A Simple Recipe: Estimating the Effect of a Prenatal Nutrition Program on Child Health at Birth

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Abstract

We study the impact of a Canadian prenatal nutrition program on child health at birth. The objective of the OLO program is to reduce the incidence of prematurity and low birth weight by providing a specific food basket and nutritional guidance to pregnant women in situations of poverty. Our identification strategy exploits exogeneous variations in access to the program caused by the progressive implementation of the program by local community service centers. The administrative birth records used in this study provide early health outcomes (birth weight and gestational age) for over 1.5 million newborns, along with a number of family characteristics. Our results suggest that the program had a positive impact on the birth weight of children and reduced the incidence of low birth weight, with larger impacts on children of mothers with a high school degree or less. While the cost of the program is equivalent to the US comparable WIC program, the food basket is simpler and the gains on birth weight are larger.

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1 Introduction

Recent research suggests that investments *in utero* may be less costly and more effective than interventions after birth, including those in early childhood (Doyle et al., 2009). A number of recent studies have investigated the association between the U.S. Supplemental Nutrition Program for Women, Infants, and Children (WIC) and child health at birth, but rarely document its cost effectiveness. Generally, these studies suggest that children of mothers participating in prenatal nutrition programs have higher birth weights and reduced likelihood of low birth weights compared to children whose mothers did not participate in such programs.

This paper investigates the impact of the OLO[1] program on child health at birth in Québec (Canada's second largest province). This program shares important similarities with WIC, yet has a number of distinctive features. Both OLO and WIC emerged following the seminal work of Higgins (1976).[2] In an experimental setting she showed the benefit on infant health of providing food and nutrition counselling to pregnant women in situations of poverty. In order to reduce the incidence of prematurity and low birth weight, both programs offer food packages and some nutrition counselling to disadvantaged pregnant women. While the costs of the programs are comparable (about $49 per month, Bitler and Currie (2005)), the content of the food package is very different. OLO provides milk, orange juice, eggs and vitamin tablets in specific quantities to ensure that pregnant mothers consume essential nutrients for fetal development on a daily basis. WIC varies by state and allows mother to choose from a wide variety of food items such as enriched cereals, fruits and vegetables (fresh, frozen, canned or dry), cheese, and soy-based beverages. As such, the content of the food packages provided by WIC depends on both the mother's choice and area of residence, while it is uniquely defined under OLO since all mothers receive the same package. This study therefore estimates the impact of a unique tightly defined low-cost prenatal nutrition program on infant health.

[1] OLO comes from the french acronym "oeuf-lait-orange" (eggs-milk-oranges). We further detail the program in section 3.

[2] Higgins et al. (1989) attributes the idea of supplemental food programs during pregnancy to Jeans et al. (1955).

While the OLO program has a fairly long history in Canada, this paper is the first to estimate the impact of *in utero* exposure to a nutrition program on birth outcomes in the Canadian context using a quasi-experimental approach. With a long standing comprehensive public health care system and a large safety net for families (social assistance and child benefits), the Canadian context differs from that of its neighbor. While WIC may serve as a gateway to Medicaid (Rossin, 2013), participation in OLO has no impact on access to health care services for mother or child. Other ways in which the program may impact mother and child are investigated in this paper. Our findings suggest that the program is effective mainly due to improved maternal nutrition.

The OLO program was deployed by public local community service centres (LCSC). The mother's place of residence determines whether and when she is eligible for the program or not. Similar to Hoynes et al. (2011), we exploit the historical and geospatial progressive implementation of the program throughout the province in a differences-in-differences framework. As pointed out by Hoynes et al. (2011), using LCSC-level variation avoids the bias caused by non-random selection into treatment encountered in previous studies. Compared to their study, our observation period is more recent (1986 to 2008 compared to 1971 to 1982) and we also have exact figures on the number of treated mothers for certain years during the implementation.

We use the birth records of all children in the province since 1986. Not only can we observe the early health outcomes (birth weight and gestational age) of over 1.5 million newborns, but also the mother's place of residence (i.e. postal code), age, education, language, and marital status, along with the child's gender, birth order, multiple birth indicator and month of birth. The postal code allows us to precisely geolocate mothers at the time of birth. The family and child characteristics are used to verify that the geospatial implementation was not correlated with maternal characteristics and also to estimate the impact of the reform on various subgroups of the population. We find that the program increased the birth weight of treated children by 67 grams on average and by 120 grams in the long run. The program also had positive and significant impacts on the probability of carrying a baby to term and having a fair weight baby ($\geqslant$ 2500gr).

Finallly our cost-benefit analysis suggests that a large part of the program costs are recovered through neonatal cost savings alone. Accounting for additional gains from increased birth weight shows that the benefits outweigh the costs.

The rest of the paper is organized as follows. Section 2 reviews the literature on the determinants of birth weight and in particular the effect of nutrition programs. Section 3 provides institutional information about health and social services in Canada and Québec. Section 4 describes the nutrition program and implementation over the sample time frame. Section 5 describes the data. Section 6 discusses the identification strategy and section 7 presents the main results and investigates the mechanisms. Section 8 presents a simple cost-benefit analysis, and the final section concludes.

2 Previous evidence on nutrition programs during pregnancy

Research in the last decade in many disciplines (epidemiology, social science, medicine, neurosciences, and economics) has shown the long term consequences of early life conditions on adulthood socioeconomic and health outcomes (Almond and Currie, 2011a). *In utero* exposure to under nutrition and cigarette smoking are two of the most important determinants of low intrauterine growth. These early conditions, in addition to infection and pollution, have long been a concern in the literature linking *in utero* exposure to birth outcomes (low birth weight, prematurity, intrauterine growth retardation, neonatal death) (Painter et al. 2005; Grossman and Joyce 1990; Almond et al., 2005; Barreca, 2010; Almond and Currie, 2011b; Currie, 2011; Currie, 2009). In economics, the literature on "fetal origins" is fairly recent. Studies on the effects of prenatal health on subsequent human capital and health find substantial effects (Almond and Currie 2011a, p. 1369). Furthermore, recent research on the intergenerational transmission of birth weight finds that a mother's birth weight is positively correlated that of her child (Conley and Bennett, 2000; Boivin et al., 2012).

The most common outcome to study fetal development has been birth weight and the incidence of low birth weight (LBW)[3] because this measure is linked with later life socioeconomic and health outcomes (e.g., Currie and Hyson, 1999; Black, Devereux and Salvanes, 2007; Oreopolous, Stabile, Roos and Walld, 2008), in addition to being comparable across countries and generally available in the birth registry data of many developed countries. A major health-related policy objective in most developed countries, likely influenced by research results, is to increase the birth weight of children in low-birth weight populations as well as develop effective prenatal and postnatal public policies targeting preschool children. Almond and Currie (2011a) review a large body of empirical economic literature on a variety of programs aimed at reducing the incidence of low birth weight (among other objectives). Examples of programs in the American context are income enhancement programs (e.g. welfare and earned income tax credits), near-cash programs (e.g. Food Stamps) combined or not with early intervention programs (home visits, supplemental nutrition), and health care access and coverage (in the US, Medicaid expansions for pregnant women). We now focus our attention on studies on the effects of supplemental nutrition programs on child health at birth.

Likely one of the most studied programs in this literature is the US Supplemental Feeding Program for Women, Infants, and Children (WIC), reviewed and analyzed in Currie (2003) and Bitler and Currie (2005). In the economic literature, many of the early studies on WIC have been criticized because of potential selection issues (e.g., participating mothers among eligibles may have better birth outcomes), identification problems, and omitted variables bias (e.g., within-mother analysis may suffer from changes in family environment between births). Currie and Bitler (2005) specifically addressed the alleged selection problems and found that participating mothers, compared to eligible mothers, were in fact negatively selected on a number of observed characteristics, such as education, marital status, ethnicity, and teenage status. These mothers had, on average, babies of lower birth weight compared to other eligible mothers, yet the authors found that WIC participation was positively associated with birth weight (about 62 grams), gestation and maternal weight gain once they controlled for individual characteristics and a full set of state-year dummies to account for annual variation

[3] A birth weight of less than 2,500 grams is defined as LBW by the World Health Organization (WHO).

at the state level. Their findings further suggested that the estimated effects were larger for disadvantaged mothers, including teenage mothers, single high school dropouts and those receiving public assistance.

A large variety of pregnancy outcomes have been studied to estimate the impact of the WIC program on treated and control groups over time or region: mean birth weight, fraction of LBW or very low birth weight (<1,500 grams), prematurity (gestation length less than 37 weeks), incidence of small for gestational age (SGA) or intrauterine growth retardation (IUGR), and neonatal and infant deaths. These studies have used different econometric approaches, data sets, periods or sub-regions. In general the most significant results were related to birth weight and incidence of LBW. The most recent ones (Rossin, 2013; Gueorguieva, Morse, and Roth, 2008; Figlio et al. 2008; Joyce, Gibson, and Colman, 2004; Joyce, Yunzal-Butler and Racine, 2001; Kowaleski-Jones and Duncan, 2002) led to a diversity of estimates on the proportion of LBW and the impact on birth weight, but the results were generally positive and significant, ranging between 40 to 180 grams for birth weight.

Using a research design based on the roll-out of WIC across counties between 1974-79, Hoynes et al. (2011), found that the average birth weight of participating counties increased by 7 grams and the incidence of LBW decreased by 1.4 percent among pregnant women most likely eligible (low levels of education, blacks). When they scaled their results by an estimated 8% participation rate for pregnant women in 1998, the average impact on the birth weight of children of treated mothers was 29 grams (a 10% increase). They also found that the probability of LBW decreased by 11 percent for mothers with less than a high school degree. The same research design was used to independently estimate the impact of the Food Stamp Program (FSP) during the 1960s and early 1970s (Almond et al., 2011) with similar results for average birth weight and incidence of LBW. By 1975, all counties had implemented FSP, and by 1978 changes in FSP led to an increase in the take-up rate. Hoynes et al. (2011), in their study of WIC, included an indicator for availability of FSP in the county-year since their observation period (1972 to 1982) overlaps with that of the implementation of FSP.

In the Canadian research literature a few studies stand out. The Montreal Diet Dispensary (MDD), under the guidance of a professional dietitian (Higgins 1976) developed the (Higgins) nutritional intervention programs to treat the risk of adverse pregnancy outcomes (pregnant women in states of under-nutrition, under-weight or stress). The program involved regular and individual nutrition counselling in addition to the provision of specific food items. The program was applied in collaboration with a number of Montreal hospitals having a public maternity clinic. Using sibling fixed-effect on 552 sibling pairs, Higgins and al. (1989) found that the average weight gain was 107 grams ($p<0.01$) for the 552 participants, 146 grams ($p<0.001$) for the 142 considered as undernourished, and 119 grams ($p<0.05$) for those 100 considered to have multiple risk conditions (excluding underweight). The LBW odds ratio decrease was significant only for the overall sample. Effects on neonatal mortality and IUGR indicators were not significant. For the 327 pairs involved in a minimum of four counselling sessions during pregnancy, the average weight gain was 190 grams ($p<0.001$), suggesting that counselling is an important part of the treatment. For both the overall sample (552 pairs) and the high counselling sample (327 pairs) higher birth weights were observed for almost all risk categories (undernourished, underweight, stress conditions, multiple conditions). Also, for the overall group the likelihood of LBW decreased significantly. Similar but less marked results were obtained for twin pregnancies (Dubois et al., 1991).

Muhajarine et al. (2012) study the link between birth outcomes and the Canada Prenatal Nutrition Program (CPNP) initiated in 1995 and financed by the government of Canada. The CPNP consists of more than 330 projects involving 2,000 communities across Canada but outside the province of Québec (see next section). Data on mothers participating in the program during pregnancy were collected in 2002-2005. A diversity of health behaviors and birth outcomes as well as neonatal health measures were collected for approximately 23,000 mothers (and infants). The link between program exposure (high and low from dimensions of time initiation, intensity, and duration) and outcomes was estimated using a multivariate approach. In general, high exposure was correlated with better outcomes, except, surprisingly, with large weights for gestational age. This study did not account for selection into treatment and other cofounding factors, such as time trends due to technological changes or other programs affecting birth outcomes.

We add to this literature by identifying the impact of a nutrition counselling and food supplement program that is similar to WIC, yet offers a unique food basket in which the items and their quantities are fixed (see details below) and where the program participants have also access to the same free health care services as the rest of the population.

3 The OLO program and its contextual setting

In the Canadian federation, health and social services have always been under the jurisdiction of the provinces. Over the past fifty years, a number of landmark changes[4] have transformed the health care system in Canada allowing the emergence of a fully public regime where health care is mostly free at the point of use, since the billing and reclaim of health care costs to the government are handled by doctors, hospitals and clinics. This is fairly unique in the world, even compared to European countries where patients typically have to assume a small share of the costs, and in some cases have to pay the total amount upfront and get reimbursed later through public insurance. Canadian provinces each decide the primary care services and programs they want to provide and also assume a large share of the funding (with per capita block funding from the Federal government)

In Québec, the Régie de l'assurance maladie du Québec (RAMQ), is the sole public agency authorized by the government to pay for services provided by physicians participating in the system (practically all of them). Starting in the early 1970's, the Québec government launched an ambitious reform project promoting a territorial approach to health and social services which led to the creation of the LCSCs. These primary care organizations were entirely public, in terms of funding, infrastructure and resources, but also governance. The

[4] In 1957, Canada's federal government proposed a hospital insurance program and passed the Hospital Insurance and Diagnostic Services Act (HIDS) to be funded jointly with the provinces to which Québec subscribed later starting in January 1961. From this date, hospitals provided free services and institutional support to specialists for their clinical activities. In 1966, the federal government introduced the Medical Care Act that extended the HIDS Act cost-sharing to allow each province to establish a universal health care plan. It also set up the Medicare system; the unofficial name for Canada's publicly funded universal health insurance system. It was only later in 1971 that Québec's government agreed to provide coverage for medical fees not included in the universal hospital insurance system.

LCSC model was innovative with regard to governance because it was under the hierarchical responsibility of the Ministry of Health and Social Services (MSSS), and also because it incorporated the social service component into the provision of health care services. A variety of professionals work in LCSCs: physicians, nurses, occupational therapists, physiotherapists, nutritionists, psychologists and social workers. LCSCs provide both preventative and curative services, as well as support services such as home care, re-adaptation and reinsertion services. LCSCs are one of the entry points into the health care system. Initially, 200 LCSCs were planned for all of Québec, to each serve a population of 10,000 to 40,000 inhabitants. Currently, there are 163 LCSCs territories, once you exclude those located on first nations' reserves. In 2004, the LCSCs, together with hospitals, centres for old-age nursing homes, and re-adaptation centres, were regrouped under 95 Health and Social Services Centres (HSSCs) created to broaden the range of services offered and ensure a population-based plan for health care services.

As mentioned in the introduction, the OLO program operates mainly through the LCSCs and has its roots in the Higgins (1976) method developed in the 1970s' at the Montreal Diet Dispensary. Disadvantaged pregnant mothers, either because of under nourishment, thinness, unfavorable past pregnancies, close pregnancy, gaining less than 4.5 kg by the 20th week of pregnancy, persistent vomiting, or serious emotional/social problems and lack of support, have smaller babies. The Higgins method provides nutrition counselling along with protein and calorie corrective measures to reduce the incidence of low birth weight among disadvantaged mothers. Inspired by the Higgins method, the OLO program provides disadvantaged pregnant mothers with one egg, one liter of milk and 125ml of orange juice per day, in addition to prenatal vitamin tablets and nutrition counselling. Mothers typically start receiving the food supplements and nutrition counselling by the 12^{th} to 15^{th} week of gestation.

The program first started in the early 1980s through a pilot project financed by the MSSS in the LCSC of Matane semi-urban region, and the LCSC of St-Henri, a Montreal neighborhood with a high level of poverty. At the time, only milk was provided to disadvantaged pregnant mothers. The program, as we know it today, was then initiated in the

LCSC of Valleyfield in 1983. In addition to milk, this LCSC started providing eggs, orange juice and vitamin tablets. The OLO program was born. At the beginning of the program, these free packages included either the goods themselves or vouchers to be redeemed at local participating food stores and were financed by gifts from the community (local food stores and firms, and public and non-profit organizations such as the Québec Knights of Columbus). According to our matched data set, in 1986, 17 (out of 163) LCSCs offered these free packages along with nutrition counselling (see Table 1). Over the years, a number of LCSCs joined the OLO program and in 1991, the OLO Foundation was created to ensure the proper financing of the program and promote the deployment of the program across the province. Currently, the program is mainly funded by the OLO Foundation and the CPNP, which also operates programs similar to the OLO program in each of the other provinces in Canada.[5] The current program continues to provide the same food items but mainly in terms of vouchers administered by the OLO Foundation. Nutrition counselling is also provided, but the frequency and the type of counselling varies by LCSC. Group counselling is more widespread than recommended by the Higgins method.

Table 1: Number of LCSCs by OLO participation status and year

Year	Before 1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Full history															
OLO	7	17	25	33	41	55	69	84	106	125	138	142	144	144	146
Not in OLO	150	140	132	124	116	102	88	73	51	32	19	15	13	13	11
Missing	6														
Total	163														

[5]In 1994, the federal government implemented the Community Action Program for Children (CAPC), a community-based children's program delivered by the Public Health Agency of Canada jointly managed with the provinces and territories. The CAPC has provided long term funding to community groups and coalitions across Canada to develop programs that promote the healthy development of young children (0-six years). Through CAPC, support and activities are made available to children and their families facing challenging life circumstances. In 1995, the federal government announced the Canada Prenatal Nutrition Program (CPNP), which extended the support offered by CAPC into the prenatal period. The objectives were to reduce incidence of low-birth weight, improve the health of pregnant women and their infants, promote and support the initiation and duration of breastfeeding, increase the accessibility of services and community support for pregnant women, and build partnerships, linkages and collaboration within communities. In Québec, funding from CPNP is directed to the LCSCs OLO program.

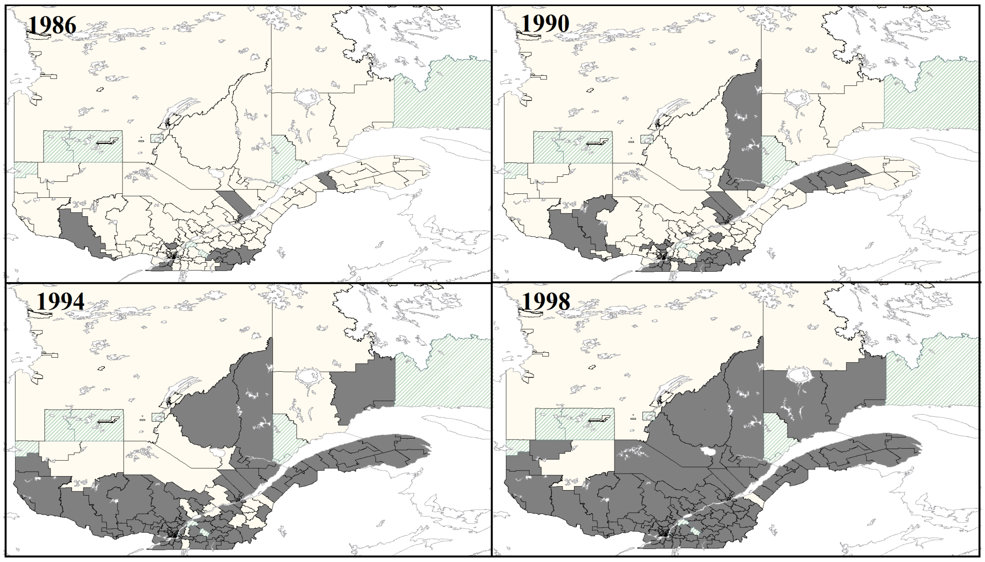
4 Data sets and program implementation

Since the OLO program was implemented by LCSCs and because LCSCs serve specific geographic areas linked to the postal codes[6] of residences of the population served, we are able to determine the geographic progression of the program using the LCSCs geographical territories data set in combination with the historic implementation of the OLO program data set. The LCSCs geographical territories data set contains the association between the LCSCs and the residential postal codes served by each of the LCSCs. This data set is the property of the MSSS. The historic implementation of the OLO program data set contains both historic records of implementation provided by the OLO Foundation and data collected by the authors directly from the LCSCs.

Figures 1 and 2 were constructed using these data sets and show the progression of the implementation of the program throughout Québec and the city of Montréal, where a majority of the Québec population lives. Together, these figures show that the majority of the implementation took place between 1986 and 1998 and that the progression was not concentrated in specific geographic areas within the province.

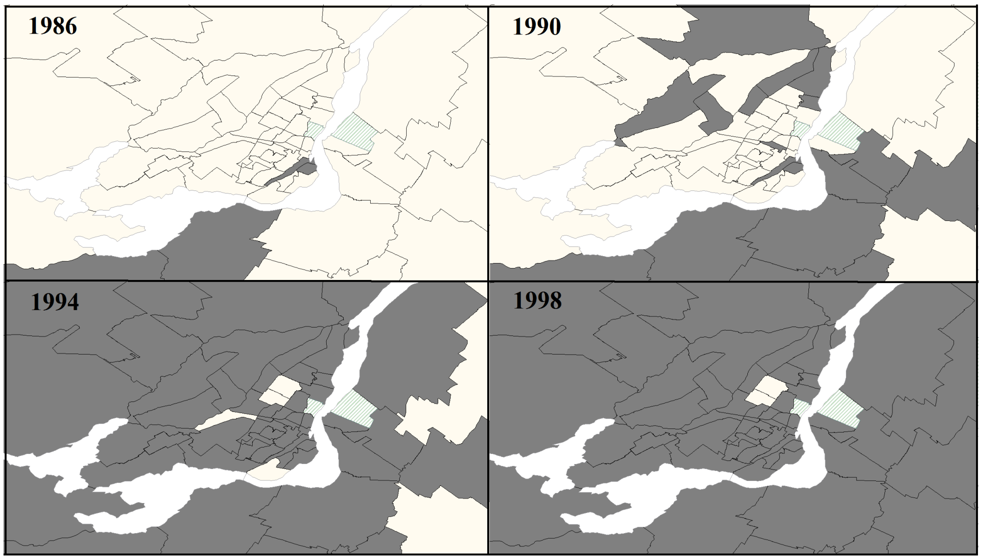
[6]The postal code in Canada is a six-character code defined and maintained by Canada Post Corporation for the purpose of sorting and delivering mail.

Figure 1: Program progressive implementation – province of Québec



Note: This figure shows the progressive implementation of the program throughout the province. LCSC territories running the OLO program are in black, those not running it are in grey, and unknown status are indicated by the shaded areas.

Figure 2: Program progressive implementation – Montréal area



Note: This figure shows the progressive implementation of the program throughout the greater metropolitain area of Montréal. LCSC territories running the OLO program are in black, those not running it are in grey, and unknown status are indicated by the shaded areas.

The birth registry data set of the Institut de la Statistique du Québec (ISQ) contains administrative data on all live births in the province of Québec from 1986 to 2008. Not only can we observe the early health outcomes (birth weight and gestational age) of over 1.5 million newborns but also the mother's postal code, age, education, language, and marital status, along with the child's gender, birth order, multiple birth indicator and month of birth. In Canada, the average number of households served by a postal code is approximately 19. The postal code therefore allows us to precisely geolocate mothers at the time of birth and accurately determine if the OLO program was available to them while they were pregnant.

We restrict our attention to children born in LCSC territories for which we have complete historic information regarding the OLO program (157 LCSCs out of 163).[7] We also exclude children whose birth weight and gestation length are missing, along with children for which the mother's age, years of education, and place of birth, as well as primary language at home and type of birth (single, twin, or more) are missing.[8] Finally, based on the medical perception of medical viability in the 1990s' (Alexander et al., 2003; Sanders et al., 1995), we exclude children born below 500 grams or with less than 25 weeks of gestation in our analysis[9]. Table 2 presents the summary statistics of our main sample.

[7]This restriction implies that we use 93.3% of the birth records.

[8]These restrictions imply that we discard 8% of the birth records, of which maternal education account for 6% and maternal place of birth accounts for 1%. The birth weight distribution for observations with missing data is extremely similar to the rest of the sample. This suggests that our results are unlikely to be impacted by these restrictions.

[9]This represents less than 0.2% of our observations. Including these children slightly increases the estimated impact of the OLO program on each of the outcomes we use.

Table 2: Summary statistics - Birth registry

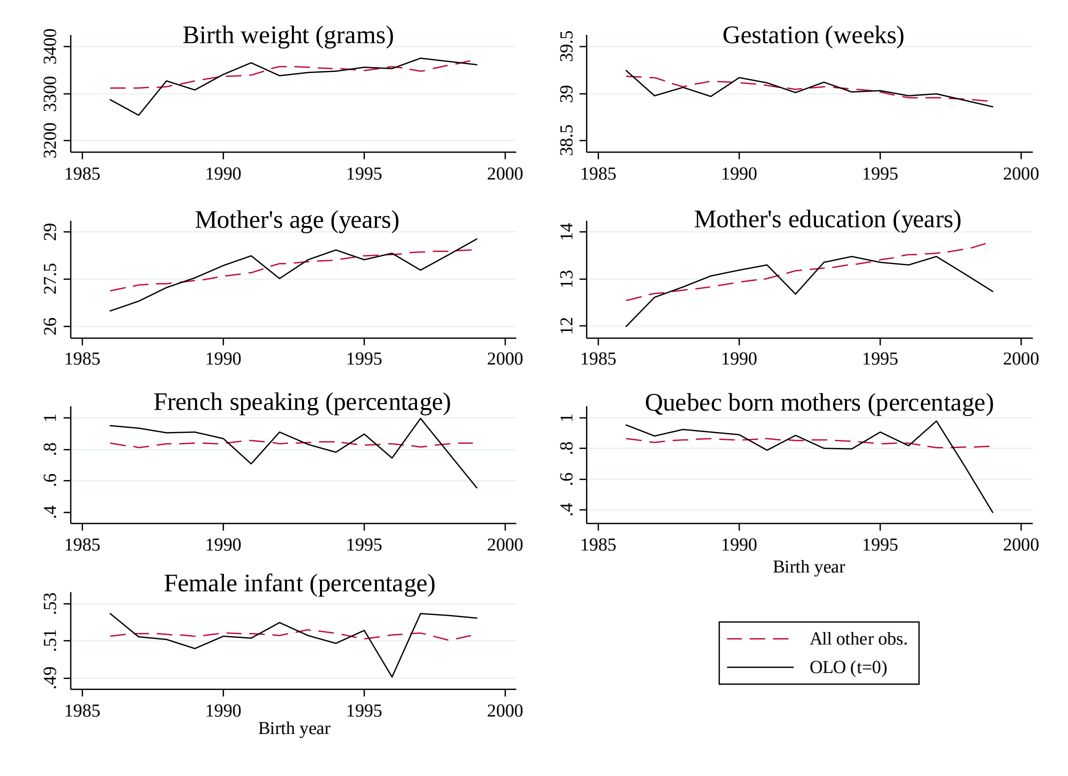
Period	1986-2008	1986-1989		1990-1993		1994-1997		1998-2001	
LCSC of residence	All obs.	In OLO	Not in OLO	In OLO	Not in OLO	In OLO	Not in OLO	In OLO	Not in OLO
Outcome variables									
Weight (grams)	3352.06	3307.31	3320.05	3346.00	3350.47	3351.62	3357.60	3373.86	3338.22
	(547.00)	(544.81)	(540.64)	(544.1)	(546.25)	(549.60)	(573.67)	(547.55)	(567.94)
Fair weight (dummy)	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.95	0.93
	(0.23)	(0.24)	(0.24)	(0.23)	(0.23)	(0.23)	(0.24)	(0.22)	(0.25)
N	1 619 736	66 556	195 998	233 999	103 735	283 253	12 482	256 451	4 604
Gestation (weeks)	38.98	39.08	39.15	39.09	39.08	39.00	38.95	38.92	38.74
	(1.80)	(1.81)	(1.79)	(1.79)	(1.80)	(1.80)	(1.86)	(1.78)	(1.81)
Full-term (dummy)	0.86	0.87	0.88	0.87	0.87	0.86	0.86	0.86	0.83
	(0.34)	(0.33)	(0.32)	(0.33)	(0.33)	(0.34)	(0.34)	(0.35)	(0.37)
N	1 609 017	66 556	195 998	233 999	103 735	283 253	12 482	256 451	4 604
Control variables									
Male	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.52
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Multiple births	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)	(0.16)	(0.16)
Birth order	1.80	1.71	1.74	1.79	1.81	1.85	1.89	1.80	1.84
	(0.97)	(0.88)	(0.91)	(0.96)	(0.94)	(1.00)	(1.07)	(1.00)	(1.04)
Birth month	6.47	6.51	6.50	6.42	6.43	6.41	6.44	6.42	6.38
	(3.37)	(3.37)	(3.37)	(3.38)	(3.38)	(3.37)	(3.38)	(3.38)	(3.42)
Mother's									
Age	28.28	27.11	27.40	27.87	27.83	28.30	27.42	28.49	26.80
	(5.03)	(4.49)	(4.63)	(4.77)	(4.76)	(5.11)	(5.28)	(5.29)	(5.24)
Years of education	13.48	12.71	12.73	13.15	12.98	13.50	12.36	13.81	12.96
	(3.04)	(2.70)	(2.83)	(2.90)	(2.91)	(3.06)	(3.12)	(3.13)	(3.12)
Mother's place of birth									
Québec	0.82	0.91	0.84	0.86	0.84	0.84	0.69	0.80	0.96
	(0.38)	(0.29)	(0.36)	(0.35)	(0.37)	(0.37)	(0.46)	(0.40)	(0.20)
RoC	0.04	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.03
	(0.19)	(0.15)	(0.16)	(0.18)	(0.18)	(0.2)	(0.21)	(0.2)	(0.17)
Other	0.14	0.07	0.13	0.10	0.13	0.12	0.26	0.16	0.01
	(0.35)	(0.25)	(0.33)	(0.31)	(0.33)	(0.33)	(0.44)	(0.36)	(0.11)
Language at home									
French	0.83	0.91	0.81	0.85	0.81	0.84	0.67	0.83	0.92
	(0.37)	(0.28)	(0.39)	(0.35)	(0.39)	(0.37)	(0.47)	(0.37)	(0.27)
English	0.11	0.06	0.13	0.09	0.11	0.10	0.11	0.11	0.04
	(0.31)	(0.23)	(0.33)	(0.29)	(0.31)	(0.3)	(0.32)	(0.31)	(0.21)
Other	0.06	0.03	0.06	0.05	0.08	0.06	0.21	0.06	0.04
	(0.24)	(0.17)	(0.24)	(0.22)	(0.27)	(0.25)	(0.41)	(0.23)	(0.19)
Civic status									
Couple	0.87	0.68	0.70	0.88	0.87	0.90	0.87	0.91	0.90
	(0.34)	(0.47)	(0.46)	(0.33)	(0.34)	(0.29)	(0.33)	(0.29)	(0.31)
Single	0.05	0.00	0.00	0.05	0.05	0.07	0.1	0.07	0.09
	(0.22)	(0.03)	(0.03)	(0.21)	(0.21)	(0.26)	(0.31)	(0.26)	(0.29)
Missing	0.08	0.32	0.30	0.08	0.09	0.02	0.02	0.02	0.01
	(0.27)	(0.47)	(0.46)	(0.26)	(0.28)	(0.15)	(0.15)	(0.14)	(0.11)
N	1 622 464	67 129	197 783	234 003	103 737	283 439	12 492	256 527	4 604

Note: Shows the mean and standard deviation (in parentheses) of the main variables available in the birth registry data. The sample used to construct this table is restricted to children born in LCSC territories for which we have the complete historic information regarding the OLO program (157 LCSC out of 167) and children for which the following variables are not missing: mother's age, years of education and place of birth, as well as primary language at home and multiple births. Fair weight is equal to 1 for birth weights of 2,500 grams or more and 0 otherwise, and full-term is equal to 1 for gestation period of 37 weeks or more and 0 otherwise.

The top panel of Table 2 shows the outcome variables (birth weight, fair weight, gestation and full-term), while the bottom panel shows the control variables. The first column presents the birth summary statistics for the entire sample, while columns 2 to 9, show the statistics by sub-period and by LCSC's participation status during the period in which the program is in expansion. Note that we do not observe which mothers were participating in the OLO program within a LCSC. We can only determine eligibility based on the mother's postal code and the LCSC's participation status. As such, all births within a LCSC's territory are either classified as being eligible for the OLO program or not. Furthermore, if a LCSC participates in the program at one point during the period, all births during that period are classified as being in the OLO program. This allows us to compare the statistics of births within LCSCs already in the program or joining the program during the observation period compared to LCSCs still not in the program. Since LCSCs with more at-risk mothers may have an incentive to join the program earlier, comparing the statistics by participation over several periods helps us assess the importance of such selection into treatment.

If we compare the mean value of the control variables by participation status within a period, we do not find evidence of LCSCs with more disadvantaged mothers joining the program earlier on. For example, looking at the 1986-1989 period, we see the mean value of mother's age and years of education is almost identical for births in the territories of LCSCs participating in the OLO program and births in LCSCs not participating in the program. This is also true during other periods. Figure 3 further shows the evolution of the characteristics of new entrants – LCSCs participating to the program for the first year – versus all others. Clearly, LCSCs with more at-risk pregnant mothers did not self-select into the program earlier.

Figure 3: Descriptive statistics of new entrants versus all others



Note: This figure shows the descriptive statistics of newly added LCSCs at $t = 0$ compared to all other LCSCs.

Looking at the outcome variables, we find that birth weight is increasing over time (from 3,316 to 3,364)[10] while gestation is fairly stable and even slightly decreaseasing (from 39.1 to 38.8). Table 2 shows that both LCSCs participating and not participating in the program follow similar trends. The increase in birth weight is slightly larger in LCSC participating to the program (+67 vs +18). While this suggests a positive impact of the OLO program, clearly the increase is not restricted to LCSCs participating to OLO. Technological changes and modifications to other safety net programs impacting disadvantaged pregnant women likely contributed to the increase in birth weight over time. The empirical strategy allows us to isolate the impacts of underlying trends not due to the OLO program.

[10]These are the average birth weights for all observations for the 1986-89 period versus 2002-08 period (not reported in the Table).

5 Empirical strategy

We exploit the progressive geographic implementation of the program in a differences-in-differences framework, where LCSCs not yet participating in the program serve to control for underlying trends in the outcome variables. The empirical model is as follow:

$$Y_{ict} = \alpha + \delta OLO_{ct} + \gamma_1 X_{it} + \vartheta_c + \rho_t + \varepsilon_{ct} \quad (1)$$

where Y_{ict} is the outcome variable (e.g. birth weight) of child i in LCSC c in time t. The term OLO_{ct} equals 1 if the LCSC is running the OLO program at time t, and 0 otherwise. The terms ϑ_c and ρ_t are fixed effects for LCSC and year. The LCSC fixed-effects account for regional permanent differences, while the year fixed-effects account for underlying trends in the outcome variables which could result from technological progress during the period or changes to programs affecting disadvantaged pregnant women (e.g. cash transfers)[11]. The estimated impacts of the program are unbiased if there are no LCSC-level variations that are correlated with the implementation of the program and influence infant health at birth. To verify the robustness of our results, we also control for cofounding factors, including child and family characteristics X_{it}. In some specifications, we also interact the OLO_{ct} dummy with years in the OLO program dummies to allow for a progressive impact of the program. Indeed, one can expect that it takes a few years for a LCSC to reach 100% of its targeted population. The empirical model becomes:

$$Y_{ict} = \alpha + \delta_1 OLO^1_{ct} + \delta_2 OLO^2_{ct} + \delta_3 OLO^3_{ct} + \delta_4 OLO^4_{ct} + \delta_5 OLO^5_{ct} + \gamma_1 X_{it} + \vartheta_c + \rho_t + \varepsilon_{ct} \quad (2)$$

where OLO^1_{ct} equals 1 if the LCSC is running the OLO program for the first year in time t, and 0 otherwise, and the same logic holds for OLO^2_{ct} to OLO^4_{ct} while the term OLO^5_{ct} equals 1 if the LCSC is running the OLO program for the fifth year or more in time t, and 0 otherwise. We cluster on LCSC and report cluster-robust standard errors. Finally, we also

[11] Note that the results presented below are robust to controlling for underlying time trends using the LCSCs not offering the OLO program in combination with those who started offering the program before 1986.

estimate this model on different sub-groups of the population to assess the heterogeneity of the impact of the program.

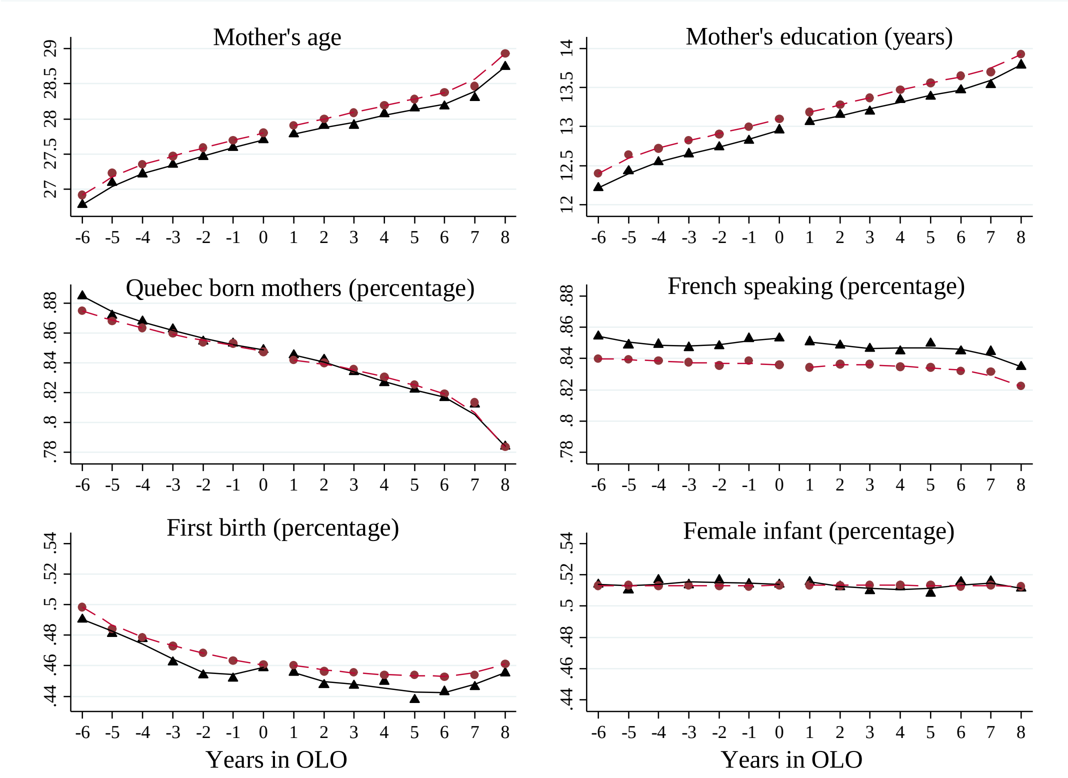
Four outcome variables are used: birth weight, fair weight dummy (equal to 1 for birth weights of 2,500 grams or more), weeks of gestation, and full-term dummy (equal to 1 for gestation period of 37 weeks or more). As mentioned above, birth weight is a key indicator of health at the time of birth and has been shown to influence later life health and socioeconomic outcomes. Gestation is also an important measure as it is closely related to birth weight. Furthermore, a number of permanent health conditions may result from preterm birth. We therefore measure the impact of the program on the probability of carrying the baby to term. For binary outcome variables, we use a logit approach and report the average marginal effect across all observations.

6 Results

Before proceeding to the results, we first check that the main characteristics of mothers and infants followed similar trends pre and posttreatment in both the treatment and control groups. In theory, mothers could change their area of residence to become eligible to the program, so we want to make sure that selective manipulation of treatment status is not a serious concern. Figure 4 shows the evolution of these caracteristics over time. Since the rollout takes place over many years, in each time period we set the clock to $t = 0$ the year prior to the implementation of the program and then aggregate the results. We find that the trends in maternal and infant characteristics are extremely similar. Maternal age and years of education increase over time in both groups. In both groups, the percentage of French speaking mothers and female infant is stable, and the percentage of Quebec born mothers and first birth decreases. In sum, our control group captures well the evolution of maternal and infant characteristics over time and there is no evidence of selection into treatment.[12]

[12] This is reasonnable given the cost a moving compared to the monetary value of the OLO program (about $543 in 2008).

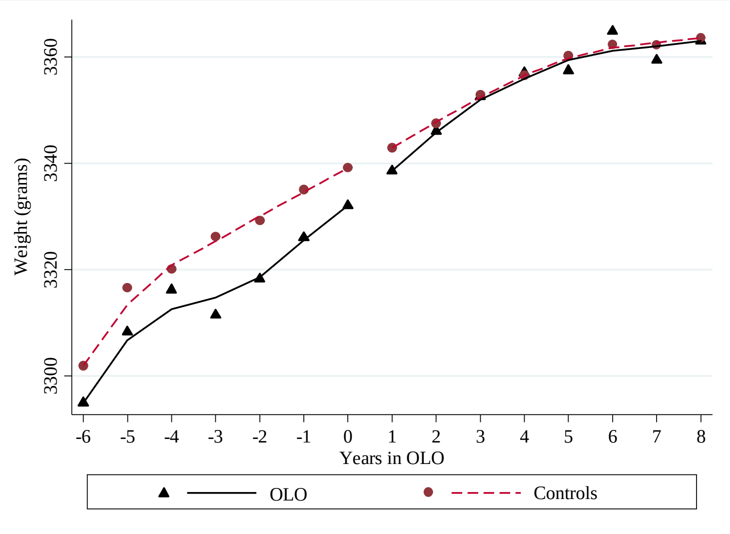
Figure 4: Individual characteristics by treatment status



Note: This figure shows the trends in individual characteristics by treatment status over time (we use triangles for OLO and circles for the controls, and $t = 0$ marks the last year prior to observing treated OLO babies).

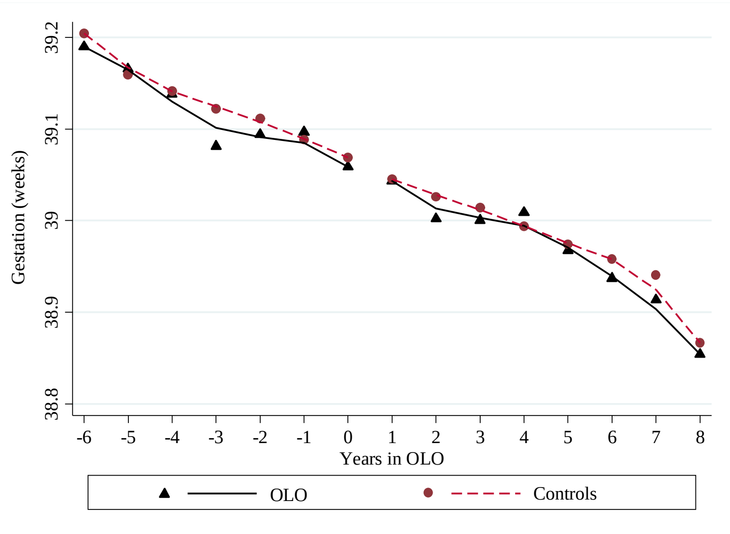
Our identification strategy also relies on the assumption that control and treated LCSCs share a common trend in the outcome variables. Figures 5 and 6 show the descriptive evolution of mean birth weight and gestation. Prior to the program, birth weight is slightly below in treated LCSCs but clearly follows a similar trend. The gap is partially eliminated in the first year of the program, and, over time, treated LCSCs completely close the gap. This suggests a progressive impact of the program. For gestation (measured in weeks), both the treatment and control groups show a slightly negative trend over time. There are no apparent differences suggesting a positive or negative impact of the program. Together, these figures suggest that our empirical approach is well suited to isolate the impact of the OLO program from the underlying evolution of the outcome variables.

Figure 5: Birth weight by treatment status



Note: This figure shows the trends in birth weight by treatment status over time. $t = 0$ marks the last year prior to observing treated OLO babies

Figure 6: Average weeks of gestation by treatment status



Note: This figure shows the trends in gestation by treatment status over time. $t = 0$ marks the last year prior to observing treated OLO babies

Birth weight Table 3 presents the estimates of the impact of the OLO program on birth weight (top panel) and the probability of delivering a fair weight baby (bottom panel). For each panel, we first present the average impact of the program (δ) estimated using model (1). Then we present the progressive impact of the program (δ_1 to δ_5) estimated using model (2). Set 1 includes the year dummies (ρ_t) and LCSC dummies (ϑ_c) only, while set 2 additionally includes the child and family characteristics (X_{it}). First we estimate both models using the full sample to which we have access which covers all births between 1986 and 2008. Second, we estimate both models using only birth records between 1986 and 2004. Since the majority of the implementation of the OLO program took place between 1986 and 1999, this smaller time period allows a maximum of 5 years post implementation for the last LCSCs joining the OLO program. We do this to ensure that our larger data set is not driving our results.[13]

Improving the birth weight outcome is one of the primary objectives of the OLO program. Through improved proteins and caloric intakes, it is expected that babies of disadvantaged mothers should attain a more desirable weight. Since we do not identify which babies are treated by the program or not, Table 3 reports the intention-to-treat (ITT) effects of the program. In other words, it reports the average effect of the program across all births as opposed to the specific effect of the program on babies of mothers participating in the program. To recover treatment-on-the-treated (TOT) effects, we multiply the estimated impacts by a factor of 13.16 which is the inverse of the percentage of treated births in 1995. The OLO Foundation provided the information on the number of babies born under the OLO program between 1993 and 1995. The percentage of treated babies (through their mothers) in the LCSC who joined the OLO program during our observation period is 4.8% in 1993 and increases to 7.6% by 1995. Today, the percentage of treated babies is estimated at 14.8%. Since 1995 marks the middle point of our main observation period, we assume that 7.6% is likely to be the average number of treated babies during our sample period, with the percentage being smaller prior to 1995 and likely higher after as the program progresses. Therefore, the average treatment effect is weakly significant and suggests an increase in birth weight of the order of 68.9 grams (set 1: 5.237/0.076) if we do not control for child and

[13] We also computed the estimates for 1986 to 2001 and obtained comparable results.

family characteristics, and 67.4 grams (set 2: 5.123/0.076) if we do. Since the composition of LCSCs may have changed over time, it appears important to control for child and family characteristics. Restriction to births prior to 2005 leads to comparable results: 73.9 and 66.2 grams for set 1 and 2 respectively.

Table 3: Estimated impacts on birth weight and fair weight

Period	1986-2008		1986-2004	
Controls	set 1	set 2	set 1	set 2
Weight (grams)				
OLO (δ)	5.237	5.123*	5.619*	5.028*
	(3.172)	(2.830)	(2.903)	(2.650)
Year 1 (δ_1)	1.862	2.576	2.324	2.693
	(2.958)	(2.618)	(2.746)	(2.483)
Year 2 (δ_2)	5.865	5.570*	6.546*	5.824*
	(3.675)	(3.329)	(3.488)	(3.234)
Year 3 (δ_3)	5.577	4.894	6.368*	5.166*
	(3.617)	(3.317)	(3.319)	(3.107)
Year 4 (δ_4)	9.698**	8.822**	10.676**	9.188**
	(4.607)	(4.04)	(4.379)	(3.86)
Year 5 (δ_5)	8.577*	9.158**	10.250**	9.728**
	(4.495)	(4.005)	(4.262)	(3.812)
Fair weight (dummy)				
OLO (δ)	0.002***	0.002***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Year 1 (δ_1)	0.001*	0.002**	0.002*	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Year 2 (δ_2)	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Year 3 (δ_3)	0.004***	0.003***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Year 4 (δ_4)	0.004***	0.003***	0.004***	0.004***
	(0.002)	(0.001)	(0.002)	(0.001)
Year 5 (δ_5)	0.003**	0.003***	0.003***	0.003**
	(0.001)	(0.001)	(0.002)	(0.001)
N	1 619 736		1 347 494	

Note: Shows the estimated impacts of the OLO program on birth weight (top panel) and the probability of delivering a fair weight baby (bottom panel). The OLO coefficient refers to the average impact across years, while the Year 1 to Year 5 coefficients refer to the progressive impact of the program from year 1 to year 5 plus. Therefore, each column reports the results of four different specifications (two per outcome variable). Set 1 includes only year and LCSC dummies. Set 2 includes year and LCSC dummies, and the following control variables: male (dummy), twin and triplets plus dummies (single omitted), maternal age categories (16 or less, 17 to 35, above 35 omitted), years of education dummies, months of birth dummies, birth order (first birth, second birth, third or more omitted), language at home dummies (French, English, other omitted), and the mother's place of birth dummies (Québec, RoC, other omitted). All standard errors are clustered on LCSC. Significance is denoted using asterisks: *** is p<0.01, ** is p<0.05, and * is p<0.1.

The progressive impacts suggest that during the first year the estimated effect (δ_1) is postive but not significant. As time progresses the impact increases and eventually reaches 120.5 grams (9.158/0.076) when we control for X_{it} (and 128.0 grams (9.728/0.076) when we exclude births between 2005 and 2008). These effects are not only large (larger than those estimated by Hoynes and al. (2011) on WIC), they are also significant ($p < 0.05$). One interpretation is that the OLO program takes time to reach its target population. The process by which pregnant women are referred to the program is not automated. Doctors and health practitioners may refer pregnant women to the program, and pregnant women may also directly contact the administrators of the program in their LCSC. It is therefore highly plausible that in the first few years, only a small fraction of eligible pregnant women participated in the program. At the end of the observation period (year 2008), the OLO Foundation estimates that most of its target population was being served across the province.

Fair weight We now turn to the probability of delivering a fair weight baby (above or equal to 2,500 grams). The bottom panel of Table 3 reports the estimated ITT effects. The results suggest that the program increases the probability of having a fair weight baby by 0.3% across the entire population, or that participation in the program increases the probability by 3.4% for the treated group (0.0026/0.076). This effect is not only positive, but highly significant and holds across all four models.

Again the progressive effects suggest that in the first year the program has no effect, but eventually reaches 0.3–0.4% which implies that participating pregnant mothers have a probability of delivering a fair weight baby that is 4.6% higher (0.0035/0.076). Since the 2,500 grams threshold marks a point where the likelihood of having birth defects leading to chronic health conditions are greatly reduced, these findings have potentially important implications for the health care system. We come back to these when we conduct the cost-benefit analysis.

Gestation and full-term Table 4 presents the estimates of the impact of the OLO program on weeks of gestation (top panel) and the probability of carrying the baby to term (bottom panel). The structure of the table follows that of Table 3 with results from model (1) presented first followed by results from model (2).

Table 4: ESTIMATED IMPACTS ON GESTATION AND FULL-TERM

Period	1986-2008		1986-2004	
Controls	set 1	set 2	set 1	set 2
Gestation (weeks)				
OLO (δ)	0.007	0.007	0.012	0.010
	(0.015)	(0.014)	(0.013)	(0.012)
Year 1 (δ_1)	0.005	0.007	0.008	0.010
	(0.013)	(0.013)	(0.012)	(0.012)
Year 2 (δ_2)	0.003	0.003	0.008	0.006
	(0.016)	(0.015)	(0.015)	(0.014)
Year 3 (δ_3)	0.005	0.002	0.011	0.007
	(0.017)	(0.017)	(0.016)	(0.015)
Year 4 (δ_4)	0.021	0.018	0.028	0.023
	(0.019)	(0.018)	(0.018)	(0.017)
Year 5 (δ_5)	0.011	0.014	0.020	0.020
	(0.024)	(0.023)	(0.022)	(0.021)
Full-term (dummy)				
OLO (δ)	0.004***	0.004***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Year 1 (δ_1)	0.003*	0.003**	0.004**	0.004**
	(0.002)	(0.001)	(0.002)	(0.001)
Year 2 (δ_2)	0.003*	0.002	0.004**	0.003**
	(0.002)	(0.001)	(0.002)	(0.001)
Year 3 (δ_3)	0.004**	0.003**	0.005***	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Year 4 (δ_4)	0.006***	0.006***	0.008***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
Year 5 (δ_5)	0.004**	0.005***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
N	1 609 017		1 336 770	

Note: Shows the estimated impacts of the OLO program on gestation weeks (top panel) and the probability of caring the baby to term (bottom panel). The rest of the table follows the same structure as Table 3. All standard errors are clustered on LCSC. Significance is denoted using asterisks: *** is p<0.01, ** is p<0.05, and * is p<0.1.

Increasing the number of weeks of gestation also contributes to improving the health of the newborn. Table 4 reports the estimated ITT effects on weeks of gestation. Results suggest that the program did not have any significant effects on gestation on average (δ) or in the first five years (δ_1 to δ_5). The TOT after five years, once we include controls, is 0.30 weeks (0.020/0.076), which is about 1.8 days. This effect is small but comparable to other findings in the WIC literature. One important limitation relates to the accuracy and precision of the gestation measure available to researchers. Not only is gestation measured in weeks, it is measured rather imprecisely. Therefore, it remains possible that the supplemental nutrition program increases gestation by a few days, but the available measures prevent us from detecting this effect.

We now look at the impact of the program on the probability of carrying a baby to term (37 weeks or more). We find strongly significant effects for both observation periods of the order of 0.004. This implies that for those treated by the program, the probability of carrying a baby to term increases by 5.3% (0.004/0.076). Looking at the progressive effects, we find that the effect is generally increasing and significant. For both observation periods the results 5 years post implementation (δ_5) suggest that the program significantly increases the probability of carrying a baby to term by about 6.3% (0.0048/0.076) to 8.5% (0.0065/0.076).

Program heterogeneity Finally we assess the impact of the program across various subgroups of the population. In Table 5, results from specifications based on model (1) and (2) are presented for each subgroup and always control for child and family characteristics (X_{it}). First, the impact of the program appears to differ by mother's education level (estimated using the number of years of education completed). The birth weight of babies whose mothers have at least a high school degree but have not yet started university is higher by about 91.7 grams (6.971/0.076).[14] This is also true on average for mothers having at least one year of university education. These findings are also reflected in the probability of delivering a fair weight baby. Although the birth weight of babies of mothers with no more than a high school degree does not seem to increase significantly, the probability of delivering a fair weight baby increases due to the program (0.003). When we focus on university educated mothers aged less than 28 we notice that the effect is large and significant early on, but quickly fades. One interpretation is that mothers aged less than 28 are more likely to still

[14] We use 13.16 to recover ATE even within the subgroups because we have no information on the participation rate by subgroup.

Table 5: Estimated impacts on birth weight outcomes by subgroup

	Mother's education					Civc Status	Multiple births		Mother's place of birth			Birth order	
	High School ≤ 13 years all	In Between 13 to 15 years all	University ≥ 16 years all	University ≥ 16 years aged <28	University ≥ 16 years aged >=28	Single	One Child	Twins	Québec	RoC	Other	First	Second or more
Weight													
OLO	3.554	6.971*	8.880**	16.883**	5.227	4.153	5.306*	-3.343	5.937**	3.492	5.262	8.077**	2.838
	(3.374)	(3.926)	(4.321)	(6.511)	(4.865)	(7.950)	(2.818)	(16.777)	(2.986)	(11.767)	(5.789)	(3.149)	(3.366)
Year 1	1.720	2.807	6.090	25.331***	-1.807	5.886	2.819	-11.269	2.746	22.539	0.618	7.131**	-1.121
	(3.614)	(4.023)	(5.203)	(9.537)	(5.997)	(11.207)	(2.583)	(20.466)	(2.654)	(14.039)	(7.366)	(3.566)	(3.347)
Year 2	2.464	6.971	13.660***	19.108**	10.938*	-2.275	5.969*	-10.804	6.544*	7.255	3.358	4.782	6.511
	(3.982)	(5.164)	(5.103)	(9.505)	(6.089)	(11.662)	(3.313)	(24.05)	(3.583)	(13.054)	(7.036)	(4.285)	(4.024)
Year 3	2.794	8.760*	7.596	5.220	8.045	7.124	4.763	14.148	6.073*	-19.554	10.111	9.623**	1.184
	(4.289)	(5.292)	(5.485)	(8.562)	(6.272)	(9.842)	(3.352)	(25.741)	(3.603)	(16.19)	(7.414)	(4.118)	(3.992)
Year 4	9.413*	11.742**	7.805	14.811*	4.220	5.962	8.976**	1.142	10.219**	-8.753	9.119	12.767***	5.605
	(5.36)	(5.432)	(6.168)	(8.783)	(6.892)	(11.184)	(4.070)	(26.963)	(4.351)	(14.788)	(7.62)	(4.684)	(5.015)
Year 5	8.751*	12.730**	9.956	7.696	9.838	5.782	9.239**	2.199	10.435**	-4.506	11.648	10.871**	7.843
	(5.031)	(5.691)	(6.574)	(9.729)	(7.014)	(10.442)	(3.892)	(21.376)	(4.134)	(18.148)	(7.802)	(4.257)	(4.967)
Fair weight (dummy)													
OLO	0.003**	0.002	0.003**	0.002	0.003*	-0.001	0.002***	-0.002	0.003***	0.006	0.002	0.003**	0.002**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.001)	(0.013)	(0.001)	(0.004)	(0.002)	(0.001)	(0.001)
Year 1	0.002	0.000	0.004*	0.004	0.003	-0.005	0.002*	0.006	0.001	0.016***	0.002	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.005)	(0.001)	(0.016)	(0.001)	(0.005)	(0.002)	(0.002)	(0.001)
Year 2	0.003	0.002	0.002	0.000	0.003	-0.001	0.002**	-0.013	0.002**	0.001	0.000	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.006)	(0.001)	(0.021)	(0.001)	(0.006)	(0.003)	(0.002)	(0.001)
Year 3	0.005**	0.002	0.004*	0.002	0.005*	0.004	0.003***	-0.002	0.004***	0.000	0.004	0.004**	0.003**
	(0.002)	(0.002)	(0.002)	(0.004)	(0.003)	(0.005)	(0.001)	(0.02)	(0.001)	(0.005)	(0.002)	(0.002)	(0.001)
Year 4	0.003	0.004**	0.003	0.001	0.004	-0.001	0.003**	0.003	0.004***	-0.001	0.000	0.004**	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.001)	(0.021)	(0.001)	(0.005)	(0.003)	(0.002)	(0.002)
Year 5	0.004**	0.004**	0.001	-0.004	0.002	-0.005	0.003**	-0.005	0.003*	0.006	0.005*	0.003*	0.003*
	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)	(0.005)	(0.001)	(0.017)	(0.001)	(0.006)	(0.003)	(0.002)	(0.001)
N	713 318	479 957	426 461	103 633	322 828	85 003	1 581 394	37 313	1 330 297	57 549	231 890	745 511	874 225

Note: Shows the estimated impacts of the OLO program on birth weight (top panel) and the probability of delivering a fair weight baby (bottom panel) by subgroup (defined at the top of each column). Again, the OLO coefficient refers to the average impact across years, while the Year 1 to Year 5 coefficients refer to the progressive impact of the program from year 1 to year 5 plus. Therefore, each column reports the results of four different specifications (two per outcome variable). All specifications use the entire sample (period 1986 to 2008) and include all available control variables (Set 2 definition in Table 3). All standard errors are clustered on LCSC. Significance is denoted using asterisks: *** is $p<0.01$, ** is $p<0.05$, and * is $p<0.1$.

be studying or just entering the labor market, and as a result more likely to be eligible for the program. University educated mothers aged more than 27 do not seem to benefit from the program. These mothers are less likely to be participating in the program in the first place as they typically earn higher incomes and therefore would not be eligible.

Looking at the long run effects we find that highly educated mothers no longer experience largely significant effects after 5 years while less educated mothers (high school) have important significant effects: 115.1 grams and 5.3%. Mothers with 13 to 15 years of education also experience important positive effects.

We now look at civic status. Table 2 revealed that civic status was often missing. This is especially true in the early years of the program's implementation. Furthermore, since only a small fraction of infants are born in single parent families (about 5%), the sample size is relatively small and focused on implementations starting in 1990. We find that the impacts on birth weight appear to be large, but not significant.

On average and in the long run, the program appears to benefit mothers expecting a single child but not twins. The coefficients for the average effect is 5.3: in the first year the impact of the program is not significant at 2.8 and as of year 2 it becomes significant and increases up to 9.2 after 5 years, which suggests an impact on birth weight of the order of 121.6 grams. Results on fair weight mirror those of birth weight. Results on twins should be interpreted with caution as the sample size is about 10 observations per LCSC-year which is not sufficient to derive conclusive results for this subgroup.

The mother's place of birth seems to be playing a role also, with babies of mothers' born in Québec and the RofC gaining more weight than babies of other mothers, but it is only significant for Québec born mothers. While the progressive impact is increasing for Québec born mothers, it is decreasing and even negative (but not significant) for mothers born in the RofC. With 15 observations per LCSC-year on average, the sample size for RofC mothers is too small to draw any firm conclusion. For mothers born outside of Canada the estimated coefficient is comparable to that of Québec born mothers but not significant. The progressive effect is steep (but remains not significant). At first this may be surprising, but since participation in the program is not automatic when one meets the criteria, it may only reflect that these mothers are less aware of the program in the first few years. These mothers are often more isolated since they are far from their families and in an environment that is less familiar, and are therefore more likely to be in a situation of need from a nutritional standpoint. Informal discussions with practitioners in the field indeed reveal that a growing number of participating mothers recently immigrated to Canada.

Finally, we look at birth order. We find that the effect of the program is bigger for first born babies, both in terms of weight and probability of being fair weight (106.3 vs 37.3 grams; 3.9% vs 2.6%). Although the same food basket is provided to both groups, we have no data on whether or not mothers actually consume the food provided by the program. Mothers in situations of poverty who already have children could be inclined to give the food to their children instead of consuming the food themselves. This hypothesis is supported by our discussions with practitioners in the field. It appears that only regular counselling explaining the reasons why it is important for the mother to consume the food herself may prevent this behavior. For both groups, we observe that the estimates from model (2) are increasing over time. Early on in the program, counselling was limited. Over the years, counselling became more prevalent, which may explain the convergence of the impacts between both groups. A complementary interpretation is that mothers having a first baby are generally younger and more likely to be either studying or earning lower wages. They may also be more likely to seek help or be referred to the program as this is their first experience with childbearing. Their participation rate may thus be higher, such that the long run TOT may very well be the same across both groups. Unfortunately we do not have this level of detail on the participation rate.

Table 6 shows the estimated effects by subgroup on gestation and the probability of carrying the baby to term. In general, most of the estimated effects are not significant. A few exceptions lie in the long run effects (5 years). These are in line with previous findings, such that the probability of caring a baby to term is higher for less educated mothers, single births, and Québec born mothers.

Table 6: Estimated impacts on gestation outcomes by subgroup

	Mother's education					Civc Status	Multiple births		Mother's place of birth			Birth order	
	High School $\leq$ 13 years all	In Between 13 to 15 years all	University $\geq$ 16 years all	University $\geq$ 16 years aged <28	University $\geq$ 16 years aged >=28	Single	One Child	Twins	Québec	RoC	Other	First	Second or more
Gestation (weeks)													
OLO	0.002	0.022	0.019	0.024	-0.003	-0.128	0.003	0.010	-0.025	0.02	0.01	0.004	0.000
	(0.016)	(0.019)	(0.024)	(0.02)	(0.033)	(0.079)	(0.015)	(0.014)	(0.034)	(0.021)	(0.015)	(0.015)	(0.000)
Year 1	0.004	0.002	0.028	0.048	0.021	0.029	0.010	-0.169	0.003	0.017	0.017	0.019	-0.003
	(0.014)	(0.017)	(0.02)	(0.03)	(0.022)	(0.04)	(0.012)	(0.105)	(0.013)	(0.045)	(0.021)	(0.016)	(0.015)
Year 2	0.004	-0.006	0.017	0.021	0.017	0.034	0.007	-0.172	0.001	-0.029	0.007	-0.009	0.012
	(0.018)	(0.018)	(0.021)	(0.036)	(0.022)	(0.047)	(0.015)	(0.111)	(0.015)	(0.042)	(0.027)	(0.017)	(0.016)
Year 3	-0.003	0.001	0.021	0.006	0.027	-0.065	0.004	-0.043	-0.002	-0.090*	0.039	0.013	-0.007
	(0.019)	(0.022)	(0.023)	(0.034)	(0.025)	(0.041)	(0.017)	(0.128)	(0.018)	(0.047)	(0.028)	(0.019)	(0.018)
Year 4	0.021	0.016	0.022	-0.011	0.034	-0.008	0.021	-0.093	0.016	-0.015	0.013	0.016	0.020
	(0.021)	(0.022)	(0.026)	(0.036)	(0.028)	(0.044)	(0.018)	(0.126)	(0.019)	(0.044)	(0.031)	(0.02)	(0.020)
Year 5	0.017	0.010	0.016	-0.018	0.029	-0.037	0.016	-0.087	0.005	-0.017	0.043	0.013	0.014
	(0.027)	(0.024)	(0.03)	(0.039)	(0.03)	(0.047)	(0.023)	(0.113)	(0.025)	(0.048)	(0.03)	(0.024)	(0.025)
Full-term (dummy)													
OLO	0.004	0.003	0.005*	0.004	0.006*	0.005	0.004*	0.006	0.004*	0.003	0.003	0.003	0.005*
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.006)	(0.002)	(0.015)	(0.002)	(0.006)	(0.003)	(0.002)	(0.002)
Year 1	0.004*	0.002	0.004	0.005	0.003	0.009	0.003	0.014	0.003*	0.005	0.002	0.004	0.003
	(0.002)	(0.003)	(0.003)	(0.005)	(0.003)	(0.007)	(0.002)	(0.019)	(0.002)	(0.009)	(0.004)	(0.003)	(0.002)
Year 2	0.003	0.001	0.005	0.005	0.005	0.006	0.003	-0.004	0.003	0.010	0.000	0.000	0.005*
	(0.003)	(0.003)	(0.003)	(0.006)	(0.004)	(0.008)	(0.002)	(0.02)	(0.002)	(0.008)	(0.004)	(0.002)	(0.003)
Year 3	0.002	0.005	0.008**	0.003	0.009**	-0.003	0.004	0.01	0.004	-0.010	0.005	0.004	0.004
	(0.003)	(0.004)	(0.003)	(0.006)	(0.004)	(0.008)	(0.003)	(0.022)	(0.003)	(0.008)	(0.004)	(0.003)	(0.003)
Year 4	0.008**	0.004	0.006	0.002	0.007*	0.012	0.006**	0.002	0.006**	0.006	0.003	0.005*	0.007**
	(0.003)	(0.004)	(0.004)	(0.006)	(0.004)	(0.008)	(0.003)	(0.023)	(0.003)	(0.008)	(0.005)	(0.003)	(0.003)
Year 5	0.007*	0.004	0.004	0.000	0.005	0.000	0.005	0.005	0.005	0.001	0.006	0.004	0.007
	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)	(0.009)	(0.004)	(0.022)	(0.004)	(0.009)	(0.005)	(0.004)	(0.004)
N	708 128	476 714	424 175	103 049	321 126	84 588	1 570 863	37 127	1 322 536	56 776	229 705	740 621	868 396

Note: Shows the estimated impacts of the OLO program on gestation in weeks (top panel) and the probability of caring the baby to term (bottom panel) by subgroup (defined at the top of each column). Again, the OLO coefficient refers to the average impact across years, while the Year 1 to Year 5 coefficients refer to the progressive impact of the program from year 1 to year 5 plus. Therefore, each column reports the results of four different specifications (two per outcome variable). All specifications use the entire sample (period 1986 to 2008) and include all available control variables (Set 2 definition in Table 3). All standard errors are clustered on LCSC. Significance is denoted using asterisks: *** is $p<0.01$, ** is $p<0.05$, and * is $p<0.1$.

In sum, we find positive and significant effects on birth weight and the probability of delivering a fair weight baby. The effect is generally increasing over time and is larger for less educated mothers, single births, children of mothers' born in Québec and first born babies.

Discussion We find strong evidence of a positive impact of the OLO program on birth weight and the probability of delivering a fair weight baby. The average impact on birth weight is of the order of 67 grams. While this is two times larger than comparable estimates of the WIC program (29 grams, Hoynes et al. (2011)), it is however smaller than the 107 to 146 grams reported by Higgins et al. (1989) using sibling fixed-effect. Although the 95% confidence intervals of the coefficients overlap in both cases, variations in characteristics of each studied program may explain the differences. First of all, the WIC program allows mothers to choose among a large variety of food items, while the OLO program offers a fixed basket every day ensuring that all nutrients are covered. This more rigid approach may be more successulf in ensuring that mothers consume all of the necessary nutrients. Second, the largest effects reported in Higgins et al. (1989) are for mothers who received at least 4 individual nutrition counselling sessions. The OLO program relies more on group counselling and fewer sessions. Both the OLO and WIC program devote a similar fraction of their total costs to administration and counselling. The different effects found in the literature may be due to the nature of the treatment.

An alternative explanation is that since the OLO food baskets are complemented by nutrition counselling, there is a possibility that the estimated impacts do not result from better nutrition, but from behavioral changes resulting from counselling. For example, counselling may lead to reduced smoking while pregnant. While the magnitude of the effect of smoking while pregnant on infant birth weight remains an active research area, the consensus appears to be that it has an adverse effect on birth weight (see for example Abraveya (2006)). Understanding the mechanisms by which prenatal nutrition programs may work has seldom been done in this literature. An exception is Rossin (2014) and Bitler and Currie (2005). Bitler and Currie (2005) estimate the relationship between WIC participation and prenatal care. Rossin (2014) estimates the impact of WIC access on pregnancy behaviors (including smoking, prenatal care, diabetes and hypertension).

Using Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY), we estimate the impact of having access to the program on maternal behavior during pregnancy. Our sample includes children born between 1992 and 1998. Again, we have their residential postal code and can implement the same empirical strategy, though for a shorter time period. Using equation 1, we estimate the impact of the OLO program on maternal health, prenatal care and behavior during pregnancy (Y_{ict}). The NLSCY includes several indicators of risky behaviors such as smoking, drinking alcohol, consuming over the counter drugs or prescription medication during pregnancy. It also provides information on the type of prenatal care received (by a doctor or not) and the presence of diabetes and high blood pressure during pregnancy.

Our results, presented in Table 7, suggest that maternal health and behavior did not change following the introduction of the program. All estimated impacts, except for diabetes, either suggest a worsening of maternal behavior and health, or no effect at all. None are statistically significant. Rossin (2014) also finds similar evidence, although she argues that the benefit of WIC may partially reflect the fact that WIC clinics may serve as a gateway for other social services, such as Medicaid and Food Stamps. This is unlikely to be as prevalent in Canada, since health care is free for everyone and the OLO program is provided in clinics that would otherwise exist even without the program (in contrast to the mobile WIC clinics presented in Rossin (2014)).

Table 7: Average impact on maternal behavior and health

	Set 1		Set 2		
	coef	s.e.	coef	s.e.	N
Diabete	-0.02	(0.03)	-0.03	(0.03)	2,556
Highblood pressure	0.00	(0.03)	0.01	(0.02)	2,556
Prenatal care by a doctor	-0.00	(0.03)	0.00	(0.03)	2,555
No prenatal care	0.01	(0.02)	0.01	(0.02)	2,555
Smoking	-0.01	(0.04)	-0.00	(0.04)	2,556
Alcohol	0.01	(0.04)	0.02	(0.04)	2,555
Prescription medication	0.03	(0.04)	0.03	(0.04)	2,555
Over the counter drugs	0.00	(0.04)	0.00	(0.04)	2,555
Trend + CLSC	yes		yes		
Maternal characteristics	no		no		

Shows the estimated impacts of the OLO program on maternal health and risky behavior. Maternal characteristics include the age group of the mother at child birth (25-29, 30-34, 35 or more with 14-24 the omitted group), the mother's highest level of education (less than a high school diploma, high school diploma, some postsecondary education, with postsecondary diploma, the omitted group), the presence and number of older or younger siblings or the presence of a child of the same age, and the size of the community (five groups from rural to 500,000 or more the omitted group). Significance is denoted using asterisks: *** is $p<0.01$, ** is $p<0.05$, and * is $p<0.1$.

Finally, one might wonder whether the food is actually consumed by the mother. Although we cannot directly measure maternal food consumption, we know from the OLO Foundation that around 90% of all the vouchers are redeemed at local food stores. Obviously, purchasing does not imply that the mother consumed the food herself, but it is likely that she benefits from it at least partially. Together, these findings support the idea that better nutrition may be the leading cause of birth weight gains in the Canadian context.

7 Program cost and benefit analysis

Underweight babies drive important neonatal hospital costs and carry a greater risk of malformation leading to chronic health conditions. Our results suggest that the OLO program increases the birth weight of babies of treated mothers and increases the probability of delivering fair weight babies. More specifically, we showed above that the probability of delivering a fair weight baby for the overall population increases by 0.257% on average due to the program.

Table 8 shows the neonatal costs by birth weight category (<750, 750-999, 1000-1499, 1500-1999, 2000-2499, >=2500). In order to assess the neonatal cost savings of the OLO program, we estimate the impact of the program on the probability of delivering a baby within these various categories. We find that the probability of delivery diminishes in each of the categories except for the >=2500 category where it increases. Theses effects show that the OLO program mainly impacted infants who would, without the program, have had a birth weight between 2000-2499 grams but thanks to the program reached the 2500 grams threshold. It also shows that much smaller infants (below 1000 grams) also benefited from the program and reached higher birth weights. Multiplying the average neonatal hospital cost by the average intention to treat effect by category, allows us to infer the average neonatal hospital cost savings of the program (ITT). Using the participation rate (7.6%), we find a total neonatal cost savings per treated infant of $413 (reference year 2005). If we use the long run effects of the program (5 years or more, $OLO5$), we find a total cost savings per treated infant of $524. A lower bound estimate using today's percentage of treated infant (14.8%) would be $269.

Table 8: Average neonatal cost by birth weight in Canada

Birth Weights (grams)	Avg. neonatal hospital costs ($)	OLO effect (%)	Avg. cost savings ($)	OLO5 effect (%)	Avg. cost savings ($)
<750	117,806	-0.0031	3.64	-0.0024	2.83
750-999	89,751	-0.0129	11.54	-0.0209	18.11
1000-1499	42,133	-0.0101	4.23	-0.0107	4.48
1500-1999	15,952	-0.0310	4.95	-0.0296	4.71
2000-2499	4,617	-0.2061	9.53	-0.2817	13.00
>=2500	952	0.2648	-2.52	0.3474	-3.31
Savings (ITT)			31.36		39.82
Savings per treated child (TOT 7.6%)			412.63		524.00

Source: Statistics Canada, CANSIM Table 102-4509, year 2005 and own calculation.

In 2008, the total program cost was $7.057M[15] and the number of treated babies was about 13,000. This implies a program cost per baby of the order of $543[16]. Therefore the

[15] The program cost includes all costs related to the program paid by the PCNP and all costs supported by the OLO Foundation (including the book value of services and items provided to the Foundation). The cost therefore includes the value of food items, the compensation paid to dietitians and nurses involved in the program and the overall administration cost of the program.

[16] This corresponds to a cost of $374 USD in 2004, which is comparable to WIC, at $49 per month for 7

cost of the program outweighs the average neonatal cost savings over the period by $19 to $274. These savings however fail to account for the cost of rehospitalization in the first year of life, which is known to be superior for babies of less than 2,500 grams, and the long term benefits associated with increased birth weight.

Existing evidence suggests that "fetal origins" shape many dimensions of life from infant mortality to later life outcomes such as chronic health conditions (Barker, 1995), and also cognitive development, educational attainment and earnings. The link between infant health at the time of birth and adulthood outcomes has been seldom studied in part because of severe data constraints and also due to methodological challenges in controlling for the effects of other socioeconomic and genetic factors. Evidence on the exact size/importance of the long term impacts of infant health at birth are scarce and lead to a wide range of estimates but all point to a positive impact on adulthood outcomes (e.g. Bartley et al. 1994; Currie and Hyson, 1999; Berhman and Rosenzweig 2004; Case et al. 2005; .Almond et al. 2005; Black et al. 2007; Oreopoulos et al. 2008). Studies with twins of the same cohorts (Berhman and Rosenzweig, 2004; Black et al., 2007; Oreopoulos et al., 2008; Royer, 2009; Figlio et al., 2013) find that birth weight is positively associated with height, test scores, educational attainment and wages.

More specifically, Black et al. (2007) find that a 1% increase in birth weight increases high school completion by 0.09 percentage points. Our average effect on treated children is of the order of 1.9%[17] which would imply a positive impact on high school completion of about 0.17 percentage points. In 2005 the median earnings for a full-year full-time earner was $32,029 for someone who did not graduate from high school while it was $37,403 for a high school graduate.[18] Assuming the real increase in wage equals the discount rate, we find that over a 35 yearlong career the program would lead to an expected additional revenue of $321 per

months ($343). We use Statistics Canada Consumer Price Index on Food purchased from stores to deflate the cost of the OLO program from 2008 to 2004 (115,2 to 103,2) and convert the amount using the yearly average exchange rate for 2004 (0.77USD, source Board of Governors of the Federal Reserve System).

[17]The percentage increase in birth weight is obtained using our most conservative average impact of the program on birth weight (5.03) divided by the percentage of treated children (0.076) divided by the average birth weight in Québec during the period (3352 grams).

[18]Source: Statistics Canada, Income and Earnings Highlight Tables, 2006 census. Ottawa. Released May 1st, 2008.

child on average. These additional gains include both the accrued revenue to the government and the additional revenue to the person. The latter wouldn't be distributed equally across all treated children but concentrated among those graduating from high school. Combined with the neonatal cost savings, this offsets the cost of the program.

Together, these studies suggest that the estimated neonatal cost savings of the OLO program combined with the estimated revenue gains from increased high school completion only represent a fraction of the benefits of the program. Clearly the program is cost effective.

8 Conclusion

Using a combination of administrative data and survey data we created a unique data set allowing us to evaluate the impact of the OLO program on children's health measured at the time of birth. The progressive implementation of the program across the province of Québec allows us to identify the impact of treatment while controlling for underlying trends in the outcome variables. This study adds to the literature in several ways. First, it is the first Canadian study to exploit the progressive implementation of a prenatal nutrition program. Second, compared to research based on the US WIC program, it evaluates a more targeted and specific program in which pregnant women have access to the same free health care services as the rest of the population. Third, we evaluate not only the impact on health outcomes and maternal behavior, but also compare some of the benefits to the costs of the program.

We find strong evidence of a positive impact of the OLO program on birth weight and the probability of delivering a fair weight baby: treated children gain 67 grams on average and are 3.4% more likely to be delivered fair weight. The effect is generally increasing over time and is larger for less educated mothers, single births, children of mothers' born in Québec and first born babies. Our estimated effects are larger than comparable estimates of the WIC program (29 grams, Hoynes et al., 2011), but smaller than results reported in Higgins et al. (1989). While the OLO program provides a specific food basket which may better ensure the proper nutrition of pregnant mothers, counselling sessions vary by LCSC and may not be as effective as the individual sessions recommended by Higgins. Counselling may have an impact on child health at birth by changing maternal behavior with respect not only to nutrition, but also smoking, for example. Using the NLSCY, we have shown that the OLO program did not impact maternal health and behavior during pregnancy or access to health care in the Canadian context. This suggests that the program mainly works through a change in maternal nutrition.

Finally, we have shown that the program is cost effective. Our estimate suggests that the neonatal hospital cost savings combined with revenue gains from increased high school completion rate are larger than the costs of the program. While our cost-benefit analysis includes all costs, not all savings have been accounted for (e.g. the costs of rehospitalisation and the lifetime costs of chronic health conditions related to low birth weight). The estimated effects found in this paper may not be generalizeable to other contexts but the simplicity and small cost of the program makes it an attractive policy intervention to raise infant health outcomes and reduce health inequalities among children.

This paper is limited in two ways. First, our data set did not contain any information on who was actually treated and when they were actually treated. As a result, we are not able to provide any guidance on the stage of pregnancy at which the program is more effective. Furthermore, we have provided an estimate of the long-term cost savings by exploiting the estimated impacts of birth weight on long-term outcomes found in other studies. A better approach would have been to directly estimate the impact of the program on long term outcomes but our data set does not contain such information. To our knowledge there is scarce evidence on the long-term educational and socioeconomic impact of nutrition programs during pregnancy.[19] These should be the focus of future research.

[19]Hoynes et al. (2012) study the impact of the Food Stamp Program and find that the program has effects decades after initial exposure. Almond et al. (2014) study the impact of Ramadan during pregnancy on human capital at age 7 and find that children of mothers' exposed to Ramadan have lower test scores.

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