]. Due to emerging concerns about low birthweight, the recommendations were then increased to a target range of 20 to 25 pounds [67]. In 1990 the Institute of Medicine published recommendations for gestational weight gain based on pre-pregnancy body mass index (BMI) that proposed higher weight gains than had been previously recommended [68]. Although there was disagreement [69,70,71], proponents of the 1990 recommendations argued that guideline-concordant gestational weight gain was consistently associated with better outcomes than guideline-discordant gestational weight

gain [2,3,5-11,13-15,72,73].

The guidelines were subsequently revised by the Institute of Medicine in 2009 [1] and endorsed by Health Canada in 2010 [74], reflecting the demographic shift in the female population that had occurred between 1990 and 2005. Specifically, there had been a substantial increase in the proportion of women entering pregnancy at an elevated BMI and at the age of 35 or older [1].

Gestational weight gain advice that is based on shifting guidelines can thus cause confusion at a societal level. The confusion generated by gestational weight gain advice is also potentially due to the evidence that prenatal care providers, whose advice women trust, infrequently address gestational weight gain [75-78]. This is important, because although there have been very few randomized controlled trials [79], cross sectional and prospective cohort studies indicate that advice from a prenatal care provider influences gestational weight gain, and is associated with both women's gestational weight gain goals and their actual gestational weight gain [80-85].

There is evidence that prenatal care providers are hesitant to address gestational weight gain, despite reporting that they are very concerned about excess gestational weight gain [86]. They cite a number of barriers to addressing gestational weight gain, including a perceived lack of time, resources, and confidence [87,88]. In addition, these clinicians fear angering, offending or embarrassing their patients and believe that their efforts are ineffective and probably undermined by their patients' cultural beliefs. Therefore, rather than raising this issue, they wait for their patients to initiate such discussions [34,48,83,85,86,89-99]. Adding to the complexity of this issue is the controversy pertaining to whether pregnant women actually welcome advice about gestational weight gain [42,100-103].

However, there is a discrepancy in women's and prenatal care providers' perceptions regarding the provision of gestational weight gain advice [85,89,90,92,104]. This was evidenced in the Canadian pregnancy arena, where 95% of prenatal care providers in one study reported that they discussed gestational weight gain with their patients, whereas only a small percentage of patients perceived that they had such discussions with their prenatal care providers [76].

In order to address these controversies and inconsistencies, the second study in this thesis (Chapter Three), "*Women's views on advice about weight gain in pregnancy: a Grounded Theory study"*, sought to gain a deeper understanding of how women experienced gestational weight gain advice that they received from various sources. Contextual issues such as education and pre-pregnancy BMI were considered, as these factors can yield different results [37,59,105,106]. As this area is not well understood, a qualitative methodology was chosen. Specifically, Grounded Theory was selected as a suitable methodology to address the research question. This qualitative methodology approaches data collection and analysis iteratively and simultaneously, constructing theories that are grounded in the data [107,108].

4. OUTCOMES ASSOCIATED WITH GESTATIONAL WEIGHT GAIN

This section is about gestational weight gain that is below or above the 2009 Institute of Medicine guidelines for gestational weight gain. Gestational weight gain in excess of the guidelines is associated with a number of adverse outcomes for mothers and their offspring, both in the short-term and in the long-term, including an increased risk of preeclampsia, gestational diabetes, shoulder dystocia, cesarean section, blood transfusion, neonatal hypoglycemia and hyperbilirubinemia, large for gestational age, neonatal adiposity, postpartum weight retention and maternal obesity [14,15,26,32,109].

Excess gestational weight gain has also been shown to be associated with offspring excess weight at various ages ranging from early infancy to 42 years [110-122]. This is important because in Nova Scotia approximately 60% of women experience excess gestational weight [123] and around 15% of children in grade three have obesity [124]. The concern pertaining to these statistics was highlighted in 2015 when the World Health Organization declared childhood obesity "one of the most serious public health challenges of the 21st century" [125] due to its association with an increased risk of cardiovascular, endocrine, psychosocial and musculoskeletal complications, many of which are sustained into adulthood [126-128].

While most of the work exploring the relationship between gestational weight gain and childhood obesity has shown that excess gestational weight gain plays a significant role, the role of insufficient gestational weight gain is controversial. This is important to consider, as insufficient gestational weight gain is a risk factor for other adverse fetal outcomes including preterm birth, low birth weight, small for gestational age, failure to initiate breastfeeding, and shorter stature [15,30,33]. Pertaining to childhood obesity, a prospective cohort study showed that insufficient gestational weight gain was associated with childhood excess weight at 3 years [119], but other studies with children ranging from 1 week to 9 years of age did not support this [30,110,114,121,129].

There is therefore some controversy regarding the relationship between gestational weight gain concordance with the 2009 Institute of Medicine guidelines for gestational weight gain and downstream offspring obesity. A limitation of some of the retrospective cohort studies examining this question has been the challenge of accurately determining pre-pregnancy weight and thus the calculation of pre-pregnancy BMI. This has implications for two approaches to gestational weight gain measurement: total gestational weight (last measured weight at term minus the pre-pregnancy weight) and the rate of gestational weight gain (a measurement based on weekly weight gain). This is partly because data pertaining to pre-pregnancy weight have typically relied on self-report at an unspecified gestational age, during the intrapartum or postpartum periods, or to a large extent during the second or third trimesters. Although weight measurements taken within the first trimester and self-reported pre-pregnancy weight solicited within the first trimester are fairly reliable proxies for pre-pregnancy weight, this is not the case for weight data collected later in pregnancy [130-132].

Another limitation of some of the studies examining the relationship between gestational weight gain concordance with the 2009 IOM guidelines and childhood excess weight has been the gestational age at which total gestational weight gain is calculated. Women who deliver at an earlier gestational age have less time to gain weight than women who deliver later, and studies exploring gestational weight gain have not always clearly stated the gestational age at which total gestational weight gain was calculated, or have included deliveries before term with estimations about gestational weight gain presuming linearity

or consistent patterns of gestational weight gain. In these instances, total gestational weight gain calculations are potentially inaccurate, with potential implications for the results.

The third study in this thesis (Chapter Four), "*The association between women's gestational weight gain concordance with guidelines and their children's body mass index trajectories"*, sought to therefore explore children's BMI trajectories over time, comparing the trajectories among children born to mothers whose gestational weight gain was above, within, or below the 2009 Institute of Medicine guidelines. A retrospective cohort design was undertaken with careful attention given to ensure the accuracy of pre-pregnancy BMI and how guideline concordance of gestational weight gain was determined. Further, robust statistical analyses were used that accounted for the nature of the data. Specifically, multilevel modeling was employed, as it can accommodate participants with repeated observations that are unequally spaced and randomly missing data, it does not require the assumption of independence between measurements, and it can model linear and non-linear rates of change [133-142].

Obtaining a greater understanding of the relationship between gestational weight gain and childhood obesity is of relevance to women and their families, as this knowledge might be empowering and motivating in terms of trying to approximate gestational weight gain recommendations as much as possible. For prenatal care providers, in particular primary care clinicians who have a unique, long-term relationship with their patients, knowledge regarding the association between a woman's gestational weight gain concordance with the guidelines and the foreshadowing of her child's likely BMI trajectory in early childhood affords a window of opportunity to address weight management in the home environment before childhood excess weight becomes a problem. Once established, childhood weight trajectories are difficult to change and are strong predictors of weight status in adulthood [143,144].

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CHAPTER TWO

WOMEN'S PERCEPTIONS OF GESTATIONAL WEIGHT GAIN: A SYSTEMATIC REVIEW AND THEMATIC SYNTHESIS

1. INTRODUCTION

Pregnancy is a time during which women experience a number of changes in their bodies. Research shows that women often have a positive attitude towards these changes due to a new sense of meaning in life, an enhanced perception of the functionality of their bodies, and an increased sense of social connectedness [1]. A specific body change that usually occurs during pregnancy is an increase in weight, and typically this weight gain is in excess of the ranges recommended for optimal maternal and fetal outcomes [2-5] .

Non-modifiable factors such as age, parity and ethnicity can influence gestational weight gain, and modifiable factors such as awareness of gestational weight gain recommendations, health beliefs, and health behaviours also play an important role [6-11]. Further, the advice that women obtain from a number of sources such as family, friends, online resources and printed materials impacts on gestational weight gain. Advice from healthcare providers has specifically been shown to be associated with women's personal targets for gestational weight gain and their actual gestational weight gain [12-15]. From a behaviour change perspective, in order for these clinicians to provide meaningful advice regarding gestational weight gain and seize "teachable moments", an understanding of women's perceptions of gestational weight gain could be beneficial [16-18]. However, women's thoughts, ideas, beliefs and understanding regarding gestational weight gain are not well understood.

The purpose of this review was therefore to gain such an understanding from a wide variety of types of studies, including quantitative surveys, qualitative and mixed-methods studies.

2. METHODS

This study was a systematic review of the literature including a variety of research methodologies such as quantitative, qualitative and mixed methods.

2.1. Search Terms

The following search terms were used: ((weight) AND ((gestation*[Title/Abstract]) OR pregnan*[Title/Abstract])) AND ((((((((((understand*[Title/Abstract]) OR perspective*[Title/Abstract]) OR view*[Title/Abstract]) OR opinion*[Title/Abstract]) OR feeling*[Title/Abstract]) OR idea*[Title/Abstract]) OR thought*[Title/Abstract]) OR belief*[Title/Abstract]) OR awareness[Title/Abstract]) OR knowledge[Title/Abstract]) OR attitude*[Title/Abstract]) OR perception*[Title/Abstract]). These terms comprise the full search that was conducted. The databases searched were PubMed, CINAHL, Embase, and PsycInfo.

2.2. Selecting a checklist for systematic reviews

A number of checklists exist pertaining to the reporting of systematic reviews. These include QUOROM [19] , MOOSE [20], and PRISMA [21]. The present systematic review included studies of different research designs and therefore none of these checklists were entirely suitable: QUOROM pertains to systematic reviews of randomized controlled trials, MOOSE is relevant to systematic reviews of and observational studies, and PRISMA pertains to quantitative studies. Therefore, Cooper's stages of a systematic review [22] were followed. These stages are: 1) problem formulation (the purpose of this systematic review and thematic synthesis, found on page 22); 2) sampling (sections 2.1 and 2.3, which led to some papers being accepted and some papers being rejected); 3) data collection (the first stage of the thematic synthesis, contained in section 2.4); 4) analysis (the second and third stages of the thematic synthesis, contained in section 2.4); 5) reporting (section 3, Results).

2.3. Selecting a quality criteria framework

Typically, studies are judged using critical appraisal checklists or measures according to the research tradition to which the study belongs [23]. Table 2-1 shows a compilation of selected common critical appraisal checklists and measures, pertaining mostly to one design or methodology only. However, in conducting a literature review of studies from a variety of research traditions using many methods, the use of different appraisal criteria checklists is potentially cumbersome and confusing. In addition, the appraisal of qualitative studies is controversial, and there is no consensus on criteria for appraising the

methodological quality of mixed methods studies [24]. If the goal of a review of varied primary study designs is to gain broad and deep understanding based on all types of empirical research, then the appraisal of primary studies based solely on each research tradition separately could be considered philosophically incongruent with this goal. Rather, examination of qualitative, quantitative and mixed methods primary studies through a shared lens would be better suited to this goal. After reviewing the 11 checklists and measures listed in Table 2-1, the only one meeting the criterion of having a shared lens was the Mixed Methods Appraisal Tool (MMAT), a critical appraisal framework developed by Pluye et al. [25], applicable to all types of empirical research and to this writer's knowledge the only tool currently available for this purpose [26].

Table 2-1. Critical appraisal checklists and measures used for quantitative, qualitative, and mixed methods studies

Type of study	Name of tool	Target studies	Number of items	Comments
Quantitative	Jadad 1998 [27]	Randomized controlled trials (RCT)	3	Assesses the quality of clinical trials based on random assignment, double blinding, and the flow of patients
	CONSORT (1996) Consolidated Standards for Reporting Trials [28]	RCT	22	Checklist and flow diagram. Basic philosophy is widely applicable
	TREND (2004) Transparent Reporting of	Non-randomized	22	Used for intervention evaluation studies with nonrandomized designs (not

	Evaluations with Nonrandomized Designs [29]	intervention studies		for all research using nonrandomized designs)
	QUOROM (1999) Quality of Reporting of Meta-Analyses [19]	Meta-analyses of RCT	18	Checklist and flow diagram
	STROBE (2008) Strengthening the Reporting of Observational Studies in Epidemiology [30]	Cohort, case control, and cross-sectional studies	22	18 items are common to all three study designs and 4 are specific for each design
	MOOSE (2000) Meta-analysis of Observational Studies in Epidemiology [20]	Cross-sectional, case control, case series, and cohort studies	35	Knowledge of research methodology probably necessary
	CASP (2014) Critical Appraisal Skills Programme [31]	Systematic reviews, RCT, case control, and cohort studies	10 – 12	Number of items depends on study design
Qualitative	SRQR (2014) Standards for Reporting Qualitative Research [32]	Applies to various paradigms, approaches,	21	Iterative process to identify important items

		and methodologies		
	COREQ (2007) Consolidated Criteria for Reporting Qualitative Research [33]	For in-depth interviews and focus groups	32	Three domains: research team and reflexivity, study design, analysis and findings
	CASP (2014) Critical Appraisal Skills Programme [31]	No connection to interpretive paradigms	10	No knowledge of qualitative research required. Focus on issues of rigor, credibility and relevance.
Mixed Studies	MMAT (Mixed Methods Appraisal Tool) [25]	Quantitative, qualitative, mixed methods	Variable	Appraises studies through a shared lens

The MMAT (Table 2-2) stipulates an initial global assessment of a study, consisting of two screening items: 1) whether there are clear research questions or objectives; and 2) whether the data address the questions or objectives. Failure to confirm one or both of these questions suggests that further appraisal of the study should not be undertaken. For studies that meet the screening criteria, the MMAT then outlines a set of scoring criteria to be examined depending on the research design (qualitative, quantitative randomized controlled trials, quantitative non-randomized, quantitative descriptive, mixed methods). The final score for any given study can range from 0 to 1.

Table 2-2. Mixed Methods Appraisal Tool (MMAT) *

Types of mixed methods study components or primary studies	Methodological quality criteria (see tutorial for definitions and examples)	Responses		
		Yes	No	Can't tell
Screening questions (for all types)	Are there clear qualitative and quantitative research questions (or objectives), or a clear mixed methods question (or objective)?			
	Do the collected data address the research question (objective)?			
	Further appraisal may not be feasible or appropriate when the answer is "No" or "Can't tell" to one or both screening questions.			
1. Qualitative	1.1 Are the sources of qualitative data relevant to address the research question (objective)?			
	1.2 Is the process for analyzing qualitative data relevant to address the research question (objective)?			
	1.3 Is appropriate consideration given to how findings relate to the context in which the data were collected?			
	1.4 Is appropriate consideration given to how findings relate to researchers' influence?			
2. Quantitative randomized controlled (trials)	2.1 Is there a clear description of the randomization (or an appropriate sequence generation)?			
	2.2 Is there a clear description of the allocation concealment (or blinding when applicable)?			
	2.3 Are there complete outcome data (80% or above)?			

	2.4 Is there low withdrawal/drop-out (below 20%)?			
3. Quantitative non-randomized	3.1 Are participants (organizations) recruited in a way that minimizes selection bias?			
	3.2 Are measurements appropriate regarding the exposure/intervention and outcomes?			
	3.3 In the groups being compared, are the participants comparable, or do the researchers take into account the difference between these groups?			
	3.4 Are there complete outcome data (80% or above), and when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies?			
4. Quantitative descriptive	4.1 Is the sampling strategy relevant to address the quantitative research question?			
	4.2 Is the sample representative of the population under study?			
	4.3 Are measurements appropriate?			
	4.4 Is there an acceptable response rate (60% or above)?			
5. Mixed methods	5.1 Is the mixed methods research design relevant to address the qualitative and quantitative research questions (or objectives), or the qualitative and quantitative aspects of the mixed methods question (or objective)?			

	5.2 Is the integration of qualitative and quantitative data (or results) relevant to address the research question (objective)?			
	5.3 Is appropriate consideration given to the limitations associated with this integration?			
	Criteria for the qualitative component and appropriate criteria for the quantitative component must also be applied.			

* Taken from: http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/84371689/MMAT%202011%20criteria%20and%20tutorial%202011-06-29updated2014.08.21.pdf

The MMAT has been validated, is easy to use, and has been shown to generally have high inter-rater reliability scores [34-37]. The decision was made to only accept articles with greater than half of the scoring criteria for the present synthesis (i.e. a score of > 0.50), and disagreements were resolved by discussion between the two researchers (Helena Piccinini-Vallis and Moira Stewart), who independently reviewed and scored each paper with the MMAT.

2.4. Synthesis method

A number of methods have been described for the synthesis of qualitative research findings, quantitative research results, and the combination of qualitative and quantitative results [38-42]. Segregated approaches maintain clear boundaries between quantitative and qualitative data, and separate syntheses are conducted in advance of and in preparation for the final syntheses. In contrast, integrated approaches combine quantitative and qualitative data into a single synthesis. Because the purpose of this systematic review was to gain a contextually based understanding of pregnant women's perceptions of gestational weight gain, an inductive and integrated synthesis approach was deemed most appropriate, and therefore, of the six synthesis methods shown in Table 2-3, the thematic synthesis method [38] was selected. The three stages of thematic synthesis were undertaken

[43]: a) line-by-line coding of the entire text of all eligible papers, with identification and extraction of salient representative text pertaining to women's perceptions of gestational weight gain (initial codes); b) a search for similarities and differences among these initial codes in order to generate preliminary descriptive themes; c) a search for similarities among the preliminary descriptive themes in order to merge them into a list of overarching analytical themes [38,43,44] describing women's perceptions of gestational weight gain. NVivo software was used to organize the codes and themes.

Table 2-3. Integrated synthesis methodologies identified for possible use

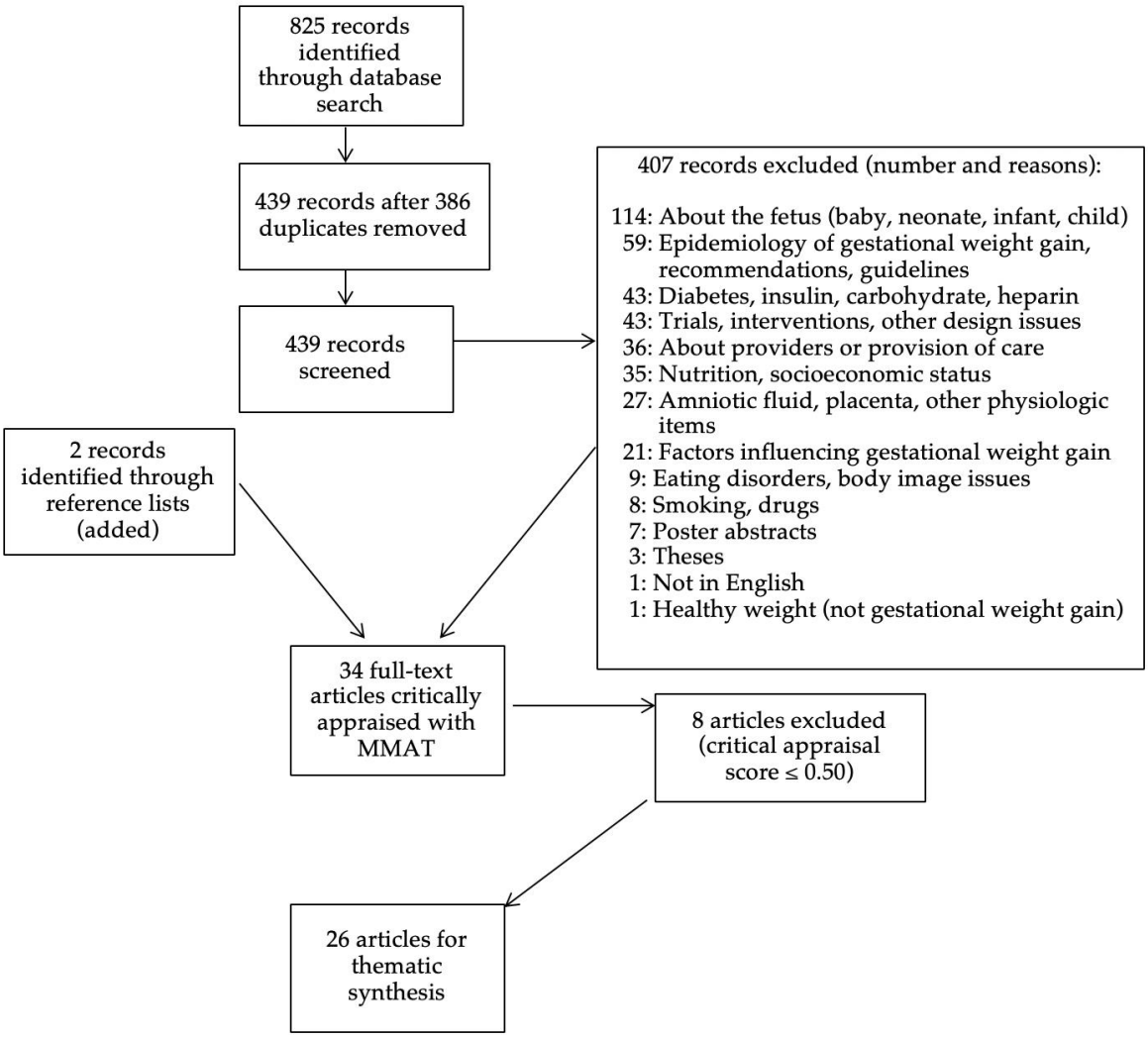
Methodology	Evidence	Methods
1.Bayesian meta-analysis [45]	Qualitative and quantitative	Content analysis of qualitative data yields categories, into which data from quantitative studies are integrated. Bayesian statistical analyses are then undertaken.
2. Content analysis [46]	Qualitative and quantitative	A systematic approach for condensing data into fewer content-related categories and then counting how many times each one occurs.
3. Critical interpretive [47]	Qualitative and quantitative	An approach to the whole review process that involves iteratively refining the research question and using theoretical sampling to select studies from the literature. Studies are appraised by relevance to theory development.
4. Realist synthesis [48]	Qualitative and quantitative	Focuses on understanding the underlying causal mechanisms by which an intervention does or does not work and under which conditions.

5. Textual narrative [44]	Qualitative and quantitative	The characteristics, context, quality and findings of studies are systematically identified according to a standard format; similarities and differences are then compared across studies, allowing for heterogeneity among studies to be transparent.
6. Thematic [43,44]	Qualitative and quantitative	An inductive approach in which codes of data are organized into "descriptive" themes, which generate "analytical" themes using a constant comparison method. The latter represent an interpretation that yields new constructs or hypotheses.

3. RESULTS

The search date was 20/10/2015 and the search included studies published from 1980 until the search date. A total of 825 articles were found with 307 studies in PubMed, 80 in CINAHL, 362 in Embase, and 76 in PsycInfo. There were 386 duplicates among the 825 articles, resulting in 439 records being screened for relevance through review of their titles and abstracts. Of these, 407 articles were excluded for a number of reasons (Figure 2-1). Two additional articles were identified through reference lists, resulting in a final list of 34 articles of studies that used a variety of research methods.

Figure 2-1. PRISMA flow diagram



The 34 studies included one mixed methods study in addition to 17 qualitative, four quantitative non-randomized (observational) and 12 quantitative descriptive studies. Details pertaining to the critical appraisal of these studies using the MMAT criteria are shown in Table 2-4.

Table 2-4. Details pertaining to the critical appraisal of the 34 selected studies with relevance to the MMAT

Type of study	Item	Yes	No

Qualitative (n=17; 16/17 met quality criteria)	Are the sources of qualitative data relevant to address the research question?	16/17	1/17
	Is the process for analyzing qualitative data relevant to address the research question?	15/17	2/17
	Is appropriate consideration given to how findings relate to the context in which the data were collected?	13/17	4/17
	Is appropriate consideration given to how findings relate to researchers' influence?	9/17	8/17
Quantitative non-randomized (n=4; 4/4 met quality criteria)	Are participants recruited in a way that minimizes selection bias?	4/4	0/4
	Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes?	4/4	0/4
	In the groups being compared, are the participants comparable, or do researchers take into account the difference between these groups?	3/4	1/4
	Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies?	2/4	2/4
	Is the sampling strategy relevant to address the quantitative research question?	5/12	7/12

Quantitative descriptive (n=12; 5/12 met quality criteria)	Is the sample representative of the population under study?	7/12	5/12
	Are measurements appropriate (clear origin, or validity known, or standard instrument)?	8/12	4/12
	Is there an acceptable response rate (60% or above)?	3/12	9/12
Mixed Methods (n=1; 1/1 met quality criteria)	Is the mixed methods research design relevant to address the qualitative and quantitative research questions, or the qualitative and quantitative aspects of the mixed methods question?	1/1	0/1
	Is the integration of qualitative and quantitative data relevant to address the research question?	1/1	0/1
	Is appropriate consideration given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data in a triangulation design?	0/1	1/1

The scores resulting from this quality review ranged from a low score of 0 to a high score of 1. A cut-off score of 0.50 was chosen, in advance, to represent a high-quality study. Eight papers had a score lower than or equal to 0.50 and were therefore rejected from further inclusion in the synthesis to follow, with 26 studies remaining which included 16 qualitative studies, four quantitative non-randomized studies, five quantitative descriptive studies and one mixed methods study. Table 2-5 shows details of these 26 studies included in the synthesis.

Table 2-5. Details of the 26 studies included in the synthesis

Year and first author	MMAT score	Location (country)	Study objective(s)	Study design	Data collection method	Participant characteristics
1. 1994 Abraham [49]	0.75	Australia	Explore women's attitudes towards their gestational weight gain (GWG)	Quantitative descriptive	Survey	N = 100; mean age 27 (range 17 to 42); BMI < 19 - > 30; nulliparous; postpartum.
2. 1998 Wiles [50]	0.75	England	Examine the beliefs of women of above average weight about appropriate levels of GWG	Qualitative	In-depth interviews	N = 37; age 16 to 35; mean pre-pregnancy BMI = 32; nulliparous and multiparous; antenatal and postpartum.
3. 2000 Devine [51]	1.0	USA	Explore women's experiences of and strategies towards pregnancy and postpartum weight changes	Qualitative	In-depth interviews	N = 36; age 18 to 41; nulliparous and primiparous; at least high school education;

						antenatal and postpartum.
4. 2006 Vallianatos [52]	1.0	Canada	Explore Cree women's perceptions of GWG and postpartum weight loss	Qualitative	Semi-structured interviews	N = 30; mean age 21.7; BMI > 25; nulliparous and multiparous; aboriginal; low SES; postpartum.
5. 2008 Everette [53]	0.75	USA	Describe women's perspectives on GWG and pregnancy dietary habits	Qualitative	In-depth interviews	African American, low income; postpartum.
6. 2009 Groth [54]	0.75	USA	Describe the perceptions of ethnically diverse mothers about GWG	Qualitative	Semi-structured interviews	N = 49; mean age 24.9; low income; postpartum.
7. 2010 Haruna [55]	0.75	Japan	Explore the perceptions of pregnant women and healthcare providers regarding appropriate GWG	Qualitative	Focus groups	N = 9 pregnant women; mean age 33; mean pre-pregnancy BMI = 21.2; higher SES; antenatal.

8. 2010 Tovar [56]	0.75	USA	Evaluate pregnant women's knowledge, attitudes and beliefs regarding GWG	Qualitative	Focus groups	N = 29; age 18 to 40; Puerto Rican; low income; antenatal.
9. 2011 Gaudet [57]	0.75	Canada	Determine the proportion of pregnant women who were able to correctly classify BMI	Quantitative descriptive	Survey	N = 117; mean age 33.4; higher education; antenatal.
10. 2011 Olander [58]	0.75	England	Explore women's and health professionals' views regarding GWG	Qualitative	Focus groups	N = 13 women; moderately deprived; antenatal and postpartum.
11. 2012 Brooten [59]	0.75	USA	Examine pregnant women's perception of GWG	Quantitative descriptive	Survey	N = 54; mean age 28.6; low income; antenatal.
12. 2012 de Jersey [60]	1.0	Australia	Evaluate women's GWG concordance with guidelines, their knowledge of the guidelines, and healthcare professional advice regarding GWG	Quantitative non-randomized	Surveys and clinical measures	N = 664; mean age = 29.9; mean BMI 24.3; nulliparous and multiparous; antenatal.

13. 2012 Groth [61]	1.0	USA	Explore how pregnant women perceived and managed GWG	Qualitative	Focus groups	N = 26; age 18 to 39; African American; low income; antenatal.
14. 2012 Herring [62]	0.75	USA	Explore pregnant women's perceptions of high GWG, sources of GWG advice, and barriers and facilitators to gaining within guidelines	Qualitative	Focus groups	N = 31; mean age 24 years (range 18 to 40); African-American; low income; antenatal.
15. 2013 Goodrich [63]	0.75	USA	Explore women's perceptions of appropriate GWG, and barriers and facilitators to exercise and healthy eating	Qualitative	In-depth interviews	N = 33; mean age 25.9; mean pre-pregnancy BMI = 29.0; African-American; low income; antenatal and postpartum.
16. 2013 Shub [64]	0.75	Australia	Assess pregnant women's knowledge regarding their BMI category, awareness of GWG guidelines, and expectations regarding GWG concordance with guidelines	Quantitative descriptive	Survey	N = 364; median and interquartile age 31.1(range 28 to 35); antenatal.

17. 2014 Haakstad [65]	0.75	Norway	Evaluate pregnant women's knowledge of and attitudes towards GWG and compare GWG attitudes with GWG concordance with guidelines	Quantitative descriptive	Survey	N = 467; mean age 31.6; higher income; antenatal.
18. 2014 Jette [66]	0.75	Canada	Explore how low-income women of diverse sociocultural backgrounds experience health and GWG	Qualitative	Interviews	N = 15; low income; antenatal.
19. 2014 Murray [67]	1.0	Canada	Investigate the meaning and experiences of GWG for women with high GWG	Qualitative	Interviews	N = 7; mean age 27.3; primiparous and multiparous; antenatal.
20. 2015 Darroch [68]	0.75	Canada	Explore how urban Aboriginal women understand GWG and physical activity (PA)	Qualitative	Focus groups and semi-structured interviews	N = 26; age 16 to 39; aboriginal; low income; antenatal and postpartum.
21. 2015 de Jersey [69]	0.75	Australia	Evaluate and compare GWG related risk perception in early pregnancy among women	Quantitative descriptive	Survey	N = 582; mean age 29; antenatal.

			entering pregnancy at a healthy weight and overweight			
22. 2015 McPhie [70]	0.75	Australia	Explore and compare GWG expectations and knowledge on GWG	Quantitative non-randomized	Repeated surveys	N = 166; mean age 31; mean pre-pregnancy BMI 24.5; mixed SES; antenatal
23. 2015 Padmanabhan [71]	1.0	England	To explore pregnant women's attitudes and beliefs towards GWG	Qualitative	Face to face interviews	N = 19; age 19 to 38; low SES; nulliparous and multiparous; antenatal.
24. 2015 Smid [72]	0.75	USA	Explore the difference in GWG advice received by English and Spanish speaking pregnant women, their perceptions of safety of GWG control strategies and risks of excessive GWG	Quantitative descriptive	Survey	N = 279; antenatal.
25. 2015 Wang [73]	0.75	USA	Examine psychosocial factors that could prevent excess GWG (knowledge and attitudes	Qualitative	Semi-structured interviews	N = 62; age 18 to 36; Latina; low income; antenatal.

			toward GWG, sources and content of GWG advice)			
26. 2015 Whitaker [74]	0.75	USA	Examine women's behavioral, normative, and control beliefs toward GWG, PA, and nutrition in pregnancy using the Theory of Planned Behaviour	Mixed methods	Survey and qualitative (content analysis)	N = 199; mean age 30.3; mean pre-pregnancy BMI 25.7; mixed SES; antenatal.

For the thematic synthesis, line-by-line coding of the entire text of all eligible papers yielded a total of 310 initial codes. A search for similarities and differences among these initial codes generated nine preliminary descriptive themes, and finally six interconnected overarching analytical themes emerged that described women's perceptions of gestational weight gain. These six themes that emerged from the thematic synthesis were: 1) The baby's health comes first; 2) Uncertainty about weight gain amounts; 3) Control over gestational weight gain: the body has its own mind; 4) Feelings regarding gestational weight gain: mostly a struggle; 5) Influences on gestational weight gain: from genes to community; and 6) Advice received: often inconsistent. These themes are described below, along with supporting data.

3.1. The baby's health comes first

This was a theme that threaded through all the other themes, establishing its centrality. Women asserted that their baby's health was their top priority and they wanted above all else to avoid any harm to the baby: *"I'm like whatever, I'm not trying to watch how much weight I gain or lose while I'm pregnant. I just pray that my baby is healthy."* (qualitative, participant) [61, page 801]. They therefore did not worry about excess weight gain and specifically wanted to avoid insufficient weight gain, as they perceived the latter to be a greater threat to the baby's health:

> "I'd rather get big myself and have a healthy baby rather than stay slim and end up having a little six pounder who wasn't as healthy. So I tend to push all my feelings aside about my weight because I know that I'm going to end up having a healthy child because of it. So I can worry about myself after I gave birth." (qualitative, participant) [71, page 7].

The maternal instinct to protect the baby was the crux of women's perceptions of gestational weight gain and was consistently reflected in the other themes generated from the thematic synthesis of all eligible papers.

3.2. Uncertainty about weight gain amounts

Women's beliefs about how much weight they should gain were somewhat ambiguous. They believed that they should not gain excess weight due to a risk of personal negative

outcomes, including their appearance and function during pregnancy and their ability to return to their pre-pregnancy weight: *"...a higher proportion of women reported that pre-pregnancy weight and excess gestational weight gain would be likely to cause problems for their own health compared with the health of their baby."* (quantitative, author) [69, page 685]. However, they ultimately anchored their estimates around the health of the baby: *"The main criterion used to assess adequacy of weight gain was birth outcome. If the health of the baby and mother was fine, then the women assumed that the amount they had gained was "good.""* (qualitative, author) [52, page 108]. Additionally:

> "Despite the general relaxed view towards weight gain, the pregnant women realised there may be some health complications with gaining too much weight. In response to being asked if there was anything that would make the women change their weight-related behaviour, the women reported being worried about their baby's health." (qualitative, author) [58, page 45].

When asked about specific amounts of weight that should ideally be gained during pregnancy, women demonstrated generally poor knowledge of the guideline recommendations: *"The majority (65.1%) of women overestimated the maximum amount of weight they should gain during pregnancy."* (quantitative, author) [70, page 23]. They clearly expressed uncertainty about how much weight they should gain:

> "Well, I weigh myself all the time, but…I don't know whether or not I'm gaining a lot and I don't know if I'm not gaining enough. I weigh myself all the time at home and…it's not a reassuring thing cause you don't really know what you're looking at. Like I know I'm gaining weight, but am I supposed to gain five pounds more than that? Am I supposed to lose three pounds?...It's an unsure feeling." (qualitative, participant) [67, page 2546].

Beyond their poor knowledge, some women also exhibited indifference towards the recommendations: *"Overall, women articulated that having a healthy baby and a healthy pregnancy were priorities to them, but that having a healthy baby was not related to pregnancy weight gain or complying with weight gain recommendations."* (qualitative, author) [56 page 944].

3.3. Control over gestational weight gain: the body has its own mind

Women wanted to control the amount of weight that they gained during pregnancy, in part for the health of the baby. However, they experienced gestational weight gain to be ultimately out of their control: *"It's been difficult because sometimes the body has its own mind. It's going to gain whatever it wants to gain."* (qualitative, participant) [73, page 814]. They expressed not knowing the cause of their weight gain:

> I can't believe I've put on so much weight… It's not for what I'm eating by no means because I don't eat fast-food/take-outs. I try to eat as healthy as possible and the weight is just gone crazy. It's ridiculous actually…I've got all this weight on and I don't understand where it's coming from." (qualitative, participant) [67, page 2546].

In their struggle to control gestational weight gain, health care professionals were recognized as potentially helpful partners: *"The women's attitudes to weight gain and whether they could or should exert control over it were influenced by the comments made and advice offered by the health professionals with whom the interviewees came into contact."* (qualitative, author) [50, page 258].

3.4. Feelings regarding gestational weight gain: mostly a struggle

The results from the present synthesis revealed that when reflecting on gestational weight gain, women cited feelings of confusion, worry and distress. In particular, the alterations to their bodies required an adjustment of their self-image which they found difficult but wanted to tolerate, as they believed the weight gain translated to a healthy baby:

> "So, it was hard to see myself. You don't recognize yourself in the mirror. I loved the belly, but all the rest of it was a bit hard… You get comments from friends and family about your size and you realize that it's all for the best in the end for the baby's sake, but it is still something that you struggle with… When you look in the mirror and you see something different than what you're used to looking at, it's confusing… You just do a double take in the mirror and [you] have to get used to this new body." (qualitative, participant) [67, page 2545].

Women felt vulnerable and had an awareness that family members and healthcare providers were watching their pregnancy weight gain with a critical eye. Although varying by culture, women experienced negative feelings as a result, including defensiveness:

> "In other cases health professionals made negative comments about women's weight which seemed to reinforce the view that their weight and their weight gain was out of their control: The midwife said, 'You're terribly overweight', and I thought that was a really horrible thing to say to me, it's not my fault. I've always been big." (qualitative, participant) [50 page 258].

However, in spite of all the challenges they faced related to gaining weight, some women disclosed that they perceived benefits to gestational weight gain, especially when it was distributed in desirable places that enhanced their sense of femininity:

> "I like my boobs better [laughs] I've actually got some now… I didn't have a big chest and now it's gone up a couple of sizes and I quite like it. I just feel a bit more womanly which is quite strange, I didn't expect them to grow like they have [laughs] I know they will probably go back to normal later." (qualitative, participant) [71 page 10].

3.5. Influences on gestational weight gain: from genes to community

Women cited a number of personal health behaviours as factors that influenced gestational weight gain, alluding to their personal responsibility to gain an appropriate amount of weight.

> "The dominant belief was that overeating and poor diet quality caused high weight gain in pregnancy: ''[I] was eating so much, the weight was coming so fast''. Mothers described larger portions as normative in pregnancy: ''[I can eat] like a whole box of cereal at one time''. ''You be eating double or more'', said another mother." (qualitative, author and participant) [62, page 1839].

However, they also reported that society should also bear a share of the responsibility:

> "The participants discussed that women in their communities do not seem concerned with obesity or weight gain in pregnancy, that they often gain a great deal of weight and do not exercise during pregnancy, and that overweight/obesity has become normalized within their communities." (qualitative, author) [68, page 7.]

Women had a somewhat negative perception of the power that their families exerted over their gestational weight gain, referring to sometimes intrusive comments and feeling like they were being strongly encouraged to eat:

> "Some of the women who discussed the importance of pregnancy weight gain for a healthy infant indicated that their thinking and behaviors were influenced by other people: My significant other, the baby's father, he wants me to gain weight

> because he feels like . . . his baby will be healthy. So he's like, "Eat! And stop complaining about that! Eat it! You're pregnant, what do you expect?"" (qualitative, author and participant) [61, page 802].

However, they contextualized others' comments with the general concern for the health of the baby: *"When you are pregnant I think family pushes you more; they think the fatter you get, the healthier the baby is."* (qualitative, participant) [56, page 943]. Aside from their families, women recognized a number of other influences on their gestational weight gain that were perceived to be non-modifiable, including genetics, age, and socioeconomic factors:

> "The women indicated that heritability was a factor in what happened with weight during and after pregnancy: "Yeah 'cause to me, weight gain is depressing. To me, because genetics doesn't make it any better, you know, I wasn't made to be small anyway, I've always been a hefty, a hefty chick, you know?"" (qualitative, author and participant) [61, page 802].

3.6. Advice received: often inconsistent

Women obtained information and advice from a number of different sources, solicited or not, about how much weight they should gain during pregnancy and about the importance of gestational weight gain:

> "The pregnant women sought out information about weight gain, diet, and health during pregnancy from many sources. Their information sources, other than health-care professionals, included co-workers, friends, magazines (e.g. Tamago Club), Internet sites, and books". (qualitative, author) [55, page 23].

They believed that the role of the family was significant in terms of being a source of information: *"Family members played an important role in providing advice about weight gain during pregnancy in all of the groups"* (qualitative, author) [56, page 943]. This advice was often conflicting and caused confusion, and on occasion the cultural beliefs competed with the medical narrative:

> "The conflicting statements the participants heard from other people led to confusion. The pregnant women were unsure if their weight gain was excessive or not and they were confused about what they should be doing, if anything. Family members and friends encouraged the pregnant women to dismiss the medical advice they received if it entailed the idea that their weight gain was high." (qualitative, author) [67, page 2546].

However, the consistent message was that the health of the baby remained key: *"Another woman referred to her mother: "She [the mother] said I'm getting fatter—she said at least I'm having a big, healthy baby . . . she said that's good.""* (qualitative, author and participant) [61, page 802]. Women often reported not receiving gestational weight gain advice from their healthcare providers, including physicians, midwives and dietitians: *"More than two-thirds of the women participating in this study reported never or rarely receiving advice from a health professional regarding healthy weight gain."* (quantitative, author) [60, page 549]. Further, they assumed that if gestational weight gain was an important topic, their prenatal care providers would raise the issue:

> "It's 'cos my midwife wasn't concerned, she said it wasn't something she was going to check, so in my opinion it's not something that is that important if my midwife doesn't need to check it, 'cos she checks the important things." (qualitative, participant) [58, page 45].

When women did receive advice about gestational weight gain from their healthcare providers, it did not seem very clear or relevant to them, implying a lack of contextual understanding on the part of the healthcare providers.

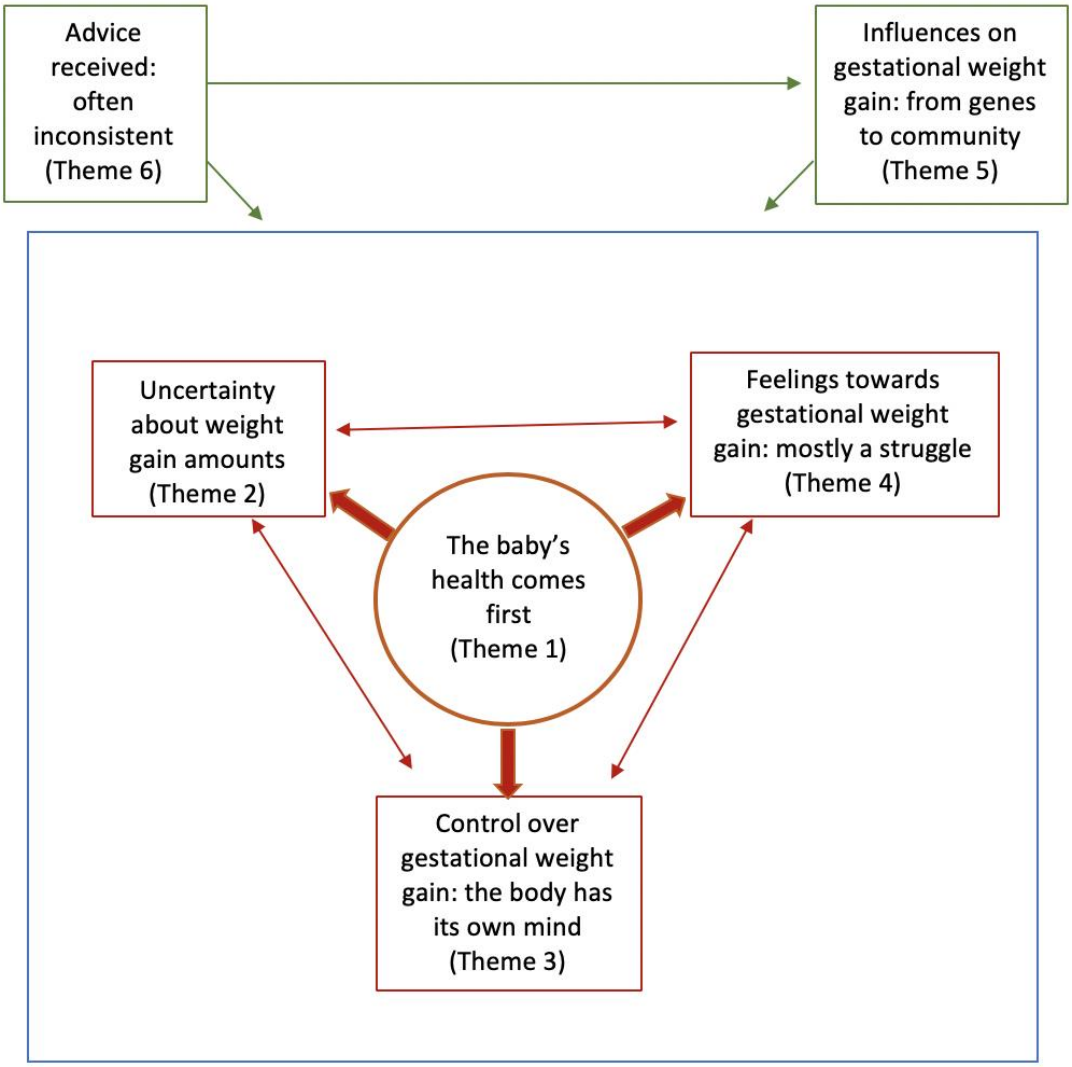
> "I find they [healthcare professionals] do a whole lot of talking about us. How much we gain weight and gestational diabetes and blah, blah, blah. But they never focus any of their care around us and our culture or our communities. So if they want to fix the problems, they need to at least acknowledge our background in order to provide culturally sound care. You know? To where we'll feel comfortable and want to work out and want to feel healthy instead of feeling ostracized." (qualitative, participant) [68, page 8].

4. DISCUSSION

The present systematic review yielded data that were based on 26 good quality studies with a variety of research designs. The six analytical themes that emerged from the thematic synthesis and their interconnections are shown in Figure 2-2, illustrating that women perceive gestational weight gain through a lens that is fundamentally focused on providing a healthy environment for their unborn child: the health of the baby is central. This first, pivotal theme influences women's beliefs about how much weight should be gained during pregnancy and about controlling gestational weight gain, and their feelings regarding gestational weight gain. The factors they perceive to influence gestational

weight gain and the advice they receive related to gestational weight gain are then filtered through this critical lens.

Figure 2-2. Diagrammatic representation of the six analytic themes



Participants in the present systematic review were mostly uncertain about how much weight they should gain during their pregnancies, basing and confirming their estimates around the health of the baby, as shown in the second theme. However, they were unambiguous in fearing that insufficient gestational weight gain was unacceptable as it posed a serious threat to their baby's health, as reflected in their stated ambivalence

towards the gestational weight gain guidelines. This points to the increasingly recognized notion that the relationship between a mother and her child, the maternal-fetal attachment, begins while the child is in utero [75]. Attachment was defined in a seminal study in 1981 as "the extent to which women engage in behaviours that represent an affiliation and interaction with their unborn child" [76 (page 282)]. Specifically: the mother's desire to know her unborn child; the joy she experiences as a result of her interactions with her unborn child; and her desire to protect her unborn child [77]. This last dimension, the desire to protect the unborn child, is a critical element of maternal-fetal attachment, more powerful than the mother's love for the fetus, and serves to promote a favourable intrauterine environment and eliminate threats to the fetus [78].

As described in the third theme, participants in the present systematic review perceived gestational weight gain to be difficult to control. Weight control is perceived to be challenging for the majority of the population, pregnant or not [79,80], and maintaining control of weight changes is even more difficult in pregnancy due to the contributions from maternal tissue, fluid accumulation, the placenta, and the fetus [81].The social determinants of health are also associated with a decreased ability to manage weight in the non-pregnant and pregnant populations [82,83]. It is therefore not surprising that difficulty in controlling gestational weight gain emerged as a theme, as the psychosocial characteristics of the participants in the studies included in the present review included primarily low socioeconomic levels, low educational attainment, and/or ethnic minority status.

A perceived lack of control over gestational weight gain, when combined with the uncertainty about healthy gestational weight gain amounts and a sense of potential threat to the health of the baby, culminated in participants experiencing conflicting feelings towards gestational weight gain, as shown in the fourth theme. While they were accepting of gestational weight gain due to their perception of its positive association with their baby's health, they also found it confusing and a source of worry, a feeling that is common in pregnancy and usually pertains to the baby's health [84]. Worry is at one end of a continuum; if persistent it can lead to stress, a negative emotional state associated with chronic arousal, impaired function, and the potential to progress to clinical anxiety and/or

depression [85]. Stress in pregnancy is thus the state that is reached when a mother perceives that she can no longer cope with a specific source of worry, and is inversely related to socioeconomic status [86,87]. It is likely, considering the participants' psychosocial characteristics as shown in Table 2-5, that they were experiencing some degree of stress rather than just being worried about their baby's health. This is potentially concerning, as prenatal stress is significantly related to mothers' psychological health [86].

Although participants in the present systematic review did not specifically identify stress as a factor that influenced their gestational weight gain, a number of other factors were cited, as described in the fifth theme. While personal health behaviours were recognized as being important, the impact of family members' advice and expectations was also clearly expressed. This theme reflects the findings of previous studies, in which women disclosed the pressure they experienced from family members to gain weight and in some cases even to overeat [88], with specific advice that they should be eating for two [89]. Such influence from family typically reflects cultural beliefs, which are powerful predictors of health behaviors including lifestyle decisions [90]. Participants in the present study did not reject their families' pressures to overeat, perhaps as they perceived their family members' goals to align with their own – protecting the health of the baby. This common goal could be seen as a unifying factor, and it is likely that the women who adopted and embraced their family's cultural beliefs perceived greater social support. During pregnancy, the perception of inadequate social support increases emotional distress, especially among women of low socioeconomic status [91,92]. Conversely, adequate perceived social support has a buffering effect on maternal stress, especially when the social support comes from family and healthcare providers, potentially enhancing maternal-fetal attachment [86,93].

Women in the present systematic review maintained that prenatal care providers do not usually address gestational weight gain and therefore assumed that it was of little concern, as shown in the sixth theme. Further, they divulged that when clinicians actually do address gestational weight gain, the advice that is provided lacks the integration of their context. This is consistent with findings from other work [94,95] , and is an important point

that illustrates a gap in pregnant women's interface with their healthcare providers, who are in a unique position to influence women's perceptions of gestational weight gain [96,97]. Healthcare providers are generally perceived to be credible sources of health information and they could potentially help alleviate women's confusion, worry and distress by having patient-centered discussions about gestational weight gain that included exploring women's experience of gestational weight gain, understanding their contexts such as their cultural beliefs, and thus being able to provide them with meaningful gestational weight gain advice. It is possible that such contextually based discussions could decrease women's experience of stress during pregnancy and enhance their sense of being able to protect their unborn child.

4.1. Implications for Canadian prenatal care

The foregoing themes were revealed in the five Canadian studies included in this systematic review and thematic synthesis. Women reported being uncertain about gestational weight gain amounts [57], they perceived gestational weight gain to be out of their control [67], they had mixed feelings about their weight gain [66], and they perceived a lack of community support [52,68].

4.2. Strengths and limitations

The main strengths of the present systematic review are that the data came from studies of diverse types of designs that were critically appraised using a common lens and then synthesized using an integrated approach that combined the quantitative and qualitative data.

There are also some limitations in the present systematic review. First, although a number of databases were searched, the grey literature was not accessed and therefore some work might have been missed. Second, although a critical appraisal tool was used by two reviewers independently to determine the quality of the studies to be included in the present systematic review, there is nonetheless a degree of subjectivity inherent in this process and the reproducibility could be challenged. Third, the data for the present systematic review originated from a variety of countries and backgrounds. Specifically,

the majority of participants were of low socioeconomic levels, low educational attainment, and/or ethnic minority status. Therefore, the findings of the present systematic review might in some cases not be applicable to other specific patient populations. However, this is the first thematic synthesis to our knowledge that has explored women's perceptions of gestational weight gain through a variety of research designs and with implications for the provision of prenatal care.

5. CONCLUSION

The health of the baby is women's top priority, and they are unsure about the contribution of gestational weight gain due to the conflicting messages that they receive from a number of sources and the lack of advice they obtain from healthcare providers. They experience some degree of gestational weight gain-related stress as a result and could benefit from social support in order to decrease this feeling. Healthcare providers are in a strategic position to provide such support, in particular if they approach discussions about gestational weight gain in a patient-centered manner and help women navigate the interface between the medical narrative and women's own beliefs influenced by their individual proximal and distal contexts.

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CHAPTER THREE

WOMEN'S VIEWS ON ADVICE ABOUT WEIGHT GAIN IN PREGNANCY: A GROUNDED THEORY STUDY

1. INTRODUCTION

Most women experiencing a pregnancy, regardless of their country of origin or their culture, want their babies to be as healthy as possible [1,2], and generally perceive a sense of personal responsibility for the health of their unborn children [3,4]. A factor that contributes to the overall health of a pregnancy is the amount of weight that women gain, and the most recent guidelines for weight gain in pregnancy provide, depending on a woman's pre-pregnancy body mass index (BMI), weekly and total weight gain recommendations [5]. The higher a woman's BMI at conception, the lower the weekly and total weight gain recommendations during the pregnancy. Retrospective and prospective cohort studies have identified a number of adverse outcomes associated with guideline-discordant gestational weight gain for mothers and their offspring, both in the short-term and in the long-term [6-12]. However, fewer than 30% of women in North America gain weight within the ranges recommended in these guidelines, and close to 60% of women gain weight in excess of the recommended amounts [13-15].

As with any other life event, every woman experiences pregnancy within the particularities of her proximal and distal contexts, giving meaning to changes in her body and helping her understand health, disease, and natural processes [16]. There are a number of non-modifiable factors that influence gestational weight gain, such as a woman's age, parity and ethnicity; modifiable factors include awareness of the recommendations for weight gain, health beliefs and health behaviours [17-26]. Research has shown that both women's knowledge of targets for personal gestational weight gain and their awareness of the risks associated with excess gestational weight gain in general are limited, especially among women with a higher pre-pregnancy BMI [27-32].

There is evidence that weight gain advice from a prenatal care provider potentially plays a role, having been shown to be associated with women's gestational weight gain goals and with their actual gestational weight gain [33-40]. However, despite evidence that women want their prenatal care providers to address gestational weight gain, it is unclear whether these health care providers offer such advice, with some studies showing that they regularly do offer gestational weight gain advice and others showing that they do so

infrequently [41-50]. This discrepancy has been specifically demonstrated in the Canadian pregnancy arena, with 95% of prenatal care providers in one study reporting having discussed gestational weight gain with their patients and only a small percentage of patients perceiving that they had such discussions with their prenatal care providers [47]. When women do receive advice from providers, they are often advised to gain too much weight, particularly if they have a high pre-pregnancy BMI [37,39].

The reality for women is that they encounter a number of different messages and opinions about gestational weight gain from a variety of sources that reflect a wide range of cultural beliefs, practices, and values [4,51-54] and that can be conflicting and confusing [4,27,39]. A salient narrative for pregnant women is that they are more concerned about not gaining enough weight during pregnancy rather than about gaining too much, and their worries about the latter are often mitigated by powerful cultural beliefs that strongly favour substantial weight gains [3,27,55,56], with stereotypical phrases such as "eating for two" driving the gestalt. There is therefore uncertainty as to how much women actually value advice from their clinicians, especially when the advice "conflicts with a woman's sense of what is right or what she hears from family members" [57 page 173].

Women's experiences of receiving differing types of gestational weight gain advice are not well understood. The purpose of the present study was thus to help increase our understanding of the processes that influence how women experience the range of advice that they receive about gestational weight gain. As this is a poorly understood area, the use of qualitative methodology is ideal [58].

1.1. Research question

How do pregnant women experience the gestational weight gain advice they receive from healthcare providers and from family, friends, and other sources?

2. METHODOLOGY AND METHODS

2.1. Methodology

As the research question for the present study pertained to understanding processes, we

chose Grounded Theory as a well-suited methodology. Grounded Theory is a qualitative methodology with methods for collecting and analyzing data pertaining to a social process or an action over time in order to "construct theories 'grounded' in the data themselves" [59], [page 2]. With this methodology, the data collection and analysis inform one another in an iterative process of constant comparison as theory is "constructed", as per the constructivist Grounded Theory approach [58]. This approach was taken justified by the stance that "neither observer nor observed come to a scene untouched by the world" [59, page 15] , and acknowledging that the "resulting theory is an interpretation" and that "the theory depends on the researcher's view" [59, page 130].

2.2. Participant recruitment

English-speaking women with healthy singleton pregnancies who were receiving prenatal care in a primary care setting in Halifax, Canada, were invited to participate in the study. Women with an unwelcomed pregnancy were excluded from the study, as they would likely have a less positive frame of mind that could influence their experiences of the entire pregnancy, including the advice they receive about how much weight they should gain. Posters advertising the study were placed in family physicians' offices throughout the city with the principal investigator's work email address for interested women to contact in order to discuss the study. Potential participants then received the consent form for the study by email for their review and were invited to ask any questions. At the time of the interview, informed consent was obtained.

2.3. Ethics Approval

Approval from the Nova Scotia Health Authority Research Ethics Board was obtained (Appendix 3-1).

2.4. Data collection

One-on-one audio-recorded intensive interviews lasting approximately 45 minutes were conducted by the principal investigator. The interviews took place in a private setting at a place and time that suited the participants' personal schedules. Two digital audio recorders were used during the interviews. A semi-structured interview guide (Appendix

3-2) consisting of broad, open-ended, non-judgmental questions and ready probes directed the discussion by asking the participants to reflect on their experiences of receiving gestational weight gain advice from healthcare providers and from family, friends, and other sources. In keeping with a constructivist approach, the interviewer tried to elicit participants' assumptions and implicit meanings, while maintaining constant reflexivity about the nature of their questions and staying alert to interesting leads from the participants in order to generate rich data.

2.5. Qualitative rigour

A number of steps were taken in order to enhance the trustworthiness and credibility of the data. These included taking field notes during the interviews, memo-writing, verbatim transcription of the audio-recordings of the interviews, and individual and team analysis of the data. Further, the interviewer was aware of her assumptions pertaining to the research question and how she related to the participants, in particular as she is a family physician and the participants were all aware of this. This reflexive stance entailed attending to body language, maintaining non-judgemental curiosity and active listening throughout the interviews in order to encourage participants to openly convey their thoughts.

2.6. Data analysis

Audio recordings were transcribed verbatim and constituted the data source. The transcripts were reviewed, and line-by-line coding was undertaken independently by both researchers (Helena Piccinini-Vallis and Judith Belle Brown) who met on multiple occasions to compare and discuss the main concepts and themes that were emerging from the data in an iterative manner. This generated initial provisional codes using gerunds. The researchers tried to ensure that any of their preconceived ideas earned their way into the analysis inductively rather than being superimposed on the data. Maintaining this open and constant comparison approach, focused coding was undertaken to categorize the data. Next, theoretical coding was undertaken, a step in which the relationships between these categories are conceptualized [59]. Next, a second step in the sampling occurred, called theoretical sampling, which clarified the relationships between the categories,

developed the emerging theory, and achieved theoretical saturation [59]. NVivo (version 12) software was used to assist in organizing the data. Finally, diagramming was used to provide a visual representation of the conceptual model findings.

3. FINDINGS

3.1. Description of participants

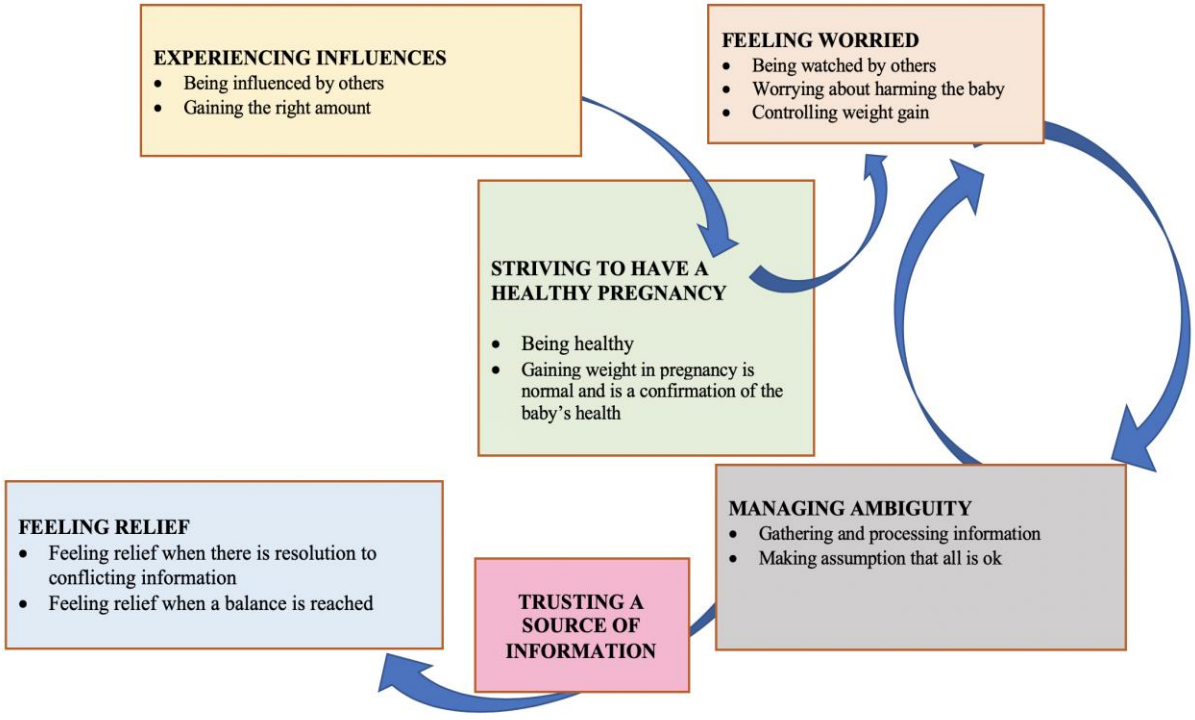
Fifteen women participated in the study: 13 women initially and then two additional women were recruited at the step of theoretical sampling in order to achieve theoretical saturation. The participants were all in a significant relationship (married or common-law) and with one exception were all Caucasian. They were between 27 and 37 years old (mean 31 years), which is in keeping with Nova Scotia provincial data showing that 80% of pregnant women are 20 to 34 years of age [15]. They were all highly educated with a minimum of a bachelor's degree, with four having a graduate and four having professional degrees, compared to approximately 23% of Nova Scotia women having a bachelor's degree or higher education [60]. Some of the participants or their partners worked in the health care industry. In addition, the majority (nine) of these women had a pre-pregnancy BMI in the normal range; one participant had an underweight pre-pregnancy BMI, four had an overweight pre-pregnancy BMI, and one had a pre-pregnancy BMI in the obese range. This also distinguishes them from the approximately 50% of Nova Scotia pregnant women wo have an elevated pre-pregnancy BMI [15]. Importantly, these characteristics set the participants apart from other participants in the qualitative literature on gestational weight gain, who have typically been low income, minority populations with lower educational attainment [3,27,28,39,51-53,55,56,61,62] .

3.2 Themes

Twenty-seven initial codes emerged from the data through line-by-line coding; iterative constant comparison by the two researchers together with theoretical sampling resulted in six final codes. The model that emerged from these data is shown in Figure 2-1. The six interconnected themes were: 1) Striving to have a healthy pregnancy; 2) Experiencing influences; 3) Feeling worried; 4) Managing ambiguity; 5) Trusting a source of

information; and 6) Feeling relief. The anchoring theme (Theme 1) was striving to have a healthy pregnancy, specifically a healthy baby. This striving was impacted by experiencing influences (Theme 2), particularly pertaining to the magnitude of weight gain that was healthy for the baby. This striving was equally interlaced with a sometimes intensely experiencing feeling worried about the health of the unborn child (Theme 3). The confluence of these three themes was addressed by managing ambiguity (Theme 4) and trusting a source of information on gestational weight gain (Theme 5), ultimately leading to feeling relief (Theme 6).

Figure 3-1: How women perceive gestational weight gain advice



3.2.1. Striving to have a healthy pregnancy

At the center of the model was the belief held by all the participants that having a healthy pregnancy was the foundational construct to which they oriented: *"You know, even if you're not a first-time mom, all you think about and all your world revolves around right now is this baby that's growing inside of you."* (Participant 13). This feeling was perhaps heightened for those who had experienced challenges in becoming pregnant: *"So when*

we finally got pregnant, I really wanted to make sure I was doing everything like just right so that I could have the healthiest baby possible." (Participant 5). Some of the women even disclosed that they had pro-actively prepared for their pregnancies in order to optimize its health: *"I started dieting and exercise as soon as I thought that I would be trying to conceive. And then I started the pregnancy with a super healthy weight."* (Participant 8).

Participants believed that gaining weight in pregnancy was normal: *"So obviously you have to gain weight just because there's fetus and fluids and you need some extra fat and all of that stuff. So I guess I just see it as something that happens necessarily."* (Participant 1). This weight gain, especially through healthy eating and some physical activity, had an impact on the health of both mother and baby and could be taken as confirmation of the baby's health:

> "I think I've had a positive experience with pregnancy and weight gain in general. I think I'm fortunate. But it's also been something that I've at least tried to somewhat pay attention to – to eat healthy and stay as active as I can." (Participant 4).

The notion of health was perceived as being about behaviours rather than just numbers on the scale:

> "I think the number on the scale isn't as important as like what I'm putting into my body or how I'm exercising because there are other things in pregnancy that are affected by those things. So I think I've shifted my focus away from the number on the scale to kind of just overall like how is my body feeling during pregnancy, and how can I optimize that?" (Participant 9).

While perceived as a normal and necessary process to promote the baby's health, weight gain nonetheless pose a period of adjustment for some:

> "I think before I was pregnant, as with most women, you tried not to gain weight and you feel like you have your average weight that you've been for a while, and you usually don't want to deviate too much from that. And it was an adjustment at first when I got pregnant to think that it was normal to be gaining weight. I don't think I've been this heavy since, you know, ever. So it's been a big change and adjustment. But I think just reminding myself that it's healthy to be gaining this weight, and normal, and that it's a good thing." (Participant 2).

However, the health of the baby was prioritized, and women prepared for the bodily

challenge they knew they were going to face:

> "I mean it's funny because I've just been thinking about the baby's health. I'm not really thinking about myself as much. But I guess I want to eat healthy so that I can become strong… The idea is like my body is about to go through a marathon. So I want to try to put the right fuel in it, and try to do the proper amount of exercises just to kind of build my strength." (Participant 5).

3.2.2. Experiencing influences

Participants reported a variety of sources that potentially influenced their knowledge and perception of gestational weight gain. Although they were all well-educated, participants had only a vague understanding of how much weight should be gained during pregnancy: *"I guess you want it to be in that Goldilocks happy medium where you're gaining just not too much."* (Participant 15). They were aware of various sources of information about gestational weight gain but stated that they had not received much unsolicited advice:

> "In terms of like informal sources, friends and family haven't really said a lot, other than like commenting…like it's all in my belly or if you look at me from behind, I don't look like I'm pregnant. Like those kinds of comments. But not necessarily like weight gain numbers." (Participant 7).

Families were perceived as being supportive and focusing on health: *"I think within my own family on my side, it's really been much more of a focus on health all the time rather than specific amount of weight gain. And that's kind of the discourse that I've grown up with."* (Participant 3). Co-workers did not spontaneously offer gestational weight gain advice and participants did not expect that they would:

> "I don't think there's anyone in my circle of work community or personal life community that would to my face make comments about whether I'm gaining enough and even in terms of comments about eating and so on. It's a pretty progressive group." (Participant 3).

Similarly, gestational weight gain advice from friends was negligible: *"Sometimes my friends tell me what were their experiences about gaining weight. But other than that, it's like, "Oh, no, you're doing great.""* (Participant 8). The only exception to this was participants' innermost circles – their life partners – who offered supportive comments:

> "I would say that honestly people in my life right now would be more hesitant to try and give any advice on weight gain when you're pregnant. I mean my husband all the time says like that it's healthy…when I'm having body issues with my changing body, he'll just say that I look great and that it's normal, and it's the baby. But that's the only person that's said anything." (Participant 2).

Participants believed that social media provided a very unrealistic portrayal of gestational weight gain and therefore paid little heed to that source of information:

> "Instagram and all of that, it's just so flawed in terms of what's represented and how it's represented versus what the reality is. And so I feel like I'm fortunate in that I'm educated enough that I don't pay a lot of attention to that." (Participant 15).

Participants even had a sense of social irresponsibility in the portrayal of gestational weight gain that they accessed on social media:

> "So I think it's kind of dangerous for young women to see all those pictures of celebrities who are still wearing…you know, who still look exactly the same except they have a little tiny bump on top. But it's not realistic. So those kinds of images probably aren't too helpful for women to see. But that's not the kind of woman I see around me in real life." (Participant 9).

The information participants gained from apps was perceived as being more of entertainment rather than a credible resource about gestational weight gain:

> *"*I enjoy hearing…reading updates throughout the week about how the baby may be progressing. Like, you know, it's likely at this point they have eyebrows. And by this point they're blinking and they can respond to light. And the developmental updates are enjoyable. Different articles or tidbits will come up every day*."* (Participant 10).

Participants reported that their healthcare providers provided them with little if any unsolicited information about gestational weight gain: *"In terms of specific weight-related advice, I haven't really gotten anything. Other than at the doctor's office, they just said, "We have to weigh you at every appointment." But that's pretty much it."* (Participant 11).

3.2.3. Feeling worried

Prior to pregnancy, most of the participants had been health-conscious, active women. Now, during pregnancy, they were at times not confident that they would be able to control their weight gain and wondered if they would be able to reach the minimum target for optimal pregnancy weight gain: *"I've always had trouble gaining weight. So I was concerned. And most women when they get pregnant are concerned about how much they're going to gain. I was concerned I was going to not gain enough for the baby."* (Participant 13). They were surprised that weight gain did not happen as easily as they had anticipated:

> "And so I think as time went on then I felt more concerned. You know, is there going to be a problem that I might not gain enough. Which I never thought would even be an issue. I thought it was just automatic, you just balloon up when you get pregnant. And so there have been times when I've kind of doubted that." (Participant 10).

Participants perceived a sense of little control over how much weight they were gaining and inappropriate weight gain could have been a difficult situation:

> "I don't know what I would have done if I started going way outside of the boundaries though. That's the thing. I mean I'm monitoring it. But then if I was gaining too much, I don't really know how I would have stopped that because I'm not actually eating a ton more." (Participant 4).

They mostly worried, sometimes almost obsessively, that if they gained insufficient weight they could be harming the baby: *"I kept weighing myself like multiple times a day, and like why am I not gaining enough weight, is there something wrong with the baby, is there something wrong?"* (Participant 5).

Participants heard comments about their appearance that, although mostly positive, left them with the sense that their weight gain was being watched by others and for some contributed to their feelings of worry:

> "And people will say things like, "Oh, you look so tiny," or "You look so cute with the baby bump." And so I don't know, it kind of perpetuates this feeling…just because I'm a small person to begin with, people expect that I will stay kind of the same size and just have the belly get bigger." (Participant 9).

Participants remarked that a common and somewhat intriguing comment from others, who were well-meaning, was that they did not look pregnant from behind:

> "I just thought those words were so funny because there could be so many things wrong…so many things going on in our pregnancies that she might not be privy to. But it was that, "You're perfect because you don't look pregnant from behind." (Participant 6).

3.2.4. Managing ambiguity

In order to deal with the uncertainty, worry and the feeling of being watched, participants gathered and processed information. They admitted to comparing themselves to others as an approach to address their concerns related to gestational weight gain:

> "And along with that it's very easy to kind of compare whether they [friends] look like they're getting bigger than I am, or they don't look like they've gained anything at all. And, you know, where I do I fit in with that? And maybe I should look more like that person, or maybe I should look more like that person at this point. It's hard to kind of stop that comparison game." (Participant 10).

Participants undertook their own research on what constituted appropriate gestational weight gain, looking for evidence-based information: *"Mostly has been through my own research. Like looking into what is recommended. Because I do have that research background, I've looked into evidence-based recommendations and things like that."* (Participant 7). They felt confident enough that they would be able to discern credible from less valid information on the subject of gestational weight gain:

> "So I feel like I generally have a decent perception of this is relatively good information, or this is…there's like 18 different ads popping up on this, and where is this coming from? So I feel like I generally have a decent ability to kind of separate what's legit and what's fluff." (Participant 14).

Participants at times solicited information about gestational weight gain from their healthcare providers: *"I was actually the one who brought up my weight gain in around the 25-week mark because I wanted to know if what I was gaining was normal. Because she was like taking my weight but wasn't really saying anything. So I asked."* (Participant 7). They stated that when they questioned their healthcare providers, they were hoping to receive specific advice on how to manage their pregnancy weight gain:

> "I feel like I'm almost craving it 'cause I….after that one doctor said aiming between 25 and 35 is like on the higher standards in his opinion, I feel like I've been asking doctors, like you know can you just give me a little spiel on keeping your weight down in pregnancy. One other doctor did but the others just say just

> follow the recommendations. So I want more information, even though I know, sometimes I just like to be told." (Participant 12).

However, another strategy that participants undertook to deal with the uncertainty and worry they experienced was to just make the assumption that the lack of communication from their healthcare providers about their weight gain meant that it was not a problem:

> "And I haven't really had anyone recoil at my weight during my appointments to my face or say anything in particular. So I can only assume based on their silence that things are at least not really bad. Because that seems to be the way it goes for all pregnancies. So unless like it's missing a limb or something like that, you don't really hear any information. So I'm kind of going with the same logic." (Participant 3).

3.2.5. Trusting a source of information

Even though direct information regarding their gestational weight gain from healthcare professionals was scant, this remained participants' most trusted source of advice. They were aware that most other sources of information explicitly deferred to the advice of a physician: *"The caveat everywhere is always 'but check with your family doctor'. [laughs] So I guess they all kind of have that disclosure clause. Like none of this takes the place of a physician's advice".* (Participant 10).

Further, they trusted their physicians would inform them if there were any concerns: *"I trust my doctors a lot. I really rely on them to indicate to me, this isn't normal, or like I said, no news is good news type thing."* (Participant 13). However, the trust placed on physicians by this educated group of women was challenged if evidence-based information did not agree with the advice by the physician:

> "Because I know what the actual recommendations are, for me it's easy to not remember or pay attention to things that don't necessarily align with that. But I think it could easily happen. That if you're receiving conflicting advice, especially from different sources that you trust for different reasons, that it could be a problem. Especially if it's the recommendations versus what your doctor is telling you. Things like that I could see causing a little bit more anxiety for me than if a friend had said something that I know wasn't what was recommended versus what my doctor had told me." (Participant 7).

Notwithstanding such potentially tense situations, participants' perceptions of their relationship with their physicians ultimately underlined the trust that was so important to them:

> "I believe him and I trust, and I just put my faith and my trust in what he says because I just feel like we have a really…we have a good relationship. I feel like he's a great doctor and that he's not going to lead me down the wrong path." (Participant 5).

3.2.6. Feeling relief

Participants' response to their management of their ambiguity varied. In some instances, they resigned themselves to letting nature take its course:

> "I've kind of turned a corner and now I'm just kind of like what's going to happen is going to happen. My body knows how to produce a baby. It knows how much the baby needs… I'm sure I'll gain as much as I need to. I've kind of become much more like it will all work out." (Participant 5).

For others, the trust they had in their prenatal care providers was the linchpin of their being able to reach a point of feeling relief from their worry about gestational weight gain and its impact on the health of the baby:

> "Given that weight is always…measurements are always taken at all of the appointments, I've kind of taken it as, you know, if anyone was particularly alarmed by it or if there was something I needed to know then I would be told. Based on the interactions and everyone seeming fine and happy enough about how things are progressing, I've kind of assumed again if I'm a little bit above or a little bit below, it's not within any significant margin to be concerned about. So that's how I've interpreted it." (Participant 3).

Regardless, participants reflected on the fact that they perceived themselves to be more anxious and even worried about gestational weight gain than their physicians:

> "In my understanding from things…articles I've read and things I've read, that there are risks associated both with not gaining enough and with gaining too much. And knowing that there is a sweet spot. But feeling worried about not…what if I don't get in that spot, and how do I know for sure? I'm not a doctor. What's normal and what's going to be healthy? And I think when I'm reading articles online or apps, it seems very black and white. And I guess what I'm seeing and having constant check-ups with the family doctor, it's that it's not quite so black and white, and that the healthy range for a healthy baby is bigger

than I would have assumed based on what I read. And that it's much more on my mind than it is on my family physician's mind, is what I'm finding. [laughs]" (Participant 10).

4. DISCUSSION

The present Grounded Theory study resulted in a deeper understanding of women's perceptions of the advice that they receive pertaining to gestational weight gain. Participants were unambiguous in highlighting the foundation of their pregnancy-related beliefs: the health of the baby was their top priority. The impact of gestational weight gain on this focal point was a source of concern, in part due to the nature of the gestational weight gain-related information they came across through friends, family, social media, apps, and sometimes their prenatal care providers. They managed this challenge by searching for gestational weight gain-related information themselves, specifically looking for evidence-based materials. Finding a trusted source of information was key in feeling a sense of resolution.

Participants in the present study were all experiencing a welcomed pregnancy and their greatest wish was to have a healthy baby. This is a ubiquitous finding in the literature that pertains to the bond that forms between a mother and her unborn child, the maternal-fetal attachment [63]. Although there are some inconsistencies, objective measurements of this construct have generally found it to be not significantly related to age, marital status, income, or education [64,65]. It is therefore not surprising that the health of the baby emerged as the central theme for participants in the present study, consistent with the results of a large number of studies [3,4,28,51,56,61,66].

The knowledge of participants regarding appropriate gestational weight gain amounts was lacking. Although they believed that there was a healthy range, they were not sure that they could define the range. This was an interesting finding, as recent work showed that level of educational attainment was positively associated with the knowledge of appropriate gestational weight gain and pre-pregnancy BMI was negatively associated with that knowledge [67]. Considering the high level of educational attainment and the low prevalence of elevated pre-pregnancy BMI of this sample, a higher degree of knowledge pertaining to appropriate gestational weight gain amounts could have been expected.

However, this finding is consistent with recent literature showing that in general, pregnant women's knowledge of how much weight they should gain in pregnancy is low [67-69].

Participants perceived gestational weight gain information found on social media and apps as being unworthy of serious attention and instead a source of entertainment. Although not specifically having addressed gestational weight gain, a qualitative study and a systematic review both showed that pregnant women placed high value on pregnancy-related information they obtained from online resources and social media [70,71]. Similar to the present study, participants in these studies also had higher education, although perhaps not to the same degree. The difference in the results between the present study and these other studies could be due to the passage of at least four years since the data for these studies were collected. In that period of time, our society has landed firmly in the "post-truth" era and people's awareness of the presence of "fake news" has likely increased, perhaps leading to more skepticism in general as to whether online information can be trusted. Importantly, and adding to the existing literature, the highly educated participants in the present study wanted to specifically obtain evidence-based information about gestational weight gain.

A striking difference between the present study and the majority of the related literature is that gestational weight gain-related advice was uncommonly received from family and friends. This could be due to the fact that, in addition to their high level of education, some of the participants or their partners were working in health-related fields, so perhaps family and friends perceived the participants to already hold the relevant knowledge. However, consistent with other work, participants did not receive much information about gestational weight gain from their healthcare providers either. It is difficult to have confidence in interpreting this finding as stemming from healthcare providers' perception that participants already held the relevant knowledge, as a lack of gestational weight gain-related advice is a common finding in studies exploring whether providers discuss gestational weight gain with their patients [43,45,50,72-74]. Nonetheless, participants in the present study trusted their prenatal care providers and translated the lack of information from these clinicians into personal reassurance about the health of the pregnancy and specifically the health of the baby. This is consistent with other work that has included

participants from a variety of socioeconomic levels, illustrating that this strategy is not uncommon [41,66,75-77]. It also illustrates how important the trust that patients have in their physicians is. Trust is a critical element of the physician-patient relationship [78]. This trust is formed by the interconnection of interpersonal trust and social trust, and refers to the patient's belief that the physician's actions are intended to benefit the patient [79]. Interpersonal trust develops over time as patients test the trustworthiness of their physicians' behaviour. In contrast, contextually bound social trust refers to the trust that society has in an institution, such as the collective body of physicians [80]. Social trust frames interpersonal trust [80], so it is perhaps not surprising that the participants in the present study were willing to take a passive stance and assume that "no news is good news", regardless of whether they had accumulated the time necessary to develop a high level of interpersonal trust with their prenatal care providers or not.

However, participants in the present study also demonstrated a level of assertiveness as they sometimes challenged the lack of gestational weight gain-related advice from their prenatal care providers or advice from these clinicians that was inconsistent with evidence-based information. This is interesting considering that interactions between health care providers and patients are typically rooted in a power relationship, with the provider in the superior position and in control of health-related information [81]. This power differential is especially vulnerable to economic and social stratifications; as the participants in the present study were all highly educated and some of them were in the healthcare industry, that may explain why they were assertive and challenged that power.

The reported scarcity of spontaneous advice about gestational weight gain offered by prenatal care providers to this group of pregnant women warrants further discussion. A systematic review showed that physicians gave more medical information to patients in higher socioeconomic status levels [82]. The high socioeconomic status participants in the present study believed that they were not receiving much gestational weight gain-related information from their providers, and according to the literature probably received more advice than their lower socioeconomic status counterparts would have. This finding suggests that prenatal care providers have considerable room to improve the frequency with which they address gestational weight gain and its potential adverse consequences

for mothers and their babies. This would be an important change, as pregnant women want nothing more than to have a healthy baby.

The barriers cited by prenatal care providers in addressing gestational weight gain have been explored and include a perceived threat to the patient–clinician relationship, and a perceived lack of competence, time, and remuneration [83,84]. A tool based on principles of patient-centeredness and behaviour change theory to help address the first two barriers was launched by Obesity Canada in 2014: The 5As of Healthy Pregnancy Weight Gain [85]. Following this, a pilot randomized controlled trial was undertaken to evaluate gestational weight gain for pregnant women whose providers were either trained in the use of this tool or who delivered usual care [86]. The results showed no difference in gestational weight gain between the two groups and future work is necessary to further explore this area.

4.1 Strengths and limitations

The present study employed a number of techniques to increase the credibility of the findings. There was a consistent approach to the interviews, as all fifteen participants were interviewed with the use of open-ended questions by the principal investigator. Line-by-line coding, iterative constant comparison, and theoretical sampling were undertaken by both authors to generate the final themes. However, three limitations are: 1) member checking did not take place to confirm that the model fit the participants' experience of the advice they receive pertaining to gestational weight gain; 2) participants' parity and gestational age were not considered in this study, and such contextual information could be important in the interpretation of the findings, a potential consideration for future studies; and finally 3) the participants in this study were all highly educated and this could be perceived as a limitation, but in fact this population has not been well studied. To the best of the authors' knowledge, this is the first qualitative study with highly educated participants exploring the advice that women receive about gestational weight gain.

5. CONCLUSION

Similar to the results of previous studies, the participants in the present study placed the health of their babies as their top priority. They generally had a low level of knowledge about how much weight they should gain in pregnancy and received little advice from their healthcare providers regarding gestational weight gain. They trusted their healthcare providers and assumed that no news was good news. In contrast to the results of previous studies, the participants in the present study received little if any advice about gestational weight gain from their families and friends, and they were particularly interested in obtaining evidence-based information about gestational weight gain either from their healthcare providers or from other trustworthy sources.

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APPENDICES

Appendix 3-1: Research Ethics Board Approval

Nova Scotia Health Authority Research Ethics Board
Centre for Clinical Research, Room 118
5790 University Avenue
Halifax, Nova Scotia, Canada B3H 1V7

September 28, 2018
Dr. Helena Piccinini-Vallis
Medicine\Family Medicine
Dalhousie Family Medicine Mumford Professional Centre
6960 Mumford Road, Suite 0265
Halifax NS B3L 4P1

Delegated Review
Full Approval Letter
(September 28, 2018 to September 28, 2019)

Dear Dr. Piccinini-Vallis:
RE: Women's views on advice about weight gain in pregnancy
NSHA REB ROMEO File #: 1023844

Thank you for your response regarding your proposed study.

Document Name	Comments	Version Date
Research Protocol	Version #2	2018/09/27
Consent Form	Version #2	2018/09/27
Investigator Response/Revisions	PI responses to initial letter	2018/09/27

I have reviewed these documents on behalf of the Research Ethics Board (REB) and note that all requested changes have been incorporated.

I am now pleased to confirm the Board's full approval for this research study, effective today. This includes approval / favorable opinion for the following study documents:

Document Name	Comments	Version Date
Curriculum Vitae (CV)	PI's CV	2018/08/22
Certificate of Completion TCPS 2: CORE	PI's TCPS 2	2013/08/26
Supporting Materials	Ad for participants - V1	2018/08/22
Supporting Materials	Interview guide - V1	2018/08/22
Letter of Support	Dept Head support letter	2018/08/23

Researcher's Checklist for Submission	Checklist	2018/08/22
Research Protocol	Version #2	2018/09/27
Consent Form	Version #2	2018/09/27
Investigator Response/Revisions	PI responses to initial letter	2018/09/27

Continuing Review

1. The Board's approval for this study will expire one year from the date of this letter **(September 28, 2019).** To ensure continuing approval, submit a Request for Annual Approval to the Board 2-4 weeks prior to this date. If approval is not renewed prior to the anniversary date, the Board will close your file and you must cease all study activities immediately. To reactivate a study, you must submit a new Initial Submission (together with the usual fee) to the REB and await notice of re-approval.
2. Please be sure to notify the Board of any:
* Proposed changes to the initial submission (i.e., new or amended study documents or supporting materials),
* Additional information to be provided to study participants,
* Material designed for advertisement or publication with a view to attracting participants,
* Serious unexpected adverse reactions experienced by local participants,
* Unanticipated problems involving risks to participants or others,
* Sponsor-provided safety information,
* Additional compensation available to participants,
* Upcoming audits /inspections by a sponsor or regulatory authority,
* Premature termination / closure of the study (within 90 days of the event).
3. Approved studies may be subject to internal audit. Should your research be selected for audit, the Board will advise you and indicate any other requests at that time.

Important Instructions and Reminders

1. Submit all correspondence to Ethics Coordinator, Starla Burns at the address listed at the top of this letter (do not send your response to the REB Chair or Co-Chair).
2. Login to the Research Portal; click Applications (Post Review), browse through files to locate the study in which you wish to make revisions to; click the Events Button and choose the type of revision you wish to make from the table provided; complete the electronic form and attach document under the attachments tab if required and Click on the Submit button.
3. Be sure to reference the Board's assigned file number, Romeo No. 1023844, on all communications.
4. Highlight all changes on revised documents, and remember to update version numbers and/or dates.

Best wishes for a successful study.
Yours very truly,

Sue Pleasance, RN
Co-Chair, NSHA Research Ethics Board

This statement is in lieu of Health Canada's Research Ethics Board Attestation:
The Research Ethics Board for the Nova Scotia Health Authority operates in accordance with:
- Food and Drug Regulations, Division 5 "Drugs for Clinical Trials Involving Human Subjects"
- Natural Health Products Regulations, Part 4 "Clinical Trials Involving Human Subjects"
- Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2)
- ICH Good Clinical Practice: Consolidated Guideline (ICH-E6)

cc: Lisa Underwood, Director, Research Services

Appendix 3-2: Semi-Structured Interview Guide

I: Welcome and Instructions to Participant

Thank you again for taking the time to participate in this interview. The purpose of this interview is to help me explore what you think about the advice that you have received about how much weight you should gain during your pregnancy.

This interview will take about 1 hour. There are no right or wrong answers. As a reminder, I will be audio taping this session, but your name will not be connected to the recording – I will give a number to your file.

Do you have any questions about the study? If not, I will begin recording.

II: Introductory Questions

To begin with, let me ask you:

- How important do you think weight gain in pregnancy is for your health while you go through your pregnancy? *Probe: Why is that?*
- How do you think that the weight you gain in pregnancy affects your health?
- How important do you think weight gain in pregnancy is for your baby's health? *Probe: Why is that?*
- How do you think that the weight you gain in pregnancy affects your baby's health?

III: Guiding Questions for Discussion

We get information from so many different sources - friends, family, neighbours, co-workers, books, social media, prenatal classes, Internet etc. I would like to talk about all those sources from which you might have received information about how much weight you should gain during your pregnancy.

- Tell me about the sort of advice you would like to receive about how much weight you should gain during your pregnancy.
- Tell me about the sort of advice you have received about how much weight you should gain during your pregnancy. *Probe for information regarding advice from family physician or another clinician if it is not spontaneously mentioned.*
- What were the sources from which you received advice about weight gain in pregnancy? *Probe: What did each source tell you about how much weight you should gain (and did they explain to you why)?*
- What did you think of that advice? *Probe: What made you decide to follow or not to follow or believe that advice? What kinds of difficulty did you come up against with your decision?*

Some women come from families or communities that have strong ideas about what is good for your health and the baby's health during pregnancy. I am interested in hearing about whether that is the case for you.

- Tell me about your family's/community's ideas or beliefs about weight gain in pregnancy.
- How do those beliefs agree with the information about weight gain in pregnancy that you obtained from other sources?
- What do you think that people who give you advice about how much weight you should gain during your pregnancy should know? *Probe: Why is that?*

IV: Conclusion

Is there anything else that you would like to share with me? If not, thank you very much for taking the time to participate in this study. Your comments on the advice that women receive about weight gain in pregnancy are very valuable to this work.

CHAPTER FOUR

THE ASSOCIATION BETWEEN WOMEN'S GESTATIONAL WEIGHT GAIN CONCORDANCE WITH GUIDELINES AND THEIR CHILDREN'S BODY MASS INDEX TRAJECTORIES

1. INTRODUCTION

The current recommendations for gestational weight gain (GWG) were published by the Institute of Medicine in 2009 [1] and adopted by Health Canada in 2010 [2]. The recommendations are based on the 2000 World Health Organization (WHO) body mass index (BMI) categories that were derived from the association of BMI with mortality [3]. The WHO classification system stratifies BMI into underweight (BMI < 18.5), normal weight (BMI 18.5 - < 25.0), overweight (BMI 25.0 - < 30.0) and obese (BMI ≥ 30.0). Within the highest category, BMI is further stratified into Class I (BMI 30.0 - < 35.0), Class II (BMI 35.0 - < 40.0), and Class III (BMI ≥ 40.0). For women with singleton pregnancies, these most recent guidelines provide, depending on a woman's pre-pregnancy BMI, weekly and total weight gain recommendations, the latter assuming a term pregnancy (i.e. pregnancy duration 37 to 41 weeks' gestation). The higher a woman's pre-pregnancy BMI, the less weight gain is recommended during the pregnancy.

Retrospective and prospective cohort studies identified a number of adverse short-term and long-term outcomes associated with excess GWG for mothers and their offspring [4-35]. In addition, retrospective cohort studies, systematic reviews and meta-analyses demonstrated that children at various specific ages whose mothers experienced excess GWG were at greater risk of having obesity than children whose mothers' GWG was concordant with the guidelines [36-49]. A recent meta-analysis exploring the association between excess GWG and childhood obesity showed a pooled odds ratio of 1.38 [50]. There is controversy, however, as to whether and how the relationship between excess GWG and childhood obesity is modified by the mother's pre-pregnancy BMI [51-53] , and whether insufficient GWG is also implicated in this risk [54].

Childhood obesity has increased in prevalence worldwide, leading the WHO to declare it in 2015 "one of the most serious public health challenges of the 21st century"[55], due to its association with an increased risk of cardiovascular, endocrine, psychosocial and musculoskeletal complications, many of which are sustained into adulthood [56-58]. In addition, obesity in children is associated with excess weight in adulthood [59-62].

The majority of women in North America gain weight in excess of the current guidelines [17,63-65]. Recent work from New Zealand, Australia, and the USA revealed excess GWG in as many as 60% to 70% of pregnant women [27,29]. Therefore, a large proportion of pregnant women are at risk of complications and their children are at risk of having obesity. In Canada, it is estimated that 21.5% of children aged two to five years have overweight (15.2%) or obesity (6.3%) [66]. In Nova Scotia, approximately 58 % of women gain excess weight during pregnancy [67,68] and approximately 15% of children in grade 3 have obesity [69].

To date, much of the work exploring the relationship between the guideline concordance of mothers' GWG and their children's BMI has only offered a cross-sectional view of childhood weight status. The present study aimed to obtain a clearer longitudinal understanding of this relationship using prenatal (maternal) and postnatal (child) primary care data in Nova Scotia.

1.1. Research question

Do mothers with total GWG at term that is above, within, or below guidelines [1] recommended for their specific pre-pregnancy BMI deliver offspring whose BMIs are different over time (i.e. measured monthly multiple times up to approximately 5 years of age), controlling for maternal age, parity, smoking, pre-pregnancy BMI, socioeconomic status (SES) quintile, and the child's sex?

1.2. Hypothesis

Based on the literature cited in this chapter's introduction, the hypothesis was that children whose mothers gained weight above the GWG guidelines would have higher BMI trajectories than children whose mothers gained within the recommended amounts and children whose mothers experienced insufficient GWG.

2. METHODS

Ethics approval was obtained from the Nova Scotia Health Authority Research Ethics Board (Appendix 4-1).

2.1. Design

This was a retrospective cohort study using longitudinal data collected over the period starting from the mother's last prenatal visit and ending in the child's last visit up to approximately 5 years of age.

2.2 Setting and Sources of Data

This study took place in the Dalhousie Family Medicine clinics in Halifax, Nova Scotia, Canada. These teaching clinics are affiliated with the Department of Family Medicine at Dalhousie University and provide interdisciplinary care for patients, including prenatal care for approximately 100 women per year. There were two sources of data for this study. First, pregnancy data stored in the Dalhousie Family Medicine electronic medical record in a Smartform (the Nova Scotia Prenatal Record), were obtained for women who received prenatal care at the DFM clinics. Second, children's data stored in the Dalhousie Family Medicine electronic medical record in a different Smartform (the Rourke Baby Record), were obtained for the children who attended well child visits at the Dalhousie Family Medicine clinics. These data were extracted from the two Smartforms and exported into two electronic spreadsheets.

2.3. Participants

Women with singleton pregnancies who received prenatal care at the Dalhousie Family Medicine clinics between January 1, 2010 and December 31, 2017, and the liveborn children from these pregnancies were included in the study. For women who had more than one child within this time frame, only data pertaining to the earliest eligible pregnancy were used.

2.4. Exclusion criteria

The following were the exclusion criteria for the study:

1. Women who did not have recorded evidence, specifically a weight measurement, of having delivered at term (i.e. 37 to 41 weeks' gestation [70]) were excluded from the study.

2. Women for whom determination of pre-pregnancy BMI was not possible were excluded from the study. Determination of pre-pregnancy BMI required either a recorded entry for pre-pregnancy BMI in the chart, or the ability to calculate that variable using pre-pregnancy weight and height.
3. Women less than 18 years of age were excluded, because the 2009 Institute of Medicine guidelines for GWG rely on the WHO BMI categories, which pertain only to adults 18 years of age and older.
4. Children with less than three BMI measurements were excluded from the study. Although recent literature indicates that one or more data points per participant is sufficient [71-74], earlier work assumed a more standard approach of including only participants with at least three data points [75,76], and this more conservative approach was used.

2.5. Variables for the study

The following were the variables for the study, described in more detail in Appendix 4-2.

1. Outcome variable: child BMI, repeated over time (months of age).
2. Main independent variable: GWG concordance with the guidelines ("GWG concordance"). Although the WHO defines a "term pregnancy" as being "From 37 completed weeks to less than 42 completed weeks (259 to 293 days) of gestation" [70], recent evidence suggests that this is not a homogeneous time period but rather represents a biologic continuum [77,78] . Therefore, the GWG concordance for the women in this study was adjusted based on the last gestational age (within the range of 37 to 41 completed weeks) recorded in the prenatal record. This was accomplished by assuming GWG concordance to reflect the minimum and maximum amounts based on pre-pregnancy BMI category that are recommended in the guidelines at 40 weeks' gestation, as shown in Table 4-1.

Table 4-1. 2009 Institute of Medicine guidelines for GWG [1]

Pre-pregnancy BMI category (kg/m^2)	**Total weight gain at 40 week's gestation (kg)**	**Weekly minimum and maximum weight gain (kg)**
< 18.5	12.5 – 18.0	0.44 – 0.58
18.5 - < 25.0	11.5 – 16.0	0.35 – 0.50
25.0 - < 30.0	7.0 – 11.5	0.23 – 0.33
≥ 30.0	5.0 – 9.0	0.17 – 0.27

For every week under or over 40 weeks' gestation, the weekly minimum and maximum amounts based on pre-pregnancy BMI category were then subtracted from or added to the target amounts for 40 weeks' gestation, as shown in Table 4-2.

Table 4-2. Adjustment of GWG concordance with the 2009 Institute of Medicine guidelines for GWG by pre-pregnancy BMI category and weeks' gestation

GWG concordance with the guidelines	Pre-pregnancy BMI category (kg/m^2)	Guideline recommendations for GWG (kg) by weeks' gestation				
		37 weeks' gestation	38 weeks' gestation	39 weeks' gestation	40 weeks' gestation	41 weeks' gestation
Above the guidelines	< 18.5	> 16.26	> 16.84	> 17.42	> 18.0	> 18.58
	18.5 - < 25.0	> 14.5	> 15.0	> 15.5	> 16.0	> 16.5
	25.0 - < 30.0	> 10.51	> 10.84	> 11.17	> 11.5	> 11.83
	≥ 30.0	> 8.19	> 8.46	> 8.73	> 9.0	> 9.27

Within the guidelines	< 18.5	11.18 ≤ GWG ≤ 16.26	11.62 ≤ GWG ≤ 16.84	12.06 ≤ GWG ≤ 17.42	12.5 ≤ GWG ≤ 18.0	12.94 ≤ GWG ≤ 18.58
	18.5 - < 25.0	10.45 ≤ GWG ≤ 14.5	10.8 ≤ GWG ≤ 15.0	11.15 ≤ GWG ≤ 15.5	11.5 ≤ GWG ≤ 16.0	11.85 ≤ GWG ≤ 16.5
	25.0 - < 30.0	6.31 ≤ GWG ≤ 10.51	6.54 ≤ GWG ≤ 10.84	6.77 ≤ GWG ≤ 11.17	7.0 ≤ GWG ≤ 11.5	7.23 ≤ GWG ≤ 11.83
	≥ 30.0	4.49 ≤ GWG ≤ 8.19	4.66 ≤ GWG ≤ 8.46	4.83 ≤ GWG ≤ 8.73	5.0 ≤ GWG ≤ 9.0	5.17 ≤ GWG ≤ 9.27
Below the guidelines	< 18.5	< 11.18	< 11.62	< 12.06	< 12.5	< 12.94
	18.5 - < 25.0	< 10.45	< 10.8	< 11.15	< 11.5	< 11.85
	25.0 - < 30.0	< 6.31	< 6.54	< 6.77	< 7.0	< 7.23
	≥ 30.0	< 4.49	< 4.66	< 4.83	< 5.0	< 5.17

3. Other independent variables: maternal age, parity, smoking, pre-pregnancy BMI, SES quintile and child sex (see Appendix 4-2 for details).

2.6. Data linkage between women and their children

In order to conduct the study, data pertaining to women who received prenatal care had to be linked to their children's data, thus identifying dyads of mothers and children. Data for the mothers and children were initially contained in separate Excel documents, and a

deterministic linkage approach [79], by which an exact match is required, was taken to link women to their specific children using the telephone number recorded in the women's and the children's records. The accuracy of this linkage approach had been examined in a preliminary study by Dr. Piccinini-Vallis using the DFM electronic medical record, showing a sensitivity of 84% and a specificity of 100% (see Appendix 4-3).

2.7. Sample size calculation

Studies using multilevel modeling as a statistical approach do not typically require a sample size calculation as a sample of 50 participants in the second level (in this case 50 children) has been shown to be sufficient [80]. However, others in the field suggest that statistical power is an evolving area in multilevel modeling [81], and therefore a more conservative approach was taken for the present study.

In a recent retrospective cohort study [82], the mean BMI at 4 years for 269 children who had a higher birth size was 18.1 kg/m^2 (SD = 1.7); in comparison, the mean BMI at 4 years for 287 children with a lower birth size was 14.7 kg/m^2 (SD = 1.0). Based on this large effect size and setting alpha (two-sided) at 0.05 and beta at 0.10, the number of children required in each of the three groups in the present study would be 23 [83]. However, as the proportion of women in Nova Scotia who gained weight below (17.8%), within (26.9%), and above (55.3%) the guidelines in 2014 [84] is not evenly distributed (i.e. not 33.3% in each group), a conservative sample size approach for the present study was decided to be 23 children born to mothers within the first group (in order to maintain the minimum required number of children per group), 35 children born to mothers in the second group, and 71 children born to mothers in the third group, for a total of 129 children.

3. ANALYSIS PLAN

STATA (version 15) [85] was used to conduct all analyses and p-values less than 0.05 were considered significant.

3.1. Missing data analysis

Variables with ≥ 5% missing data were examined to ascertain whether the data were missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR) [86(page 96)]. This was undertaken by a couple of steps. First, dummy variables were created for each independent variable that had missing values (i.e. parity, smoking and SES quintile) with "0" denoting a missing value and "1" denoting an existing value. Second, t-tests and Chi-square tests were undertaken to explore whether there were any significant relationships among these independent variables, and the absence of significant relationships would indicate whether the missing data were ignorable or not.

3.2. Descriptive analyses

Frequency distributions and means and standard deviations were calculated for the independent variables: GWG concordance, maternal age, parity, smoking, pre-pregnancy BMI (and pre-pregnancy BMI category), SES quintile, and child sex.

3.3. Bivariate analyses

In order to compare the baseline characteristics of the main independent variable, GWG concordance, the variable's three categories were examined to determine whether they differed by the other independent variables: maternal age, parity, smoking, pre-pregnancy BMI, SES quintile, or child sex.

3.4. Multivariable analysis

Mixed-effects multilevel regression was employed in this study. This is a statistical approach that has developed across a number of different fields [75,87-90]. It can accommodate participants with repeated observations that are unequally spaced, as is the case for this study's dependent variable, the children's repeated BMI measurements [91]. Data can be structured in at least two levels, allowing for nesting that is necessary in cases in which independence between measurements for a participant cannot be assumed [92,93]. In the case of the present study, the independence between repeated BMI measurements for a given child cannot be assumed. The goal of this analysis was to determine the BMI trajectories for children born to mothers with total GWG that was

above, within, or below guidelines [1] recommended for their specific pre-pregnancy BMI, and to then control for maternal age, parity, smoking, pre-pregnancy BMI, socioeconomic status (SES) quintile, and the child's sex.

The data were transformed from the multivariate ("wide") format to the univariate ("long") format, in which each row contained a BMI measurement at a specific time point for a child, and each child had at least three rows. The lowest level of the hierarchy in the present study was child BMI, repeated over time. The number of days of age was converted to age in months by dividing the number of days by 30. Plots were drawn to depict the data, first overall and then by GWG concordance.

A number of models were examined to find the one that best fit the data. First, an unconditional model with random intercepts and fixed slopes, followed by an unconditional model with random intercepts and random slopes, was used for a linear time distribution. Second, a quadratic time distribution term was entered into the model, first with random intercepts and fixed slopes, and then with random intercepts and random slopes. Third, a cubic time distribution term was entered into the model with the same approach as above. These models were compared using likelihood ratio tests, which "provide a measure of the fit of two competing models" [94, page 791], and the best model was used in the following steps, which were to a) explore the effect of adding GWG concordance to the model and b) examine the effect of adding the interaction between GWG concordance and time to the model. These last two resulting models were then also compared using likelihood ratio test.

The contribution of the other covariates (maternal age, parity, smoking, pre-pregnancy BMI, SES quintile and child sex) to the unexplained variance was examined by adding them simultaneously to the model that had best fit the data. Finally, the mean child BMI at each month was compared among the three groups of GWG concordance.

4. RESULTS

The DFM database search identified 1034 Nova Scotia Prenatal Records and 1218 Rourke Baby Records for the time period specified (January 1, 2010 to December 31,

2017). Nova Scotia Prenatal Records that were not associated with a phone number, or that contained no data (e.g. were created for teaching demonstration purposes only), or that did not contain data pertaining to a prenatal visit at or after 37 weeks' gestation were deleted (n = 433). Similarly, Rourke Baby Records that were not associated with a phone number or that contained no data were deleted (n = 161). Thus, 601 Nova Scotia Prenatal Records and 1057 Rourke Baby Records remained.

Deterministic linkage of the mothers' and children's records by phone number resulted in 349 matches. Several of these phone matches (n = 98) were associated with either more than one Nova Scotia Prenatal Record and/or more than one Rourke Baby Record. For each of these matches with multiple records, the earliest match was selected, resulting in 349 phone matches that now consisted of only one Nova Scotia Prenatal Record and one Rourke Baby Record.

Mothers' data were examined more closely to reveal that 12 prenatal records had to be deleted because pre-pregnancy weight and/or height were not available. Similarly, examination of children's data showed that 33 children had less than three data points and were thus deleted. This resulted in a final sample of 304 unique mother-child matches meeting all the inclusion and exclusion criteria for the present study.

Only three independent variables had missing data, i.e. parity (12.17%), smoking (4.61%), and SES quintile (0.66%). Parity was therefore the only variable that had a percentage ($\geq$ 5%) of missing data requiring closer examination [86 (page 96)] to ascertain whether the missingness was MCAR, MAR, or MNAR. T-tests and Chi-square (χ^2) analyses showed no significant association between parity and any of the other independent variables (see Appendix 4-4).

The mean age for women in this study was 29.3 (SD = 5.1) years, with 79.9% being 20 to 34 years old. the mean pre-pregnancy BMI was 26.2 (SD = 6.2) kg/m^2, the mean GWG was 14.5 (SD = 6.3) kg, and the mean birthweight was 3508 (SD = 482) g. Table 4-3 shows the frequency distributions for GWG concordance, parity, smoking, pre-pregnancy BMI category, SES quintile, and child sex. These results were in keeping with available descriptive statistics pertaining to the population of pregnant women in Nova Scotia [84], as

shown in Appendix 4-5.

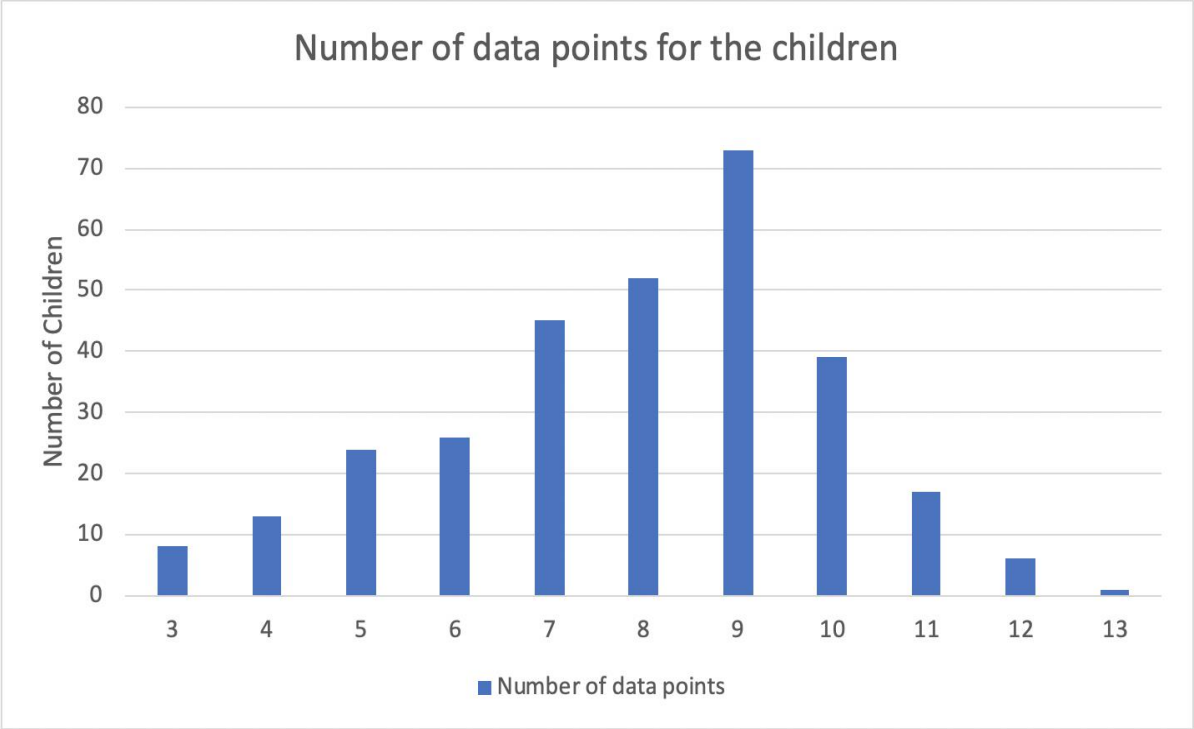
Table 4-3: Frequencies for categorical independent variables.

Variable	n (%)
GWG concordance	
Below	47 (15.5)
Within	91 (29.9)
Above	166 (54.6)
Total	304 (100)
Parity	
0	162 (53.3)
1	77 (25.3)
≥ 2	28 (9.2)
Total	267 (87.8)
Missing	37 (12.2)
Smoking	
Yes	31 (10.2)
No	259 (85.2)
Total	290 (95.4)
Missing	14 (4.6)

Pre-pregnancy BMI category	
< 18.5 kg/m^2	7 (2.3)
18.5 - < 25.0 kg/m^2	153 (50.3)
25.0 - < 30.0 kg/m^2	83 (27.3)
≥ 30.0 kg/m^2	61 (20.1)
Total	304 (100)
SES quintile	
1	37 (12.2)
2	12 (3.9)
3	101 (33.2)
4	82 (27.0)
5	70 (23.0)
Total	302 (99.3)
Missing	2 (0.7)
Child sex	
Male	158 (52.0)
Female	146 (48.0)
Total	304 (100)
Missing	0

The total number of data points (BMI measurements) was 2402. The number of data points per child ranged from three to 13, and the modal number was nine, as shown in Figure 4-1. This shows that the children had an adequate number of data points.

Figure 4-1: Number of data points for children in the sample.



The main independent variable, GWG concordance, was examined and did not differ significantly by maternal age, parity, smoking, SES quintile, or child sex. There was however a significant difference in GWG concordance by pre-pregnancy BMI category ($\chi^2(6) = 17.13$, $p = 0.009$); notably, 66.3% of women with pre-pregnancy BMI 25.0 - < 30.0 experienced excess GWG. Further, women who experienced GWG below the guidelines had a significantly lower pre-pregnancy BMI than both women who experience guideline concordant GWG ($p = 0.022$) and women who gained excess GWG ($p = 0.000$).

The observed BMI trajectories for the entire sample of children and the observed children's BMI trajectories for each value of mothers' GWG concordance are shown in Figure 4-2.

Figure 4-2: Child BMI trajectories.

BMI trajectories for all children:

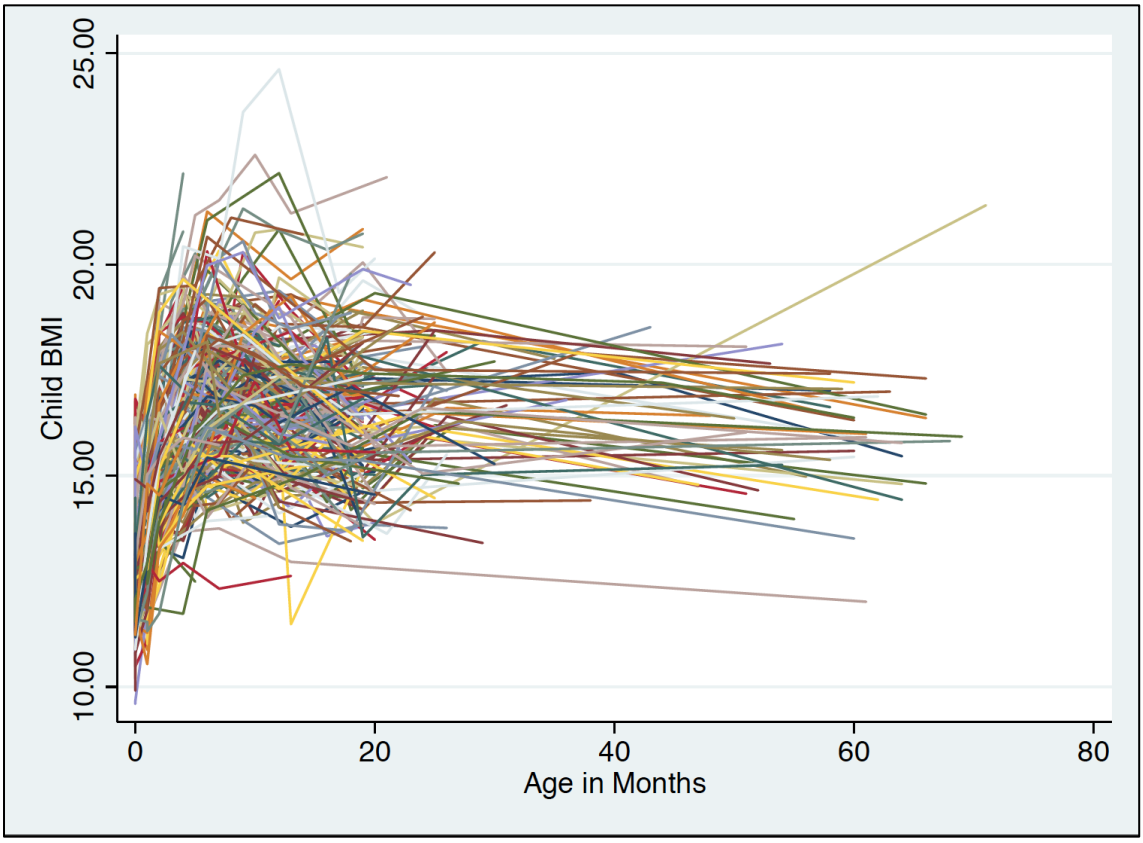


Figure 4-2: Child BMI trajectories (continued).

BMI trajectories for children of mothers with GWG below the 2009 Institute of Medicine guidelines for GWG:

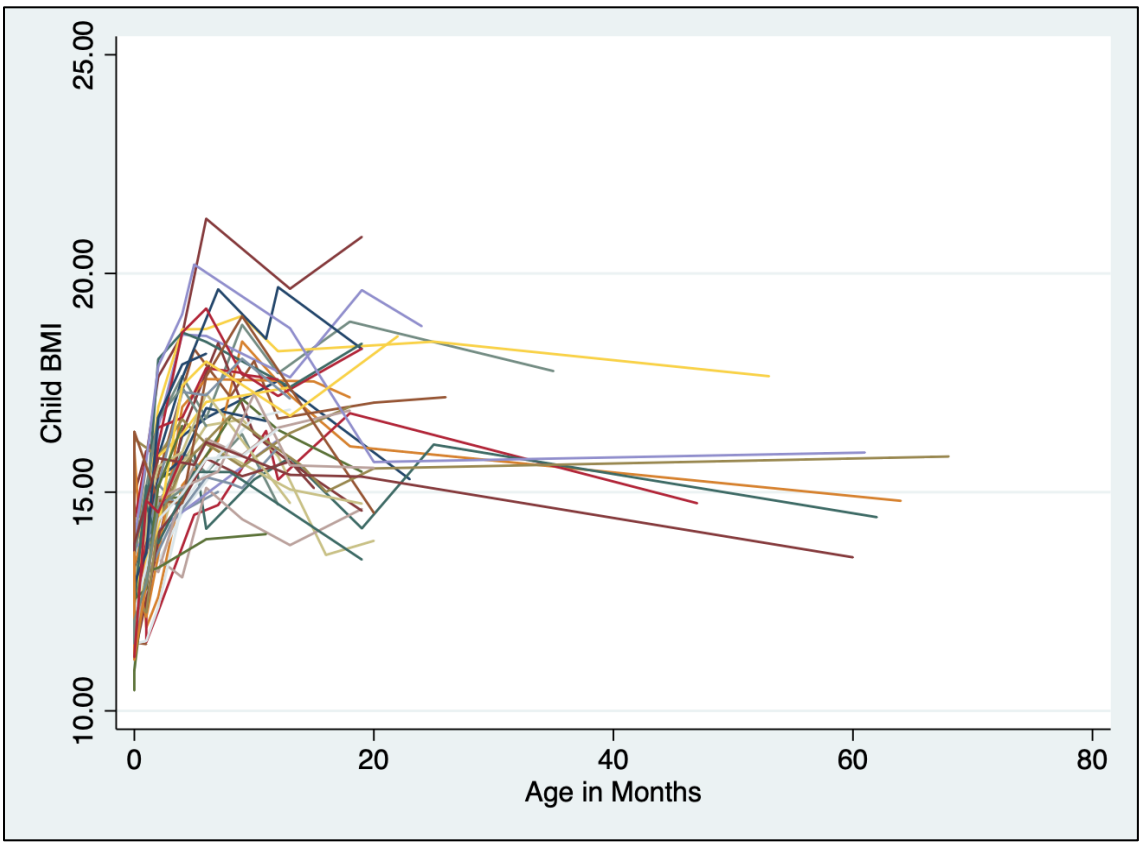


Figure 4-2: Child BMI trajectories (continued).

BMI trajectories for children of mothers with GWG within the 2009 Institute of Medicine guidelines for GWG:

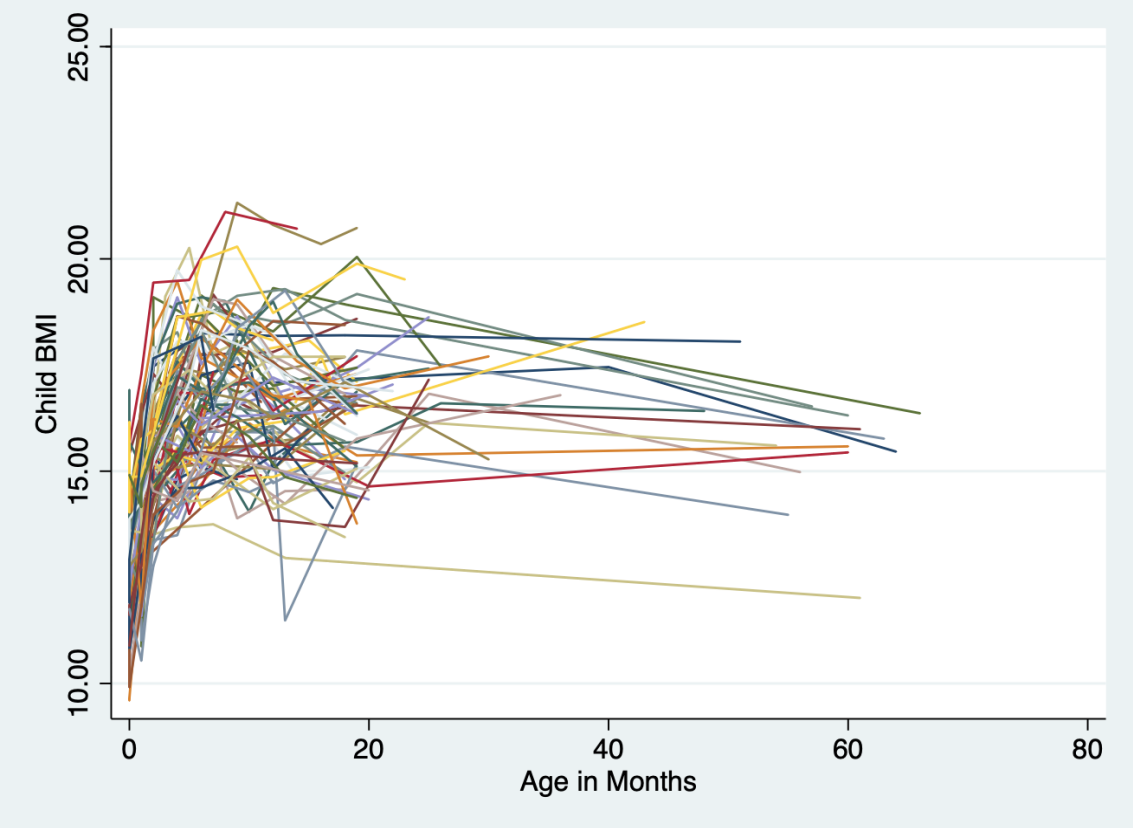
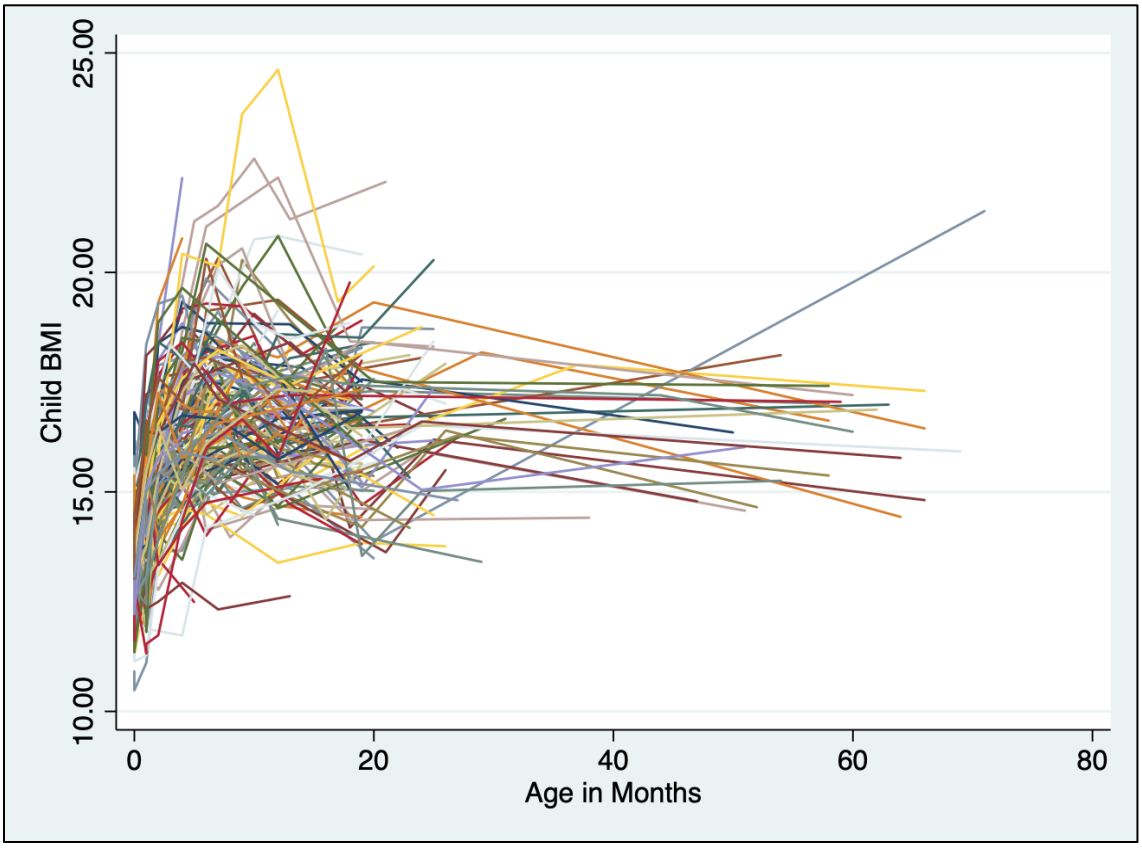


Figure 4-2: Child BMI trajectories (continued).

BMI trajectories for children of mothers with GWG above the 2009 Institute of Medicine guidelines for GWG:



The differences among the BMI trajectories for these groups were then tested statistically. The first step was to fit a model to the data. Appendix 4-6 shows the progression of models that were examined to find the one that best fit the data. Using likelihood ratio test, a mixed model with linear time distribution (MO) and random intercepts and slopes was shown to be a better fit for the data than a linear time distribution model with random intercepts and fixed slopes ($\chi^2(1) = 182.68$; $p = 0.000$). This model (with random intercepts and random slopes) was improved by the addition of a quadratic term for time distribution (MOSQ) for the random intercepts ($\chi^2(1) = 514.38$; $p = 0.000$), which in turn was improved by the addition of a quadratic term for time distribution for the random

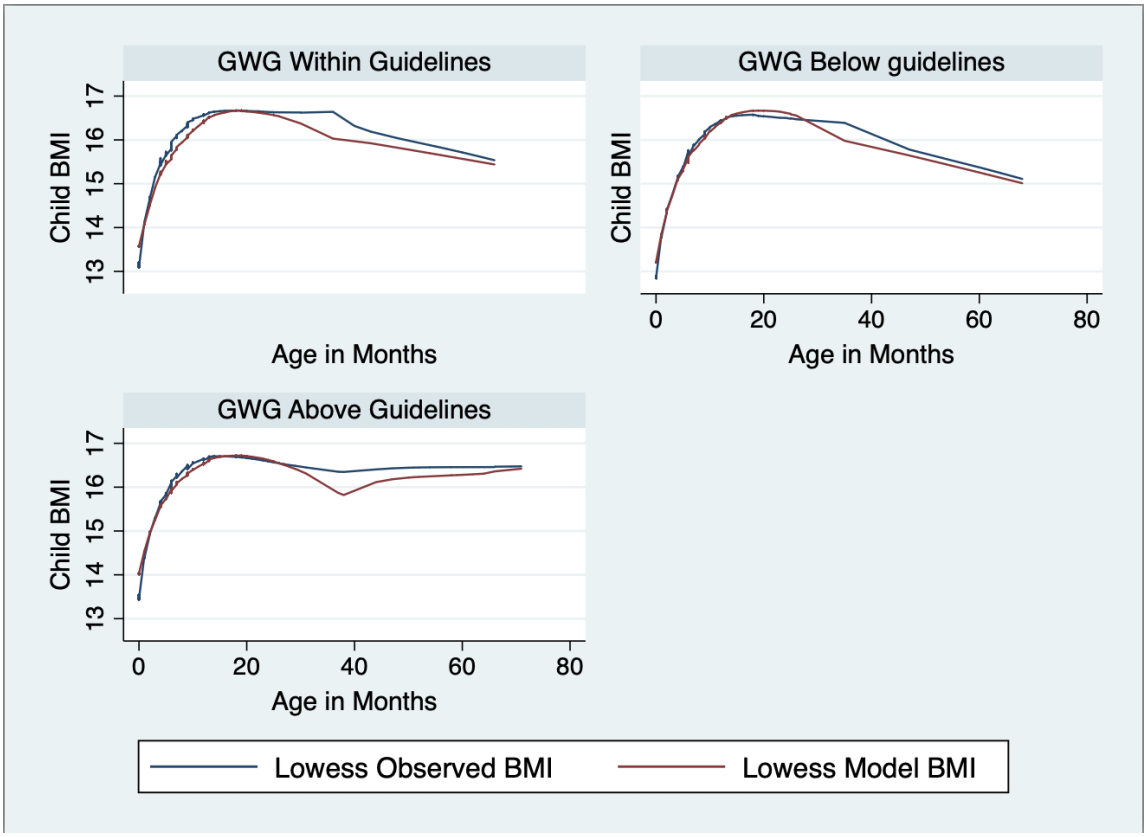
slopes ($\chi^2(1) = 18.07$; $p = 0.000$). Similarly, the addition of a cubic term for time distribution (MOCU) for the random intercepts resulted in stepwise improvement of the fit of the model from the previous model ($\chi^2(1) = 633.85$; $p = 0.000$) and finally the addition of a cubic term for time distribution for the random slopes further improved the fit of the model ($\chi^2(1) = 20.01$, $p = 0.000$). Therefore, a mixed model with cubic terms for time distributions for both random intercepts and random slopes was used in the subsequent analyses: *mixed BMI MO MOSQ MOCU || CHILD: MO MOSQ MOCU.*

Addition of GWG concordance improved the model's fit ($\chi^2(2) = 11.46$; $p = 0.003$). Comparison of this last model and a model with an interaction between GWG concordance and time again showed an improvement in the fit ($\chi^2(6) = 16.88$; $p = 0.010$): *mixed BMI i.CONC##c.(MO MOSQ MOCU) || CHILD: MO MOSQ MOCU*. The results from this model, which has only one independent variable, are shown in Appendix 4-7. Next, all the independent variables were added to the latter model to describe the full model: *mixed BMI c.AGE c.PPBMI i.PARA i.SMOKE i.SES i.SEX i.CONC##c.(MO MOSQ MOCU) || CHILD: MO MOSQ MOCU,* showing a significant improvement in the fit of the model.

Now having the best model to fit the data, the differences among the groups on the child BMI trajectories were tested. This full model showed a significant difference in the estimates of the child BMI parameters pertaining to GWG concordance. Specifically, as illustrated in Figure 4-3, there was a significant difference in the trajectories for child BMI between children whose mothers had gained above the guidelines compared to children whose mothers had gained below the guidelines ($\chi^2(1) = 12.60$; $p = 0.000$) and between children whose mothers had gained above the guidelines compared to children whose mothers had gained within the guidelines ($\chi^2(1) = 19.96$; $p = 0.000$). There was no significant difference in the trajectories for child BMI between children whose mothers had gained within the guidelines and children whose mothers had gained below the guidelines ($\chi^2(1) = 2.22$; $p = 0.136$). This full model also showed a significant difference in the parameter estimates for child BMI pertaining to mothers' parity, specifically between children whose mothers had parity ≥ 2 compared to children whose mothers had parity = 1 ($\chi^2(1) = 5.76$; $p = 0.016$) and between children whose mothers had parity ≥ 2

compared to children whose mothers had parity = 0 ($\chi^2(1) = 6.48$; p = 0.033). There was no significant difference in the parameter estimates for child BMI between children whose mothers had parity =1 and children whose mothers had parity = 0. Finally, this full model also showed a significant relationship between child BMI and pre-pregnancy BMI; specifically, for every unit increase in pre-pregnancy BMI, there was a 0.022 increase in child BMI (z = 2.19, p = 0.029). None of the other independent variables (maternal age, smoking, SES quintile, or child sex) showed a significant relationship to child BMI.

Figure 4-3: Mean observed and predicted lowess * child BMI trajectories, based on the full model, by GWG concordance with the 2009 Institute of Medicine guidelines for GWG



* Lowess is a statistical technique to smooth a scatterplot [95].

5. DISCUSSION

This retrospective cohort study examined the relationship between the guideline-concordance of mothers' gestational weight gain and their children's BMI trajectories over time. The sample for the study consisted of patients followed by primary care clinicians over a seven-year period in an urban area in Atlantic Canada.

A model with a cubic term for time distribution, random intercepts and random slopes, an interaction between GWG concordance and time, and including all the other independent variables showed significant differences in child BMI trajectories between children of mothers who had excess GWG and children of mothers who had either guideline concordant or insufficient GWG. Although there were some differences in methods, this result is consistent with previous studies examining the relationship between GWG and a longitudinal view of offspring weight up to 12 months [44,96] and 36 months [97]. This result is also consistent with meta-analyses in a number of systematic reviews [46,47,50] and with previous studies examining the relationship between GWG and a cross-sectional view of offspring weight at six months [41], at 36 months [98], at approximately five to six years [42,53], and at 9 years of age [99]. It is however inconsistent with a study that did not show a significant difference in child BMI between children of mothers who had excess GWG and children of mothers who had insufficient GWG [43] and with a retrospective cohort study that found a significant relationship between GWG and childhood BMI but only for insufficient GWG [54]. Thus, this result contributes to the literature that has previously shown inconclusive results when examining the association between insufficient GWG and offspring weight outcomes [45].

In addition to the main independent variable (GWG concordance), the full model included all the other independent variables (maternal age, parity, smoking, pre-pregnancy BMI, SES quintile and child sex) as these variables could potentially be associated with the mother's pregnancy weight gain and therefore with GWG concordance. However, the only independent variables that were shown to be significantly associated with child BMI were the mother's pre-pregnancy BMI and the mothers' parity.

Studies exploring the association between pre-pregnancy BMI and offspring weight status have shown inconsistent results. Whereas some research has shown highest childhood BMI measures to be associated with maternal pre-pregnancy BMI ranges between 18.5 - < 30.0 kg/m^2 [51,53], a larger body of studies have demonstrated, consistent with the present study, a greater risk of higher childhood BMI measures with increasing maternal pre-pregnancy BMI [44,48,52]. Also consistent with the present study, these latter studies also showed that higher pre-pregnancy BMI and GWG concordance in excess of the guidelines both contributed to increased childhood BMI.

The association between maternal parity and repeated measures of childhood weight was recently examined in a prospective cohort study [100]. In that study, higher parity was shown to be associated with a slower rate of childhood weight change. This result is potentially inconsistent with the results of the present study, in which the rate of child BMI change for higher parity (i.e. ≥ 2) was significantly higher than the rate of child BMI change for lower parities (0 or 1). However, caution should be used in comparing these two studies, as the repeated childhood measure in the present study was child BMI rather than weight.

The present study has several strengths. First, although the children's BMI data were collected at varying times that were unevenly spaced, reflecting a real-life clinical situation, the data were analyzed using a robust statistical approach, multilevel modelling, that allows for this type of data structure. In addition, the pre-pregnancy BMI was calculated with pre-pregnancy weight values that were taken in the first trimester of pregnancy, providing a more reliable estimate of BMI than pre-pregnancy weight values that are derived from recall later in pregnancy. Finally, the determination of guideline concordance of women's GWG in this study was approached so that "term pregnancy", i.e. 37 to 41 completed weeks' gestation, was not considered a homogeneous group. As per the 2009 IOM guidelines, this approach therefore targeted the correct GWG amount at 40 weeks' gestation, did not assume a homogeneous GWG at the end of the first trimester, but rather a range of approximately 0.5 to 2 kg, and provided clear boundaries of guideline concordant GWG.

The present study also has limitations. First, the retrospective cohort design is prone to bias as the data used might not have been originally collected for research purposes and could be of poor quality. In the present study, the linkage of mothers to their children, although previously undertaken in a random sample drawn from the same population as the one in this study and shown to have a high sensitivity and specificity, could nonetheless introduce a potential source of error. It is also possible that children who were and were not successfully linked to their mothers could represent different populations.

Another limitation is potential misclassification of the main independent variable (GWG concordance), determined by the mothers' last weight and corresponding gestational age that were available in the prenatal record. Such a misclassification could occur if the child's birth occurred at a later gestational age, before the time when the next prenatal visit would have occurred. However, as prenatal visits at 37 weeks' gestation and beyond occur at one-week intervals, it is unlikely that more than one weight measurement would have been missed. Nonetheless, there is the potential that some of the women have been misclassified in a lower GWG concordance category. The implication of this misclassification would be that the difference in child BMI trajectories among the three groups could be either increased or decreased, depending on the correction of GWG classification.

The reliability of weight and height measurements, necessary to calculate the BMI of infants and young children, also needs consideration. Measurement errors of weight can be due to children's normal daily variation attributable to hydration, fidgeting, urinary and gastrointestinal contents, etc. [101]. Similarly, measurement errors of height among ambulatory children can be due to the diurnal variation in water content in the intervertebral discs. Errors due to observer variation play a significant role, with those pertaining to height being at greater risk of variation than those pertaining to weight [101]. At Dalhousie Family Medicine, which was the source of the data for the present study, weights of infants and children are measured with digital scales, which offer greater accuracy than older scales [101]. However, length measurements of infants are undertaken with the "pencil and paper" method, in which a line is drawn above the head of the supine

child, the child's hips are forced into as much extension as possible, and then a line is drawn below the child's heel. This method has been found to be less reliable than other methods [102] , overestimating length by a mean of 1.3 cm [103]. However, as the vast majority of children with data in the Dalhousie Family Medicine database had height measurements undertaken in the same manner, the change in BMI calculation was likely consistent for the entire group and should not affect the comparison of the BMI trajectories.

Finally, the bulk of the BMI measurements for the children in the present study occurred prior to 20 months of age. Therefore, due to the relatively fewer observations after 20 months, the children's BMI trajectories after this age may not be reliable.

Childhood obesity has become a significant public health problem. A recent systematic review found some evidence for the effectiveness of interventions delivered by clinicians during the first 1000 days of life to prevent excess weight in children [104]. The present study complements those results, as knowledge of a woman's GWG concordance with guidelines could serve to identify her children's likelihood of having excess weight with time and help target such interventions to those children at higher risk.

6. CONCLUSION

The present study adds to the literature examining the relationship between GWG and childhood obesity, with the contribution of longitudinal data from primary care, valid determination of pre-pregnancy BMI, careful estimation of guideline-concordance of GWG, and the powerful statistical analysis conferred by multilevel modeling. The results reinforce the importance of achieving guideline concordant GWG as women who exceed the guideline-recommended amounts have children with higher BMI trajectories than women who gain weight that is concordant with the guidelines.

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APPENDICES

Appendix 4-1: Research Ethics Board Approval

Nova Scotia Health Authority Research Ethics Board
Centre for Clinical Research, Room 118
5790 University Avenue
Halifax, Nova Scotia, Canada B3H 1V7

July 17, 2018

Dr. Helena Piccinini-Vallis
Medicine\Family Medicine
Dalhousie Family Medicine Mumford Professional Centre
6960 Mumford Road, Suite 0265
Halifax NS B3L 4P1

Delegated Review
Full Approval Letter
(July 17, 2018 to July 17, 2019)

Dear Dr. Piccinini-Vallis:

RE: The Association Between Women's Gestational Weight Gain Concordance With Guidelines And Their Children's Body Mass Index Trajectories

NSHA REB ROMEO File #: 1023678

Thank you for your response regarding your proposed study.

Document Name	Comments	Version Date
Letter of Support	Letter of support # 2	2018/04/19
Investigator Response/Revisions	PI response to initial letter	2018/07/17

I have reviewed these documents on behalf of the Research Ethics Board (REB) and note that all requested changes have been incorporated.

I am now pleased to confirm the Board's full approval for this research study, effective today. This includes approval / favorable opinion for the following study documents:

Document Name	Comments	Version Date
Researcher's Checklist for Submission	Checklist	2018/06/15
Letter of Support	Letter of support # 2	2018/04/19
Investigator Response/Revisions	PI response to initial letter	2018/07/17
Waiver of Consent Addendum	Request for waiver of consent	2018/04/17
Research Protocol	Protocol - V1	2018/04/17
Current License to Practice in NS	PI's License	

Certificate of Completion TCPS 2: CORE	**TCPS 2 Certificate**	**2013/08/26**
Curriculum Vitae (CV)	**PI CV**	**2018/04/17**

Continuing Review

1. The Board's approval for this study will expire one year from the date of this letter **July 17, 2019.** To ensure continuing approval, submit a Request for Annual Approval to the Board 2-4 weeks prior to this date. If approval is not renewed prior to the anniversary date, the Board will close your file and you must cease all study activities immediately. To reactivate a study, you must submit a new Initial Submission (together with the usual fee) to the REB and await notice of re-approval.
2. Please be sure to notify the Board of any:
* Proposed changes to the initial submission (i.e., new or amended study documents or supporting materials),
* Additional information to be provided to study participants,
* Material designed for advertisement or publication with a view to attracting participants,
* Serious unexpected adverse reactions experienced by local participants,
* Unanticipated problems involving risks to participants or others,
* Sponsor-provided safety information,
* Additional compensation available to participants,
* Upcoming audits /inspections by a sponsor or regulatory authority,
* Premature termination / closure of the study (within 90 days of the event).
3. Approved studies may be subject to internal audit. Should your research be selected for audit, the Board will advise you and indicate any other requests at that time.

Important Instructions and Reminders

1. Submit all correspondence to Ethics Coordinator, Joan Morrison at the address listed at the top of this letter (do not send your response to the REB Chair or Co-Chair).
2. Login to the Research Portal; click Applications (Post Review), browse through files to locate the study in which you wish to make revisions to; click the Events Button and choose the type of revision you wish to make from the table provided; complete the electronic form and attach document under the attachments tab if required and Click on the Submit button.
3. Be sure to reference the Board's assigned file number, Romeo No. 1023678, on all communications.
4. Highlight all changes on revised documents, and remember to update version numbers and/or dates.

Best wishes for a successful study.

Yours very truly,

Anne Marie Krueger-Naug, MD, FRCPC
Co-Chair, NSHA Research Ethics Board

This statement is in lieu of Health Canada's Research Ethics Board Attestation:
The Research Ethics Board for the Nova Scotia Health Authority operates in accordance with:
- Food and Drug Regulations, Division 5 "Drugs for Clinical Trials Involving Human Subjects"
- Natural Health Products Regulations, Part 4 "Clinical Trials Involving Human Subjects"

- Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2)
- ICH Good Clinical Practice: Consolidated Guideline (ICH-E6)

cc: Lisa Underwood, Director, Research Services

Appendix 4-2: Details regarding variables for the study

1. Variables extracted from the Dalhousie Family Medicine electronic medical record (EMR):

1. Unique identifier: for all women and children. This is a 35-digit number assigned in the EMR to each patient of the Dalhousie Family Medicine clinics and is not a number with any identifying properties outside the EMR.
2. Telephone number: a 10-digit number used to link women to their children.
3. Maternal age: a continuous variable measured in whole numbers and equal to the number of completed years of life.
4. Maternal pre-pregnancy weight: a continuous variable, measured in kilograms with one decimal place, and defined as the first measured weight during the first trimester. If this measurement was not available, then the self-reported pre-pregnancy weight during the first trimester (≤ 13 weeks' gestation) was used.
5. Maternal height: a continuous variable, measured in meters with two decimal places.
6. Last gestational weight: a continuous variable, measured in kilograms with one decimal place, representing the last weight recorded in the prenatal record for the index pregnancy.
7. Last gestational age: a categorical variable, equal to the number of completed weeks of pregnancy.
8. Maternal parity: a categorical variable representing the number of pregnancies prior to the index pregnancy that resulted in > 20 weeks' gestation, and defined as follows:
    a. Parity = 0 if the number of prior pregnancies > 20 weeks' gestation = 0
    b. Parity = 1 if the number of prior pregnancies > 20 weeks' gestation = 1
    c. Parity = 2 if the number of prior pregnancies > 20 weeks' gestation ≥ 2
9. Maternal smoking: a dichotomous variable representing self-reported smoking status at the first prenatal visit, and defined as follows:
    a. Smoking = 0 if self-reported smoking status = no
    b. Smoking = 1 if self-reported smoking status = yes

10. SES quintile: an ordinal variable with values ranging from 1 (lowest SES) to 5 (highest SES).
11. Child's date of birth: (day, month, year). This was used to calculate the repeated variable "child's age".
12. Sex: a dichotomous variable, pertaining to the child, and defined as follows:
    a. Sex = 1 if male
    b. Sex = 2 if female
13. Child's height: a continuous variable, measured in centimeters; a repeated variable, extracted at each well child visit.
14. Child's weight: a continuous variable, measured in grams; a repeated variable, extracted at each well child visit.

2. Calculated variables

1. Pre-pregnancy BMI: a continuous variable with one decimal point, calculated by dividing "maternal pre-pregnancy weight" by the square of "maternal height" (i.e. kg/m^2).
2. Pre-pregnancy BMI category: a categorical variable, defined by "pre-pregnancy BMI", using the BMI classification system of the World Health Organization [1] as follows:
    a. Pre-pregnancy BMI category = 1 if pre-pregnancy BMI < 18.5
    b. Pre-pregnancy BMI category = 2 if pre-pregnancy BMI 18.5 - < 25.0
    c. Pre-pregnancy BMI category = 3 if pre-pregnancy BMI 25.0 - < 30.0
    d. Pre-pregnancy BMI category = 4 if pre-pregnancy BMI ≥ 30.0
3. GWG: a continuous variable, measured in kilograms with one decimal place, calculated by subtracting "pre-pregnancy weight" from "last gestational weight".
4. GWG concordance: a categorical variable defined by the interaction of pre-pregnancy BMI and GWG, and categorized as "above", "within", or "below" the 2009 Institute of Medicine guidelines for GWG [2], and adjusted by gestational age.
5. Child's age: a continuous variable, measured in whole numbers representing the number of days since the child was born (calculated by subtracting "child's date of birth" from the date of each well child visit) and then divided by 30 to obtain

age in months.

6. Child BMI: a continuous variable, calculated as kg/m^2.

References:

1. World Health Organization. *Obesity: preventing and managing the global epidemic.* 2000.

2. Rasmussen KM, Catalano PM, Yaktine AL. New guidelines for weight gain during pregnancy: what obstetrician/gynecologists should know. *Current opinion in obstetrics & gynecology.* 2009;21(6):521-526.

Appendix 4-3: Linkage of mothers and children

In order to conduct the proposed study, data pertaining to women who received prenatal care had to be linked to the data pertaining to their children, thus identifying dyads of mothers and children. The methods to undertake such linkages include deterministic and probabilistic approaches [1]. In deterministic linkage, the variable used to link records has to match identically, resulting in a very high specificity but at the cost of a lower sensitivity [2,3]. In comparison, probabilistic linkages are based on partial matches and an estimate of the likelihood that records are in fact linked, resulting in a higher sensitivity but at the expense of specificity [3,4]. This latter approach has been shown to be especially useful when records do not share an identification number [2,5], and the threshold for accepting a link using the probabilistic approach is determined by the user.

The accuracy of these linkages between mothers and their children was examined in a preliminary study using the Dalhousie Family Medicine EMR. In this study, the identification criterion for women who had received prenatal care between October 1, 2016 and September 30, 2017 was the presence of a Nova Scotia Prenatal Record in their charts. Among the 103 women thus identified, 25 were randomly selected for validation of identification of women who had received prenatal care and linkage to children. The selected women's attending physicians were asked to name the children pertaining to each of their patients in the sample. This was considered the reference standard [6]. The phone numbers of the women and the children were then compared deterministically to ascertain if they matched.

Similarly, the identification criterion for children who had attended routine child visits was the presence of a Rourke Record. Among the 119 children thus identified, 25 were randomly selected and their attending physicians were asked to match them to one of the 103 women who were not their mothers. The phone numbers of these dyads were then compared deterministically to ascertain if they matched.

Both the sensitivity and specificity of the method used to identify women who had received prenatal care and children who received routine child care was 100% in both cases. The following tests of discrimination were calculated, as shown in Table 4-3.1:

Table 4-3.1: Tests of discrimination for linkage of mothers and their children using telephone numbers

		Reference standard: knowledge of attending physician	
		Yes	No
Index test: deterministic match of telephone number	Yes	21	0
	No	4	25

The sensitivity of this deterministic approach using telephone number was 84%, whereas the specificity was 100%. The disadvantage of this approach to link mothers to their children lies with the false negative rate, although, at 16%, it is in keeping with previous research [3]. The telephone number found in a child's electronic chart could reflect the telephone number of an individual other than the child's mother, such as the father or a grandparent; in addition, the telephone number could have been entered incorrectly into the chart or not have been updated if there was a change of telephone number for the mother.

Another way in which to link mothers and children would be to use the unique 10-digit health card numbers assigned to all residents of the province of Nova Scotia. Children born in the province's hospitals are issued their health card number upon hospital discharge. This number is linked to the child's mother's health card number within the Atlee Perinatal Database, a provincial administrative health database containing detailed clinical and demographic information from 1988 onwards [7]. Using the health card numbers contained in the Dalhousie Family Medicine EMR belonging to the women identified to have received prenatal care in the Dalhousie Family Medicine clinics, the existing health card number linkage within the Atlee Perinatal Database between mothers and their children could then identify the children who would form the respective mother-child dyads. Assuming a high degree of accuracy, this method would have a very high

specificity and sensitivity. However, it would entail linking two databases, an undertaking that could be administratively challenging and potentially unfeasible.

References:

1. Herman AA, McCarthy BJ, Bakewell JM, et al. Data linkage methods used in maternally-linked birth and infant death surveillance data sets from the United States (Georgia, Missouri, Utah and Washington State), Israel, Norway, Scotland and Western Australia. Paediatric and perinatal epidemiology. 1997;11 Suppl 1:5-22.

2. Meray N, Reitsma JB, Ravelli AC, Bonsel GJ. Probabilistic record linkage is a valid and transparent tool to combine databases without a patient identification number. J Clin Epidemiol. 2007;60(9):883-891.

3. Baldwin E, Johnson K, Berthoud H, Dublin S. Linking mothers and infants within electronic health records: a comparison of deterministic and probabilistic algorithms. Pharmacoepidemiol Drug Saf. 2015;24(1):45-51.

4. Sayers A, Ben-Shlomo Y, Blom AW, Steele F. Probabilistic record linkage. International journal of epidemiology. 2016;45(3):954-964.

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6. Bossuyt PM, Reitsma JB, Bruns DE, et al. The STARD statement for reporting studies of diagnostic accuracy: explanation and elaboration. Annals of internal medicine. 2003;138(1):W1-12.

7. Nova Scotia Atlee Perinatal Database Report of Indicators: 2002-2011. Nova Scotia December 2012.

Appendix 4-4: Missing data analysis

The variable "parity" had 12.2% missing data, and therefore was examined to ascertain whether the data were missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). Dummy variables were created with "0" denoting a missing value and "1" denoting an existing value, and then Chi-square and t-tests were undertaken to explore whether there were any significant relationships between parity and the other independent variables, as shown in Table 4-4.1:

Table 4-4.1: Missing data analysis for the independent variable "parity"

GWG concordance with the guidelines				
	Below	Within	Above	Total
Parity = 0	7	12	18	37
Parity = 1	39	80	148	267
Total	46	92	166	304
Pearson Chi-square (2) = 0.7386, p = 0.691				
Smoking				
	No	Yes	Total	
Parity = 0	32	5	37	
Parity = 1	227	26	253	
Total	259	31	290	
Pearson Chi-square (1) = 0.3542, p = 0.552				

Pre-pregnancy BMI					
	< 18.5 (kg/m^2)	18.5 - < 25.0 (kg/m^2)	25.0 - < 30.0 (kg/m^2)	GE 30.0 (kg/m^2)	Total
Parity = 0	2	19	9	7	37
Parity = 1	6	133	74	54	267
Total	8	152	83	61	304
Pearson Chi-square (3) = 1.4116, p = 0.703					

SES quintile						
	1	2	3	4	5	Total
Parity = 0	3	0	13	10	11	37
Parity = 1	34	12	88	72	59	265
Total	37	12	101	82	70	302
Pearson Chi-square (4) = 3.0834, p = 0.544						

Child sex			
	Male	Female	Total
Parity = 0	19	18	37
Parity = 1	139	128	267
Total	158	146	304
Pearson Chi-square (1) = 0.0065, p = 0.936			

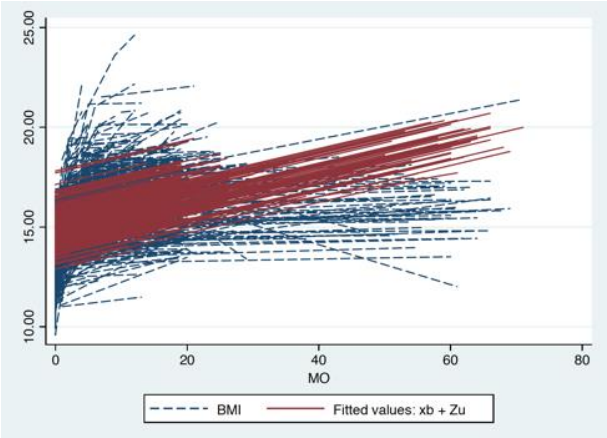
Age		
	N	Mean (SD)
Parity = 0	37	29.64 (0.80)
Parity = 1	267	29.23 (0.31)
t = 0.4654, p = 0.6420		

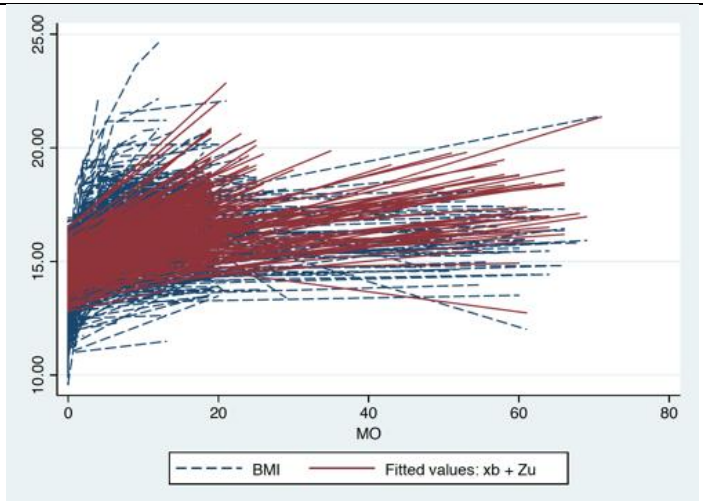
Appendix 4-5: Comparison of descriptive data from the present study to data in the Nova Scotia Atlee Perinatal Database

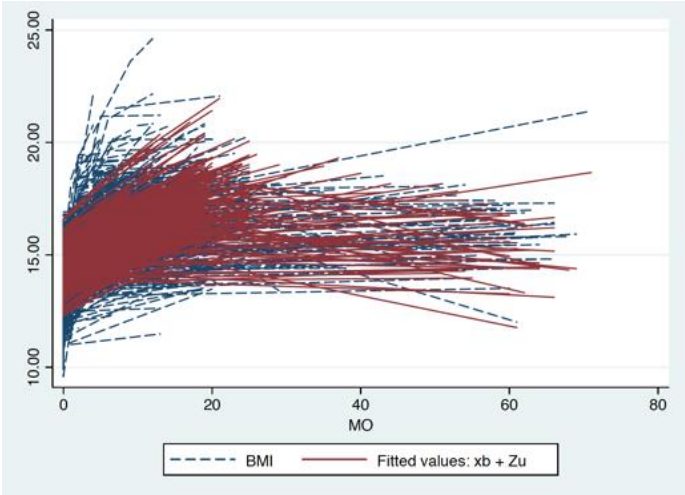
Proportion (%) of women:	Present study	Nova Scotia Atlee Perinatal Database [1]
20-34 years old	79.9	78.3
Pre-pregnancy BMI category (kg/m^2)		
Underweight (<18.5)	2.6	4.7
Normal weight (18.5 - < 25.0)	50.0	47.7
Overweight (25.0 - < 30.0)	27.3	23.7
Obese (≥ 30.0)	20.1	23.9
Parity		
0	53.3	44.8
1	25.3	35.9
≥ 2	9.2	19.3
Smoking		
Yes	10.2	16.0
No	85.2	
GWG concordance		
Below	15.1	17.8
Within	30.3	26.9
Above	54.6	55.3
Sex		
Male	52.0	50.7
Female	48.0	49.3

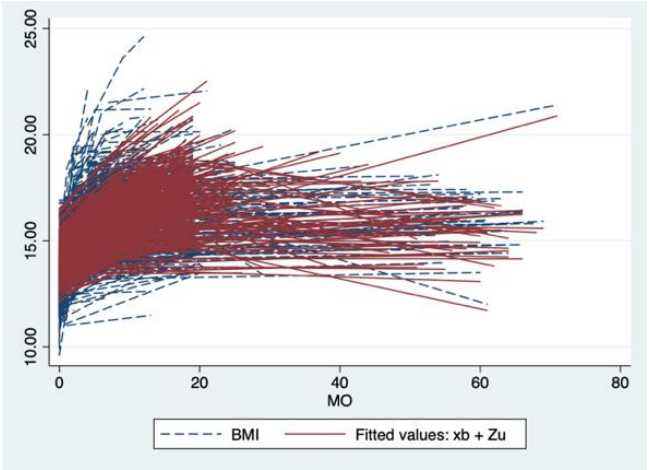
1. Nova Scotia Atlee Perinatal Database Report of Indicators 2005 - 2014. http://rcp.nshealth.ca/sites/default/files/publications/nsapd_indicator_report_2005_2014.pdf. Published 2015. Accessed 2019/11/10.

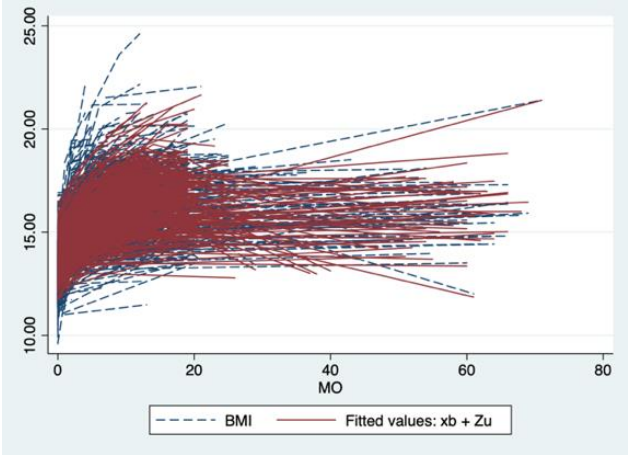
Appendix 4-6: Multilevel mixed model development

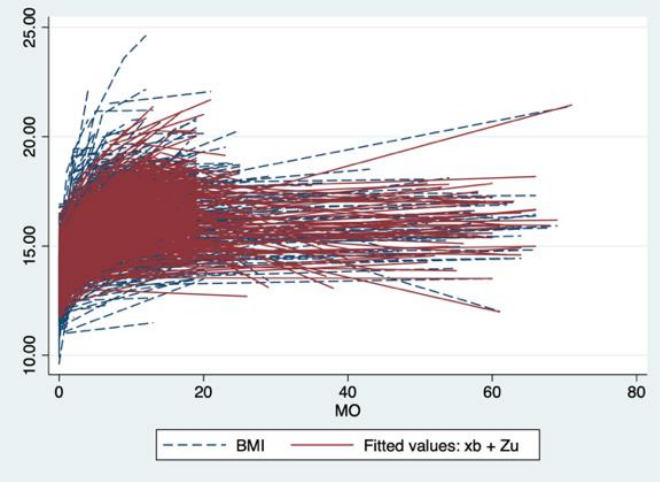
Model description	Model syntax	Output	Explanation
MODEL 1: This model has a linear term for time distribution for random intercepts; the slopes are fixed.	*Model 1 mixed BMI MO || CHILD: , mle estimates store m1 predict traj1, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj1 MO, connect (ascending))		Model 1 predicts BMI trajectories (red) that do not fit the observed data (blue) well. The slopes are all the same (fixed). N = 304
Model 1 unexplained variance = 2.789382			

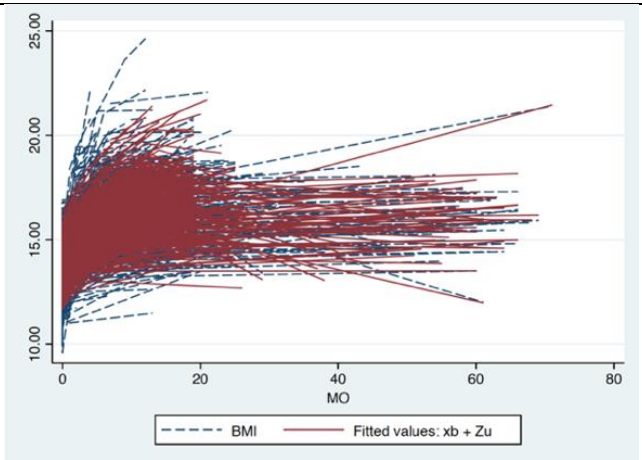
MODEL 2: This model has a linear term for time distribution for both random intercepts and random slopes	*Model 2 mixed BMI MO || CHILD: MO, mle estimates store m2 predict traj2, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj2 MO, connect (ascending))		Model 2 predicts BMI trajectories (red) that fit the observed data (blue) better than Model 1, as the slopes are now random. N = 304
Model 2 fits the data better than model 1	lrtest m1 m2	Likelihood ratio test Chi2(1) = 182.68, p = 0.000	Model 2 fits the data better than model 1
Model 2 unexplained variance = 2.305181; this is smaller than the unexplained variance in Model 1.			

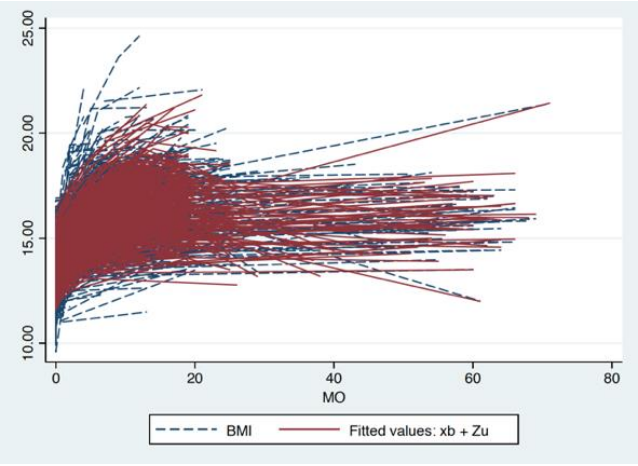
MODEL 3: This model has a quadratic term for time distribution for the random intercepts and a linear term for time distribution for the random slopes	*Model 3 mixed BMI MO MOSQ || CHILD: MO, mle estimates store m3 predict traj3, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj3 MO, connect (ascending))		Model 3 predicts BMI trajectories (red) that fit the observed data (blue) better than Model 2. N = 304
Model 3 fits the data better than model 2	lrtest m2 m3	Likelihood ratio test Chi2(1) = 514.38, p = 0.000	Model 3 fits the data better than model 2
Model 3 unexplained variance = 1.904232; this is smaller than the unexplained variance in Model 2.			

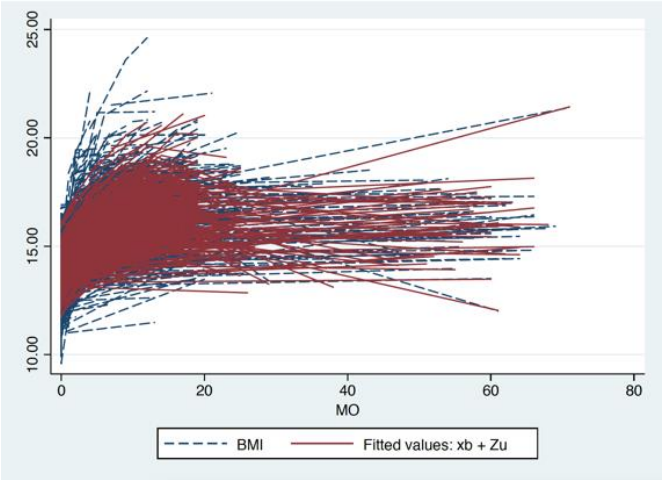
MODEL 4: This model a quadratic term for time distribution for both the random intercepts and the random slopes	*Model 4 mixed BMI MO MOSQ || CHILD: MO MOSQ, mle estimates store m4 predict traj4, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj4 MO, connect (ascending))		The addition of a quadratic term for time distribution for both the intercepts and the slopes results in Model 4 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 3. N = 304
Model 4 fits the data better than model 3	lrtest m3 m4	Likelihood ratio test Chi2(1) = 18.07, p = 0.000	Model 4 fits the data better than model 3
Model 4 unexplained variance = 1.682875; this is smaller than the unexplained variance in Model 3.			

MODEL 5: This model has a cubic term for time distribution for the random intercepts and a quadratic term for time distribution for the random slopes.	*Model 5 mixed BMI MO MOSQ MOCU || CHILD: MO MOSQ, mle estimates store m5 predict traj5, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj5 MO, connect (ascending))		The addition of a cubic term for time distribution for the intercepts results in Model 5 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 4. N = 304
Model 5 fits the data better than model 4	lrtest m4 m5	Likelihood ratio test Chi2(1) = 633.85, p = 0.000	Model 5 fits the data better than model 4
Model 5 unexplained variance = 1.291297; this is smaller than the unexplained variance in Model 4.			

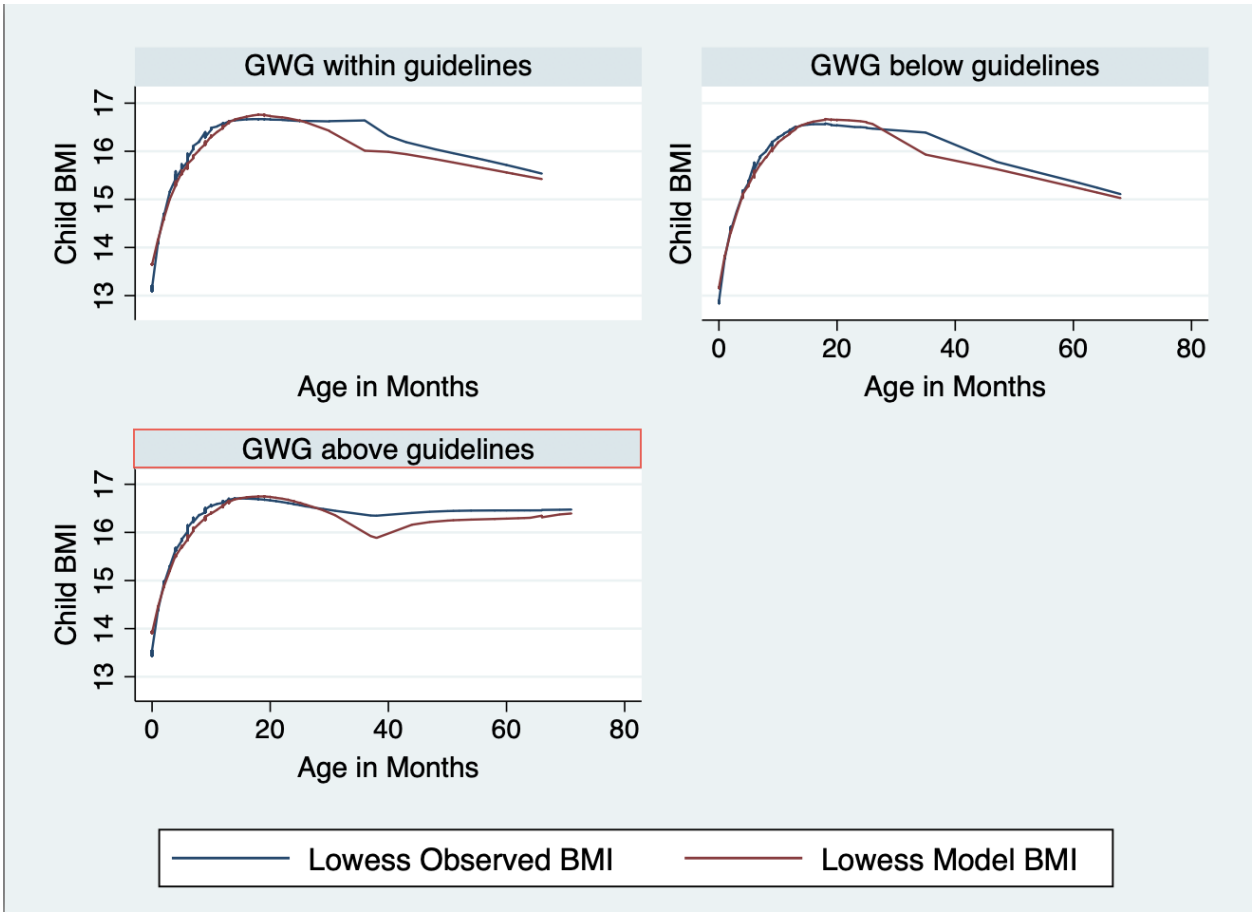
MODEL 6: This model has a cubic term for time distribution for both random intercepts and random slopes	*Model 6 mixed BMI MO MOSQ MOCU || CHILD: MO MOSQ MOCU, mle estimates store m6 predict traj6, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj6 MO, connect (ascending))		Cubic terms for time distribution for both the random intercepts and the random slopes result in Model 6 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 5. N = 304 This is the best unconditional model so it will be used for further analyses.
Model 6 fits the data better than model 5	lrtest m5 m6	Likelihood ratio test Chi2(1) = 20.01, p = 0.000	Model 6 fits the data better than model 5

Model 6 unexplained variance = 1.254021; this is smaller than the unexplained variance in Model 5.			
MODEL 7: This is the best unconditional model (Model 6) with the addition of CONC (the main independent variable).	*Model 7 mixed BMI MO MOSQ MOCU i.CONC || CHILD: MO MOSQ MOCU, mle estimates store m7 predict traj7, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj7 MO, connect (ascending))		The addition of the main independent variable (CONC) to the best unconditional model (Model 6) results in Model 7 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 6. N = 304
	lrtest m6 m7	Likelihood ratio test Chi2(2) = 11.46, p = 0.003	Model 7 fits the data better than model 6
Model 7 unexplained variance = 1.253184; this is smaller than the unexplained variance in Model 6.			

MODEL 8: This is the best unconditional model (Model 6) with the addition of an interaction term between CONC (the main independent variable) and time.	*Model 8 mixed BMI i.CONC##c.(MO MOSQ MOCU) || CHILD: MO MOSQ MOCU, mle estimates store m8 predict traj8, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj8 MO, connect (ascending))		The addition of an interaction term between the main independent variable (CONC) and time to the best unconditional model (Model 6) results in Model 8 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 7. N = 304
Model 8 fits the data better than model 7	lrtest m7 m8	Likelihood ratio test Chi2(6) = 16.88, p = 0.010	Model 8 fits the data better than model 7
Model 8 unexplained variance = 1.23733; this is smaller than the unexplained variance in Model 7.			

MODEL 9: This is the best model: there are cubic time distributions for random intercepts and random slopes; there is an interaction term between CONC (the main independent variable) and time; all the remaining independent variables have been added to the model.	*Model 9 mixed BMI c.AGE c.PPBMI i.PARA i.SMOKE i.SES i.SEX i.CONC##c.(MO MOSQ MOCU) || CHILD: MO MOSQ MOCU, mle estimates store m9 predict traj9, fitted sort CHILD *plot the predicted and the observed* Graph twoway (line BMI MO, connect(ascending) clpatt(dash)) (line traj9 MO, connect (ascending))		The addition of all the independent variables to Model 8 results in Model 9 predicting BMI trajectories (red) that fit the observed data (blue) better than Model 8. N = 251
Model 9 unexplained variance = 1.236724; this is smaller than the unexplained variance in Model 8.			

Appendix 4-7: Mean observed and predicted lowess child BMI trajectories, based on the model with only one independent variable (GWG concordance).



CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSIONS

1. SUMMARY OF FINDINGS IN THE THREE STUDIES

The overall findings from the systematic review reported in Chapter Two, a systematic review and thematic analysis, showed the health of the baby being women's top priority. Women did not focus too much on gestational weight gain other than wanting to avoid insufficient weight gain, as they perceived that to be potentially harmful to the baby. However, in reality they found it difficult to curb gestational weight gain. Their knowledge pertaining to gestational weight gain guidelines was limited and they received different messages about gestational weight gain from a number of sources. In particular, their families forced them to eat in order to gain weight and their prenatal care providers rarely addressed their weight gain. They therefore experienced some confusion and interpreted their prenatal care providers' lack of advice as confirmation that weight gain was either not an important issue, or, if it was important, that their weight gain was probably acceptable. However, this confusion was associated with some degree of stress for some women, as they believed that they were being watched by others.

The Grounded Theory study described in Chapter Three resulted in a deeper understanding of women's perceptions of the advice that they receive pertaining to gestational weight gain. Consistent with the results of the systematic review in Chapter Two, participants in this study conveyed the message that the health of the baby was their top priority. They also did not focus too much on gestational weight gain, being more interested in pursuing healthy behaviours rather than just watching the numbers on the scale. Although these women also found gestational weight gain difficult to control, in contrast to the findings in the systematic review, they feared not being able to gain sufficient weight gain. They cited feeling overwhelmed by the amount of weight that they thought they had to gain.

Also consistent with the systematic review, women in the Grounded Theory study did not have good knowledge of how much weight they should gain. They reported that they received different messages pertaining to gestational weight gain from various sources and believed that they were being watched, but in contrast to the findings in the systematic review, they did not receive much advice from family members and they did

not trust social media. They reported that their prenatal care providers also did not address gestational weight gain and this sometimes led to the assumption that their weight gain was probably acceptable. However, they managed this uncertainty by searching for evidence-based information about gestational weight gain and specifically asking their prenatal care providers for information and feedback.

Finally, the retrospective cohort study presented in Chapter Four showed, in a sample of primary care patients, one postnatal outcome associated with gestational weight gain that is discordant with the guidelines. Specifically, this study showed significantly higher BMI trajectories for children born to mothers who had excess gestational weight gain compared to the BMI trajectories of children born to mothers who had either guideline concordant or insufficient gestational weight gain.

2. OVERVIEW

The findings in both the systematic review and the Grounded Theory study revealed that the health of the unborn child was the top priority for women experiencing a pregnancy, and that although they perceived their gestational weight gain as playing a role in the health of their baby, they generally did not appreciate many details of that association. They worried more about insufficient rather than excess gestational weight gain. This is a concerning finding considering the results in the quantitative study, in which excess gestational weight gain was associated with higher BMI trajectories in children.

It is likely that pregnant women routinely receive feedback about non-sensitive measurements that typically occur during their prenatal appointments, such as their blood pressure and the fetal heart rate. However, both the systematic review in Chapter Two and the Grounded Theory study in Chapter Three demonstrated that they infrequently received feedback about their weight gain, another measurement that typically occurs during their prenatal appointments. This suggests an element of discomfort by prenatal care providers in initiating discussions about this topic. The reported lack of feedback regarding gestational weight gain was therefore confusing and for some women a source of stress. Prenatal care providers are in a strategic position to provide support to alleviate this stress if they approach discussions about gestational weight gain in a patient-centered

manner [1].

Prenatal care providers are also in a strategic position to engage in patient-centered discussions with pregnant women about some of the potential outcomes of guideline-discordant gestational weight gain, such as childhood obesity. Although there has been an increasing trend in the frequency with which primary care providers identify obesity in their pediatric patients [2], the probability of a child with obesity achieving clinically meaningful weight management outcomes ranges from 0.01% to 7.2% per year and therefore a primary prevention approach is more likely to be effective in curbing this epidemic [3]. The retrospective cohort study in Chapter Four showed that children born to mothers who gained excess weight in pregnancy had higher BMI trajectories than children born to mothers who experienced guideline-concordant or insufficient gestational weight gain. This result provides pregnant women and prenatal care providers with important information because it shows the potential for early identification of children at risk of developing obesity. A systematic review showed that childhood obesity interventions may be most preventative if they are initiated early, from conception to 24 months of age [4]. However, as with other weight-related discussions, healthcare providers are generally hesitant to address childhood obesity, for fear of compromising the patient-provider relationship [5,6]. Adopting a patient-centered approach to these sensitive conversations would be an effective solution to this problem, as this approach can alleviate clinician hesitation in addressing weight-related matters [7] and patient-centered discussions increase patient adherence to recommendations [8,9].

3. HOW THE PATIENT-CENTERED CLINICAL METHOD FITS WITH THE RESULTS OF THE THESIS

Overall, the results showed that pregnant women wanted more engagement with their prenatal care providers and saw them as a trusted resource regarding gestational weight gain. However, these clinicians did not engage in discussions about gestational weight gain, thus suggesting that this is a clinical area in which the patient-provider interactions could be enhanced.

The results of the studies in this thesis also highlight some patient experience issues and contextual details that are important to women as they progress through a pregnancy. As these items could be of help to prenatal care providers, they will be outlined in this section.

When trying to help women manage their gestational weight gain, prenatal care providers could explore women's experiences as they progress through a pregnancy in a patient-centered manner. The Patient-Centered Clinical Method (PCCM) consists of four interactive components and provides a validated framework to guide such discussions [10]. This method was described by McWhinney as one in which the clinician "tries to enter the patient's world, to see the illness through the patient's eyes"[11(p 35)]. Specific to gestational weight gain, the first component of the PCCM relates to exploring a pregnant woman's experience of gestational weight gain and how this relates to the central theme identified in both the systematic review (Chapter Two) and the Grounded Theory study (Chapter Three) in this thesis. Specifically, the health of the baby was pregnant women's top priority.

The second component of the PCCM is about gaining an understanding of the pregnant woman's context and how this influences her perceptions of gestational weight gain, for example her family's influence and the advice she has received about gestational weight gain from various sources. Having obtained a good understanding of a woman's experience of gestational weight gain and her context, the prenatal care provider and the pregnant woman might be more likely to find common ground, which is the third component of the PCCM. Thus mutual decisions can be made on how to manage gestational weight gain throughout the pregnancy, such as a mutual discussion of the woman's and the prenatal care provider's goals, potentially leading to agreeing on realistic goals for gestational weight gain and approximating the woman's weight gain to the recommended amounts as much as possible [12]. Throughout this process women feel respected [13], and the patient-clinician relationship is enhanced [14,15], which in turn allows the prenatal care provider to gain a further understanding of the woman's experience and contextual influences, and make recommendations relevant to the specific woman.

4. IMPLICATIONS FOR CLINICAL PRACTICE

Gestational weight gain related advice from prenatal care providers positively influences women's achievement of appropriate gestational weight gain targets [16-19], and pregnant women want to discuss gestational weight gain with their prenatal care providers [20,21]. However, as found in the systematic review in Chapter Two and the Grounded Theory study in Chapter Three, pregnant women do not perceive that their providers initiate discussions about gestational weight gain.

The majority of interventions pertaining to the management of gestational weight gain have targeted prenatal care providers, providing them with the opportunity to counsel pregnant women on healthy diet, physical activity, or a combination of the two. These interventions have often relied on resources not typically available to prenatal care providers and there has been heterogeneity in the results [22,23]. More recently, interventions aiming to reduce the proportion of women who gain excess weight have examined the use of electronic medical record alerts to remind participating prenatal care providers to discuss gestational weight gain with pregnant women, with promising results [24-26].

Prenatal care providers cite several barriers to initiating conversations about gestational weight gain, including lack of understanding of the pregnant woman's cultural background, poor knowledge of the woman's context, and a perceived lower quality of the patient-clinician relationship [27]. Patient-centered frameworks such as "The 5As of Healthy Pregnancy Weight Gain", the Capability, Opportunity, and Motivation Behaviour framework, and the PCCM are available to support prenatal care providers in initiating these difficult conversations and maintaining contextually meaningful discussions about gestational weight gain with pregnant women [28-30]. A study exploring the use of the "5As" framework showed significantly lower gestational weight gain among pregnant women whose prenatal care providers utilized this approach [31].

Patient-centeredness consists of a set of behaviours that render a clinician patient-centered in the eyes of a patient, including the use of verbal and non-verbal language and the display of interest, empathy, compassion, genuineness, positive regard, and non-possessive warmth [32-36]. Patient-centeredness further overlaps with therapeutic alliance [37],

patient activation [38,39] , and patient empowerment [40].

Correspondingly, a recent Canadian prospective cohort with a historical control targeted not only prenatal care providers, but also engaged pregnant women in their prenatal care, showing promising results [41]. Pregnancy has been dubbed a "teachable moment" [42]. Perhaps this should be interpreted as the opportunity to empower pregnant women to feel confident in initiating weight-related discussions during prenatal appointments if their prenatal care providers do not do so.

In summary, these implications for clinical practice are particularly relevant to family medicine. This thesis recommends that family physicians more frequently initiate discussions about GWG, potentially using EMR monitoring tools and alerts, and enacting point of care tools such as the 5As of Healthy Pregnancy Weight Gain and the PCCM in the context of a longitudinal relationship.

5. IMPLICATIONS FOR FUTURE RESEARCH

Future research exploring approaches to the management of gestational weight gain by family physicians should continue to examine the potential contribution of technology embedded in pregnant women's electronic medical charts. Reminders in the form of messages or pop-ups and alerts prompted by smart form capabilities are some examples of potential studies. In addition, such research should pay close attention to women's contextual issues and take advantage of the power of the patient-clinician relationship. Attempts to address clinician barriers to addressing gestational weight gain such as perceived lack of time, resources, and confidence are also potential studies that could be undertaken. Finally, engaging pregnant women in studies aimed at addressing gestational weight gain could be an effective approach, as this would address prenatal care providers' greatest concern – their fear of angering, offending or embarrassing their patients.

6. SUMMARY AND CONCLUSIONS OF FINDINGS

Regardless of socioeconomic status, educational attainment or ethnicity, the health of the unborn child is the highest priority for pregnant women. Although they have a sense that

the amount of weight that they gain influences their baby's health, their relevant content knowledge is limited. These women receive infrequent advice from their prenatal care providers and experience confusion, worry, and stress. Prenatal care providers are strategically positioned to address this issue and perhaps help curb downstream childhood excess weight, one of the long-term outcomes of excess gestational weight gain.

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Relevant Peer-Reviewed Publications

1. **Piccinini-Vallis H**, Vallis M. Curbing excess gestational weight gain in primary care: using a point of care tool based on behaviour change theory. International Journal of Women's Health. 2018;10:609-615.
2. Morris J, Nikolopoulos H, Berry T, Jain V, Vallis M, **Piccinini-Vallis H,** Bell RC. Health care providers' gestational weight gain counselling practices and the influence of knowledge and attitudes: A cross-sectional mixed methods study. BMJ Open 2017;**7**:e018527. doi:10.1136/bmjopen-2017-018527
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1. **Piccinini-Vallis H** (Chapter Lead), Adamo K, Bell R, Nerenberg K. *Weight Management for Women with Obesity over the Reproductive Years*. In: Adult Obesity Clinical Practice Guidelines – Executive Summary. Submitted to CMAJ; Manuscript ID: CMAJ-19-1707.

Relevant Research Grant Support

1. 2018: IWK Project Grant: *The Relationship Between Pre-Pregnancy Attempts to Lose Weight and Gestational Weight Gain: An Exploratory Primary Care Prospective Cohort Study.* PI: **Piccinini H**; Co-Is: Anini Y, Woolcott C. Funds awarded: **$19,509.95.**

2. NSHA Translating Research Into Care (TRIC) Grant *Building a research team: Caring for women who live with obesity during pregnancy, birthing, and postpartum.* List of Applicants (with names ordered as on application) Snelgrove-Clarke, E., & Cashen, N., O'Reilly, D., & Tomblin-Murphy, G., & West, J. Co-investigators: Lezama, B., Walsh, C., Casey, C., Mann, C., Woolcott, C., McKeen, D., Carson,G., Scott, H., **Piccinini-Vallis**, H., McLeod, L., George, R.,

Scott, S., Bleasedale, E, Fiander, E., Paynter, M, Bernard, M, Sims, M.. LeDrew, M., Kolanko, M., Mills, S. Start Date and Period of the Award: August 2018 – August 2019. Funds awarded: **$3,000**

3. NSHRF Development Grant: *Pregnancy weight gain and childhood BMI trajectories: a Nova Scotia cohort study using Canadian Primary Care Sentinel Surveillance Network data.* PI: **Piccinini-Vallis H**; Co-Is: Abidi S, Blanchard C, Stewart M; Partner: Attenborough R. **$14,718.00**, October 1, 2016 – September 30, 2017.

4. Capital District Health Authority, Category 2 Grant*: Curbing Excess Gestational Weight Gain In Primary Care: Using Technology Based On Behaviour Change Theory.* PI: **Piccinini-Vallis H**; Co-I: Vallis M. **$14,685.74**, February 1, 2015 – January 31, 2017.

5. Canadian Institutes of Health Research – Meetings, Planning and Dissemination Grants – Planning Grant. *Pregnancy-Related Excess Weight***.** PI: **Piccinini-Vallis H**; CoIs: Dodds L, McDonald S, Gaudet L, Woolcott C, Wicklum S, Macklin D. **$24,032**, 2011 – 2012.

Relevant Invited Presentations

1. 2019: *Current Evidence for the Management of Gestational Weight Gain for Women with Obesity.* Piccinini-Vallis H. 6th Canadian Obesity Summit April 23-26, 2019 Ottawa, Ontario.

2. 2019: *How Our "Words" Affect Our Patients.* Piccinini-Vallis H. SOGC Annual Clinical and Scientific Conference June 11-14, 2019 Halifax Convention Centre, Halifax, Nova Scotia.

3. 2018: *The Association Between Women's Gestational Weight Gain Concordance With Guidelines And Their Children's Body Mass Index Trajectories*. September 26, 2018. Dr. Ian McWhinney Lecture Series. Centre for Studies in Family Medicine, Western University, London, Ontario.

4. 2015: *Management of Gestational Weight Gain in Primary Care.* Piccinini-Vallis H. Canadian Obesity Summit. Toronto, Ontario. Plenary keynote presentation. http://hosting.epresence.tv/obesitynetwork/1/Watch/140.aspx

5. 2014: *A Patient-Centred Minimal Intervention Method for Addressing Gestational Weight Gain.* Piccinini-Vallis H, Vallis M. Reproductive Care Program of Nova Scotia Conference. Halifax.

6. 2013: *The Role of Primary Care Providers in Attenuating Excessive Pregnancy-Associated Weight Gain.* Piccinini-Vallis H. Canadian Obesity Summit. Vancouver.