Evaluation of dietary intervention and pregnancy outcomes among food insecure women attending the Montreal Diet Dispensary program

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ABSTRACT

Since 1950, the Montreal Diet Dispensary has been aiming to reduce health inequalities among pregnant women with low socio-economic status through a nutritional support program called the Higgins' intervention. In the past, the intervention was shown to be successful in reducing the rate of low-birth weight (LBW) as well as preterm births (PTB). The objective of this thesis was to conduct an outcome evaluation of the Higgins' intervention in a changing demographic population predominantly composed of visible minority and newly immigrated women. The program evaluation was done using an electronic database established in June 2013 where 1387 pregnancies were analyzed. The rate of LBW was 4.18% (95% confidence interval (CI): 3.13, 5.24), small-for-gestational age (SGA) 5.47% (95%CI: 4.28, 6.68) and PTB was 4.76% (95%CI: 3.64, 5.88). The prevalence of these outcomes were considered significantly lower than the Canadian statistics as all CIs did not overlap. Large-for-gestational age rate was 10.60% (95%CI: 8.98, 12.22) which was significantly higher than Montreal but similar to the Canadian rate. Prevalence of maternal outcomes were 17.15% (95%CI: 15.05, 19.25) for gestational diabetes (GDM), anemia was 44.88% (95%CI: 41.90, 47.86) and hypertension (HTN) was 3.82% (95%CI: 2.81, 4.83). Immigrants had similar odds of developing adverse perinatal outcomes as Canadian-born women. Black women were more at risk of having a PTB (adjusted odd ratio (aOR)=1.79, 95%CI: 1.01, 3.19) with African women mostly contributing to the increased risk (aOR=2.67, 95%CI: 1.44, 4.9). Anemia prevalence was also significantly higher in Black women compared to White (aOR=1.74, 95%CI: 1.29, 2.35). Anemia rates were higher among immigrants who were in Canada for more than 5 years (5-10 y aOR=1.99, 95%CI: 1.05, 3.78; > 10 y aOR=2.01, 95%CI: 1.01, 3.99) compared to Canadian-born. Asian women had an increased risk of having a SGA infant (aOR=2.35, 95%CI: 1.21, 4.56;) and GDM (aOR=1.86, 95%CI:

1.17, 2.98) compared to White women. This risk was particularly higher among women from South Asia who had 2.88-times the risk of developing GDM (2.88, 95%CI: 1.03, 8.07) compared to North Americans. The Higgins' intervention supported infant health as evidenced by lower infant complications, but disparities in birth outcomes were still present in this high risk population. As evidenced by high prevalence rates, the late nutritional intervention did not contribute to the prevention of anemia and GDM. Earlier nutritional intervention, prioritization of high risk groups of women and adaptation of the intervention would be needed to further reduce outcomes discrepancies among this vulnerable population.

RÉSUMÉ

La recherche en santé périnatale a su démontrer que les femmes enceintes en situation de précarité financière vivent des inégalités pouvant mener à des issues de grossesse défavorables. Depuis 1950, le Dispensaire diététique de Montréal œuvre à réduire ces disparités par le biais d'une intervention nutritionnelle ayant déjà démontré son efficacité à réduire la prévalence des bébés de petits poids à la naissance (BPPN) ainsi que la prématurité. L'objectif de cette étude est d'évaluer la méthode Higgins' dans un contexte où la population est principalement composée de femmes provenant des minorités visibles et de nouvelles immigrantes. L'évaluation a été complétée en utilisant une base de données électronique établie au Dispensaire depuis 2013. L'analyse de 1387 grossesses a révélé que le taux de BPPN était de 4.18% (95% Intervalle de confiance (IC): 3.13, 5.24), de faible poids pour l'âge gestationnel (FPAG) de 5.47% (95%IC: 4.28, 6.68) et le taux de prématurité de 4.76% (95%IC: 3.64, 5.88). Ces taux étaient tous significativement plus bas que la prévalence dans la population du Québec et du Canada. Le taux de bébé de poids de naissance élevé (BPNE) était de 10.60% (95%IC: 8.98, 12.22), ce qui est semblable au taux canadien mais significativement plus élevé que celui de Montréal. Les issues de grossesse maternelles étaient de 17.15% (95%IC: 15.05, 19.25) pour le diabète gestationnel (DBG), 44.88% (95%IC: 41.90, 47.86) pour le taux d'anémie et 3.82% (95%IC: 2.81, 4.83) pour l'hypertension. Les immigrantes ont eu un risque semblable d'issues néfastes de grossesse que les femmes nées au Canada. Les femmes noires étaient plus à risque d'avoir un bébé prématuré (OR=1.79, 95%IC: 1.01, 3.19) alors que les asiatiques avaient un risque plus élevé d'avoir un bébé de FPAG (OR=2.35, 95%IC: 1.21, 4.57) et avaient un plus grand risque de développer le DBG que les blanches (aOR=1.86, 95%IC: 1.17, 2.98). Les femmes noires (aOR=1.74, 95%IC: 1.29, 2.35), et plus spécifiquement celles nées en Afrique (aOR=2.67, 95%IC: 1.44, 4.90), avaient un risque élevé de souffrir d'anémie pendant la grossesse comparées aux femmes blanches. Le taux d'anémie était plus élevé chez les immigrantes qui étaient au Canada pour plus de 5 ans comparé aux femmes nées au Canada (5-10 ans aOR=1.99, 95%IC: 1.05, 3.78; > 10 ans aOR=2.01, 95%IC: 1.01, 3.99). L'intervention nutritionnelle semble avoir aider à préserver une meilleure santé infantile et maternelle puisque la prévalence des issues de grossesse infantile était généralement moins élevée que la moyenne nationale. Toutefois, des disparités entre les ethnies sont encore présentes dans cette population à haut risque. Afin de réduire les différences observées entre les immigrants ainsi que les minorités visibles, l'intervention nutritionnelle doit d'abord prioriser et s'ajuster à ces femmes à haut risque.

AUTHORS' CONTRIBUTIONS

V. Menard was the primary author as well as the primary investigator of this research. She was responsible for data extraction, cleaning and coding. She conducted and interpreted statistical analysis, reviewed relevant literature and drafted the manuscript of this thesis.

H. A. Weiler was the supervisor of V. Menard during her Master's program. She supervised and guided the student through all the steps of the realization of the project.

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ABBREVIATIONS

ACOG	American Congress of Obstetricians and Gynecologists
AGA	Appropriate size for gestational age
BMI	Body mass index
CIHI	Canadian Institute for Health Information
ELBW	Extremely low birth weight, < 1000 g
EPTB	Extremely preterm birth, < 28 weeks gestation
GA	Gestational age
GDM	Gestational diabetes mellitus
IUGR	Intrauterine growth restriction
LBW	Low birth weight, < 2500 g
LES	Low socioeconomic status
LGA	Large-for-gestational age, > 90^{th} percentile per sex
PTB	Preterm birth, < 37 weeks of gestation
SGA	Small-for-gestational age, < 10^{th} percentile per sex
SIDS	Sudden infant death syndrome
SOGC	Society of Obstetricians and Gynaecologists of Canada
VLBW	Very low birth weight, < 1500 g
VPTB	Very preterm birth, 28-32 weeks gestation

1.0 LITERATURE REVIEW

1.1 INTRODUCTION

Thirteen perinatal health priority indicators have been identified by the Canadian Perinatal Surveillance System (CPSS) as key for maternal, fetal and infant health. Preterm birth (PTB), small-for-gestational age (SGA), large-for-gestational age (LGA) and severe maternal morbidity (e.g., eclampsia) are among the serious health outcomes needing prevention. In addition to being at an increased risk of chronic health conditions, such as type 2 diabetes and hypertension (1), infants born at a low-birth weight (LBW) or prematurely put higher costs on the healthcare system throughout their lives than infants that are born of normal weight or at term(2; 3; 4). Related costs represent about 43% of all infant hospitalization and 27% of all costs associated with the pediatric age group in the USA (5).

Socio-economic disparities in birth outcomes are one of the most persistent findings in perinatal research. Poverty leads to adverse living conditions such as poor housing and nutrition, and is thus one of the major factors affecting pregnancy outcomes (6). For more than the last 60 years, the Montreal Diet Dispensary has been a model in prenatal nutrition with its primary mission to improve pregnancy outcomes of low-income pregnant women. The unique intervention used, called the Higgins' method, showed its effectiveness to reduce the incidence of LBW and premature infants in 1989 (7) in the low-income population within Montreal. However, an important shift in the population of Montreal may have changed the needs of the low-income population. Canada has the highest proportion of immigrants from all G8 countries with an estimation of 20.6% of its population in 2011. With 91% of the immigrant population living in urban areas, it has influenced Montreal's population (8) with a doubling in the proportion of immigrants to 33% [9] compared to 16% in 1986 in the metropolitan region [10]. Recent immigrants are 2.5 times more likely to have lower income [11] and thus are more at risk of poor pregnancy outcomes. Immigrants may be at higher risk of certain adverse pregnancy outcomes, either genetically or as a consequence of adverse lifestyles habits. These outcomes may be different from the ones that have been targeted at the inception of the program. For example, immigrants may have different eating pattern than Canadian-born women which may put them at risk of certain deficiencies or even overconsumption of certain foods or nutrients. This change makes it urgent to re-evaluate the dietary intervention program to better suit this new population and prevent adverse pregnancy outcomes.

1.2 BIRTH OUTCOMES

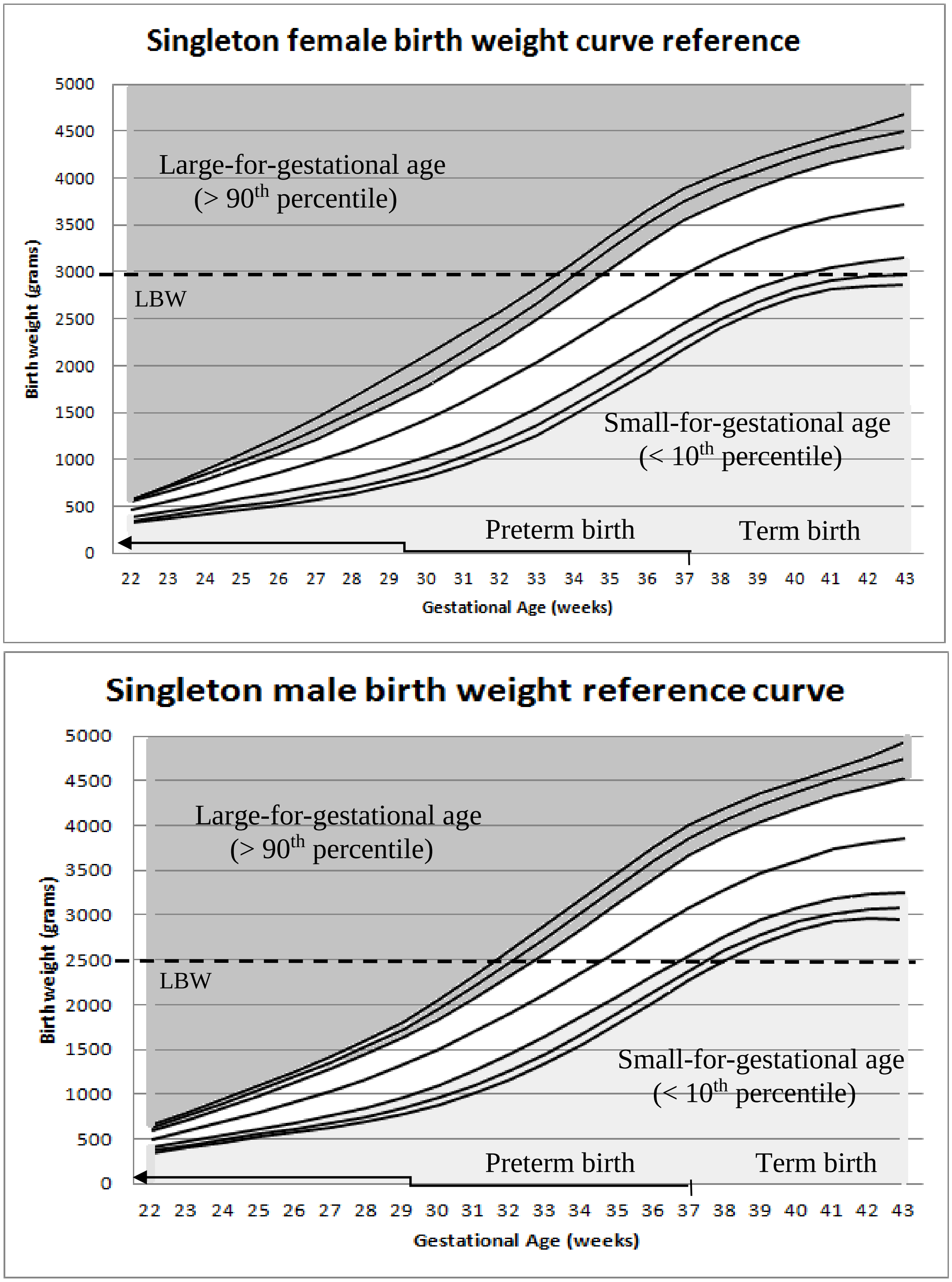
Adverse pregnancy outcomes, such as SGA, LGA or PTB, increase the risk of morbidity and mortality for both mothers and infants. Understanding predisposing factors is key in reducing the incidence of these outcomes, their associated costs and is necessary to improve prenatal care practices.

1.2.1 Birth weight: small-for-gestational age and low-birth weight infants

1.2.1.1 Definition

After centuries of research, birth weight has clearly been identified as an indicator of perinatal health. In fact, mean population birth weight is a strong predictor for infant mortality [12]. Although extensive research has been done on the consequences of being born small, terminology to assess birth weight is inconsistent [13]. Infants can be classified as LBW (< 2500 g at birth) or SGA (< 10th birth weight percentile at birth) depending on their weight and if gestational age is used or known. LBW infants are typically the result of a PTB or SGA, but not all SGA are premature and not all premature infants are SGA (Figure 1). LBW has been used

Figure 1: Birth weights and gestational age definitions [(14)]



previously to assess newborn health risks, but is not as precise as the SGA classification which takes into account gestational age at birth. In 2005-2006 in Canada, 96% of LBW (but not SGA) were preterm compared to only 25% of SGA infants [15]. Another term, IUGR, is used when estimated fetal weight is below the 10th percentile during pregnancy or with abdominal circumference < 10th percentile on the basis of ultrasound measures. While the Society of Obstetricians and Gynaecologists of Canada (SOGC) state that being SGA may not necessarily imply developmental issues, IUGR may have long lasting consequences [1; 16; 17].

1.2.1.2 Consequences

In the short term, SGA infants are more at risk of suffering from postpartum complications than those of healthy weights. They are predisposed to hypoglycemia, jaundice, hypothermia, necrotizing enterocolitis, respiratory distress syndrome (odd ratio (OR)=1.09, 95%CI: 1.02, 1.16) [18] and sepsis soon after birth [13]. SGA born infants also have a higher risk of premature mortality (OR=1.91, 95%CI: 1.66, 2.18) [18]. The "developmental origins of adult disease" theory supports that fetal growth is greatly influenced by the intrauterine environment and especially exposure within the nutrition context [19]. Undernourished fetuses have the ability to adapt to a poor nutrient environment for better survival by what is called developmental plasticity [19]. It has been hypothesized that in a nutritionally poor milieu, the nutrient supply to the brain and heart are prioritized (for survival purposes) at the expense of other organs such as the pancreas and liver [17] which are left with potentially fewer numbers of cells [19], explaining poor glucose metabolism and impaired cholesterol metabolism [1] later in life. A U-shaped relationship has been observed between extreme birth weights and the prevalence of type 2 diabetes mellitus. In animal models, fetal protein undernutrition leads to 33% reduction in the number of nephrons which could contribute to hypertension later on [1; 16]. Effects of the intrauterine environment influences growth and development differently depending on the events at conception and by events after birth (ex., childhood weight gain, living conditions as adult life) [19]. Brain development and capacity seem to be affected on the long term for very-low-birth weight (VLBW) infants. Cognitive deficits seen by academic underachievement and grade failures have been observed with greater severity in the smallest birth weight groups [20]. Growth restricted infants may have lifelong health consequences impairing many aspects of their life and so prevention is crucial.

1.2.1.3 Prevalence of LBW and SGA among demographic groups

The rate of LBW infants in Canada was 6.1% in 2010 [21] while the SGA rate was 8.3% in 2012 [22]. Using these examples, SGA captures more small infants, especially those born early and so SGA is the recommended condition to be used in this thesis research. Factors contributing to SGA include both physiological and social factors. Better contraception education, birth planning, more time spent in post-secondary education and an increase of the presence of women in the workforce have led to having children much later in reproductive life [23]; conceiving later implies an increase in certain risks. Being older than 40 years at conception increases the risk of having a LBW infant by about 1.50 to 3.33 [24; 25] compared with women between 20-40 y. An overall disadvantaged in the reproductive health has been observed: older women are less fertile, are at higher risk of gestational diabetes (GDM), gestational hypertension (HTN) and placental dysfunction which all may predispose to adverse pregnancy outcomes such as LBW [25]. Paternal age may also be associated with an increased risk of LBW, but the underlying mechanism still needs to be elucidated [26]. Maternal education is also a predictor for adverse pregnancy outcomes. Poor education significantly increases the risk of SGA (OR=1.86, 95%CI: 1.82, 1.91) [27] compared with more educated women (< 11 y vs. > 14 y education) by affecting health care services knowledge and by decreasing the potential of generating revenues which affects many environmental aspects such as shelter and proper diet [28].

Owing to the important linkages between size at birth and infant health, public assistance and health programs have evolved. In Canada, every citizen and permanent resident has access to a free health care system [29] and to income assistance in case of financial struggling after 3 months of residency [30]. Families receiving this allowance barely cover basic needs and this situation increases the risk of LBW by 1.8 (95%CI: 1.35, 2.42) compared to families with other income sources [24]. Similarly, mothers in the lowest neighborhood income quintile in Quebec (who were more likely to be single, < 20 years of age and to be less educated (< 11 years)) were 1.18 times more likely to have a SGA infant (aOR=1.18, 95%CI: 1.15, 1.21) [27]. Many hypotheses on the association for low socio-economic status and higher risk for SGA were proposed, but it is complex and influenced by many individual and external factors. Food insecurity, which is often associated with poverty [31], may be part of the answer with an increase of the risk for LBW (OR=3.2, 95%CI: 1.2, 7.9) [32]. Food insecurity has also been linked to obesity and higher gestational weight gain, increasing the risk of further pregnancy complications [31].

1.2.1.4 Physiological causes

Gestational growth delays are caused either by maternal or fetal/placental factors. Inadequate nutrition, adolescent pregnancy, chronic diseases, birth order, vaginal infections and genetic factors are the main maternal causes reported [13; 33]. Multiple pregnancy as well as prior stillbirths (OR=3.99, 95%CI: 2.74-5.80) [24] are known to be predictors of an increased risk of SGA and LBW infants. Severe pre-gestational diabetes increases the risk of having a SGA infant. Substance abuse such as cocaine, alcohol and tobacco can also decrease fetal growth [13;

33)]. Health issues could also explain growth restricted infants: about 2.7% of IUGR infants could be explained by severe anemia (hemoglobin < 9 g/L) and/or by insufficient maternal pregravid weight (BMI< 19.8 kg/m^2) [(34)].

At the placental level, insufficiency or umbilical cord abnormalities may cause fetal growth restriction by limiting delivery of nutrients and oxygen to the fetus [(13)]. The use of assisted conception, which may be an indication of poor uterine environment, increases the risk of IUGR in the third trimester [(35)] as well as LBW (RR=1.60; 95%CI: 1.29, 1.98) [(36)]. A range of 10-25% of all IUGR cases [(34; 37)] are a consequence of pre-eclampsia while about 13% would be secondary to gestational hypertension [(34)]. Affecting about 3 to 5% of all pregnancies, the causes of pre-eclampsia are not yet known, but it seems clear that poor placentation is a predisposing factor rather than the cause of it [(37; 38)]. Obesity, primiparity and the presence of chronic diseases are all factors that at least double the risk of having an SGA infant while a past history of preeclampsia increases more than 12-fold the risk of recidivism (aOR=12.7, 95% CI: 10.0, 16.2) [(34)]. Calcium supplementation of > 1 g per day has been shown to reduce the incidence of pre-eclampsia by 64% (average RR=0.36, 95%CI: 0.20, 0.65) in women consuming prior low calcium diets [(39)], which is often the case in low-income populations. Supplementation in high risk population may be an option to decrease maternal and infant morbidity and mortality related to hypertensive disorders during pregnancy.

1.2.1.5 LBW – Canada compared to other countries

According to the recent report of the Organization for Economic Co-operation and Development (OECD) [(40)], Canada experienced a 13% increase in the number of LBW births between 1990 and 2011 while the average was 22% for the 34 member countries of OECD (which were mostly well developed). Canada's LBW rate in 2011 was 6.11%. Higher worldwide LBW rates are partly attributable to an increased used of fertility treatment, which is known to increase the risk of PTB [36; 41] and LBW infants [36], with an increase in average maternal age at conception [40]. Birth weight disparity among different ethnicities had been reported in many studies, but has not been well documented in Canada. In 2014 in the USA, 12.8 % of LBW births were from Black women while only 7.0 % were from White women. While some studies suggest that the difference between ethnicities is related to socioeconomic status, others claim that genetics would be the main cause [41].

1.2.2 Birth weight: large-for-gestational age

1.2.2.1 Definition and consequences

A consistent definition of LGA is not evident throughout literature. While the SOGC uses the 90^{th} percentile to classify LGA infants, it has been discussed that the use of 97^{th} would better represent the cut-off that relates to increased health risks associated with larger birth weight [42]. The American Congress of Obstetricians and Gynecologists (ACOG) uses their macrosomia definition to classify large infants with 4000 g or 4500 g at birth independently of gestation age, but specify that cohort studies support the use of the 4500 g as the best measurement to use [43]. Many others suggest that LGA classification is the most appropriate since infants born < 4000 g, but large for their GA carry the same health concerns as all other large infants [44].

Large infants increase the risk of health complications for both infant and mother. LGA infants (> 90^{th} percentile) are at greater risk of a complicated birth with a high incidence of caesarean-section (33.3% vs. 20.1% for appropriate gestational age), shoulder dysplasia (OR=2.61, 95%CI: 1.97, 3.43), hypoglycemia (2 [44] to 15 [45] times more risk) and longer hospitalization (mean of

LGA 90th =3 days vs. 2.7 days for AGA, $p < 0.001$) [44]. The higher the weight (or growth curve percentile), the higher the OR for the associated complications in the mother and infant. Postpartum hemorrhage is more frequently reported in mothers giving birth to LGA infants (OR=1.81, 95%CI: 1.13, 2.88). The risk of stillbirth almost triples for infants born in the 4500-4999 g range compared to 3500-3999 g birth weights and is 13-fold higher with ≥ 5000 g (OR=2.7, 95%CI: 2.2, 3.4; OR=13.2, 95%CI: 9.8, 17.7). Perinatal mortality is increased with heavier infants [45; 46]: neonatal deaths are significantly higher for the infants born at 5 kg or more (0-6 days after birth OR 6.4, 95%CI: 3.9, 10.4; 7-27 days after birth OR=5.2, 95%CI: 2.9-9.4; 28-364 days after birth OR 2.3, 95%CI: 1.5-.5) [46]. Sudden Infant Death Syndrome (SIDS) is more prevalent in infants born ≥ 5 kg while asphyxia is more common in the 4500-4999 g group as major causes of infant death [46]. The proportion of LGA within each sex is not consistent in the literature, but males tend to be heavier [46]. Surprisingly, research in Israel suggests that the risks of certain complications, such as shoulder dystocia, hypoglycemia and respiratory complications, were lower for the female infants compared with males, yet LGA proportions were similar for both sexes [44]. The reason for lower morbidity in females is not well understood.

Higher birth weights are most often the result of maternal diabetes during pregnancy. Esakoff et al. (2009) [47] looked at the relationship of high birth weight (≥ 4000 g) with or without GDM and perinatal outcomes. Infants born ≥ 4000 g and from a diabetic mother were found to be 10-fold more at risk of shoulder dystocia and brachial injury compared with infants born < 4000 g, also born from mothers with diabetes. Both birth weight greater than 4 kg and presence of GDM increase the risk for adverse perinatal outcomes but when combined, outcomes are exacerbated. Infants born ≥ 4000 g had 16-fold the risk of shoulder dystocia with GDM (aOR=16.45, 95%CI:

6.71, 40.33) when those without GDM had about 10-fold increase (aOR=9.62, 95%CI: 7.38, 12.54). Also, the risk of neonatal hypoglycemia increases in LGA infants from both diabetic and non-diabetic mothers. Those complications increase the risk of re-hospitalization after birth (OR=1.30, 95%CI: 1.09, 1.54) or postpartum acute care for both mothers (RR=1.89, 95%CI: 1.45, 2.47) and infants (RR=1.41, 95%CI: 1.27, 1.57) [45]. Neonatal seizures are more commonly seen in infants born heavier (OR= 1.6, 95%CI: 1.3, 2.0 for 4500-4999 g, OR=3.3, 95%CI: 2.1, 5.3 for ≥ 5000 g) [46]. Being born LGA, often the result of hyperglycemia, increases the risks for morbidity for both mother and infant, often complicating birth and increasing newborn mortality rates.

1.2.2.2 Prevalence among demographic groups

In 2010, 10.4% of Canadian births (excluding Ontario data) were LGA infants [22] which was near the expected proportion of 10.0% as per LGA definition. It is pertinent to mention that birth weight reference curves were generated using Canadian-births from 1994 to 1996; a time where 17.4% of the Canadian population was of immigrant status. No information related to the ethnicity of the population used for the generation of the curve was available, but it is clear that immigrants were not well represented [48] – even more when knowing that Ontario, which data contains a large share of immigrants in Toronto (composed of 47.0 % of immigrants in 1996 [49]), was excluded of the Canadian analysis due to errors.

LGA births are more likely to occur later in pregnancy (≥ 41 weeks) and in older mothers [44; 46]. Mothers of infants of ≥ 5000 g in a White American cohort were more likely to be married, educated, multiparous and less likely to be smokers [46]. Excessive weight before conception or excessive weight gain during pregnancy also increases the risk of having a large infant [44; 46].

Women with a previous macrosomic infant or an abnormal increase of amniotic fluid (polyhydramnios) appear at higher risk of having subsequent LGA infants [33]. GDM is the main risk factor for LGA compared to AGA infants (7.7% for LGA vs. 4.0% for AGA) [44] but still, a large proportion of LGA are born from non-diabetic mothers [47; 50] which suggests the condition is not well understood. Compared to their receiving countries (e.g., Austria, United Kingdom, Norway, Spain), immigrants of specific ethnicities, such as women from South-Eastern Asian (OR=2.05, 95%CI: 2.15, 3.05), South-Central Asia (OR=2.05, 95%CI: 1.32, 3.18), Caribbean (RR=3.03, 95%CI: 2.26, 4.05) and unspecified African (RR=2.46, 95%CI: 2.12, 2.85), had higher risk of GDM than native-born women [51].

1.2.3 Preterm birth

1.2.3.1 Definition and impact

Gestational age is used to characterize preterm births classified as: extreme (< 28 weeks); severe (28-31 weeks); moderate (32-33 weeks) and near term (34-36 weeks) [52]. Each classification implies different health concerns and severity with near term births being the most common, but also the least severe [52]. While preterm births (PTB) account for only 7.7% of pregnancies in Canada, three quarters of perinatal mortality [52] are related to it. Immature organs at birth are more vulnerable to diseases or dysfunction and thus may be the cause of major health issues. Depending on gestational age (meaning depending on their stage of development), different organs may be of concern. The brain, which attains 80% of adult weight at birth [53], is particularly sensitive to early birth. Neurodevelopmental delay, visual or auditory impairments, difficulty to regulate body temperature and motor difficulties are of the different neurological impact of being born too early [20; 54]. Immature lungs also cause respiratory distress syndrome for the majority of extreme and severe preterm births complicating the first days of life, prolonging the stay in hospital and sometimes necessitating repetitive hospitalizations [20]. The risk of developing non-communicable diseases such as diabetes and hypertension later on in adult life is also a major concern for those infants [41].

1.2.3.2 Prevalence among demographic groups

In 2010 in Canada, 7.7% of births were preterm [22] while in 2014 in the US it was 9.6% [55]. The rate of PTB is elevated with multiple pregnancies with 53% of twins and 98% of triplets being born before 37 weeks of gestation [22]. It is also one of the most common complications of preeclampsia accounting for 15-67% PTB incidence rate [37]. A meta-analysis looked at the prevalence of PTB and found a decrease as the neighborhood deprivation decreased (3.8-6.7% vs. 5.6-11.9% for the most deprived quintiles) [6]. Confirming the previous study, a study in the UK showed that the risk of having either an extremely or very PTB almost doubles when being in the most deprived decile (EPTB aRR=1.94, 95%CI: 1.62, 2.32 and VPTB aRR=1.94, 95%CI: 1.73, 2.17) [56]. In Quebec, the analysis of PTB rates by income quintiles showed that there were significantly more in the lowest income (8.2%) compared with the highest (6.7%, $p < 0.001$) and that the risk was almost exclusively in urban areas [27]. So being poor not only predisposes women to early birth, but also to a much earlier one.

Adding to the socioeconomic disparities, ethnic differences are very commonly cited in the literature as a causal link to PTB. In the USA and UK, Black women are not only more likely to have a premature delivery than White women (16-18% compared with 5-9%, respectively), PTB is more likely to occur earlier in the pregnancy [52]. This tendency seems to remain constant throughout decades. Major leading causes for both ethnicities are different, as Whites have more preterm contractions compared to Black women having more ruptured membranes. Farley et al.

[57] found many differences at the individual level between White and Black women that potentially can help explain the difference in risk. Blacks are pregnant at a younger age (10.9% vs. 4.0%), are not married (76.4% vs. 26.8%) and higher proportion have inadequate prenatal care (20.4% vs. 6.3%). Also, they seem to experience more vaginal infections than Whites (aOR=2.9, 95%CI: 2.5, 3.4) [58] which could be the potential cause of the ruptured membranes [52]. There is no clear understanding of this phenomenon yet, but this is certainly a disadvantage for the Black population.

Many maternal characteristics, such as maternal age, were shown to be strong predictors of PTB. Being an adolescent or older than 35 y increase the risk of PTB [54]. Being a single mother, having close pregnancies or having had a previous preterm infant also increase the risk of giving birth early in the course of the pregnancy [52]. Substance use such as tobacco [59], cocaine and heroin [52] also have been linked to preterm births.

1.2.3.3 Physiological causes

The main causes of PTB are induced births related to maternal or fetal emergencies or spontaneous birth with intact or ruptured membranes [52]. An induced premature birth is a consequence of a life threatening condition affecting maternal health, infant health or both. Growth restriction, hypertension, diabetes or fetal distress are examples of urgent medical situations leading to an induction. A common cause and also potential consequence of ruptured membranes is intrauterine infection. In the very early premature labor, infections seem to be an important factor leading to premature birth. Poorer prenatal care leads a higher probability of getting an infection which could have a dramatic impact on the timing of birth.

As the condition can be deadly for mother and infant, the risk of induced preterm delivery in women with preeclampsia is elevated (aOR=3.8, 95%CI: 3.3, 4.5) and predisposes to a very early preterm delivery (< 32 weeks) (aOR=3.0, 95%CI: 2.2, 4.2). Gestational hypertension also increases the risk of having an early birth (aOR=1.2, 95%CI: 1.1, 1.4) [(34)]. In addition to HTN, any condition or state that increases uterine volume has the ability to precipitate PTB: multiple pregnancy, LGA infant or large amniotic fluid volume also (aOR=1.13, 95%CI: 1.08, 1.18, p < 0.01) [(50)] are good examples. Use of *in vitro* fertilization seems to increase the risk of PTB compared to spontaneously conceived singletons (RR=1.84, 95%CI: 1.54, 2.21) [(36)]. Multiple hypotheses may explain this association, but more research is needed to understand the phenomenon.

Stress [(41)] and anxiety have been linked to premature contractions. Women with high pregnancy-related anxiety, such as bed rest (often related to other pregnancy health issues such as premature contractions) or adverse reproductive history, have about twice the risk of PTB (adjusted risk ratio (aRR)=2.1, 95%CI: 1.5, 3.0) [(60)] than women who are not anxious. The association was weaker after adjusting for medical co-morbidities, but still present. Experiencing negative life events (RR=1.8, 95%CI: 1.2, 2.7) also doubles the risk of early birth [(60)]. Although the mechanism of stress on pregnancy is not well understood, it was hypothesized that stress-related hormones in addition to an inflammatory response would be responsible for premature labor [(32; 52)]. A study in the US found that African-Americans experience more chronic stress than other ethnic groups which may contribute to an increased pregnancy outcomes disparities [(32)]. Intense physical activity including physical work could also put the mother at risk of giving birth early [(41)].

Being underweight before pregnancy increases the risk of having a PTB [41]. However, while people with low-income tend to weigh more than their more affluent counterparts, they face a variety of other complications increasing the risk of PTB (e.g., congenital abnormalities, diabetes and preeclampsia) [52]. Achievement of a healthy preconception weight is then essential to decrease PTB risks factors related to maternal weight. Nutritional status also plays a role since low serum levels of certain nutrients seems to increase the risk of having a premature infant. Nutrients that promote blood volume expansion such as iron and folate also influence uterine blood flow which can affect oxygen and nutrient transport to the fetus. Low zinc level also seems to be a risk factor for preterm birth [52]. As per nutritional supplementation, evidence is not clear whether it is efficient in reducing prematurity. Specific micronutrients (e.g., zinc, calcium, omega-3 long chain polyunsaturated fatty acids, vitamin C) or energy and protein supplementation yielded controversial results in clinical trials and/or observational studies [41; 61] and so no conclusion can be made. The World Health Organisation (WHO) states further research is needed to determine the best timing to start nutritional counselling with or without supplementation in order to reduce the risk of giving birth earlier than expected [41].

1.3 COSTS ASSOCIATED WITH PTB AND LBW INFANTS

Early births increase the costs of health care primarily due to increased hospitalization duration and the need for diverse specialists and interventions. The younger or the smaller the infant, the higher the cost (Figure 2) [54]. Timing of birth is also a determinant of related care costs. Moderate preterm births cost four times more than the near term births depending on the severity of the needs which are often higher with the earliest GA at birth. Delaying birth by two weeks can lead to a $14 000 difference in care costs per newborn. In a 2002-2003 report of the Canadian Institute for Health Information (CIHI), it was reported that vaginal birth of a healthy

Figure 2: Average hospital costs by gestational age in Canada (2005-2006) [54]

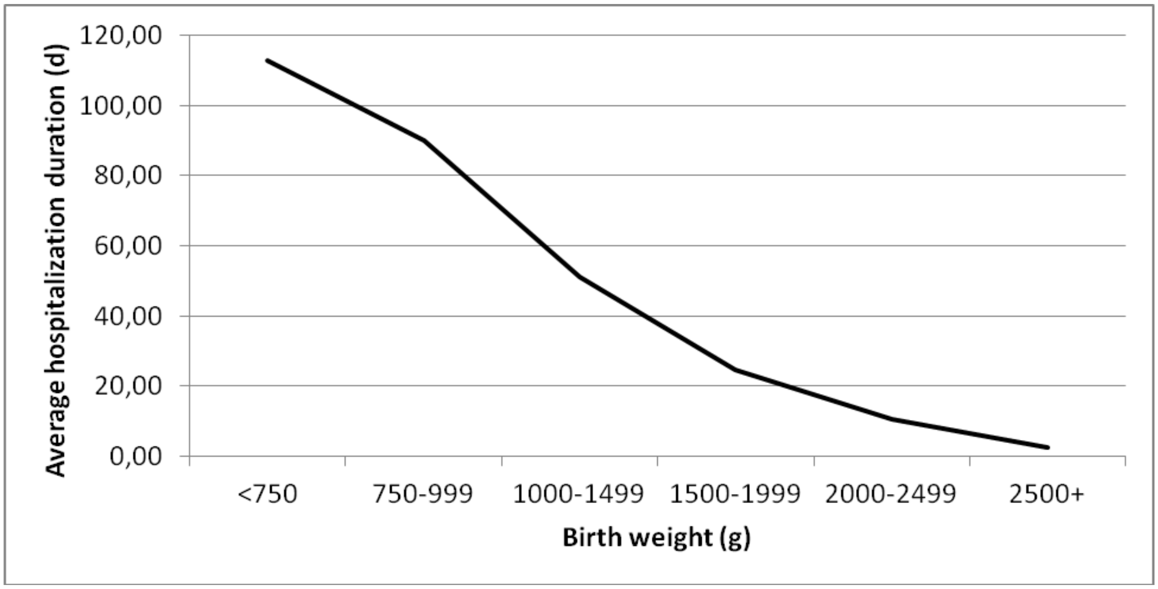
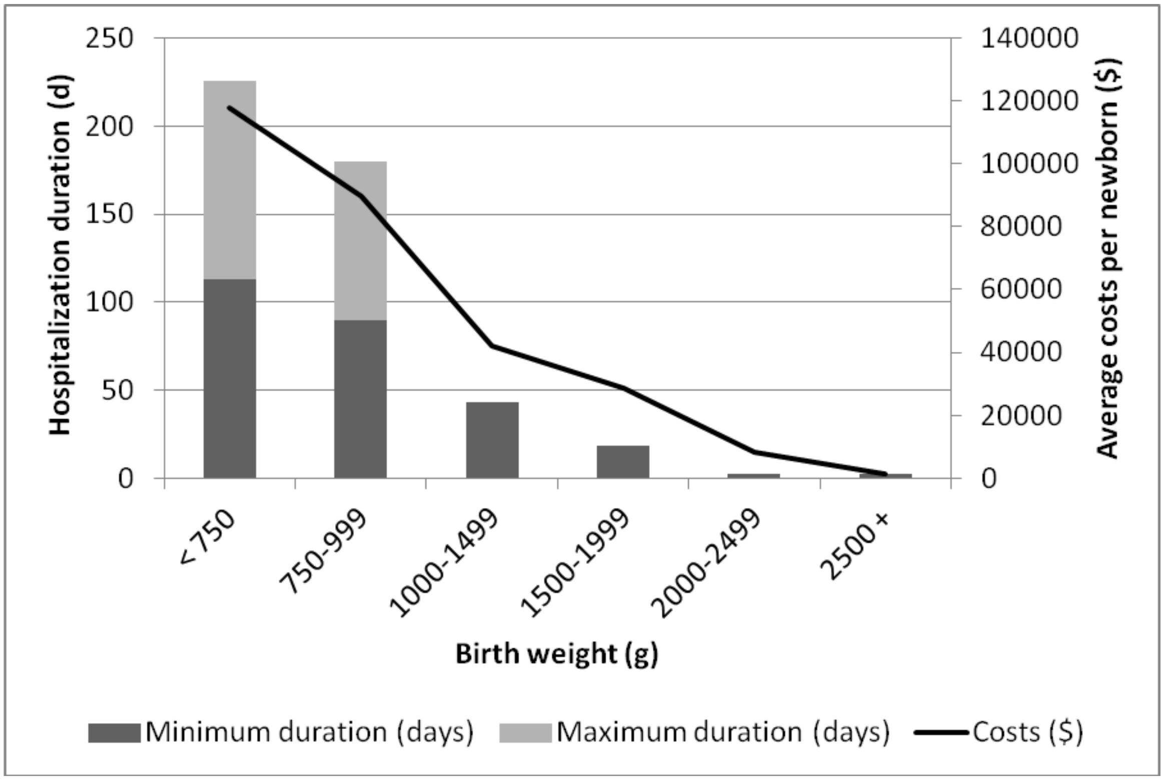


Figure 3: Average length of hospital stay and related costs associated with birth weight (2002-2003) [(15)]



weight infant costs about $750 with a two-day average hospital stay. As shown in Figure 3, being born just below the healthy birth weight (from 2000-2499 g) can cost about 20 times more than a healthy infant depending on the complications with an average of 2 to 19 days in hospital [15]. The costs are directly linked with the complications which also influence the duration of hospital stay. In the first years of life, preterm infants are at greater risk of being hospitalized for respiratory-related infections [2; 4]. Neurological disorders, which may also affect infants who were born too early, increase the needs for support from health professionals throughout childhood. Even later, in adulthood, adults who were born preterm experience more psychiatric disorders, in which case worsens as gestational age at birth decreases [4]. Developmental delay, autism spectrum disorders and cerebral palsy are other examples of neurological impairment that are more experienced by early preterm infants [62] which make them more likely to be enrolled in special educational programs during childhood. For infants born < 2000 g, with no disabilities, it was estimated that they require about 5-times more health services during a 9 year follow-up than for a matched child born at an adequate gestation age and size [63]. Those health issues seen in PTB or LBW infants impose a substantial burden on special education and social services, on health care system and on society in general [3].

1.4 PRENATAL NUTRITION SUPPORT FOR WOMEN LIVING WITH LOW-INCOME

1.4.1 The Montreal Diet Dispensary

Acknowledging that adverse pregnancy outcomes are more common in women living in poverty, the Montreal Diet Dispensary developed its unique intervention in reducing health inequalities. Founded in 1879, its primary mission was first to provide food to the poor and ill people of Montreal. Unhealthy food habits were thought to contribute to the development of diseases and so providing nutritious food was preventative. Funded by private funds, the Dispensary was providing free health services mainly by volunteers. In 1924, the first dietitian was hired and by this time, nutrition became a major interest for the organization. Food budget planning became a specialty and the Dispensary played an important role for the governmental family allowance determination. In 1959, Agnes Higgins' interest in prenatal nutrition grew when she observed that poor women were giving birth to smaller infants. Her intervention, named the Higgins' method, was based on the following premises:

1- A well-nourished mother has a better chance of giving birth to a healthy infant
2- Birth weight is a key indicator of an infant 's health
3- Often women with low-income are malnourished when they become pregnant and cannot obtain the food needed for a successful pregnancy.
4- Low birth weight is much more frequent among those with low-income.

Food supplementation with milk, egg and orange juice as well as nutrition counselling became the core of the program. Additional energy and protein than pregnancy needs are added to correct specific risk factors such as previous LBW infant, underweight before pregnancy, low protein intake at first visit, poor weight gain, pernicious vomiting, close pregnancies and severe stress. Repeated meetings with the same dietitian help in developing a strong trust relationship and motivational strategies are implemented to improve nutritional intake. The Higgins' method proved its efficacy to reduce adverse pregnancy outcomes throughout the decades. First, in 1981, the Dispensary's intervention was shown to increase infants' birth weight by 40 g ($p < 0.05$) compared to controls (regular prenatal follow-ups). It was especially significant for women who were less than 140 lbs pre-pregnancy and for those who were primipare. The number of visits greatly influenced the infants' birth weight independently of nutritional support initiation timing [64]. In 1989, a within-mother study was performed and infants whose mother received the support during the pregnancy were on average 107 g ($p < 0.01$) bigger than their siblings which translated as a fifty percent decrease in the number of LBW infants (7). In 1991, birth weight of twins were improved: the intervention decreased by 25% the incidence of LBW and by 50% the VLBW infants. In addition, maternal morbidity and bleeding at birth were significantly reduced in the intervention group leading to both better infant and maternal outcomes (65).

1.4.1.1 Changing demographics

Since the implementation of the nutritional program at the Dispensary, the Montreal population has evolved to be more diverse in ethnicity as in addition to an increasing rate of obesity. With an important increase in obesity (from 13.8% in 1978 to 25.4% in 2008), Canada is now in the top 4 countries of OECD for the highest prevalence of obesity behind the US, New Zealand and Mexico (66). In Montreal, 16% of adults are obese (67), confirming that Canadian urban centers tend to have lower prevalence than the national rates (66). While the program was developed when hunger and undernutrition was of a serious concern, it seems now that overconsumption of foods leading to excess weight is even more problematic.

This change in the population also correlates with a more culturally diverse population. In 2010, compared to other G8 countries, Canada had the highest proportion of foreign-born population (20.6%) followed by Germany (13%) and the United States (12.9%). Population projections estimate that by year 2031 between 25% to 28% could be foreign born (68). In 2012-2013, the Dispensary's clientele was composed of more than 80% of immigrants and 46% having lived in Canada for less than 2 years. Maternal origins were mainly Africa (46%), Asia (14%), Canada (13%) and Caribbean (12%). This change in demographics influences perinatal health with immigrants facing different challenges than Canadian born women. Women who immigrated to

Canada, referred as first generation Canadians, tend to have more work challenges as foreign training and work experiences are not always recognized in their new country [69; 70] which increases unemployment rate and the risk of living with insufficient income [70]. Immigration diversifies the population with an increase proportion of the visible minority groups. Visible minority women are more susceptible to unemployment and generally earn less than non-visible minority women [69] which makes them more at risk to food insecurity and stress: 28% had low-income compared with 14% for White women. Vulnerable women have a higher birth rate while being more at risk for adverse pregnancy outcomes which presses the government to implement policies and programs to support these women [68].

1.4.2 Other nutritional support programs

1.4.2.1 The WIC (Women, Infant and Children) program

The success of the nutrition support program offered at the Dispensary influenced national and international perinatal initiatives. In the 1970s, a supplementation program for the nutritionally at risk in the United States [71], called the WIC program (Women, Infant and Children) was implemented. It was designed to provide nutritional support to pregnant, postpartum, breastfeeding women as well as infants and children under 5 y to improve pregnancy adverse outcomes and infant health. The program is currently available in all states and is accessible for women who have income below 185 percent of the US federal poverty guideline (e.g., below US$ 44,955 before taxes for a family of 4 in 2016-2017) [72]. A recent program evaluation in New York (N=1,232,007) showed that the program was effective at reducing LBW (-6.12%), PTB (-10.05%) and SGA (-2.92%). Improvements were even more important for mothers with less than 12 y of education or who were Black [73]. This aligns with another study done using data from 19 states data comparing outcomes of women (N=60,731) whose deliveries were paid for by Medicaid who did not receive WIC (but were eligible to) vs. to those who did. Their conclusions were that WIC participants had 30% less LBW and PTB rates [74]. Data on LGA and on maternal outcomes is less evident.

Throughout the years, many demographic changes in the WIC population were observed. First, immigration largely contributed to population growth mainly from an increase in Asian and Hispanic populations. In addition, decreased physical activity, increased BMIs and increases in the prevalence of chronic diseases have evolved, putting additional challenges to the achievement of healthy outcomes in the participants. In order to provide food that will benefit WIC participants without contributing to adverse health outcomes, the evaluation of the food package is performed every 10 years by the IOM [75]. The food package was last improved in 2009 where food vouchers changed to introduce more fresh fruits and vegetables and less juice, whole grains and low fat milk [76]. These changes were made to assure adequate nutrient supplementation leading to proper intake while decreasing energy dense foods that could lead to excess energy intake.

1.5.2.2 Canada Prenatal Nutrition Program (CPNP)

For the last 20 years, the CPNP has provided funding to about 330 community projects, including the Montreal Diet Dispensary, aimed to provide support to improve maternal and infant health in low-income populations across Canada through nutritional support. In the 2012 CPNP program evaluation report, success in reducing SGA (0.89, 95% Confidence Interval (CI): 0.83, 0.96), LBW (0.66, 95%CI: 0.60, 0.72) and PTB (0.74, 95%CI: 0.65-0.84) were observed in participants who were the most exposed to the intervention, but a higher prevalence of LGA infants (1.22, 95%CI: 0.65, 0.84) was detected [77]. However, CPNP projects in Quebec were not included in the analyses due to different administrative systems. This is an important omission as Quebec represents a significant proportion of the migrant population in Canada and so the Dispensary's program evaluation would provide data to fill this knowledge gap.

1.5 RATIONALE AND OBJECTIVES

The Dispensary's program was implemented when hunger and under-nutrition were the major health issues faced by disadvantaged families in Montreal. The last outcome evaluation of the program was performed in 1997 when the clientele was mainly White and Canadian born. Women attending the program are now represented by more than 80% immigrants and almost half are in Montreal for less than 2 years showing an important shift in the population over time. To date, few studies have been done on pregnancy outcomes in a recently immigrated population in Canada. While the main focus of the intervention was to prevent LBW infants, the growing number of LGA infants brings a new health concern that has never been reported at the Dispensary. Therefore, the objectives of the study were to determine:

1) the prevalence of pregnancy adverse outcomes (LBW, SGA, PTB, LGA, GDM, anemia, gestational hypertension) of the Dispensary program participants compared to the Canadian population;

2) if the intervention is as effective at reducing pregnancy complications among women recently migrated to Canada compared to those born in Canada and those residing in Canada for more than 5 years; and

3) if the intervention is effectively reducing pregnancy complications among women of visible minority compared to White women.

2.0 MANUSCRIPT

Evaluation of dietary intervention and pregnancy outcomes among food insecure women attending the Montreal Diet Dispensary program

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2.1 ABSTRACT

The Montreal Diet Dispensary is a community-based program focused on improving nutrition and perinatal health in low-income women. This study aimed to conduct an outcome evaluation in a shifting population of low-income, predominantly visible minority and newly immigrated women to Canada. Data (June 2013-December 2015) from 1387 pregnancies was tested for prevalence rates and compared to national statistics. Risk was evaluated using logistic regression adjusted for covariates. Maternal (32 ± 5 y, average ± SD) interventions commenced at 26.4 ± 4.4 weeks of gestation. Most had stable immigration status (94.16%, 95%CI: 92.92, 95.39) and resided in Canada for < 5 years (65.75%, 95%CI: 63.25, 68.25). Ethnicity included White (55.30%, 95%CI: 52.68, 57.92), Black (30.14%, 95%CI: 27.72, 32.55) and Asian (14.56%, 95%CI: 12.71, 16.42). The prevalence of small-for-gestational age (SGA) infants, preterm births (PTB) and low-birth weight (LBW) were below national rates as all CIs did not overlap. The rate of large-for-gestational age (LGA) infants (10.60%, 95%CI: 8.98, 12.22) was similar to national rates. The prevalence of gestational diabetes mellitus (GDM) was 17.15% (95%CI: 15.05, 19.25), anemia 44.88% (95%CI: 41.90, 47.86) and hypertension (HTN) 3.82% (95%CI: 2.81, 4.83). Black women were more at risk of PTB (adjusted odd ratio (aOR)=1.79, 95%CI: 1.01, 3.19). Anemia rates were higher among immigrants residing in Canada for > 5 years (5-10 y aOR=1.99, 95%CI: 1.05, 3.78; > 10 y aOR=2.01, 95%CI:1.01, 3.99) compared to Canadian-born and among Black women compared to White (aOR=1.74, 95%CI: 1.29, 2.35). Asian women had an increased risk of SGA (aOR=2.35, 95%CI:1.21, 4.56;) and GDM (aOR=1.86, 95%CI: 1.17, 2.98) compared to White women. Single women had greater risk of LBW (aOR=3.3, 95%CI: 1.4, 7.6) and SGA (aOR=3.1, 95%CI: 1.5, 6.5) than women who had a partner. The Higgins' intervention supported infant health as evidenced by lower complications, but disparities in

maternal and infant outcomes were still present for some groups of women. Earlier nutritional intervention, prioritization of high risk groups of women and adaptation of the intervention would be needed to further reduce outcomes discrepancies among this vulnerable population.

2.2 INTRODUCTION

Pregnancy is a critical period during which maternal nutrition and lifestyle choices are major influences on maternal and child health [78]. Unfortunately, one of the most persistent findings in perinatal research is that socio-economic disparities exist. In fact, women living in poverty are at greater risk of adverse pregnancy outcomes [79].

The Canadian Prenatal Surveillance System (CPSS) has indicated 13 key indicators on health determinants and outcomes for mother, fetus and infant which include PTB (< 37 gestational weeks at birth), SGA (< 10^{th} birth weight percentile), LGA (> 90^{th} birth weight percentile) and severe maternal morbidity [22]. The Canada Prenatal Nutrition Program (CPNP) is a community-based program delivered through the Public Health Agency of Canada (PHAC) targeted at low-income women which prevention objectives align with CPSS indicators. A separate report highlights the success of the program in reducing SGA, but mentions a growing concern for LGA births [24]. The CPNP projects in Quebec were not included in these analyses due to different administrative systems. This is an important omission as Quebec represents a significant proportion of the migrant population in Canada.

The Montreal Diet Dispensary is a CPNP funded project in Quebec with a history of leadership and research in nutrition for low-income pregnant women [7; 80]. Its objectives are to: reduce the number of disadvantaged low-birth weight infants; promote and support breastfeeding; through a social nutrition approach, prepare families to take charge of their physical and mental well-being while at the same time encouraging social integration [7; 80]. More recently, the clientele attending the Dispensary has changed, with more than 80% of the clientele represented by immigrants with

47% residing in Canada for < 2 years. The countries of origin are mainly from Africa (51%) followed by Asia (13%), Caribbean (13%), Canada and US (12%), Mexico and Latin America (5%), Middle East (3%) and Europe (3%). The program has been successful with the most recent rates of LBW (4.0%) and prematurity (4.0%) below national rates [81].

Despite continued evidence of success, the Dispensary's program has not been evaluated since 1997. Therefore, the objectives of the study were to determine: 1) the prevalence of pregnancy adverse outcomes (LBW, SGA, PTB, LGA, GDM, anemia, gestational hypertension) compared to the Canadian population; 2) if the intervention is as effectively reducing pregnancy complications among women recently migrated to Canada compared to those born in Canada and those residing in Canada for more than 5 years; and 3) if the intervention is effectively reducing pregnancy complications among women of visible minority compared to White women.

2.3 MATERIALS AND METHODS

2.3.1 Ethics

This research project was reviewed and approved by the Faculty of Agricultural and Environmental Sciences Research Ethics Board at McGill University. The Board of the Dispensary accepted the use of the data for this research.

2.3.2 Data

The program evaluation was conducted using secondary data analysis from an electronic database established in June 2013 at the Dispensary. All files closed between June 2013 and December 2015 were evaluated for inclusion in this study. After exclusion of women who either did not receive the standard nutrition program (n=44), had a twin pregnancy (n=30), a stillbirth (n=6), were not seen by a dietitian during pregnancy (n=14), were seen very late (> 36 weeks, n=38) or with missing information (n=37), 1387 files were available for analysis. Demographic and socio-economic data were surveyed and entered at the opening of the patient's file. Countries of origins were categorized into regions as per the World Bank classification [82]. Ethnicity information was self-disclosed (White, Black or Asian). White included Arab and Hispanic women while Asian included women from all the Asian countries: India, Pakistan, Sri Lanka, China and Bangladesh. Black women included those originating from the Caribbean or Africa. Participants were classified by either being a Canadian-born or immigrant and by the number of years living in Canada using Statistics Canada definitions: very recent immigrant (< 5 years), recent immigrant (5-10 years) or established immigrant (> 10 years) [83]. Marital status was grouped into 2 groups to reflect family support system: single parent or dual parent households. Participants with a visa (work, visitor or study), refugee status or with a pending status were categorized as "unstable status" while permanent resident and Canadian citizens were combined to form a "stable status" category. The first category is usually temporary and does not always benefit from free health care support which may increases stress on health and on finances. After-tax family income was adjusted with the family size developed by Statistic Canada [84] and compared to the yearly low-income measure (LIM) per family size. Years of education were available and grouped to reflect the highest education attained. In the Quebec educational system, having completed less than 11 years indicates the mother has not finished high school, 11 years indicates she completed high school, 12-13 years indicates vocational or college training, 14 years or more indicates some college and/or university education. Gravida and parity were obtained at the first visit. Self-reported pre-pregnancy weight and measured height, which was measured at first visit, were used to calculate BMI. Weight was measured on the same balance scale at each follow-up. Total pregnancy weight gain was assessed with the last known weight before giving birth, which was also reported by the participants, and classified as per the Institute of Medicine's (IOM) guidelines [85]. Dietary intakes were collected using 30-day food frequency questionnaires and cross-checked with a usual intake as well as grocery shopping quantity comparison. Vitamin/mineral supplement intake was also documented and compliance self-reported. The total number of visits was documented and each woman was normally seen by the same professional every visit. Gestational age was based on the last menstrual period as reported by the participant. Diabetes, anemia and hypertension were self-reported by the patient and ascertained using copies of medical reports. Anemia (hemoglobin (Hgb) < 100 g/L [86]) was coded positive when the patient had anemia at any moment of pregnancy (no distinction was made between trimesters). Hypertension complications were grouped since both pre-eclampsia and gestational hypertension (diastolic pressure > 90 mmHg [87]) were not well defined in the database . Gestational diabetes and pre-pregnancy diabetes were examined separately. Diagnosis of GDM was defined using results from a 75 g oral glucose tolerance test and if more than 1 plasma glucose value was abnormal: fasting plasma glucose ≥ 5.3 mmol/L, 1 hour ≥ 10.6 mmol/L, 2 hours ≥ 9.0 mmol/L [88]. After birth, information related to the infant, such as weight and number of weeks at birth were taken from the vaccine carnet. Gestational size at birth was assessed using Kramer's growth curve reference [14].

2.3.3 STATISTICAL ANALYSIS

Descriptive statistics of the participants were generated for the study group. If 95%CI did not overlap, values were considered to significantly vary from the Canadian statistics. Maternal characteristics were compared using ANOVA among different subgroups of women. Differences in proportions of pregnancy complications among immigration status and visible minority categories were tested using Chi X^2. Both univariate and multivariable logistic regression were used to generate odds ratios (OR) with Wald's 95%CI. Independent variables were PTB, LBW (< 2500 g), SGA, LGA, anemia, GDM and hypertension. Age, maternal education level, income, parity, ethnicity, marital status and smoking were forced as obligatory covariates while other covariates were included in the final model if they would result in an adjusted odds ratio different than the crude odd ratio by more than 5%. Consequently, the additional covariates were infant sex, BMI and weight gain categories. The number of appointments and the number of gestational weeks at first visit were not added since the variables did not significantly modify the effect. Significance was set at $p < 0.05$. Data analyses were conducted using SAS software (9.4, SAS Institute Inc., Cary, NC, USA).

2.4 RESULTS

<u>Descriptive statistics</u>

In total, 1387 women were included in the final analysis. Participants registered at 20.4 ± 7.0 weeks to receive nutrition services and were seen at 26.4 ± 4.4 (mean ± standard deviation) weeks of gestational age. Each mother had an average of 4.5 ± 1.6 appointments with the dietitian during the pregnancy. Maternal age was 32 ± 5 y with most of the participants (67.05%) in the 20-34 years of age category (Table 1). The majority of the participants were White, married, well-educated and had a stable immigration status in Canada. Most of the mothers were born abroad (90.20%) and were mainly from Algeria (16.92%), Morocco (15.64%), China (10.71%), Haïti (10.32%) and followed by Cameroun, Congo, Tunisia and Colombia with smaller proportions. Most of the clientele was living in Canada for less than 5 years (65.75%). The main source of income of families was welfare (22.47%) and inadequate salary from employment for 37.00%. Almost all participants had an income lower than the Canadian low-income measure (LIM: lower than 50% of the median adjusted household income [84]). Most participants reported taking prenatal supplements and/or folate at first visit with 15% taking no supplements. A minority of women were substance users with 0.68% consuming alcohol or taking drugs (e.g., marijuana). About as many women overall had a normal BMI vs. overweight and obese combined, but 50% of participants gained excessive weight during pregnancy (Table 2). Excluded participants were similar in age, in ethnicity and education as the final sample (Appendix: Table 1).

Analysis of pregnancy outcomes as compared to national and regional statistics (Figure 1) demonstrated that while the average birth weight of the infants at the Dispensary (3407 ± 529 g) is in the healthy range, 10.60% (95%CI: 8.98, 12.22) of infants were born LGA which overlaps with the national rate of 10.7% (95%CI: 10.7, 10.8). However, this proportion was significantly higher than in Montreal (8.5%, 95%CI: 8.2, 8.8), but not different from Quebec overall or for those of low-income. As shown in Figure 1, the study population had significantly less SGA, PTB and LBW than the local and national rates. Interestingly, the prevalence of GDM (17.15%, 95%CI: 15.05, 19.25) and maternal anemia (44.89%, 95%CI: 41.90, 47.86) were significantly higher than the Canadian rates (GDM: 5.5%, 95%CI: 5.4, 5.5, anemia: 22.8%, unreported CI). Gestational hypertension rate was similar to the Canadian population with overlapping 95%CI.

Looking at the different adverse pregnancy outcomes within demographic subgroups (Figure 2 and Figure 3), it was seen that the unstable status group was less likely to have a LBW and GDM but more likely to associate with SGA, PTB and HTN than the stable status group. On the other hand, the stable status category had higher rates of LGA. The frequency of SGA was inversely related to maternal education. Women who had 11 y of education were more likely to develop GDM than the other age groups. Single women showed higher prevalence of outcomes in general compared to women who have a partner except for LGA and maternal anemia. Among the 3 ethnicities studied, Whites were more likely to have LGA infants, Asian were more likely to have SGA and Blacks PTB and anemia. Established immigrants had lower PTB, LBW, SGA than the other groups of immigrants. Women who were in Canada for 5-10 y had higher prevalence of LGA infants than the other immigration categories. The frequency of LBW, SGA and maternal anemia rates were inversely related to maternal age, but LGA, GDM and HTN prevalence increased as maternal age did.

When comparing subgroups of women by maternal characteristics (Table 3), it was observed that immigrants were significantly older, more educated and had lower BMI than women born in Canada. Women with a stable status were older than the ones with an unstable one. When divided into duration in Canada, very recent immigrants were the youngest of all groups, were more educated, had lower parity and lower BMI. On the other hand, established immigrants were more likely to be less educated and to have higher parity than the other immigration duration categories. Based on ethnicity, Asian women were older than Black women, but not older than White. Blacks were more likely to be less educated and had higher BMI than the other ethnicities. Asian women, more specifically from East Asia, were the most educated compared to North Americans. Asians also had significantly less parity compared to other ethnicities and countries of origins and were more likely to have significantly lower BMI and a higher weight gain.

Additional analyses were done to look at the relationship between energy and protein intake and weight gain pattern. Women who gained excessive weight gain were more likely to have consumed less protein per adjusted-body-weight (ABW) and energy (protein: 1.50 ± 0.33 g/kg, energy: 1.09 ± 0.17 times the IOM energy recommendations (mean ± SD)) than women who gained adequate weight during pregnancy (1.60 ± 0.34 g/kg ABW of protein; 1.12 ± 0.17 x energy needs).

<u>Multivariate analysis</u>

Large-for-gestational age infant

Adjusted odds for LGA did not differ by maternal education level attained (< 11 y aOR=0.86, 95%CI: 0.45, 1.66). Higher pre-pregnancy BMI (overweight aOR=1.75, 95%CI: 1.14, 2.69; obese aOR= 2.15, 95%CI: 1.28, 3.59) and excessive pregnancy weight gain (aOR=1.63, 95%CI: 1.07, 2.48) both increased the odds of having a LGA vs. women with healthy BMI or adequate weight gain. When looking at the different ethnicities, the proportion of LGA in Whites and was not significantly different from Asians and Blacks (Table S1). Women from Europe and Central Asia had significantly higher risk of having a LGA (aOR (adjusted odd ratio) = 3.77, 95%CI: 1.24, 10.89, $p < 0.05$) than American women (Table 5).

Small-for-gestational age infant

Once adjusted with covariate, the link between maternal age and SGA was lost. No significant differences of SGA rates in maternal age categories compared to the 20-34 y group were observed. However, the association with maternal education was not modified: women who had 11 years of education had 2.63 times the risk of having a SGA infant (95%CI: 1.16, 5.97) compared with those who were highly educated (> 14 y). The association with SGA odds was still valid after controlling the model: single women had three times higher odds than women who had a partner (aOR=3.07, 95%CI: 1.46, 6.47). Similar SGA prevalences were observed among immigrants overall as well as when stratified by duration of stay in Canada compared to Canadian-born women (Table S1). SGA prevalence was similar among women having an unstable immigration status compared to women having their Canadian citizenship or their permanent residency. Compared to White women, Blacks had similar SGA rate and Asians, as what was observed in the descriptive statistics, had significantly higher odds (aOR=2.35, 95%CI: 1.21, 4.57) even when controlled for age, parity, BMI and other covariates. No differences in SGA odds were observed for all pre-pregnancy BMI categories compared to the normal BMI. The same was observed for women who gained insufficient weight compared with adequate gain. Excessive weight gain on the other hand was shown to be protective (OR=0.33, 95%CI: 0.18, 0.60) compared to adequate weight category.

Low-birth weight infant

Maternal age was a predisposing factor for LBW in our study even after adjusting the model: mothers who were in the 35-39 y group had significantly more LBW than the 20-34 y (aOR=2.98, 95%CI: 1.62, 5.49). However, no significant difference was observed for women over 40 y (aOR=0.97, 95%CI: 0.21, 4.39) compared to the same age group. The prevalence of LBW was not different between the less educated and those who had more than 14 years of education (aOR=1.13, 95%CI: 0.42, 3.08). Single mothers were significantly more at risk of having a LBW infant (aOR=3.32, 95%CI: 1.44, 7.65) than those who had a partner. Immigrants overall had a similar risk of developing LBW than non-immigrants but an increased in risk was observed for the South Asian women compared to women born in North America (Table 5). When comparing categories of immigrants by the time spent in Canada to Canadian-born women, no differences in LBW prevalence were observed. Immigrants with an unstable status had similar rates of LBW compared with women who had a stable one (aOR=0.43, 95%CI: 0.10, 1.89). Although no significant differences in LBW rates among pre-pregnancy BMI groups were observed (underweight aOR=1.29, 95%CI: 0.39, 4.19; overweight aOR=1.05, 95%CI: 0.53, 2.08; obese aOR=1.36, 95%CI: 0.58, 3.19), pregnancy weight gain was a significant outcome predictor when compared with women who gained weight in the recommended range for their BMI: insufficient weight gain increased the risk of having a LBW infant by 2.49-fold (95%CI: 1.29-4.81) while excessive weight gain decreased the risk by half (aOR=0.49, 95%CI: 0.23, 1.00).

Preterm birth

Women from 35-39 y had significantly higher PTB rates (aOR=2.21, 95%CI: 1.24, 3.95) than the ones between 20-34 y. Surprisingly, this was not observed for women older than 40 y (n=104) (aOR=1.47, 95%CI: 0.48, 4.50). No difference of PTB rate was observed among the education level categories (< 11 y vs > 14 y school aOR=1.19, 95%CI: 0.50, 2.81) nor among marital status (single vs. with a partner OR=1.18, 95%CI: 0.52, 2.67). Immigrants, from all countries of origins, did not show a significant difference in PTB prevalence compared to non-immigrants (Table S1 and S2). Women with unstable immigration status had a similar prevalence of PTB than those that had their citizenship or their residency (aOR=1.36, 95%CI: 0.51, 3.63). The association between Blacks and higher PTB rates was also confirmed by the multivariate analysis. Black mothers had significantly higher PTB compared to Whites (aOR=

1.79, 95%CI: 1.01, 3.19, p=0.03). Maternal obesity doubled the odds of having a PTB (aOR=2.20, 95%CI: 1.12, 4.63) compared to women with healthy pre-pregnancy BMI while being underweight or overweight did not have a significant impact on the outcome (underweight aOR: 0.85, 95%CI: 0.18, 3.91; overweight aOR: 1.37, 95%CI: 0.73, 2.57). Maternal weight gain did not affect the prevalence of PTB in the study population (insufficient weight gain aOR=1.85, 95%CI: 0.96, 3.55, excessive weight gain aOR: 0.63, 95%CI: 0.33, 1.18).

Gestational diabetes mellitus

Adjustment for covariates did not modify the association between advanced age and GDM. Older women had a higher prevalence of GDM with a 2.46-fold increase for the 35-39 y age group (aOR=2.46, 95%CI: 1.73, 3.50) and 2.79-fold for women older than 40 (aOR=2.79, 95%CI: 1.65, 4.73) compared to the age group reference (20-34 y). Women who had between 11 years of education were at higher risk than those who completed 14 y or more (aOR= 1.77, 95%CI: 1.03, 3.03, p=0.03). Stability of status in Canada and marital status did not have any impact on the development of GDM in our population. Immigrants had similar rates as non-immigrants and no difference was observed when stratified by duration of stay in Canada (Table S1 and S2). After adjustments, the link between ethnicity and GDM persisted: Asian women had 1.86 times the risk of developing the condition compared to White. Specifically, South Asian women had higher risks of GDM compared to American women (Table 5). Compared to healthy pre-pregnancy BMI, being overweight or obese doubled the odds of GDM (overweight aOR= 1.93, 95%CI: 1.32, 2.82, obese aOR=2.56, 95%CI: 1.62, 4.06) while being underweight reduced the risk by 90% (aOR=0.12, 95%CI: 0.02, 0.88). Gaining inadequate weight during pregnancy led to higher odds of GDM (aOR=1.64, 95%CI: 1.05, 2.54) while excessive weight gain had no significant impact (aOR: 0.88, 95%CI: 0.61, 1.28).

Hypertension

While women between 35-39 y had similar HTN rate compared to women in 20-34 y age category (aOR=1.67, 95%CI: 0.84, 3.30), women over 40 y had 3-fold the risk of HTN (aOR=3.03, 95%CI: 1.15, 8.00) when compared to the same group. Level of education, stability of status and marital status did not influence the prevalence of the outcome. Immigrants had similar rates as non-immigrants and no difference was observed when stratified per duration of stay in Canada or per country of origins (Tables S1 and S2). Controlling the effects of covariates did not change the associate between Black women being more at risk of HTN: compared to White, they add more than 2-fold the odds of having from the condition (aOR=2.16, 95%CI: 1.14, 4.09). Pre-pregnancy maternal obesity increased by 6-times the risk of having HTN (aOR=6.30, 95%CI: 2.80, 14.19) while the 2 other BMI groups, compared with the normal range, did not affect the prevalence of the outcome (underweight aOR=0.90, 95%CI: 0.10, 7.05; overweight aOR=2.01, 95%CI: 0.90, 4.48). Weight gain during pregnancy did not affect the odds of developing HTN in this population (insufficient weight gain aOR: 0.37, 95%CI: 0.12, 1.14; excessive weight gain aOR=0.87, 95%CI: 0.45, 1.68).

Anemia

Immigrants, including those with unstable status, had similar anemia rates than non-immigrants but when stratified into duration of stay in Canada it was seen that both recent and established immigrants had significantly higher rates of anemia than Canadian-born women (Table S1).

Level of education of 11 y significantly decreased the risk of anemia (aOR=0.50, 95%CI: 0.30, 0.83) compared with > 14 y of school. The other education category did not have a significant impact on this outcome. Adjustment of covariates modified the association between age and anemia: age was not a predictor for the development of anemia as all age categories were similar to 20-34 y group (< 20 y aOR 1.67, 95%CI: 0.44, 6.28; 35-39 y aOR=0.97, 95%CI: 0.71, 1.32; > 40 y aOR=0.78, 95%CI: 0.48, 1.29). Compared with White women, Black mothers (specifically from Africa) had 1.74-fold the risk of anemia during pregnancy and Asians had a 46% reduction of risk (Table 4). Compared to biparental families, single women had lower risks of developing anemia (aOR=0.59, 95%CI: 0.37, 0.93). Women who were underweight or obese before pregnancy had similar risk of developing anemia than those of normal BMI (underweight aOR=0.75, 95%CI: 0.37, 1.52; obese aOR=0.75, 95%CI: 0.51, 1.12). On the other hand, overweight women had a reduction of risk of 30% (aOR=0.70, 95%CI: 0.52, 0.94). While gaining excessive weight during pregnancy did not predict if women would develop anemia (aOR= 0.90, 95%CI: 0.68, 1.20), poor weight gain was shown to significantly increase the risk (aOR=1.54, 95%CI: 1.07, 2.22) in our population.

2.5 DISCUSSION

This study is one of the few to examine adverse pregnancy outcomes taking into account many individual characteristics in a low-income recently immigrated population of women. The Dispensary's intervention was successful in supporting the health of infants as indicated by lower rates of LBW, SGA and PTB compared to available statistics for Montreal [89; 90; 91], Quebec [22; 92; 93; 94; 95] and Canada [22; 87; 95; 96]. In contrast, anemia and GDM rates were significantly higher and yet LGA similar to the national rates. These data show that this population is susceptible to develop nutrition-related conditions and would need specific nutritional intervention(s) adapted to their needs. Considering the intervention presently commences early in the third trimester, earlier interventions may be necessary as anemia often develops over time and as GDM is most often diagnosed during the last trimester [88].

The Dispensary's nutrition program was put into place to help women from low socioeconomic status to have better pregnancy outcomes. While LBW and SGA overall were reduced in our study, this contrasts other studies where single women showed a 3-fold increased risk of LBW and SGA [97; 98]. To some extent, this increase may be related to a reduced level of psychosocial support and relationship stability leading to a more stressful environment. It is possible that the program, through intensive nutritional follow-up and socialization activities, may have benefited these high risk women who needed more support. It is also well known that extreme maternal ages increase the risk for certain prenatal outcomes. In our study, women between 35-39 y had higher odds of developing GDM [25; 50] while women ≥ 40 had increased the risk of HTN [25]. Even though these conditions were similar to the literature, women ≥ 40 y of our population did not have higher PTB or LBW as was expected [24; 25]. This difference suggests that the intervention may be effective in supporting healthy pregnancy outcomes in older women.

Weight gain was also related to many outcomes which were well supported by the literature. Poor weight gain often associates with increased LBW [99] and anemia [100]. Contrarily, excessive weight gain, regardless of women' pre-pregnancy BMI [44] increases the risk of LGA [99; 101] and decreases both LBW [101; 102] and SGA risks. As high weight gain is usually a risk factor for GDM, it was surprising to observe that women with GDM were more likely to have lower weight gain than recommended. Pregnant women with GDM are recommended to follow a carbohydrate-controlled diet in order to improve glycemic control which may have led to a smaller total weight gain. In this case, the insufficient weight gain was probably not the cause of GDM, but rather a consequence of a controlled diet. Indeed the dietary data suggests this is true as both protein and energy intakes were aligned with a controlled diet. This might also have contributed to normalize the LGA prevalence in our population. Alternatively, genetic predisposition of women who develop diabetes, such as for Asian women typically develop diabetes at lower BMIs than Whites [(103)]. Weight before pregnancy as well as pregnancy weight gain have been shown to be good predictors of GDM, but if women are genetically at risk, weight should be assessed using different cut-points [(104)].

Even though immigrants overall did not have significantly different pregnancy outcomes compared to Canadian-born women, those who were in Canada > 5 y had an increased risk of anemia. Overall, the literature reports that immigrants are usually disadvantaged compared to native-born when looking at pregnancy outcomes [(105)], specifically, established immigrants have an increased risk of PTB compared to Canadian-born women [(106)]. In our study, no differences in outcomes among immigration duration categories in Canada were observed for all infant's outcomes studied. This finding may be an indication that the nutritional program is overall efficient in reducing PTB related health inequities among immigrants overall. Looking more closely into adverse pregnancy outcomes disparities, Black women have higher risk of PTB, HTN and anemia while Asian women had more LBW, SGA and GDM. This was consistent with previous studies that examined birth weight differences among racial groups [(107)]. Many researchers argue that an ethnic-specific birth weight curve reference must be used [(108)] since Asian infants tend to be smaller than other ethnicities which could be explained by physiological factors not leading to higher morbidity and mortality [106; 108]. The use of non-specific growth curves may overestimate the number of infants at risk for health complications leading to unnecessary medical interventions. On the other hand, WHO found little variability in infant birth weight among ethnicities [109] suggesting the adequacy of general birth weight curve reference usage. In addition to SGA, Asian women were also more at risk of developing GDM [107; 110; 111] even though they had lower BMIs than Whites. South Asian were 3 times more likely to develop GDM than Caucasian which aligns with past studies [103].Predisposition for GDM in Asian women is closely linked with being born SGA. In fact, women who were born SGA themselves via fetal under nutrition may have increases in abdominal fat and thus are predisposed to insulin resistance. The pregnant women may also have been exposed to hyperglycemia while in the uterine environment herself [103]. Both conditions increase the risk of developing GDM or diabetes later in life [112]. The Higgins' intervention should continue to promote normal glycemia and weight gain recommendations in this GDM high risk group of women and if possible start interventions earlier in pregnancy.

Another racial difference potentially contributing to adverse pregnancy outcomes is the lower hemoglobin levels in Black vs. White women leading to higher prevalence of anemia [113]. Reevaluation of cut-off values to a lower 10 g/L Hgb for Blacks have even been proposed to decrease false positive diagnosis [113; 114] but has not been used by WHO since only scarce data exist on the subject. In the present analysis a conservative cut-point of 100 g/L was used. A high prevalence of anemia, which has been linked to an increased risk of PTB [115; 116; 117; 118], was also observed in the Black population of our study. Disparity between Black and White PTB rates has not changed over decades, even present in higher socioeconomic status women [113; 119] which contributes to racial health inequalities [52]. Previous reports also observed that Blacks have higher LBW rates than Whites in addition to PTB, which was not observed in our population. This is odd since LBW is often the result of PTB. This means that even though the rates of PTB were similar to other studies, infant birth weight and/or GA were probably higher in our study since SGA was not different between Black and White infants.

As for the 2 other disparities discussed, our finding aligns with previous literature supporting higher risk for hypertensive disorders during pregnancy for Black women [120]. However, an increased risk was also reported for Asian women, but was not observed in our study. A hypothesis could be that calcium-rich supplementation received at the Dispensary, composed of one liter of whole milk and prenatal supplements daily, may have contributed to decreases the discrepancies among ethnicities [39]. Unfortunately, this cannot be confirmed since there was no comparison group involved in the study.

The major strength of this study was the quantity of comprehensive information available for the assessment of the risk factors related to immigration and ethnicity. It allowed subgroup analyses (e.g., by duration of stay in Canada) as well as consideration of important covariates in the logistic regression model. Few studies have individual income information, relying on neighborhood income database to compare the prevalence of the outcomes of interest. In addition to this, rare studies have access to both income and immigration information. Our study brings a new piece of information specific to ethnicity, duration of stay in Canada in a low-income community of Montreal. However, there are some limitations to this study. Some important information in the file was self-reported by the participant (e.g. pregravid weight). Maternal anemia, hypertension or GDM were the conditions with high risk of misreporting. Finally, our results cannot be generalized to the low-income migrant women population since results are dependent on the nutrition intervention offered at the Montreal Diet Dispensary.

In summary, the nutrition program offered at the Dispensary was successful in supporting healthy pregnancies: participants had less SGA, PTB and LBW infants among its participants than the national rates. While the prevalence of LGA and HTN were similar to the national rate, GDM and anemia rates were shown to be significantly greater in this population than the Canadian statistics. Many disparities may also have been reduced between immigrants and Canadian-born women, but racial differences were still present. This evaluation helped to identify groups of women who may be more at risk of developing certain adverse pregnancy outcomes in this specific population. The results need to be used by the organization to prioritize and adapt the intervention for those higher risk women and further decrease the disparities between immigration and racial groups.

2.6 TABLES

Table 1. Characteristics of the study population

		n	%	**95% CI**	
Maternal Age (years)	< 20	15	1.1	0.5	1.6
	20-34	930	67.1	64.6	69.5
	35-39	338	24.4	22.1	26.6
	≥ 40	104	7.5	6.1	8.9
Race	White[1]	767	55.3	52.7	57.9
	Black[2]	418	30.1	27.7	32.6
	Asian[3]	202	14.6	12.7	16.4
Education (years)	< 11	142	10.2	8.6	11.8
	11	124	8.9	7.4	10.4
	12-13	256	18.5	16.4	20.5
	≥ 14	865	62.4	59.8	64.9
Marital status	Single/Divorced	187	13.5	11.7	15.3
	With a partner	1200	85.5	84.7	88.3
Maternal country of origin	Middle East and North Africa	539	38.9	36.3	41.4
	Latin America and Caribbean	243	17.5	15.5	19.5
	Africa	218	15.7	13.8	17.6
	East Asia and Pacific	163	11.8	10.1	13.5
	North America	138	10.0	8.4	11.5
	Europe and Central Asia	48	3.5	2.5	4.4
	South Asia	38	2.7	1.9	3.6
Immigration status	Canadian citizen or permanent resident	1306	94.2	92.9	95.4
	Visa/Refugee/Waiting status	81	5.8	4.6	7.1
Period living in Canada	Canadian born	136	9.8	8.2	11.4
	Very recent immigrant (< 5 years)	912	65.8	63.3	68.3
	Recent immigrant (5-10 years)	206	14.9	13.0	16.8
	Established immigrants (> 10 years)	133	9.6	8.0	11.1
Income	Below Low-income measure	1275	91.9	90.5	93.4

Legend: 1. Includes Caucasian, Arab and Hispanic women. 2. Includes both Black African and Blacks from the Caribbean. 3. Includes South Asian and East Asians.

Table 2. Pregnancy-related characteristics of the study population (%)

	N	%	95% CI	
Gravida (median, IQR)		2.0	2.0	
Parity (median, IQR)		1.0	2.0	
Pregravida BMI				
Underweight (< 18.5 kg/m^2)	54	3.9	2.9	4.9
Normal (18.5-24.9 kg/m^2)	671	48.4	45.7	51.0
Overweight (25.0-29.9 kg/m^2)	443	31.9	29.5	34.4
Obese (≥ 30.0 kg/m^2)	219	15.8	13.9	17.7
Weight gain (mean, SD) (kg)		14.3	7.0	
Weight gain adequacy*				
Adequate	439	31.7	29.2	34.1
Below	250	18.0	16.0	20.1
Excessive	698	50.3	47.7	53.0
Protein intake**				
Above recommendation	1297	93.5	92.2	94.8
Below recommendation	90	6.5	5.2	7.8
Energy intake**				
Above recommendation	1045	75.4	73.1	77.6
Below recommendation	342	24.7	22.4	26.9
Infant sex				
Female	677	48.8	46.2	51.4
Male	710	51.2	48.6	53.8
Infant birth weight (mean, SD) (g)		3410	529.0	
Birth weight z-score (median, IQR)		0.04	1.22	
Adequacy of birth weight				
SGA	76	5.5	4.3	6.7
LGA	147	10.6	8.9	12.2
Gestational weeks at birth (mean, SD)		39.4	1.6	
Adequacy of birth timing				
PTB	66	4.8	3.6	5.9

Legend: *Based on pre-pregnancy BMI and compared to IOM pregnancy weight gain recommendations. **Compared to IOM pregnancy protein and energy requirements. Definitions: IQR=interquartile range, BMI=body-mass-index, SD=standard deviation, SGA=small-for-gestational Age, LGA=large-for-gestational age, PTB=preterm birth.

Table 3. Maternal characteristics per demographic subgroups

	Age (y)	P	Education (y)	P	Parity	P	BMI (kg/m^2)	P	Weight gain (kg)	P
Immigrant		<0.0001		<0.0001		0.09		<0.05		0.55
No	27.3 (5.9)		12.1 (2.5)		1.3 (1.7)		26.4 (6.3)		14.4 (7.6)	
Yes	32.5 (4.9)		14.6 (3.0)		1.1 (1.1)		25.4 (4.9)		14.1 (5.8)	
Status stability		<0.01		0.053		0.11		0.19		0.42
Stable	32.1 (5.2)		14.3 (3.0)		1.1 (1.1)		25.5 (5.0)		14.1 (6.1)	
Unstable	30.2 (4.8)		15.0 (3.3)		0.9 (1.2)		24.7 (5.6)		14.7 (5.4)	
Immigrants by duration		<0.0001		<0.0001		<0.0001		<0.0001		0.82
Canadian-born	27.4 (5.8)[a]		12.1 (2.5)[a]		1.3 (1.7)[a]		26.4 (6.3)[a]		14.5 (7.6)	
< 5 y	32.1 (4.5)[b]		15.1 (2.8)[b]		0.9 (0.9)[b]		24.8 (4.5)[b]		14.0 (5.6)	
5-10 y	33.6 (5.3)[c]		13.8 (2.8)[c]		1.4 (1.2)[a]		26.9 (5.3)[ac]		14.1 (6.1)	
> 10 y	33.3 (6.1)[c]		12.1 (2.8)[a]		1.7 (1.4)[c]		26.7 (6.0)[ac]		14.4 (6.9)	
Ethnicity		<0.05		<0.0001		<0.0001		<0.0001		<0.01
White	31.9 (5.3)[a]		14.4 (2.9)[a]		1.1 (1.1)[a]		25.7 (4.6)[a]		13.7 (5.9)[a]	
Black	31.5 (5.3)[a]		13.6 (3.2)[b]		1.2 (1.3)[a]		26.7 (5.7)[b]		14.5 (6.7)[ab]	
Asian	32.9 (4.2)[b]		15.4 (2.7)[c]		0.8 (0.9)[b]		21.9 (3.5)[c]		15.1 (4.8)[b]	
Maternal country of origins		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001
North America	27.3 (5.8)[a]		12.2 (2.5)[a]		1.3 (1.7)[a]		26.3 (6.3)[a]		14.4 (7.5)[ab]	
East Asia and Pacific	33.1 (4.0)[b]		16.1 (2.2)[b]		0.6 (0.7)[b]		21.3 (3.0)[b]		15.1 (4.6)[a]	
Europe and Central Asia	31.4 (5.2)[b]		15.5 (2.5)[bc]		0.9 (1.1)[ab]		23.4 (3.8)[c]		15.6 (5.2)[ab]	
Africa	31.6 (4.8)[b]		14.3 (3.2)[c]		1.2 (1.1)[a]		26.5 (5.4)[a]		15.1 (6.1)[a]	
South Asia	31.9 (4.8)[b]		12.7 (3.0)[a]		1.3 (1.1)[a]		24.3 (3.9)[ab]		15.4 (6.0)[ab]	
Middle East and North Africa	32.7 (4.9)[b]		14.7 (2.8)[c]		1.2 (1.1)[a]		25.8 (4.2)[a]		13.4 (5.8)[b]	
Latin America and Caribbean	32.7 (5.1)[b]		13.5 (3.3)[d]		1.1 (1.2)[a]		26.7 (5.4)[a]		13.4 (6.3)[ab]	

Values are mean (SD). The p-values in the columns identify if a difference exists between groups by ANOVA. Values with different superscript letters are different, p<0.05, and were obtained by Hochberg's GT2 post hoc test.

Table 4. Crude and adjusted odd ratios (ORs) of adverse pregnancy outcomes per ethnicities compared to White women (95%CI)

		PTB	SGA	GDM	Anemia	HTN
Black	Crude	1.49 (0.89-2.50)	1.51 (0.88-2.59)	1.01 (0.72-1.42)	1.48 (1.13-1.94)**	2.34 (1.31-4.16)*
	Adjusted	1.79 (1.01-3.19)*	1.24 (0.67-2.30)	0.94 (0.64-1.38)	1.74 (1.29-2.35)**	2.23 (1.18-4.21)*
Asian	Crude	0.55 (0.21-1.42)	2.61 (1.45-4.68)*	1.17 (0.78-1.77)	0.65 (0.45-0.95)**	0.68 (0.23-2.00)
	Adjusted	0.69 (0.25-1.90)	2.35 (1.21-4.57)*	1.86 (1.17-2.98)*	0.54 (0.36-0.81)**	1.10 (0.35-3.46)

Legend: *p<0.05,**p<0.0001. PTB=preterm birth SGA=small-for-gestational age, LGA=large-for-gestational age, GDM=gestational diabetes mellitus, HTN= hypertensive disorders. Odd ratios have been adjusted for: income, parity, age, infant sex, education, smoking, BMI, weight gain and marital status.

Table 5. Crude and adjusted odd ratios (ORs) of adverse pregnancy outcomes per country of origins compared to North America

		LBW	SGA	LGA	GDM	Anemia
Africa	Crude	0.62 (0.20-1.97)	0.70 (0.26-1.86)	1.77 (0.80-3.94)	1.44 (0.75-2.78)	2.58 (1.46-4.54)*
	Adjusted	1.10 (0.28-4.25)	1.22 (0.39-3.76)	1.29 (0.55-3.03)	1.21 (0.59-2.50)	2.67 (1.44-4.98)*
South Asia	Crude	2.59 (0.69-9.69)	3.77 (1.24-10.89)*	2.69 (0.89-8.10)	2.75 (1.10-6.92)	2.91 (0.99-8.56)
	Adjusted	7.10 (1.48-34.15)*	10.09 (2.69-37.79)*	2.16 (0.66-7.06)	2.88 (1.03-8.07)*	3.33 (1.06-10.43)
Europe & Central Asia	Crude	N/O	N/O	3.77 (1.43-9.96)*	0.68 (0.21-2.14)	1.43 (0.62-3.29)
	Adjusted	N/O	N/O	3.77 (1.32-10.76)*	0.70 (0.21-2.42)	1.26 (0.52-3.05)

Legend: *p<0.05,**p<0.0001. PTB=preterm birth SGA=small-for-gestational age, LGA=large-for-gestational age, GDM=gestational diabetes mellitus, HTN=hypertensive disorders. Odd ratios have been adjusted for: income, parity, age, infant sex, education, smoking, BMI, weight gain and marital status.

2.7 SUPPLEMENTAL TABLES

Table S1. Odd ratios (ORs) of adverse pregnancy outcomes per immigration categories and ethnicities

		PTB	LBW	SGA	LGA	GDM	Anemia	HTN
Immigrants (compared to non-immigrants)								
	Crude	0.77 (0.36-1.65)	0.93 (0.39-2.21)	0.91 (0.43-1.94)	1.73 (0.86-3.49)	1.31 (0.74-2.31)	1.61 (0.98-2.66)	0.70 (0.31-1.58)
	Adjusted	0.92 (0.35-2.43)	1.45 (0.48-4.35)	1.27 (0.50-3.22)	1.52 (0.70-3.29)	1.01 (0.52-1.93)	1.60 (0.91-2.82)	0.60 (0.23-1.58)
Immigrants by duration (compared to Canadian-born)								
< 5 y	Crude	0.87 (0.40-1.88)	1.07 (0.45-2.57)	0.98 (0.46-2.12)	1.55 (0.76-3.14)	1.20 (0.67-2.13)	1.62 (0.98-2.68)	0.58 (0.25-1.36)
	Adjusted	1.55 (0.50-4.81)	3.32 (0.87-12.73)	1.90 (0.67-5.39)	1.40 (0.63-3.12)	1.02 (0.52-2.02)	1.44 (0.80-2.59)	0.61 (0.22-1.70)
5-10 y	Crude	0.82 (0.31-2.12)	0.76 (0.25-2.32)	0.90 (0.35-2.30)	2.50* (1.15-5.43)	1.85 (0.98-3.51)	1.86 (1.05-3.31)	1.45 (0.57-3.65)
	Adjusted	1.26 (0.36-4.37)	1.90 (0.43-8.35)	1.58 (0.50-4.99)	1.84 (0.79-4.29)	1.20 (0.58-2.48)	1.99* (1.05-3.78)	0.98 (0.33-2.88)
> 10 y	Crude	0.12 (1.02-0.98)	0.33 (0.07-1.67)	0.50 (0.15-1.69)	2.07 (0.89-4.82)	1.47 (0.72-3.00)	1.56 (0.83-2.92)	0.43 (0.11-1.68)
	Adjusted	0.13 (0.02-1.16)	0.35 (0.06-2.05)	0.53 (0.14-2.02)	1.52 (0.62.3-74)	0.83 (0.37-1.83)	2.01* (1.01-3.99)	0.24 (0.05-1.07)
Immigrants by status (compared to stable)								
Unstable	Crude	1.34 (0.53-3.44)	0.57 (0.14-2.36)	1.70 (0.75-3.82)	0.42 (0.15-1.17)	0.70 (0.33-1.50)	1.29 (0.77-2.16)	1.33 (0.47-3.79)
	Adjusted	1.36 (0.51-3.63)	0.43 (0.10-1.89)	1.31 (0.55-3.14)	0.44 (0.15-1.26)	0.78 (0.35-1.72)	1.21 (0.71-2.06)	1.23 (0.40-3.79)
All population by ethnic groups (compared to White)								
Black	Crude	1.49 (0.89-2.50)	1.65 (0.92-2.96)	1.51 (0.88-2.59)	0.87 (0.59-1.28)	1.01 (0.72-1.42)	1.48** (1.13-1.94)	2.34* (1.31-4.16)
	Adjusted	1.79* (1.01-3.19)	1.73 (0.88-3.0)	1.24 (0.67-2.30)	0.78 (0.51-1.18)	0.94 (0.64-1.38)	1.74** (1.29-2.35)	2.23* (1.18-4.21)
Asian	Crude	0.55 (0.21-1.42)	1.71 (0.83-3.54)	2.61* (1.45-4.68)	0.61 (0.34-1.06)	1.17 (0.78-1.77)	0.65** (0.45-0.95)	0.68 (0.23-2.00)
	Adjusted	0.69 (0.25-1.90)	1.93 (0.85-4.39)	2.35* (1.21-4.57)	0.78 (0.42-1.43)	1.86* (1.17-2.98)	0.54** (0.36-0.81)	1.10 (0.35-3.46)

Legend: *p<0.05,**p<0.0001. Odd ratios were adjusted for: income, parity, age, sex, education, smoking, BMI, weight gain, marital

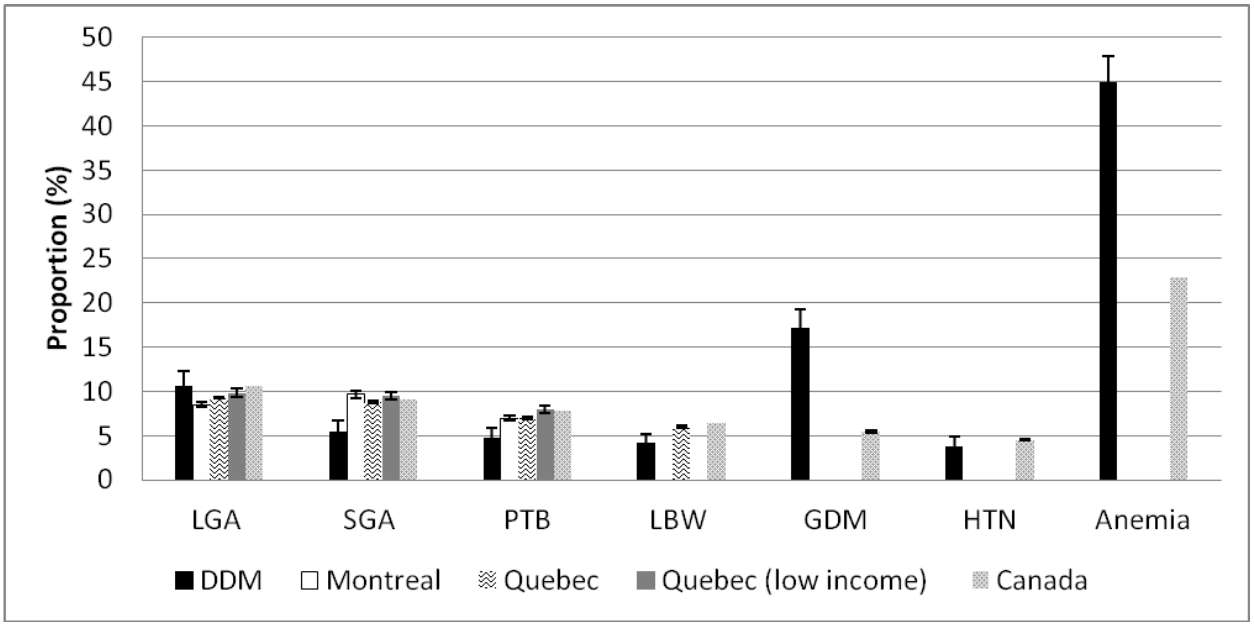
Table S2. Odd ratios (ORs) of adverse pregnancy outcomes per country of origins compared to North America (OR 95%CI)

		Prematurity	LBW	SGA	LGA	GDM	Anemia	Hyper-tension
Africa	Crude	0.78 (0.30-2.03)	0.62 (0.20-1.97)	0.70 (0.26-1.86)	1.77 (0.80-3.94)	1.44 (0.75-2.78)	2.58* (1.46-4.54)	0.90 (0.33-2.42)
	Adjusted	0.95 (0.30-2.94)	1.10 (0.28-4.25)	1.22 (0.39-3.76)	1.29 (0.55-3.03)	1.21 (0.59-2.50)	2.67* (1.44-4.98)	0.73 (0.24-2.21)
South Asia	Crude	0.90 (0.18-4.44)	2.59 (0.69-9.69)	3.77* (1.24-10.89)	2.69 (0.89-8.10)	2.75 (1.10-6.92)	2.91 (0.99-8.56)	N/A
	Adjusted	1.42 (0.25-8.04)	7.10* (1.48-34.15)	10.09* (2.69-37.79)	2.16 (0.66-7.06)	2.88* (1.03-8.07)	3.33 (1.06-10.43)	N/A
Europe & Central Asia	Crude	N/A	N/A	N/A	3.77* (1.43-9.96)	0.68 (0.21-2.14)	1.43 (0.62-3.29)	1.25 (0.31-5.03
	Adjusted	N/A	N/A	N/A	3.77* (1.32-10.76)	0.70 (0.21-2.42)	1.26 (0.52-3.05)	1.59 (0.34-7.45)
Middle East & North Africa	Crude	0.76 (0.33-1.72)	0.67 (0.26-1.75)	0.72 (0.32-1.66)	2.00 (0.97-4.12)	1.33 (0.77-2.52)	1.84 (1.10-3.07	0.43 (0.17-1.10)
	Adjusted	0.85 (0.30-2.43)	1.16 (1.34-3.98)	1.66 (0.58-4.79)	1.61 (0.71-3.65)	1.09 (0.54-2.18)	1.73 (0.96-3.11)	0.37 (0.12-1.14)
Latin America & Caribbean	Crude	1.38 (0.59-3.24)	0.54 (0.73-4.79)	1.15 (0.48-2.75)	1.57 (0.71-3.48)	1.19 (0.62-2.29)	1.60 (0.92-2.77)	1.41 (0.57-3.48)
	Adjusted	1.54 (0.55-4.29)	2.83 (0.90-8.92)	1.64 (0.59-4.57)	1.20 (0.51-2.80)	0.80 (0.39-1.65)	1.71 (0.93-3.14)	0.98 (0.35-2.73)
East Asia & Pacific	Crude	0.31 (0.08-1.17)	0.99 (0.32-3.01)	1.41 (0.57-3.50)	0.74 (0.27-1.97)	1.22 (0.61-2.45)	0.87 (0.47-1.59)	0.47 (0.14-1.64)
	Adjusted	0.36 (0.08-1.69)	1.39 (0.33-5.75)	2.02 (0.63-6.49)	0.92 (0.31-2.70)	1.62 (0.71-3.67)	0.67 (0.34-1.33)	0.73 (0.17-3.10)

Legend: aOR=adjusted odd ratio, N/A: not applicable/no case reported *p < 0.05 **p < 0.0001.
Odd ratios have been adjusted for: income. parity. maternal age. infant sex. education. smoking. pre-pregnancy BMI. pregnancy weight gain and marital status.

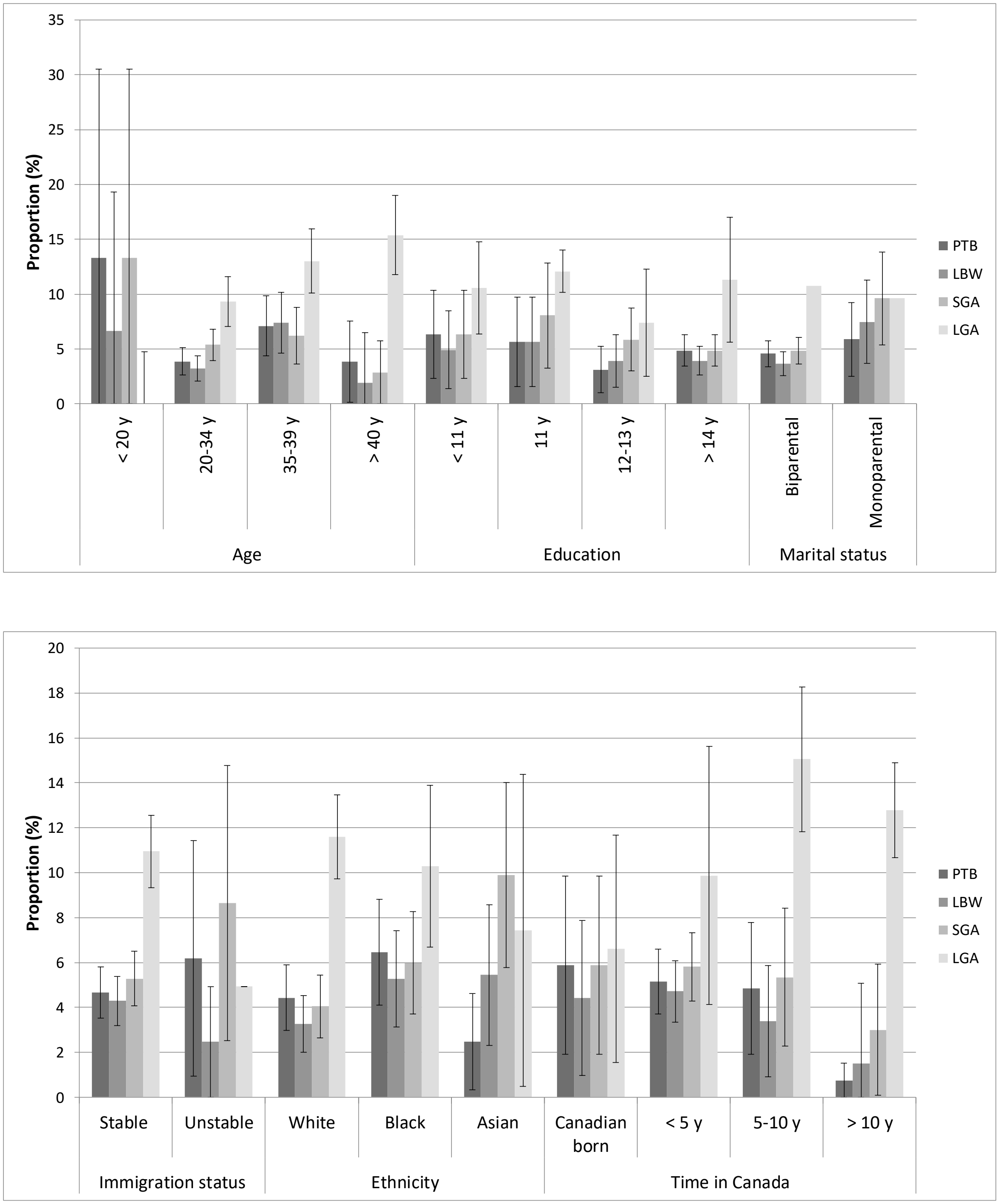
2.8 FIGURES

Figure 1: Pregnancy outcomes of the study population compared to Montreal, Quebec and Canada (with 95%CI)



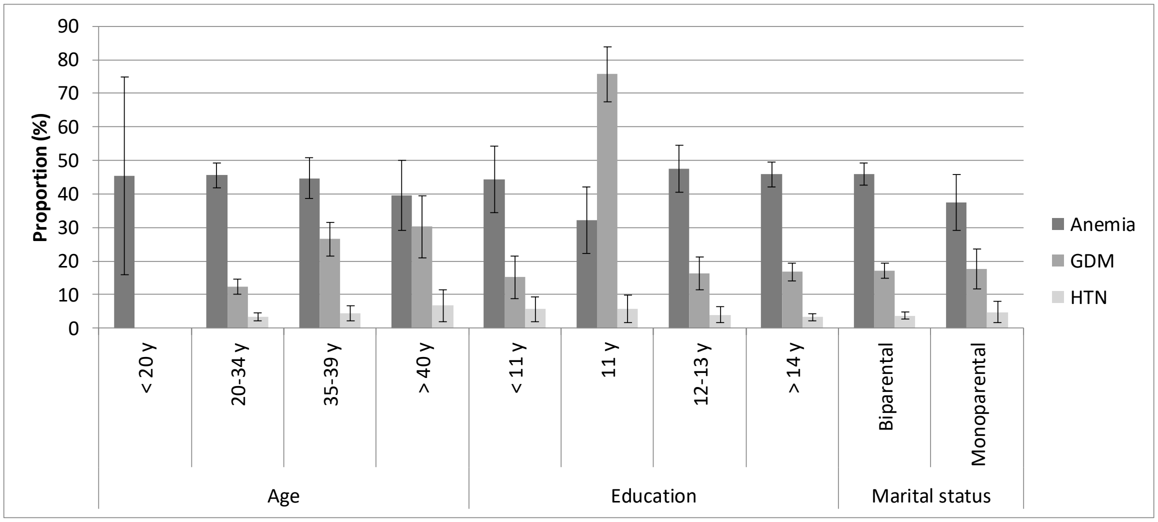
Sources of data: Montreal (89; 90; 91), Quebec (22; 95), Quebec (low-income) (92; 93; 94), Canada (22; 87; 95; 96). **Legend:** DDM= Montreal Diet Dispensary, LGA=large-for-gestational age, SGA=small-for-gestational age, PTB=preterm birth, LBW=low-birth weight, GDM=gestational diabetes mellitus, HTN=hypertensive disorders.

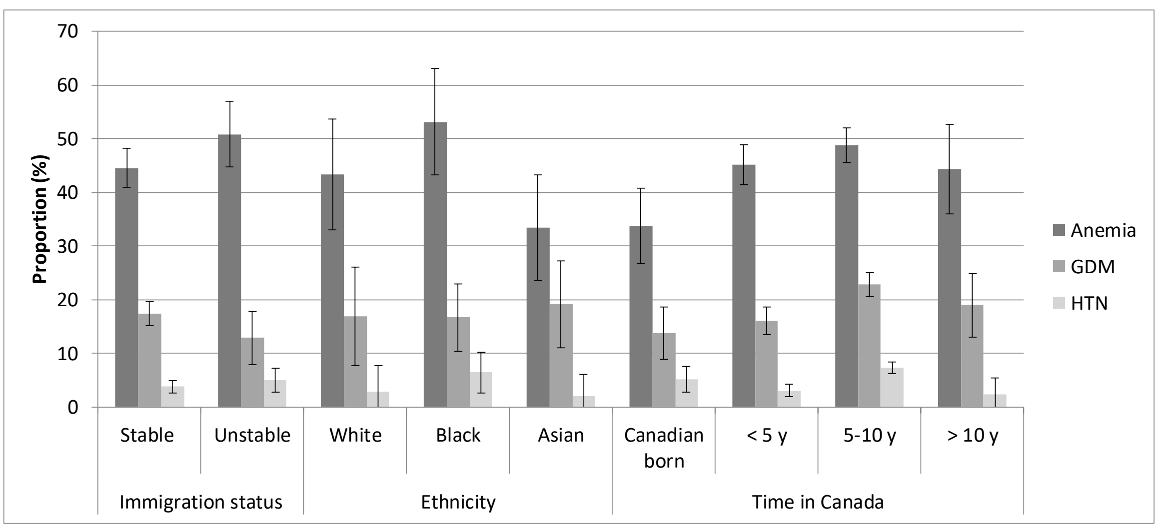
Figure 2: Infant complications as a proportion (95%CI) per demographic subgroup of women attending the Montreal Diet Dispensary nutrition program



Legend: PTB=preterm birth, LBW=low-birth weight, SGA=small-for-gestational age, LGA=large-for-gestational age.

Figure 3: Maternal pregnancy complications as a proportion (95%CI) per demographic subgroup of women attending the Montreal Diet Dispensary nutrition program





Legend: GDM=gestational diabetes mellitus, HTN=hypertensive disorders.

3.0 GENERAL DISCUSSION

3.1 FINDINGS

This thesis aimed to study the effectiveness of a nutrition support program designed to help women of low socioeconomic status to have healthier pregnancies. This program has shown its effectiveness in the past, but had to be reevaluated in regard to an important demographic change with many immigrants now participating in the program. This was the first evaluation that looked at SGA and LGA rates as infant health indicators in addition to LBW and PTB. The analysis showed that the intervention was successful in supporting the health of newborn infants overall with significantly lower rates of LBW, SGA and PTB than Montreal, Quebec and Canada. Similar conclusions were drawn when comparing with the rates of the poorest income quintile of Quebec. On the other hand, the prevalence of LGA infants was significantly larger than the rate in Montreal, although it was not different from Canada overall.

One of the objectives of the study was to look at disparities in the outcomes related to immigration. First, the outcomes of our population were different than other Canadian reports in the literature [121] as they were not affected by the healthy migrant effect. The concept of the healthy migrant effect is that newcomers tend to have better health at arrival in a country than native-born. Going through an extensive medical screening before migrating, people with diseases usually stay in their country. Over time, health of migrants seems to decline as the time spent in the receiving country increases and becomes comparable to the host population [122; 123]. In our population, outcomes in migrants tended to decrease, except for anemia, even though not significantly different from Canadian-born, as time in Canada increased. An explanation for this higher prevalence could be that established immigrant women who come to the Dispensary all have low socio-economic status which probably lasts since arrival in Canada. Living in a food insecure household is often linked with lower food quality which may translate into insufficient iron intake and/or poor iron bioavailability in the diet [(124)]. Consequently, established immigrants with low-income may be at higher risk of developing maternal anemia and possibly other micronutrient deficiencies. Future research should test targeted interventions to redefine, prevent and manage anemia in this high risk immigration group.

In addition to the infant health indicators, this study also looked at maternal health outcomes. Even though we are uncertain the intervention had an impact on these outcomes, it was interesting to know the prevalence among the different subgroups of women. Maternal anemia, HTN and GDM have rarely been evaluated in this specific population with a comprehensive set of covariates available. Gestational diabetes had a very high prevalence of 17% while the proportion in Canada across all demographic groups was 4.7% in 2010 [(96)]. Maternal characteristics such as maternal age, surely have contributed to the high prevalence of GDM since our population was older: in 2011, median maternal age at birth in Canada was 28.1 y (unreported CI) compared to 32 ± 5 y in our population [(54)]. In our study, the odds ratios (ORs) for GDM associated with mothers between 35-39 y were 2.46 (95%CI:1.73-3.50) and over 40 y 2.80 (95%CI: 1.65-4.06). The intervention probably did not prevent any case of GDM because of the late pregnancy intervention and follow-ups, but it may have helped in the management of

GDM with dietary advice and food donations. Some data supports this supposition as both protein and energy intakes were closely aligned with the recommendations. This analysis fills an important knowledge gap about the prevalence of GDM in the low-income immigrant population of Montreal, Quebec. Future studies need to test for interventions designed specifically for GDM management and post-partum follow-up in this low-income group.

Overall, the prevalence of maternal hypertension showed similar results as Canada. A Cochrane review has shown that women with poor calcium intake (< 600 mg/d) decreased their risk of hypertension and pre-eclampsia during pregnancy by taking calcium supplements (≥ 1 g/d) [39]. Low-income women are more at risk of food insecurity and poor calcium intake [124] and so may benefit from a specific nutritional supplementation. The intervention of the Dispensary, which includes a supplementation of 1 L of whole milk per day, contributes to about 1 g calcium per day as food supplement. Data about hypertensive disorders during pregnancy of low-income women living in a wealthy country are rare and thus could not been compared, but it may be anticipated that the present population may have had higher prevalence without the intervention.

3.2 STRENGTHS AND LIMITATIONS

The major strength of this study was the quantity of information available for the analysis. An extensive number of variables were known and were added to the statistical model. Relying on statistics databases, hospital discharge databases or birth registration, often restrict the information available for research. Pre-pregnancy weight or body-mass-index [27; 106; 107; 110; 125], smoking [106] and maternal education [11; 106; 125] were characteristics that were often unknown and not considered in the statistical analysis of many studies. Certain studies used data that were entered at time of immigration (e.g., education, marital status) and which may have changed at the time of pregnancy [106]. Individual information about income was rare, relying on neighborhood income database to compare the prevalence of the outcomes of interest. Certain individuals may not share all of characteristics of their neighborhood and some conclusions may not apply to them.

Data were entered by dietitians who had received the *Higgins' method* training and had between 5 to 35 years of experience which contributed in getting accurate information about participants. Data used were taken right from the beginning of the electronic files database's implementation. While this was a great opportunity for extraction and analysis, this may have led to unrefined data with dietitians who may not have fully understood how to use the software; or drift in quality of data entry over time. This is possible since standardization of data entry was clearly an issue as well as missing information. Oral glucose tolerance test results are a good example of how a dietitian needs to adjust to electronic files: most results were present in the dietitian notes instead of being mentioned in the laboratory values section where it could be easily extracted. The reviewer had ascertain data from files with missing results and read the dietitians' note to see if the patient had a positive or a negative test. Other data were sometimes entered in a non-standardized manner which also complicated the classification of data (e.g. gestational hypertension) and may have lead to more missing data in case of doubt.

Much of the information present in the file were self-reported (e.g. pregravida weight, laboratory values). Even though dietitians do their best to ensure entered data are as accurate as possible, this may have led to erroneous data. For example, total weight gain calculation was obtained from pregravida weight and maternal weight before birth. Final weight was cross-checked with the last dietitian appointment, where weight was taken at every visit, to make sure it was realistic. Maternal anemia, hypertension or GDM were the conditions with high risk of misreporting since poor understanding of certain participants may have led the professional to make wrong conclusions.

Data were retrospective and there is no control over who attends or not as is the case with many public health interventions. Since it is a voluntary program, selection bias may be present: women seeking help may be different from those that did not . Ideally, one should compare a similar group of women not receiving the nutrition services to determine the impact of the program which ethically is not possible. The comparison with low-income women in general was used in addition to local, regional and national rates so to become closer to the population of interest, but keeping in mind that those attending the Dispensary might have different characteristics, such as being mainly immigrants.

The way ethnicity was reported made it less pertinent for the analyses since many different groups were mixed together (e.g., White included Arab and Hispanic women). Those groups may have shared different risks which were not detected as a result of combining the data. Since maternal country of birth was available, other analyses have been done in order to give results that may differentiate certain ethnicities, such as Arab or Hispanic women from the general White category. A limit of this analysis is that Canadian-born women from other ethnicities was not able to be differentiated at this point.

The large sample size of the study allowed the analysis of many outcomes from different subgroups of women. However, some women may have been poorly represented. Women from South Asia, from Europe and Central Asia, younger than 20 y or older than 40 y and women with an unstable status were few and so related findings may be spurious.

Finally, the present results cannot be generalized to the low-income migrant women population since results are dependent of the nutrition intervention offered at the Montreal Diet Dispensary.

3.3 CONCLUSIONS

In summary, the nutrition program offered at the Dispensary remains successful in supporting healthy pregnancy for some women in the low socioeconomic sector: women who received the services had overall lower prevalence rates of SGA, PTB and LBW than the low-income region of Montreal and overall Canada's population. The prevalence of LGA and HTN were similar to the Canadian rate. There was no difference in complications for immigrants compared to Canadian-born women. The study population showed decreased discrepancies in perinatal outcomes among certain groups but many still exist. As evidenced by high prevalence rates, the late nutritional intervention did not contribute to the prevention of anemia and GDM. Earlier nutritional intervention, prioritization of high risk groups of women and adaptation of the intervention would be needed to further reduce outcomes discrepancies among this vulnerable population.

3.4 FUTURE DIRECTIONS

The present study has no comparison group making it difficult to make strong conclusions about the impact of the intervention. A majority of eligible families of Montreal receive the nutritional support, either by the Dispensary or the OLO (Oeufs, Lait, Oranges) program which offers similar services, and so comparing our participants to low-income families is virtually impossible. Future studies should examine the pregnancy outcomes in the same family- such as a within-mother study. This design would allow examination of two pregnancies from the same women with the main difference being the Dispensary's intervention at the second pregnancy.

Another research direction should look at adherence to supplementation vs. adverse pregnancy outcomes. The current study did not assess the individual supplement intakes but rather looked at the intervention as a whole. This would help in determining if food supplements are contributing to better outcomes and establish if changes in the types and/or quantities of food offered are needed. In addition, the quality of food supplements should be reevaluated in view of a changing population. As discussed in the review, the WIC program reevaluated their food supplements aligning with current nutrition recommendations. An extensive review of the literature has lead the IOM to recommend a decrease in the milk fat (m.f. skim or 2%) content and replacement of juice in favor of fresh fruit in their food packages so to decrease saturated fat intake and increase fiber intake. The foundations of these recommendations are also valid for the Canadian population and need to be considered for the improvement of the food supplements offered. This is especially important in view of excess weight gain in some of the women and increasing rates of LGA. Improving the intervention, similar to the revised WIC program, may also enhance micronutrient intakes towards improved pregnancy outcomes.

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5.0 APPENDIX

5.1 TABLES

Table 1. Characteristics of the excluded participants

		N	%	95% CI	
Age					
	< 20 years	5	1.4	0.2	2.6
	20-34 years	249	68.2	63.4	73.0
	35-39 years	87	23.8	19.4	28.2
	≥ 40 years	24	6.6	4.1	9.2
Race					
	White	156	58.0	52.1	63.9
	Black	90	33.5	27.9	39.1
	Asian	19	7.1	4.0	10.2
	Native	4	1.5	0.1	3.0
Period living in Canada					
	Canadian born	40	13.1	9.3	16.9
	Very recent immigrant (< 5 years)	179	58.5	53.0	64.0
	Recent immigrant (5-10 years)	55	18.0	13.7	22.3
	Established immigrant (> 10 years)	32	10.5	7.1	13.9
Education					
	< 11 years	23	11.2	6.9	15.5
	11 years	14	6.8	3.4	10.3
	12-13 years	43	21.0	15.4	26.6
	≥ 14 years	125	61.0	54.3	67.7