

Antenatal Midwifery Care and Reduced Prevalence of Small-  
for-Gestational-Age Birth and Other Adverse Infant Birth  
Outcomes for Women of Low Socioeconomic Position  
*A Population Based Cohort Study Comparing Midwifery and Physician-  
Led Models of Care*

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University of Saskatchewan, Saskatoon

By  
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## Abstract

**Purpose:** The purpose of this research was to determine if antenatal midwifery care was associated with reduced odds of small-for-gestational-age (SGA) birth, preterm birth (PTB), large-for-gestational-age (LGA) birth, Apgar score less than seven at one minute (low Apgar score), newborn extended length of hospital stay (ELOS), or low birth weight (LBW) compared to antenatal care provided by general practitioners (GPs) or obstetricians (OBs) for women with low socioeconomic position (SEP).

**Methods:** Prior to the main analysis, I conducted a systematic scoping review investigating if, over the last 25 years in high resource countries, midwives' clients of low SEP were at more or less risk of adverse infant birth outcomes compared to physicians' patients. The primary analysis was a population level, retrospective cohort study restricted to women with low to moderate risk pregnancy. Women were included if they had been residing in British Columbia, Canada, had singleton births between January 1, 2005 to December 31, 2012, no more than two provider-types involved in care, did not have registered Indian Status, and received Medical Services Plan (MSP) premium subsidy assistance (n=57,872). Generalized estimating equation logistic regression models were used to control for confounding.

**Results:** For patients receiving antenatal midwifery vs. physician care, adjusted odds of SGA birth were reduced (MW vs. GP: OR 0.73, 95% CI: 0.63-0.84; MW vs. OB: OR 0.60, 95% CI: 0.51-0.70), as were odds of preterm birth (MW vs. GP: OR 0.74, 95% CI: 0.63-0.86; MW vs. OB: OR 0.53, 95% CI: 0.45-0.62). Odds of LGA birth were higher for those in the care of midwives vs. physicians (MW vs. GP: OR 1.28, 95% CI: 1.16-1.40; MW vs. OB: OR 1.46, 95% CI: 1.30-1.63). Odds of low Apgar score were only significantly reduced for midwives' vs. GPs' patients (OR 0.85, 95% CI: 0.77-0.95). Odds of newborn ELOS were reduced among midwives' vs. physicians' patients (MW vs. GP: OR 0.65, 95% CI: 0.57-0.74; MW vs. OB: OR 0.56, 95% CI: 0.49-0.65). Odds of LBW were reduced for patients receiving antenatal midwifery vs. physician care (MW vs. GP: OR 0.66, 95% CI: 0.53-0.82; MW vs. OB: OR 0.43, 95% CI: 0.34-0.54). Midwifery vs. physician patients with substance use and/or mental health conditions, and substance using teen mothers, had even lower odds of some adverse infant outcomes. A second analysis showed a reduction in odds of PTB for midwives' vs. GPs' patients of transient low SEP (OR 0.51, 95% CI: 0.37-0.71), but no difference in odds for patients of chronic low SEP.

**Conclusion:** Changes in physicians' antenatal models of practice, to align with the midwifery model, may improve newborn outcomes for vulnerable women at a population level. Midwifery care should be equally available and accessible to all women, using intensive outreach for women of low SEP if necessary, to promote the highest level of health for all infants.

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## **Dedication**

To my kids, Natalie Jane, Michael, Kieran, Vanessa, Claire, and Jack, your joy, laughter and lightheartedness has been the perfect counterbalance to academic work

To James, my greatest champion, who deserves a PhD in “holding the fort”

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## Abbreviations

AA African American

AOR adjusted odds ratio

APNCU Adequacy of Prenatal Care Utilization Index

ARD adjusted risk difference

ARR adjusted relative risk

BC British Columbia

BCPDR British Columbia Perinatal Data Registry

BMI body mass index

CA census agglomeration

CDC Centers for Disease Control and Prevention

CHR corticotrophin-releasing hormone

CI confidence interval

CIHI Canadian Institute for Health Information

CMA census metropolitan area

CNM certified nurse midwife

CPNP Canadian Prenatal Nutrition Program

DA dissemination area

ELOS extended length of hospital stay (newborn)

EPHPP Effective Public Health Practice Project

FAE fetal alcohol exposure

GEE generalized estimating equation

GP general practitioner

HIV human immune deficiency

HPA hypothalamic-pituitary-adrenal

ICD 10-CA International Classification of Diseases Version 10 (Canadian Edition)

ITT intent to treat analysis

IUGR intrauterine growth restriction

LBW low birth weight

LGA large-for-gestational-age

LHA local health area

MD medical doctor  
MES Maternity Experiences Survey  
MSP Medical Services Plan  
MW midwife/midwifery  
NAS neonatal abstinence syndrome  
NHA Northern Health Authority  
NICU neonatal intensive care unit  
NSSD non-statistically significant difference in effect estimates  
OB obstetrician  
OECD Organization of Economic Cooperation and Development  
OR odds ratio  
PF preventative fraction  
PSBC Perinatal Services British Columbia  
PTB preterm birth  
QIC Quasi-likelihood under Independence Model Criteria  
RD risk difference  
RR relative risk  
SEP socioeconomic position  
SGA small-for-gestational-age  
STI sexually transmitted infection  
TPR true positive rate  
VIF variance inflation factor  
VLBW very low birth weight  
WHO World Health Organization

## Definitions

**Adequacy of prenatal care utilization:** determined from Kotelchuck's *Adequacy of Prenatal Care Utilization (APNCU) Index* which is based on the number of antenatal visits the mother attends, the trimester prenatal care begins, and the infant's gestational age at birth (1)

**Adequacy of weight gain during pregnancy:** based on the following Health Canada recommendations (2):

<b>Pre-Pregnancy Body Mass Index</b>	<b>Recommended Weight Gain (kg.) During Pregnancy</b>
<b>&lt;18.5</b>	12.5-18.0
<b>18.5-24.9</b>	11.5-16.0
<b>25-29.9</b>	7.0-11.5
<b>≥ 30</b>	5.0-9.0

**Antepartum morbidity:** a composite variable comprised of pregnancy induced hypertension, gestational diabetes either insulin dependent or non-insulin dependent, anemia, intrauterine growth restriction, viral disease, infection and parasitic disease, placenta previa without hemorrhage, polyhydramnios or oligohydramnios, antepartum hemorrhage  $\geq 20$  weeks, sexually transmitted infection, or HIV, or premature separation of the placenta

**Body mass index:** a ratio of pre-pregnancy weight (kg) /height (m); underweight  $<18.5$ , normal weight 18.5-24.9, overweight 25-29.9, and obese  $\geq 30$

**Chronic low SEP:** women who delivered multiple times during the study period and received MSP premium assistance during more than one delivery year

**Extended length of stay:**  $\geq 3$  days for a vaginal delivery and  $\geq 4$  days for a caesarean delivery

**Large-for-gestational-age:** birth weight greater than the 90th percentile, as per Kierans and colleagues' sex specific, B.C. population birthweight charts (3)

**Local health area:** geographic regions classified by the B.C. Ministry of Health; combined areas form health service delivery areas, and Health Authorities

**Local health area income inequality rank:** determined by B.C. Stats, rankings created by dividing a local health area's total household earnings for individuals earning less than the median income, by total household earnings for all residents (4)

**Local health area socioeconomic rank:** an index calculated by B.C. Stats, based on a wide range of social determinants of health reflecting area-level economic and social processes, and policy decisions (5)

**Low Apgar score:** Apgar score less than seven at one minute

**Low birth weight:** birth weight less than 2,500 grams

**Low socioeconomic position:** based on low income, determined by receipt of B.C.'s Medical Services Plan regular premium subsidy assistance for the mother's household during the year of delivery

**Medical risk (controlled variable):** a composite variable comprised of maternal disease of the respiratory or digestive system, and endocrine, nutritional, or metabolic disease

**Mental illness/disorder:** anxiety disorder, depression, postpartum depression, bipolar disorder, schizophrenic disorders, mood disorders, psychotic disorders, phobic anxiety, obsessive-compulsive disorders, and reaction to severe stress and adjustment disorders, or other or unknown mental illness

**Neighbourhood SEP:** determined by calculating the average, single-person income in a Canadian census dissemination area (approximately 400 to 700 people), and assigning each individual a ranking according to their residential postal code

**Northern residence:** usual maternal residence in the Northern Health Authority, determined by residential postal code

**Preterm birth:** less than 37 weeks completed gestation

**Prior obstetric risk (controlled variable):** a composite variable comprised of at least one of the following conditions in past pregnancy: major congenital anomaly, neonatal death, stillbirth, or 1 preterm delivery

**Rural local health area:** LHAs with a population less than 10,000 people (as of 2009), and not part of a census metropolitan area or a census agglomeration

**Small-for-gestational-age:** birth weight less than the 10th percentile, as per Kierans and colleagues' sex specific, B.C. population birthweight charts (3)

**Substance use:** heroin/opioids, cocaine, methadone, solvents, marijuana, or other/unknown drugs used at any time during pregnancy, or prescription or other drug use identified as a risk at any time during pregnancy



**Transient low socioeconomic position:** women who delivered multiple times during the study period but received MSP premium assistance during only one delivery year

**Urban local health area:** LHAs with equal or greater than 10,000 residents (as of 2009), or those in a census metropolitan area or a census agglomeration

## Chapter 1 Background and Rationale

### 1.1 Introduction

In high resource countries there are significant disparities in prevalence of adverse infant birth outcomes, such as small-for-gestational-age birth (SGA) and preterm birth (PTB) among infants born to women of low versus high socioeconomic position (SEP).(6) SEP demarcates social class based on material and social resources, (i.e. wealth and educational credentials), and prestige (i.e. occupation or other measures of social rank).(7) Women experiencing low SEP face material deprivation, directly impacting their and their infant's health through diet, housing, and environmental factors. These women also contend with social deprivation, such as limited social inclusion which curbs employment, community, recreation and educational opportunities.(7) When economic and social barriers consistently lead to adverse health outcomes for historically marginalized populations, such as women of low SEP, health disparity reflects social injustice.(8) Therefore, based on the principles of fairness and the universal human right to "the highest attainable standard of health",(9) there is an ethical imperative to investigate and rectify avoidable maternal and infant health disparity.(8)

Low SEP is an established predictor of PTB and SGA in Canada and other high resource countries.(6, 10) In a Quebec retrospective cohort study (n=825,349) which examined birth certificate data (1991-2000) linked with socioeconomic data from Canadian censuses, researchers found that women in the lowest neighbourhood income quintile were 1.14 times more likely to deliver a preterm infant (95% CI: 1.10-1.17) and 1.18 times more likely to have a SGA infant (95% CI: 1.15-1.21) compared to women in the highest income quintile.(11) For women who did not complete high school, compared to women who completed community college or attended some university, the odds of having a PTB was 1.48 times greater (95% CI:1.44-1.52) and the likelihood of a SGA birth was 1.86 times greater (95% CI:1.82-1.91). These results coincide with those of a retrospective cohort study examining birth data from 1988 to 1995 in Nova Scotia. Analyzing cases in the Atlee Perinatal Database (n=92,914), linked with federal income tax records provided by Statistics Canada, researchers found that the lowest

family income group had an adjusted relative risk of 1.34 for SGA birth (95% CI: 1.18-1.53) compared to women from the highest income group.(12) Internationally, research results paint a similar picture of infant health disparities based on maternal SEP. In a systematic review by Blumenshine et al., 93 out of 106 studies investigating the relationship between low SEP and adverse birth outcomes reported a significant association, including 11 Canadian, 36 European, 50 U.S., and nine studies from other countries.(6)

Persistent low SEP across the life course has been shown to influence adverse infant birth outcomes to a greater degree than transient low SEP, as demonstrated in longitudinal studies. In a 10 year study based on the *National Longitudinal Survey of Labor Market Experience of Youth*, conducted in the U.S., infants born to White women (n=2,440) who had a household income below the federal poverty rate during the year of birth were 80% (adjusted odds ratio (AOR) 1.80, 95% CI: 1.17-2.76) more likely to be LBW than those born to White women above the poverty level.(13) However, when researchers took into account low income during the previous five to 10 years before delivery, the relative risk of having a LBW infant was 3.3 times higher for impoverished White women compared to similar women who had not experienced long-term poverty.

Causes of spontaneous PTB, and SGA appear to be multifactorial with only a few individual-level, modifiable risk factors identified. Yet, women of low SEP are more commonly exposed to these known causal determinants compared to women of higher SEP, including: smoking, substance use, low gestational weight gain, short stature, prolonged standing and strenuous work activity, inadequate prenatal care, bacterial vaginosis, and psychological factors such as depression, physical abuse and low social support.(14) In a Manitoba case-control study utilizing a structured questionnaire and health records, 220 cases and 458 controls were recruited during their postpartum hospital stay to investigate risk factors for spontaneous PTB among Aboriginal and non-Aboriginal women.(15) Researchers found that women reporting inadequate prenatal care were more than twice as likely to experience preterm delivery (OR 2.44, 95% CI: 1.08-5.52) compared to women reporting adequate prenatal care, with no significant difference in effect among Aboriginal vs. non-Aboriginal women.

## 1.2 Population-Level Effects of Inequity

At a population level, higher rates of adverse infant birth outcomes among the socially disadvantaged result in increased prevalence of short and long-term disability and disease and inflated health care expenditure. Statistics Canada identifies “short gestation and low birth weight” as second only to congenital anomalies in the leading causes of infant mortality in Canada.(16) Immediate and long-term morbidity often accompany PTB, as the last several weeks of gestation involve critical fetal development, including 35% of brain growth.(17) At birth, SGA and PTB infants are at greater risk of respiratory distress, failure to regulate temperature, and hospital readmission.(18-20) Long-term, these infants have higher rates of delayed cognitive, emotional, and developmental growth compared to those born at full-term (21) and as adults may have increased odds of cardiovascular disease, hypertension and diabetes.(22, 23)

In Canada, singletons born at less than 37 weeks gestation incur, on average, nine times the hospital costs of full-term infants.(24) Likewise, newborns weighing between 1500-1999 grams, on average incur approximately \$20,000 in hospital costs compared to \$1,000 for infants weighing 2,500 grams or more.(24) In an analysis of Canadian birth data (excluding Quebec) from 2006-2007, the Canadian Institute for Health Information (CIHI) reported SGA prevalence of 9.9% (95% CI: 9.6-10.1) for singletons born to mothers residing in neighbourhoods with the lowest average income, compared to 7.1% (95% CI: 6.8-7.3) for infants born to mothers from neighbourhoods with the highest average income.(24) Discrepancies in newborn outcomes such as this suggest the socioeconomic gradient has significant public costs.

Because some of the causes and consequences of adverse infant birth outcomes associated with low SEP are potentially avoidable, strategies that promise even modest improvements in birth outcomes warrant serious consideration. In a Cochrane Review (2016) examining 15 randomized trials that compared midwifery-led continuity of care models to other care models for childbearing women (n=17,674), researchers found that midwifery care was associated with a reduction in the likelihood of preterm birth by 24% (relative risk (RR) 0.76, 95% CI: 0.64-0.91) and fetal/neonatal death by 16% (RR 0.84, 95% CI: 0.71-0.99).(25) If these findings are equally applicable for women of low SEP, whose infants are at the greatest risk of adverse outcomes, midwifery-led care may be an ideal model for women with vulnerabilities.

### 1.3 Model of Care

Often, physician-led care is informed by a biomedical model of care. In this model the aim of prenatal care is to reduce the risk of maternal and fetal/infant morbidity and mortality through screening, diagnosis and treatment of complications as they arise.(26) In practice, pregnancy is approached as a medical process, parturient women are viewed as patients, and childbirth is planned exclusively in an institutional setting.(26) The biomedical model assumes a standardized approach to pregnancy and childbirth, with deviations from the norm often countered through medical intervention.(27) Although family-centered maternity care is encouraged within the biomedical model,(28) the model is shaped by pathology (29) and a positivist, empirical, medical paradigm.(30) The influence, however, of the biomedical model on clinical practice varies between individual practitioners and physician-types. For example, when caring for women with normal, healthy pregnancies, family practitioners have been shown to have significantly lower rates of medical intervention, including induction and/or augmentation with oxytocin (RR 95% 0.83, CI: 0.77-0.89), caesarean delivery (RR 0.77, CI: 0.63-0.93),(31) and episiotomy (OR 0.47, 95% CI: 0.41-0.55),(32) compared to obstetricians. This suggests that obstetricians' specialized training and expertise in management of high-risk pregnancy may also influence their approach to lower risk pregnancy.

In contrast to the biomedical model, midwifery care specifically focuses on preserving the mother's "social, emotional, cultural, spiritual, [and] psychological" well-being, as well as addressing the "normal physiologic process" of pregnancy and birth.(33, p1) Core elements of the Canadian model of midwifery care are informed choice, and continuity of care provider, in which a midwife known to the women is available on call 24 hours a day, seven days a week.(34) Another key feature of midwifery care is empowerment of women as partners in health care,(33) requiring mutual trust, and regard for the "woman's need for time, information, encouragement, validation and a supportive presence".(35, p10) To this end, Canadian midwives use the non-medicalized term, "client" to refer to women in their care, "to emphasize that women are the primary decision-makers".(36) In the midwifery model long appointment times, between 30 to 60 minutes, facilitate the development of meaningful clinician-client relationships and allow midwives to provide individualized care. This creates an opportunity for midwives to be responsive to the contextual factors shaping clients' clinical profiles and health seeking behaviors (37) including the degree of personal autonomy, access to material and social

resources, and individual abilities they possess.(38) Continuity in care provider and personalized care allow a woman to feel that her prenatal caregiver knows and remembers her and her health history from one visit to the next, aspects of care that have been shown to result in a three-fold increase in “very good” patient care ratings.(39) This is especially important for women of low SEP who have reported lower levels of satisfaction in care compared to women of higher SEP.(40) In addition, for low income women, practitioner continuity has been linked with practitioner-patient trust, a characteristic of care that has been found to improve patients’ adherence to clinical advice.(41) All of these elements of care: time, trusting relationship, and individualized care, along with emotional support, and the de-medicalization of pregnancy, have been identified as key attributes of quality prenatal care by women and care providers of all types.(42)

Having made a distinction between physician and midwifery models of care, it is important to note that in practice, models of care lie on a continuum.(26) The attributes of midwifery care described above are not exclusive to the midwifery profession, it is a clinician’s philosophy of care that determines their model of practice.

Table 1.1: Mechanisms by Which the Midwifery Model of Care May Mitigate Adverse Infant Birth Outcomes for Women of Low SEP

<b>Risk Factors for Adverse Birth Outcomes for Women of Low SEP</b>	<b>Risk Mechanisms</b>	<b>Midwifery Care May Reduce Risk By . . .</b>
<b>Absolute Poverty (43) &amp; Relative Poverty (44-46)</b>	Smoking, inadequate nutrition, chronic hypertension, anemia,(47-50) low self-esteem, poor self-efficacy (51)	Allowing long appointment times and practitioner continuity (52) to assess the need for social services or other referrals, increasing patient disclosure
<b>Low Neighbourhood SEP (11)</b>	Environmental hazards,(51, 53-55) unhealthy social norms (53, 56)	Addressing the “social, emotional, cultural, spiritual, psychological and physical” determinants of health specific to the women in their care (33)
<b>Long-Term Poverty (13)</b>	Enduring stress (56, 57)	Reducing stress through continuity of care and 24/7 telephone access to a known midwife (34)
<b>Biological Susceptibility</b>	Infection,(115) the ‘weathering effect’ of long-term low SEP,(116) short maternal stature (14)	Providing personalized, holistic care, having an in-depth knowledge of a woman’s health and social history to address the associated risks (34)
<b>Low Social Support</b>	Depression, anxiety, stress,(57-59) lack of childcare/transportation (10)	Offering emotional, social and practical support, continual availability, home visitation (34)
<b>Stigmatization</b>	Disrespect, lack of autonomy in decision-making, dissatisfaction with care (60, 61)	Empowering women as primary decision-makers, engaging them in self-care,(33) encouraging self-efficacy, greater satisfaction in care(61)
<b>High-risk behavior (62-64)</b>	<i>In utero</i> exposure to harmful substances (47)	Providing accountability, motivational support, and referral, in a non-authoritarian manner (34, 65)
<b>Low Prenatal Utilization (66-68)</b>	Lack of preventative care, prenatal nutritional counselling (38, 69-71)	Reducing access barriers through an in-depth, trusting relationship (33)

Table 1.1 outlines risk factors for adverse infant birth outcomes for women of low SEP and possible mechanisms by which midwifery care may mitigate these risks. Despite evidence suggesting midwifery care could be an ideal fit in prenatal model of care for women of low SEP, this has yet to be scientifically established. To date there is only one Canadian study, and a small

number of current, moderate quality, international studies examining this relationship. Collectively these studies are inconclusive in determining whether midwifery care reduces the risk of adverse infant birth outcomes for women of low SEP because of heterogeneity in study design and analytical methods, combined with inconsistent findings (see Chapter 3 for a detailed discussion of the extant literature).

## 1.4 Purpose

The central purpose of this thesis is to determine if midwifery clients of low SEP have reduced odds of small or large-for-gestational-age birth, preterm birth, Apgar score less than seven at one minute, newborn extended length of hospital stay, or low birth weight, compared to general practitioner or obstetrician patients. This research is valuable as it contributes to the significant gap in knowledge of this largely undocumented topic. Moreover, the results of this research have the potential to inform midwifery and health-equity policy and programming development. It provides decision-makers and maternity practitioners of all types with a current, high quality, population-level assessment of this association, specific to the Canadian context. This information is critical in the evaluation of strategies that are effective in reducing infant morbidity for vulnerable populations. These findings may have implications that practically impact individual maternal infant health, and population-level health equity in high resource countries.

The objective of this thesis is to answer the following questions:

**Research Question 1:** According to the current literature, are midwives' clients of low socioeconomic position at greater, equal, or lesser risk of adverse infant birth outcomes compared to physicians' patients?

**Hypothesis 1:** According to the current literature, midwives' patients of low socioeconomic position are at less risk of adverse infant birth outcomes compared to physicians' patients.

**Research Question 2:** Are the odds of SGA birth or other adverse infant birth outcomes significantly less for women of low SEP with low to moderate medical and obstetric risk, who receive antenatal care from midwives versus general practitioners or obstetricians?

(a) Do individual or community-level characteristics of vulnerability modify the relationship between model of care and SGA birth or other adverse infant birth outcomes?



(b) Do women with *multiple*, intersecting vulnerabilities have less odds of having a SGA infant, or other adverse infant birth outcomes, if in the care of midwives versus general practitioners or obstetricians?

**Hypothesis 2:** Women with low SEP who receive antenatal midwifery care are less likely to have SGA infants, or other adverse infant birth outcomes, compared to those who receive antenatal care from general practitioners or obstetricians, controlling for maternal and environmental characteristics.

**Hypothesis 2a:** In addition to low SEP, women with a reported individual or community-level characteristic of vulnerability have even less odds of SGA birth or other adverse infant birth outcomes, if they receive antenatal care from midwives, compared to general practitioners or obstetricians.

**Hypothesis 2b:** In addition to low SEP, women with multiple, intersecting vulnerabilities have even less odds of SGA birth or other adverse infant birth outcomes if they receive antenatal care from midwives, compared to general practitioners or obstetricians.

**Research Question 3:** Is the relationship between model of care and adverse infant birth outcomes modified by duration of low SEP?

**Hypothesis 3:** Women of chronic low SEP have less odds of SGA birth or other adverse infant birth outcomes than women of transient low SEP, if they receive antenatal care from midwives versus general practitioners or obstetricians.

## **1.5 Organization of the Thesis**

My thesis is organized into seven chapters beginning with an introductory section that explains the background, rationale, objectives, conceptual approach, and theory for the research. This is followed by a systematic scoping review, answering the first research question. The following chapter describes the methods used to answer research questions two and three. Next, results for the two cohort studies are presented in two separate chapters, and the thesis ends with a chapter devoted to a general discussion and conclusions.

The first chapter explains the importance and aim of the thesis. Chapter two defines pertinent terms, and explains the theory guiding the study design, analysis, and interpretation of results. This chapter also explains why I have selected specific covariates and measures, as per the literature describing their relationship to the outcomes of interest.

Chapter three describes the first study, a scoping review of midwifery-led versus physician-led care for vulnerable women. This review was conducted by a seven-person team, based on methods developed by Arksey and O'Malley, and a quality assessment utilizing the *Effective Public Health Practice Project Quality Assessment Instrument*. The search strategy included all relevant citations in 12 journal databases, six grey literature databases, and a hand search in four journals. This chapter provides a comprehensive overview of all moderate quality, relevant studies conducted in the last 25 years in high resources settings; useful in situating my research in relation to the larger body of literature on this topic.

In chapter four I report on the methods employed for research questions two and three, including the inclusion/exclusion criteria, data sources, analysis plan, and ethical considerations. Chapter five reports on the results and interpretation of study two, a population-level, retrospective cohort study investigating the association between model of care and adverse infant birth outcomes for women of low SEP in the care of midwives versus general practitioners or obstetricians. This study utilized eight years of provincially collected data supplied by Perinatal Services B.C. and supplemented with socioeconomic data from the Ministry of Health, Population Data B.C., and B.C. Stats. Various intrapersonal and interpersonal co-variates were tested as potential confounders in the models, and characteristics of vulnerability (i.e. mental illness/disorder and/or substance use) were examined as effect modifiers.

In the sixth chapter I explain the effect of duration of low SEP on the relationship between model of care and adverse infant birth outcomes. Results were stratified by chronic and transient low SEP, measured at a household level. Chapter seven provides a general discussion and interpretation of the three studies, synthesizing the results. The chapter ends with a discussion of the implications for future policy, practice, and research.

## **Chapter 2 Conceptual Approach and Theory**

In this chapter I explain the theories used to develop studies two and three. Further, I define the independent and dependent variables that are analyzed in these studies and describe what is known about the relationship between them, to provide a rationale for why they were chosen and why they were measured as they were.

### **2.1 Population Health Approach**

The research questions I examined in this thesis were designed and analyzed from a population health approach. The aim of this approach is to decipher, in and between populations, determinants which shape the systematic distribution of health and disease, to ultimately improve the health of whole populations and reduce health disparities.(72-74) As explained in the *Ottawa Charter for Health Promotion*, health is understood as “social and personal resources and physical capabilities” (75, p1) dependent upon income, social environment, child development opportunities, working conditions, gender, and other social determinants.(72) A population’s social structures and values influence individual health across the life course, and shape the distribution of health at a population-level. Gradients exist in all of the major health domains,(76) reflecting social and economic hierarchies, and are apparent nationally and internationally.(77) Health gradients are consistent over time, and persist regardless of advances in health care accessibility or gains in national income,(78-81) therefore it is important (and in some instances even more illuminating) to examine a broad spectrum of social characteristics in conjunction with individual risk factors.(82)

### **2.2 Intersectionality Theory**

Intersectionality theory adds another layer of complexity to a population health approach by acknowledging that the social determinants of health are rarely experienced one at a time but

rather reinforce each other and are therefore experienced in clusters.(53) Health inequity is the product of multiple factors intersecting along lines of social position and experience, as well as via power differentials.(83) The term ‘intersectionality’ was first introduced in 1989 by law professor Kimberlé Crenshaw, in an article critiquing “antidiscrimination doctrine, feminist theory and antiracist politics” which, she argued, had failed to account for African American women’s experiences of marginalization because of their focus on single aspects of identity. As she explained, when feminist theory addresses sexism from a white women’s experience, and racism is conceptualized from a male perspective, “Black women are theoretically erased” from the discourse.(84, p139) This type of error is inevitable when social categories are examined solely from the perspective of those in the most privileged positions within each category. By exploring the interaction between multiple sources of disadvantage (generally more reflective of lived experience), a more nuanced understanding of the relationship between discriminated identities and outcomes of interest can be detected, and sub-group differences identified. Also, because multiple sources of marginalization can affect the magnitude and nature of an individual’s social experience, analysis that simply adds established risk factors to an explanatory model, without exploring how each characteristic modifies the other, may obscure the true nature of the relationships.(84)

Unlike most theories, which are comprised of a logically related set of propositions used to describe a phenomenon,(85) intersectionality theory offers a general collection of assumptions, applied in various ways by researchers from a number of disciplines.(86) Three guiding principles of intersectionality theory include directionality, simultaneity, and multiplicativity.(86) Directionality pertains to the assumption that marginalized individuals will experience poorer outcomes than those who are more advantaged. Simultaneity concerns the indivisibility of one’s identity implying that analysis should incorporate multiple dimensions of identity, in part to avoid categorical oversimplification which can generate results inapplicable to anyone.(87) In addition, although identity influences outcomes, not all sources of disadvantage have equivalent implications within society nor are all parts of one’s identity equally influential in shaping outcomes. Intersectionality theory helps to generate hypotheses useful in delineating aspects of identity which are particularly salient for targeted outcomes.(86) Multiplicativity relates to the “multiple jeopardy” (88, p53) generated from intersecting positions and levels of social marginalization.(86) Individuals experiencing various forms of discrimination, due to

differing aspects of their identity that are socially stigmatized (i.e. a substance using, single mother, on social assistance), may be at greater risk of poor health outcomes, and the type of poor outcomes may differ, compared to those experiencing a fewer number of vulnerabilities. Analysis of the interaction between various social positions and experiences can help in accurately understanding how layers of vulnerability create new experiences of disadvantage, and in turn, unique health outcomes.(89)

The Canadian Research Institute for the Advancement of Women has developed the following diagram (see Figure 2.1), to illustrate how social inequities are formed through the intersection of various multi-level factors. Unique circumstances of power, privilege and identity at the individual level (level 1, center of the circle) are influenced by personal attributes and experiences (level two), which in turn are impacted by discriminatory social attitudes (level three).(90) At a macro-level, a variety of structural forces are influential in preventing or contributing to inequity through policy and practice that either deconstruct or contribute to oppressive social norms (level four).(83) From an intersectionality perspective, improvements in health equity require change in policies and practices at the macro-level (level four) in order to spark a domino effect, in which individual circumstances may be improved.

In relation to this study, the health care system and in particular antenatal models of care fit within the outer layer of the circle as structural components. Although no data were available to directly measure the impact of discriminatory attitudes, as outlined in the third level, interactions between multiple, stigmatized social positions and antenatal models of care were examined in relation to age, social status, neighbourhood locale, life experience (substance use, receipt of social assistance), and disability (mental illness/disorder). I chose these variables because they allowed an examination of the intersection between different categories of discrimination (ageism, classism, ableism), and I hypothesized that the midwifery model, with its emphasis on personalized, holistic care, would best mitigate risk associated with all types of discriminated social identity.



Figure 2.1: CRIA W Intersectionality Wheel (90)

### 2.3 Defining Low SEP

Key to understanding how marginalized social identity impacts health status is an understanding of “socioeconomic position”. The concept of SEP is theoretically grounded in Karl Marx and Max Weber’s social theories.(91) Marx maintains that the individual is shaped by their economic ties as either an exploiter or one who is exploited. Unlike those who possess the “means of production” and reap the benefits of surplus production, workers will always be in an inferior economic and social position creating conflict between the classes.(91) Societal structures produce and propagate this inequity, borne of circumstances beyond the exploited

worker's influence. Max Weber's theory includes social class alongside other ranked factors such as education, occupation and income to explain social relations. He holds that those who are similarly positioned will likely have similar opportunities in life. From this view, opportunities for advancement are created when individuals are able to successfully exchange skills and abilities in the marketplace for improved social standing. Weber differs from Marx in his understanding of the individual's ability to initiate change in social position as opposed to being at the life-long mercy of birth circumstances.(91-93)

Both theories contribute to a modern day understanding of SEP in relation to health equity. They suggest that social relations are largely circumscribed along economic lines. Economic standing influences lifestyle and behavior and defines a group's status within the larger society. Further, wealthier groups control more of society's resources and manage them in a way that serves their interests, but often is detrimental to the health of disadvantaged groups. There are echoes of Marx and Weber in the population health approach and in intersectionality theory, with their ideas underpinning the notion that systematically unequal societal structures contribute to inequity in exposures and therefore unequal risk of disease and illness experienced by differing socioeconomic groups. Although SEP is often measured at an individual level, it is based on social rank, determined by inter-group societal relations.(91) In contrast, socioeconomic status (SES) describes resource discrepancy between groups and/or individuals "without necessarily attributing any causal connection between the status of one individual vis-à-vis another".(94, p23)

#### **2.4 Pathways to Poor Birth Outcomes for Women of Low SEP**

As a result of the social and economic limitations which parturient women of low SEP experience, they are often exposed to intrapersonal and interpersonal risk factors associated with poor birth outcomes, including: anxiety,(95) depression,(58) teen pregnancy,(96) low pre-pregnancy BMI or low weight gain during pregnancy (47, 65) low education,(11) smoking during pregnancy,(97) exposure to second-hand smoke,(98) alcohol or substance use,(63, 99) and lone parent status.(100) According to a social causation perspective,(101) many of these characteristics and behaviours are socially patterned, the product of political and socioeconomic conditions.(102) From an "ecosocial" viewpoint, the complex interaction between individuals and their social and physical environment is thought to potentially contribute to a biologically

“embodied” susceptibility to poor health outcomes for individuals of low SEP by shaping genetic expression.(102, p672) In the following sections these and other hypotheses are explored suggesting differing biological, psychosocial, and behavioural mechanisms, as well as pregnancy characteristics (although these categories are neither exclusive nor exhaustive), linking low SEP to adverse infant birth outcomes.

## **2.4.1 Biological Risk**

Biological risk factors that increase the likelihood of adverse infant birth outcomes for all women, include adolescent maternal age or older maternal age ( $\geq 35$  years old),(103, 104) nulliparity,(105) medical risk or prior obstetric risk,(106-109) high or low prenatal BMI, weight gain above or below the recommended amount during pregnancy,(32, 47, 65) inadequate prenatal care,(110) caesarean delivery,(111) infant sex,(112, 113) and chronic stress.(50, 114)

### **2.4.1.1 Medical Risk and Prior Obstetric Risk**

Maternal medical conditions such as asthma, thyroid disease, hepatitis, or HIV, can complicate pregnancy and may have serious consequences on infant birth outcomes.(106-109) Similarly, having a history of obstetric complications, such as previous preterm delivery or IUGR, and significant antepartum complications (i.e. pregnancy induced hypertension or gestational diabetes) can pose a risk to fetal/infant health.(50, 114) In most instances, there are higher rates of these conditions among women of low SEP compared to women of higher SEP.(115-117) Some of this disparity can be traced to higher risk behaviours for women of low SEP, such as greater physical inactivity, inadequate vegetable and fruit consumption,(117) higher prevalence of overweight BMI, smoking, substance use/abuse, and inadequate gestational weight gain during pregnancy.(14) However, social values and norms, built environment, and macro-level environmental factors, such as government policy, play a vital role in shaping individual health behaviours. For example, fewer recreational resources (118) and less healthy, affordable food options in low income neighbourhoods, compared to higher income neighbourhoods, have been shown to contribute toward prevalence of obesity,(119, 120) a disease-inducing condition. Similarly, greater prevalence of sexually transmitted infection (STI), including HIV, among women of low SEP has been attributed to migration resulting from unemployment, incarceration, and residential and marital instability.(121) These factors often disrupt sexual networks,



potentially increasing an individual's number of lifetime sexual partners, thereby increasing the risk of exposure to STIs.

#### **2.4.1.2 Pre-Pregnancy BMI and Weight Gain in Pregnancy**

Pre-pregnancy BMI and inappropriate weight gain in pregnancy have been associated with both poor infant outcomes and low SEP. In a recent systematic review investigating SES and obesity, 63% of the associations linked low SES with higher body size.(122) In explaining this disparity, the authors point to the lower consumption of nutritious food among those of low SES, due to high cost and access barriers, and fewer opportunities for physical activity (both at work and at home). Others have suggested that the disparity in obesity between individuals of high and low SEP may be due to nutritional deprivation in utero, which might permanently affect metabolism regulation, causing the body to store excess fat regardless of food availability.(123, 124)

Parturient women who are overweight or obese face greater risk of preeclampsia, gestational diabetes, and cesarean section delivery, than those of normal weight.(32) Infants born to women with high pre-pregnancy BMI, or to women who gain more weight during pregnancy than that recommended by Health Canada, are at higher risk of having an infant that is LGA and/or has macrosomia, with risks increasing in a dose-response fashion.(32, 125, 126) Low gestational weight gain also increases neonatal risk, namely odds of IUGR,(125) PTB, SGA birth, or LBW, compared to normal gestational weight gain.(126) Canadian women with low SEP appear to be overrepresented amongst those with high or low gestational weight gain. As reported in the Canadian *Maternity Experiences Survey* (MES), women who gained excessive gestational weight were more likely to be single, have less than high school education, and be in the lower-middle or middle income group, compared to women with weight gain within the recommended range.(127) Likewise, women reporting low weight gain during pregnancy were more likely to be immigrants, have smoked during the last three months of pregnancy, have an unplanned pregnancy, and/or have experienced health problems during pregnancy.

A recent study, utilizing Canadian data from the MES, highlights the potential for prevention of PTB, SGA and LGA when lifestyle factors are moderated.(128) Calculating the population attributable fraction (PAF), researchers found that 18.2% (95% CI: 17.8-18.7) of the prevalence of PTB could be attributed to excess gestational weight gain, an even greater

proportion than what is attributable to smoking during the third trimester (PAF 3.2, 95% CI: 3.0-3.3). As well, 15.9% of LGA births (95% CI: 15.4-16.3) could be avoided if excess gestational weight gain was entirely prevented. For SGA, 9.2% (95% CI: 9.0, 9.4) of the disease burden was attributed to low gestational weight gain, and 8.7% to smoking (95% CI: 8.6, 8.8).

In a systematic review and meta-analysis (n=96) studying major risk factors for stillbirth in high-income countries, reviewers found that overall, compared to normal pre-pregnancy weight, maternal overweight (*five studies*) and obesity (*four studies*) were the most influential, modifiable risk factors for stillbirth.(129) The population attributable risk was approximately 8% to 18% across the five study countries (Australia, Canada, U.S., U.K., and the Netherlands). In comparison, the population attributable risk for smoking was between 4% and 7% in the five countries investigated, but the authors estimated it could be as high as 20% for disadvantaged populations because of higher smoking prevalence.

### **2.4.1.3 Chronic Stress**

Based on an overview of prospective, population-based studies, employing varying designs and methods over the last 25 years, Wadhwa and colleagues estimate that women who report high levels of psychosocial stress have an approximate 25% to 60% increased risk of PTB compared to women who report low stress levels.(57) Women with low SEP are exposed to multiple material and psychosocial stressors related to their status, including poor housing conditions, food insecurity, lack of transportation, powerlessness, domestic violence, discrimination, negative interpersonal relationships, and social exclusion.(65, 101, 130, 131) Maternal chronic prenatal stress is thought to affect birth outcomes through the interaction of two physiological mechanisms: altered maternal neuroendocrine regulation and compromised immune function.(132, 133) Stress appears to stimulate the release of cortisol which, at high levels and over time, may decrease the normal functioning of the hypothalamic-pituitary-adrenal (HPA) axis, a critical regulator of metabolism and stress response.(123) Abnormal endocrine signaling, due to heightened cortisol exposure, may damage the maternal cardiovascular, immune and central nervous system, as well as disturbing metabolic and brain functions, increasing the risk of illness and disease.(55, 134) In the fetus, dysregulation of the HPA axis due to high cortisol exposure during critical or sensitive periods of development may permanently alter patterns of gene expression, increasing the risk of obesity in later life, and

inducing high stress reactivity.(123, 124) Individuals with high stress reactivity, when faced with a stressor, are subject to abnormally high increases in cortisol, followed by a slower than average decrease, compounding the potential for neuroendocrine dysfunction.(124)

In addition when cortisol, as well as other stress associated hormones (corticotropin-releasing hormone (CHR), and adrenocorticotrophic hormone), are released into the maternal-placental-fetal system, they may stimulate the production of pro-inflammatory cytokines (proteins involved in cell communication),(133) potentially triggering the release of prostaglandins prior to term, which can cause uterine contractions and the risk of preterm labour or premature rupture of membranes.(133) Further, high corticoid levels may decrease the normal production and response of lymphocytes (cells involved in immune response), to pro-inflammatory cytokines, increasing susceptibility to inflammation and infection, an established risk factor for PTB.(133)

These physiological adaptations may explain why researchers have found parturient women experiencing high stress to be more than twice as likely to have bacterial vaginosis, compared to women with lower stress levels.(135) In a cross-sectional prevalence study, pregnant women at approximately 14 weeks gestation (n=454) who reported moderate and high levels of stress, measured on the *Cohen Perceived Stress Scale*, were between 2.3 and 2.2 times (95% C.I. 1.2-4.3; 95% CI: 1.1-4.2) more likely to be clinically diagnosed with bacterial vaginosis than women reporting low stress, after adjustment. Bacterial vaginosis occurs when the normally abundant lactobacillus flora in the vagina is diminished and pH rises, due to excess growth of anaerobic organisms normally present in the vagina in small quantities.(136) Bacterial vaginosis is the most frequently reported lower genital tract infection occurring among women of childbearing age in the U.S.(137) In a meta-analysis pooling adjusted odds ratios from seven studies conducted in the U.S., Australia, and Indonesia, bacterial vaginosis was shown to increase women's odds of PTB by 60% (OR 1.60, 95% CI: 1.44-1.74), compared to uninfected women.(138)

Additionally, an association has been found between stress and an elevated risk of hypertension and preeclampsia,(139) leading causes of elective preterm delivery. In a post-delivery, hospital based case-control study (n=4,314), utilizing medical records and a questionnaire, researchers found more than a two-fold increase in odds of preeclampsia for women reporting high lifetime stress (OR 2.1, 95% CI:1.6–2.8), and a 1.7 increase in odds of

preeclampsia for women reporting high perceived stress during pregnancy (OR 1.7, 95% CI: 1.3–2.1).(139)

## **2.4.2 Psychosocial Risk**

### **2.4.2.1 History of Depression, Anxiety and Other Mental Disorders/Illnesses**

Mental health disorders are inversely associated with SEP (140-142) and increase the likelihood of poor birth outcomes.(143-145) In a large national study (n=10,108) conducted in Great Britain, researchers linked residential postal sectors stratified by SES, with data derived from *Revised Clinical Interview Schedule* questionnaires, to investigate the association between SES and neurotic disorder. They determined that the prevalence of neurotic psychiatric disorder (which included conditions such as panic disorder, depression, anxiety, social phobia, and obsessive-compulsive disorder) was significantly less for those belonging to social class I, the highest class, compared to those in classes II through IV. There were increases in prevalence mirroring the social gradient in every class with the exception of social class V, in which neurotic disorder had a borderline association with social class (AOR 1.42, 95% CI: 1.00-2.01). In addition, lone parent status (AOR 1.74, 95% CI: 1.41-2.16) and unemployment (AOR 1.64, 95% CI: 1.39-1.93), characteristics more prevalent among individuals of low SEP, were strongly associated with neurotic disorder.(146)

Anxiety and mood disorders are both stress inducing,(58) and exacerbated by stress, which may explain the physiological pathway between less severe mental illness and adverse infant outcomes. In a 2009 systematic review of studies from the U.S., Canada, Denmark, Israel, and South Korea, investigating the association between maternal stress, depression, anxiety, cortisol levels, and PTB, the majority of the 15 studies identified a significant association.(147) Medication used to treat depression and anxiety may also mediate the relationship between these conditions and adverse infant birth outcomes. In a study utilizing population health records, depressed mothers taking serotonin reuptake inhibitor antidepressants (n=817) were matched, using propensity scoring, to mothers untreated for their depression (n=805).(148) For mothers taking antidepressants, risk of having a preterm infant (Risk Difference (RD) 0.033, 95% CI: 0.007- 0.059), or an infant with respiratory distress (RD 0.044, 95% CI: 0.013-0.077), was significantly greater than for mothers who were untreated for their depression.

For women living with schizophrenia, studies show greater prevalence of obstetric complications such as antenatal bleeding, preeclampsia, diabetes and rhesus incompatibility, and at delivery, greater likelihood of emergency cesarean sections, uterine atony and infant asphyxia.(149) Additionally, infants born to mothers with schizophrenia are at greater risk of low birth weight (LBW) and congenital anomaly. Mental illness may indirectly affect birth outcomes by diminishing parturient women's motivation for self-care, impacting nutritional habits, prenatal utilization, and follow-through on clinical advice.(58, 150) Moreover, women with mental illness may self-medicate with tobacco, alcohol, and illicit drugs, increasing their risk of adverse infant birth outcomes. In a Swedish, population level retrospective cohort study (n=155,071) examining birth outcomes of women living with schizophrenia, researchers noted a significant difference ( $p < .0001$ ) between smoking prevalence for mothers with schizophrenia compared to those without schizophrenia (51% vs. 24%), which appeared to contribute to their inflated risk of adverse infant birth outcomes.(151) However, even after adjustment for smoking status, risk of LBW (OR 1.4, 95% CI: 1.1-1.8) and PTB (OR 1.5, 95% CI: 1.2-2.0) remained significantly greater for women with schizophrenia.

#### **2.4.2.2 Low Social Support**

Low social support has been identified as a risk factor for adverse infant birth outcomes, while adequate social support is closely associated with “good health” ratings.(152) It is hypothesized that social support effects emotional wellbeing and mood, in turn influencing behaviour and shaping health outcomes. The positive association between social support and health has been demonstrated in a number of perinatal studies, as has the negative impact of single parent status, a suspected proxy of relatively low social support.(153) In a study by Muhajarine et al., researchers found that single mothers residing in neighbourhoods with high social disconnection had higher odds of delivering LBW infants, compared to similar women living in neighbourhoods of lower social disconnection (OR 1.57, 95% CI: 1.18-1.93).(154) The researchers cited “social processes that enhance neighbourhood connectedness, trust and efficacy” as the likely mechanisms improving infant health.(154, p133) Other authors have likewise suggested that “social integration and collective efficacy”, in which neighbours are committed to acting in a way which benefits the group, may mitigate adverse birth outcomes by decreasing maternal stress and the associated risks.(51, p2)

For vulnerable women and their infants, social support in the form of home visitation, continual access to a care provider by phone, and nutritional and risk-behavior counselling has been shown to improve infant birth outcomes.(155, 156) Home visitation and phone support may reduce stress and high-risk behaviours by providing emotional and motivational support, and accountability. It may also improve prenatal care utilization by removing childcare or transportation barriers.(157) As part of a systematic review, a quantitative data synthesis of three U.S. trials (n=2,037), determined that women either at risk of delivering a LBW infant or of low income, who received telephone support from a health practitioner, had a 22% reduction in risk of LBW delivery compared to women receiving usual care (RR 0.78, 95% CI: 0.63-0.97).(157) Similarly, in a U.S. controlled trial (n=501), “socially disadvantaged women” randomized to receive bi-weekly home visitation to encourage healthy behavior, and to provide social and informational support, were 57% less likely to have a LBW infant than those not receiving home visitation (AOR 0.43; 95% CI: 0.21-0.89).(158) In addition, the risk of LBW was further reduced (AOR 0.32, 95% CI: 0.14-0.74) by early exposure to home visitation ( $\leq$  24 weeks gestation). Although the authors did not identify the specific mechanisms involved, it could be that greater contact with health practitioners allowed for early recognition of health complications, or that home visitation altered patient awareness and motivation, encouraging the pursuit of healthier behaviours.(159)

Despite these promising results concerning social support, they are in contrast to the results of numerous other experimental studies, and some observational studies, that have found no association between social support interventions and pregnancy outcomes.(159) In a 2010 Cochrane systematic review of 17 trials, researchers concluded that there was no evidence of a statistically significant association between interventions enhancing social support through emotional support (i.e. counseling or sympathetic listening), information, advice, or tangible assistance (i.e. childcare, transportation to prenatal appointments), and a reduced likelihood of LBW or PTB .(160) Yet, because of ambiguity in definition and measurement of “social support” it is plausible that research involving cohorts with different characteristics than those studied, or women exposed to different duration and intensity of support, type of support, support provider, or an interaction between these factors,(159) could produce differing results.

Strategies to improve adverse infant birth outcomes involving model of care have demonstrated a reduction in psychosocial risk for marginalized women. In a Calgary, Alberta

study the effect of the CenteringPregnancy model of prenatal care was examined in relation to psychosocial health.(161) The CenteringPregnancy model involves group clinical and educational sessions aimed at encouraging peer, relational support for women at similar stages of pregnancy coupled with professional education on pregnancy-related health topics and prenatal health assessments. Women enrolled in the CenteringPregnancy program (n=106) were compared to women receiving standard prenatal care plus prenatal education classes (n=619). The researchers found that although program participants had greater vulnerability due to poverty, language barriers, and significantly higher levels of depression, stress, and anxiety upon entry into the program, compared to the standard care study participants there was no significant difference in psychosocial health by four months post-partum. Program participants had higher rates of improved psychosocial health than those in the comparison group (improved depressive symptoms: 16.3% vs. 8.5%,  $p=0.017$ ; improved stress: 24.2% vs. 13.9%,  $p=0.017$ ; improved anxiety 22.1% vs. 8.7%,  $p<0.001$ ). These results suggest that model of prenatal care may be an important component in improving maternal infant health by decreasing some of the excess depression, stress, and anxiety marginalized women experience.

In another CenteringPregnancy study, model of care was associated with a reduction in PTB. A randomized controlled trial involving 1,047 women between the ages of 14 and 25 years of age, demonstrated a 33% reduction in odds of PTB for women receiving care within the CenteringPregnancy model (OR 0.67, 95% CI: 0.44-0.99), compared to standard prenatal care.(162) A sub-population analysis revealed an even greater reduction in PTB amongst African American women receiving group vs. standard prenatal care (OR 0.59, CI: 0.38-0.92). Other CenteringPregnancy studies have likewise shown significant reductions in PTB and LBW amongst women of low SEP,(163-165) again suggesting that model of care is a significant determinant of maternal infant health for clients of low SEP.

### **2.4.2.3 Stigmatized Identities**

Women of low SEP are often stigmatized due to disadvantaged identities, including racial or ethnic minority status, influencing birth outcomes. For example, U.S. studies have demonstrated racial disparity in the prevalence of PTB between African American and non-Hispanic Caucasian women at all levels of SEP,(166) with the greatest racial inequity occurring among women of highest income/education.(167) For these women, it appears race may be a

risk factor with a psychosocial origin—the product of continual vigilance against discrimination for a historically oppressed population—and could be fueled by emersion in an often White-dominant work environment.(167, 168) Racial differences in the distribution of adverse infant birth outcomes have given rise to a “weathering” theory, in which social inequality experienced over the life course is thought to cause premature physiological aging and early decline in health status that is evident at a population level.(169) In support of this theory, studies have confirmed distinct maternal age by LBW distributions for African American vs. Caucasian women.(170)

Social stigma, the devaluation and exclusion of individuals or groups on the basis of what society deems non-normative behavior or social identity, or because of illness or disability,(171) is present when a negatively perceived trait is accepted as the defining characteristic of an individual,(172) and they are “reduced in our minds from a whole and usual person to a tainted, discounted one”.(173, p11) The effects of stigma may differ depending on whether it is perceived, experienced, or internalized, or a combination of manifestations.(174, 175) Perceived stigma, in which biased treatment is regularly anticipated, can lead to a state of hypervigilance (174) in which chronic psychosocial stress wears on physiological systems involved in stress response, even in the absence of experiences of stigma.(174) Perceived stigma and internalized (or self) stigma, in which individuals attribute negative social stereotypes to themselves,(174) has been shown to independently effect health status, and promote avoidance, delay and non-adherence to medical treatment.(175, 176) In a study by Sirey et al., perceived stigma was shown to decrease adherence to antidepressant treatment, as fear of external judgement was seen to outweigh perceived benefits.(177) Likewise, in an Australian survey, 46% of respondents felt friends and family would think lowly of them if they were to seek help for depression from a psychiatrist, demonstrating the detrimental health implications of perceived mental health stigma.(178)

Discrimination on the basis of socially stigmatized identity is patterned along the lines of social and economic advantage/disadvantage. Those more advantaged define the boundaries of socially acceptable behaviour and identity,(174) and have greater influence over structural stigma—the institutional policies and practices that discriminate against those who deviate from social norms or are part of a minority class.(179) As a result, “stigma plays a key role in producing and reproducing relations of power and control”,(180, p13) and works to reinforce social and health inequity by further demeaning the social status of those in low social



categories. For example, as the acceptability of smoking has diminished in the last number of decades, so the burden of smoking stigmatization—in many instances intentionally created by policy-makers, and enshrined in regulations intended to benefit the public’s health—is disproportionately shouldered by those with the lowest SEP, as they are the most prevalent smokers.(181)

Stigmatization is often used as a tool to enforce social norms and maintain control over social problems or illness/disease within society.(171) An underlying assumption is that the undesirable characteristic is a moral flaw, as are the circumstances under which it develops (182); therefore it is assumed individuals could avoid the sanctioned behavior or identity but have chosen not to. Societal blame and shaming is often considered a legitimate response to socially “deviant” (172, p369) behaviour.(176)

Stigmatization can create barriers to social and health services (176) and minimize access to the social determinants of health, such as employment and housing. In a qualitative study utilizing data from 10 focus group discussions (n=82), low income, African American, single mothers felt that their place of residence and receipt of social assistance affected their access to employment as potential employers were biased against hiring individuals from inner-city neighbourhoods or those receiving public aid.(172) Labels such as “welfare mother”, denoting a lazy and irresponsible character, and lack of parenting skills, reinforced negative stereotypes,(172, p371) contributing to social and health barriers.

In addition, practitioner stigma may impact health outcomes by arousing feelings of powerlessness for the patient, reducing appointment duration, quality of care, and amount of practitioner-patient contact.(183) In an Australian quantitative survey (n=627), using self-reported measures, perceived quality of treatment was assessed for women of varying pre-pregnancy weight categories.(184) Women who had high pre-pregnancy BMI were significantly more likely to report perceived negative treatment from practitioners during pregnancy ( $\beta=.12$ ,  $p=0.003$ ) and after birth ( $\beta= -.11$ ,  $p=0.010$ ), compared to women with lower pre-pregnancy BMI. In a second part of the study, medical and midwifery students (n=248) were surveyed on attitudes and perceptions of pregnant women, based on patients’ BMI. Respondents reported less positive attitudes toward caring for overweight and obese women ( $\beta=.21$ ,  $p<0.001$ ), compared to normal weight women, and viewed them as having poorer self-management and health ( $\beta=.48$ ,  $p<0.001$ ). Like illicit drug users and others with stigmatized identities, obese

individuals might, in some instances, be judged by care providers and the public as those who financially drain the healthcare system through overuse, are under-invested in their own health, and/or are noncompliant in treatment efforts.(185)

Clinical stereotyping can influence decision-making practices, significantly affecting birth processes and outcomes. In a Canadian study utilizing 10 years of data from the *McGill Obstetrics and Neonatal Database* (n=11,922), researchers revealed that practitioners were more likely to administer oxytocin (AOR 1.51, 95% CI: 1.31-1.75), less likely to use forceps (AOR 0.78, 95% CI: 0.61-0.99) or vacuum extraction (AOR 0.71, 95% CI: 0.53-0.93), and quicker to resort to cesarean section delivery during the second stage of labour for obese patients, (mean=-23.1 minutes, SD 83.9, p=0.04) compared to those of normal BMI, after adjustment for known risk factors.(186) A retrospective cohort study utilizing data from the *Nova Scotia Atlee Perinatal Database* and income tax files from Statistics Canada (n=76,440) also found that Canadian women of low SEP (measured by income) are at greater risk of cesarean delivery (ARR 1.12, 95% CI: 1.03-1.23), compared to women of higher SEP.(187) These results suggest that differences in the way that practitioners manage labour, due to perceptions associated with stigmatized characteristics such as high BMI or low SEP, may contribute to existing disparity in health outcomes.

Individuals coping with stigmatization may attempt to conceal unaccepted behaviours or identity, or avoid potentially discriminating social environments. Thus, stigma management may promote social exclusion/isolation, depression, and lower self-esteem.(183) In a study by Wiemann et al., pregnant adolescents who reported experiencing stigma because of their pregnancy were more likely to use alcohol during pregnancy (13.3% vs. 9.1%, p = 0.044), report peer isolation (36.6% vs. 24.4%, p<0.001), and score significantly lower on the *Rosenberg Self-Esteem Scale* ( $31.5 \pm 4.93$  vs.  $33.0 \pm 4.62$ , p = 0.028), compared to those who did not report stigmatization.(188)

### **2.4.3 Behavioural and Lifestyle Risk**

#### **2.4.3.1 Smoking and Exposure to Second-Hand Smoke**

Between 2005 and 2008 an estimated 9.4% of B.C. women smoked during pregnancy.(189) Across Canada, the highest proportion of maternal smokers (38%) were

mothers between the ages of 15 and 19, representing a seven-fold increase in prevalence compared to the proportion of smokers aged 35 and older.(190) Analyzing data from the *Canadian Community Health Survey* (2009/10), researchers found that women from the lowest income quintile were 56% to 91% more likely to smoke compared to women of higher income ( $p < 0.01$ ).<sup>(97)</sup> Measured according to education level, smoking prevalence was twice as common for individuals with a high school education or less, compared to those with a university degree.<sup>(191)</sup> These results suggest, from a population health perspective, that infants of mothers with low SEP are at increased susceptibility to nicotine exposure and the associated adverse infant birth outcomes, namely IUGR, SGA, and PTB.<sup>(192)</sup> For women of low SEP, it may be more difficult to prevent smoking initiation or quit smoking because social, employment and/or home environments often have a higher proportion of smokers, therefore there are fewer social incentives to avoid smoking. Like overeating or alcohol and illicit drug use, smoking may function as a coping mechanism for women of low SEP facing stressful life circumstances.<sup>(193)</sup> Whereas individuals of higher SEP generally have a number of options for recreation and relaxation, smoking may be the only immediate, readily available source of relief from daily financial and/or interpersonal stressors facing women of low SEP.

Like maternal smoking, exposure to environmental tobacco smoke is harmful to a developing fetus and can increase the risk of LBW and infant morbidity.<sup>(194)</sup> Suggested mechanisms between tobacco smoke and adverse infant outcomes include fetal hypoxia from carbon monoxide exposure, maternal vascular constriction with resulting decreased blood flow and placental insufficiency, lower immunity to genital tract infection and inflammation, and toxicity from exposure to heavy metals and other chemical components of cigarettes, such as cotinine and cadmium.<sup>(195)</sup>

#### **2.4.3.2 Alcohol Use**

According to the 2006 *Maternity Experiences Survey*, self-reported alcohol consumption during pregnancy was 7.8% in B.C. during the study period.<sup>(196)</sup> Although no association was found between measures of SEP and alcohol use in the MES, higher prevalence in alcohol use was associated with smoking (OR 1.54, 95% CI: 1.12-1.87).<sup>(196)</sup> Other studies have shown both significant and non-significant associations between low SEP and self-reported alcohol use during pregnancy,<sup>(63, 197)</sup> with some studies reporting a stronger positive relationship between

alcohol use and high SEP.(198) Frequency patterns, and quantity of alcohol consumption tend to differ by age and SEP. Binge drinking (consuming five or more drinks on one occasion) appears to be more prevalent among younger women and those of lower income.(198) An Alberta study found that 9.2% of women earning less than \$10,000 annually reported binge drinking at least once per week, compared to 4% to 5% of women earning over \$20,000 per year.(198) Variations in drinking patterns according to SEP may reflect differing social expectations. For example, where binge drinking may be normative in a low SEP environment and socially undesirable in a higher SEP context, infrequent or moderate drinking may be more common in a high SEP environment.(199)

Maternal alcohol exposure has been shown to increase the risk of spontaneous abortion, stillbirth, prematurity, sudden infant death syndrome (200, 201) and SGA birth,(202) as well as having long-term consequences associated with fetal alcohol syndrome/spectrum disorder. Fetal alcohol exposure is one of the foremost causes of birth defects and developmental delays in Canadian children (203) and fetal alcohol spectrum disorder is estimated to affect nine out of every 1000 live births.(204)

### **2.4.3.3 Substance Use**

Women of low SEP have reported higher rates of substance dependence than women of higher SEP.(63, 99) Intrauterine substance exposure increases the risk of perinatal mortality, IUGR, PTB, LBW,(205) infant hypoxemia,(206, 207) seizure, respiratory distress (205, 208, 209) and neonatal abstinence syndrome (NAS).(99) NAS has been shown to increase the risk of LBW by 19% ( $p<0.001$ ) and respiratory complications by almost 31% ( $p<0.001$ )(99) and is often accompanied by seizures and feeding difficulties.(99) According to data from Canadian Institute of Health Information (CIHI), infants displaying symptoms of drug withdrawal due to “maternal use of drugs of addiction” have, on average, a 15 day post-birth hospital stay.(210)

Prenatal cocaine exposure has been associated with temperature instability, sepsis,(211) seizures, respiratory distress,(205, 209) and cerebral infarctions of the newborn.(207) Cocaine use has been shown to increase dopamine, norepinephrine and serotonin levels in the blood stream,(212) and at high levels can cause fetal and maternal vasoconstriction,(213) potentially “predisposing the fetus to injury at key sites during embryogenesis (e.g. brain, eye, heart, kidneys, gastrointestinal tract)”.(211, p1) Maternal vasoconstriction limits the quantity of blood and

nutrients crossing the placenta and may lead to hypoxemia and IUGR.(206). In addition, cocaine use diminishes appetite, therefore chronic use can contribute to maternal malnourishment and IUGR.(214) Like cocaine, heroin/alcohol/tobacco exposure is associated with IUGR, placental abruption, prematurity and stillbirth.(205, 207) Heroin is also associated with fetal/infant intercranial hemorrhage.(207) Inhalants have been shown to increase the prevalence of congenital anomalies and central nervous system abnormalities.(207)

Amount, duration, and timing of exposure, as well as interaction with other illicit substances and alcohol, appear to influence infant outcomes in a dose-response fashion.(211) As well as the direct biological impact of alcohol and substance use on the developing fetus, exposure during pregnancy can lower maternal social and economic conditions, diminishing quality of housing, nutrition, and adequacy of prenatal care, and may lead to higher risk behaviours, including polydrug use.(213)

Women of low SEP may be more susceptible to substance abuse than women of higher SEP because of social and economic factors that aid physical and psychological dependence. For example, studies have shown an independent association between residence in a low income neighbourhood that has a high prevalence of visible drug dealing activity, or drug-related arrests, and drug use.(215, 216) Visible neighbourhood drug activity may contribute to the ease of impulse drug purchasing, trigger cravings, and discourage cessation. Low SEP women are also at greater risk of homelessness and incarceration than women of higher SEP, factors strongly associated with drug use.(217) Because of the daily challenges related to poverty, such as unemployment and food insecurity, women of low SEP may have less time and/or energy available for preventative self-care, and drug use may provide a temporary reprieve from adverse social conditions. In addition, studies have shown that individuals of low SEP rely more heavily on emergency services for the provision of regular health care, than those of higher SEP.(218) For substance using women of low SEP, lack in continuity of care provider may reduce opportunities to learn about risk-reduction strategies, and the detection of comorbidities (i.e. mental illness).

#### **2.4.4 Institutional and Community-Level Risk Factors**

Institutional-level characteristics can support or impede healthy infant birth outcomes by limiting health care service availability, accessibility, and socio-culturally acceptability.(219)

Furthermore, environmental risk factors such as high area-level income inequality, maternal residence in a low SEP neighbourhood, or urban/rural residence, may independently increase the risk of adverse infant birth outcomes. In this section I will explain how institutional and community-level risk factors may act as mechanisms, linking low SEP to adverse infant birth outcomes.

#### **2.4.4.1 Barriers and Facilitators to Adequate Prenatal Care**

Notable barriers to prenatal care utilization for vulnerable women include intrapersonal and interpersonal challenges related to low SEP (i.e. addictions, low social support), and service impediments (i.e. negative provider attitudes).(220) In a Canadian study involving semi-structured interviews with service providers (n=24), participants identified both the patients' personal characteristics, and weak service provision—the product of unfavorable programs and services, health care systems, and caregiver characteristics—as influential factors inhibiting prenatal uptake for women residing in inner-city Winnipeg.(220) Other studies both confirm and add to this list of impediments to antenatal service uptake for women of low SEP, including: lack of transportation, high childcare costs, unavailable weekend and evening appointments, and long appointment wait times in the accompaniment of small children.(66-68, 70, 71) Psychosocial factors, such as a fear of disclosure of alcohol or drug use, or unrecognized need for prenatal care, may also contribute to lower prenatal service utilization.(38, 67, 69, 221, 222)

Studies suggest clinician-client trust, associated with prenatal service utilization,(221) is closely related to continuity in care provider, or “relational continuity”.(223, p1229) Haggerty et al., summarizing themes emerging from a multidisciplinary review (n=583), found that continuity in care provider permitted a woman's health history to influence her present care, and present care to inform future utilization.(224) Further, continuity in care provider created a sense of patient-practitioner trust and mutual regard, helping to foster open communication. Continuity in care allowed women to experience health care services as “coherent and connected and consistent with . . . [their] medical needs and personal context”,(224, p1221) a feature especially pertinent for women of low SEP who, because of complex circumstances, may benefit from individualized care provision.

As suggested by Sword, a close examination of the philosophy of care, underpinning the design and delivery of care, can help in explaining why service barriers exist for vulnerable

women and how they may be mitigated.(225) Utilizing a socio-ecological approach, Sword has developed a preliminary model to explain barriers to prenatal care for women of low income. Individual behavior is understood to be motivated by personal and contextual factors, namely social networks, community characteristics, and public policy, influencing personal decision-making. These factors interact with micro, meso, and macro features of health services, including service provider skills and attitudes, financial resources available in the healthcare system, and broader health policies. Health care utilization is understood to be dependent upon the congruence between patients' personal and situational needs and available programs and services. Further, the model highlights the pivotal role of the patient-provider relationship, as this is where the personal and situational factors, and the delivery of services, intersect.

In agreement with Sword's theory, a 2009 qualitative meta-synthesis (n=8) determined that a patient's perception of their clinician's respect for life experience, cultural and emotional sensitivity, aptitude for communication, and skill in providing caring interaction, played an important role in adequate utilization of prenatal care for marginalized women.(38) Similar results were found in a qualitative case-study of two Aboriginal<sup>1</sup> organizations seeking to improve services for pregnant and parenting individuals. Through interviews and small group discussions with community leaders, community members, and service providers, researchers found that participation in prenatal care was dependent upon perceived trust and cultural safety, by-products of mutual respect and equality in the clinician-client relationship.(226) In addition, participants identified positive change (i.e. reduction in addictions, greater infant attachment and incidence of breastfeeding, open discussion regarding abuse) over consecutive pregnancies and over generations, as a primary, relevant, and attainable goal of prenatal service utilization, with long-term implications.(226) Participants felt that women who developed a strong relationship with their healthcare provider were more likely to utilize care again, and earlier or more consistently during pregnancy, than women without a strong patient-practitioner relationship. In turn, this could help to promote healthy behaviours such as decreased tobacco and alcohol use, increased nutritional intake, and capacity building skills that built confidence and personal growth.(226)

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<sup>1</sup> In this article the term "Aboriginal" refers to First Nations, Inuit and Métis Peoples of Canada. The participants' nations were not identified.

Despite differing study designs, methods, and sample populations, much of the evidence concerning barriers to prenatal care for marginalized women points to the importance of a trusting clinician-client relationship. This is illustrated in a Canadian study involving a secondary analysis of 26 semi-structured interviews with Aboriginal<sup>2</sup> parents, Elders, leaders, and service providers from four health/social service organizations providing care to pregnant and parenting Aboriginal people.(222) Van Herk et al. found that the most influential factor in perinatal care uptake among Aboriginal participants was the woman’s perception of how the service provider identified her. Aboriginal women who felt they were identified as “bad mothers” according to a Western parenting model, struggled to feel safe in accessing care.(222, p62) As the authors noted, “Aboriginal women’s identity as mothers remains highly tumultuous within the health care setting as a result of historical and present day violence and discrimination attached to their role as mothers”.(222, p62) In light of the residential school history and the disproportionately large number of Aboriginal children in foster care, Aboriginal mothers hesitated to access care for themselves or their children when they felt negatively judged by health care practitioners utilizing an authoritarian approach. Conversely, women who were affirmed by service providers who recognized their strengths, particularly as mothers, recounted positive experiences and indicated that they were more likely to access care in the future.(222)

Although prenatal practice guidelines are often based on the assumption that pregnant patients have a “healthism” mindset—the desire to strive for good health and the independence, ability, and resources to achieve it (38, p519)—women experiencing vulnerabilities, including newcomers to Canada, may make decisions based on social, cultural, and religious values that are contrary to the assumptions of healthism. For example, cultural and religious restrictions may prevent newcomers from accepting advice or treatment on reproductive issues that contravene their customs and beliefs.(227) In a qualitative study utilizing 15 key informant interviews, one focus group, and a semi-structured survey (n=14), to investigate the quality of reproductive health services for Somali Bantu refugees in Connecticut, researchers found that cultural deference to authority and a traditional understanding of gender roles, as well as language barriers, inhibited women’s ability to self-advocate for services or oppose unwanted treatment.(227)

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<sup>2</sup> Participants’ nations were not identified.



The studies cited in this section highlight the necessity of respectful maternity care, delivered by culturally competent providers, in order to promote optimal health outcomes. Time and a quality clinician-patient relationship can enhance mutual trust and foster open communication, enabling sensitive care. Within an emotionally safe clinician-patient relationship there is the opportunity to replace general assumptions about a patients' culture, race/ethnicity, and experiences, with an informed understanding of a patient's beliefs, traditions, and values.(228) When perinatal care is individualized it can accommodate cultural preferences and respond to the health-shaping influence of culturally embedded social structures (i.e. racism, colonialism). Having time to engage in effective clinician-patient communication, including non-verbal communication (i.e. body language, eye-contact), can aid in establishing and maintaining a culturally attuned clinician-patient relationship,(229) and may be especially helpful for women with low SEP by clarifying unspoken patient expectations and values, bolstering patient capacity, and addressing patients' feelings.(229)

#### **2.4.4.2 Absolute and Relative Income Inequality**

Debate exists over the influence of absolute versus relative income inequality in shaping maternal infant health outcomes. When examining population-level discrepancy in maternal infant health status, materialist theorists maintain that absolute income, rather than other hierarchies, is of primary importance because it reflects access to health-enhancing material and psychosocial resources.(43) Evidence in support of this theory is illustrated by the curvilinear relationship between income and infant health, in which health steadily increases according to income until a certain threshold, at which point income increases no longer produce equivalent gains in health status.(44) This relationship between absolute income and infant health suggests that minimizing infant health disparity is contingent upon the reduction of absolute deprivation at an individual level (i.e. through increased income transfers).(44)

Conversely, the Relative-Position Hypothesis proposes that not only absolute deprivation but one's rank in the income distribution as well as other relative measures of social conditions, affect health status.(44) Relative position can be measured as an individual's socioeconomic rank in the community or the community's socioeconomic rank within the population. Choice of relative measure has been shown to alter the relationship between deprivation and adverse birth outcomes, and thus, choice of measure may have differing policy and practice implications.(45)

Hypothesized pathways between relative income inequality and adverse maternal fetal health outcomes include increased risk of poor self-concept, leading to lower commitment to pregnancy and unhealthy lifestyle choices,(51) and decreased social capital in areas of low income.(46) Social capital refers to “features of social organization, such as trust, norms, and networks” (230, p167) that promote collective aims (i.e. safe neighbourhoods). Kawachi and colleagues found that state-level income inequality in the U.S. was associated with infant mortality through social mistrust ( $r^2$  0.32,  $p=0.007$ ), and perceived lack of fairness ( $r^2$  0.42,  $p=0.0005$ ); both being features of social capital that may inhibit voluntary acts of good will between community members (i.e. informal babysitting, snow shoveling, shared transportation, etc.).(46) In order to understand the effects of poverty on health outcomes, studies should ideally examine both absolute and relative income inequality, to determine what proportion of an association can be attributed to each type of income inequality.

In a systematic review of 14 studies investigating the relationship between population income inequality and infant mortality, nine found a significant, positive association.(231) Income inequality is closely linked to government social policy, such as a living minimum wage. While investigating cross-country differences in infant mortality rates, Pampel and Pillai found that total government spending, including health care and social welfare, was significantly inversely associated with post-neonatal mortality rates (death between 29 days to 1 year old).(232) Likewise, Bradley et al. found that countries with high social-to-health spending ratios, had significantly smaller infant mortality rates, after adjusting for gross domestic product, implying that population level investment in both health and social domains can minimize the health risks associated with the socioeconomic gradient.(134) Although causality cannot be established through ecological studies, the correlation between social spending and infant health warrants further investigation of relative income inequality in relation to adverse infant birth outcomes.

#### **2.4.4.3 Neighbourhood SEP**

In assessing neighbourhood SEP against individual measures of SEP, neighbourhood SEP has been found to have a weaker, yet statistically significant association with health and socioeconomic characteristics.(51, 54, 233) Differences in the magnitude of the association between individual and neighborhood SEP could be because neighbourhood SEP 1) measures

distinct area-level contextual factors; 2) captures unmeasured individual characteristics, such as wealth in addition to income; or 3) lacks precision due to differing size or geography of area, or homogeneity of SEP within neighbourhoods.(233) The value in measuring SEP at both an individual and neighbourhood level is that it allows for an examination of a broad variety of personal and social determinants, useful in confirming established mechanisms and in identifying otherwise unknown pathways linking SEP to health outcomes.

In B.C. there is a distinct birth weight gradient by neighbourhood income for infants born between 37 and 42 weeks gestation. Infants born into the wealthiest income quintile<sup>3</sup> have the highest average birth weight, with a decline in weight at each successive income quintile thereafter.(3) Between 43 and 44 weeks gestation a reverse gradient is apparent where infants in the poorest income quintile are at the greatest risk of LGA birth and the attending complications. Both area-level “contextual” disadvantage and “compositional” disadvantage have been suggested mechanisms contributing to the relationship between residence in a neighbourhood of low SEP and adverse infant birth outcomes.(51, 53-55) Contextual disadvantage describes the direct environmental hazards, such as exposure to industrial pollutants, unsafe housing, criminal victimization, etc., as well as indirect exposures such as residential instability, that characterize low SEP neighbourhoods.(234)

In a study linking census tract-level data on social risk to birth certificate data, O’Campo et al. found that the relationship between individual-level risk factors and LBW was modified by neighbourhood contextual factors, such as high neighbourhood unemployment rates.(235) The expected protective effect of early initiation of prenatal care on LBW was less pronounced for women from higher risk neighbourhoods (measured according to average wealth or unemployment rates), compared to those from lower risk neighbourhoods. The authors speculate that high unemployment at a neighbourhood level may capture a “lack of political and economic empowerment and resources” for all neighbourhood residents, influencing outcomes, regardless

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<sup>3</sup> Neighbourhood income quintiles reflect the average, single-person income in a Canadian census dissemination area (DA), an area populated by approximately 400-700 people. To determine an individual’s neighbourhood income quintile, their residential postal code is mapped to a census DA and the quintile of the DA is assigned to the individual. From: British Columbia Ministry of Health [creator] (2015): Consolidation File (MSP Registration & Premium Billing). Population Data BC [publisher]. Data Extract. MOH (2014). Available from: <http://www.popdata.bc.ca/data>.

of individual SEP.(235, p1117) These results highlight the importance of multilevel analysis in understanding how individual and contextual factors interact and contribute to the prevalence of adverse infant birth outcomes.

Compositional disadvantage refers to the negative implications (i.e. social, economic, and health) of living in an area with a high density of low SEP individuals (measured by income, education, or occupation).(53) In Canada, neighbourhoods in the highest and lowest income quintiles have nine to ten times greater income homogeneity than middle income quintile neighbourhoods.(236) In effect, individuals residing in neighbourhoods at either end of the income spectrum are exposed to the greatest concentration of benefits or consequences associated with neighbourhood characteristics.

Although women of low SEP more frequently engage in unhealthy behaviours, such as smoking, binge drinking, and poor dietary habits, associated with the risk of SGA birth and other adverse infant birth outcomes,(62-64) individual behavior is shaped and constrained by resources available in one's physical and social environment,(78) and by social norms.(53) Residence in a low SEP neighbourhood often implies less access to healthy food and at higher costs,(122) resulting in a "diet gradient", reflective of the health gradient.(193, 237) Women of low SEP have less resources to spend on recreation and may live in neighbourhoods with fewer parks or green spaces, factors that influence activity patterns.(238) Low SEP neighbourhoods (measured by income or employment) have been shown to have greater neighbourhood disorder, marked by crime, graffiti, abandoned buildings, gang activity, etc.,(239, 240) potentially having a detrimental effect on individual health. In a U.S. study, Ross et al. utilized data from the *Community, Crime and Health* survey (n=2,482) to examine mediators between residence in a disadvantaged neighbourhood and self-reported health, physical functioning, and chronic conditions. Perceived neighbourhood disorder and the fear it induced, measured with a validated index that assessed physical and social signs of disorder such as vandalism and drug use, was found to be the major mechanism linking disadvantaged neighbourhoods with poorer individual health status.(241) The authors of the study speculate that the continual environmental threats posed by neighbourhood characteristics induce chronic stress, with physiological consequences.

As well as neighbourhood disorder, low SEP neighbourhoods often have less social cohesion, or connectedness, trust, and reciprocity between community members, shaping health behaviours.(242) In a cross-sectional survey examining the influence of area-level social

cohesion on smoking status, 10,062 adults were randomly surveyed, using the *Survey of the Health of Adults, the Population, and the Environment*.(242) Results of the survey indicated that higher area-level social cohesion was significantly associated with a lower likelihood of smoking, after adjustment for measures of SEP (AOR 0.85, 95% CI: 0.74-0.98). In neighbourhoods with lower social cohesion, smoking practices may be more invisible, and therefore less subject to social stigma, or social cohesion may provide practical, emotional, and social support, reducing stress and improving mood and lifestyle choices.

This research supports a social contagion hypothesis that suggests health practices are largely influenced by the health of those in one's social network, with behavior shaped by norms, attitudes, and information acquired through friends, neighbours and family.(237) From this perspective, health disparity is reinforced through social and economic segregation, a relationship that has been demonstrated in obesity research. In a study analyzing over 220,000 responses from the *U.S. National Health Interview Survey*, linked to neighborhood-level data from the National Center for Health Statistics, researchers found that residence in a poor neighbourhood significantly increased the likelihood of obesity (OR 1.11,  $p < .001$ ). Individuals residing in neighbourhoods with above average levels of obesity were significantly more likely to be obese, compared to respondents living in areas with an average proportion of obese neighbours, regardless of individual risk characteristics (OR 1.62,  $p < .001$  vs. OR 1.34,  $p < .001$ ). (237) As the authors explain, in neighbourhoods with a high proportion of obese residents, continual exposure to unhealthy behaviors as well as less pronounced social stigma around obesity may, over time, create a "collective minimization of obesity".(237, p9) This type of social conditioning helps explain why poor health and health behaviours cluster in neighbourhoods of disadvantage, but it still fails to explain the underlying causes that lead to unhealthy behavior amongst low SEP individuals in the first place.(193)

#### **2.4.4.4 Urban Versus Rural Residence**

According to CIHI, between 2007/08 and 2011/12 approximately 11% of all B.C. deliveries occurred in rural areas or small towns with a population of less than 10,000 people.(243) Despite a higher proportion of rural women in the lowest income quintile (rural 21.5% vs. urban 15.2%), and a higher proportion of births to women under 20 (rural 6.7% vs. urban 2.7%), overall, rural women had lower rates of SGA (rural 8.2% vs. urban 10.3%; OR 0.7,

95% CI: 0.7-0.7) and preterm birth (7.6% vs. 8.1%; OR 0.9, 95% CI: 0.9-1.0),(243) compared to urban women. However, rural women also had greater prevalence of LGA infants than urban women (12.5% vs. 9.4%; OR 1.4, 95% CI: 1.4-1.4). Higher rates of SGA and PTB in urban areas may be due to relative income inequity, which is typically greater in urban areas, and could increase maternal stress for women of low SEP.(54) Rural areas may also offer greater social support, as rural residents are significantly more likely to trust their neighbours, have a strong sense of belonging in their community, and report knowing all or most of their neighbours compared to urban residents.(244)

Although rural residence reduces the risk of certain infant morbidities, inequity in service availability appears to be responsible for an increased risk of other adverse perinatal outcomes. A study by Grzybowski et al. demonstrated that rural Canadian women evacuated prior to delivery from their local community (due to unavailable services) had higher rates of induction for logistical reasons and their newborns were at greater risk of extended length of stay in level 2 and 3 NICUs (facilities with higher levels of care).(245) Discrepancy in rates of adverse birth outcomes and NICU length of stay for infants born to women required to travel for delivery, compared to those who do not, could be the result of increased stress, complications resulting from lack of access to care either during the prenatal stage or at delivery, or bias in discharge practices for newborns returning to communities with few pediatric resources.(246) As well, travelling for delivery most often involves the disruption of family and social ties during a vulnerable period and may incur significant financial costs from lost wages, housing, travel, and additional childcare expenses.(245) Nonetheless, 67% of rural Canadian women deliver in urban centers and 17% travel more than two hours for delivery.(243) Rural women choosing to birth locally generally have less access to specialists' care, and investigators have found that odds of cesarean delivery are significantly higher in hospitals where surgical services are offered only by general surgeons, compared to obstetricians (OR 1.12, 95% CI: 1.03-1.22).(247) Because of a trend toward centralization of health services, resulting in the closure of 20 rural maternity units in B.C. in the last 15 years, and due to the difficulty in recruiting and retaining health care professionals in rural areas, these issues will likely continue to be an obstacle for rural, parturient women in the future.(248)

### **2.4.5 Relevance of Individual and Social Risk Factors for Study Design**

The previous two sections outline individual and social risk factors that may moderate, mediate, or confound the relationship between model of care and adverse infant birth outcomes for women of low SEP. Five of these social risks were tested as potential moderators including: substance use, mental illness/disorder, neighbourhood SEP, receipt of social assistance, and teen maternal age. In this chapter I have presented numerous possible mediators that could link antenatal model of care with infant birth outcomes, but with the exception of smoking, alcohol use, substance use, and mental illness/disorder I did not test for mediating effects in this study. Various intra/interpersonal risk factors outlined in this chapter were tested as potential confounders. From the literature, these were identified as: biological, psychosocial, and behavioral and lifestyle risk factors. In addition, variables that denoted community-level risk and were associated with both model of care and poor infant birth outcomes were examined, including: relative income inequality and socioeconomic rank at the local health area level, neighbourhood SEP, urban vs. rural residence, and northern residence.

## **2.5 Conclusion**

This chapter provides an overview of the theory, definitions, and rationale used to design the thesis studies. A population health approach is fundamental in examining this topic from an equity perspective. Intersectionality theory provides a lens through which social vulnerability can be examined in light of each model of care. Understanding for whom and under what conditions model of care is associated with improved infant birth outcomes for women of low SEP is key to understanding what interventions may be best able to alter mutable factors and re-route health trajectories.

## Chapter 3 A Scoping Review

### 3.1 Introduction

To date there has been no review of the literature examining infant birth outcomes for women of low SEP receiving antenatal midwifery care compared to physician-led care. To address this deficiency I, along with a group of co-investigators, conducted a systematic scoping review to identify all available information on this topic in order to present a summary of the “extent, range and nature” of the research, determine key gaps in the literature, and provide guidance for future studies.(249, p21) For this review we investigated if, in the last 25 years in countries belonging to the Organization of Economic Co-operation and Development (OECD),(250) midwives’ patients of low socioeconomic position were at greater or lesser risk of adverse infant birth outcomes compared to physicians’ patients.

### 3.2 Methods

A review team, with combined expertise from obstetrics, epidemiology, midwifery, sociology, and public health conducted this review. Methods were based on Arksey and O’Malley’s scoping studies framework,(249) with the exception of a quality assessment in which we used the *Effective Public Health Practice Project Quality Assessment Instrument*.(251) Five inclusion criteria were identified to guide the study selection. Studies must have a) been conducted in a country belonging to the OECD; b) compared antenatal care exclusively or predominantly delivered by midwives with physician-led care; c) reported on one or more of the following outcomes: PTB, IUGR, SGA birth, Apgar score, birth weight (including mean, low and very low birth weight), and/or NICU admission; d) included participants of low SEP (operationalized as low income, education or occupational class); and e) had a publication date no earlier than January 1, 1990. No language restrictions were applied.



Table 3.1: Keywords Searched

<b>Prenatal care</b>	<b>prenatal* OR antenatal* OR pregnan*</b>
<b>Low SEP</b>	poor OR poverty OR “low income” OR socioeconomic OR socio-economic OR depriv* OR disadvantag* OR marginali?e* OR vulnerabl* OR “low education” OR “low prestige” OR “social class” OR “social classes” OR disparit* OR inequalit* OR discriminat* OR inequit* OR indigent OR impoverish*
<b>OECD countries</b>	Australia OR Austria OR Belgium OR Canada OR Chile OR Czech Republic OR Denmark OR Estonia OR Finland OR France OR Germany OR Greece OR Hungary OR Iceland OR Ireland OR Israel OR Italy OR Japan OR “Korea Republic” OR Luxembourg OR Mexico OR Netherlands OR “New Zealand” OR Norway OR Poland OR Portugal OR “Slovak Republic” OR Slovenia OR Spain OR Sweden OR Switzerland OR Turkey OR “United Kingdom” OR UK OR England OR Scotland OR Wales OR “United States” OR US OR USA ( <i>manually searched</i> )
<b>Infant birth outcomes</b>	“preterm birth” OR “preterm births” OR “pre-term birth” OR “pre-term births” OR prematur* OR “small for gestational age” OR “small-for-gestational-age” OR apgar OR “birth weight” OR “birth weights” OR birthweight* OR “intrauterine growth restriction” OR “intrauterine growth retardation” OR “neonatal intensive care” OR NICU OR “infant outcome” OR “infant outcomes” OR “birth outcome” OR “birth outcomes”
<b>Midwifery-led care</b>	midwif* OR midwives OR nurse-midwif* OR nurse-midwives
<b>Physician-led care</b>	physician* OR obstetrician* OR doctor* OR “family practitioner” OR “family practitioners” OR “shared care” OR “medical led” OR “medical-led” OR “medical managed” OR “medical-managed” OR “medical model” OR “medical models” OR “usual care” OR “standard care”

Only studies conducted in OECD countries were included to ensure the results of the review would be relevant to healthcare systems in high resource settings. With the exception of Mexico and Turkey, infant mortality rates for OECD countries range between 0.9 and 7.7 per 1000 live births. Canada’s infant mortality rate is 4.8, somewhat above the median of 3.5.(250) As infant mortality is a commonly accepted indicator of maternal infant health,(252) reflecting in part the quality of national healthcare systems, membership in the OECD can be considered a proxy for similarly adequate maternal infant healthcare services across study locations. Because standards of perinatal practices and trends in birth outcomes continually change, we restricted the

search to studies published after 1990 to ensure the results would be relevant for current policy and practice.

The search strategy (see Table 3.1) included all relevant citations in 12 databases (see Table 3.2) between June 8<sup>th</sup> and 10<sup>th</sup>, 2015. When possible, email alerts were requested from databases to capture any new publications, up until August 31, 2015. Grey literature, including government reports and dissertations, was searched in six databases and a hand search was conducted of all articles published between January 1, 2010 and August 31, 2015 in four journals (see Table 3.2). Reference lists from studies meeting the inclusion criteria were manually searched to further identify relevant studies. Because some articles omit the national setting, referring only to the city and/or state/province, the study setting was searched manually. All citations and abstracts were imported into EndNote X7 to facilitate management and remove duplicates. To minimize bias and error in the selection of the studies, myself and another reviewer independently assessed the list of titles and abstracts retrieved from the initial key search against the inclusion criteria.

Table 3.2: Sources Searched

<b>Electronic Databases</b>	<b>Grey Literature</b>	<b>Hand Searched</b>
<b>MEDLINE</b>	Effective Public Health Practice Projects	American Journal of Epidemiology
<b>EMBASE</b>	New York Academy of Medicine Grey Literature Report	American Journal of Public Health
<b>CINAHL</b>	Public Health Grey Literature Sources	Journal of Midwifery and Women’s Health
<b>Ovid Healthstar</b>	Centre for Review and Dissemination (UK)	Midwifery
<b>Cochrane Library</b>	Health Evidence	
<b>ProQuest: Public Health</b>	OIAster	
<b>PubMed</b>	Google Scholar	
<b>Global Health</b>		
<b>AMED</b>		
<b>Web of Science Core Collection</b>		
<b>Joanna Briggs Institute EBP Database</b>		
<b>ProQuest Dissertations and Theses Global</b>		

Although scoping reviews generally do not assess individual study quality, we chose to include a quality assessment to evaluate the adequacy of the research evidence. The *EPHPP Quality Assessment Instrument* (251) for quantitative studies was utilized to ensure standardized quality assessment. The content/construct validity and reliability of this tool has been previously assessed,(253) and the National Collaborating Centre for Methods and Tools has given it a strong methodological rating.(254)

Myself and another reviewer (from a total of six) independently scored study quality on a scale that examined selection bias, study design, confounding, blinding, data collection, and rates of participant withdrawal/attrition. The instrument required a strong rating on at least four of the six component areas, and no weak ratings in any area, to merit a “strong” quality rating. Studies with less than four strong ratings and one weak rating were deemed “moderate” and those with two or more weak ratings were considered “weak”.(253) Discrepancies between reviewers’ overall ratings were discussed and consensus reached for all quality ratings. Using a

standardized form, I extracted all relevant data, and it was verified by a second reviewer. A narrative description of the results is reported.

### **3.3 Results**

#### **3.3.1 Selection of Studies**

The search yielded 917 records, of which 164 were duplicates. Of the remaining 753 titles and abstracts screened using the inclusion criteria, 722 records were excluded per criteria (see Figure 4.1). Thirty-one studies that either appeared to meet all of the inclusion criteria, or in which it was unclear whether or not the study met the criteria, were retained for full review. Fourteen of these studies were subsequently excluded because they did not compare midwifery-led care with physician-led care, and a further six did not specifically examine outcomes for women of low SEP. The remaining 11 articles and dissertations, representing nine studies, met all of the inclusion criteria.

From the quality assessment we determined that eight of the nine studies were of moderate methodological quality (255-262); one study was given a weak rating (263); and none received a strong quality rating. Of the nine studies selected, seven were reported in peer-reviewed articles,(255-260, 263) one was described in a dissertation,(262) and one was documented in both a dissertation and a peer-reviewed article.(261)

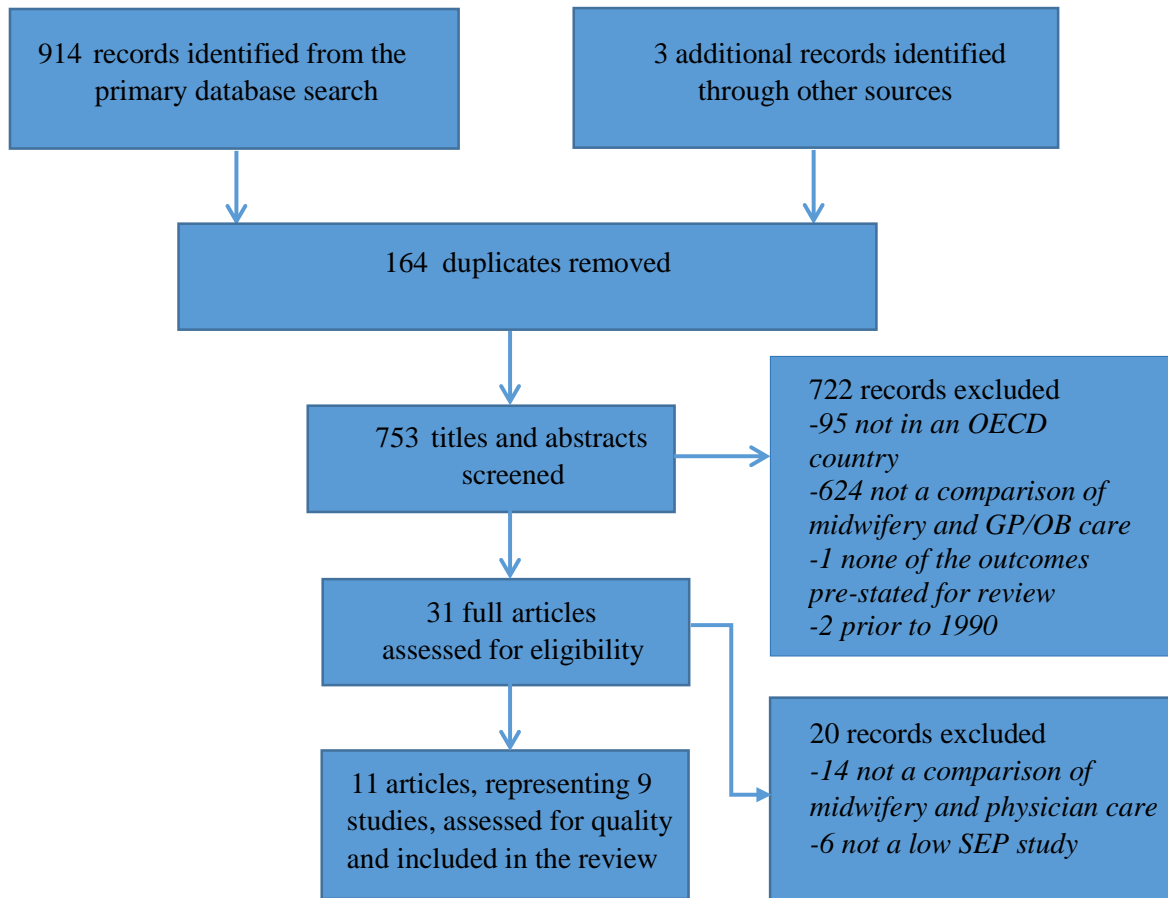


Figure 3.1: Results of the Study Selection Process

### 3.3.2 Quality of Included Studies

Confounding due to differences in perinatal risk between groups was adequately controlled for in four studies through: a) inclusion/exclusion criteria based on established birth center midwifery eligibility;(257, 258) b) a previously developed scale and risk scoring conducted by public health nurses:(255) and c) by state and national clinical guidelines.(262) With the exception of three studies,(259, 261, 263) the remainder of the studies also employed analytical methods, such as matching, to control for known perinatal risk. However, in the study by Visintainer et al. (259) the administrative data utilized lacked information on current/prior health

complications, potentially introducing major confounding as physicians' scope of practice includes higher risk patients, more likely to experience poor birth outcomes. In the study by Simonet and colleagues (261) there was, likewise, no adjustment for differences in current/prior health complications, due to a lack of data, but the study design may have helped to mitigate confounding. Women were classified as midwifery or physician patients according to the type of practitioner that provided the majority of care in their place of residence (both locations had a predominant practitioner-type which provided antenatal care). This could have introduced some misclassification of provider type but may have minimized confounding, if the residents of the two communities had relatively equal prevalence of current/prior maternal health complications. In the study by Blanchette, there was no attempt to control for any type of confounding, and the comparison groups had significantly different characteristics, therefore it was given a weak quality rating.

Intent to treat analysis (ITT), in which a woman's birth outcomes were analyzed according to the practitioner type with whom she initiated care—regardless of subsequent cross-over—was utilized in five of the studies.(255-259) Three studies either did not use ITT, or failed to report it.(260, 261, 263) One study used a “modified” approach in which ITT was used for all cases, with the exception of women who transferred between provider types and received greater than 60% of their care from their second provider (n=21).(262) These cases were then excluded from the analysis. Studies that failed to utilize an ITT analysis may have introduced bias, as the exclusion of women referred from midwifery-led care to physician-led care could have skewed the overall health profile and related outcomes in the midwifery cohorts.

In this review, power estimates were described for primary outcomes in four studies,(255, 258, 261, 262) with Simonet et al. and Cragin citing rare outcomes or small samples sizes as limitations.(261, 262) Wide confidence intervals support these claims (i.e. the odds of SGA for midwifery clients vs. physician patients in Simonet et al.'s study was 1.48, 95% CI: 0.82-2.68).(261) In the studies by Blanchette et al. and Fischler et al.,(260, 263) and in the post hoc sub-analyses by McLaughlin et al. and Heins et al.,(255, 256) no *a priori* power analysis was reported, and small sample sizes appear to have prevented the detection of clinically relevant and statistically significant differences. When assessed by observed power analysis using OpenEpi 3.01, all four studies/sub-analyses appeared to be inadequately powered (<80%,  $\alpha=0.05$ ). The

two studies which did find an overall statistically significant difference in PTB (257) and low birth weight (LBW)(259) for midwifery clients each included more than 15,000 cases.

Although LBW (< 2,500 g.) is a frequently reported birth outcome in the literature, this classification often includes preterm infants and those born SGA because of IUGR.(14) In order to understand what factors influence the relationship between model of care and gestational age, and model of care and fetal growth, it is necessary to examine each outcome separately; however none of the studies reviewed examined IUGR.

### **3.3.3 Adverse Birth Outcomes According to Model of Care**

Six studies reported on PTB (255, 257, 258, 260, 261, 263)—with only Benatar et al.'s (257) study finding a statistically significant reduction (30%) in odds for women in the care of midwives versus physicians (AOR 0.70,  $p < 0.01$ ). A sub-analysis of outcomes among African American women demonstrated similar results (AOR 0.71,  $p < 0.01$ ). The other five studies reported no statistically significant association.

The most frequently investigated outcome was LBW. Although LBW was examined in all nine studies, only Visintainer et al.(259) reported a statistically significant lower risk (41%) of LBW among midwives' patients (RR 0.59, 95% CI: 0.46-0.73) compared to physicians' patients. An even lower risk was reported when the analysis was restricted to Medicaid recipients (RR=0.44, 95% CI: 0.34-0.57). Six of the remaining studies reported findings that favored midwifery care, but were not statistically significant.(255, 257, 258, 261-263)

Three studies reported on very low birth weight (VLBW),(255, 258, 259) all indicating lower risk for midwifery compared to physician patients, but only two reported a statistically significant difference either overall, or for a sub-group of participants. Visintainer et al. reported reduced risk for VLBW (RR 0.44, 95% CI: 0.23-0.85) for midwifery clients; the risk for VLBW babies was further reduced when the analysis was restricted to only Medicaid recipients (RR 0.32, 95% CI: 0.16-0.63).(259) Heins et al. reported no statistical difference in outcomes according to practitioner type for the overall sample, but a post hoc, sub-analysis found reduced odds in VLBW babies for African American women with high risk scores for adverse outcomes cared for by midwives compared to similar women cared for by obstetricians (OR 0.35, 95% CI: 0.1-0.9).(255)

Three studies reported mean birth weight of newborns; one indicated birth weights that overall were statistically significantly higher for women receiving midwifery care; the second study reported significantly higher newborn birth weight for patients in the care of private practice nurse-midwives, but not for women receiving care from nurse-midwives in a hospital clinic, and the third study reported significantly higher birth weight only for primiparous women cared for by midwives vs. physicians. Benatar et al. reported average birth weights of 3,325 grams for midwives' patients versus 3,282 grams ( $p < 0.01$ ) for physicians' patients.(257) Fischler et al. reported that, in a private-practice setting, nurse-midwives' patients had a 191 gram higher mean birth weight (Beta 0.13,  $p < 0.05$ ), but no statistically significant difference in birth weight for midwives' patients cared for in a hospital clinic, compared to physicians' patients.(260) McLaughlin et al. found, in a post hoc, sub-analysis, mean birth weight was significantly higher, by 144 grams, for primiparous but not multiparous women in the care of midwives (Beta 0.17,  $p < 0.05$ ). (256)

Two studies reported on NICU admission with neither Fischler et al. (260) nor Jackson et al. (311) finding significant differences in NICU admissions for midwifery compared to physician patients. Two studies examined SGA,(258, 261) and four studies reported on Apgar scores,(257, 258, 260, 263) but none found significant associations between midwifery-led care and these outcomes, compared to physician-led care. (See Table 3.3).



Table 3.3: Study Characteristics

<b><u>Author, Setting</u></b>	<b><u>Study Design</u></b>	<b><u>Participant Characteristics</u></b>	<b><u>Relevant Outcomes*</u></b> Adjusted measures reported unless noted	<b><u>Quality Rating, Comments</u></b>
<p><b>Benatar et al.(257) (2013)</b></p> <p>Washington DC, USA 2005-2008</p>	<p>Matched, retrospective cohort</p> <p>Birth certificate data</p> <p>Clients initiating prenatal care from nurse-midwives at a free-standing birth center vs. women receiving usual care</p> <p>No reported distinction between primary and secondary outcomes</p>	<p>Midwifery group (n=872); primarily low income, 21.9% ≤ 19 years old, 85% African American, African American subgroup (n=744)</p> <p>Usual care group (n=42,987); derived from propensity scoring, matched to the study population on sociodemographic, medical, and health history characteristics; AA subgroup (n=27,095)</p> <p>Included:</p> <ul style="list-style-type: none"> <li>-women who gave birth in DC, and DC residents who gave birth in other jurisdictions</li> <li>-at least 2 prenatal visits</li> <li>-singleton birth</li> <li>-gestational age ≥ 24 weeks</li> </ul>	<p>-PTB<sup>a</sup> 7.9% vs. 11.0% (OR=0.70, p&lt;0.01)</p> <p>-AA sub-analysis 8.6% vs. 11.8% (OR=0.71, p&lt;0.01)</p> <p>-5 min. Apgar &lt;7, 3.4% vs. 3.7% (OR=0.92, nssd)</p> <p>-AA sub-analysis 3.4% vs. 3.7% (OR=0.90, nssd)</p> <p>-LBW<sup>b</sup> 8.0% vs. 10.0% (OR=0.81, nssd)</p> <p>-AA sub-analysis 9.8% vs. 11.1% (OR=0.872, nssd)</p> <p>-Average birth weight at term 3,325g. vs. 3,282g. (p&lt;0.01)</p>	<p>Moderate quality</p> <p>Intent to treat analysis</p> <p>Propensity scoring used to construct a matched comparison group</p>

			-AA sub-analysis 3,325g. vs. 3,282g. (p<0.01)	
<b>Simonet et al. (261)(2009)</b>  14 Inuit communities of Hudson Bay and Ungava Bay, Nunavik, QC, Canada 1989-2000	Retrospective cohort  Statistics Canada's linked live birth, infant death, and stillbirth data  Midwives provided majority of prenatal care and attended over 73% of deliveries in Hudson Bay vs. physicians who provided prenatal care and attended 95% of deliveries in Ungava Bay  Primary outcome: perinatal death, relevant secondary outcomes: PTB, SGA, LBW	Hudson Bay Inuit births (n=1,529); 36.0% primiparous, 39.1% single mothers, 61.5% < 11 yrs. education  Ungava Bay Inuit births (n=1,197); 29.7% primiparous, 43.1% single mothers, 64.6% <11 yrs. education  Included: -women residing in Nunavik, based on geocoding maternal residence  Excluded: -births with missing data on birthweight or gestational age -births < 500g. or < 20 wks. gestation -women with non-Inuit mother tongue	-PTB <sup>c</sup> 10.3% vs. 10.8% (OR=0.94, 95% CI: 0.73, 1.20)  -SGA <sup>d</sup> 6.1% vs. 5.4% (OR= 1.48, 95% CI: 0.82, 2.68)  -LBW <sup>b</sup> 5.3% vs. 6.0% (OR=0.85, 95% CI: 0.61, 1.18)	Moderate quality  Adjustment for age, educ., marital status, parity, infant sex, plurality, community size and community-level random effects  No adjustment for preexisting health complications or maternal morbidity  Authors acknowledged failure to reach 80% power (α=.05) for a 30% difference in the primary outcome
<b>Jackson et al.(258) (2003)</b>  San Diego CA, USA	Prospective cohort study/ retrospective chart review	Collaborative care (n=1,808); 22% < 20 yrs. old, 54% single mothers, 86% Hispanic  OB-led traditional care (n=1,149); 22% < 20yrs. old,	-5 min. Apgar < 7 0.8% vs. 0.4% (RD=0.9, 95% CI: -3.7, 5.4)	Moderate quality  Intent to treat analysis  Adjusted for race/ethnicity, parity

<p>Feb. 1, 1994- Nov. 1, 1996</p>	<p>Medical records and a self-administered patient survey</p> <p>Collaborative care offered at a birth center vs. OB/OB resident care</p> <p>For collaborative care, 95% of the prenatal care was delivered by CNMs (65% of participants collaboratively managed through consultation or necessary visits with an OB), 5% by OBs</p> <p>Collaborative care included case management, health education, nutrition counselling, social services</p> <p>Primary outcomes: cesarean section; major intrapartum, or neonatal complications; NICU admissions</p>	<p>57% single mothers, 61% Hispanic</p> <p>Excluded: -if ineligible for midwifery care at a birth center due to perinatal risk -women with private or military insurance -if entered care <math>\geq</math> 33 wks. gestation</p>	<p>-PTB<sup>c</sup> 6.4% vs. 6.5% (RD=0.2, 95% CI: -1.7, 2.1)</p> <p>-LBW<sup>b</sup> 3.8% vs. 4.0% (RD=0.5, 95% CI: -1.7, 2.7)</p> <p>-VLBW<sup>e</sup> 0.5% vs. 0.6% (RD= -0.2, 95% CI: -5.6, 5.2)</p> <p>-SGA<sup>f</sup> 5.9% vs. 4.5% (RD=1.7, 95% CI: -1.5, 4.8)</p> <p>-NICU (any) 9.7% vs. 11.8% (RD= -1.3, 95% CI: -3.8, 1.1)</p> <p>-NICU 1-3 days 3.3% vs. 5.6% (RD = -1.8, 95% CI: -3.9, 0.2)</p>	<p>and caesarean section history, educ., age, marital status, country of origin, height, smoking during pregnancy</p> <p>Crossover between study groups, 1.9% for collaborative care vs. 1.3% for traditional care</p> <p>Power of 80% (<math>\alpha=.05</math>) to detect significant risk differences of 3% to 5% for primary outcomes</p>
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<p><b>Cragin, L.(262) (2002)</b></p> <p>CA, USA April 1, 1999- March 31, 2000</p>	<p>Retrospective cohort</p> <p>Paper/computerized medical records</p> <p>Outcomes for nurse midwifery clients vs. OB patients at 2 study sites</p> <p>Primary outcome: LBW, no relevant secondary outcomes</p>	<p>Nurse-midwifery care (n=801); 62% single mothers, &gt; 90% non-White, average educ. 9.6 yrs., 99% receiving Medicaid</p> <p>OB-led care (n=372); 55% single mothers, &gt; 85% non-White, average educ. 11 yrs., 71% receiving Medicaid</p> <p>Inclusion: -delivery at 1 of 2 study sites -moderate medical or medical/social risk - ≥ 60% of antenatal care with initial provider</p> <p>Excluded: -women transferring care provider after 20 wks. gestation and having less than 75% of care at a study site</p>	<p>-LBW<sup>b</sup> 5.5% vs. 6.7% nssd</p>	<p>Moderate quality</p> <p>Provider type determined by clinician with whom a patient had &gt; 60% of their care</p> <p>“Modified intent to treat analysis”, ITT used except for women who transferred between provider types and received &gt; 60% of care from the second provider (n=21)</p> <p>Adjustment made for maternal demographics and medical complications</p> <p>Power estimated at 80% (α=.05) to detect β -371 for the primary outcome</p> <p>Author acknowledged sample size was too small to find a statistically significant difference</p>
<p><b>Visintainer et al.(259) (2000)</b></p>	<p>Retrospective cohort study</p>	<p>Enhanced care births (n=1,474); 37% of women</p>	<p>- LBW<sup>b</sup> (unadjusted) 4.1% vs. 6.9%</p>	<p>Moderate quality</p> <p>Intent to treat analysis</p>

<p>Westchester County, NY, USA 1992-1994</p>	<p>Outcomes of enhanced care, which included prenatal care administered by nurse-midwives, vs. all County births</p> <p>Sub-analysis compared enhanced care cohort with County Medicaid births only</p> <p>Enhanced care included: access to counselling, individual and group instruction on childbirth, nutrition and exercise, and a Medicaid worker to assist in enrollment in federal assistance programs</p> <p>Primary outcome: LBW</p>	<p>initiated care during the first trimester, 13% teen mothers</p> <p>County births (n=39,749); 77% of women initiated care during the first trimester, 5% teen mothers</p> <p>Inclusion: -recipient of Medicaid or no healthcare coverage (enhanced care clients only) -resident of Westchester County -15 - 44 years of age -live birth <math>\geq</math> 23 wks. gestation</p>	<p>(RR=0.59, 95% CI: 0.46, 0.73) - Medicaid sub-analysis (RR=0.44, 95% CI: 0.34, 0.57)</p> <p>- VLBW<sup>e</sup> (unadjusted) 0.6% vs.1.4% (RR=0.44, 95% CI: 0.23, 0.85) -Medicaid sub-analysis (RR=0.32, 95% CI: 0.16, 0.63)</p>	<p>Results stratified by 5 year age groups, race and Medicaid</p> <p>No adjustment for preexisting health complications or perinatal risk</p> <p>89% of a sample of women who began the enhanced care program delivered through it</p>
<p><b>Blanchette(263) (1995)</b>  Berkeley, CA</p>	<p>Retrospective cohort  Clinic medical records</p>	<p>CNM patients (n=496); 15.5% <math>\leq</math> 19 yrs. old, 19.6% White, 19.2 % initiated prenatal care <math>\leq</math> 12 wks., 10.3% substance abuse</p>	<p>-PTB<sup>g</sup> 2.4% vs. 2.9%, nssd</p> <p>-Apgar score 1 min. average 8.0 vs. 7.9, 7 min. average 9.0</p>	<p>Weak quality</p> <p>No adjustment for confounders</p>

	<p>Compared outcomes for patients of a primary Care Access Clinic, the Clinic offered comprehensive care to all patients, with primary care delivered by CNMs who were supervised by 4 OBs vs. the OBs private practice patients</p> <p>No reported distinction between primary and secondary outcomes</p>	<p>OB patients (611); 2.6% <math>\leq</math> 19 yrs. old, 62.36% White, 58.76% initiated prenatal care <math>\leq</math> 12 wks., substance use unknown</p> <p>Included: -any patients who accessed the CNMs at the Clinic or were private patients of the OBs during the study period</p> <p>Excluded: CNM patients who transferred care antepartum/intrapartum due to medical risk</p>	<p>vs. 8.9, 1 min <math>&lt;</math> 7, 8.0% vs. 9.66%, 5 min. <math>&lt;</math> 7, 0.8% vs. 1.13%, all nssd</p> <p>-Birth weight <math>&lt;</math> 5lbs. 2.4% vs. 3.07%, nssd, all other birth weight comparisons nssd</p>	<p>Significantly different comparison groups</p> <p>Patients transferring antepartum or intrapartum from midwifery to physician care (n=12) were excluded from the analysis</p>
<p><b>Fischler et al.(260) (1995)</b></p> <p>A rural county in northwestern USA Jan. 1, 1989- June 30, 1990</p>	<p>Retrospective cohort</p> <p>Medical charts</p> <p>Compared outcomes for CNM patients in private practice to CNM patients in a hospital sponsored clinic, and to MD patients in a private practice setting</p> <p>No reported distinction between</p>	<p>CNM patients in private practice (n=111), 100% receiving Medicaid, 25% <math>&lt;</math> 12 yrs. educ., 33% primiparous, 33% smokers</p> <p>CNM patients in a hospital-sponsored clinic (n=309); 17% receiving Medicaid, 32% <math>&lt;</math> 12 yrs. educ., 48% primiparous, 32% smokers</p> <p>MD patients in private practice (n=297); 100% Medicaid, 51% <math>&lt;</math> 12 yrs.</p>	<p>-Average birth weight positively associated with CNMs in private practice (3,598g.) compared to MDs (3,407.3 g., <math>\beta</math> 0.13, <math>p &lt; 0.05</math>)</p> <p>-nssd between average birth weight for CNM clients in a hospital clinic (3,400.0g.) and MDs</p>	<p>Moderate quality</p> <p>Adjustment for age, race, marital status, parity, educ., medical factors of pregnancy, smoking, adequacy of prenatal care, and setting</p> <p>No mention of how analysis was conducted for clients requiring transfer of care from CNMs to</p>

	primary and secondary outcomes	educ., 39% primiparous, 47% smokers  Included: -women identified as low-income either by Medicaid eligibility or financial screening by the County Health Dept.  Excluded: -women who attended a prenatal practice that used a combination of CNMs and MDs -if prenatal care provider could not be identified -multiple births	-Low Apgar score, NICU admission, PTB <sup>h</sup> , and LBW <sup>h</sup> nssd between all comparison groups	MDs/OBs for medical indication
<b>McLaughlin et al.(256) (1992)</b>  Davidson County, TN, USA	RCT  Comprehensive care from a multi-disciplinary team including primary care from nurse-midwives vs. standard care from OB residents  Comprehensive care included care from social workers, a nutritionist,	Comprehensive care (n=217); complete perinatal data (n=170), birth weight and demographic data only (n=183)  Sub-analysis of primiparas (n=86), sub-analysis of multiparas (n=97)  Standard care (n=211); complete perinatal data (n=138), birth weight and demographic data only (n=167)	-LBW <sup>i</sup> 10% vs. 9%, nssd  -Average birthweight positively associated with comprehensive care for primiparas 3,233 g. vs. 3,089 g. ( $\beta$ 0.17, $p < 0.05$ ) -nssd for all women and for multiparas	Moderate quality  Intent to treat analysis  Subject loss for comprehensive group (n=34), for standard care group (n=44)  Adjustment for age, African American race, marital status, educ., pregravid weight, male sex of infant, maternal height, pregravid

	<p>paraprofessional home visitors, and a psychologist</p> <p>Primary outcome: infant birth weight</p>	<p>Sub-analysis of primiparas (n=79), sub-analysis of multiparas (n=88)</p> <p>Inclusion:</p> <ul style="list-style-type: none"> <li>-women who attended Metropolitan Nashville General Hospital for their 1st prenatal visit</li> <li>-at risk for child maltreatment</li> <li>-care initiated at &lt; 28 wks. gestation</li> <li>-residing in Davidson County</li> <li>-live-born singleton</li> </ul>		<p>medical problems, drug/alcohol use and smoking</p>
<p><b>Heins et al. (255)(1990)</b></p> <p>South Carolina, USA July 1, 1983- Oct. 31, 1987</p>	<p>RCT</p> <p>Comprehensive prenatal care provided primarily by nurse-midwives and nurses under their supervision vs. standard high risk prenatal care provided by OBs</p> <p>Primary outcome: LBW, secondary outcome: VLBW</p>	<p>Clients randomized to nurse-midwifery care (n=728); &lt; grade 12 63.1%, 10-19 risk score 73.5%, smoking <math>\geq</math> 11 cig./day 38.0%</p> <p>Sub-analysis of African American women (n=348)</p> <p>Patients randomized to OB care (n=730); &lt; grade 12 61.7%, 10-19 risk score 74.8%, smoking <math>\geq</math> 11 cig./day 25.0%</p>	<p>-PTB &lt; 37 wks. gest. 16% vs. 18%, and PTB &lt; 33 wks. 5% vs. 5%, nssd</p> <p>-LBW<sup>b</sup> 15.4% vs. 16.3% (OR=0.92, 95% CI: 0.7, 1.2)</p> <p>- AA sub-analysis 17.0% vs. 18% (OR=0.74, 95% CI: 0.5, 1.1)</p> <p>-VLBW<sup>e</sup> 3.6% vs. 4.1% (OR=0.87, 95% CI: 0.5-1.5)</p> <p>- AA sub-analysis 2.6% vs. 6.7%</p>	<p>Moderate quality</p> <p>Intent to treat analysis</p> <p>Midwifery subjects lost or ineligible (n=61), OB subjects lost or ineligible (n=51)</p> <p>Power of 90% (<math>\alpha=.05</math>) to detect significant reduction in odds of LBW from 13% to 8%</p>



		<p>Sub-analysis of African American women (n=370)</p> <p><b>Inclusion:</b></p> <ul style="list-style-type: none"> <li>-attended a state-funded prenatal clinic</li> <li>-scored <math>\geq 10</math> on the first prenatal visit for risk of LBW due to social factors and previous medical risk, on a scale described by Papiernik-Berkhauer and modified by Creasy et al.(264) and/or had a LBW infant in their last pregnancy</li> <li>-no known medical or pregnancy complications at entry</li> <li>-live-born singleton</li> </ul>	(OR=0.35, 95% CI: 0.1, 0.9)	
<p>*Reference group is physician-led care</p> <p><b>Abbreviations:</b> PTB preterm birth; AA African American; OR odds ratio; nssd non-statistically significant difference; LBW low birthweight; CI confidence interval; SGA small-for-gestational-age birth; OB obstetrician; ITT intent to treat analysis; CNM certified nurse-midwife; RD risk difference; VLBW very low birthweight; NICU neonatal intensive care unit; MD medical doctor; RR relative risk</p> <p><b>Definitions:</b> <sup>a</sup>PTB birth at <math>\leq 36</math> wks.; <sup>b</sup>LBW <math>&lt; 2,500</math> grams; <sup>c</sup>PTB <math>&lt; 37</math> completed wks. gestation; <sup>d</sup>SGA <math>&lt; 10^{\text{th}}</math> percentile based on Kramer et al.'s Canadian fetal growth standards <sup>(265)</sup>; <sup>e</sup>VLBW <math>&lt; 1,500</math> grams; <sup>f</sup>SGA as defined by Williams et al. <sup>(266)</sup>; <sup>g</sup>PTB <math>&lt; 36</math> wks. gestation; <sup>h</sup>undefined; <sup>i</sup>LBW <math>\leq 2,500</math> grams</p>				

### 3.4 Discussion

Of the eight moderate quality studies reviewed, primary care delivered by midwives—either exclusively or as part of a comprehensive prenatal intervention—was associated with similar outcomes to that of physician-led care. Significant associations favoring midwifery care were found in: one of five studies for preterm birth, one of eight studies for low birth weight, one of three studies for very low birth weight, and one of three studies investigating higher mean birth weight. Sub-analyses also found significantly better outcomes for midwifery clients in one study examining very low birth weight, and in two other studies investigating mean birth weight. However, instances of inadequate adjustment for confounding, inadequate power, and variability in design, limit the conclusiveness of the evidence.

Although almost all of the studies were given a moderate quality rating, two studies were of the highest caliber within this category. Benatar et al.'s and Heins et al.'s studies were well designed, controlling for a number of observable confounders through propensity scoring or RCT protocol, and their main analyses had adequate power to detect statistically significant differences.(255, 257) Both of these studies reported statistically significant effects for adverse infant outcomes experienced by African American midwifery clients compared to physician patients of similar race/ethnicity, and neither study found a statistically significant difference in LBW. Their results diverged for PTB, with only Benatar et al. finding a statistically significant protective effect for midwifery patients (OR=0.70,  $p<0.01$ ). (255, 257)

Mean birth weight was significantly higher among midwifery clients, in every moderate quality study in which it was examined.(255, 256, 259) Other studies have reported a birth weight gradient associated with maternal education, a common measure of SEP.(267, 268) In a Danish study by Mortensen et al., maternal smoking was identified as the key mediator reducing infant birth weight for women with low education.(268) The three studies in this review that found a significant positive association between midwifery care and heavier birth weights, controlled for smoking in their analyses. However, none of the studies measured smoking reduction or cessation over the course of pregnancy by practitioner-type, a factor that could have influenced the outcomes.

This raises the question of self-selection bias, commonly suspected in midwifery/physician comparison studies, in which cohorts have systematically different health or behavioral characteristics associated with choice of caregiver. Four of the moderate quality studies demonstrated evidence of adjustment for self-selection bias. Both of the randomized controlled trials included in this review (255, 256) attained comparability between cohorts on all measured demographic characteristics, with the exception of marital status for primiparas in the study by McLaughlin et al., suggesting unknown confounders were likely controlled for through design. Benatar et al. utilized propensity score modeling to create a comparison group with almost identical observable characteristics to that of the midwifery cohort.(257) And, in the study by Simonet et al. there was likely little to no self-selection bias as all women were classified as midwifery or physician patients on the basis of their community of residence, regardless of the actual maternity provider involved in care.(261)

Of interest, in Fischler et al.'s study, a significant difference in average birth weights was reported between private practice midwifery clients and physician patients (191g,  $p < 0.05$ ), but not among midwifery clients serviced at a hospital-based clinic compared to physician patients—despite controlling for demographic and medical risk.(260) In interpreting these differing results, Fischler et al. speculate that the model of care provided by midwives in a hospital setting may bear a greater resemblance to the medical model of care than to midwifery care, thus producing outcomes similar to those of physician-led care.

Among reviewed studies that found an association between midwifery care and lower prevalence of adverse birth outcomes, three included women with more than one social or medical predictor of risk. In the study by McLaughlin et al., meaningful reductions in average birth weight were reported for midwives' patients who were nulliparous and poor, compared to physicians' patients,(256) but not for multiparous women who are at less risk of poor birth outcomes.(269) These results are in agreement with theory underlying other successful antenatal interventions aimed at lowering prevalence of adverse infant birth outcomes for low income women. For example, the Nurse-Family Partnership Program (270) has traditionally only included first time mothers, as it is hypothesized that they are especially receptive to perinatal and lifestyle counselling, (a major component of midwifery care) compared to multiparous women who may resist new advice in favor of deferring to previous personal experience.(271)

Secondly, Benatar et al. utilized a sample population comprised of 85% African American, low-income women, finding a significant improvement in PTB rates for midwifery clients.(257) In the U.S., women of African American race/ethnicity have higher prevalence of PTB, as do women of low-income.(272) Lastly, in a post hoc, sub-analysis Heins et al. found midwifery care to significantly lower VLBW *only* for African American women who had high medical and/or social risk scores.(255)

In examining why African American patients of midwifery care had lower prevalence of adverse infant birth outcomes in two of these studies, it is important to assess the significance of “race”. Nancy Krieger defines race/ethnicity as “a social, not biological, category, referring to social groups, often sharing cultural heritage and ancestry, that are forged by oppressive systems of race relations . . .”.(273, p696) Persistent discrimination, experienced across the life course, can invoke psychological distress resulting from feelings of inferiority and social exclusion,(274) as well as the internalization of racialized stereotypes.(275) Studies have found that perceived racial discrimination is a significant predictor of adverse infant outcomes for African American women, after controlling for socioeconomic and health characteristics.(168, 276) Racial discrimination may biologically manifest as chronic stress,(168) which has been measured at higher levels among parturient African American women compared to non-Hispanic White women.(277) Pregnant women experiencing high stress are more than twice as likely to have bacterial vaginosis, compared to women with lower stress levels,(135) increasing their odds of PTB by 60%, compared to uninfected women.(138) Likewise, elevated cortisol levels caused by chronic stress have been associated with PTB,(278) and maternal stress has been found to increase the risk of hypertensive disorders such as preeclampsia (279)—a leading cause of elective preterm delivery.(57)

Race, as a powerful marker of social risk, may have an independent effect on health status, or modify an existing relationship,(280) as suggested in the studies by Heins et al. and Visintainer et al. Yet, controlling for race (as was done in six studies) could obscure its effect.(280) Just as the causes of disparity in PTB and LBW have yet to be fully elucidated, (281) so the mechanisms for countering these disparities are not fully identified to date; however, studies reviewed provide evidence that midwifery care, with its emphasis on relationship, anticipatory guidance and shared-decision making, could play an important role.

Midwifery care may be a particularly effective model for all women experiencing multiple, intersecting forms of systematic marginalization. Intersectionality theory is useful in exposing how the *interaction* between discriminated social identities leads to unique experiences of disadvantage, often greater than what is understood by examining individual sources of discrimination singly or consecutively.(86, 87) Combined experiences of inequality due to race, class, sex, gender, ability, religion, immigrant status, etc. may modify health disparities, as was demonstrated in the study by Heins et al. in which racism and classism appear to increase the prevalence of LBW, compared to the effects of classism (low SEP) alone. In a conceptual model developed by Bogossian,(282) it is suggested that the individualized social and emotional support midwives offer affects birth outcomes by alleviating maternal stress—a by-product of oppressed social identity. Drawing on four theories of social support, Bogossian hypothesizes that midwifery care moderates stress by improving mood and emotional wellbeing, affecting positive behavior and biopsychological response; minimizing or eliminating a woman’s “stress appraisal response”; promoting security and worth; and helping to establish a respectful clinician-patient relationship, which in turn develops maternal self-esteem.(282, p171)

### **3.4.1 Limitations of the Review**

In some instances, differences in sample populations and study designs inhibited comparability between studies. In the study by Simonet et al.,(261) the educational preparation of apprenticeship trained midwives differed from that of the Certified Nurse-Midwives in the other eight studies, therefore the results could be a measure of risk associated with model of care and/or a reflection of the practitioners’ education. Likewise, quantity of practitioner exposure was only measured in four studies,(256, 258, 260, 262) thus differences in exposure between study populations may have influenced the results. Differing measures of low SEP and varying definitions of PTB, SGA, and LBW (see Definitions following Table 3.3) could have impacted study outcomes, as well as hampering comparability.

In five of the studies, midwifery care was part of an enhanced care intervention to improve birth outcomes which included strategies such as case management, health and nutrition education, intense follow-up of missed appointments, counselling, social services, and home visitation.(255, 256, 258, 259, 263) In the remaining studies, the objective was to specifically

examine the effects of midwifery care as practiced in a particular setting, such as a hospital or public clinic, private practice, free-standing birth center or geographical location. The degree to which enhanced services may have influenced the results is unknown, and the effect of midwifery care cannot be considered independent of the influence of these additional services; although both positive and null associations were found for programs offering specialized care compared to those providing standard midwifery care.

In seven of the studies,(255, 256, 258, 260-263) comparison cohorts were comprised of physician (OB, GP, resident) patients, whereas the other two studies (257, 259) conducted in the U.S. compared midwifery clients' birth outcomes to a similar population receiving "usual" perinatal care. Studies comparing outcomes of midwifery care to "usual care", rather than physician care, may have included a small percentage of midwifery services, mitigating the associations. But, only 7.8% of U.S. deliveries are midwifery-led,(283) therefore "usual care" is primarily non-midwifery care.

Because the *EPHPP Quality Assessment Instrument* has only three global ratings—"weak", "moderate" or "strong"—there is a range of quality variation within each category. Using this instrument, studies can have one weak component rating (i.e. control for confounding, a major limitation for this type of study) but still have a moderate overall rating. Of the moderate studies, some were clearly stronger than others, with some of them being of borderline, moderate quality.

Although all eligible studies conducted in OECD countries are included in this review, only one study was conducted outside of the U.S. Because many OECD countries use shared care models (MW and OB care), and have fewer women with low medical/obstetric risk exclusively utilizing OB or GP antenatal care, there is less opportunity outside of North America for observational study of midwifery care in contrast to physician-based care. It is uncertain how results from this review apply in environments with differing health care systems, rates of midwifery utilization, and/or rates of adverse birth outcomes due to divergent socioeconomic and cultural influences.

### **3.4.2 Recommendations**

Future prospective cohort studies examining antenatal midwifery care vs. physician-led care should be conducted on the basis of carefully defined comparison groups comprised of women with equivalent perinatal risk, who remain in the care of their initial primary providers throughout pregnancy. Studies need to be adequately powered, utilize intent to treat analysis, and control for confounders, including quantity of practitioner exposure. Defining and operationalizing low SEP according to theoretical principles, including the use of a composite indicator that includes measures of income/education/prestige would increase the sensitivity of SEP classification, allowing for dose-response analyses. Data collection on various risk characteristics such as perceived racial discrimination, domestic abuse, housing vulnerability, neighbourhood segregation, and early childhood disadvantage would facilitate an understanding of how these factors contribute independently and modify this association. This could help to determine whether midwifery models of care benefit only women of specific demographics, or all women experiencing social marginalization; and if improvement in prevalence of poor birth outcomes is proportionate to the magnitude of a woman's social disadvantage. Analysis of change in health behavior over the course of pregnancy, according to practitioner-type, would also be useful in identifying mechanisms involved in improving outcomes. Future research should examine differences in practice characteristics such as duration of practitioner contact, content of care, and quality of the clinician-patient relationship, to delineate for all practitioner-types, what components of care are advantageous for women of low SEP and in particular, among communities of colour. Qualitative research, from the women's and practitioners' perspectives, would be useful in exploring what characteristics of midwifery care they feel confer the greatest benefits and why.

### **3.5 Conclusion**

This review provides a summary and critique of the current body of knowledge concerning the association between midwifery-led care and infant birth outcomes, compared to physician-led care, for women of low SEP. Individual studies provide evidence, in some instances, of modest improvements in birth outcomes for vulnerable women in the care of midwives. Yet overall, divergent results, heterogeneity in study designs, definitions, outcomes and analytical methods,

and methodological weaknesses, highlight the need for more high quality studies to definitively establish if and how midwifery-led care influences birth outcomes for vulnerable women.

As a part of this thesis, this review provides a strong rationale for the research studies described in the following chapters. In the studies to follow I have specifically addressed the quality issues identified in this review by 1) defining comparison groups comprised of women with equivalent perinatal risk, 2) controlling for a comprehensive set of confounders, 3) limiting the included pregnancies to those in which one practitioner-type delivered the majority of the antenatal care and patients had no more than one antenatal visit (or one partial trimester of midwifery care) with another practitioner-type, 4) verifying that all patients had a minimum quantity of antenatal care exposure (equivalent to three antenatal visits), and 5) ensuring adequate power for the main effects to detect clinically meaningful differences.



# Appendix 3-A: Published Scoping Review



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## Review Article

### Is model of care associated with infant birth outcomes among vulnerable women? A scoping review of midwifery-led versus physician-led care



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#### ABSTRACT

This scoping review investigates if, over the last 25 years in high resource countries, midwives' patients of low socioeconomic position (SEP) were at more or less risk of adverse infant birth outcomes compared to physicians' patients. Reviewers identified 917 records in a search of 12 databases, grey literature, and citation lists. Thirty-one full documents were assessed and nine studies met inclusion criteria. Eight studies were assessed as moderate in quality; one study was given a weak rating. Of the moderate quality studies, the majority found no statistical difference in outcomes according to model of care for preterm birth, low or very low birth weight, or NICU admission. No study reported a statistically significant difference for small for gestational age birth (2 studies), or mean or low Apgar score (4 studies). However, one study found a reduced risk of preterm birth (AOR=0.70,  $p < 0.01$ ), and heavier mean infant birth weight (3325 g vs. 3282 g,  $p < 0.01$ ) for midwifery patients. Another study reported lower risk of low (RR=0.59, 95% CI: 0.46, 0.73) and very low birthweight (RR=0.44, 95% CI: 0.23, 0.85) for midwifery care. And, a third study reported a decrease in stays (1–3 days) in NICU (Adjusted Risk Difference= -1.8, 95% CI: -3.9, 0.2) for midwifery patients, though no overall difference in NICU admission of any duration. Other studies reported significant differences favoring midwifery care for mean birth weight (3598 g vs. 3407.3 g,  $p < 0.05$ ; 3233 g vs. 3089 g,  $p < 0.05$ ; 2 studies) and very low birth weight (OR=0.35, 95% CI: 0.1, 0.9), for sub-groups within the larger study populations. This scoping review documented heterogeneity in study designs and analytical methods, inconsistent findings, moderate methodological quality, and lack of currency. There is a need for new studies to definitively establish if and how a midwifery-led model of care influences birth outcomes for women of low SEP.

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## Chapter 4 Methods

### 4.1 Study Design

To analyze if model of care was associated with the primary and secondary outcomes of interest (SGA, PTB, LGA, Apgar score less than seven at one minute, newborn extended length of hospital stay and LBW) I used a population-based, retrospective cohort design. Although a randomized controlled trial could have been definitive in establishing a causal relationship, women have been unwilling to be assigned randomly to midwifery vs. other models of care.(284) A cohort design is the most rigorous of all observational methods and was especially appropriate for this research because there was only a small amount of missing data for the independent and dependent variables for all comparison groups, and temporality was clearly established as model of care was determined prior to infant birth outcomes.(285, 286) A cohort study allowed for the investigation of multiple adverse infant birth outcomes, both those that have been shown to have a positive association with MW care and others that have never been tested in relationship to MW care for this demographic. Additionally, using a population-based design minimized the risk of selection bias and random error due to sampling, as all eligible maternal-infant dyads were included in the analysis.(285, 287)

### 4.2 Exposure: Antenatal Model of Care

The primary exposure of interest was antenatal model of care defined according to caregiver [midwife (MW), general practitioner (GP), or obstetrician (OB)]. In B.C., GPs and OBs bill by antenatal visit whereas MWs bill according to partial or full trimester of care. To be included in the study, women must have had a minimum level of exposure to one model of care. Antenatal care with a GP was defined as at least three routine antenatal visits with a GP and no more than one routine antenatal visit with an OB, or no more than one partial trimester of MW care. Antenatal care with an OB was operationalized as: at least three routine antenatal visits

with an OB and no more than one routine antenatal visit with a GP, or no more than one partial trimester of MW care. Antenatal midwifery care was operationalized as: at least two partial or full trimesters of MW care (equivalent to a *minimum* of three routine antenatal physician visits) and no more than one routine GP or OB antenatal visit. (Obstetrician consultations were not included as routine antenatal visits.) The purpose of this criteria was to establish a minimum level of exposure to a single practitioner-type, as has been done in other MW/physician comparison studies.(257, 262) Secondly, in B.C. women may require a GP referral to access OB care or may not be aware of MW care as a maternity care option, particularly women of low SEP. Therefore, women may have an initial antenatal care visit with a GP prior to securing a referral to an OB, or may learn of maternity care options at or after the initial visit. To accommodate a switch in provider-type after the initial antenatal visit, I allowed a single routine antenatal visit with a physician other than the type providing the majority of the care, or one partial trimester of MW care for physicians' patients. Much like intent to treat analysis, in which subjects randomized into groups are analyzed according to their assigned groups regardless of the type of treatment they actually receive, I categorized cases by the practitioner-type they saw during the antepartum period (with the exception of one physician visit with another type of practitioner or one partial trimester of MW care), regardless of subsequent transfer to a differing provider-type during the intrapartum period.

Service billing codes were used to assess women's antenatal model of care. The MSP claim specialty codes, "General Practice" or "Obstetrics and Gynecology", in conjunction with the fee item codes, "14090 prenatal visit-complete exam", "14091 prenatal visit-subsequent exam", or "04717-prenatal office visit-complex obstetrical patient", were used to classify women into the GP and OB cohorts, respectively. The following MSP codes were used to determine a full or partial trimester of MW care:

Table 4.1: MSP Midwifery Service Codes for Determining Full and Partial Trimesters of Care

<b>36010</b>	Midwife Phase 1 (1rst trimester) Total Care
<b>36014</b>	Midwife Phase 1 (1rst trimester) Trans to other 40%
<b>36016</b>	Midwife Phase 1 (1rst trimester) Trans to other 60%
<b>36020</b>	Midwife Phase 2 (2nd trimester) Total Care
<b>36024</b>	Midwife Phase 2 (2nd trimester) Trans to other 40%
<b>36026</b>	Midwife Phase 2 (2nd trimester) Trans to other 60%
<b>36030</b>	Midwife Phase 3 (3rd trimester) Total Care
<b>36034</b>	Midwife Phase 3 (3rd trimester) Trans to other 40%
<b>36036</b>	Midwife Phase 3 (3rd trimester) Trans to other 60%

### 4.3 Primary Outcome: Small-for-Gestational-Age Birth

The primary outcome of interest was SGA birth determined by weight less than the 10th percentile, as per Kierans and colleagues’ sex specific, B.C. population birth weight charts (3) (see Appendix 4-A: Small and Large-for-Gestational-Age Thresholds). This conventional definition of SGA was chosen to facilitate comparability between this and other studies and because of the significant increase in risk of mortality and morbidity observed amongst infants below the 10<sup>th</sup> percentile threshold.(288) In a large U.S. based study (n=17,979,120), Xu et al. found that infant birthweight below the 10th percentile more than doubled the risk of neonatal death (RR at preterm 2.30, 95% CI: 2.21-2.40, RR at term 3.51, 95% CI: 3.34-3.70, RR at post-term 3.96, 95% CI: 2.91-5.39) compared to infants in the 25th to 75th percentile.(288)

#### 4.3.1 Kierans et al.’s Population-Based Growth Reference

Kierans and colleagues’ population-based growth reference summarizes birth weight distributions for the period between 1981 and 2000,(3) and was approved for use in B.C. provincial hospitals as of 2006.(289) The charts are intended to guide clinical intervention for SGA or LGA births by specifying an “ideal” or “target” weight for gestational age, based on provincial averages.(3, p9) Critics, however, argue that the population–based charts are flawed due to the inclusion of all women, regardless of health status or practices, in the construction of the curves. Mothers who have a higher risk of delivering an infant with poor growth, due to factors such as smoking, hypertension or previous preterm delivery, contribute to the birth weight distribution and proportion of SGA, LGA and appropriate for gestational age (AGA)

births. In essence, the health status and practices of the population define normal fetal growth and determine target weight for gestational age.(290)

Critics of growth chart *references* contend that typical growth patterns are a poor indicator of healthy development compared to ideal growth *standards*. Standards describe infant growth for those living in optimal fetal environments.(291, 292) Problems arise with growth references when the reference population is unhealthy. For example, on the Centers for Disease Control and Prevention (CDC) population-based curve a female infant weighing 3,400 grams at term would be plotted at the 50<sup>th</sup> percentile. The same infant would be charted mid-point between the 50<sup>th</sup> and 75<sup>th</sup> percentile on the World Health Organization's (WHO) international growth standard, based on optimal fetal growth.(293) The danger in utilizing population level weight and height references that are higher than the ideal standard for gestational age is that it "could result in 'normalizing' high BMI and overweight".(294, p564) In addition, population-specific growth references are criticized for creating discordance between definitions of SGA, LGA, and AGA, hampering opportunities to compare research results, compared to growth standards.(295)

#### **4.3.2 WHO International Growth Standard**

Recently there has been a move away from the CDC and Canadian growth references to standards based on expected growth potential. As of 2010 the Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada, and Community Health Nurses of Canada issued a collaborative statement endorsing the use of the international child growth charts produced by the WHO, for all full-term infants, and preterm infants after discharge from a NICU.(295) This includes a recommendation that population health surveillance organizations adopt the use of the standardized universal growth charts to allow for comparisons within and between countries.(295) In 2014 the Canadian Paediatric Endocrine Group joined in the collaborative endorsement.(296)

The underlying theory for the WHO charts is that healthy children thriving in an optimal environment will have similar growth trajectories regardless of maternal characteristics, including ethnicity or geographic residence.(297) In keeping with the purpose and theory underlying the creation of the charts, namely to produce a universal, "gold standard" growth curve, a six country, longitudinal growth study was conducted between 1997 and 2003.(297) Infants were excluded from the study if their mothers smoked during pregnancy or lactation,

were of low socioeconomic status, delivered prior to 37 weeks or beyond 42 weeks, had multiple births, had significant morbidity, or did not adhere to feeding recommendations. Infants with weight-for-length measurements greater than three standard deviations were also excluded from the sample.(297) The mean length measurements in the six countries sampled (Brazil, Ghana, India, Norway, Oman, and the U.S.) were nearly identical for infants zero to 24 months.(297)

But international standards of optimal growth have been challenged, particularly from ethnic groups unrepresented in the WHO sample population. Field tests in Hong Kong indicate that by age three, children were on average 1.3 cm shorter than the WHO sample population from which the charts were derived, despite access to healthy environmental conditions.(294) Researchers suggest that gene expression rather than genetic composition may play a role in the apparent population-wide failure to meet growth expectations. They point to the socioeconomic history of the area as a possible factor impacting height norms. The lack of East Asian representation in the creation of the WHO charts casts doubt on the generalizability of the standard, and suggests that the choice of countries represented may have biased the claim of near identical length/height mean measurements for differing nationalities.(294)

#### **4.3.3 Customized Growth Charts: Ethnicity-Specific and Intrauterine**

A third option for assessing growth by gestational age is the use of ethnic-specific standards, which account for differences in infant birth weight patterns according to ethnicity, controlling for other maternal characteristics. In a hospital based B.C. study involving healthy, non-smoking mothers who delivered at term, Janssen and colleagues found that infants of European decent were significantly larger than infants of Chinese ( $p < 0.001$ ) or South Asian ( $p < 0.001$ ) descent.(81) Researchers suggest that physiological differences and/or regional influences may result in differing ethnic population distributions requiring context specific, frequently updated growth curves to accurately capture growth potential.(294)

The challenge in choosing an appropriate birth weight curve is to determine which distribution best distinguishes between infants who are pathologically SGA, the result of IUGR in which maternal or fetal disease, placental insufficiency, or a poor uterine environment inhibits infant growth potential,(298) and those who are healthy, but constitutionally small.(290, 299-302) In a study by Hanley et al., Janssen's ethnicity-specific standard was tested for infants

classified as SGA, and was shown to more accurately predict: 5 minute Apgar score < 7, need for ventilation, extended length of stay, infection, hypoglycemia, NICU admission, and hypothermia, by two to seven times that of Kierans' growth chart reference, demonstrating that the ethnicity-specific standard better predicted pathological SGA, and reduced the risk of false positive classification.(299)

Choice of growth distribution can have a particularly significant impact on SGA and IUGR classification for preterm births. Preterm infants have greater odds of exposure to *in utero* conditions inhibiting optimal growth.(302) For preterm infants, growth references based on birth weight at gestational age are, on average, lower than intrauterine birth weight estimates of healthy infants (measured by either symphysiofundal height or by single or serial ultrasound scans) at the same gestational age, who are carried to full-term.(73,84) In a study comparing three methods of identifying SGA for children born very preterm and with delayed cognitive function/academic achievement, investigators found that the risk of having a mental processing composite score of <85 on the *Kaufman Assessment Battery for Children* increased for those who were deemed AGA on a standard birth weight reference<sup>4</sup>, and considered SGA according to an intrauterine reference,<sup>5</sup> compared to children deemed AGA by both the birth weight and intrauterine references (AOR 1.74, 95% CI: 1.22-2.28).(302) This suggests that the intrauterine reference was better able to capture pathological SGA and the accompanying consequences of it, compared to the birth weight reference.

As Cameron et al. note, “the choice of growth chart depends on the question being asked”, if the purpose of the chart is to understand infant growth as it occurs in a particular population, then a cross-sectional birth weight reference is the appropriate tool.(303, p155) If the intent is to define optimum growth potential and identify cases that deviate from that standard, then ethnicity-specific charts, developed from a longitudinal study, utilizing intrauterine references, will likely be more useful.

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<sup>4</sup> French Association of Users of Computerized Files in Perinatology, Obstetrics and Gynecology

<sup>5</sup> Hadlock and colleagues' growth curves modified by Gardosi et al. in Gardosi J, Mongelli M, Wilcox M, Chang A. An adjustable fetal weight standard. *Ultrasound Obstet Gynecol*, 6 (1995), pp. 168–174.

In this study the aim was to assess SGA as it occurred in a B.C. population, therefore Kierans et al.'s B.C. growth charts provided an appropriate reference. For this study, use of the WHO growth standard was not feasible because the growth curves begin at birth (age 0) without specifying an infant's gestational age. Kierans' growth distributions include measures between 20 to 44 weeks completed gestation, allowing for an assessment of SGA or LGA at term and preterm gestations.

Because more than 26% of B.C.'s population self-identifies as East or Southeast Asian or Chinese,(304) the combined lack of data on ethnicity in the birth record and the use of Kierans' distribution for this research may have resulted in some misclassification, where infants of an appropriate size within their own ethnic population were labelled SGA. Without ethnicity data, it is unknown if differences existed in ethnic/racial composition of patient populations for the three models of care, and how this may have influenced rates of SGA between cohorts.

#### **4.4 Secondary Outcomes**

All secondary outcome measures were documented in the B.C. Perinatal Data Registry (BCPDR) newborn record. Secondary outcomes included PTB, defined as birth equal or greater than 20 weeks completed gestation and less than 37 weeks completed gestation, LGA at birth, standardized for age and newborn sex ( $> 90^{\text{th}}$  percentile), Apgar score less than seven at one minute, and extended length of hospital stay (ELOS) for the newborn ( $\geq 3$  days for vaginal delivery or  $\geq 4$  days for cesarean delivery). Apgar score less than seven at one minute was chosen over Apgar score less than seven at five minutes as it has been shown to have a higher predictive accuracy for severe adverse outcomes.(305) In a B.C. study (n=8,466) examining Apgar score at one or five minutes as a predictor of severe neonatal morbidity (measured using a composite outcome of hypoxic ischemic encephalopathy, NICU level 3 stay  $\geq 2$  days, ventilator support, or neonatal death), Apgar score at one minute had a sensitivity and specificity of 81%, vs. 57% sensitivity and 97% specificity for Apgar score less than seven at five minutes.(305) For the studies in this thesis, Apgar score less than seven at one minute was also a more appropriate outcome to examine as it occurs at a much higher rate than Apgar score less than seven at five minutes, providing a large sample of outcomes—required for multilevel modelling.



The definition of ELOS used in this study has been used in a previous study investigating adverse infant birth outcomes,(299) and aligns with the time frame for appropriate infant discharge discussed in the Society of Obstetricians and Gynaecologists of Canada's policy statement discouraging early infant discharge (< 36 or < 48 hours depending on the study cited) due to increased risk of neonatal mortality and morbidity.(306)

Apgar score and ELOS, unlike the other outcomes in this study, are influenced by both antenatal maternal fetal health and the processes of labour and delivery. Although antenatal model of care may diminish prevalence of low Apgar score and ELOS by influencing prenatal health status, these improvements may be negated when complications arise during the intrapartum period. The influence of antenatal model of care and the birth process on Apgar score and ELOS cannot be teased apart with the data available in this study, therefore this is a notable limitation in the analyses of these two outcomes.

Lastly, low birth weight (LBW) (< 2,500 g.) was included in this study for the sake of comparison with other studies and to allow for the results of this study to be included in any future meta-analyses. Although LBW is a frequently reported birth outcome in the literature, this classification can include preterm infants and those born SGA because of IUGR.(14) Separate analyses of PTB, SGA, and IUGR would be more informative than that of LBW in understanding the pathology of infant morbidity.

#### **4.5 Inclusion and Exclusion Criteria**

Pregnancies were included if a mother had low socioeconomic position. Low SEP was operationalized as low income determined by receipt of Medical Services Plan regular premium subsidy assistance for the mother's household during the year of delivery. Regular premium subsidy assistance is based on a household's previous years' income and is granted as a 20%, 40%, 60%, 80% or 100% reduction of assessed premiums (women on social assistance receive 100% premium assistance). There is also temporary premium assistance (100%) for households experiencing unexpected hardship. For the studies in this thesis, low SEP was assessed only on the basis of regular premium assistance (20% to 100%) including premium assistance paid by social services. Between 2005 and 2012 the minimum eligibility criteria for regular MSP premium assistance for individuals and families, based on annual combined net income, less

deductions for age, family size, disability, Universal Child Care Benefit, and Registered Disability Savings Plan Income, was between \$20,000 and \$30,000 for families of three or more depending on the year.(307) In comparison, between 2005 and 2010 the after-tax low income cut-off in Canada was \$32,757 to \$37,036 for a family of three.(308)

For individuals receiving social assistance, who are not registered Status Indians, health-care premiums are paid directly by the B.C. Ministry of Social Development and Social Innovation (formerly the Ministry of Employment and Income Assistance). All other British Columbians must apply in order to receive premium assistance. Studies from 2003 and 2005 show that 17% of families eligible for full premium assistance did not apply for it,(309) including 13.9% of lone mothers.(310) Therefore, defining low SEP on the basis of receipt of MSP subsidy assistance likely resulted in misclassification of some women with low SEP. Yet, previous studies using this methodology to examine coronary heart disease, hospitalization for depression, and emergency contraceptive use, have been successful in detecting substantial differences in health practices and outcomes for low income individuals compared to the remainder of the population.(311, 312)

For this study, additional eligibility criteria included pregnancies in which the mother:

- was a B.C. resident;
- had a singleton birth;
- delivered between 1 January 2005 and 31 December 2012;
- had low to moderate obstetric/medical risk based on “Indications for Discussion, Consultation and Transfer of Care”,(313) guidelines endorsed by the College of Midwives of B.C., as well as expert consultation from members of my Advisory Committee;
- received antenatal care from a MW, OB, or GP;
- had no more than two antenatal providers involved in care;
- was not a registered Status Indian;

During the study period women who were registered Status Indians had their insurance premiums paid through Health Canada and therefore did not collect MSP premium subsidy assistance, the key indicator used to assess low SEP.

Pregnancies were excluded if mothers had: maternal disease of the blood, blood forming organs or of the circulatory system; pre-existing hypertension; diabetes; liver disorders; tuberculosis; or malaria. Women were also excluded who had higher obstetric risk, defined as: more than one preterm birth; more than two spontaneous abortions (prior to 20 weeks gestation); more than two cesarean section deliveries; multiple fetuses in the current pregnancy; pre-eclampsia/eclampsia; placenta previa with hemorrhage; isoimmunization; incompetent cervix; hyperemesis gravidarum with metabolic disturbance; or adolescents who were less than 14 years old. (See Appendix 4-B for a list of exclusion terms and their ICD 10-CA codes where applicable.)

#### **4.6 Data Sources**

The primary data source for this study was the BC Perinatal Data Registry.(314) Administrative data supplied by obstetrical facilities, and registered midwives in the case of home births, are housed in the province-wide BCPDR, managed by Perinatal Services B.C. (PSBC). The BCPDR also contains International Statistical Classification of Diseases (ICD-10-CA) codes imported from the Canadian Institutes of Health Information Discharge Abstract Database. As of April 1, 2000, the BCPDR has captured approximately 99% of all B.C. births.(315) Validation studies report that the BCPDR has a 97% accuracy rate over all data fields.(315)

BCPDR data were linked to data provided by the B.C. Ministry of Health, contained in their MSP Payment Information File,(316) and Population Data BC's Consolidation File.(317) The MSP File contains fee-for-service provincial billing information for medically necessary care, listed by date of service. Files were linked by Population Data BC to allow assessment of maternal receipt of the regular premium assistance subsidy for medical insurance, receipt of social assistance, and prenatal provider-type, as well as to confirm accuracy of the infant birth data recorded in the BCPDR. For example, approximately 99% of the cases I identified as midwifery-led according to the MSP billing data had the BCPDR variable "midwife involved in maternal or neonatal care" indicated in the maternal record.

The Consolidation File contains annual demographic information, including neighbourhood income quintile for each individual in B.C. who is eligible to receive medical

services. The File is comprised of data from the B.C. Ministry of Health Services, B.C. Ministry of Health Services Registration & Premium Billing Files, MSP Payment Information, Discharge Abstract Database, B.C. Stats Translation Master File, and Statistics Canada Postal Code Conversion File. Both the MSP and the Consolidation Files are subject to internal audits and quality checks to ensure high standards for data collection.(317) Maternal infant data supplied in the BCPDR was linked to the MSP and Consolidation Files by data analysts at Population Data BC.

B.C. Stats has publically available demographic and socioeconomic equity data for each local health area (LHA), based on the 2005/06 Canadian census.(4, 5, 318) The quality of the census data has been verified against other data sources, and imputed data due to missing or inconsistent responses amount to less than 3%.(319) Permission was granted from all Data Stewards to link B.C. Stats data on population size, relative income inequality, and socioeconomic rank for each LHA to individual-level maternal infant data from all other data sources. See Appendix 4-C for a summary list of variables and their data sources.

#### **4.7 Measures of Maternal, Community, and Institutional Level Characteristics**

Potential covariates were identified *a priori* from the literature and limited by data availability. All data for these variables were supplied by PSBC, the B.C. Ministry of Health, Population Data BC, or B.C. Stats.

##### **4.7.1 Biological Characteristics**

Maternal age was categorized as (14-19, 20-24, 25-29, 30-34, 35-39,  $\geq 40$ ) to divide women into age categories of known risk. Parity was dichotomously coded as multiparous/nulliparous. Medical risk was measured as a composite variable that included: maternal disease of the respiratory or digestive system, and endocrine, nutritional, or metabolic disease. History of obstetric risk included women who had at least one of the following conditions in past pregnancy: major congenital anomaly, neonatal death, stillbirth ( $\geq 20$  weeks gestation), or one preterm delivery.

Women's pre-pregnancy BMI was calculated as a ratio of a woman's weight compared to height, and classified according to the following Health Canada guidelines: underweight  $<18.5$ ,

normal 18.5-24.9, overweight 25-29.9, and obese  $\geq 30$ .(2) As per recommendations developed by the Institute of Medicine (2009) and adopted by Health Canada, the following guidelines (see Table 3.2) were used to assess patients' weight gain during pregnancy.(2) On the basis of these recommendations patients were classified as having greater than recommended, within recommended, less than recommended, or unknown weight gain during pregnancy.

Table 4.2: Pre-Pregnancy BMI Classifications and Recommended Weight Gain During Pregnancy (2)

<b>Pre-Pregnancy Body Mass Index</b>	<b>Pre-pregnancy BMI Classification</b>	<b>Recommended Weight Gain (kg.) During Pregnancy</b>
<18.5	Underweight	12.5-18.0
18.5-24.9	Normal weight	11.5-16.0
25-29.9	Overweight	7.0-11.5
$\geq 30$	Obese	5.0-9.0

Antepartum morbidity included: pregnancy induced hypertension, gestational diabetes either insulin dependent or non-insulin dependent, anemia, intrauterine growth restriction, viral disease, infection and parasitic disease, placenta previa without hemorrhage, polyhydramnios or oligohydramnios, antepartum hemorrhage  $\geq 20$  weeks, sexually transmitted infection, or HIV, or premature separation of the placenta.

#### **4.7.2 Psychosocial Characteristics**

Mental illness/disorder included any of the following diagnoses prior to, or during the current pregnancy: anxiety disorder, depression, postpartum depression, bipolar disorder, schizophrenic disorders, mood disorders, psychotic disorders, phobic anxiety, obsessive-compulsive disorders, and reaction to severe stress and adjustment disorders. See Appendix 4-C for ICD 10-CA codes related to mental illness/disorder.

### **4.7.3 Behavioural and Lifestyle Characteristics**

Smoking status was defined as never, former, current or unknown. The variable “substance use” included: heroin/opioids, cocaine, methadone, solvents, marijuana, or other/unknown drugs used at any time during pregnancy, prescription or other drug use identified as a risk at any time during pregnancy, or dependent or non-dependent abuse of drugs as coded in the ICD 10-CA (see Appendix 4-C for specific codes). Alcohol exposure, including alcohol dependence was determined by the midwife/physician identifying it as a risk during pregnancy and was indicated in the BCPDR checklist and/or by an ICD 10-CA code (see Appendix 4-C).

Kotelchuck’s Adequacy of Prenatal Care Utilization (APNCU) Index was used to describe prenatal utilization by model of care (1) (see Appendix 4-D). The index is based on two key indicators, 1) adequacy of initiation of prenatal care, and 2) adequacy of received services. To assess the first indicator, timing of care was categorized according to the first visit occurring during gestational months 1-2, 3-4, 5-6, or 7-9. To determine the second indicator, a ratio was calculated for the observed to expected number of visits. For this Index, guidelines for expected number of visits are derived from standards developed for uncomplicated pregnancies by the American College of Obstetricians and Gynecologists. After the adequacy of received services were adjusted to account for the timing of initial care and gestational age at delivery, overall prenatal utilization was categorized as adequate plus, adequate, intermediate, inadequate or unknown.(210)

Receipt of social assistance, a potentially stigmatizing social characteristic, was tested as both a confounding and modifying factor. Social assistance at delivery was determined from MSP payment information, indicating that the Ministry of Employment and Income Assistance had made a payment on behalf of the recipient.

### **4.7.4 Community and Institutional Level Risk Factors**

#### **4.7.4.1 Neighbourhood Income**

Neighbourhood income was defined as low/medium or high, based on neighbourhood income quintiles one through four (low/medium) vs. quintile five (high). This allowed me to measure if and how residence in the most affluent neighbourhoods influenced the odds of adverse infant birth outcomes by model of care compared to those in less affluent

neighbourhoods. Data used to construct neighbourhood income quintile were derived from Statistics Canada, and the neighbourhood quintile variable was available in Population Data BC's Consolidation File. Neighbourhood income quintiles reflect the average, single-person income in a Canadian census dissemination area (DA), an area populated by approximately 400 to 700 people.(320) To determine the average income for a single-person, the total income of a DA is divided by the total number of weighted "single-person equivalents".(321) A single-person household receives a weight of 1.0, a two-person household a weight of 1.24, and a three person household a weight of 1.53, etc. In determining an individual's neighbourhood income quintile, their residential postal code is mapped to a census DA and the quintile of the DA is then assigned to the individual.(317) Population coding errors, amounting to 7.6%, have been detected when evaluating this method against a "gold standard"—a one percent sample of the 1996 Canadian census data.(321)

#### **4.7.4.2 Urban Versus Small/Rural Area Residence**

LHA population estimates were derived from B.C. Stats data.(318) LHAs with a population less than 10,000 people (not in a census metropolitan area or a census agglomeration<sup>6</sup>) were considered rural areas. LHAs of equal or greater than 10,000 residents, or those in a census metropolitan area or a census agglomeration, were considered urban areas. A similar 10,000 resident threshold (based on census data) has been used for classifying rural/urban status by the Canadian Institute for Health Information when reporting on hospital births in Canada,(243) and preterm and SGA births by urban and rural residence.(24)

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<sup>6</sup> Census metropolitan areas (CMAs) and census agglomerations (CAs) are areas comprised of core populations surrounded by smaller municipalities. CMAs must have at least 50,000 residents in a core area, and a minimum 100,000 person population. CAs have a minimum 10,000 person core population. From: Statistics Canada. 2006 Census Dictionary. Statistics Canada Catalogue no 92-566-XWE. Ottawa, ON.

#### **4.7.4.3 Local Health Area Income Inequality Index**

Area-level income inequality, in which there is a large disparity in annual income amongst households residing within the same region, was included in some models as a confounding factor. In a previous area-level study demonstrating increased risk of adverse birth outcomes in urban areas, the authors suggested that income inequality could have influenced the results.(54) To measure if income inequality had an effect on the relationship between model of care and adverse infant birth outcomes in this study, B.C. Stats “Income Inequality Index” rankings (4) were divided into terciles to categorize LHAs as having low, medium, or high income inequality. B.C. Stats determines income inequality rankings by dividing a LHA’s total household earnings for individuals earning less than the median income, by total household earnings for all residents.(4)

#### **4.7.4.4 Local Health Area Socioeconomic Index Rank**

A third area-level measure, the LHA “Overall Regional Socioeconomic Index”, was also included in the analysis as a potential confounder. This index is calculated by B.C. Stats, based on a wide range of social determinants of health reflecting area-level economic and social processes, and policy decisions.(5) The Index is based on six weighted indicators of area-level socioeconomic position including: economic hardship, crime, health problems, educational concerns, and children and youth at risk, derived from data compiled between 2008 and 2012. Each of the indicators is comprised of three or four variables, such as “Percent of the population 0 and over receiving income assistance continuously for over one year”. For this study, socioeconomic rankings were divided into terciles and women were categorized as living in LHAs with low, medium, or high area-level socioeconomic position (or unknown). See Appendix 4-E for a list of LHAs and their urban or rural area status, income inequality rank, and socioeconomic rank.

Of note, B.C. Stats combined the data for all Vancouver LHAs (n=6), and for both Surrey LHAs, reporting one income inequality and one socioeconomic index rating for each area. As there are stark social and economic differences between LHAs within Vancouver, and between LHAs within Surrey, this method may have obscured some of the effects of area-level risk.



#### **4.7.4.5 Northern Residence**

Previous research suggests that women residing in northern B.C. may be exposed to more maternal risk factors and have greater prevalence of adverse infant birth outcomes for some conditions, compared to women in other regions of B.C. For example, women in the Northern Health Authority (NHA) have higher rates of women with high BMI (overweight and obese) and initiate prenatal care later than women in any other Health Authority in the province.(322) Infants born to mothers from the NHA have the second highest percentage of newborn hospital readmission and the highest proportion of infants with sepsis requiring NICU admission than any other provincial Health Authority.(322) To analyze the influence of northern residence on the relationship between model of care and infant birth outcomes, all cases were classified as residing within or outside of the NHA.

#### **4.7.4.6 Birth Year**

Over time, variation in perinatal service availability, diagnostic procedures and standards, and changes in practice within and between models of care may affect trends in birth outcomes. To account for these differences I tested individual birth year (2005, 2006, etc.) as a confounder in all models.

### **4.8 Analysis Plan**

#### **4.8.1 Data Cleaning**

In order to understand the distribution of the data and relationships between covariates, frequency tables and bar charts were constructed for discrete variables. For continuous variables the mean, standard deviation, and range of values were explored using the PROC UNIVARIATE procedure and box-whisker plots. The preliminary exploration of the data allowed for data cleaning and informed the coding process (i.e. revealing cells with low (<5) or zero frequency that could be collapsed into larger categories or deleted). Data were also inspected to determine what type of variables had missing data and the extent of the missing data. SGA and all other dependent variables were coded dichotomously—presence or absence of disease/condition. SAS Enterprise 7.1 (SAS Institute, Cary, NC, USA) was utilized for all data analysis.

#### 4.8.2 Univariate Analysis

To select variables for initial inclusion in the multivariable analysis I ran univariate logistic regression models, regressing the outcomes of interest on suspected predictors, confounders and moderators, to generate odds ratios, 95% confidence intervals, and p-values using the Pearson Chi-Square test. As suggested by Hosmer and Lemeshow, variables that had a p-value less than 0.25 and had been previously identified in the literature as independent predictors, or variables which met the criteria for confounders or effect modifiers, were selected for the initial regression models along with variables of clinical relevance.(323)

To identify potential confounders, I considered covariates which were 1) associated with model of care; 2) did not appear to be on the causal pathway between model of care and the outcome under investigation; and 3) were either a cause of the outcome or a proxy variable for a factor that caused the outcome.(287) For example I suspected that the following variables, amongst others, fit the confounding criteria for the association between model of care and SGA birth: maternal age, parity, medical risk, prior obstetric risk, and pre-pregnancy BMI. To assess if variables were correlated with both exposure and outcome, I modelled each separately as the dependent variable in relation to model of care and then as an independent variable in relation to SGA.(324) This confirmed that each of these covariates were correlated with both the exposure and outcome at an alpha level of  $p < 0.25$ . A further proof of their potentially confounding influence, all of these covariates were present before women were exposed to a model of care, meaning none lay on the pathway between model of care and SGA.

Four behaviours/conditions (smoking status, substance use, alcohol use, and mental illness/disorder) were suspected to both confound and mediate the relationships between model of care and the outcomes under investigation depending on when they occurred. If data on smoking status, etc. were collected at the first antenatal appointment, prior to exposure to care, and systematic differences were apparent according to model of care, then smoking status, etc. could potentially confound the relationships of interest because these behaviours/conditions have been shown to be casually related to the outcomes of interest.(202, 205) In instances where smoking status, etc. data were collected after adequate exposure to model of care, these behaviours/conditions could have mediated the association, linking model of care to SGA and other outcomes.(324) However, because the BCPDR does not specify when during pregnancy

data are collected, there was no way to tease apart the confounding effects of these characteristics from the mediating effects, although it is likely both were at work, influencing the effect estimates. Therefore, I chose to run models with and without these variables, and have reported both odds ratios for each outcome, as the “true” effect estimates likely lie somewhere in between the two results.

### **4.8.3 Multivariable Analysis**

To account for possible homogeneity in variance due to multiple births to the same mother, and community-level correlation in outcomes, logistic regression models were developed using Generalized Estimating Equations (GEEs). Observations with correlated data provide less unique information about a sample than independent observations, biasing standard errors. GEEs correct for the effect of the correlated data by generating robust estimates for standard errors.(325)

To gain a preliminary understanding of the data, multivariable logistic regression models were run to generate unadjusted odds ratios. Model building then began with an intercept-only logistic GEE model, adjusted for family and community level correlation using the mother’s identification number and the local health area in which the mother usually resided. Differing correlation structures (exchangeable, unstructured, AR1 autoregressive) were specified and compared using the Quasi-Likelihood Under the Independence Model Criteria (QIC) to determine the most appropriate correlation structure (the smaller the QIC the better the correlation structure’s fit).(326) The exchangeable correlation structure was chosen. Next, covariates which had been selected during the univariate analysis were added to the model at the same time using a manual, backward elimination approach.(327) Variables with a Z statistic p-value of greater than 0.05 were excluded one at time, beginning with the covariate having the highest p-value. After each exclusion the smaller model’s QICu statistic (which adds a penalty to the quasilikelihood to account for the number of parameters in the model) was compared to the previous model’s to determine if values were decreasing, an indication that the more complex model was improving fit.(325) In addition, when suspected confounders were removed from the model, coefficient estimates from models with and without the suspected confounder were examined to determine if the exclusion of the covariate produced more than a 20% change in any

coefficient in the model.(323) If a change of this magnitude was detected the eliminated variable was returned to the model as it provided a meaningful adjustment to (an)other variable(s) in the model.(328) This process was repeated until the only variables remaining in the model were 1) those with a p-value of less than 0.05, 2) those which produced a meaningful (>20%) adjustment to other covariates, or 3) those which had been previously identified as clinically pertinent.

Model diagnostics were run to assess model fit. For each model, the variance inflation factors (VIF) were evaluated to identify whether there was potential multicollinearity amongst covariates. As no VIFs exceeded four, there was no indication of multicollinearity and all covariates were retained.(329) Plots of Pearson residuals and leverage were used to visually inspect for potential outliers and influential cases.(330) To assess if specific cases were unduly influencing the parameter estimates, DFBETAS were inspected for the 10 most extreme cases per covariate.(331) This statistic measures how much a single observation increases or decreases the estimate of a regression coefficient, with a DFBETAS greater than 1.00 suggesting a case may have an overly large influence over the model.(332) DFBETAS values for all outcomes were less than 1.00, with the exception of a single observation for preterm birth. This suspected influential observation was temporarily removed from the data set and the regression models re-run to test for the effect of the observation on the models.(331) In the main adjusted model regressing preterm birth on model of care, odds were minimally changed (by less than 0.01) with the removal of this observation, therefore the observation was retained in the analysis and all original effect estimates reported.(331)

The second step in the analysis was to test, one at a time, for variables which modified the association of interest. Product terms comprised of model of care and each suspected effect modifier (mental disorder/illness, substance use, receipt of social assistance, teen parent status, and neighbourhood SEP) were included in the models, as well as all lower order variables, to test the hypothesis that women in positions of social vulnerability, in addition to low SEP, were at less risk of SGA and other adverse infant birth outcomes if receiving antenatal MW care vs. OB or GP care. As recommended in the intersectionality literature, I relaxed the significance threshold for all interaction terms to  $p < 0.10$  to accommodate the large number of categories resulting from multiple interactions.(86, 333) Odds ratios and Wald statistic 95% CIs for each association are reported. The third stage of analysis was similar to the second stage but product

terms consisted of two positions of social vulnerability (i.e. substance using, teen mother) and model of care.

#### **4.9 Feasibility: Sample Size and Power**

Power calculations were conducted prior to study analysis, based on the following information: between 1 January 2005 and 31 December 2012 there were approximately 345,352 births in B.C.(334) Of these infants, approximately 25,643 were delivered by MWs.(335) As B.C.'s population was an estimated 4,631,302 in July of 2014,(336) and a Freedom of Information release from the B.C. Government stated that 752,867 individuals (counting only individuals or families of two or three) received premium subsidy assistance in March of 2014,(337) an estimated 16.2% of the population received MSP premium assistance (or were considered low SEP for the purposes of this study). If 16.2% of MW clients were subsidy recipients between 2005 and 2012, then approximately 4,154 MW clients in the study population would be classified as low SEP.

For the GP/OB comparison group, the sample size estimate was adjusted to account for patients of higher perinatal risk. In a report released by the Midwives Association of B.C., the organization estimates 30% of B.C.'s pregnancies are not midwifery eligible, therefore approximately 95,913 physician deliveries were expected to be excluded from this study on the basis of higher perinatal risk. If an estimated 16.2% of the remaining cases were low SEP, approximately 36,255 comparison cases would be available for the analyses. Power analyses, based on rates of SGA (7.6%), PTB (7.5%) and LGA (11.4%) in B.C. from 2006 to 2010,(190) were calculated using OpenEpi Version 3.01. Statistical power, based on the projected sample size, was estimated at greater than 99 percent likelihood to detect a true association if one existed for all three outcomes.

#### **4.10 Ethical Considerations**

Ethics approval for this study was granted from the University of Saskatchewan, Biomedical Research Ethics Board and the University of British Columbia, Children's and Women's Health Center of B.C. Research Ethics Board. All data linkage, with the exception of data derived from B.C. Stats, was performed by data analysts at Population Data BC and all data

was de-identified before being released. Data was stored in a Secure Research Environment (SRE) with access to Population Data BC's central server protected through an encrypted Virtual Private Network, a firewall, password timeouts, and a YubiKey. The research was of minimal risk as only aggregate, unidentifiable results are reported.

#### Appendix 4-A: Small and Large-For-Gestational-Age Thresholds

Male Singleton		
	SGA < 10 <sup>th</sup> percentile	LGA >90 <sup>th</sup> percentile
Gestational age @ birth	Admission weight in grams	Admission weight in grams
20	≤ 290	≥ 590
21	≤ 360	≥ 550
22	≤ 400	≥ 675
23	≤ 460	≥ 710
24	≤ 590	≥ 870
25	≤ 640	≥ 937
26	≤ 700	≥ 1,150
27	≤ 809	≥ 1,300
28	≤ 930	≥ 1,540
29	≤ 1,049	≥ 1,690
30	≤ 1,160	≥ 2,060
31	≤ 1,300	≥ 2,130
32	≤ 1,520	≥ 2,410
33	≤ 1,700	≥ 2,630
34	≤ 1,900	≥ 2,900
35	≤ 2,116	≥ 3,155
36	≤ 2,340	≥ 3,480
37	≤ 2,560	≥ 3,680
38	≤ 2,790	≥ 3,900
39	≤ 2,948	≥ 4,050
40	≤ 3,080	≥ 4,215
41	≤ 3,201	≥ 4,360
42	≤ 3,232	≥ 4,440
43	≤ 3,260	≥ 4,480
44	≤ 3,175	≥ 4,550

Female Singleton		
	SGA < 10 <sup>th</sup> percentile	LGA >90 <sup>th</sup> percentile
Gestational age @ birth	Admission weight in grams	Admission weight in grams
20	≤ 260	≥ 850
21	≤ 320	≥ 570
22	≤ 400	≥ 630
23	≤ 454	≥ 700
24	≤ 520	≥ 840
25	≤ 600	≥ 964
26	≤ 685	≥ 1,100
27	≤ 740	≥ 1,260
28	≤ 850	≥ 1,500
29	≤ 930	≥ 1,640
30	≤ 1,150	≥ 2,280
31	≤ 1,235	≥ 2,046
32	≤ 1,401	≥ 2,381
33	≤ 1,620	≥ 2,600
34	≤ 1,820	≥ 2,852
35	≤ 2,020	≥ 3,090
36	≤ 2,250	≥ 3,400
37	≤ 2,460	≥ 3,550
38	≤ 2,680	≥ 3,770
39	≤ 2,835	≥ 3,900
40	≤ 2,950	≥ 4,040
41	≤ 3,062	≥ 4,180
42	≤ 3,090	≥ 4,245
43	≤ 3,090	≥ 4,330
44	≤ 3,025	≥ 4,309

Kierans W, Kramer M, Wilkins R, Liston R, Foster LT, Uh S-H, et al. Charting birth outcome in British Columbia: determinants of optimal health and ultimate risk--an expansion and update. British Columbia Vital Statistics Agency; 2008 [cited 2014 Feb 16]. Available from: <https://www.researchgate.net/publication/301231720> Charting birth outcome in British Columbia determinants of optimal health and ultimate risk -- an expansion and update

## Appendix 4-B: Exclusion Criteria

Variables	Available in the BCPDR Checklist or as ICD 10-CA Codes
<b>Number of births</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Singleton</li> <li>• All other categories (excluded)</li> </ul>
<b>Maternal diseases of the circulatory system and blood/blood forming organs</b>	Codes beginning with: O99.1 Other disease of the blood and blood-forming organs and certain disorders involving the immune mechanism complicating pregnancy O99.4 Disease of the circulatory system complicating pregnancy O99.8 Other specified disease and conditions complicating pregnancy, childbirth and the puerperium
<b>Pre-existing hypertension complicating pregnancy, hypertensive heart disease, hypertension secondary to renal disease</b>	Codes beginning with: O10.1 Pre-existing hypertensive heart disease complicating pregnancy, childbirth, and the puerperium O10.2 Pre-existing hypertensive renal disease complicating pregnancy, childbirth and the puerperium O10.3 Pre-existing hypertensive heart and renal disease complicating pregnancy, childbirth and the puerperium O10.4 Pre-existing secondary hypertension complicating pregnancy, childbirth and the puerperium O10.9 Unspecified pre-existing hypertension complicating pregnancy, childbirth and the puerperium
<b>Antihypertensive drugs, hypertensive chronic renal disease, hypertension due to other causes</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes (excluded)</li> <li>• No</li> </ul>
<b>Diabetes mellitus (insulin dependent), diabetes mellitus (non-insulin dependent)</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes (excluded)</li> <li>• No</li> </ul> Codes beginning with: O24.5 Pre-existing type 1 diabetes mellitus in pregnancy O24.6 Pre-existing type 2 diabetes mellitus in pregnancy O24.7 Pre-existing diabetes mellitus of other or unspecified type in pregnancy
<b>Liver disorders</b>	Codes beginning with: O26.6 Liver disorders in pregnancy, childbirth and the puerperium
<b>Tuberculosis, malaria</b>	Codes beginning with:



	O98.0 Tuberculosis complicating pregnancy, childbirth and the puerperium O98.6 Protozoal diseases complicating pregnancy, childbirth and the puerperium
<b>Number of previous pre-term deliveries</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• <math>\leq 1</math></li> <li>• <math>&gt;1</math> (excluded)</li> </ul>
<b>Number of spontaneous abortions</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• <math>\leq 2</math></li> <li>• <math>&gt;2</math> (excluded)</li> </ul>
<b>Pre-eclampsia, eclampsia, or either superimposed on pre-existing hypertension</b>	Codes beginning with: O11 Pre-existing hypertensive disorder with superimposed proteinuria O14 Gestational hypertension with significant proteinuria O15 Eclampsia O16 Unspecified maternal hypertension
<b>Hemorrhage from placenta previa</b>	Codes beginning with: O44.1 Placenta praevia with haemorrhage
<b>Rh immunoglobulin given or isoimmunization</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes (excluded)</li> <li>• No</li> </ul> Codes beginning with: O36.0 Maternal care for rhesus isoimmunization O36.1 Maternal care of other isoimmunization
<b>Incompetent cervix</b>	Codes beginning with: O34.3 Maternal care for cervical incompetence
<b>Severe Hyperemesis</b>	O21.1 Hyperemesis gravidarum with metabolic disturbance
<b>Previous cesarean deliveries</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• <math>\leq 2</math></li> <li>• <math>&gt;2</math> (excluded)</li> </ul>
<b>Maternal age</b>	Grouped into the following categories: <ul style="list-style-type: none"> <li>• <math>\geq 14</math> years</li> <li>• <math>&lt; 14</math> years (excluded)</li> </ul>

#### Appendix 4-C: Covariate Description, Data Source, and ICD 10-CA Codes

Variable	Description	Variable Values	Data Source
<b>Maternal Characteristics</b>			
<b>Biological Risk</b>			
<b>Maternal age</b>	Age at date of delivery	Grouped into the following categories: <ul style="list-style-type: none"> <li>• 14-19</li> <li>• 20-24</li> <li>• 25-29</li> <li>• 30-34</li> <li>• 35-39</li> <li>• <math>\geq 40</math></li> </ul>	BCPDR
<b>Parity</b>		Grouped into the following categories: <ul style="list-style-type: none"> <li>• Nulliparous</li> <li>• Multiparous</li> </ul>	BCPDR
<b>Medical risk</b>	Maternal disease of the respiratory or digestive system, and endocrine, nutritional, or metabolic disease	O99.5 Diseases of the respiratory system complicating pregnancy, childbirth and the puerperium O99.6 Disease of the digestive system complicating pregnancy, childbirth and the puerperium O99.2 Endocrine, nutritional and metabolic disease complicating pregnancy, childbirth and the puerperium	BCPDR
<b>Prior obstetric risk</b>	Has had at least one of the following conditions in past pregnancy: neonatal death, stillbirth, infant with major congenital anomaly, or 1 preterm delivery	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCPDR
<b>Pre-pregnancy BMI</b>	Ratio of a women's pre-pregnancy weight (kg) to height (m)	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Underweight (&lt;18.5)</li> <li>• Normal (18.5-24.9)</li> <li>• Overweight (25-29.9)</li> <li>• Obese (<math>\geq 30</math>)</li> <li>• Unknown</li> </ul>	BCPDR

<b>Weight gain during pregnancy</b>	Calculated: Admission weight - pre-pregnancy weight (kg)	Grouped into the following categories: <ul style="list-style-type: none"> <li>• More than recommended</li> <li>• As recommended</li> <li>• Less than recommended</li> <li>• Unknown</li> </ul>	BCPDR
<b>Antepartum morbidity</b>	Hypertension ( $\geq$ 140/90) during pregnancy, pregnancy induced hypertension, gestational diabetes insulin dependent, non-insulin dependent, IUGR identified as a risk during the antenatal period, antepartum hemorrhage $\geq$ 20 weeks	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul> Codes beginning with: O13 Gestational hypertension w/o significant proteinuria O24.8 Diabetes mellitus arising in pregnancy (gestational) O99.0 Anemia complicating pregnancy, childbirth and the puerperium O99.0 Maternal care for restricted fetal growth O98.4 Viral hepatitis complicating pregnancy, childbirth and the puerperium O98.5 Other viral diseases complicating pregnancy, childbirth and the puerperium O98.8 Other maternal infectious and parasitic disease complicating pregnancy, childbirth and the puerperium O98.9 Unspecified maternal infectious or parasitic disease complicating pregnancy, childbirth and the puerperium O44.0 Placenta previa specified as without haemorrhage	BCPDR

		<p>O40 Polyhydramnios  O41 Oligohydramnios  O98.1 Syphilis complicating pregnancy, childbirth and the puerperium  O98.2 Gonorrhoea complicating pregnancy, childbirth and the puerperium  O98.3 Other infections with a predominantly sexual mode of transmission complicating pregnancy, childbirth and the puerperium  O98.7 Human immunodeficiency disease complicating pregnancy, childbirth and the puerperium  O45 Premature separation of placenta</p>	
<b>Psychosocial Risk</b>			
<b>Mental disorder or illness</b>	Anxiety, depression, bipolar, postpartum depression, other and unknown mental disorders	<p>Grouped into the following categories:</p> <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCPDR
		<p>Codes beginning with:</p> <p>F20 Paranoid schizophrenia  F21 Schizotypal disorder  F22 Delusional disorders  F23 Brief psychotic disorder  F24 Shared psychotic disorder  F25 Schizoaffective disorder  F28 Other psychotic disorder not due to a substance or known physiological condition  F29 Unspecified psychosis not due to a substance or known physiological condition  F30 Manic episode  F31 Biopolar disorder  F32 Major depressive disorder, single episode  F33 Major depressive disorder, recurrent  F34 Persistent mood [affective] disorders  F39 Unspecified mood [affective] disorder  F40 Phobic anxiety disorders  F41 Anxiety disorder  F42 Obsessive-compulsive disorder</p>	

		F43 Acute stress reaction O99.3 Mental disorders and disease of the nervous system complicating pregnancy, childbirth and the puerperium	
<b>Behavioural and Lifestyle Risk</b>			
<b>Smoking status</b>		Grouped into the following categories: <ul style="list-style-type: none"> <li>• Never</li> <li>• Former</li> <li>• Current</li> <li>• Unknown</li> </ul>	BCPDR
<b>Alcohol exposure</b>	Alcohol during pregnancy identified as a risk by care provider	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No or blank</li> </ul>	BCPDR
		Codes beginning with: F10 Alcohol dependence, abuse, use with alcohol-induced disorder	
<b>Substance Use</b>	Heroin/opioids, cocaine, methadone, solvents, prescription, marijuana, other, unknown drugs	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No or blank</li> </ul>	BCPDR
		Codes beginning with: F11 Opioid dependence, abuse, use F12 Cannabis dependence, abuse, use F13 Sedative, hypnotic or anxiolytic dependence, abuse, use F14 Cocaine dependence, abuse, use F15 Other stimulant dependence, abuse, use F16 Hallucinogen dependence, abuse, use F18 Inhalant dependence, abuse, use F19 Other psychoactive substance dependence, abuse, use	
<b>Adequacy of prenatal care utilization</b>	Algorithm based on date of first contact with physician/midwife; number of antenatal visits; gestational age at	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Intense</li> <li>• Adequate</li> <li>• Intermediate</li> <li>• Inadequate</li> <li>• Unknown</li> </ul>	BCPDR

	birth in completed weeks		
<b>Receiving social assistance</b>	Regular MSP subsidy assistance paid for by the Ministry of Employment and Income Assistance	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCMOH
<b>Chronic low SEP</b>	Two or more delivery dates during the study period; regular MSP premium assistance during more than one delivery year	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCMOH, BCPDR
<b>Transient low SEP</b>	Two or more delivery dates during the study period; regular MSP premium assistance during only one delivery year	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCMOH, BCRDR
<b>Community Characteristics</b>			
<b>Neighbourhood SEP</b>	Assigned on the basis of residence, reflects the average single-person income in a geographical area populated by approximately 400-700 people	Grouped into the following categories: <ul style="list-style-type: none"> <li>• High</li> <li>• Low/Medium</li> </ul>	Population Data BC, Consolidation File
<b>Urban/rural residence</b>	Population estimates (2009) of LHAs	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Urban</li> <li>• Rural</li> <li>• Unknown</li> </ul>	B.C. Stats, Stats Canada
<b>LHA socioeconomic index</b>	LHAs in BC ranked according to area-level socioeconomic status, based on six indicators: human	Grouped into the following categories: <ul style="list-style-type: none"> <li>• High</li> <li>• Medium</li> <li>• Low</li> <li>• Unknown</li> </ul>	B.C. Stats and a number of social ministries <sup>a</sup>

	economic hardship, crime concerns, health problems, education concerns, children at risk, and youth at risk		
<b>LHA income inequality</b>	LHAs in BC ranked according to area-level income inequality	Grouped into the following categories: <ul style="list-style-type: none"> <li>• High</li> <li>• Medium</li> <li>• Low</li> <li>• Unknown</li> </ul>	B.C. Stats
<b>Northern residence</b>	Residing in the Northern Health Authority at delivery	Grouped into the following categories: <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>	BCPDR
<b>Institutional Characteristics</b>			
<b>Birth year</b>	Infant's birth year	Grouped into the following categories: <ul style="list-style-type: none"> <li>• 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012</li> </ul>	BCPDR

<sup>a</sup> B.C. Stats. Socio-economic indices: LHA indices reports. Human economic hardship: income inequality measure. 2013 [cited 2014 Nov 4]. From: <http://www.bestats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/SocioEconomicIndices/LHARports.aspx>.

## **Appendix 4-D: Outline of the Kotelchuck Adequacy of Prenatal Care Utilization Index**

### **I. Month prenatal care began (Adequacy of Initiation of Prenatal Care)**

- Adequate Plus: 1st through 4th month
- Adequate: 1st through 4th month
- Intermediate: 1st through 4th month
- Inadequate: 5th month or later or no prenatal care

### **II. Proportion of the number of visits recommended by the American College of Obstetricians and Gynecologists received from the time prenatal care began until the time of delivery (Adequacy of Received Services)**

- Adequate Plus: 110% or more
- Adequate: 80-109%
- Intermediate: 50-79%
- Inadequate: less than 50%

### **III. Summary of Adequacy of Prenatal Care Utilization Index**

- Adequate Plus: prenatal care began by the end of the 4th month and 110% or more recommended visits received
- Adequate: prenatal care began by the end of the 4th month and 80-109% of recommended visits received
- Intermediate: prenatal care began by the end of the 4th month and 50-79% of recommended visits received
- Inadequate: prenatal care began after the 4th month or less than 50% of recommended visits received

Quoted from: Kotelchuck M. An evaluation of the Kessner adequacy of prenatal care index and a proposed adequacy of prenatal care utilization index. *Am J Public Health*.1994;84(9):1414-1420.



**Appendix 4-E: Local Health Areas and Their Urban or Rural Area Status, Income Inequality Rank, and Socioeconomic Rank**

<b>Local Health Area</b>	<b>Rural /Urban Population<sup>a</sup></b>	<b>Income Inequality Rank<sup>b</sup> (3=worst)</b>	<b>Socioeconomic Rank Designation<sup>c</sup> (3=highest)</b>
<b>001 Fernie</b>	Urban	1	3
<b>002 Cranbrook</b>	Urban	1	2
<b>003 Kimberley</b>	Rural	1	3
<b>004 Windermere</b>	Rural	3	3
<b>005 Creston</b>	Urban	1	2
<b>006 Kootenay Lake</b>	Rural	3	2
<b>007 Nelson</b>	Urban	2	3
<b>009 Castlegar</b>	Urban	1	3
<b>010 Arrow Lakes</b>	Rural	2	3
<b>011 Trail</b>	Urban	1	3
<b>012 Grand Forks</b>	Rural	1	2
<b>013 Kettle Valley</b>	Rural	3	1
<b>014 Southern Okanagan</b>	Urban	1	2
<b>015 Penticton</b>	Urban	2	2
<b>016 Keremeos</b>	Rural	2	2
<b>017 Princeton</b>	Rural	3	2
<b>018 Golden</b>	Rural	1	3
<b>019 Revelstoke</b>	Rural	1	3
<b>020 Salmon Arm</b>	Urban	1	2
<b>021 Armstrong-Spallumcheen</b>	Rural	1	3
<b>022 Vernon</b>	Urban	2	2
<b>023 Central Okanagan</b>	Urban	2	2
<b>024 Kamloops</b>	Urban	2	2
<b>025 100 Mile House</b>	Urban	2	2
<b>026 North Thompson</b>	Rural	1	2
<b>027 Cariboo-Chilcotin</b>	Urban	2	1
<b>028 Quesnel</b>	Urban	2	1
<b>029 Lillooet</b>	Rural	3	1
<b>030 South Cariboo</b>	Rural	3	1
<b>031 Merritt</b>	Urban	3	1
<b>032 Hope</b>	Rural	3	1
<b>033 Chilliwack</b>	Urban	2	1
<b>034 Abbotsford</b>	Urban	2	2
<b>035 Langley</b>	Urban	2	2
<b>037 Delta</b>	Urban	1	3
<b>038 Richmond</b>	Urban	3	3

<b>040 New Westminster</b>	Urban	2	2
<b>041 Burnaby</b>	Urban	3	2
<b>042 Maple Ridge</b>	Urban	1	2
<b>043 Coquitlam</b>	Urban	2	3
<b>044 North Vancouver</b>	Urban	3	3
<b>045 West Vancouver Bowen Island</b>	Urban	3	3
<b>046 Sunshine Coast</b>	Urban	2	3
<b>047 Powell River</b>	Urban	2	2
<b>048 Howe Sound</b>	Urban	2	3
<b>049 Bella Coola Valley</b>	Rural	3	1
<b>050 Queen Charlotte</b>	Rural	2	1
<b>051 Snow Country</b>	Rural	*	*
<b>052 Prince Rupert</b>	Urban	3	1
<b>053 Upper Skeena</b>	Rural	3	1
<b>054 Smithers</b>	Urban	1	2
<b>055 Burns Lake</b>	Rural	2	1
<b>056 Nechako</b>	Urban	3	1
<b>057 Prince George</b>	Urban	1	1
<b>059 Peace River South</b>	Urban	2	2
<b>060 Peace River North</b>	Urban	1	2
<b>061 Greater Victoria</b>	Urban	3	3
<b>062 Sooke</b>	Urban	1	3
<b>063 Saanich</b>	Urban	2	3
<b>064 Gulf Islands</b>	Urban	3	3
<b>065 Cowichan</b>	Urban	2	2
<b>066 Lake Cowichan</b>	Rural	1	1
<b>067 Ladysmith</b>	Urban	1	2
<b>068 Nanaimo</b>	Urban	2	1
<b>069 Qualicum</b>	Urban	2	3
<b>070 Alberni</b>	Urban	1	1
<b>071 Courtenay</b>	Urban	2	3
<b>072 Campbell River</b>	Urban	2	2
<b>075 Mission</b>	Urban	2	1
<b>076 Agassiz-Harrison</b>	Rural	1	1
<b>077 Summerland</b>	Urban	1	3
<b>078 Enderby</b>	Rural	2	1
<b>080 Kitimat</b>	Rural	1	1
<b>081 Fort Nelson</b>	Rural	1	1
<b>083 Central Coast</b>	Rural	*	*
<b>084 Vancouver Island West</b>	Rural	2	2
<b>085 Vancouver Island North</b>	Urban	2	1
<b>087 Stikine</b>	Rural	*	*
<b>088 Terrace</b>	Urban	2	1
<b>092 Nisga'a</b>	Rural	3	*

<b>094 Telegraph Creek</b>	Rural	*	*
<b>161 Vanc-City Centre</b>	Urban	3	3
<b>162 Vanc-Downtown Eastside</b>	Urban	3	3
<b>163 Vanc-North East</b>	Urban	3	3
<b>164 Vanc-Westside</b>	Urban	3	3
<b>165 Vanc-Midtown</b>	Urban	3	3
<b>166 Vanc-South</b>	Urban	3	3
<b>201 Surrey</b>	Urban	2	2
<b>202 South Surrey</b>	Urban	2	2
* Data suppressed due to small numbers			

<sup>a</sup>B.C. Stats. Sub-provincial population estimates (2009). 2015 [cited 2015 Dec 8]. Available from: <https://www.bcstats.gov.bc.ca/apps/PopulationEstimates.aspx>

<sup>b</sup>B.C. Stats. Socio-economic indices: LHA indices reports. Human economic hardship: income inequality measure. 2013 [cited 2014 Nov 4]. Available from: <http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/SocioEconomicIndices/LHAREports.aspx>

<sup>c</sup>B.C. Stats. Socio-economic indices: overall regional socio-economic index. 2013 [cited 2014 Nov 4]. Available from: <http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/SocioEconomicIndices/LHAREports.aspx>

## **Chapter 5 Antenatal Midwifery Care and Odds of Small-for-Gestational-Age Birth and Other Adverse Infant Birth Outcomes for Women of Low Socioeconomic Position: A Cohort Study**

### **5.1 Introduction**

The purpose of this retrospective, cohort study was to investigate if MW clients with low to moderate medical and obstetric risk had lower odds of SGA birth or other adverse infant birth outcomes compared to physicians' patients. In addition, I explored if individual characteristics of vulnerability modified the relationship between model of care and the outcomes of interest. Lastly, I examined if women with low SEP and *multiple* characteristics of vulnerability had even less odds of SGA birth or other adverse infant birth outcomes if receiving antenatal care from MWs vs. GPs or OBs.

### **5.2 Study Eligibility**

In this study there were 4,705 cases in the MW cohort, 45,114 cases in the GP cohort, and 8,053 cases in the OB cohort for a total of 57,872 eligible cases for analysis. Figure 5.1 outlines the number of cases included/excluded.

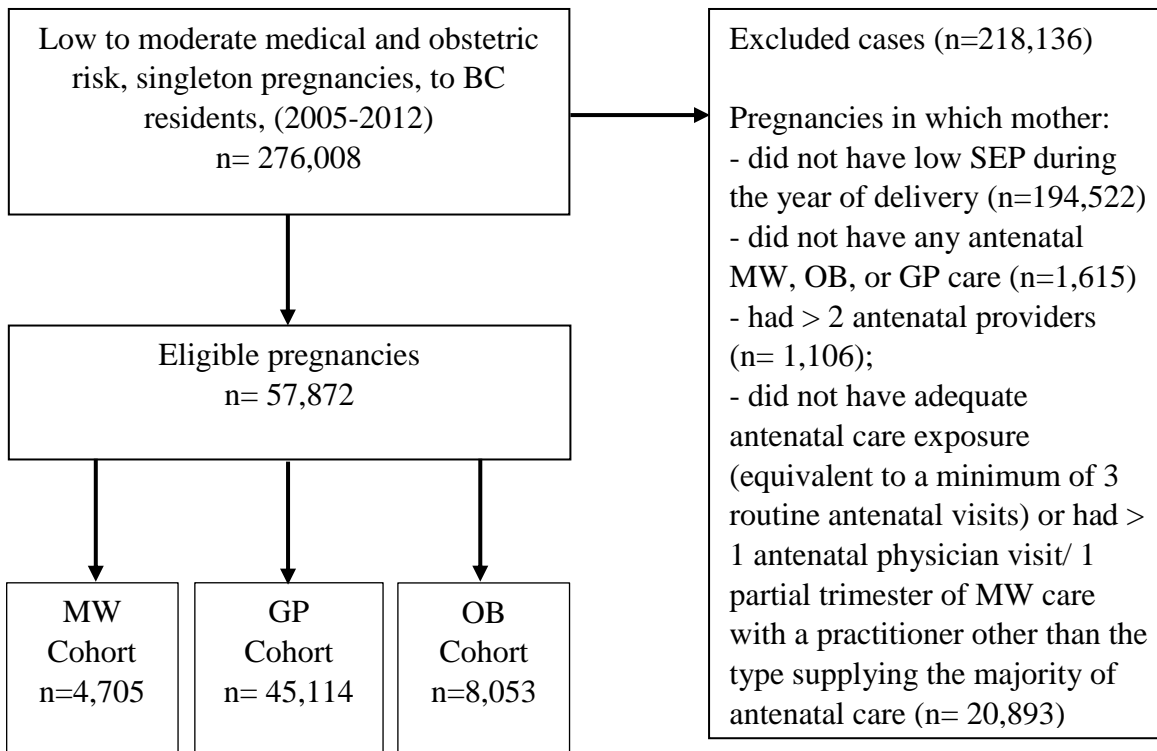


Figure 5.1: Study Two, Eligibility Flow Chart

### 5.3 Maternal Characteristics

Women in the study ranged in age from 14 to 50 years. The average maternal age was 25 for nulliparous women and 27 for multiparous women. Of the women in their care, GPs had a greater proportion of teen mothers (10.41%), compared to MWs (3.29%), or OBs (4.20%) (see Table 5.1). In contrast, OBs and MWs had older patient populations, with 23.00% of OB patients 35 years of age or older and 14.37% of MW clients in this same demographic compared to 9.98% of GP patients. MWs and OBs had smaller proportions of nulliparous patients in their care (MW: 46.27%, OB 44.92%) compared to GPs (51.30%). Maternal age, like all of the individual and community characteristics examined, differed significantly (chi-square:  $p < 0.0001$ ) by model of care.

Of the three groups, MW patients had the lowest rate of medical risk complicating pregnancy, including endocrine, nutritional, metabolic, respiratory, or digestive disease (0.30%

vs. GP: 0.92% and OB: 1.64%), although these conditions were very rare across all cohorts. Prior obstetric risk was defined as at least one of the following conditions in past pregnancy: major congenital anomaly, neonatal death, stillbirth, or one preterm delivery. Prior obstetric risk affected 2.64% of MW clients, 3.70% of GP patients and 5.94% of OB patients. Almost 22% of MW clients had a reported mental illness/disorder diagnosed during or prior to pregnancy, including anxiety, depression, bipolar disorder, postpartum depression, or other or unknown mental illness. In contrast, 11.41% of GP patients and 7.57% of OB patients had a mental illness/disorder diagnosis.

More MW clients were of normal pre-pregnancy BMI (55.52%) than physician patients (GP: 37.19%; OB: 37.13). MW and GP patients had higher rates of overweight or obese BMI (MW: 21.76%; GP: 21.33%) than OB patients (16.84%). Current tobacco smoking rates were approximately 10% for MW and OB patients, but almost 22% for GP patients. Likewise, substance use and alcohol use identified as a risk during pregnancy, were more prevalent among GP patients (substance use 7.25%, alcohol 2.46%) vs. MW (substance use 3.80%, alcohol 1.21%) or OB (substance use 3.75%, alcohol 0.78%) patients.

According to the maternal record, MW clients had a higher average number of prenatal visits than GP or OB patients. As per Kotelchuck's Adequacy of Prenatal Care Utilization (APNCU) Index, which is based on number of antenatal visits, trimester prenatal care begins, and infant's gestational age at birth, a higher rate of MW clients adequately utilized prenatal care (30.18%) than GP or OB patients (15.19% and 11.20% respectively). Approximately 12% of OB and 16% of GP patients received inadequate prenatal care, compared to less than 6% of MW clients. For all models of care there was a considerable amount of missing data for this variable with OBs missing the greatest amount (43.59%) followed by GPs (24.48%) and MWs (20.98%).

Rates of weight gain during pregnancy that fell within the recommended guidelines provided by Health Canada were similar across models of care (MW: 16.60%, GP: 15.88%, OB: 16.58%). For weight gain during pregnancy that exceeded recommendations, rate differences were apparent between cohorts (MW: 24.51%, GP: 27.69%, OB: 22.74%).

Almost 16% of the study population experienced some antepartum morbidity, which included pregnancy induced hypertension, gestational diabetes either insulin dependent or non-insulin dependent, anemia, intrauterine growth restriction, viral disease, infection and parasitic

disease, placenta previa without hemorrhage, polyhydramnios or oligohydramnios, antepartum hemorrhage  $\geq 20$  weeks, sexually transmitted infection, or HIV, or premature separation of the placenta. Antepartum morbidity was most prevalent among OB patients (24.28%) vs. GP (15.17%) or MW (7.42%) patients.

Table 5.1: Frequencies and Rates of Maternal Characteristics by Model of Care

Co-variates	Antenatal Model of Care		
	MW n=4,705 (%)	GP n=45,114 (%)	OB n=8,053 (%)
<b>Age</b>			
14-19	155 (3.29)	4,697 (10.41)	338 (4.20)
20-24	893 (18.98)	14,789 (32.78)	1,447 (17.97)
25-29	1,619 (34.41)	13,161 (29.17)	2,303 (28.60)
30-34	1,362 (28.95)	7,966 (17.66)	2,113 (26.24)
35-39	573 (12.18)	3,730 (8.27)	1,387 (17.22)
≥40	103 (2.19)	771 (1.71)	465 (5.77)
<b>Parity<sup>a</sup></b>			
Nullipara	2,177 (46.27)	23,141 (51.30)	3,617 (44.92)
Multipara	2,528 (53.73)	21,972 (48.70)	4,435 (55.08)
<b>Medical risk<sup>b</sup></b>	14 (0.30)	414 (0.92)	132 (1.64)
<b>Prior obstetric risk<sup>b</sup></b>	124 (2.64)	1,669 (3.70)	478 (5.94)
<b>Mental illness/disorder<sup>b</sup></b>	1,020 (21.68)	5,146 (11.41)	610 (7.57)
<b>Receiving social assistance<sup>b</sup></b>	310 (6.59)	5,833 (12.93)	814 (10.11)
<b>Pre-pregnancy BMI</b>			
Underweight	229 (4.87)	2,300 (5.10)	519 (6.44)
Normal	2,612 (55.52)	16,777 (37.19)	2,990 (37.13)
Overweight	689 (14.64)	5,829 (12.92)	877 (10.89)
Obese	335 (7.12)	3,792 (8.41)	479 (5.95)
Unknown	840 (17.85)	16,416 (36.39)	3,188 (39.59)
<b>Smoking Status</b>			
Never	992 (21.08)	6,666 (14.78)	1,868 (23.20)
Former	690 (14.67)	5,028 (11.15)	434 (5.39)
Current	471 (10.01)	9,910 (21.97)	800 (9.93)
Unknown	2,552 (54.24)	23,510 (52.11)	4,951 (61.48)
<b>Substance use in pregnancy<sup>b</sup></b>	179 (3.80)	3,273 (7.25)	302 (3.75)
<b>Alcohol identified as a risk<sup>b</sup></b>	57 (1.21)	1,109 (2.46)	63 (0.78)
<b>Utilization of prenatal care</b>			
Intense	98 (2.08)	304 (0.67)	60 (0.75)
Adequate	1,420 (30.18)	6,851 (15.19)	902 (11.20)
Intermediate	1,927 (40.96)	19,929 (44.17)	2,601 (32.30)
Inadequate	273 (5.80)	6,986 (15.49)	980 (12.17)
Unknown	987 (20.98)	11,044 (24.48)	3,510 (43.59)
<b>Weight gain during pregnancy</b>			
Less than recommended	517 (10.99)	4,434 (9.83)	939 (11.66)
As recommended	781 (16.60)	7,165 (15.88)	1,335 (16.58)
More than recommended	1,153 (24.51)	12,490 (27.69)	1,831 (22.74)
Unknown	2,254 (47.91)	21,025 (46.60)	3,948 (49.03)
<b>Antepartum morbidity<sup>b</sup></b>	349 (7.42)	6,843 (15.17)	1,955 (24.28)

<sup>a</sup>missing cases amount to 5 or less  
<sup>b</sup>values represent cases classified as “Yes”, the remainder of the cases were classified as “No”, “Unknown”, or were undocumented



#### 5.4 Community Characteristics

Approximately 11% of the study participants lived in high income neighbourhoods, including 13.26% of MW clients, 11.05% of GP patients, and 8.02% of OB patients (see Table 5.2). GPs had the greatest proportion of patients residing in rural areas (5.71%), defined as a local health areas with a population less than 10,000 people (not in a census metropolitan area or a census agglomeration<sup>7</sup>). In comparison, only 3.08% of MW clients and 1.80% of OB patients resided in rural areas. Over half of the MWs' and OBs' patients resided in local health areas of high socioeconomic rank (56.07%, 50.20% respectively) in contrast to 29.45% of GPs' patients. Over half of all OB patients (51.87%) lived in local health areas of high income inequality, a measure created by dividing a local health area's total household earnings for individuals earning less than the median income by total household earnings for all residents.<sup>(4)</sup> In contrast, 35.43% of MW clients and 23.57% of GP patients lived in areas of high income inequality. MW clients rarely resided in the Northern Health Authority (2.89%) and nor did OB patients (3.61%), compared to GP patients (13.37%).

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<sup>7</sup> Census metropolitan areas (CMAs) and census agglomerations (CAs) are areas comprised of core populations surrounded by smaller municipalities. CMAs must have at least 50,000 residents in a core area, and a minimum 100,000 person population. CAs have a minimum 10,000 person core population. From: Statistics Canada. 2006 Census Dictionary. Statistics Canada Catalogue no. 92-566-XWE. Ottawa, ON; 2007 [cited 2014 Nov 3]. Available from: <https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/index-eng.cfm>.

Table 5.2: Frequencies and Rates of Community Characteristics by Model of Care

Co-variates	Antenatal Model of Care		
	MW n=4,705 (%)	GP n=45,114 (%)	OB n=8,053 (%)
<b>Neighbourhood SEP</b>			
High	624 (13.26)	4,984 (11.05)	646 (8.02)
Low/Medium	4,081 (86.74)	40,130 (88.95)	7,407 (91.98)
<b>LHA Population Demographic</b>			
Urban	4,548 (96.66)	42,489 (94.18)	7,889 (97.96)
Rural	145 (3.08)	2,576 (5.71)	145 (1.80)
Unknown	12 (0.26)	49 (0.11)	19 (0.24)
<b>LHA Socioeconomic Rank</b>			
High (Best)	2,638 (56.07)	13,287 (29.45)	4,043 (50.20)
Medium	1,472 (31.29)	22,011 (48.79)	3,197 (39.70)
Low	582 (12.37)	9,710 (21.52)	739 (9.18)
Unknown	13 (0.28)	106 (0.23)	74 (0.92)
<b>LHA Income Inequality Rank</b>			
High (Worst)	1,667 (35.43)	10,635 (23.57)	4,177 (51.87)
Medium	2,326 (49.44)	25,544 (56.62)	3,311 (41.12)
Low	699 (14.86)	8,841 (19.60)	530 (6.58)
Unknown	13 (0.28)	94 (0.21)	35 (0.43)
<b>Northern Residence<sup>a</sup></b>	136 (2.89)	6,032 (13.37)	291 (3.61)

<sup>a</sup>Values represent cases classified as “Yes”, the remainder of the cases were “No”

## 5.5 Outcomes: Small-for-Gestational-Age Birth

Table 5.3: Frequencies, Rates and Adjusted Odds Ratios for Small-for-Gestational-Age Birth by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Small-for-Gestational-Age Birth by Model of Care						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>SGA</b>	234/4,695 (4.98)	3,217/45,004 (7.15)	701/ 8,025 (8.74)	0.73 (0.63-0.84)	0.60 (0.51-0.70)	0.82 (0.75-0.90)
<b>Mental Ill./Dis.</b>						
Yes	43/1,019 (4.22)	350/5,134 (6.82)	51/608 (8.39)	0.66 (0.48-0.92)	0.50 (0.33-0.77)	0.75 (0.55-1.04)
No	191/3,676 (5.20)	2,867/39,870 (7.19)	650/7,417 (8.76)	0.74 (0.64-0.86)	0.62 (0.52-0.73)	0.83 (0.76-0.91)
<b>Substance Use</b>						
Yes	7/179 (3.91)	342/3,308 (10.34)	40/302 (13.25)	0.40 (0.19-0.83)	0.30 (0.13-0.68)	0.76 (0.53-1.09)
No	227/4,516 (5.03)	2,875/41,696 (6.90)	661/7,723 (8.56)	0.74 (0.65-0.86)	0.62 (0.52-0.72)	0.83 (0.75-0.91)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	9/155 (5.81)	330/4,682 (7.05)	32/333 (9.61)	0.81 (0.41-1.61)	0.55 (0.26-1.20)	0.68 (0.46-1.01)
No (24-29 yrs.)	77/1,617 (4.76)	943/13,125 (7.18)	219/2,298 (9.53)	0.70 (0.55-0.90)	0.54 (0.41-0.70)	0.77 (0.65-0.90)
<b>Mental Ill./Dis, Substance Use</b>						
Both	5 or less /96 <sup>a</sup>	94/966 (9.73)	13/86 (15.12)	0.33 (0.10-1.05)	0.19 (0.05-0.72)	0.59 (0.31-1.14)
Neither	187/3,593 (5.20)	2,619/37,528 (6.98)	623/7,201 (8.65)	0.75 (0.64-0.88)	0.62 (0.52-0.74)	0.82 (0.75-0.91)
Models adjusted for all variables listed except stratifying variables: maternal age, parity, pre-pregnancy BMI, infant sex, smoking status, substance use, mental illness/disorder, and local health area socioeconomic rank						
<sup>a</sup> Percentage suppressed due to small cell size						
Odds ratios based on 4,152 births with SGA and 57,724 total births with no missing information for this analysis						

There were 4,152 (7.19%) SGA infants in the study population. Unadjusted odds ratios demonstrated a significant reduction in odds of having an infant with SGA stature for MW vs. GP patients (OR 0.68, 95% CI: 0.60-0.78) and MW vs. OB patients (OR 0.55, 95% CI: 0.47-0.64). GP vs. OB patients were also less likely to experience a SGA birth (OR 0.80, 95% CI: 0.74-0.88). After adjustment, women receiving antenatal care from MWs had reduced odds of having a SGA infant (OR: 0.73, 95% CI: 0.63-0.84), compared to GP patients. Compared to OB patients, MW clients were on average 40% less likely to experience a SGA birth (OR: 0.60, 95% CI: 0.51-0.70). GP antenatal care also was associated with reduced likelihood of SGA birth compared to OB antenatal care (OR 0.82: 95% CI: 0.75-0.90). The adjusted model controlled for maternal age, parity, pre-pregnancy BMI, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, and family and community level correlation.

Models were fitted without adjustment for smoking status, substance use, and mental illness/disorder, due to the possibility that these factors were on the causal pathway between caregiver model and SGA stature. Models that did not adjust for these behaviours/conditions differed only slightly from models that did (see Appendix 5-A), suggesting these factors were not mediating the association between provider-type and outcomes.

The preventative fraction, a measure that quantifies the proportion of cases that could theoretically be prevented by exposure (vs. non-exposure) to an intervention, assuming a causal relationship, was calculated for each of the outcomes.(338) Based on the preventative fraction, if all women in the study had received antenatal care from MWs, 30.4% of SGA births among GP patients, and 43.0% of SGA births among OB patients could have theoretically been prevented (see Preventative Fraction calculations in Appendix 5-B). This translates to 1,279 fewer SGA births during the study period.

To determine if vulnerabilities in addition to low SEP modified the association between model of care and SGA, I compared odds ratios across strata of mental illness/disorder, substance use, teen maternal age (yes/no), or mental illness/disorder and substance use (both/neither). There was no evidence of mental illness/disorder or teen maternal age modifying the association between model of care and SGA status. Substance use, however, did appear to modify the relationship between model of care and SGA (see Figure 5.2). Odds of SGA were reduced to a greater extent among substance using MW vs. GP patients (OR 0.40, 95% CI: 0.19-0.83) than among non-substance using patients (OR 0.74, 95% CI: 0.65-0.86) (Table 5.3). For

MW vs. OB patients, there was also a greater reduction in odds of SGA for substance using patients (OR 0.30, 95% CI: 0.13-0.68) than for non-substance using patients (OR 0.62, 95% CI: 0.52-0.72). The interaction term “model of care x substance use” included in the logistic regression model was borderline significant for MW vs. GP care (p=0.10) given the *a priori* significance threshold (p<0.10), and was significant for MW vs. OB care (p=0.09), further suggesting that substance use had a modifying effect on antenatal model of care and SGA. Odds of SGA for GP vs. OB patients with substance use (OR: 0.76, 95% CI: 0.53-1.09) were similar to odds for non-substance using patients (OR 0.83, 95% CI: 0.75-0.91).

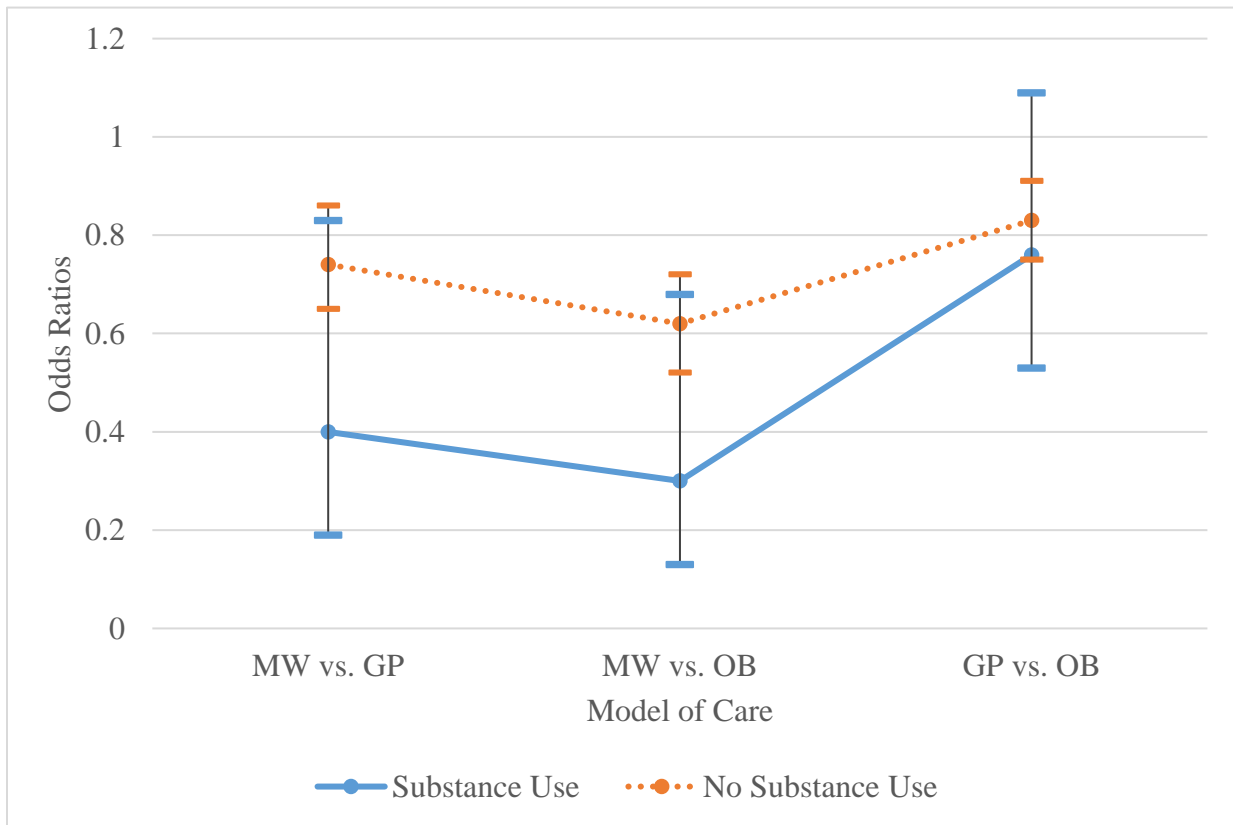


Figure 5.2: Odds and 95% CIs of Small-for-Gestational-Age Birth by Model of Care and Substance Use vs. No Substance Use

I examined odds of SGA according to model of care for women with both a mental illness/disorder and substance use vs. neither (see Table 5.3 and Figure 5.3). MW vs. GP patients who had both a mental illness/disorder and substance use appeared to have a reduction in the odds of SGA (OR 0.33, 95% CI: 0.10-1.05), but the odds ratio was statistically non-significant. In comparison, MW vs. GP patients with neither mental illness/disorder nor

substance use had a smaller, yet statistically significant reduction in odds of SGA (OR 0.75, 95% CI: 0.64-0.88). The interaction term, “model of care x mental illness/disorder and substance use” in the GEE logistic model was not statistically significant ( $p=0.16$ ), despite the large difference in odds ratios across strata, therefore mental illness/disorder and substance use was not considered an effect modifier.

For MWs’ vs OBs’ patients who had mental illness/disorder and substance use, odds of SGA were less (OR 0.19, 95% CI: 0.05-0.72) than odds of SGA for MW vs. OB patients with neither of these characteristics (OR 0.62, 95% CI: 0.52-0.74). The interaction term (model of care x mental illness and substance use) included in the logistic model was statistically significant ( $p=0.08$ ). Whereas odds of SGA were reduced for MW vs. OB patients with mental illness/disorder (OR 0.50, 95% CI: 0.33-0.77) and substance use (OR 0.30, 95% CI: 0.13-0.68), the combined effect of these characteristic produced an even greater reduction in odds (OR 0.19, 95% CI: 0.05-0.72).

Overall, no characteristics of vulnerability modified the relationship between GP vs. OB antenatal care and SGA. Only substance use appeared to modify the relationship between MW vs. GP antenatal care and SGA. Both substance use, and the combination of mental illness/disorder and substance use, modified the association between MW vs. OB antenatal care and SGA.

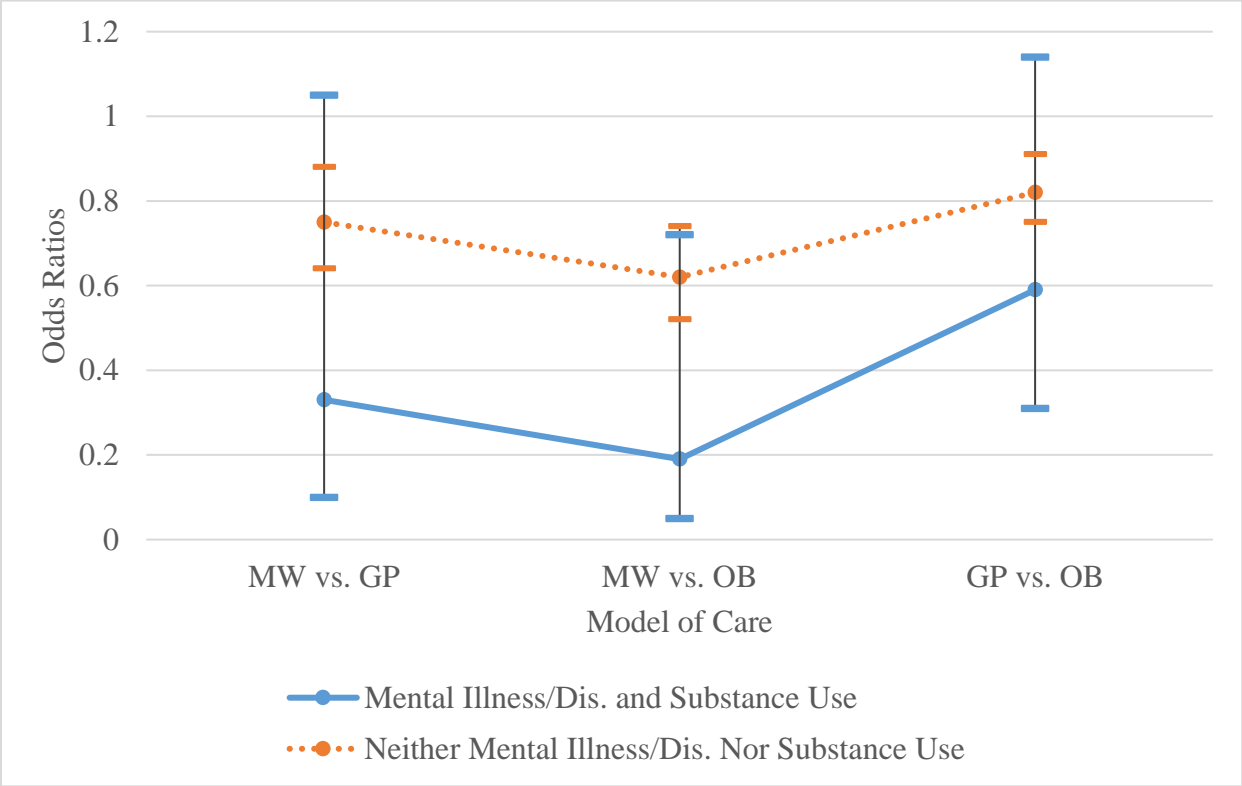


Figure 5.3: Odds and 95% CIs of Small-for-Gestational-Age Birth by Model of Care, and Both Mental Illness/Disorder and Substance Use vs. Neither

## 5.6 Preterm Birth

Table 5.4: Frequencies, Rates and Adjusted Odds Ratios for Preterm Birth by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Preterm Birth by Model of Care						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>PTB</b>	208/4,703 (4.42)	2,860/45,040 (6.35)	701/8,036 (8.72)	0.74 (0.63-0.86)	0.53 (0.45-0.62)	0.72 (0.65-0.79)
<b>Mental Ill./Dis.</b>						
Yes	58/1,020 (5.69)	368/5,140 (7.16)	79/610 (12.95)	0.92 (0.68-1.24)	0.51 (0.35-0.74)	0.56 (0.43-0.73)
No	150/3,683 (4.07)	2,492/39,900 (6.25)	622/7,426 (8.38)	0.69 (0.58-0.82)	0.51 (0.42-0.62)	0.74 (0.67-0.82)
<b>Substance Use</b>						
Yes	9/179 (5.03)	336/3,310 (10.15)	60/302 (19.87)	0.52 (0.26-1.01)	0.25 (0.12-0.52)	0.49 (0.36-0.67)
No	199/4,524 (4.40)	2,524/41,730 (6.05)	641/7,734 (8.29)	0.75 (0.64-0.87)	0.55 (0.47-0.66)	0.74 (0.67-0.82)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	11/155 (7.10)	346/4,687 (7.38)	36/334 (10.78)	0.97 (0.52-1.81)	0.64 (0.32-1.31)	0.66 (0.46-0.96)
No (24-29 yrs.)	63/1,619 (3.89)	787/13,137 (5.99)	168/2,301 (7.30)	0.69 (0.53-0.90)	0.57 (0.40-0.82)	0.81 (0.67-0.96)
<b>Social Assistance</b>						
Yes	21/310 (6.77)	470/5,819 (8.08)	95/810 (11.73)	0.90 (0.57-1.43)	0.63 (0.38-1.03)	0.69 (0.55-0.88)
No	187/4,393 (4.26)	2,390/39,221 (6.09)	606/7,226 (8.39)	0.72 (0.62-0.84)	0.52 (0.44-0.62)	0.72 (0.65-0.80)
<b>Neigh. SEP</b>						
Low/Medium	184/4,079 (4.51)	2,572/40,069 (6.42)	665/7,391 (9.00)	0.75 (0.64-0.87)	0.52 (0.44-0.62)	0.70 (0.63-0.77)
High	24/624 (3.85)	288/4,971 (5.79)	36/645 (5.58)	0.66 (0.43-1.02)	0.71 (0.41-1.21)	1.08 (0.75-1.54)
<b>Mental Ill./Dis, Substance Use</b>						
Both	5 or less /96 <sup>a</sup>	101/966 (10.46)	18/86 (20.93)	0.42 (0.15-1.17)	0.21 (0.07-0.65)	0.50 (0.28-0.87)
Neither	145/3,600 (4.03)	2,257/37,556 (6.01)	580/7,210 (8.04)	0.69 (0.58-0.83)	0.52 (0.43-0.63)	0.75 (0.68-0.83)
<b>Mental Ill./Dis., Social Assistance</b>						
Both	8/131 (6.11)	122/1,263 (9.66)	29/179 (16.20)	0.68 (0.32-1.45)	0.41 (0.18-0.95)	0.61 (0.39-0.95)
Neither	137/3,504 (3.91)	2,144/35,344 (6.07)	556/6,795 (8.18)	0.67 (0.56-0.80)	0.49 (0.41-0.60)	0.74 (0.66-0.82)



<b>Substance Use, Social Assistance</b>						
Both	5 or less /50 <sup>a</sup>	141/1,201 (11.74)	31/141 (21.99)	0.65 (0.22-1.93)	0.34 (0.11-1.06)	0.52 (0.33-0.81)
Neither	182/4,264 (4.27)	2,195/37,112 (5.91)	577/7,065 (8.17)	0.73 (0.62-0.85)	0.54 (0.45-0.64)	0.74 (0.66-0.82)
<p>Models adjusted for all variables listed except stratifying variables: maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, infant sex, birth year, receipt of social assistance, smoking status, substance use, alcohol use, mental illness/disorder, neighbourhood SEP, local health area socioeconomic rank, local health area income inequality, and northern residence</p> <p><sup>a</sup>Percentage suppressed due to small cell size</p> <p>Odds ratios based on 3,769 PTB births and 57,779 total births with no missing information for this analysis</p>						

Overall, preterm birth occurred in 6.52% of the eligible study sample. In this low to moderate medical/obstetric risk population, OBs had a preterm birth rate of 8.72%, compared to 6.35% for GPs, and 4.42% for MWs. Unadjusted odds of PTB were smaller for MW vs. GP patients (OR 0.68, 95% CI: 0.59-0.79) and MW vs. OB patients (OR 0.48, 95% CI: 0.41-0.57). Similarly, GP patients were less likely to experience a PTB than OB patients (OR 0.71, 95% CI: 0.65-0.77). The adjusted GEE logistic regression model controlled for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, infant sex, birth year, receipt of social assistance, smoking status, substance use, alcohol use, mental illness/disorder, neighbourhood SEP, local health area socioeconomic rank, local health area income inequality and northern residence, as well as community and family level correlation (see Table 5.4). After adjustment, the likelihood of PTB remained statistically significantly smaller for woman receiving antenatal care from MWs vs. GPs (OR 0.74, 95% CI: 0.63-0.86) and MWs vs. OBs (OR 0.53, 95% CI: 0.45-0.62). On average, GP patients were also less likely to have a PTB than OB patients (OR 0.72, 95% CI: 0.65-0.79). When modelling excluded adjustment for smoking status, substance use, alcohol use, and mental illness/disorder, adjusted ORs differed minimally (see Appendix 5-A). In terms of the preventative fraction, 30.4% of all PTBs to GP patients, and 49.3% of all PTBs to OB patients could have theoretically been prevented had all women in the study received antenatal MW care. This is equivalent to 1,215 fewer PTBs over the study period.

MW vs. GP patients without mental illness/disorder had reduced odds of PTB (OR 0.69, 95% CI: 0.58-0.82), however for women with mental illness/disorder there was no statistically significant difference in odds of PTB (OR 0.92, 95% CI: 0.68-1.24) (see Table 5.4 and Figure 5.4). As there was a notable difference in odds ratios across strata for MW vs. GP patients, a mental illness/disorder diagnosis appeared to modify the association between antenatal model of care and PTB. A p-value of 0.10 for the interaction term “model of care X mental illness/disorder” for MW vs. GP patients, provided further evidence of effect modification. For MW vs. OB patients, there was an equivalent reduction in odds in PTB for women with (OR 0.51, 95% CI: 0.35-0.74); and without mental health conditions (OR 0.51, 95% CI: 0.42-0.62). For GP vs. OB patients, the odds of PTB were lower for women with a mental illness/disorder diagnosis (OR 0.56, 95% CI: 0.43-0.73), compared to woman without a mental illness/disorder diagnosis (OR 0.74, 95% CI: 0.67-0.82). The p-value for the interaction term “model of care x

mental illness/disorder” for GP vs. OB patients was 0.05, further evidence that mental illness/disorder moderated the association between GP vs. OB antenatal care and preterm birth.

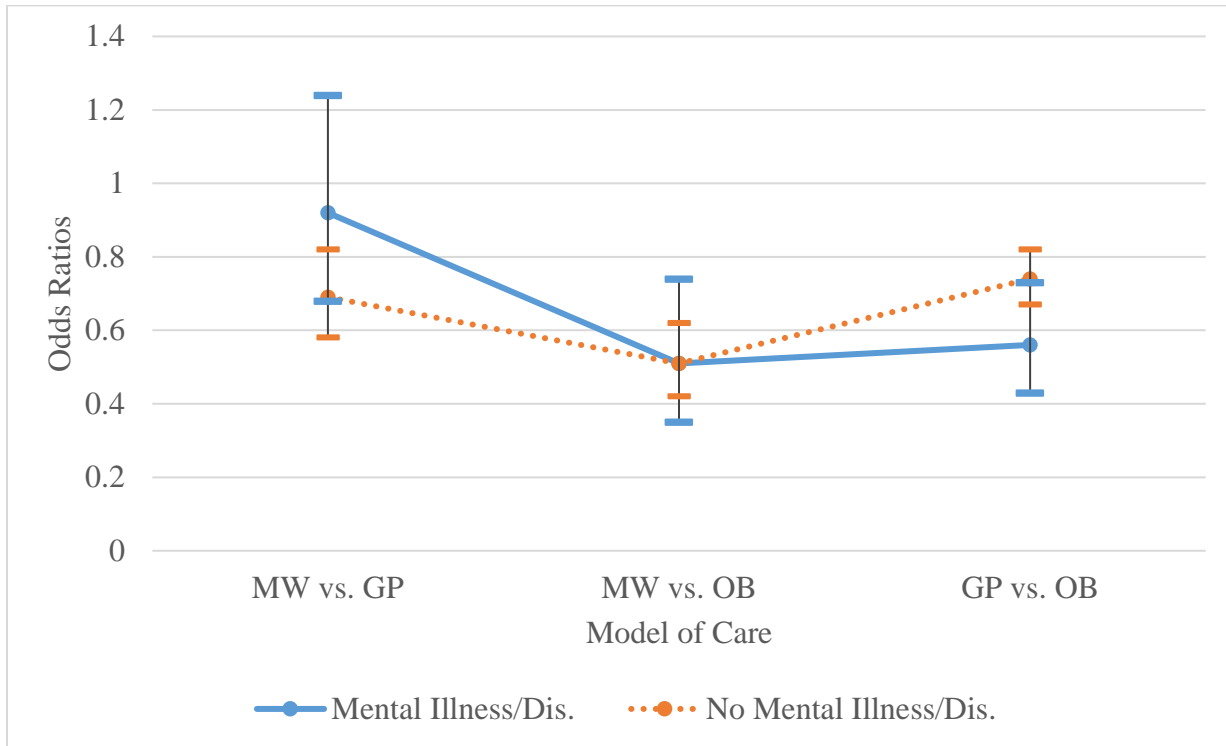


Figure 5.4: Odds and 95% CIs of Preterm Birth by Model of Care and Mental Illness/Disorder vs. No Mental Illness/Disorder

For MW vs. OB patients, the odds of PTB was modified by substance use. Substance users had lower odds of PTB (OR 0.25, 95% CI: 0.12-0.52) vs. non-substance users (OR 0.55, 95% CI: 0.47-0.66), and the interaction term “model of care x substance use” was significant ( $p=0.04$ ) (see Figure 5.5). Likewise, substance use significantly modified the relationship between GP vs. OB antenatal care and PTB. Substance using GP vs. OB patients had smaller odds of PTB (OR 0.49, 95% CI: 0.36-0.67) compared to non-substance using GP vs. OB patients (OR 0.74, 95% CI: 0.67-0.82), and the interaction term had a  $p$ -value of 0.01.

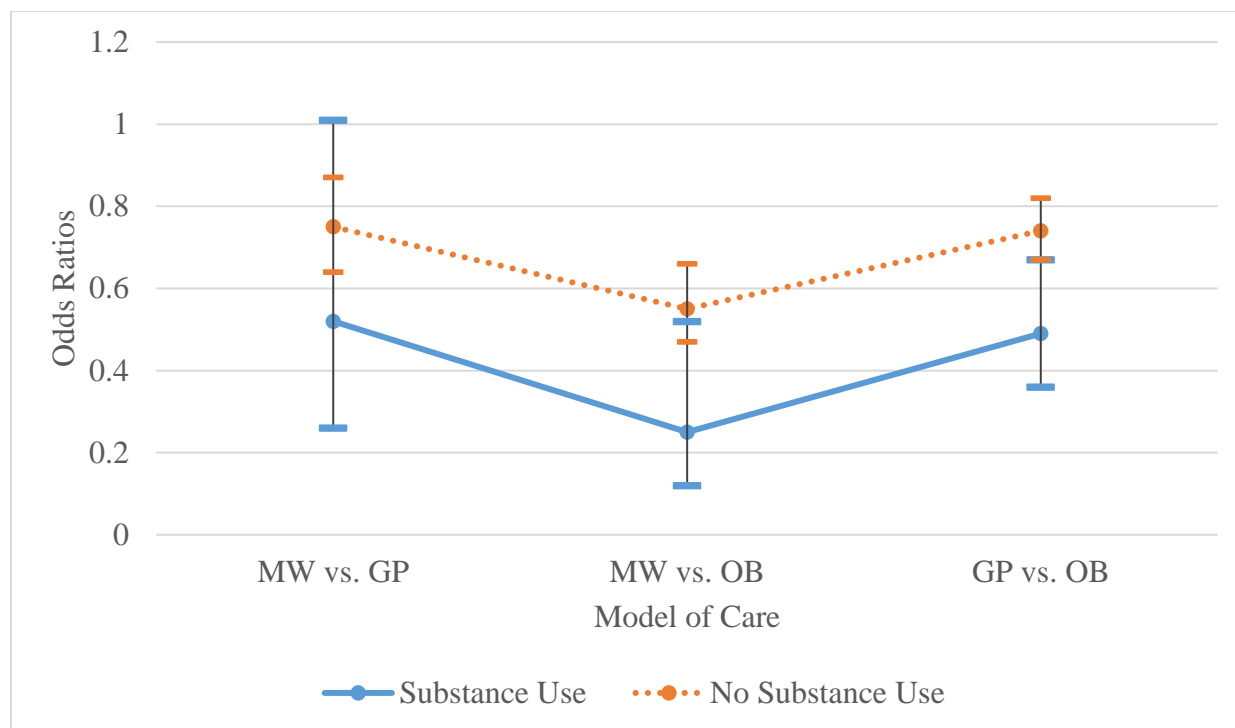


Figure 5.5: Odds and 95% CIs of Preterm Birth by Model of Care and Substance Use vs. No Substance Use

The effect of neighbourhood SEP varied according to model of care (see Table 5.4 and Figure 5.6). MW vs. GP patients residing in low or medium SEP neighbourhoods had significant reductions in odds of PTB (OR 0.75 95% CI: 0.64-0.87). For patients residing in high SEP neighbourhoods, the reduction in odds was slightly greater, but was not statistically significant (OR 0.66, 95% CI: 0.43-1.02). As there was little difference in point estimates of PTB for MW vs. GP patients in low/medium vs. high SEP neighbourhoods, neighbourhood residence did not appear to modify the association between MW vs. GP care and preterm birth. In contrast, the opposite relationship between neighbourhood SEP and preterm birth was observed for MW vs. OB patients. Those residing in low or medium SEP neighbourhoods had a greater reduction in odds of PTB (OR 0.52, 95% CI: 0.44-0.62) than that of patients residing in high SEP neighbourhoods (OR 0.71, 0.41-1.21). However, the small difference in odds of PTB across strata of neighbourhood SEP, suggests that neighbourhood SEP did not modify the relationship between antenatal model of care and PTB for MW vs. OB patients. For GP vs. OB patients residing in low or medium SEP neighbourhoods, the odds of PTB was significantly reduced (OR 0.70, 95% CI: 0.63-0.77), however for those residing in high SEP neighbourhoods odds of PTB

were comparable for GP vs. OB patients (OR 1.08, 95% CI: 0.75-1.54). The large difference in odds ratios across strata of neighbourhood SEP, and a statistically significant interaction term for antenatal model of care and neighbourhood SEP ( $p=0.02$ ) in the logistic model suggest that neighbourhood SEP modified the association between GP vs. OB antenatal care and PTB.

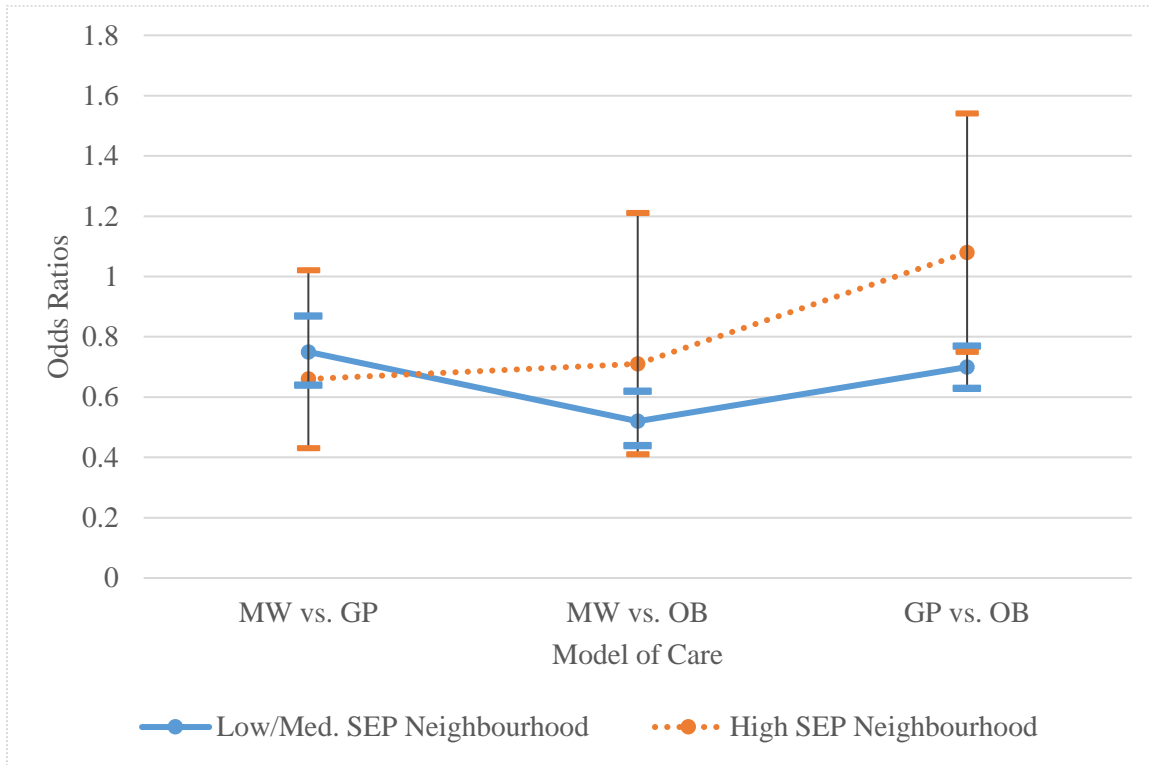


Figure 5.6: Odds and 95% CIs of Preterm Birth by Model of Care and Low/Medium Neighbourhood SEP vs. High Neighbourhood SEP

When investigating model of care and PTB stratified by multiple vulnerabilities (i.e. substance use and social assistance) there did not appear to be any modifying effects. In summary, no characteristics of vulnerability appeared to reduce the odds of PTB for MW vs. GP patients. Only substance use modified the association between MW vs. OB antenatal care and PTB. For GP vs. OB patients, model of care and PTB was modified by mental illness/disorder, substance use, and neighbourhood SEP.

## 5.7 Large-for-Gestational-Age Birth

Table 5.5: Frequencies, Rates and Adjusted Odds Ratios for Large-For-Gestational-Age Birth by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Large-for-Gestational-Age Birth by Model of Care						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>LGA</b>	662/4,695 (14.10)	5,428/45,004 (12.06)	815/8,025 (10.16)	1.28 (1.16-1.40)	1.46 (1.30-1.63)	1.14 (1.05-1.24)
<b>Mental Ill./Dis.</b>						
Yes	146/1,019 (14.33)	672/5,134 (13.09)	70/608 (11.51)	1.18 (0.96-1.43)	1.47 (1.07-2.01)	1.25 (0.95-1.63)
No	516/3,676 (14.04)	4,756/39,870 (11.93)	745/7,417 (10.04)	1.30 (1.18-1.45)	1.47 (1.30-1.67)	1.13 (1.03-1.23)
<b>Substance Use</b>						
Yes	16/179 (8.94)	283/3,308 (8.56)	34/302 (11.26)	1.11 (0.66-1.88)	0.87 (0.47-1.62)	0.78 (0.53-1.14)
No	646/4,516 (14.30)	5,145/41,696 (12.34)	781/7,723 (10.11)	1.28 (1.17-1.41)	1.48 (1.32-1.67)	1.16 (1.06-1.26)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	28/155 (18.06)	569/4,682 (12.15)	38/333 (11.41)	1.74 (1.13-2.67)	2.10 (1.22-3.61)	1.21 (0.84-1.73)
No (24-29 yrs.)	229/1,617 (14.16)	1,503/13,125 (11.45)	213/2,298 (9.27)	1.34 (1.14-1.56)	1.54 (1.26-1.90)	1.16 (0.99-1.35)
<b>Social Assistance</b>						
Yes	48/310 (15.48)	768/5,812 (13.21)	97/809 (11.99)	1.18 (0.85-1.65)	1.39 (0.95-2.05)	1.17 (0.93-1.48)
No	614/4,385 (14.00)	4,660/39,192 (11.89)	718/7,216 (9.95)	1.28 (1.17-1.41)	1.45 (1.29-1.64)	1.13 (1.04-1.24)
<b>Neigh. SEP</b>						
Low/Medium	577/4,072 (14.17)	4,856/40,034 (12.13)	737/7,380 (9.99)	1.27 (1.15-1.40)	1.49 (1.32-1.68)	1.17 (1.07-1.28)
High	85/623 (13.64)	572/4,970 (11.51)	78/645 (12.09)	1.32 (1.03-1.69)	1.12 (0.80-1.56)	0.85 (0.65-1.09)
<b>Mental Ill./Dis., Social Assistance</b>						
Both	21/131 (16.03)	157/1,262 (12.44)	14/179 (7.82)	1.33 (0.80-2.22)	2.57 (1.22-5.40)	1.93 (1.07-3.49)
Neither	489/3,497 (13.98)	4,145/35,320 (11.74)	662/6,787 (9.75)	1.33 (1.20-1.48)	1.48 (1.30-1.69)	1.11 (1.01-1.22)
<b>Substance Use, Social Assistance</b>						
Both	5 or less /50 <sup>a</sup>	89/1,200 (7.42)	15/141 (10.64)	1.03 (0.35-3.01)	0.69 (0.21-2.27)	0.68 (0.38-1.22)
Neither	602/4,256 (14.14)	4,466/37,084 (12.04)	699/7,055 (9.91)	1.29 (1.17-1.42)	1.45 (1.28-1.64)	1.13 (1.03-1.23)

Models adjusted for all variables listed except stratifying variables: maternal age, parity, medical risk, pre-pregnancy BMI, smoking status, substance use, alcohol use, mental illness/disorder, receipt of social assistance, neighbourhood SEP, urban residence, local health area socioeconomic rank, local health area income inequality, and northern residence

<sup>a</sup>Percentage suppressed due to small cell size

Odds ratios based on 6,905 LGA births and 57,724 total births with no missing information for this analysis

Almost 12% of the study population had infants that were large-for-gestational-age (LGA) at birth, defined as weight for gestational age above the 90<sup>th</sup> percentile according to Kierans and colleagues growth chart references.(3) Infants born to mothers receiving antenatal care from MWs had the highest rates of LGA birth (14.10%), followed by GPs (12.06%) and OBs (10.16%). Unadjusted odds ratios showed an increase in the likelihood of LGA birth for women in the care of MWs compared to those in the care of GPs or OBs (MW vs. GP: OR 1.20, 95% CI: 1.10-1.31; MW vs. OB: 1.45, 95% CI: 1.30-1.62. GP vs. OB patients were also at increased odds of having LGA infants (OR 1.21, 95% CI: 1.12-1.31). Models were adjusted for maternal age, parity, medical risk, pre-pregnancy BMI, smoking status, substance use, alcohol use, mental illness/disorder, receipt of social assistance, neighbourhood SEP, urban residence, local health area socioeconomic rank, local health area income inequality, northern residence, and family and community level correlation. Adjusted odds ratios indicated, on average, a greater likelihood of having a LGA infant for MW vs. GP patients (OR 1.28, 95% CI: 1.16-1.40), and MW vs. OB patients (OR 1.46, 95% CI: 1.30-1.63) (see Table 5.5). Likewise there were smaller, yet statistically significant odds of LGA birth for GP vs. OB patients (OR 1.14, 95% CI: 1.05-1.24). When smoking status, substance use, alcohol use, and mental illness/disorder were removed from the model, odds of LGA increased for MW vs. GP, and MW vs. OB patients, but slightly decreased for GP vs. OB patients (see Appendix 5-A).

When stratifying the sample by substance use, there was only a small difference in odds of LGA birth for MW vs. GP patients with substance use (OR 1.11, 95% CI: 0.66-1.88) compared to those without substance use (OR 1.28, 95% CI: 1.17-1.41) (see Table 5.5 and Figure 5.7). For MW vs. OB patients, odds of LGA birth were statistically significant for those without substance use (OR 1.48, 95% CI: 1.32-1.67), but not for those with substance use (OR 0.87, 95% CI: 0.47-1.62). Both the large difference in point estimates across strata for MW vs. OB patients, and a p-value of 0.10 for the interaction term, “model of care x substance use” in the logistic regression model, suggest that substance use had a modifying effect on MW vs. OB care and LGA. For GP vs. OB patients differences in odds ratios and a significant interaction term (p=0.05) for “model of care x substance use”, indicated substance use had a modifying effect. GP vs. OB patients who were not substance using had significantly greater odds of having a LGA infant (OR 1.16, 95% CI: 1.06-1.25). In contrast, substance using GP vs. OB patients had statistically similar odds of LGA birth (OR 0.78, 95% CI: 0.53-1.14).



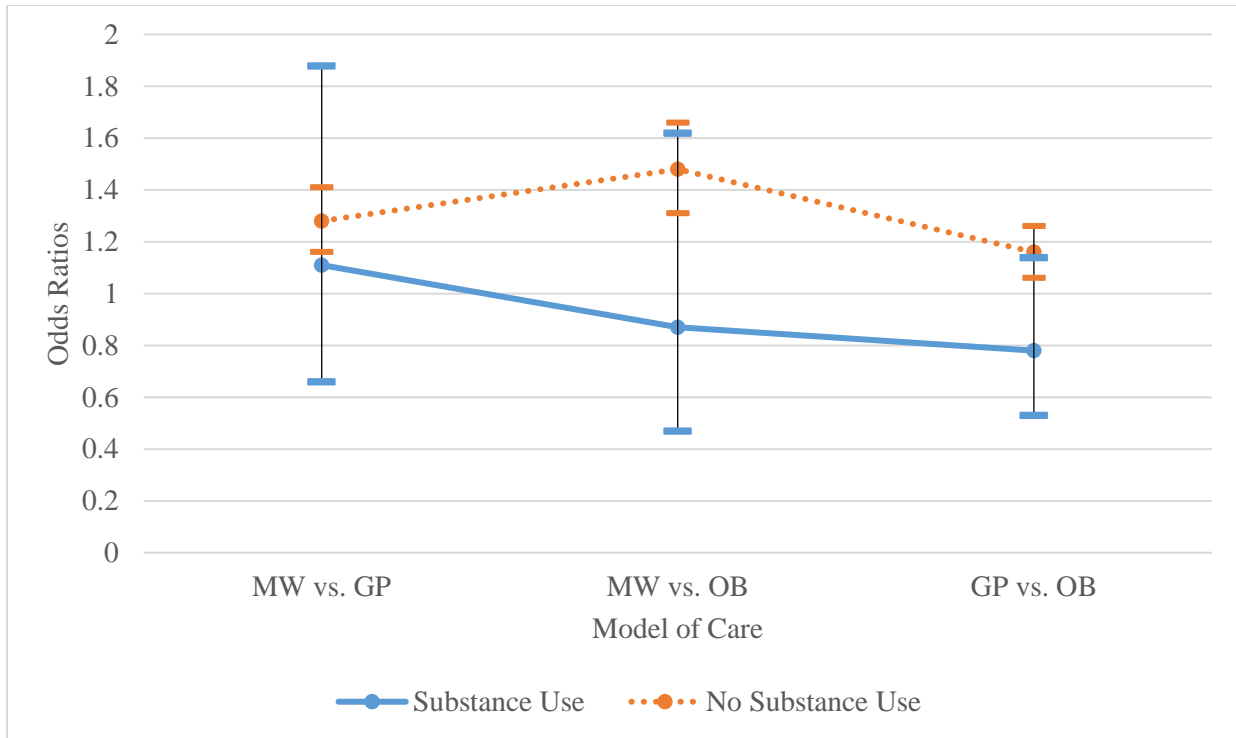


Figure 5.7: Odds and 95% CIs of Large-for-Gestational-Age Birth by Model of Care and Substance Use vs. No Substance Use

Neighbourhood SEP modified the relationship between GP vs. OB antenatal care and LGA birth. For GP vs. OB patients there was increased odds of LGA birth for those residing in low/medium SEP neighbourhoods (OR 1.17, 95% CI: 1.07-1.28), but no statistically significant difference in odds for those residing in high SEP neighbourhoods (OR 0.85, 95% CI: 0.65-1.09) (see Table 5.5 and Figure 5.8). Furthermore, the interaction term “model of care x neighbourhood SEP” was statistically significant (p=0.02).

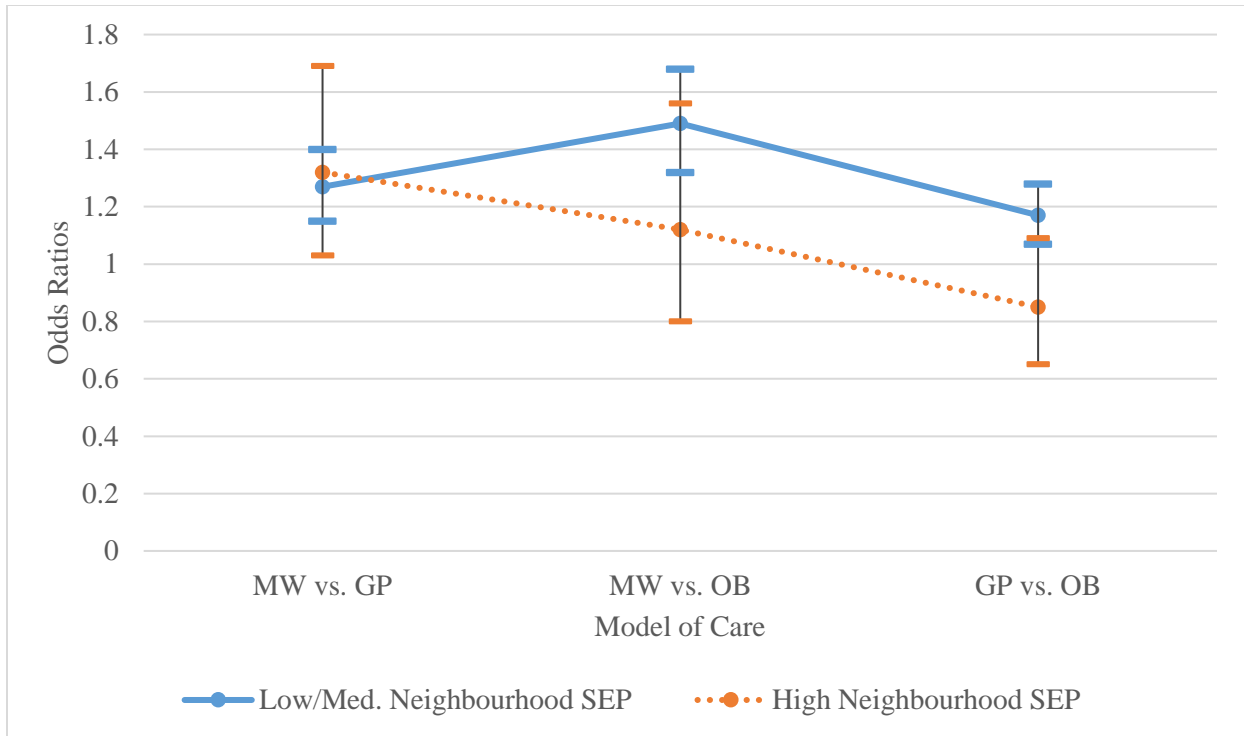


Figure 5.8: Odds and 95% CIs of Large-for-Gestational-Age Birth by Model of Care and Low/Medium vs. High Neighbourhood SEP

I examined odds of LGA stratified by multiple, intersecting vulnerabilities. GP vs. OB patients with mental illness/disorder and social assistance had 1.93 times the odds of having an LGA infant (95% CI: 1.07-3.49), whereas GP patients with neither mental illness/disorder nor social assistance appeared to have 1.11 times the odds of LGA birth, but this was not statistically significant (95% CI: 1.01-1.22) (see Table 5.5 and Figure 5.9). The interaction term “model of care x mental illness/disorder and social assistance” in the logistic regression model was significant ( $p=0.07$ ) which together with the two-fold decrease in odds of LGA birth among women with vs. without mental illness/disorder and social assistance suggest that these combined characteristics of vulnerability modified the association between antenatal model of care and LGA birth for GP vs. OB patients.

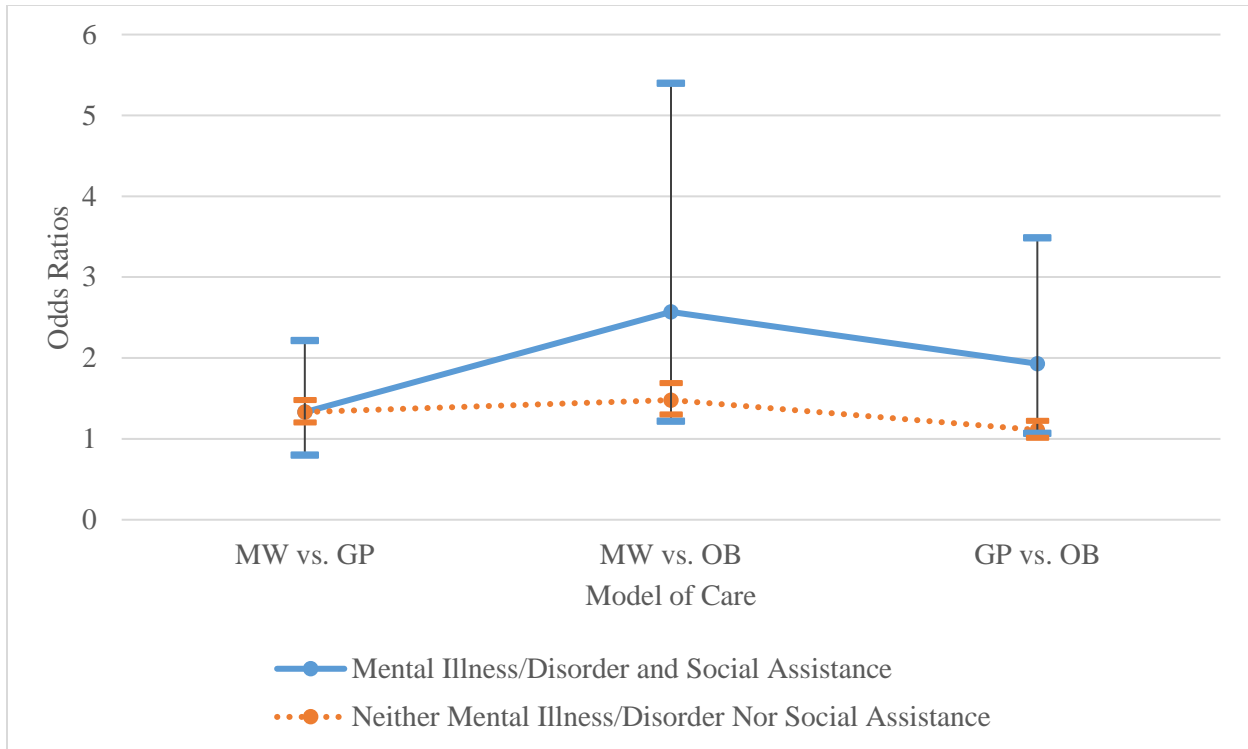


Figure 5.9: Odds and 95% CIs of Large-for-Gestational-Age Birth by Model of Care, and Both Mental Illness/Disorder and Social Assistance vs. Neither

For GP vs. OB patients who were substance using and received social assistance during the year of delivery there was no statistically significant difference in odds of LGA birth (OR 0.68, 95% CI: 0.38-1.22) (see Figure 5.10). In contrast, GP vs. OB patients who were not substance using and did not receive social assistance had significantly greater odds of LGA (OR 1.13, 95% CI: 1.03-1.23). The interaction term for “model of care x substance use and social assistance” was significant in the logistic regression model ( $p=0.09$ ), further signifying a modifying effect.

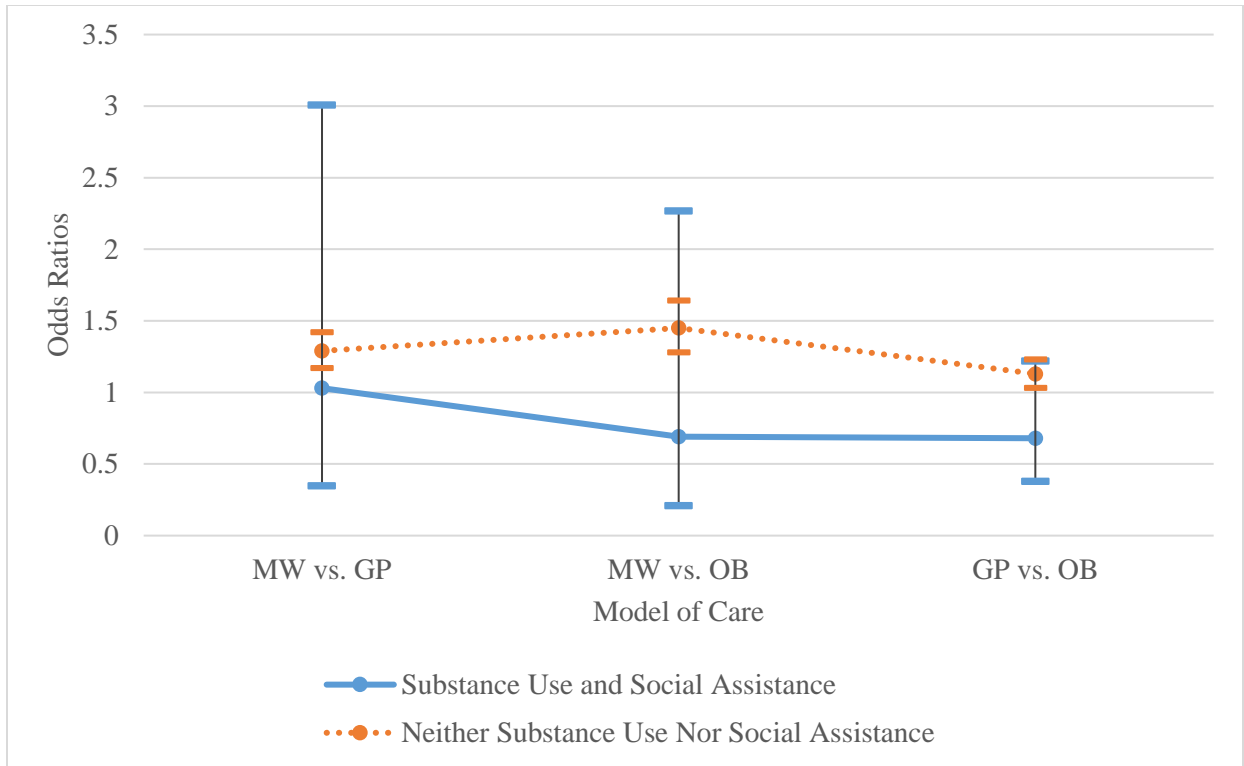


Figure 5.10: Odds and 95% CIs of Large-for-Gestational-Age Birth by Model of Care, and Both Substance Use and Social Assistance vs. Neither

In conclusion, only for MW vs. OB antenatal care and GP vs. OB antenatal care did substance use appear to modify the relationship between model of care and LGA stature. For GP vs. OB antenatal care other modifying characteristics included neighbourhood SEP, and combinations of mental illness/disorder and social assistance, and substance use and social assistance.

## 5.8 Apgar Score

Table 5.6: Frequencies, Rates and Adjusted Odds Ratios for Apgar Score Less Than Seven at One Minute by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Apgar Score Less Than Seven At One Minute						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Apgar Score</b>	472/4,689 (10.07)	5,569/44,994 (12.38)	721/8,038 (8.97)	0.85 (0.77-0.95)	1.03 (0.91-1.16)	1.20 (1.10-1.31)
<b>Mental Ill./Dis.</b>						
Yes	114/1,017 (11.21)	779/5,130 (15.19)	90/608 (14.80)	0.81 (0.65-1.01)	0.76 (0.56-1.03)	0.93 (0.73-1.19)
No	358/3,672 (9.75)	4,790/39,864 (12.02)	631/ 7,430 (8.49)	0.87 (0.78-0.98)	1.08 (0.94-1.24)	1.24 (1.13-1.36)
<b>Substance Use</b>						
Yes	19/179 (10.61)	530/3,308 (16.02)	41/307 (13.36)	0.64 (0.40-1.04)	0.73 (0.41-1.31)	1.14 (0.81-1.62)
No	453/4,510 (10.04)	5,039/41,686 (12.09)	680/7,731 (8.80)	0.87 (0.78-0.96)	1.04 (0.92-1.19)	1.20 (1.10-1.32)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	23/155 (14.84)	716/4,687 (15.28)	30/336 (8.93)	1.00 (0.63-1.57)	1.70 (0.95-3.06)	1.71 (1.15-2.52)
No (24-29 yrs.)	155/1,614 (9.60)	1,520/13,129 (11.58)	200/2,299 (8.70)	0.84 (0.70-1.00)	1.02 (0.81-1.27)	1.21 (1.03-1.42)
<b>Social Assistance</b>						
Yes	35/309 (11.33)	777/5,801 (13.39)	99/808 (12.25)	0.88 (0.61-1.27)	0.88 (0.58-1.34)	1.00 (0.80-1.26)
No	437/4,380 (9.98)	4,792/39,193 (12.23)	622/7,230 (8.60)	0.85 (0.77-0.95)	1.05 (0.92-1.20)	1.23 (1.13-1.35)
<b>Mental Ill./Dis., Substance Use</b>						
Both	11/95 (11.58)	176/965 (18.24)	16/86 (18.60)	0.65 (0.34-1.24)	0.63 (0.27-1.45)	0.96 (0.54-1.72)
Neither	350/3,588 (9.75)	4,436/ 37,521 (11.82)	606/7,209 (8.41)	0.88 (0.78-0.99)	1.09 (0.95-1.25)	1.24 (1.13-1.36)
<b>Mental Ill./Dis., Social Assistance</b>						
Both	13/130 (10.00)	192/1,261 (15.23)	29/177 (16.38)	0.70 (0.39-1.28)	0.60 (0.30-1.22)	0.86 (0.56-1.32)
Neither	336/3,493 (9.62)	4,205/ 35,324 (11.90)	561/6,799 (8.25)	0.86 (0.76-0.97)	1.09 (0.94-1.25)	1.26 (1.15-1.39)
<b>Substance Use, Social Assistance</b>						
Both	5 or less/49 <sup>a</sup>	183/1,198 (15.28)	23/143 (16.08)	0.67 (0.27-1.68)	0.58 (0.21-1.59)	0.86 (0.53-1.40)
Neither	423/4,250 (9.95)	4,445/37,083 (11.99)	604/7,066 (8.55)	0.88 (0.79-0.96)	1.06 (0.92-1.21)	1.23 (1.12-1.34)

Model adjusted for age, parity, pre-pregnancy BMI, infant sex, smoking status, substance use, mental illness/disorder, receipt of social assistance, birth year, urban residence, local health area socioeconomic rank, local health area income inequality, and northern residence.

<sup>a</sup>Percentage suppressed due to small cell size

Odds ratios based on 6,762 births with Apgar score < 7 at 1 minute and 57,721 total births with no missing information for this analysis

Overall, 11.71% of the eligible infants in the study had Apgar scores less than seven at one minute (low Apgar score). Patients receiving antenatal care from GPs had the highest rate of infants with low Apgar scores (12.38%) compared to MW (10.07%) and OB (8.97%) patients. Unadjusted odds ratios showed a significant decrease in odds of low Apgar score for MW vs. GP patients (OR 0.79, 95% CI: 0.72-0.88), and an increase in odds of low Apgar score for MW vs. OB patients (OR 1.14, 95% CI: 1.01-1.28), and GP vs. OB patients (OR 1.43, 95% CI: 1.32-1.56). Adjusted odds ratios indicated an average decrease in the likelihood of low Apgar score for women receiving antenatal care from MWs' vs. GPs' (OR 0.85, 95% CI: 0.77-0.95), but no statistically significant difference among MWs' vs. OBs' patients (OR 1.03, 95% CI: 0.91-1.16) (see Table 5.6) . Compared to OB patients, GP patients were more likely to have a low Apgar score (OR 1.20, 95% CI: 1.10-1.31), after adjustment. Models were adjusted for age, parity, pre-pregnancy BMI, infant sex, smoking status, substance use, mental illness/disorder, receipt of social assistance, birth year, urban residence, local health area socioeconomic rank, local health area income inequality, northern residence, and family and community level correlation. When removing smoking status, substance use, and mental illness/disorder from the model, the adjusted ORs were similar in direction and significance to the full adjusted models (see Appendix 5-A). According to the preventative fraction, if all GP patients in the study had received antenatal care from MWs, 18.7% of GP births with a low Apgar score could have theoretically been avoided (see Appendix 5-B), equivalent to 1,041 fewer cases over the study period.

For MW vs. OB patients with a mental illness/disorder, odds of low Apgar score were reduced, but not statistically significant (OR 0.76, 95% CI: 0.56-1.03) (Table 5.6 and Figure 5.11). For women without a mental illness/disorder diagnosis, odds were slightly higher for MW vs. OB patients, but also not statistically significant (OR 1.08, 0.94-1.24). The interaction term for “model of care x mental illness/disorder” in the logistic regression model had a p-value of 0.04, indicating that mental illness/disorder had a modifying effect on the relationship between MW vs. OB care and low Apgar score.

Mental illness/disorder also modified the relationship between GP vs. OB care and low Apgar score. GP patients with no mental illness/disorder had greater odds of low Apgar score than OB patients (OR 1.24, 95% CI: 1.13-1.36), yet for GP patients with a mental illness/disorder there was no significant difference in odds of low Apgar score (OR 0.93 95% CI:

0.73-1.19). The interaction term for this association had a p-value of 0.03. The observed difference in point estimates (odds ratios) in combination with a statistically significant interaction term suggest that the presence of mental illness/disorder modified the association between GP vs. OB antenatal care and low Apgar score.

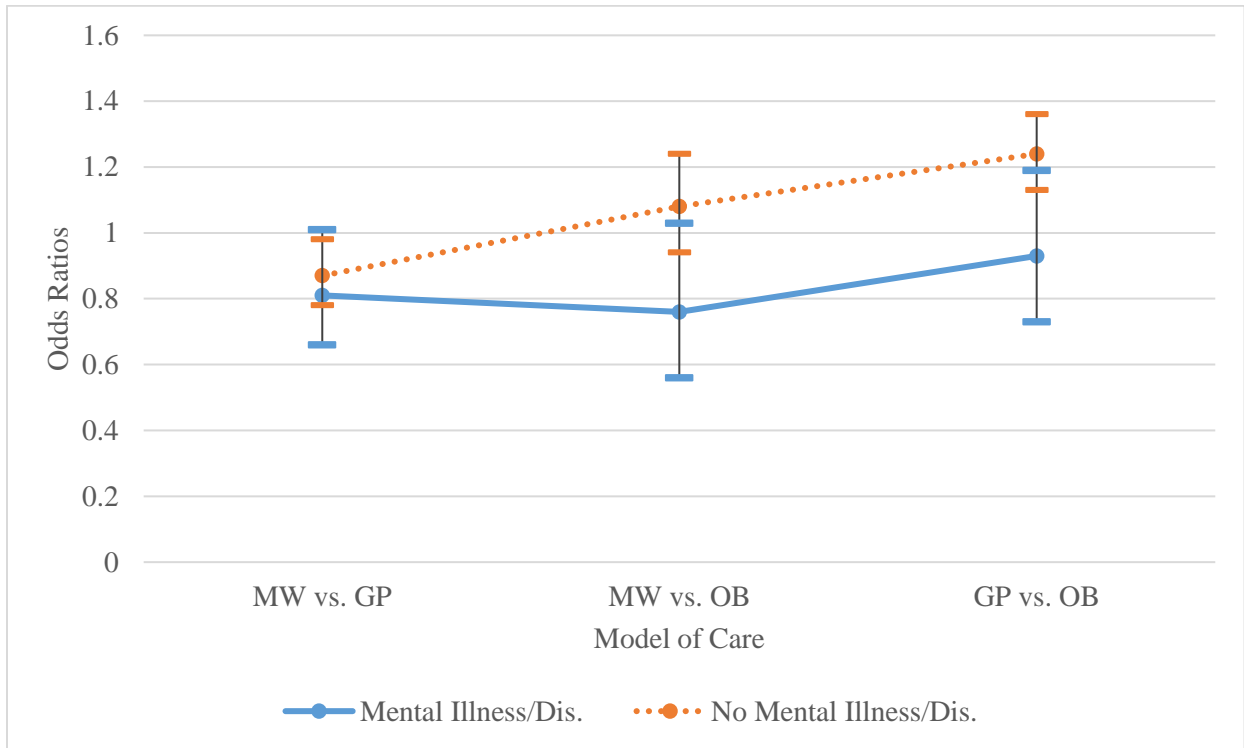


Figure 5.11: Odds and 95% CIs of Low Apgar Score by Model of Care and Mental Illness/Disorder vs. No Mental Illness/Disorder

When examining the association between MW vs. OB care and low Apgar score stratified by teen maternal age, teen mothers appeared to have a 70% increase in odds of low Apgar score, but the association was not statistically significant (1.70, 95% CI: 0.95-3.06). For MW vs. OB patients aged 25-29 years old, there was no difference in odds of low Apgar score (OR 1.02, 95% CI: 0.81-1.27) (see Table 5.6). Likewise, for GP vs. OB teen mothers, odds of low Apgar score was 71% higher (OR 1.71, 95% CI: 1.15-2.52), whereas GP vs. OB patients who were 25-29 years old had only a 21% increase in low Apgar score (OR 1.21, 95% CI: 1.03-1.42). Despite the apparent modifying effect of maternal age, the interaction term for “model of care x maternal age” was not significant for MW vs. OB patients ( $p=0.12$ ) or for GP vs. OB patients ( $p=0.11$ ).



Analysis of the effect of multiple vulnerabilities on the association between model of care and low Apgar score revealed a significant difference in GP vs. OB antenatal care for women with and without combinations of mental illness/disorder and social assistance (see Table 5.6 and Figure 5.12). GP vs. OB patients without a mental illness/disorder nor social assistance had infants who, on average, were more likely to have an Apgar score less than seven at one minute (OR 1.26, 95% CI: 1.15-1.39). In contrast, there was no statistically significant difference in odds of low Apgar score for GP vs. OB patients who had a mental illness/disorder and were receiving social assistance (OR 0.86, 95% CI: 0.56-1.32). The interaction term in the logistic model representing differences in odds ratios by strata was statistically significant ( $p=0.09$ ).

In summary, the association between model of care and low Apgar score was modified by mental illness/disorder for MW vs. OB, and GP vs. OB patients. Mental illness/disorder and social assistance also modified the relationship between GP vs. OB care and low Apgar score.

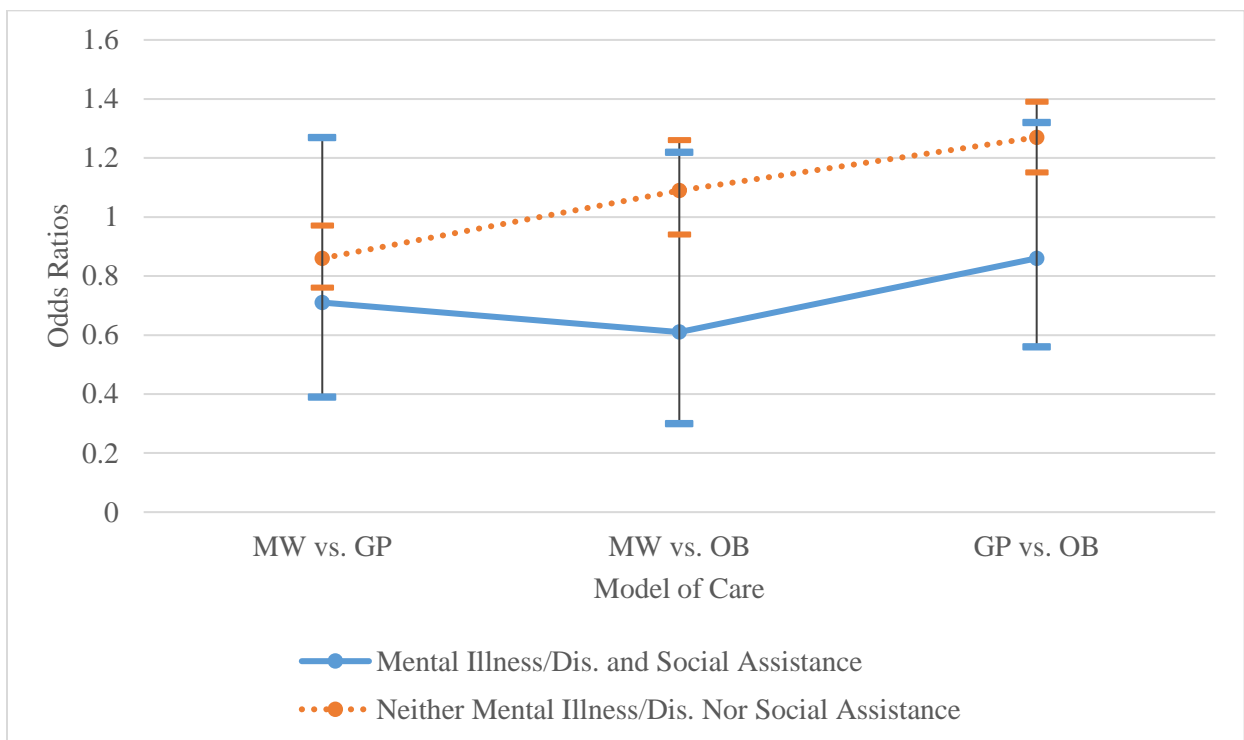


Figure 5.12: Odds and 95% CIs of Low Apgar Score by Model of Care, and Both Mental Illness/Disorder and Social Assistance vs. Neither

## 5.9 Newborn Extended Length of Hospital Stay

Table 5.7: Frequencies, Rates and Adjusted Odds Ratios for Newborn Extended Length of Hospital Stay by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Newborn Extended Length of Hospital Stay						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Extended LOS</b>	268/3,517 (7.62)	5,214/44,973 (11.59)	1,016/7,975 (12.74)	0.65 (0.57-0.74)	0.56 (0.49-0.65)	0.87 (0.80-0.94)
<b>Mental Ill./Dis.</b>						
Yes	76/736 (10.33)	750/5,129 (14.62)	138/601 (22.96)	0.75 (0.58-0.97)	0.43 (0.32-0.59)	0.58 (0.47-0.72)
No	192/2,781 (6.90)	4,464/39,844 (11.20)	878/7,374 (11.91)	0.62 (0.53-0.72)	0.57 (0.48-0.67)	0.91 (0.84-0.99)
<b>Substance Use</b>						
Yes	28/134 (20.90)	811/3,302 (24.56)	130/296 (43.92)	0.72 (0.47-1.11)	0.31 (0.19-0.50)	0.42 (0.33-0.55)
No	240/3,383 (7.09)	4,403/41,671 (10.57)	886/7,679 (11.54)	0.64 (0.55-0.73)	0.59 (0.51-0.69)	0.93 (0.86-1.01)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	18/144 (12.50)	768/4,683 (16.40)	67/324 (20.68)	0.69 (0.41-1.17)	0.50 (0.28-0.90)	0.73 (0.55-0.97)
No (24-29 yrs.)	70/1,212 (5.78)	1,308/13,127 (9.96)	279/2,286 (12.20)	0.55 (0.43-0.71)	0.45 (0.34-0.59)	0.81 (0.70-0.93)
<b>Social Assistance</b>						
Yes	46/255 (18.04)	954/5,814 (16.41)	183/807 (22.68)	1.13 (0.81-1.59)	0.73 (0.51-1.06)	0.65 (0.54-0.78)
No	222/3,262 (6.81)	4,260/39,159 (10.88)	833/7,168 (11.62)	0.60 (0.52-0.69)	0.55 (0.47-0.64)	0.92 (0.84-1.00)
<b>Mental Ill./Dis., Substance Use</b>						
Both	18/73 (24.66)	248/967 (25.65)	39/84 (46.43)	0.91 (0.52-1.58)	0.41 (0.21-0.82)	0.46 (0.29-0.73)
Neither	182/2,720 (6.69)	3,901/37,509 (10.40)	787/7,162 (10.99)	0.62 (0.53-0.73)	0.60 (0.51-0.71)	0.97 (0.89-1.06)
<b>Mental Ill./Dis., Social Assistance</b>						
Both	20/107 (18.69)	279/1,261 (22.13)	60/177 (33.90)	0.85 (0.51-1.45)	0.48 (0.26-0.87)	0.56 (0.39-0.80)
Neither	166/2,633 (6.30)	3,789/35,291 (10.74)	755/6,744 (11.20)	0.57 (0.48-0.67)	0.54 (0.46-0.65)	0.95 (0.87-1.04)
<b>Substance Use, Social Assistance</b>						
Both	16/42 (38.10)	391/1,198 (32.64)	73/139 (52.52)	1.15 (0.60-2.20)	0.51 (0.25-1.06)	0.45 (0.30-0.65)
Neither	210/3,170 (6.62)	3,840/37,055 (10.36)	776/7,011 (11.07)	0.60 (0.51-0.69)	0.57 (0.49-0.67)	0.96 (0.88-1.05)

<b>Teen Mother, Social Assistance</b>						
Both	6/34 (17.65)	164/903 (18.16)	20/80 (25.00)	0.82 (0.33-1.99)	0.48 (0.17-1.32)	0.59 (0.34-1.01)
Neither	58/1,141 (5.08)	1,073/11,631 (9.23)	243/2,076 (11.71)	0.61 (0.53-0.71)	0.53 (0.45-0.63)	0.87 (0.80-0.95)
<b>Teen Mother, Substance Use</b>						
Both	5 or less/20 <sup>a</sup>	130/635 (20.47)	19/37 (51.35)	0.82 (0.28-2.38)	0.18 (0.05-0.63)	0.22 (0.11-0.44)
Neither	65/1,177 (5.52)	1,102/12,337 (8.93)	245/2,210 (11.09)	0.66 (0.57-0.76)	0.57 (0.49-0.67)	0.87 (0.80-0.95)
Model adjusted for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, receipt of social assistance, birth year, infant sex, smoking status, substance use, alcohol use, mental illness/disorder, local health area socioeconomic rank, and northern residence						
<sup>a</sup> Percentage suppressed due to small cell size						
Odds ratios based on 6,498 births with extended length of hospital stay and 56,465 total births with no missing information for this analysis						

Extended length of hospital stay (ELOS) for the newborn, defined as equal or greater than three days for a vaginal delivery and equal or greater than four days for a caesarean delivery, was most prevalent among OB patients (12.74%), followed by GP patients (11.59%), and MW clients (7.62%). Unadjusted odds of ELOS were reduced for MW vs. GP patients (OR 0.63, 95% CI: 0.55-0.72), MW vs. OB patients (OR 0.57, 95% CI: 0.49-0.65) and for GP vs. OB patients (OR 0.90, 95% CI: 0.84-0.97). Holding all other covariates fixed, women receiving antenatal care from MWs vs. GPs had, on average, a reduction in odds of ELOS (OR 0.65, 95% CI: 0.57-0.74) (see Table 5.7). Compared to infants born to OB patients, those born to MW clients were also less likely to have ELOS (OR 0.56, 95% CI: 0.49-0.65), after adjustment. Likewise, patients attended during the antenatal period by GPs vs. OBs had reduced odds of having newborns with ELOS (OR 0.87, 95% CI: 0.80-0.94). Models were adjusted for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, receipt of social assistance, birth year, infant sex, smoking status, substance use, alcohol use, mental illness/disorder, local health area socioeconomic rank, and northern residence as well as family and community level correlation. A second model that did not adjust for smoking status, substance use, alcohol use, or mental illness/disorder produced similar odds ratios, slightly closer to the null for the association between MW vs. OB antenatal care, and GP vs. OB antenatal care (see Appendix 5-A).

On the basis of the preventative fraction, more than 34.3% of all newborn ELOS for GPs' patients could have theoretically been prevented, or 1,788 cases, if all GP patients had received antenatal care from MWs (see Appendix 5-B). Similarly, 40.2%, or 408 cases of newborn ELOS for OB patients could have theoretically been avoided if all OB patients had received antenatal MW care.

A number of characteristics of vulnerability influenced the relationship between model of care and ELOS. GP vs. OB patients with a mental illness/disorder had 0.58 odds of ELOS (95% CI: 0.47-0.72), compared to 0.91 odds of ELOS for patients without a mental illness/disorder (95% CI: 0.84-0.99) (see Table 5.7 and Figure 5.13). For GP vs. OB antenatal care there were large differences in odds ratios across strata and the interaction term for "model of care x mental illness/disorder" in the logistic model was statistically significant ( $p < 0.0001$ ), suggesting mental illness/disorder modified the association.

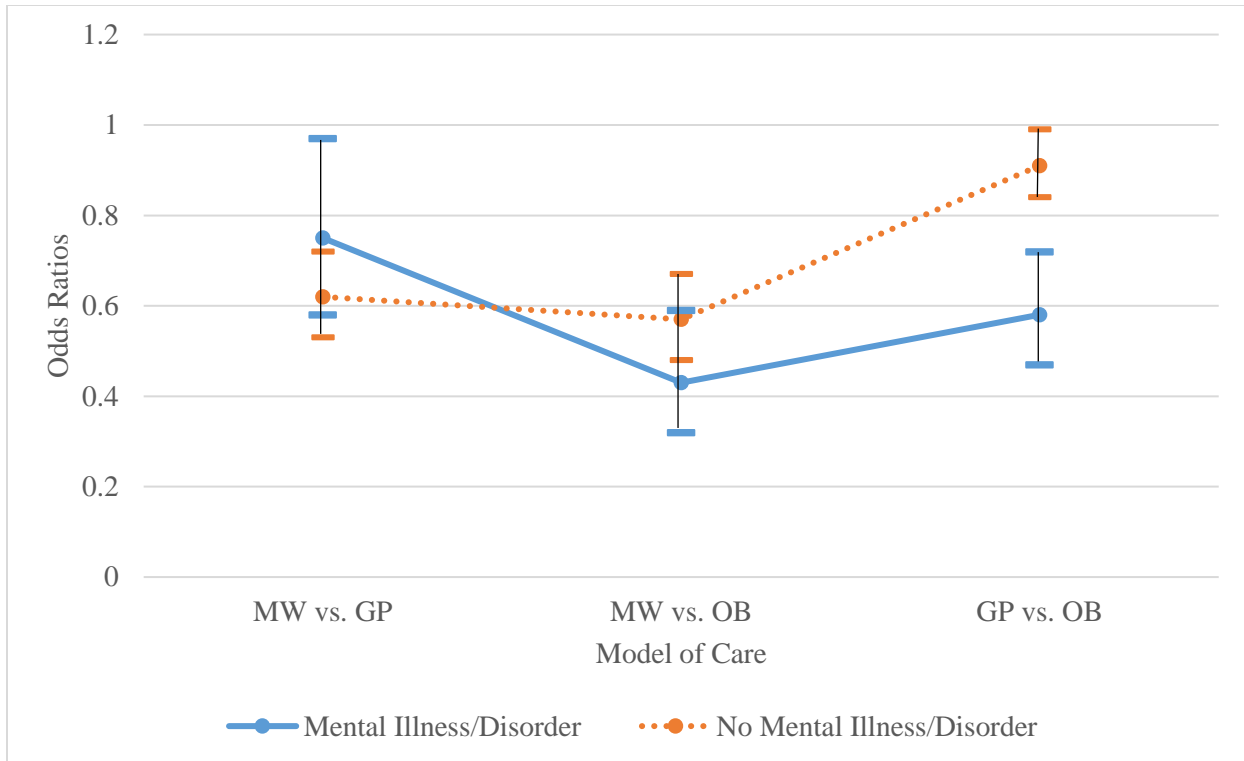


Figure 5.13: Odds and 95% CIs of Newborn Extended Length of Hospital Stay by Model of Care and Mental Illness/Disorder vs. No Mental Illness/Disorder

Substance use also modified the relationship between antenatal model of care and ELOS. For MW vs. OB patients there was a greater reduction in odds of newborn ELOS for substance users (OR 0.31, 95% CI: 0.19-0.50) vs. non-substance users (0.59, 95% CI: 0.51-0.69) (see Table 5.7 and Figure 5.14). The interaction term for this association was significant ( $p=0.01$ ). Substance use likewise modified the relationship between GP vs. OB antenatal care with substance users having reduced odds of newborn ELOS (OR 0.42, 95% CI: 0.33-0.55), while non-substance users had equivalent odds of newborn ELOS (OR 0.93, 95% CI: 0.86-1.01). For GP vs. OB antenatal care the interaction term “model of care x substance use” was significant ( $p < 0.0001$ ).

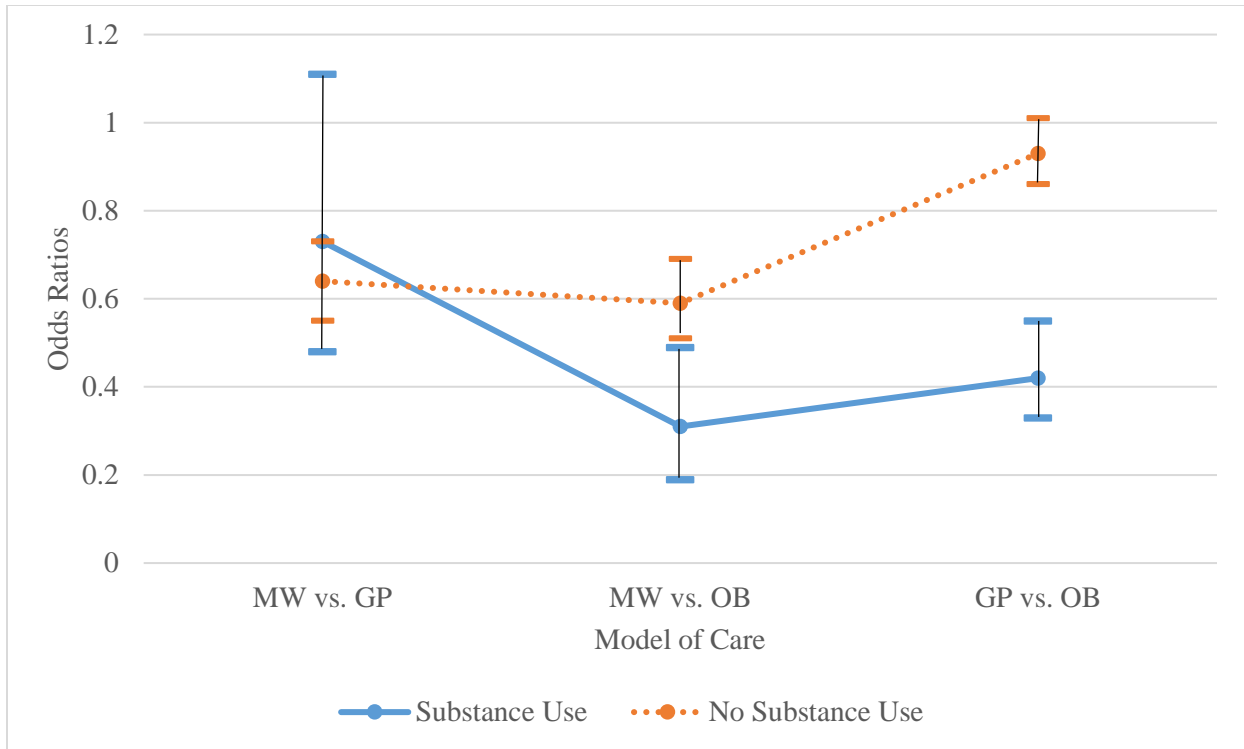


Figure 5.14: Odds and 95% CIs of Newborn Extended Length of Hospital Stay by Model of Care and Substance Use vs. No Substance Use

Social assistance modified the relationship between model of care and ELOS, with MW vs. GP patients having no statistically significant difference in odds of ELOS if they received social assistance (OR 1.13, 95% CI: 0.81-1.59), but reduced odds if they did not receive social assistance (OR 0.60, 95% CI: 0.52-0.69) (see Table 5.7). Social assistance had the opposite effect on the relationship between GP vs. OB antenatal care and ELOS. Women in the care of GPs had less odds of ELOS if they received social assistance (OR 0.65, 95% CI: 0.54-0.78), than if they did not (OR 0.92, 95% CI: 0.84-1.00). For both MWs’ vs. GPs’ patients, and GPs’ vs. OBs’ patients the interaction term for “model of care x social assistance” had a p-value of 0.001, suggesting social assistance had a modifying effect.

For GP vs. OB patients, the interaction between antenatal model of care, mental illness/disorder, and substance use was significant (p=0.002). Women having a mental illness/disorder and using substances during pregnancy had reduced odds of ELOS (OR 0.46, 95% CI: 0.29-0.73) (see Table 5.7). In contrast, GP vs. OB patients without mental illness/disorder or substance use had similar odds of ELOS (OR 0.97: 95% CI: 0.89-1.06). GP

vs. OB patients with mental illness/disorder and social assistance also had reduced odds of ELOS (OR 0.56, 95% CI: 0.39-0.80), although GP vs. OB patients without these vulnerabilities did not have reduced odds of ELOS (OR 0.95, 95% CI: 0.87-1.04). The difference in odds between strata was significant for patients with and without mental illness/disorder and social assistance ( $p=0.004$ ), further indicating a modifying effect.

MW vs. GP patients who were substance using and receiving social assistance did not have significantly different odds of ELOS (OR 1.15, 95% CI: 0.60-2.20) (see Table 5.7 and Figure 5.15). Yet, MW vs. GP patients without substance use who were not receiving social assistance, had significantly lower odds of ELOS (OR 0.60, 95% CI: 0.51-0.69). The interaction term “model of care x substance use and social assistance” in the logistic model was significant ( $p=0.05$ ), further indicating a modifying effect between MW vs. GP antenatal care and ELOS.

GP vs. OB patients who were substance using and receiving social assistance had lower odds of ELOS (OR 0.45, 95% CI: 0.30-0.65). However, GP vs. OB patients who were neither substance using nor receiving social assistance had similar odds of ELOS (OR 0.96, 95% CI: 0.88-1.05). The interaction term for “model of care x substance use and social assistance” was significant ( $p=0.0001$ ), indicating that these characteristics were modifying the relationship between GP vs. OB antenatal care and ELOS.

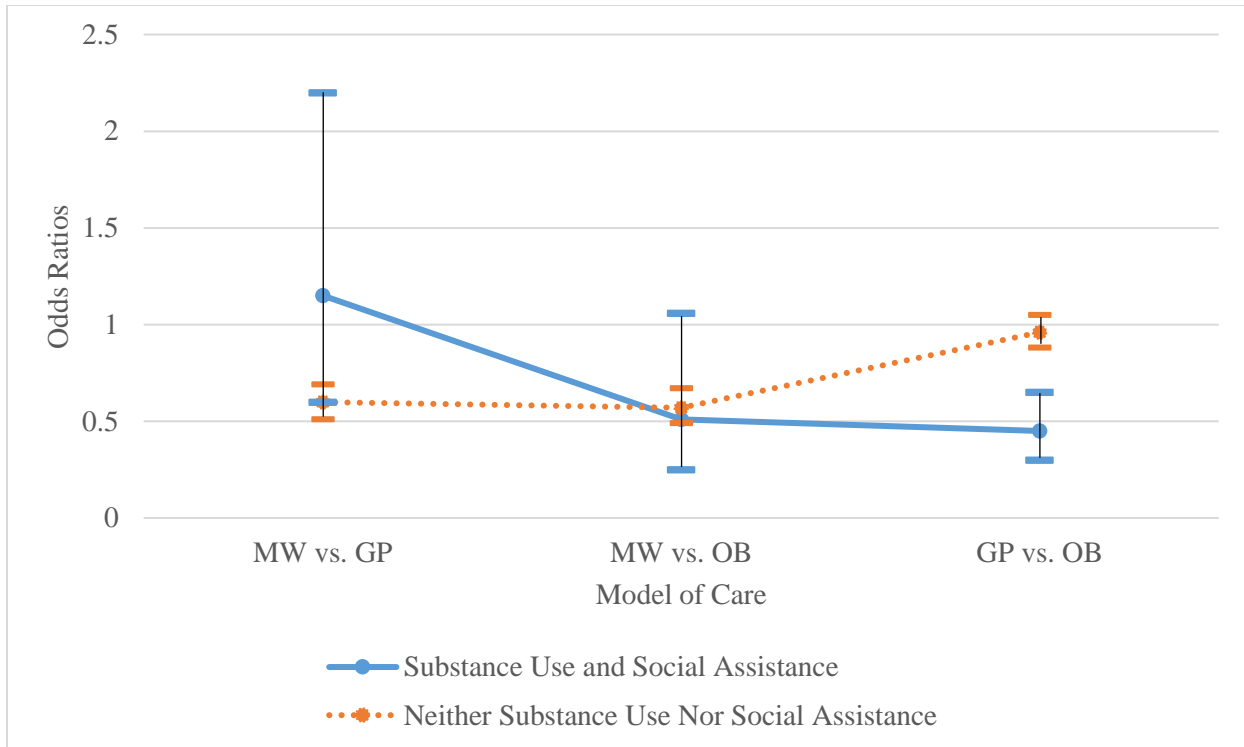


Figure 5.15: Odds and 95% CIs of Newborn Extended Length of Hospital Stay by Model of Care, and Both Substance Use and Social Assistance vs. Neither

MW vs. OB antenatal care reduced the odds of ELOS for both substance users who were teen mothers (0.18, 95% CI: 0.05-0.63) and for non-substance users who were 24-29 years of age (OR 0.57, 95% CI: 0.49-0.67) (see Table 5.7 and Figure 5.16). The large difference in odds ratios across strata and a significant interaction term for “model of care x substance use and teen maternal age” ( $p=0.07$ ), suggest that this combination of vulnerabilities modified the effect of MW vs. OB antenatal care on ELOS. The modifying effect of substance use and teen maternal age was greater for MW vs. OB patients who had both of these vulnerabilities (OR 0.18, 95% CI: 0.05-0.63), compared to those who were only substance users (OR 0.31, 95% CI: 0.19-0.50), or teenagers (OR 0.50, 95% CI: 0.28-0.90). For GP vs. OB patients, odds of ELOS were also less for substance using teens (OR 0.22, 95% CI: 0.11-0.44), than for non-substance using women, 24 to 29 years of age (OR 0.87, 95% CI: 0.80-0.95). For GP vs. OB patients, the interaction term for “model of care x maternal age and substance use” was significant ( $p=0.0001$ ).

In brief, the relationship between MW vs. GP care and ELOS was modified by social assistance, and the combination of substance use and social assistance. For MW vs. OB



antenatal care, odds of ELOS was modified when results were stratified by substance use, or teen maternal age and substance use. For GP vs. OB care and ELOS a number of characteristics of vulnerability modified the association, including: mental illness/disorder, substance use, social assistance, the combination of mental illness/disorder and substance use, mental illness/disorder and social assistance, substance use and social assistance, and teen maternal age and substance use.

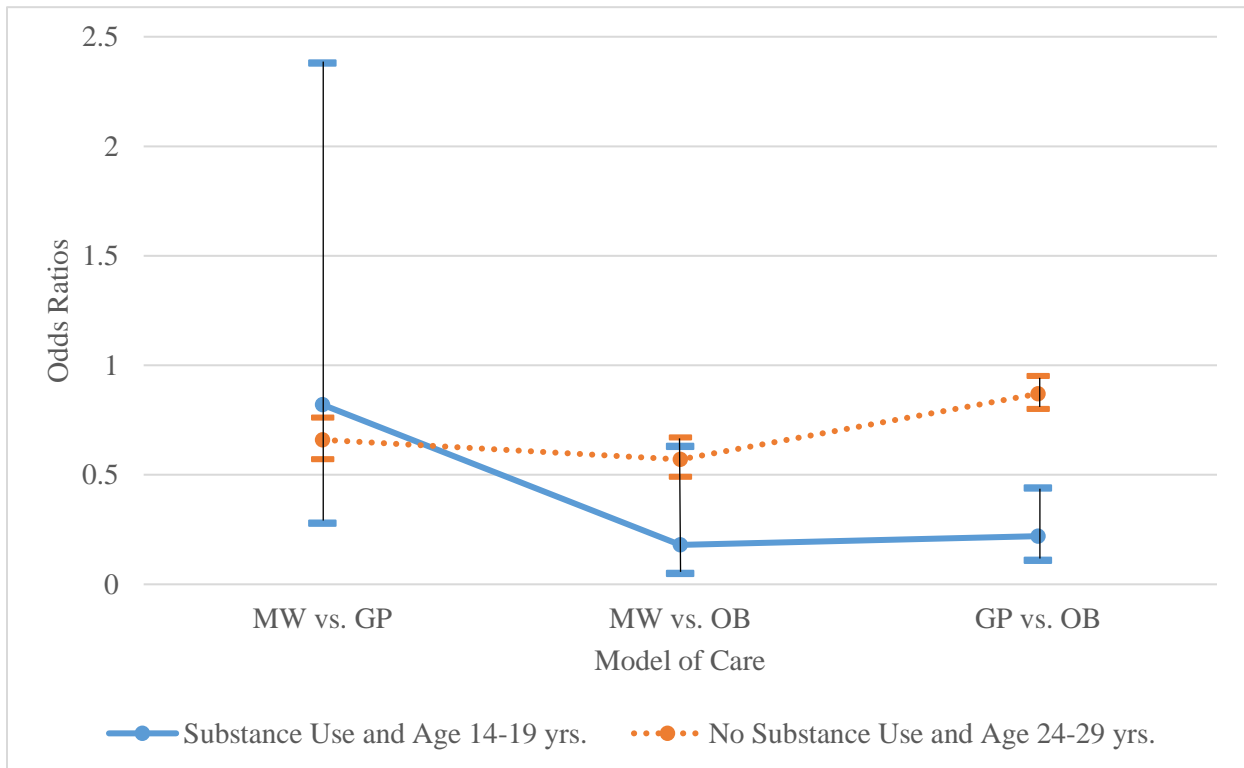


Figure 5.16: Odds and 95% CIs of Newborn Extended Length of Hospital Stay by Model of Care, and Both Substance Use and Teen Maternal Age vs. Neither

## 5.10 Low Birth Weight

Table 5.8: Frequencies, Rates and Adjusted Odds Ratios for Low Birth Weight by Antenatal Model of Care and by Maternal Characteristics of Vulnerability (n=57,872)

Low Birth Weight						
	MW n= 4,705	GP n= 45,114	OB n= 8,053	MW vs. GP	MW vs. OB	GP vs. OB
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>LBW</b>	91/4,704 (1.93)	1,438/45,091 (3.19)	393/8,046 (4.88)	0.66 (0.53-0.82)	0.43 (0.34-0.54)	0.65 (0.58-0.74)
<b>Substance Use</b>						
Yes	6/180 (3.33)	208/3,322 (6.26)	42/306 (13.73)	0.57 (0.26-1.29)	0.25 (0.11-0.60)	0.44 (0.31-0.63)
No	85/4,524 (1.88)	1,230/41,769 (2.94)	351/7,740 (4.53)	0.66 (0.53-0.82)	0.45 (0.35-0.58)	0.68 (0.60-0.78)
<b>Teen Mother</b>						
Yes (14-19 yrs.)	5 or less/155 <sup>a</sup>	157/4,697 (3.34)	24/338 (7.10)	0.79 (0.29-2.16)	0.35 (0.12-1.05)	0.45 (0.28-0.72)
No (24-29 yrs.)	28/1,619 (1.73)	401/13,150 (3.05)	107/2,302 (4.65)	0.63 (0.42-0.93)	0.41 (0.27-0.62)	0.65 (0.52-0.81)
Model adjusted for maternal age, parity, obstetric risk, pre-pregnancy BMI, infant sex, smoking status, and substance use.						
<sup>a</sup> Percentage suppressed due to small cell size						
Odds ratios based on 1,922 births with LBW and 57,841 total births with no missing information for this analysis						

Low birth weight, defined as less than 2,500 grams, occurred in 3.32% of the cases in the study population. MW patients had the lowest rates of LBW (1.93%), compared to GP patients (3.19%) and OB patients (4.88%). Unadjusted odds of LBW were lower for MW vs. GP patients (OR 0.60, 95% CI: 0.48-0.74), MW vs. OB patients (OR 0.38, 95% CI: 0.31-0.48), and GP vs. OB patients (OR 0.64, 95% CI: 0.57-0.72) (see Table 5.8). After adjustment for maternal age, parity, obstetric risk, pre-pregnancy BMI, infant sex, smoking status, substance use, and family and community level correlation, MW patients had less odds of LBW compared to GP (0.66, 95% CI: 0.53-0.82) or OB patients (0.43, 95% CI: 0.34-0.54). GP patients were also statistically significantly less likely to experience LBW, compared to OB patients (0.65, 95% CI: 0.58-0.74). Based on the preventative fraction, if all GP patients had received antenatal MW care they could have theoretically had 39.5% fewer LBW infants (568 cases). Had all OB patients received antenatal MW care, they could have theoretically had a 60.5% reduction in prevalence of LBW (238 cases) (see Appendix 5-B). When removing smoking status and substance use from the model, adjusted odds ratios differed minimally (see Appendix 5-A).

Substance use appeared to modify the relationship between GP vs. OB antenatal model of care and LBW. Substance using GP vs. OB patients had a greater reduction in odds of LBW (OR 0.44, 95% CI: 0.31-0.63) than non-substance using patients (OR 0.68, 95% CI: 0.60-0.78) (see Table 5.8 and Figure 5.17). Differences in odds ratios by strata were significant, with the interaction term “model of care x substance use” in the logistic regression model having a p-value of 0.02. The only characteristic of vulnerability that appeared to modify the relationship between antenatal model of care and LBW was substance use, and the modifying effect was only apparent for GP vs. OB patients.

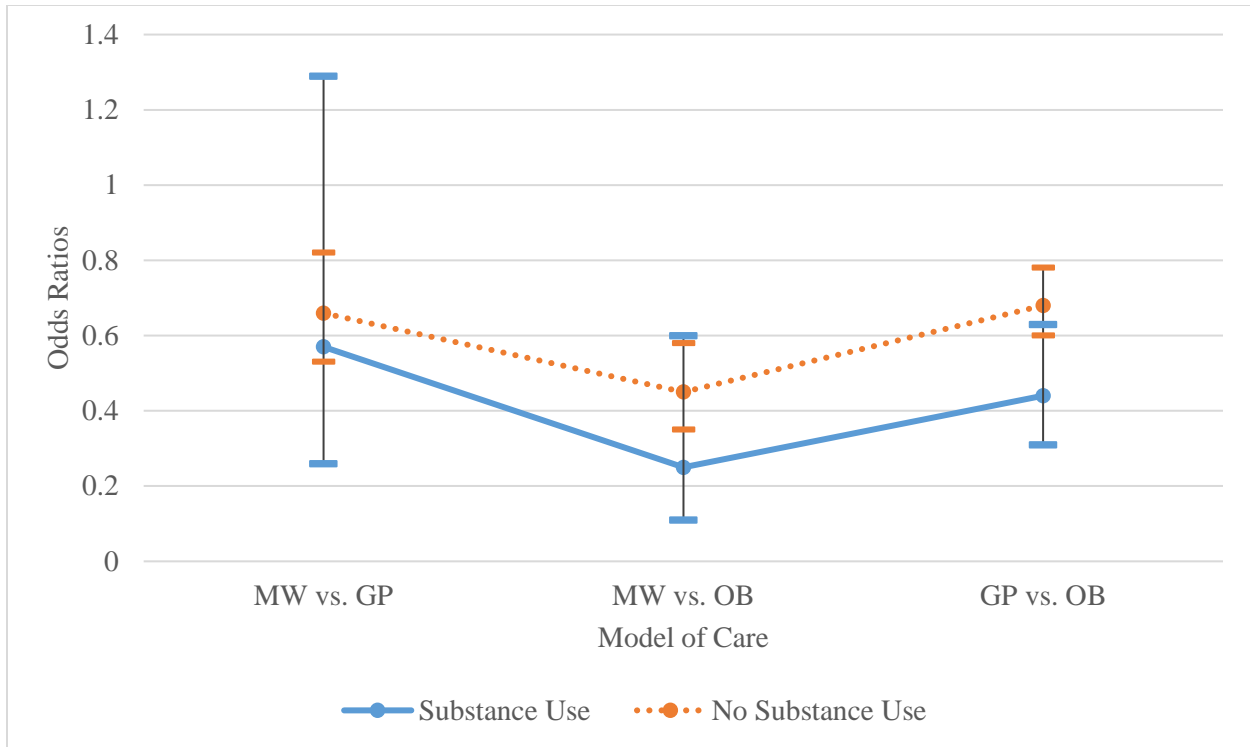


Figure 5.17: Odds and 95% CIs of Low Birth Weight by Model of Care and Substance Use vs. No Substance Use

### 5.11 Discussion

With the exception of LGA birth, provision of antenatal care by MWs was associated with a lower likelihood of SGA birth, PTB, ELOS, and LBW compared to GP or OB antenatal care. For MW vs. GP patients, odds of Apgar score less than seven at one minute were also reduced, but this was not apparent for MW vs. OB patients. Overall, odds differed the most between antenatal MW vs. OB care for all of the main outcomes. For patients receiving MW vs. OB care, odds of adverse infant birth outcomes were reduced by 40% to 57% depending on the outcome, with the greatest reduction in odds apparent for LBW (OR 0.43, 95% CI: 0.34-0.54) and PTB (OR 0.53, 95% CI: 0.45-0.62). MW vs. GP patients had a 15% to 35% reduction in odds across all outcomes, with the greatest reduction in odds apparent for newborn extended length of stay (OR 0.65, 95% CI: 0.57-0.74).

When examining how positions of social vulnerability intersected with antenatal model of care and one another it was evident that, on average, women who were substance using during pregnancy, substance using and had a mental illness/disorder diagnosed prior to or

during pregnancy, or were teen mothers and substance using, had even greater reductions in odds of SGA, PTB and/or ELOS, if receiving antenatal care from a MW compared to an OB. Substance using MW clients also had even greater reductions in odds of SGA. All of the covariates tested as effect modifiers were permanent characteristics, chronic behaviours, or contextual factors that preceded the exposure and outcome,(324) helping to explain “‘when’ or ‘for whom’” each model of care “most strongly (or weakly)” contributed to poor newborn outcomes.(p370, 324) Expanding the analysis beyond a single category of disadvantage (low SEP based on income) aided in uncovering potential individual and social “causes of the causes”,(339) which contribute to differences in infant birth outcomes among low SEP women in differing models of care.

For patients receiving antenatal GP vs. OB care, interaction between model of care and at least one of the following variables: mental illness/disorder, substance use, neighbourhood SEP, social assistance, as well as the combination of teen maternal age and social assistance, further reduced the odds of PTB, ELOS, and LBW compared to OB patients. However in over half of the cases, stratified results indicated a reduction in odds of adverse infant birth outcomes only for women with characteristics of vulnerability (i.e. substance use) in addition to low SEP, but not for women without additional vulnerabilities. These results suggest that GP vs. OB antenatal care was a better model of care for women with low SEP and other characteristics of vulnerability, but not necessarily a better model than OB care for women without additional vulnerability.

For some associations, the combined effect of two vulnerabilities resulted in a greater reduction in the odds of adverse infant birth outcomes than that observed by either variable on its own. For MW vs. OB patients, interaction between substance use and antenatal model of care yielded an odds ratio of 0.31 for ELOS (95% CI: 0.19-0.50). For MW vs. OB teen mothers, odds of ELOS were 0.50 (95% CI: 0.28-0.90), but for substance using teen mothers in the care of MWs vs. OBs odds of ELOS were 0.18 (95% CI: 0.05-0.63). Findings were similar for GPs’ vs. OBs’ patients, in which substance using teens had a much greater reduction in odds of ELOS (OR 0.22, 95% CI: 0.11-0.44) than either substance using mothers (OR 0.42, 95% CI: 0.33-0.55), or teen mothers (0.73, 95 % CI: 0.55-0.97). These results demonstrate that antenatal MW care, compared to OB care, was associated with reduced odds of ELOS for clients with single vulnerabilities (substance use or teen maternal age), and antenatal MW care was associated with

an even greater reduction in odds of ELOS for women with combined vulnerabilities (substance using, teen mothers).

Patients with mental illness/disorder receiving antenatal MW vs. OB care had 0.50 odds of SGA (95% CI: 0.33-0.77), and women with substance use had 0.30 odds of SGA (95% CI: 0.13-0.68), but women with mental illness/disorder and substance use had 0.19 odds of SGA (95% CI: 0.05-0.72). These results demonstrate that not only was there a stronger relationship between the MW model of care and reduced odds of SGA for women with vulnerability due to substance use, but as vulnerability increased (with the addition of a mental health diagnosis), so did the apparent protective effect of antenatal MW vs. OB care. Such results underscore the value of antenatal MW care for low SEP women and their infants, suggesting that equity in birth outcomes for women experiencing multiple social vulnerabilities may be improved through the provision of antenatal care that aligns with the MW model of practice. Results also highlight the importance of assessing antenatal model of care in light of differing types of social disadvantage to ensure that maternity policy and practice recommendations are inclusive of women from diverse social contexts.

In contrast to the previous results, there was little evidence supporting the hypotheses that MW vs. GP patients of low SEP with additional vulnerability (single or multiple) had even greater reductions in odds of adverse infant birth outcomes than that observed in the main models. For almost every association tested, odds of adverse infant birth outcomes did not differ significantly for MW vs. GP patients with or without single or multiple characteristics of vulnerability. For example, MW vs. GP patients with a mental illness/disorder diagnosis had 0.66 odds of SGA (95% CI: 0.48-0.92), approximately the same likelihood as women without a mental illness/disorder diagnosis (OR 0.74, 95% CI: 0.64-0.86). Both groups of MW clients had lower odds of SGA birth than GP patients, reflecting the overall reduction in odds found in the main effects model, but the similarity in odds between groups stratified by mental illness/disorder suggests that MW care, in comparison to GP care, did not confer any extra benefit for women with mental illness/disorder than for women without it.

The significant reduction in odds of SGA birth, the primary outcome of interest, for women receiving antenatal MW vs. GP care, and MW vs. OB care, has important clinical implications at a population-level as SGA birth is a leading cause of infant mortality in Canada,(16) and can have serious immediate and life-long health implications.(19, 20) Based on

calculations of the preventative fraction, approximately 1,279 SGA births could theoretically have been prevented had MW care been the sole model of care utilized for women of low SEP during the study period (see Appendix 5-B). Although there was a 27% reduction in odds of SGA for MW vs. GP patients, and 40% reduction in odds for MW vs. OB patients, because of the higher volume of GP patients, almost a quarter of all SGA cases (24%, n=978) may have been avoided had GP patients been cared for within the MW model of care, compared to a 7% (n=301) overall reduction in SGA birth if all OB patients had received MW care.

These findings may carry financial implications as reduced adverse infant birth outcomes mean fewer demands on the health care system (i.e. hospital stays, specialist visits) and a reduction in social costs (i.e. educational and community supports) associated with infant morbidity. As an illustration, the reported average Canadian hospital costs at birth for a “typical” full-term newborn in 2005/06 was \$1,011, compared to \$9,233 for a preterm infant who was not SGA.(24) Based on the preventative fraction, 1,215 PTBs could theoretically have been prevented during the seven year period of this study. Had these PTBs been avoided, greater than \$9,000,000 in hospital costs could have been saved, not accounting for reductions in hospital costs for infants who had both PTB and SGA or other co-morbidities.

In light of the reduced odds of SGA, PTB, and ELOS for patients receiving antenatal MW vs. GP or OB care, it is plausible that MW care better addressed the individual needs (medical, social, emotional, psychological, cultural, spiritual) and the structural forces (political, social, economic (340)) that contribute to increased risk of adverse infant birth outcomes for women of low SEP. In accordance with intersectionality theory, individual characteristics of disadvantage (i.e. poverty) in addition to structural factors such as social stigmatization can multiply rates of adverse outcomes when experienced simultaneously.(83, 86) For instance, for women of low SEP, substance use may exacerbate barriers to antenatal care and healthy behaviour and lifestyle choices.(86) Women using illicit substances during pregnancy may struggle with low self-esteem and feelings of worthlessness, a reflection of their stigmatized social position. Low self-esteem and social stigmatization may impede self-care and antenatal care utilization. Where these women may be devalued or excluded from society, the dignity and empowerment offered within the MW model may counteract structural barriers, helping to minimize unhealthy self-concepts, dispel expectations of clinician judgement, and thus lower the prevalence of high risk behaviours (i.e. self-medicating). The increased amount of time MWs spend with clients in the

context of a socially, emotionally, and practically supportive relationship could help in uncovering and mitigating some of the health risks associated with substance use such as food insecurity, housing vulnerability, or intimate partner violence, factors associated with poor birth outcomes.(341, 342) In addition, lower odds of adverse infant birth outcomes among patients receiving antenatal MW vs. OB care may reflect increased rates of referral to specialized services and monitoring of secondary issues associated with substance use, resulting in reduced amount and frequency of substance use for MW clients.

Substance using women of low SEP may have less knowledge and resources to sustain a healthy pregnancy, compared to those of low SEP and no other known vulnerabilities, therefore the extra educational and resource support MWs are able to offer may explain why substance using MW vs. OB patients had even lower odds of SGA, PTB, and ELOS than non-substance using women. Likewise, extended time for health and lifestyle counselling and clinical observation, coupled with higher prenatal care up-take, may have provided an effective platform for client disclosure, and increased the MWs' ability to detect symptoms associated with pregnancy complication, such as bacterial vaginosis, an established risk factor for PTB.(138)

For PTB, results of this study align with the results of two other MW/physician comparison studies. In a U.S. study (n=43,859) investigating infant birth outcomes for primarily low income women, 85% of whom were African American, Benatar et al. reported a PTB rate of 7.9% for MW clients vs. 11.0% for women receiving usual perinatal care.(257) This was equivalent to a 30% reduction in the odds of PTB, after adjustment for sociodemographic, medical, and health history characteristics (OR 0.70, p<0.01). Likewise, results from an Australian retrospective, hospital-based cohort study (n=1,908) in which young women ( $\leq 21$  years old) were allocated to caseload MW care or standard maternity care (fragmented, midwifery/obstetric care), showed that women receiving caseload MW care were 41% less likely to have PTB (6% vs. 11%, AOR 0.59, 95% CI: 0.38- 0.90).(343) Although the results of the Australian study are not directly comparable to a MW vs. physician study, they do support the hypothesis that the MW model of care is especially well suited to women with socioeconomic vulnerability compared to models of care that place less emphasis on women-centered care, clinician-client relationship, and client choice. Other MW/physician comparison studies for women of low SEP have also reported smaller rates of PTB for MW's clients compared to physician's patients,(258, 261) yet no other studies have reported statistically significant differences.(255, 258, 260, 261) These diverging



results are likely due, at least in part, to smaller sample sizes, samples comprised of unique populations, discrepancies between MW care models, and in some studies, weaknesses in methodology (see Chapter 3: A scoping review).

Clients receiving antenatal MW care were 15% less likely to deliver infants with Apgar scores less than seven at one minute (low Apgar score) compared to patients receiving antenatal care from GPs. Apgar score at one minute is an assessment tool that provides a snap-shot of an infant's physiological health immediately after birth.(344) At a population level, there are immediate and long-term consequences associated with low Apgar score, including neonatal death, and neurological and cognitive disability.(345-348) Low Apgar scores at one minute have been associated with adverse intrauterine conditions due to maternal lifestyle and/or high-risk behaviours (i.e. illicit drug use, smoking, obesity),(349-351) and intrapartum conditions (i.e. method of delivery, maternal sedation, trauma during delivery).(344) There is also an inverse relationship between gestational age and/or low birth weight and low Apgar score.(344) In light of the causes of low Apgar score, it is plausible that antenatal MW care reduced the odds of low Apgar scores associated with adverse antenatal conditions, but had no significant effect in minimizing low Apgar scores resulting from conditions related to labour and delivery. This could explain the small, yet significantly protective effect of MW vs. GP care for low Apgar score, if MWs' and GPs' patients had equivalent risk of low Apgar score associated with conditions of labour and delivery, but MWs were better able to address modifiable health and lifestyle conditions associated with low Apgar score.

For MWs' vs. OBs' patients there was no difference in odds of low Apgar score. Again, if antenatal MW care helped reduce the odds of low Apgar score associated with health or lifestyle conditions, but OB care reduced the odds of low Apgar score associated with high-risk deliveries, then the overall rate of low Apgar score could be comparable between the two cohorts. Future research investigating this hypothesis should examine antenatal model of care in relation to low Apgar score, stratified by risk status.

GP patients had a 20% increase in odds of having an infant with a low Apgar score compared to OB patients. When examining results stratified by characteristics of social vulnerability, (i.e. mental illness/disorder or women who had mental illness/disorder and were receiving social assistance), no vulnerabilities appeared to modify the relationship between MW vs. GP, or GP vs. OB antenatal care and low Apgar score. For MW vs. OB patients, the odds of

low Apgar score was 70% higher for teen mothers (OR 1.70, 95% CI: 0.95-3.06), although this was not statistically significant. In contrast, odds of low Apgar score were similar for older (24 to 29 years) MW vs. OB patients (OR 1.02, 95% CI: 0.81-1.27). The interaction term “model of care x maternal age” was non-significant (p=0.12). However, the sample size of MW and OB teen patients was small, as were the number of cases of low Apgar score (see Table 5.6), and there was inadequate power (< 80%,  $\alpha=0.05$ ) to test this association. Future research with a larger teen sample would help to clarify the relationship between MW vs. OB antenatal care and low Apgar score for teen mothers, and whether or not maternal age modified the association between MW vs. OB antenatal care and low Apgar score. In addition, both low Apgar score and ELOS are outcomes that are influenced by a combination of antenatal care and intrapartum conditions. Therefore, these outcomes provide a less precise measure of the relationship between antenatal model of care and poor infant birth outcomes than outcomes that are not associated with intrapartum conditions (i.e. SGA, PTB, LGA, or LBW).

Clients receiving antenatal MW care were less likely to have infants with extended length of hospital stay (ELOS), compared to patients receiving antenatal GP or OB care. Results for ELOS aligned with those observed for SGA, PTB and LBW which was not surprising as approximately 35% of the infants who had ELOS also had either SGA or PTB. In addition, over half of all LBW infants had ELOS. According to the Canadian Institute for Health Information, during the study period the costs incurred from admission to discharge for SGA, PTB and LBW infants ranged from an average of \$2,297 for a SGA infant to a high of \$16,244 for an average SGA infant with PTB (2005/06).<sup>(24)</sup> Thus a reduction in odds of newborn ELOS through the provision of antenatal MW care for women of low SEP may help in maximizing healthcare resources.

Odds of ELOS by antenatal model of care may have reflected severity of infant morbidity, but also may have been shaped by rural vs. urban hospital accessibility. For example, women travelling a long distance to deliver in a hospital may have had greater prevalence of newborn ELOS as infants with minor conditions could be kept longer for observation compared to infants with the same conditions born in high volume, urban hospitals. To control for these differences, rural/urban and northern residence were tested as confounders, and models adjusted for northern residence, but hospital-specific patterns of ELOS may still have influenced the analysis. In

addition, differences in *maternal* ELOS by model of care could have influenced odds of newborn ELOS, as infants are not usually discharged prior to their mothers.(24)

Approximately 15% of women using substances during pregnancy and 4% of women having alcohol use flagged as a risk during the antepartum period had infants with ELOS. For patients receiving antenatal MW vs. OB care there was a greater reduction in odds of ELOS for women who were substance using, or teen mothers and substance using. For women receiving antenatal GP vs. OB care there was a significant reduction in odds of ELOS for women with mental illness/disorder, or who were substance using, receiving social assistance, teen mothers and substance using, or had a combination of these vulnerabilities. The significant reductions in odds of ELOS for women with increased social vulnerability receiving antenatal care from MWs or GPs compared to OBs, suggest that OB care may not be the most appropriate model of care for women of low SEP with low medical/obstetric risk, but higher social risk. This demographic may benefit from a different type of antenatal care because their psychological and emotional healthcare needs may be considerably more pronounced than their physical needs. In instances where a woman with higher social vulnerability requires specialist care, a combined care model (MW and OB) may better provide the full spectrum of perinatal care required.

For all outcomes aside from ELOS, missing data was minimal (less than 0.5%). For ELOS, however, 25% of the MW cases were missing. This is likely due to a lack of data collection for “length of hospital stay” for home births in instances where MWs’ patients had no hospitalization. If this is the case, the actual percentage of MW cases with ELOS would be less than that reported in this study, potentially underestimating odds of ELOS for women receiving antenatal MW vs. physician care. In support of this explanation, between fiscal years 2005 to 2008, 24.63% of B.C. women with a MW involved in delivery intended to have a home birth.(322)

For antenatal MW clients, odds of LBW was reduced by 34% compared to GP patients and by 57% compared to OB patients. In a moderate quality retrospective cohort study (352) by Visintainer et al. (n= 41,223) a 41% reduction in risk of LBW was detected for women receiving enhanced care, which included antenatal care from a nurse-midwife, compared to usual care (mainly physician-led). However, this study failed to control for pre-existing health complications or perinatal risk which could have resulted in a healthier MW cohort as higher risk patients would more likely receive antenatal care from OBs, in turn influencing rates of LBW in

the “usual care” cohort. In six other midwifery–physician studies involving women of low SEP, findings favoured MW care, but were not statistically significant (see Chapter 3).(255, 257, 258, 261-263) In some instances, these studies failed to exclude high risk pregnancies and/or adequately control for moderate medical and obstetric conditions,(261, 263) or had inadequate power to detect differences in risk.(255, 261, 262) In contrast, in this study women were excluded if they had prior high risk medical and/or obstetric conditions and the model was adjusted to control for the confounding effect of obstetric risk. In addition, all of the main effects analyses in this study were adequately powered, evidence supporting the reliability of the results.

Of all of the adverse infant birth outcomes analyzed in the main models, only odds of LGA birth differed in direction from my initial hypothesis. Women receiving antenatal care from MWs had 46% higher odds of LGA birth while GP’s patients had 14% higher odds, compared to OB’s patients. When testing whether specific social vulnerabilities modified the relationship between model of care and LGA, it appeared that antenatal care supplied by MWs vs. OBs and GPs vs. OBs resulted in decreased odds of LGA if women were substance using, compared to non-substance using women. Substance using patients may have had lower odds of LGA than non-substance using patients because of the appetite suppressing effect of some illicit substances, (213, 214) lowering maternal weight gain, a known risk factor for LGA birth.(128)

Odds of LGA were higher for patients receiving antenatal care from GPs vs. OBs if the women resided in low/med. SEP neighbourhoods compared to high SEP neighbourhoods. Residence in a low/med. SEP neighbourhood may have contributed to the increased odds of LGA for these patients by influencing community norms and behaviours concerning BMI and food choices, such as minimizing social stigma concerning obesity (237) or normalizing unhealthy food consumption during pregnancy. Compared to high SEP neighbourhoods, low/med. SEP neighbourhoods may have had fewer recreational opportunities, increasing women’s risk of high BMI.(238) These results underscore the importance of acknowledging the influential effect of neighbourhood level risk on LGA birth and the need to address a broad spectrum of the social determinants of health in order to reduce infant health disparities.

When testing interactions between model of care and LGA stratified by multiple characteristics of vulnerability it became evident that the combination of mental illness/disorder and social assistance inflated odds of LGA for GP vs. OB patients. These covariates describe

“for whom” risk of LGA birth loomed the largest, and in part it appeared to be women who had an additional marker of poverty, namely receipt of social assistance. Both high pre-pregnancy BMI and excess weight gain during pregnancy are associated with LGA birth.(32, 125, 126) Poverty may contribute to the prevalence of LGA birth by causing food insecurity, which can fuel overconsumption due to uncertainty over future food availability.(353) Poverty further aggravates the effects of overconsumption when “low-cost, high-calorie, high-fat foods [are] more readily affordable”,(353, p61) and more accessible in low income neighbourhoods.(354)

Both high pre-pregnancy BMI and excess weight gain during pregnancy are common comorbidities of gestational diabetes, an independent risk factor for LGA birth.(128) In this analysis there was a notable discrepancy in prevalence of overweight or obesity based on pre-pregnancy BMI for MW and GP patients compared to OB patients (MW: 21.72%, GP: 21.34%, OB: 16.86%) (see Figure 5.18), although there was adjustment for this baseline difference in the analysis. Nonetheless, high pre-pregnancy BMI is associated with higher weight gain during pregnancy,(32) as was evident in this study where women whose BMI was either in the obese or overweight range were 1.9 to 2.1 times more likely to have gestational weight gain greater than the recommended amount, compared to women of normal pre-pregnancy BMI.

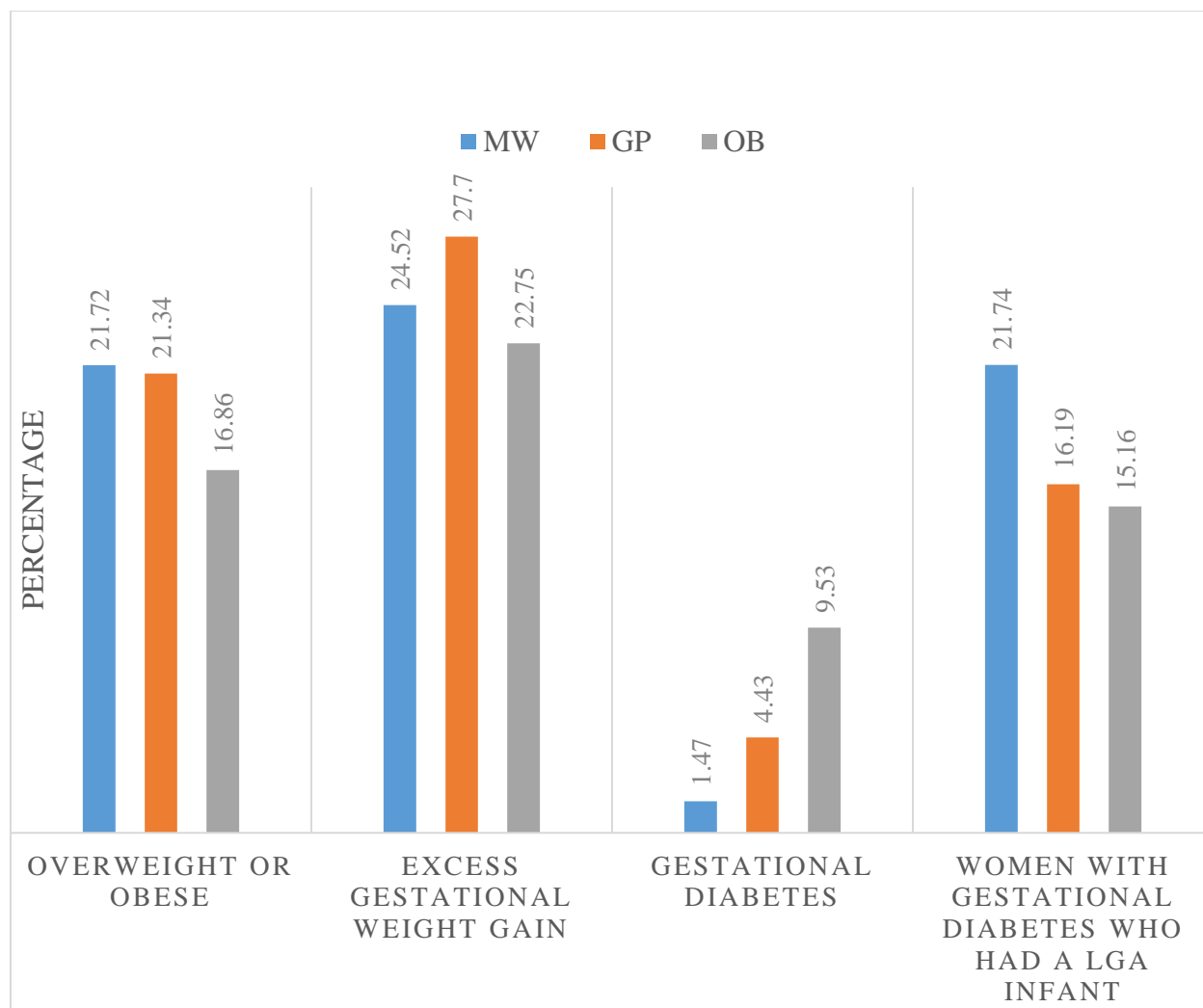


Figure 5.18: Risk Factors for Large-for-Gestational-Age Birth

Women gaining more than the recommended amount during pregnancy were 2.5 times more likely to have a LGA infant, compared to those gaining the recommended amount, and a greater proportion of women receiving antenatal MW or GP care had excess gestational weight gain (MW: 24.52%, GP: 27.70%, OB: 22.75%). Although increased odds of LGA for antenatal MWs' vs. OBs' patients were likely due, at least in part, to excess gestational weight gain, this cannot entirely explain the discrepancy in odds of LGA. For *every* category of gestational weight gain (less than recommended, as recommended, more than recommended, and unknown), antenatal MW care was associated with greater prevalence of LGA birth, compared to antenatal GP or OB care. Paradoxically, despite higher rates of overweight and obese pre-pregnancy BMI and excess weight gain amongst those receiving antenatal care from MWs vs. OBs, a gestational

diabetes diagnosis was most prevalent among OBs' patients (9.53%, GP: 4.43%, MW: 1.47%). However, only 15.16% of OB patients with gestational diabetes had a LGA birth compared to 21.74% of MW clients and 16.19% of GP patients. Of those patients with insulin dependent gestational diabetes, a smaller proportion of women receiving antenatal care from MWs (14.29%) had infants with LGA birth compared to those receiving antenatal care from GPs (20.86%) or OBs (20.16%). MW clients with non-insulin dependent gestational diabetes (a less severe and more common form of the disease), had the highest prevalence of LGA birth (22.58%) compared to GP (15.43%) or OB (13.93%) patients. These results suggest that women receiving antenatal OB care were better able to manage non-insulin dependent gestational diabetes compared to women receiving antenatal care from MWs, or only the most severe cases of gestational diabetes were diagnosed among MW clients, or a combination of these factors.

To further understand the association between model of care and LGA, future research is needed to explore 1) if women of higher BMI self-select for MW care and why; 2) why rates of gestational diabetes are lower among MW patients but odds of LGA birth for MW clients with gestational diabetes are higher; and, 3) why MW clients have higher odds of LGA birth than GP patients, although the prevalence of two major risk factors for LGA birth (excess gestational weight gain and gestational diabetes) are lower for MW clients.

Equally important is an analysis of birthing complications associated with LGA status by model of care. At birth, LGA status has been associated with increased risk of shoulder dystocia, clavicle fracture and brachial plexus nerve damage, trauma from instrumental delivery, caesarean delivery, and longer hospitalization,(355, 356) but these risks may not be equally prevalent by antenatal model of care. For example, in this study cesarean section delivery varied significantly by model of care for LGA infants. Just over 12% of the women receiving antenatal MW care, and having a LGA infant, delivered by cesarean section. In contrast, 28% of GP patients and 48% of OB patients delivering a LGA infant had a caesarean delivery. Aside from increased risk of complications associated with the birth process, LGA status has been associated with infant hypoglycemia,(355) and metabolic syndrome (obesity, hypertension, glucose intolerance or dyslipidemia) in later childhood,(357) indicative of long-term sequelae. This suggests future studies ought to investigate both birthing complications associated with LGA stature and long-term consequences, to understand if, to what degree, and by what means, LGA birth is an indicator of poor birth outcomes for patients receiving antenatal MW, GP, or OB care.

Although it is unknown why women of low SEP in the care of MWs were more likely to have an LGA birth compared to women in the care of GPs or OBs, a similar type of association has been previously reported. In a quantitative evaluation of the Canadian Prenatal Nutrition Program (CPNP) (n= 22,290), a service which provides health and social supports for pregnant women and new mothers with vulnerabilities, a similarly unexpected association was found.(358) Women having high exposure to the program's health and social supports, measured according to the timing of program initiation, intensity of contact with CPNP staff, and duration in the program, had higher odds of LGA birth (OR 1.22, 95% CI: 1.11-1.35). Moreover, a relationship was found between high program exposure and gestational weight gain greater than the recommended amount for certain groups of women (i.e. women with food insecurity, OR 1.18, 95% CI: 1.07-1.31; women with maternal age less than 19 years, OR 1.37, 95% CI: 1.13-1.65). Aside from LGA birth, all other maternal and infant outcomes were positively impacted by high program exposure, including: a reduction in SGA (AOR 0.89, 95%CI: 0.83-0.96), PTB (AOR 0.74,CI 95%: 0.65-0.83), and LBW (AOR 0.66, 95%CI: 0.56-0.72), and increased use of vitamin/mineral supplements, cessation of alcohol consumption, and reduced number of cigarettes women smoked, compared to women with low program exposure.(358) The results of the CPNP study coincide with the results of this cohort study, suggesting that there are some unidentified factors correlated with either a supportive prenatal care environment, and/or with the type of women seeking this care, that inflate the risk of LGA birth among women of low SEP.

No other midwifery-physician comparison studies involving women of low SEP, conducted in the last 25 years in high resources countries, have investigated LGA birth. Yet, a number of these studies have examined average birthweight and concluded that MW clients of low SEP have infants of significantly heavier average birth weight compared to physicians' patients, a seemingly positive outcome.(256, 257, 260) In light of the results of this study, it seems plausible that the average heavier birth weight among infants born to MWs' vs physicians' patients could be the result of a higher proportion of unmeasured LGA births, rather than heavier, healthy weight infants.



## **5.12 Conclusion**

In this chapter clients receiving antenatal MW care were shown to have reduced odds of SGA, PTB, ELLOS, and LBW compared to patients receiving antenatal GP and OB care. They also had less odds of Apgar score less than seven at one minute compared to GP patients, and equivalent odds compared to OB patients. Only for LGA birth did MWs' and GPs' patients have higher odds than OBs' patients. For all of the main effects that were found to have reduced odds for patients receiving antenatal MW vs. OB care, similarly significant yet attenuated associations were found for patients receiving antenatal GP vs. OB care.

**Appendix 5-A: Adjusted Odds Ratios Without Control for Smoking Status, Substance Use, Alcohol Use or Mental Illness/Disorder**

	<b>MW vs. GP OR (95% CI)</b>	<b>MW vs. OB OR (95% CI)</b>	<b>GP vs. OB OR (95% CI)</b>
<b>Small-for-gestational-age<sup>a</sup></b>	0.68 (0.59-0.78)	0.58 (0.50-0.68)	0.85 (0.78-0.94)
<b>Preterm birth<sup>b</sup></b>	0.72 (0.62-0.83)	0.53 (0.45-0.63)	0.74 (0.68-0.81)
<b>Large-for-gestational-age<sup>c</sup></b>	1.33 (1.22-1.46)	1.50 (1.34-1.68)	1.12 (1.04-1.22)
<b>Apgar &lt;7 at 1 minute<sup>d</sup></b>	0.87 (0.78-0.96)	1.07 (0.94-1.21)	1.23 (1.13-1.34)
<b>Newborn extended length of stay<sup>e</sup></b>	0.65 (0.57-0.74)	0.59 (0.51-0.68)	0.91 (0.85-0.99)
<b>Low birth weight<sup>f</sup></b>	0.62 (0.50-0.76)	0.43 (0.34-0.54)	0.70 (0.62-0.79)

<sup>a</sup> Model adjusted for maternal age, parity, pre-pregnancy BMI, infant sex, and local health area socioeconomic rank

<sup>b</sup> Model adjusted for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, infant sex, birth year, receipt of social assistance, neighbourhood SEP, local health area socioeconomic rank, local health area income inequality, and northern residence

<sup>c</sup> Model adjusted for maternal age, parity, medical risk, pre-pregnancy BMI, receipt of social assistance, neighbourhood SEP, urban residence, local health area socioeconomic rank, local health area income inequality, and northern residence

<sup>d</sup> Model adjusted for age, parity, pre-pregnancy BMI, infant sex, receipt of social assistance, birth year, urban residence, local health area socioeconomic rank, local health area income inequality, and northern residence

<sup>e</sup> Model adjusted for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, receipt of social assistance, birth year, infant sex, local health area socioeconomic rank, and northern residence

<sup>f</sup> Model adjusted for maternal age, parity, obstetric risk, pre-pregnancy BMI, and infant sex

## Appendix 5-B: Preventative Fraction Calculations

The estimate of the PF was manually calculated using the following formula:(286)

$$PF\% = \frac{(\text{Cumulative Incidence}_{\text{unexposed}} - \text{Cumulative Incidence}_{\text{exposed}}) * 100}{\text{Cumulative Incidence}_{\text{unexposed}}}$$

Where:

Cumulative Incidence<sub>unexposed</sub> = Incidence of outcome for GP or OB patients

Cumulative Incidence<sub>exposed</sub> = Incidence of outcome for MW patients

### 1) SGA

GP patients: PF= (7.15-4.98)/7.15= 0.3035\*100= 30.4%

30.4% x 3,217 GP cases of SGA/100= 978.0 cases prevented

OB patients: PF= (8.74-4.98)/8.74= 0.4302\*100= 43.0%

43.0% x 701 OB cases of SGA/100= 301.4 cases prevented

### 2) PTB

GP patients: PF= (6.35-4.42)/6.35= 0.3039\*100= 30.4%

30.4% x 2,860 GP cases of PTB/100=869.4 cases prevented

OB patients: PF= (8.72-4.42)/8.72= 0.4931\*100= 49.3%

49.3% x 701 OB cases of PTB/100= 345.6 cases prevented

### 3) Apgar < 7 at 1 minute

GP patients: PF= (12.38-10.07)/12.38= 0.1866\*100= 18.7%

18.7% x 5,569 GP cases of low Apgar/100= 1041.4 cases prevented

### 4) ELOS

GP patients: PF= (11.59-7.62)/11.59= 0.3425\*100= 34.3%

34.3% x 5,214 GP cases of ELOS/100= 1,788.4 cases prevented

OB patients: PF= (12.74-7.62)/12.74= 0.4019\*100= 40.2%

40.2% x 1,016 OB cases of ELOS/100= 408.4 cases prevented

### 5) LBW

GP patients: PF= (3.19-1.93)/3.19= 0.3950\*100= 39.5%

39.5 x 1,438 GP cases of LBW/100= 568.0 cases prevented

OB patients:  $PF = (4.88 - 1.93 / 4.88) = 0.6045 * 100 = 60.5\%$

$60.5\% \times 393 \text{ OB cases of LBW} / 100 = 237.8$

## **Chapter 6 Antenatal Midwifery Care and Adverse Infant Birth Outcomes Modified by Duration of Low SEP**

### **6.1 Introduction**

Maternal infant studies that incorporate time, using longitudinal approaches, allow for consideration of differing maternal life trajectories on infant birth outcomes.(238) Studies have detected subtle differences in infant birth outcomes for women of low socioeconomic position, depending on the static or dynamic nature of their SEP over time.(13, 341) In a study examining the association between a woman's SEP during childhood and her infant's birth weight, utilizing three generations of data collected over 25 years (n=987), researchers found that mothers with less than a high school diploma who had been raised in higher SEP families (their mothers had high school diplomas or more), had infants with heavier mean birth weights (adjusted mean difference 181g, 95% CI: 71-292) compared to woman who were raised in low SEP families.(359) These results demonstrate the effect childhood SEP can have on subsequent risk associated with low SEP in adulthood, in terms of healthier birth outcomes.

Higher risk of poor infant birth outcomes for women of chronic low SEP may be due to cumulative exposure to harmful psychosocial and lifestyle factors, taking a toll on general and reproductive health. The MW model of care may be especially beneficial for women of chronic low SEP who are presumably in the greatest need of intensive perinatal support. I hypothesized that compared to physicians' patients, MWs' clients with chronic low SEP would have significantly lower odds of adverse newborn outcomes vs. MWs' clients of transient low SEP. To test this hypothesis, I examined if the associations between antenatal model of care and SGA birth, PTB, LGA birth, Apgar score less than seven at one minute, newborn ELOS, or LBW, were modified by duration of low SEP (chronic vs. transient).

## **6.2 Methods**

The methods used for analysis and to determine both model of care and the primary and secondary outcomes are described in Chapter 4. The inclusion criteria used for this study was identical to that of the first cohort study except, as this was a longitudinal analysis, mothers had to have delivered multiple times during the study period and have had low socioeconomic position during at least one delivery year. Women who delivered multiple times during the study period and received MSP premium assistance during more than one delivery year were considered chronically low SEP. In contrast, women were deemed transient low SEP if they delivered multiple times during the study period but received premium subsidy assistance during only one delivery year (see Figure 6.1).

### 6.3 Results

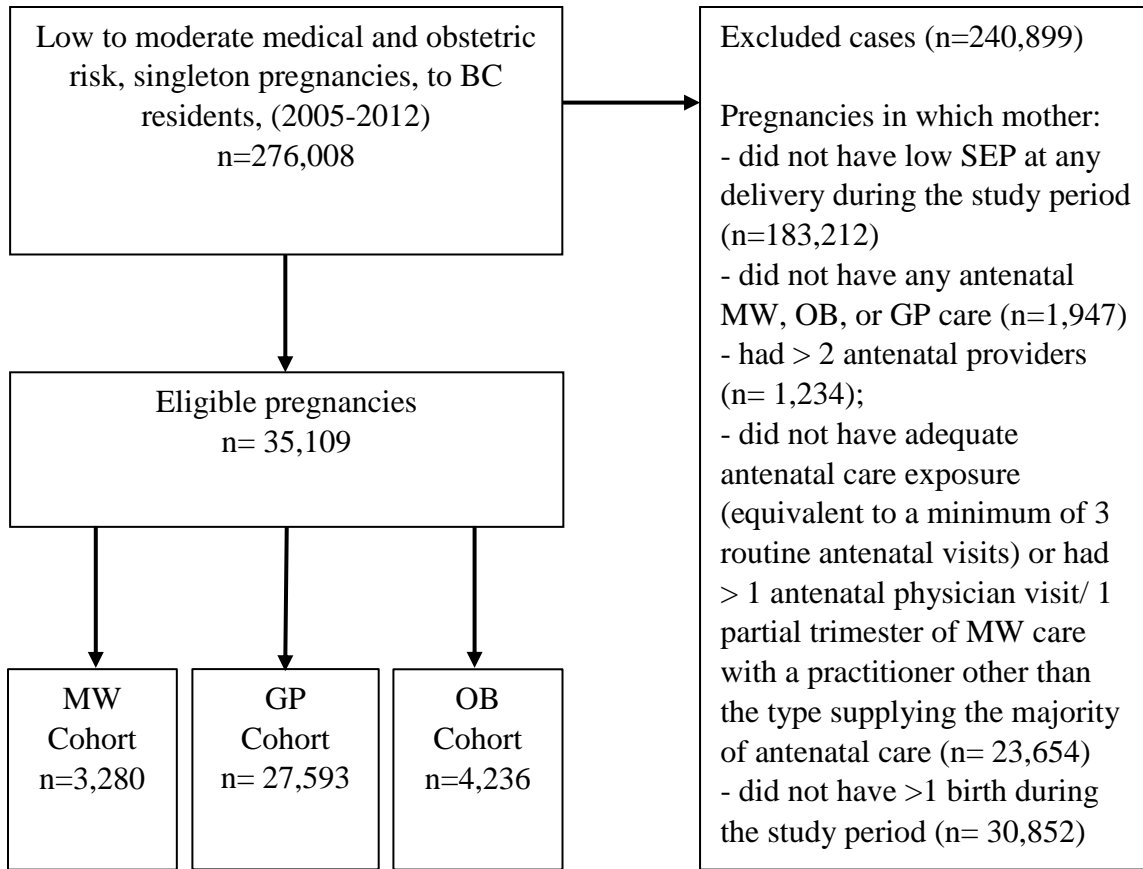


Figure 6.1: Study Three, Eligibility Flow Chart

In this sample (n=35,109) there were 21,042 infants born to mothers of chronic low SEP, compared to 14,067 infants born to mothers of transient low SEP. MW clients were somewhat more evenly split between chronic (56%) and transient (44%) low SEP than physicians' patients (see Table 6.1).

Table 6.1: Frequencies and Rates of Chronic and Transient Low SEP by Model of Care (n=35,109)

Duration of Low SEP	Antenatal Model of Care			Total n(%)
	MW n(%) 3,280 (9.34)	GP n(%) 27,593 (78.59)	OB n(%) 4,236 (12.07)	
<b>Chronic Low SEP<sup>a</sup></b>	1,827 (55.70)	16,684 (60.46)	2,531 (59.75)	21,042 (59.93)
<b>Transient Low SEP<sup>b</sup></b>	1,453 (44.30)	10,909 (39.54)	1,705 (40.25)	14,067 (40.07)

<sup>a</sup>Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year;  
<sup>b</sup>Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year



### 6.3.1 Small-for-Gestational-Age Birth

Table 6.2: Model of Care and Small-for-Gestational-Age Birth (n=35,109)

Small-for-Gestational-Age Birth						
	<b>MW</b> <b>n= 3,280</b>	<b>GP</b> <b>n= 27,593</b>	<b>OB</b> <b>n= 4,236</b>	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>Chronic<sup>a</sup></b>	64/1,824 (3.51)	1,088/16,628 (6.54)	186/2,525 (7.37)	0.59 (0.45-0.77)	0.54 (0.40-0.73)	0.92 (0.77-1.09)
<b>Transient<sup>b</sup></b>	60/1,450 (4.14)	639/10,878 (5.87)	126/1,700 (7.41)	0.78 (0.58-1.04)	0.64 (0.46-0.90)	0.83 (0.67-1.02)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 2,163 births with SGA and 35,005 total births with no missing information for this analysis						

For patients of chronic low SEP, antenatal MW vs. GP care greater diminished odds of SGA birth, compared to those of transient low SEP (chronic low SEP: OR 0.59, 95% CI: 0.45-0.77; transient low SEP: OR 0.78, 95% CI: 0.58-1.04) (see Table 6.2). Yet, the interaction term “model of care x duration of low SEP” was non-significant ( $p=0.14$ ) at a p-level of  $< 0.10$  for MW vs. GP care. Likewise, antenatal MW vs. OB care was associated with a greater reduction in odds of SGA birth (OR 0.54, 95% CI: 0.40-0.73) for women of chronic low SEP compared to women of transient low SEP (OR 0.64, 95% CI: 0.46-0.90). But again, the interaction term was non-significant, and there was no evidence of effect modification by duration of low SEP. For GP vs. OB antenatal care there was no significant reduction in risk of SGA birth by duration of low SEP (chronic: OR 0.92, 95% CI: 0.77-1.09; transient: OR 0.83, 95% CI: 0.67-1.02).

### 6.3.2 Preterm Birth

Table 6.3: Model of Care and Preterm Birth (n=35,109)

Preterm Birth						
	<b>MW</b> n= 3,280	<b>GP</b> n= 27,593	<b>OB</b> n= 4,236	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>Chronic<sup>a</sup></b>	88/1,827 (4.82)	1,088/16,650 (6.53)	221/2,527 (8.75)	0.81 (0.64-1.02)	0.56 (0.43-0.74)	0.70 (0.59-0.82)
<b>Transient<sup>b</sup></b>	41/1,453 (2.82)	615/10,891 (5.65)	122/1,703 (7.16)	0.51 (0.37-0.71)	0.39 (0.27-0.57)	0.77 (0.62-0.94)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 2,175 births with PTB and 35,051 total births with no missing information for this analysis						

There was no statistically significant difference in odds of PTB for women of chronic low SEP if they were receiving antenatal care from MWs vs. GPs (OR 0.81, 95% CI: 0.64-1.02) (see Table 6.3 and Figure 6.2). Yet, for MW vs. GP patients of transient low SEP there was a significant reduction in odds of PTB (OR 0.51, 95% CI: 0.37-0.71). Both the large discrepancy in effect estimates for women of chronic vs. transient low SEP and a significant interaction term for “model of care x duration of low SEP” ( $p=0.02$ ), indicated that duration of low SEP modified the relationship between antenatal MW vs. GP care and PTB.

For patients receiving antenatal MW vs. OB care there was a significant reduction in odds of PTB for patients of chronic low SEP (OR 0.56, 95% CI: 0.43-0.74). There was an even greater statistically significant reduction in odds of PTB for MW vs. OB patients of transient low SEP (OR 0.39, 95% CI: 0.27-0.57). However, the difference in odds between strata was not statistically significant, suggesting duration of low SEP did not have a modifying effect on MW vs. OB care and PTB. For those receiving antenatal GP vs. OB care, odds of PTB for women of chronic low SEP (OR 0.70, 95% CI: 0.59-0.82) were only slightly less than that of women with transient low SEP (OR 0.77, 95% CI: 0.62-0.94), therefore there was no indication of effect modification.

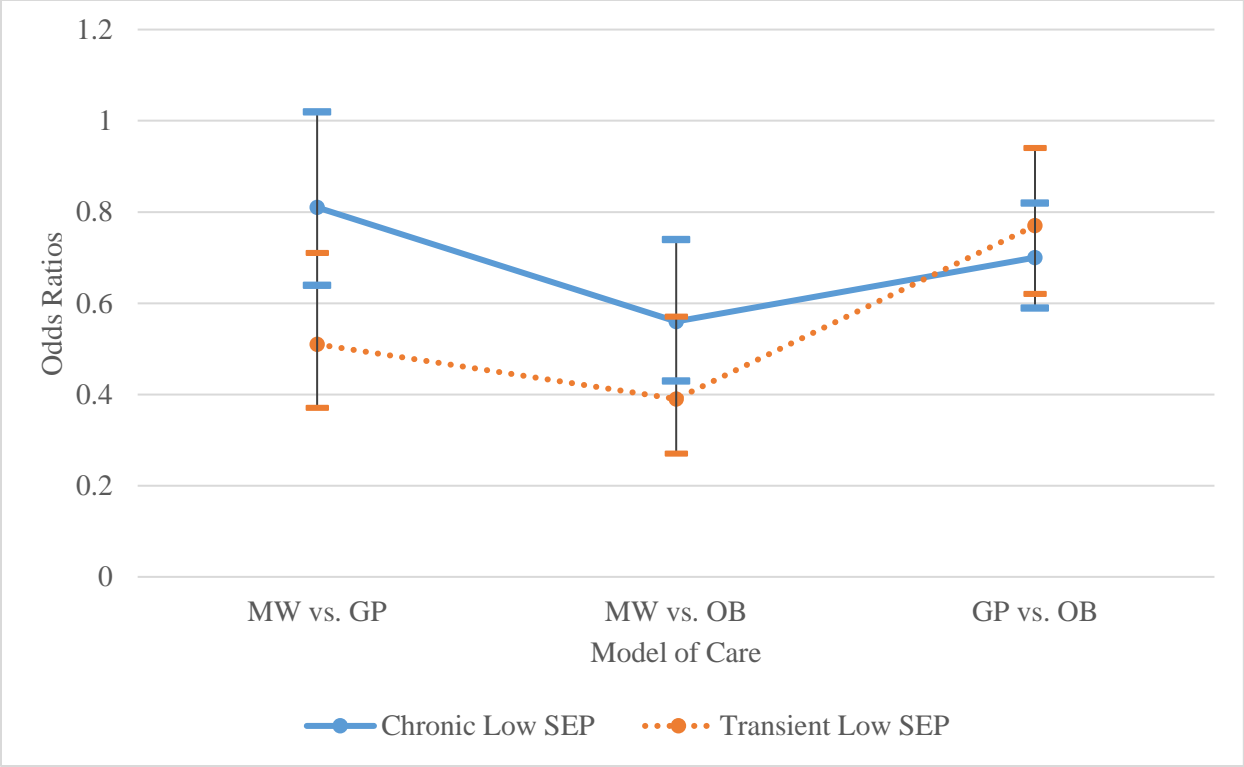


Figure 6.2: Odds and 95% CIs of Preterm Birth by Model of Care and Duration of Low SEP

### 6.3.3 Large-for-Gestational-Age-Birth

Table 6.4: Model of Care and Large-for-Gestational-Age Birth (n=35,109)

Large-for-Gestational-Age Birth						
	<b>MW</b> <b>n= 3,280</b>	<b>GP</b> <b>n= 27,593</b>	<b>OB</b> <b>n= 4,236</b>	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>Chronic<sup>a</sup></b>	300/1,824 (16.45)	2,223/16,628 (13.37)	280/2,525 (11.09)	1.26 (1.09-1.46)	1.52 (1.26-1.84)	1.20 (1.05-1.39)
<b>Transient<sup>b</sup></b>	250/1,450 (17.24)	1,421/10,878 (13.06)	178/1,700 (10.47)	1.30 (1.11-1.52)	1.60 (1.29-1.98)	1.23 (1.03-1.45)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 4,652 births with LGA and 35,005 total births with no missing information for this analysis						

MW vs. GP patients of chronic low SEP (OR 1.26, 95% CI: 1.09-1.46) and transient low SEP (OR 1.30, 95% CI: 1.11-1.52) had similar odds of LGA birth (see Table 6.4). Likewise, for MW vs. OB patients of both chronic low SEP (OR 1.52, 95% CI: 1.26-1.84) and transient low SEP (OR 1.60, 95% CI: 1.29-1.98) there were minimal differences in odds of LGA birth. GP vs. OB patients also had little difference in odds of LGA birth if they had chronic low SEP (OR 1.20, 95% CI: 1.05-1.39) or transient low SEP (OR 1.23, 95% CI: 1.03-1.45), therefore there was no evidence that model of care and LGA were modified by duration of low SEP.

### 6.3.4 Apgar Score Less Than Seven at One Minute

Table 6.5: Model of Care and Apgar Score Less Than Seven at One Minute (n=35,109)

Apgar Score Less Than Seven at One Minute						
	<b>MW</b> n= 3,280 (%)	<b>GP</b> n= 27,593 (%)	<b>OB</b> n= 4,236 (%)	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	n(%)	n(%)	n(%)	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>Chronic<sup>a</sup></b>	153/1,818 (8.42)	1,919/16,623 (11.54)	200/2,526 (7.92)	0.79 (0.66-0.94)	1.01 (0.81-1.27)	1.29 (1.10-1.51)
<b>Transient<sup>b</sup></b>	113/1,450 (7.79)	1,223/10,881 (11.24)	132/1,698 (7.77)	0.75 (0.61-0.93)	0.97 (0.74-1.27)	1.29 (1.06-1.57)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 3,740 births with Apgar score < 7 at 1 minute and 34,996 total births with no missing information for this analysis						



Duration of low SEP did not appear to modify the relationships between antenatal models of care and Apgar score less than seven at one minute (see Table 6.5). Odds of a low Apgar score were decreased for MW vs. GP patients whether they had chronic low SEP (OR 0.79, 95% CI: 0.66-0.94) or transient low SEP (OR 0.75, 95% CI: 0.61-0.93). Likewise there was little difference in odds for MWs' vs. OBs' patients if they had chronic low SEP (OR 1.01, 95% CI: 0.81-1.27) or transient low SEP (OR 0.97, 95% CI: 0.74-1.27). For GP vs. OB patients, odds of low Apgar score were identical for women of chronic low SEP (OR 1.29, 95% CI: 1.10-1.51) and those of transient low SEP (OR 1.29, 95% CI: 1.06-1.57), indicating duration of low SEP had no effect on the association between antenatal model of care and low Apgar score.

### 6.3.5 Newborn Extended Length of Hospital Stay

Table 6.6: Model of Care and Newborn Extended Length of Hospital Stay (n=35,109)

Extended Length of Hospital Stay						
	<b>MW</b> n= 3,280 (%)	<b>GP</b> n= 27,593 (%)	<b>OB</b> n= 4,236 (%)	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	n(%)	n(%)	n(%)	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>Chronic<sup>a</sup></b>	86/1,339 (6.42)	1,659/16,626 (9.98)	289/2,504 (11.54)	0.73 (0.58-0.93)	0.57 (0.44-0.75)	0.78 (0.68-0.91)
<b>Transient<sup>b</sup></b>	43/1,062 (4.05)	896/10,879 (8.24)	165/1,694 (9.74)	0.54 (0.39-0.75)	0.44 (0.31-0.63)	0.81 (0.68-0.97)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 3,138 births with extended length of hospital stay and 34,104 total births with no missing information for this analysis						

For MW vs. GP patients, there was a greater reduction in the odds of newborn ELOS for women of transient low SEP (OR 0.54, 95% CI: 0.39-0.75) than for women of chronic low SEP (OR 0.73, 95% CI: 0.58-0.93) (see Table 6.6). Likewise, for MW vs. OB patients odds of ELOS were reduced to a greater extent for women of transient low SEP (OR 0.44, 95% CI: 0.31-0.63) than for women of chronic low SEP (OR 0.57, 95% CI: 0.44-0.75). The opposite pattern was apparent among GP vs. OB patients, where women of transient low SEP had smaller reductions in odds of ELOS (OR 0.81, 95% CI: 0.68-0.97) than women of chronic low SEP (OR 0.78, 95% CI: 0.68-0.91). Yet, as the differences in stratified odds ratios for ELOS were minimal for all comparisons, and none of the interaction terms for “model of care x duration of low SEP” were statistically significant, there was no evidence that duration of low SEP significantly modified the relationship between antenatal model of care and newborn ELOS.

### 6.3.6 Low Birth Weight

Table 6.7: Model of Care and Low Birth Weight (n=35,109)

Low Birth Weight						
	<b>MW</b> n= 3,280 (%)	<b>GP</b> n= 27,593 (%)	<b>OB</b> n= 4,236 (%)	<b>MW vs. GP</b>	<b>MW vs. OB</b>	<b>GP vs. OB</b>
	n(%)	n(%)	n(%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Chronic<sup>a</sup></b>	30/1,819 (1.65)	507/16,628 (3.05)	123/2,504 (4.91)	0.66 (0.46-0.96)	0.37 (0.24-0.56)	0.56 (0.45-0.69)
<b>Transient<sup>b</sup></b>	16/1,448 (1.10)	280/10,883 (2.57)	71/1,694 (4.19)	0.51 (0.30-0.86)	0.29 (0.16-0.52)	0.58 (0.44-0.76)
<sup>a</sup> Chronic low SEP: delivered > 1 infant during the study period and had MSP premium assistance during more than 1 delivery year <sup>b</sup> Transient low SEP: delivered > 1 infant during the study period and had MSP premium assistance during only 1 delivery year Model adjusted for maternal age, parity, pre-pregnancy BMI, birth year, infant sex, smoking status, substance use, mental illness/disorder, local health area socioeconomic rank, northern residence, and family and community level correlation Odds ratios based on 1,027 births with LBW and 34,976 total births with no missing information for this analysis						

For women of transient low SEP, antenatal MW vs. GP care was associated with lower odds of LBW (OR 0.51, 95% CI: 0.30-0.86) than that experienced by women of chronic low SEP (0.66, 95% CI: 0.46-0.96) (see Table 6.7). The same pattern was evident among patients receiving antenatal MW vs. OB care, in which woman of transient low SEP had lower odds of LBW (OR 0.29, 95% CI: 0.16-0.52) than women of chronic low SEP (OR 0.37, 95% CI: 0.24-0.56). The opposite pattern emerged for GP vs. OB patients, in which women of transient low SEP had slightly greater odds of LBW (OR 0.58, 95% CI: 0.44-0.76) than women of chronic low SEP (OR 0.56, 95% CI: 0.45-0.69). However, as the differences in odds ratios between strata were small for all of the associations investigated, and there were no statistically significant interaction terms, duration of low SEP did not appear to modify the association between antenatal model of care and LBW.

#### **6.4 Discussion**

For this study, I hypothesized that women of chronic low SEP receiving antenatal MW vs. physician care would have greater reductions in odds of adverse infant birth outcomes than MW vs. physician patients of transient low SEP. Results did not support my hypothesis, rather they indicated that duration of low SEP did not modify the relationship between MW vs. GP or OB care and SGA, LGA, Apgar score less than seven at one minute, newborn ELOS, or LBW at a statistically significant level. There was also little evidence of effect modification for GP vs. OB patients. However, differences were apparent in odds of PTB for antenatal MW vs. GP patients of chronic vs. transient low SEP. Whereas MW clients of chronic low SEP did not have a significant reduction in odds of PTB compared to GP patients, MW clients of transient low SEP were significantly less likely to have a PTB compared to GP patients.

These results suggest that 1) there are differences in pathology linking chronic vs. transient low SEP to PTB, and 2) that the MW model of care may be better able to mitigate the risks associated with transient low SEP than chronic low SEP for PTB. If women deemed “chronic low SEP” were more likely to have experienced low SEP throughout childhood and adolescence, then the cumulative effects of physical, developmental and emotional risk across the life-course may not have been modifiable via antenatal care, regardless of the type of model. Also, residual effects of intergenerational low SEP may have been more prevalent among women of chronic low SEP, and less amendable to MW care than risks attributable to transient low SEP. For

example, maternal exposure to adverse conditions *in utero* are thought to permanently modify biological systems, causing increased risk of cardiovascular disease,(360) hypertension,(361) diabetes,(362) and obesity,(363) risk factors associated with adverse infant birth outcomes. An “early programming” hypothesis, suggests biological systems are modified by maternal stress *in utero*, inducing higher stress reactivity and inflammatory dysregulation in a developing fetus, characteristics that can lead to increased risk of PTB and LBW in successive generations.(238) In support of this theory, studies have demonstrated that a significant association exists between low *maternal* birth weight and infant LBW and PTB.(364, 365) If women of chronic low SEP were more likely to have been exposed to adverse intergenerational effects, incurring epigenetic modification, then that may explain why the more relationally intensive services available in MW care did not appear to have a sufficient effect in reducing the risk of PTB for women of chronic low SEP.

Of interest, the opposite relationship between chronic and transient low SEP was observed when analyzing model of care on SGA modified by duration of low SEP. The odds of SGA for patients receiving antenatal MW vs. physician care were reduced to a greater extent for women of chronic low SEP (MW vs. GP: OR 0.59, 95% CI: 0.45-0.77; MW vs. OB: OR 0.54, 95% CI: 0.40-0.73) than for women of transient low SEP (MW vs. GP: 0.78, 95% CI: 0.58-1.04; MW vs. OB: OR 0.64, 95% CI: 0.46-0.90), although the interaction terms for “model of care x duration of low SEP” were non-significant. These results align with my initial hypothesis, which held that women of chronic low SEP would benefit to a greater extent from the comprehensive, individualized services of midwives compared to women of transient low SEP, because of their need for more intensive services. These findings suggest different mechanisms may be involved in reducing risk of SGA, compared to PTB, by model of care. For instance, depending on severity, food insecurity could have had a greater impact on the risk of SGA than PTB. Food insecurity is likely more common among women of chronic low SEP and is a modifiable risk factor MWs could address as part of their holistic model of care.

This was an exploratory analysis, the first of its kind, examining duration of low SEP as a modifier in the relationship between antenatal model of care and adverse infant birth outcomes. Results of this study will help in delineating the bounds within which the MW model of care can improve infant birth outcomes, compared to physician models of care. A strength of this analysis was the use of a longitudinal measure for low SEP, as it accounts for the dynamic nature

of income and is a more accurate indicator of low SEP than a measure taken at a single point in pregnancy. Classifying low SEP as chronic vs. transient also allowed for a measure of low SEP severity, permitting a more nuanced analysis of the data.

## **6.5 Conclusion**

The associations between antenatal model of care and SGA, LGA, Apgar score less than seven at one minute, newborn ELOS, and LBW were not significantly modified by duration of low SEP. There was a statistically significant reduction in odds of PTB for patients of transient low SEP receiving antenatal care from MWs vs. GPs, but no significant effect for antenatal MW vs. GP patients of chronic low SEP. This suggests that mechanisms linking low SEP to PTB may differ for women of chronic vs. transient low SEP, and the MW model of care may be most effective in addressing the risk factors associated with transient low SEP. Having identified a group of women that appear to have especially benefited from MW care, it is important to understand why this association exists so that results can be generalized to other low SEP populations. Further research is needed to delineate how risk factors of PTB differ for women of chronic vs. transient low SEP, and which aspects of MW care are related to diminished risk.

## Chapter 7 General Discussion and Conclusions

### 7.1 Introduction

The primary purpose of this thesis was to determine if antenatal midwifery care was associated with reduced odds of adverse newborn outcomes for women of low SEP with low to moderate medical and obstetric risk. To accomplish this, I began with a scoping review of the literature from high resource countries over the last 25 years. Results from the scoping review showed that MW clients of low SEP, or subgroups within the population, had lower risk of low birth weight, very low birth weight, and preterm birth, as well as an increase in mean birth weight by 43g to 191g. However, some of these studies failed to control for medical and obstetric risk, had no minimum level of antenatal care exposure, were inadequately powered, or were investigating enhanced care models that included MW care alongside other interventions, making it impossible to assess the effects of antenatal MW care alone.

To address these shortcomings I designed a population-level, retrospective cohort study to compare odds of SGA, PTB, LGA birth, Apgar score less than seven at one minute, newborn ELOS, and LBW among women of low SEP who had received antenatal care predominantly from MWs vs. GPs or OBs. I excluded higher risk patients to create cohorts with similar perinatal risk, and further controlled for confounders at an individual-level (including moderate medical and obstetric risk), and at a community-level. Pregnancies were only included for women who had one practitioner-type delivering the majority of antenatal care and no more than one antenatal visit (or one partial trimester of midwifery care) with another practitioner-type, to reduce the risk of mixed-care cases nullifying differences in effect between models of care. In addition, all patients had to have had a minimum quantity of antenatal care exposure (equivalent to three antenatal visits), and the main effects analyses were adequately powered to detect clinically meaningful differences.



Odds of SGA birth, PTB, newborn ELOS and LBW were significantly reduced for women receiving antenatal MW vs. GP care, and antenatal MW vs. OB care. Odds of low Apgar score were reduced for recipients of antenatal MW vs. GP care, but no significant difference in odds was detected for those receiving antenatal MW vs. OB care. The odds of LGA birth was higher for those either in the care of MWs vs. GPs, or for those in the care of MWs vs. OBs. When examining if woman of low SEP with additional vulnerabilities (i.e. substance use, mental illness) had even lower odds of adverse infant birth outcomes if receiving antenatal care from MWs vs. physicians, it was apparent that odds of SGA were reduced further for MWs' vs. GPs' patients who were substance using, and for MWs' vs. OBs' patients who were substance using, or substance using and had mental health conditions. Likewise, odds of preterm birth were greater reduced for substance using patients receiving antenatal MW vs. OB care. Odds of ELOS were also less for MWs' vs. OBs' antenatal patients who were substance using, or were teen mothers and substance using.

Results of the third study indicated duration of low SEP had a significant, modifying effect on antenatal MW vs. GP care for PTB. There was a significant reduction in odds of PTB for MWs' vs. GPs' patients of transient low SEP, but no statistically significant difference in odds of PTB for women of chronic low SEP. Aside from this, there was no evidence suggesting that duration of low SEP modified the association between model of care and any of the other adverse infant birth outcomes investigated.

Results from the two cohort studies provide evidence supporting the value of antenatal midwifery care for low SEP populations with low to moderate medical and obstetric risk. Furthermore, they identify specific types of women who appear to especially benefit from the MW model of care, namely women of low SEP living with concomitant mental health conditions and/or substance use, substance using teens, and women of transient low SEP.

## **7.2 Interpreting the Results**

Discrepancies in prevalence of poor newborn outcomes between MWs', GPs', and OBs' patients appear to be due to differing antenatal models of practice. The approach to antenatal care employed by midwives, which includes long appointment times and 24 hour telephone access to a known MW throughout the perinatal period, a meaningful clinician-client relationship, maternal choice, and client capacity-building (i.e. self-confidence in decision

making) may have influenced women's modifiable health and lifestyle conditions, in turn reducing odds of adverse infant birth outcomes. In the first cohort study MW clients were 2.3 times more likely than GP patients to adequately utilize antenatal care, and 2.5 times more likely than OB patients. Results from a 2015 qualitative, systematic scoping review investigating aspects of antenatal care which women named as the most important components in supporting a positive pregnancy experience, identified the need for integration of "local practices and knowledge" in the delivery of antenatal care, and the provision of "social, cultural, emotional, [and] psychological support", as well as relevant information, supplied in a timely manner.(366, p533)

Congruency between what women value in antenatal care and MW philosophy and practice may explain why MW clients in these cohort studies were more likely to access care early, or more frequently than physicians' patients. Moreover, women of low SEP are more likely than other women to report perceived disrespect from their caregiver,(60, 367) lack of autonomy in decision-making,(61, 367, 368) and less satisfaction with maternity care,(368, 369) suggesting relational deficits between perinatal clinicians and patients of low SEP may hinder antenatal care utilization, compared to women of higher SEP.(38, 220) Inadequate antenatal care utilization may impede the effectiveness of preventative care and inflate rates of infant morbidity, as adequate antenatal care has been shown to protect against low birth weight, PTB, stillbirth, and neonatal and infant death.(110, 370)

Unsatisfactory clinician-patient relationships may also inhibit adherence to clinical advice, compared to woman with more satisfactory care,(221) and impact patient disclosure of compromising health conditions,(343, 371) reducing the opportunity for comprehensive care. For MW clients there was some evidence of greater disclosure of high risk behaviours/conditions, compared to GP or OB patients. Most notably, proportions of mental illness/disorder diagnosis were highest both overall and in every available category (i.e. depression, anxiety, bipolar disorder) for MW vs. GP or OB patients. MW patients were 3.4 times as likely as OB patients to have a previous or current mental illness/disorder diagnosis and 2.2 times as likely as GP patients. When examining depression by model of care, the percentage of midwifery patients afflicted was much closer to average antenatal depression rates reported in the literature than that reported by OBs' or GPs' patients. In a review of 16 studies on antenatal depression (n=35,419) researchers reported a mean rate of 17.2%, with the risk of depression

higher for women with low education and/or unemployment, markers of low SEP.(372) Yet, in the first cohort study in this thesis the proportion of depressed OB patients, during the period in which data on depression were collected (2009-2012), was only 7.42% compared to 12.76% for GP patients and 18.84% for MW clients. This discrepancy likely reflects greater disclosure and/or time for clinical observation within the MW model of care.

In a recent systematic review and meta-analysis (n= 25,663; 23 *studies*) examining birth outcomes for women with untreated antenatal depression vs. no depression, results indicated an increase in the odds of LBW (OR 1.96, 95%CI: 1.24-3.10) and PTB (OR 1.56, 95% CI: 1.24-3.10) for women with untreated depression.(373) Although there are conflicting results concerning the association between anti-depressant medication use during pregnancy and adverse infant birth outcomes, a variety of non-pharmaceutical interventions (integrated behavioural therapy, yoga, massage, programming to promote the transition to parenthood) have been shown to reduce depression and improve infant birth outcomes, including prevalence of LBW and PTB.(374-377) If greater disclosure of mental health issues amongst MW clients increased the likelihood of referral to specialized services, this may partly explain why MW patients had reduced odds of adverse infant birth outcomes.

Greater disclosure of sensitive information among women receiving care within the MW model, compared to other models of care, have been noted in other MW comparison studies. An Australian MW cohort study (n=1,908) examining maternal and infant outcomes reported that young women in a caseload MW cohort (similar to the Canadian MW model of care) were significantly (p<0.01) more likely to report a history of mental illness, illicit drug use, and involvement with the Department of Child Safety, than those receiving standard (fragmented MW/OB) maternity care.(343) Likewise, in a small retrospective cohort study (n=194) conducted in the U.K. researchers examined birth outcomes by caseload MW care to standard maternity care for women experiencing “domestic violence, homelessness, mental health issues, substance and/or alcohol abuse, seeking asylum or refugee status, learning and/or physical disabilities, safeguarding issues, or women living within the travelling community<sup>8</sup>”.(371, p411) Women in the caseload MW cohort were statistically significantly more likely to receive a referral to psychiatric care and/or domestic violence or other support services, possibly indicative

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<sup>8</sup> The authors use the Oxford English Dictionary, 2014 definition of “travelling community”: “A group of people who hold New Age values and lead itinerant and unconventional lifestyles”.

of higher rates of disclosure among MW clients. Of note, in both of these studies participants in the caseload MW cohorts had either a higher mean number of antenatal appointments,(371) or a lower percentage of inadequate prenatal utilization of care (< 5 visits),(343) which would have increased clinician-client familiarity, a factor that has also been shown to influence domestic abuse disclosure.(378)

In the first cohort study odds of antepartum morbidity, a factor strongly associated with adverse infant birth outcomes,(108, 114, 138, 139) were lower for MWs' vs. physicians' patients, providing another clue as to the mechanisms linking MW care to reduced odds of poor newborn outcomes. MW vs. GP patients were 55% less likely to have antepartum morbidity (see definition in Appendix 7-A), and MW vs. OB patients were 75% less likely. Longer appointment times and a holistic understanding of the clients' needs, may have made it possible for MWs to identify pre-morbid conditions (i.e. borderline hypertension or anemia) early, and implement preventative measures before conditions progressed to antepartum morbidity. Additionally, the MW model encourages MWs to be emotionally "present", (379, p25) taking time to offer "nearness and availability in both an emotional and physical sense".(380, p13) Emotional engagement fosters a relational connection and information sharing,(223) which may have enabled MWs to better address the full spectrum of the determinants of health. MW care could have also directly reduced antepartum morbidity by minimizing stress, a correlate of hypertension and preeclampsia,(139) via the emotional and social support offered.

Furthermore, the MW model allows women to maintain "agency", described as the autonomy and empowerment that exist when women are able to retain control as the primary-decision makers in their care.(379, p26) MW care may have indirectly reduced the odds of antepartum morbidity by facilitating a sense of ownership over pregnancy, health, and lifestyle choices, and imbuing a sense of self-efficacy—the belief that one has the ability to effect personal change or reach goals.(222, 226) For marginalized women, control and respect have been identified as factors minimizing the power inequalities of gender, class, and social position.(367) Thus midwifery's woman-centered model which encourages informed choice (34) and has high client ratings for respectful care,(60) may have reduced the prevalence of antepartum morbidity by minimizing the prominence of social hierarchy in the patient-practitioner relationship, in turn encouraging patient engagement.(381) Patient engagement could have provided opportunities for health and lifestyle education and counselling, increasing

motivation for self-care (i.e. consumption of a nutritious diet, vitamin supplementation, fewer number of cigarettes smoked).

Alternately, the lower odds of antenatal morbidity among MWs' vs. physicians' patients could have been the result of residual confounding. If for example, women self-selected antenatal OB care because of prior health conditions (i.e. gestational diabetes in a previous pregnancy which required specialized care), which were not documented in the BCPDR, then the OB cohort would be comprised of systematically higher-risk patients due to self-selection bias. To investigate this issue, after building the final models I controlled for selected antepartum morbidities (see Appendix 7-A). The associations between model of care and SGA, and model of care and PTB, were somewhat attenuated but remained statistically significant (see Appendix 7-A). This supports the claim that the observed associations were not an artefact of unaccounted baseline differences in health status between cohorts.

Among the three models of care, the greatest discrepancies in odds of adverse infant birth outcomes were between MWs' vs. OBs' patients. If the value of the antenatal MW model of care for this low SEP population lay in the opportunity it afforded for individualized education and promotion of healthy lifestyle choices, preventative healthcare, emotional support, client capacity-building, and the development of a trusting clinician-client relationship, then it is not surprising that there was a smaller difference in outcomes between MWs' vs. GPs' patients compared to MWs' vs. OBs' patients. Patients cared for by GPs were likely to have had regular contact over time with their GP prior to pregnancy, therefore some aspects of the clinician-patient relationship (i.e. level of disclosure of personal information) would more closely resemble that of a MW-client relationship than that experienced by an OB patient. In practice, antenatal MW and GP models of care may have had greater overlap than MW and OB antenatal care, though heterogeneity in care practices within models of care are to be expected.

## **7.3 Limitations of the Research**

### **7.3.1 Data Availability**

This study was limited by an observational design; therefore it cannot establish a causal relationship between model of care and adverse infant birth outcomes. Until women are willing

to be randomly assigned to MW vs. physician-led care, evidence for causality will need to be established by repeated observational studies with representative samples over time.

Secondly, this study was subject to data limitations. Low SEP was defined in this study on the basis of low household income, but there were no robust, individual measures of low SEP available (i.e. education or occupation). Household income based on income tax records (MSP premium assistance was assessed using annual income tax data) does not account for accumulated wealth (i.e. home ownership) which can affect SEP. To counter these limitations I conducted stratified analyses using other indicators of SEP (receipt of social assistance and neighbourhood SEP) and found, for some outcomes (PTB, LGA, ELOS), these additional markers of low SEP increased the magnitude of the associations which had been detected in the main models.

I did not have access to data on race/ethnicity and thus could not assess whether confounding by race/ethnicity may have influenced the findings. Women who were Status Indians were excluded and therefore study findings are not generalizable to Status women. In addition, despite access to eight years of data, sample sizes for groups stratified by characteristics of vulnerability were small so I did not have adequate power to test some categories of vulnerability, or interaction terms in the logistic models. For example, specific mental health conditions could not be assessed.

Because the measure of chronic and transient low SEP was defined by household income during the year of delivery, women who were chronically low SEP but did not deliver more than one infant during the study period were excluded from the analysis. A longitudinal measure of income that did not depend on repeat deliveries would have permitted a larger sample size.

### **7.3.2 Validity of Self-Reported Data**

Studies examining the validity of self-reported smoking, alcohol and illegal substance use during pregnancy indicate that under-reporting may routinely underestimate quantity of fetal exposure.(382-385) In a population-based study (n=793), prevalence of maternally reported fetal alcohol exposure (FAE), measured with the *Parkyn Screening Tool* was compared with prevalence of FAE detected from anonymous meconium samples tested for fatty acid ethyl esters, a validated FAE biomarker.(386) There was a fivefold increase in prevalence of FAE

when measured by the biomarker compared to the self-reported data (2.5% vs. 0.5%,  $p < 0.001$ ) indicating a serious discrepancy between the two measures.

There are, however, a number of factors that improve the validity and reliability of self-reported behavior in pregnancy including: the type of questionnaire or screen used to determine the factor of interest,(387) the duration since last use of the substance in question,(388) the number of times a practitioner questions a patient,(389) the level of patient-practitioner trust,(382) and the perceived “costs” incurred by disclosing information.(383) These factors may differ between practitioner-types and between individual providers. For the studies included in this thesis there was no information in the data regarding the techniques used to ascertain self-reported data, therefore this is a notable limitation.

### **7.3.3 Data Accuracy by Practitioner-Type**

There is some evidence that there may be differences in charting practices between practitioner-types, potentially introducing measurement error into MW/physician comparison studies. In a U.S. retrospective cohort study ( $n=2,699$ ) investigating the accuracy of birth certificate data and hospital discharge data completed by certified nurse midwives (CNMs) and OBs or GPs, researchers found that CNMs were significantly more accurate in medical charting.(390) An examination of birth certificate data, compared to hospital medical records—considered the gold standard—revealed significantly greater accuracy in recording of pregnancy induced hypertension (True Positive Rate (TPR): 73.3% vs. 37.2%,  $p < 0.001$ ), premature rupture of membranes (TPR: 56.0% vs. 26.1%,  $p=0.002$ ), labour augmentation (TPR: 50.7% vs. 30.5%,  $p=0.001$ ) and labour induction (TPR: 67.7% vs. 49.7%,  $p < 0.001$ ), for CNMs versus physicians. The researchers cited longer clinician-client exposure, lower patient risk, and lower patient volume as possible explanations for these differences. In the data used for my studies there was no measure of data accuracy by model of care, although OBs did have the most missing data for “pre-pregnancy BMI”, “smoking status”, “utilization of prenatal care” and “weight gain during pregnancy” compared to MW or GP patients. If MWs’ and GPs’ more accurately reported risk factors such as pregnancy induced hypertension, which was controlled for in the analysis, then odds of adverse infant birth outcomes could be inflated for OB patients.

#### **7.3.4 Self-Selection Bias**

An often cited limitation of midwifery vs. physician studies pertains to the potential for self-selection bias if health attitudes, beliefs, and values systematically differ amongst patients, according to practitioner-type. In B.C. women utilizing midwifery care may need to be more pro-active in ascertaining services because of the extra effort required to secure a midwife in a climate with fewer practicing registered midwives (230 as of 2015),(391) particularly in rural areas, compared to other perinatal practitioners. In light of this barrier, it is plausible that women who secure midwifery care are more invested in their health, have more knowledge about the health care system, and/or have greater ability to pursue preferred health care services. Although there were no data pertaining to choice of antenatal care provider for these studies, I did control for smoking, alcohol, substance use, and pre-pregnancy BMI, which are health behaviours/conditions that may reflect women's attitudes, beliefs, and values.

#### **7.4 Strengths of the Research**

To my knowledge, this is the first large-scale, population-level, observational MW/physician comparison study for women of low SEP. It is also the only study examining the association between model of care and adverse infant birth outcomes in light of multiple, intersecting positions of vulnerability. This study provides a method for ascertaining exposure to antenatal model of care according to prenatal billing data, useful for future MW/physician comparison studies. In addition, ascertainment of exposure was based on the equivalent of a minimum of three antenatal visits and no more than one routine antenatal visit with a second-type of practitioner (or one partial trimester of MW care). This definition for exposure to model of care ensured that there were few instances where a women had two provider-types involved in care, minimizing the risk of misclassification. I addressed a limitation of published studies to date by using GEE logistic regression modelling to control for correlation in outcomes due to women giving birth more than once during the study period, and for community-level correlation influencing birth outcomes.

A comprehensive collection of covariates were investigated as potential confounders, including area-level factors such as income inequality, which are rarely included in perinatal studies. Of the observational studies in the scoping review, only the studies by Simonet et al. and Benatar et al. controlled for community level factors including community size, community-



level random effects,(261) and unobserved individual/community risk factors (measured by distance between residence and the birth center).(257) Testing a wide range of potential confounders, both those at an individual and community-level, strengthened the quality of the study as differences in risk of adverse infant birth outcomes between cohorts, independent of model of care, were minimized.

For the cohort studies a broad range of outcomes were examined, more than any other study included in the scoping review. In the scoping review studies, authors did not investigate SGA, but rather investigated LBW and very LBW.(259, 262) By examining LBW and SGA birth I was able to compare my results with the LBW studies and explore the effect of model of care on birthweight, adjusted by gestational age, a more informative indicator of pathology. Likewise, a number of previous MW/physician comparison studies for women of low SEP have examined average birthweight (256, 257, 260) but no studies have examined LGA birth. By including this outcome I was able to uncover a novel association between model of care and LGA birth and these results may explain the previous reports of heavier average infant birth weights for MW vs. physician patients.

Findings from this study further our understanding of best-practices in perinatal care for women of low SEP. The association between antenatal MW care and reduced adverse infant birth outcomes suggest that there are principles of care that could be adopted by other maternity practitioners to improve birth outcomes and inequity in outcomes among vulnerable women and infants. Findings also indicate that the care MWs are currently offering is critical in maintaining the health of physically healthy, but socially high risk populations.

## **7.5 Conclusions**

The consistent, significant reduction in odds of adverse infant birth outcomes for MW clients vs. GP and OB patients demonstrated in this B.C. study, highlights the potential impact of MW care on women of low SEP in Canada and other high resource countries. This study reveals a significant proportion of infant morbidity and the related direct (i.e. hospital costs) and indirect (i.e. lost employment, quality of life) costs, may be avoidable were the MW model of care utilized to a greater extent by women of low SEP. Furthermore there were significant, yet smaller reductions in odds of adverse infant birth outcomes for GPs' vs. OBs' patients. In many instances, these reduced odds could be attributed to GP patients who had low SEP and additional

vulnerabilities (i.e. substance use and mental illness/disorder). Only MW care appeared to be effective in reducing odds of adverse newborn outcomes for women of low SEP, both with and without other socially vulnerable identities. Change in physician practice to align more closely with the MW model of care may improve infant outcomes.

### **7.5.1 Policy Implications**

Provincial healthcare policy that supports access to MW care for women of low SEP should address the current unmet demand for MW care.(392) Likewise, there is a need to ensure MW care is equitably accessible particularly in low socioeconomic regions. If current inequity in infant birth outcomes are to be addressed via the provision of MW care for women of low SEP, it is imperative that the public is made aware of the availability of MW care, how it can be accessed, the equivalency in outcomes compared to physician-led care, and, in most provinces, that it is fully covered under provincial medical plans. Midwifery uptake in Canada is directly correlated with SEP (measured by level of education), with more highly educated women more frequently using MW services;(393) a lack of public awareness of MW care among women of low SEP is likely perpetuating this inequity in uptake.(394) In addition, decision-makers should consider policy which increases availability of MW services for targeted sub-groups of vulnerable women, as in Saskatchewan where salaried MWs are encouraged to save spots in their caseloads for “priority populations”, those who are under 21 years old, experiencing poverty, living in social isolation, using substances during pregnancy, or living with domestic violence.(395) Policy should also be created to incentivize outreach by MWs to women with concurrent vulnerabilities. In Ontario additional remuneration is available for midwives conducting outreach and supplying services to “special populations”, women requiring more time than average clients, including teen mothers and low income women.(392) This could include substance using women and those with mental health conditions, or a combination of risk factors. Results of this study suggest prioritization of policy that supports the National Aboriginal Council of Midwives vision, to have Aboriginal MWs working in every community,(396) as Aboriginal women have more than twice the rate of poverty than non-Aboriginal women.(397) Support for this vision could address a significant nation-wide gap in maternal infant health equity.

### **7.5.2 Future Research**

Various attributes of antenatal MW care were suspected to mediate the relationship between model of care and adverse infant birth outcomes for vulnerable women. Future studies should employ qualitative, observational, and survey methods to test, by model of care, components of care and qualities of the caregiver mediating the relationships apparent in these studies. Examining patients' perception of their antenatal caregiver using scoring indexes such as the "Mothers on Respect index"(60) or "The Mothers' Autonomy in Decision-Making scale"(61) which include patients' assessments of their caregivers' involvement in decision making, respectfulness, cultural sensitivity, as well as overall patient satisfaction in care and duration of practitioner-patient contact, would help in explaining why differences in poor birth outcomes exist between models of care for women of low SEP. Furthermore, future studies should describe and quantify the content of antenatal care, continuity in care provider, referral to support services (i.e. psychological, addictions, social services), patients' adherence to clinical advice, perceptions of caregivers' trustworthiness and ability to provide emotional support, and capture changes in high risk behavior over the course of pregnancy by model of care.

In addition, studies should examine sub-populations other than those identified here, to determine factors that render women especially responsive to MW care. Qualitative methods that glean insight from women's and practitioners' perspectives, and ethnographic studies which allow for observation of clinician-patient interaction, would be valuable in exploring why women of low SEP do or do not access MW care and what characteristics of MW care they feel confer the greatest benefits.

In this thesis I have provided evidence of an association between antenatal MW care and reduced odds of adverse infant birth outcomes for women of low SEP and low medical and obstetric risk, compared to GP and OB care. These findings suggest MW care should be equally available and accessible to all women in B.C. and Canada, using intensive outreach to women of low SEP if necessary, in order to promote the highest level of health for all infants.

**Appendix 7-A: Adjusted Odds Ratios With and Without Control for Antepartum Morbidity**

<b>Antenatal Model</b>	<b>Without Controlling for Antepartum Morbidity OR (95% CI)</b>	<b>Controlling for Antepartum Morbidity OR (95% CI)</b>
<b>Small-for-Gestational-Age Birth (&lt; 10<sup>th</sup> percentile)<sup>a</sup></b>		
<b>MW vs. GP</b>	0.73 (0.63-0.84)	0.79 (0.69-0.91)
<b>MW vs. OB</b>	0.60 (0.51-0.70)	0.69 (0.59-0.81)
<b>GP vs. OB</b>	0.82 (0.75-0.90)	0.87 (0.79-0.95)
<b>Preterm Birth (&lt; 37 weeks gestation)<sup>b</sup></b>		
<b>MW vs. GP</b>	0.74 (0.63-0.86)	0.80 (0.69-0.93)
<b>MW vs. OB</b>	0.53 (0.45-0.62)	0.60 (0.51-0.71)
<b>GP vs. OB</b>	0.72 (0.65-0.79)	0.75 (0.69-0.83)
<sup>a</sup> Model adjusted for maternal age, parity, pre-pregnancy BMI, infant sex, smoking status, substance use, mental illness/disorder, and local health area socioeconomic rank. <sup>b</sup> Model adjusted for maternal age, parity, medical risk, obstetric risk, pre-pregnancy BMI, infant sex, birth year, receipt of social assistance, smoking status, substance use, alcohol use identified as a risk, mental illness/disorder, neighbourhood SEP, local health area socioeconomic rank, local health area income inequality, and northern residence.		

**Antepartum morbidity:** a composite variable comprised of pregnancy induced hypertension, gestational diabetes either insulin dependent or non-insulin dependent, anemia, intrauterine growth restriction, viral disease, infection and parasitic disease, placenta previa without hemorrhage, polyhydramnios or oligohydramnios, antepartum hemorrhage  $\geq$  20 weeks, sexually transmitted infection, or HIV, or premature separation of the placenta

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