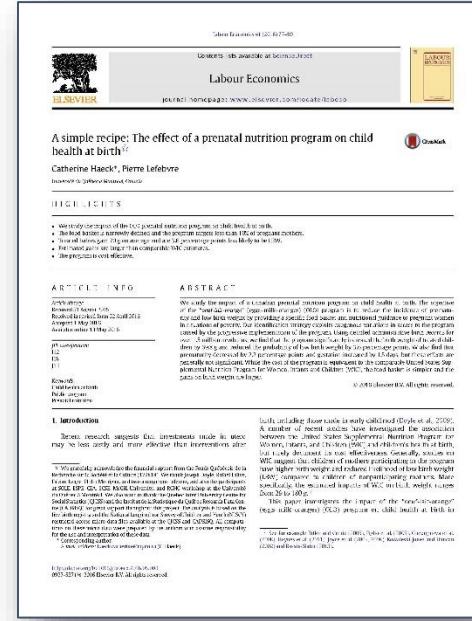


“A Simple Recipe: Estimating the Effect of a Prenatal Nutrition Program on Child Health at Birth”

Un article scientifique sur l’efficacité de l’intervention nutritionnelle OLO

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A simple recipe: The effect of a prenatal nutrition program on child health at birth^{1,2}

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ABSTRACT

We study the impact of a prenatal nutrition program on child health at birth. We compare children born to mothers who received the intervention to those born to mothers who did not receive the intervention. We identify the intervention's impact by comparing the outcome in terms of the program participants and non-participants. We find that the intervention has a positive effect on birth weight. A child born to a mother who received the intervention is born on average 70 g heavier than a child born to a mother who did not receive the intervention. This result is robust to various sensitivity analyses. We also find that the intervention has a positive effect on birth length. A child born to a mother who received the intervention is born on average 0.7 cm longer than a child born to a mother who did not receive the intervention. Finally, we find that the intervention has a positive effect on the probability of being born at term. The intervention increases the probability of being born at term by 1.6 percentage points. © 2016 Elsevier Inc. All rights reserved.

MESSAGES À RETENIR

L’étude démontre que :

- Avec un coût moyen de 543 \$ par bébé, l’intervention OLO est rentable dès la naissance puisqu’elle permet d’économiser entre 600 et 700 \$ en coûts d’hospitalisation dus à des problèmes de santé liés au faible poids. Cette économie ne comprend pas tous les bienfaits sur la santé globale de l’enfant à moyen et à long terme;
- Les bébés OLO ont un poids en moyenne 70 g plus élevés que ceux qui sont nés dans le même territoire et le même contexte socioéconomique avant l’implantation du programme;
- L’intervention OLO contribue ainsi à réduire de 1,6 fois le risque que le bébé naîsse avec un faible poids (c.-à-d. moins de 2 500 grammes). Le poids du bébé à la naissance peut être déterminant pour son avenir, puisque les enfants nés avec un faible poids sont notamment plus à risque de présenter des retards ou des difficultés dans le développement de leurs fonctions cognitives (attention, fonctions exécutives, etc.).
- Le suivi OLO engendre des impacts positifs sur la réussite éducative plus tard dans l’enfance.
- Le suivi OLO est innovant et plus performant que le programme similaire aux États-Unis.

Synthèse de l’article rédigée par Julie Deschamps, nutritionniste à la Fondation OLO

Objectif de l’étude

Évaluer l’impact de l’intervention nutritionnelle OLO sur trois indicateurs stratégiques de la santé des enfants à leur naissance (poids à la naissance, prématurité et durée de la gestation).

L’intervention nutritionnelle OLO est efficace

- Le poids de naissance des bébés OLO est plus élevé, en moyenne, de 70g.
 - La comparaison est réalisée avec des bébés du même territoire et du même contexte socioéconomique nés avant l’implantation du programme.

- La proportion de bébés de faible poids diminue de 3,6 points de pourcentage avec l'intervention nutritionnelle OLO. L'intervention OLO contribue ainsi à réduire de 1,6 fois le risque que le bébé naîsse avec un faible poids.
- On remarque que ces effets sont significatifs :
 - chez les mères ayant un plus faible niveau d'éducation (études secondaires seulement) ;
 - lors de naissances uniques (versus jumeaux) ;
 - chez les mères nées au Québec ;
 - Pourrait être expliqué parce que ces femmes sont plus informées par leurs réseaux sociaux que les femmes nées hors Canada
 - lorsqu'il s'agit du premier bébé de la famille.

Pourquoi s'intéresser au poids à la naissance ?

Le poids à la naissance est un indicateur pour la santé future (au cours de la vie) ainsi qu'un indicateur de résultats au niveau socioéconomique.

Le faible poids à la naissance (< 2 500 grammes) peut avoir de nombreuses répercussions sur la santé et le développement des enfants. Les enfants nés avec un faible poids sont plus à risque de présenter des retards ou des difficultés concernant leurs fonctions cognitives (attention, fonctions exécutives, etc.). Il en est de même pour leur développement neuromusculaire et moteur : risque accru de présenter des problèmes sur le plan de la vision, des habiletés motrices, de la coordination, etc.

Source – Observatoire des tout-petits

Les programmes comparables

- Les résultats des programmes sont semblables, car ils se situent dans les intervalles de confiance de chaque étude qui se recoupent. Les différences observées sur les poids peuvent s'expliquer par les variations des caractéristiques des études.
- Programme WIC (United States Supplemental Nutrition Program for Women, Infants, and Children) démontre une plus faible augmentation des poids de naissance, soit de 29g, comparativement au programme OLO (étude de 2011).
 - L'intervention nutritionnelle OLO a un effet plus grand et plus significatif que WIC.
 - Différence expliquée par l'offre d'aliments spécifiques pour répondre aux besoins de la femme enceinte dans le cas de l'intervention nutritionnelle OLO.
- La méthode Higgins, à l'origine de l'intervention nutritionnelle OLO et du programme WIC, démontre une augmentation des poids de naissance de 107-146 g (étude de 1989).
 - Les suivis offerts dans les CLSC varient beaucoup entre les régions (nombre de suivis, type d'intervention en groupe ou individuel) comparativement à l'approche Higgins qui assurent au moins 4 suivis individuels avec la mère.

L'intervention nutritionnelle OLO est rentable

Toutes les sources d'économies ne sont pas prises en compte dans l'énoncé ci-dessus, mais nous savons que de naître avec un poids normal diminue les coûts liés à l'hospitalisation dû à des problèmes de santé liés au petit poids (première année de vie) et que cette résultante apporte aussi des effets bénéfiques tout au long de la vie (ex. : diminuer les risques de maladies chroniques = moins de dépenses en soins de santé).

Coût individuel de l'intervention nutritionnelle OLO = \$543

- En 2008, l'intervention nutritionnelle OLO a coûté 7 057 000\$ pour aider 13 000 femmes enceintes à donner naissance à un bébé en santé.
- Le coût comprend la valeur des aliments, le salaire des nutritionnistes/infirmières impliquées dans le programme et les coûts administratifs de celui-ci.

L'intervention nutritionnelle OLO engendre des économies au niveau des soins néonataux

- Une analyse coût-bénéfice montre que le coût de l'intervention nutritionnelle OLO est largement couvert par les économies réalisées auprès des coûts néonataux requis lorsque les bébés naissent avec un plus petit poids.
- L'intervention nutritionnelle OLO permet de générer entre 600 \$ et 700 \$ en moyenne par enfant quant aux coûts néonataux à l'hôpital.

Impact sur la réussite scolaire

L'article s'attarde aux effets de l'intervention nutritionnelle OLO sur le taux de diplomation au niveau des études secondaires.

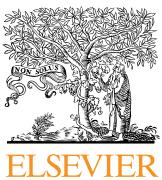
- Une étude a montré qu'une augmentation de 1% du poids de naissance d'un bébé augmente la diplomation au niveau des études secondaires de 0,09 point de pourcentage. L'intervention nutritionnelle OLO augmente les poids de naissance de 2,0%, ce qui permettait d'extrapoler que celle-ci pourrait avoir le potentiel d'augmenter de 0,15 point de pourcentage le taux de diplomation au niveau des études secondaires.
- En lien avec la compléion des études secondaire, l'intervention nutritionnelle OLO pourrait augmenter les revenus des gens nés d'une mère ayant reçu cette intervention.
 - En 2005, les revenus d'une personne :
 - n'ayant pas terminé ses études secondaires = 32 029\$ (médiane)
 - ayant terminé ses études secondaires = 37 403\$ (médiane)
 - L'extrapolation de ces résultats montre que sur une carrière de 35 ans, un bébé OLO aurait un revenu plus élevé de 339\$, en moyenne. L'intervention nutritionnelle OLO aurait donc le potentiel d'augmenter les revenus individuels, mais aussi des gouvernements.

Autres faits saillants

- Première étude qui montre l'impact causal de l'intervention nutritionnelle OLO sur le poids des bébés.
- En effet, c'est la première étude canadienne où il est possible d'analyser l'effet de l'implantation progressive d'un programme de nutrition prénatal. Nous avons donc une relation causale de l'intervention nutritionnelle OLO.
- L'efficience du programme est principalement due à l'amélioration de l'alimentation de la mère pendant la grossesse.
- Première étude canadienne à utiliser un modèle quasi-expérimental pour évaluer l'impact d'un programme de nutrition prénatal sur le développement intra-utérin.

Méthodologie en bref

- Consultation des fichiers sur les naissances au Québec entre 1986 et 2008 de l'Institut de la statistique du Québec.
- L'implantation progressive de l'intervention nutritionnelle OLO dans les CLSC de la province permet d'avoir une référence de contrôle pour évaluer l'évolution dans le temps et de constater les impacts de l'intervention.
- Précision : Cette progression se déroule sur toute la durée de la mise en place du programme, soit de 1986 à 1998. Après 1998, on considère que pratiquement tous les CLSC se sont joint à l'initiative.
- Il est possible d'évaluer l'implantation de l'intervention nutritionnelle OLO en faisant le lien entre les CLSC participants à l'intervention et le code postal des mamans à la naissance de leur enfant.
- Le code postal de résidence de la mère, une information disponible dans les fichiers sur les naissances, permet donc de lier chaque naissance à un CLSC et de vérifier si la mère était potentiellement couverte par un CLSC participant à l'intervention nutritionnelle OLO (indépendamment de la distance entre sa résidence et le lieu de services du CLSC).
- La stratégie empirique utilisée repose sur une approche quasi-expérimentale qui identifie par géolocalisation les femmes enceintes couvertes par l'intervention nutritionnelle OLO. Elle permet de neutraliser les autres facteurs susceptibles d'influencer les résultats (ex. : évolution technologique, amélioration des programmes d'aide sociale).
- La période d'observation de l'étude s'étend de 1986 à 2008. À la fin de cette période, l'intervention nutritionnelle OLO rejoignait 90% des femmes enceintes et potentiellement éligibles à recevoir l'intervention OLO.



A simple recipe: The effect of a prenatal nutrition program on child health at birth[☆]



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HIGHLIGHTS

- We study the impact of the OLO prenatal nutrition program on child health at birth.
- The food basket is narrowly defined and the program targets less than 10% of pregnant mothers.
- Treated babies gain 70 g on average and are 3.6 percentage points less likely to be LBW.
- Estimated gains are larger than comparable WIC estimates.
- The program is cost effective.

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ABSTRACT

We study the impact of a Canadian prenatal nutrition program on child health at birth. The objective of the “oeuf-lait-orange” (eggs–milk–oranges) (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 exogenous variations in access to the program caused by the progressive implementation of the program. Using detailed administrative birth records for over 1.5 million newborns, we find that the program significantly increased the birth weight of treated children by 69.8 g and reduced the probability of low birth weight by 3.6 percentage points. We also find that prematurity decreased by 2.2 percentage points and gestation increased by 1.5 days, but these effects are generally not significant. While the cost of the program is equivalent to the comparable United States Supplemental Nutrition Program for Women, Infants and Children (WIC), the food basket is simpler and the gains on birth weight are larger.

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1. Introduction

Recent research suggests that investments made in utero may be less costly and more effective than interventions after

birth, including those made in early childhood (Doyle et al., 2009). A number of recent studies have investigated the association between the United States Supplemental Nutrition Program for Women, Infants, and Children (WIC) and children's health at birth, but rarely document its cost effectiveness. Generally, studies on WIC suggest that children of mothers participating in the program have higher birth weight and reduced likelihood of low birth weight (LBW) compared to children of nonparticipating mothers. More specifically, the estimated impacts of WIC on birth weight ranges from 29 to 180 g.¹

This paper investigates the impact of the “oeuf-lait-orange” (eggs–milk–oranges) (OLO) program on child health at birth in

[☆] We gratefully acknowledge the financial support from the Fonds Québécois de la Recherche sur la Société et la Culture (172818). We thank Joseph Doyle, Rafael Lalive, Fabian Lange, Philip Merrigan, and two anonymous referees, and also the participants at SOLE, ESPE, CEA, SCSE, McGill University, and RGHC workshop at the Université du Québec à Montréal. We also want to thank the Quebec Inter-University Centre for Social Statistics (QICSS) and the Institut de la Statistique du Québec Research Data Centre (CADRISQ) for great support throughout this project. The analysis is based on the live birth registry and the National Longitudinal Survey of Children and Youth (NLSCY) restricted-access micro data files available at the QICSS and CADRISQ. All computations on these micro-data were prepared by the authors who assume responsibility for the use and interpretation of these data.

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¹ See for example Bitler and Currie (2005), Figlio et al. (2009), Gueorguieva et al. (2008), Hoynes et al. (2011), Joyce et al. (2005, 2008), Kowaleski-Jones and Duncan (2002) and Rossin-Slater (2013).

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
<i>Full history</i>															
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														

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 and offer both food packages and some nutrition counseling to disadvantaged pregnant women in order to reduce the incidence of prematurity and LBW among these mothers. 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 mothers to choose from a wide variety of food items such as enriched cereals, cheese, soy-based beverages, fruits and vegetables (fresh, frozen, canned or dry). As such, the content of the food packages provided by WIC depends on both the mother's choice and her area of residence, while the content 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.

To our knowledge, this paper is the first to estimate the impact of in utero exposure to a nutrition program on birth outcomes outside the United States, using a quasi-experimental approach with multiple treatment groups.³ With a long-standing, comprehensive, universal health care system and a large safety net for families (social assistance and child benefits), the Canadian context resembles that of many European countries but differs from the United States context. While WIC may serve as a gateway to Medicaid (Rossin-Slater, 2013) in the United States, participation in OLO has no impact on social assistance or access to health care services for mother or child in Canada.

The OLO program was deployed by public local community service centers (LCSCs). The mother's place of residence and poverty status strictly determines whether and when she is eligible for the program. We exploit the historical and geospatial progressive implementation of the program throughout the province to identify the overall impact. This approach is similar to that of Hoynes et al. (2011), who studied the impact of the WIC program by exploiting variations in WIC sites at the county level between 1974 and 1979.⁴ Using county-level variation avoids the bias caused by non-random selection into treatment encountered in previous studies. Hoynes et al. (2011) found that the average birth weight of participating counties increased by 2.3 g, but found no effects on the incidence of LBW. 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 g. When they focus on pregnant women who are the most likely eligible (low level of education), they find both an increase in birth weight and a decrease in the probability of LBW.

Compared to their study, we estimate the impact of the program not only on birth weight (in grams) and the probability of LBW (less than 2500 g), but also on gestation (in weeks) and the probability of delivering preterm (less than 37 weeks). Our observation period is more recent (1986 to 2008 compared to 1971 to 1982), and we have exact figures on the number of treated mothers for certain years during the implementation to infer the treatment-on-the-treated (TOT).

For this study, we use the birth records of every child in the province between 1986 and 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 place of residence, age, education, language and marital status – all measured at the time of birth. We also have information on the child's gender, birth order, multiple birth indicator and month of birth. We find that the program increased the birth weight of treated children by 69.8 g on average and reduced the probability of being LBW by 3.6 percentage points, but had no significant effect on gestation measured in weeks. The long-term effects of the program further suggest an increase in birth weight of 121.6 g and a reduction in LBW of 4.1 percentage points. These effects are larger than comparable estimates for WIC. In sum, this paper reinforces the conclusions of WIC studies but points to differences that might explain the larger impacts of OLO.

Finally, our cost-benefit analysis suggests that a large part of the program costs are recovered through neonatal cost savings. 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 provides information about the program and health services in Québec. Section 3 describes the data sets and the implementation of the program. Section 4 discusses the identification strategy, and Section 5 presents the main results and investigates the mechanisms. Section 6 presents a simple cost-benefit analysis, and Section 7 concludes.

2. The OLO program

Pregnant mothers who are disadvantaged because of undernourishment, thinness, unfavorable past pregnancies, closely spaced pregnancies, or serious emotional or social problems, as well as lack of support, generally have smaller babies. Inspired by the Higgins method,⁵ the OLO program provides nutrition counseling along with protein and calorie corrective measures to reduce the incidence of LBW among disadvantaged mothers. More specifically, mothers participating in the program receive per day one egg, one liter of milk, 125 ml of orange juice and a prenatal vitamin tablet. The frequency and the type of counseling vary by LCSC, but generally a minimum of one counseling session per month is offered.

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

³ A brief summary of the Canadian literature on prenatal nutrition programs is provided in our Web Appendix.

⁴ 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 FSP implementation.

⁵ In an experimental setting, Higgins (1976) showed the benefit on infant health of providing food and nutrition counseling to pregnant women in situations of poverty.

The program first started in the early 1980s through a pilot project financed by the Ministry of Health and Social Services (MHSS) in the LCSC of Matane semiurban 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 described above, was initiated in the LCSC of Valleyfield in 1983. At the beginning of the program, these free packages included either the goods themselves or vouchers to be redeemed at local participating food stores. According to our matched data set, in 1986, 17 (out of 163) LCSCs offered these free packages along with nutrition counseling (see Table 1). Over the years, a number of LCSCs joined the OLO program and, today, almost every LCSC offers the program. LCSCs provide both preventative and curative services and are one of the entry points into the free public health care system in Québec. There are 163 LCSC territories, once you exclude those located on First Nations reserves. A variety of professionals work in LCSCs (e.g., physicians, nurses, occupational therapists, nutritionists and social workers), but the OLO program mainly relies on nurses and nutritionists.

The OLO program is targeted. Only mothers below Statistics Canada low-income cutoffs (LICOs) are eligible. These income thresholds depend on family size and essentially measure the point at which families are expected to spend 20 percentage points more than the average family on food, shelter and clothing. Mothers are not automatically signed up for the program and must present themselves at their local LCSC to register for the program. Eligibility is determined during the first visit to the LCSC, and mothers typically start receiving the food supplements and nutrition counseling by the 12th to 15th week of gestation. Mothers residing in adjacent LCSCs that had not yet implemented the program were not eligible for the program. In sum, the mother's place of residence and poverty status strictly determines whether and when she is eligible for the program. During our observation period, approximately one

in every thirteen babies were treated by the program through their mothers.

3. 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 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 LCSC. This data set is the property of the MHSS. 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.

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

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. We can observe not only 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 at the time of the birth. Since the average number of households served by a postal code is approximately 19, the postal code allows us to precisely geolocate mothers at the time of birth and accurately determine if the OLO program was

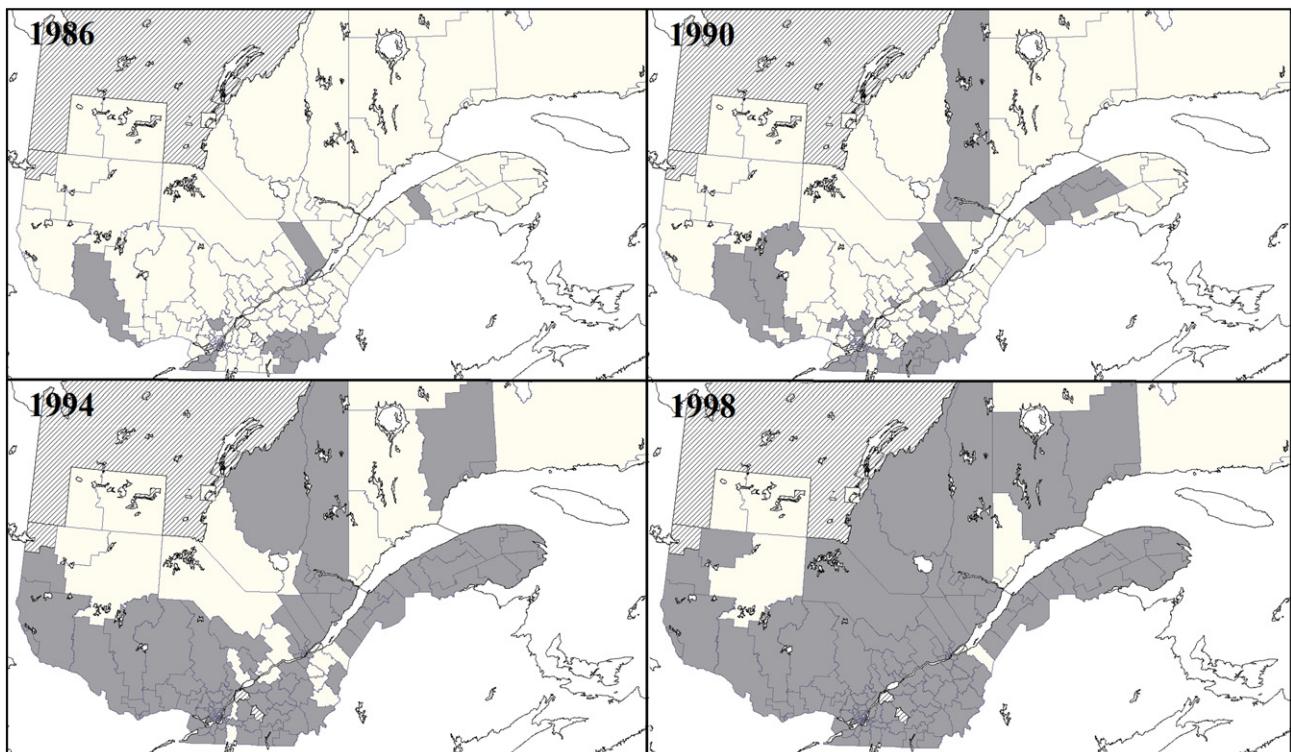


Fig. 1. Program progressive implementation – province of Québec. Note: This figure shows the progressive implementation of the program throughout the province. LCSC territories running the OLO program are in black, those not running it are in gray, and unknown status are indicated by the shaded areas.

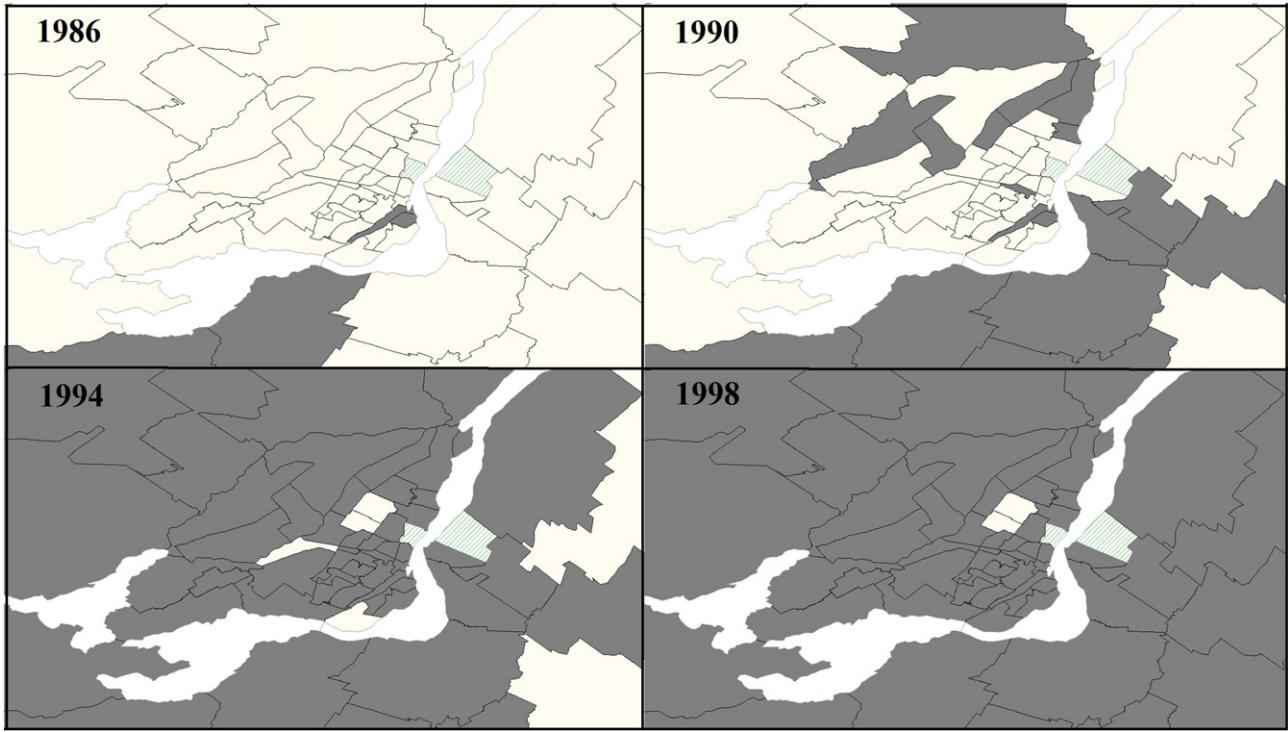


Fig. 2. Program progressive implementation – Montréal area. Note: This figure shows the progressive implementation of the program throughout the greater metropolitan area of Montréal. LCSC territories running the OLO program are in black, those not running it are in gray, and unknown status are indicated by the shaded areas.

available to them while they were pregnant. This data set also contains information on the child's gender, birth order, multiple birth indicator and month of birth.

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).⁶ We also exclude children whose birth weight and gestation length are missing, along with children for which the mother's age, years of education, place of birth or primary language at home are missing.⁷ Based on the medical perception of medical viability in the 1990s (Alexander et al., 2003; Sanders et al., 1995), children whose birth weight was under 500 grams or whose gestation was under 25 weeks of gestation are excluded in our analysis.⁸ Finally, following the literature, multiple births are excluded from our main sample.⁹ Multiple births are very distinct in terms of birth outcomes and have been on the rise since the introduction of in vitro fertilization (IVF). Nonetheless, we test the robustness of our results to their exclusion in Section 5. Table 2 presents the summary statistics of our main sample.

The top panel of Table 2 shows the outcome variables (birth weight and gestation), 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 subperiod 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 an LCSC. We can only determine eligibility based on the mother's postal code and the LCSC's participation status. As such, all births within an LCSC's territory are classified either as being eligible for the OLO program or not eligible. Furthermore, if an 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 not yet 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 for 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. For example, looking at the 1986–1989 period, we see that 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, except for the last one. Between 1998 and 2001, compared to mothers in OLO LCSCs, mothers in LCSCs not yet in OLO are generally younger, slightly less educated, and more likely to be single, French speaking and born in Québec. During that period, less than 2% of all births were in LCSCs not yet offering the OLO program. This pattern does not support the idea that disadvantaged areas received the program first. Nonetheless, we test in Section 5 the robustness of our results to the exclusion of LCSCs never joining the program during our observation period. Below, we also use our empirical strategy to further check the selection pattern.

⁶ This restriction implies that we use 93.3% of the birth records.

⁷ These restrictions imply that we discard 8% of the birth records, of which maternal education accounts 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.

⁸ 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 that we use. These results can be obtained from the authors on request.

⁹ This exclusion represents, on average, 2% of all our observations.

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						
<i>Outcome variables</i>									
Weight (grams)	3374.94 (525.53)	3325.84 (527.96)	3338.10 (523.92)	3365.37 (526.30)	3369.72 (528.19)	3373.57 (529.22)	3380.79 (552.32)	3398.49 (523.88)	3367.02 (540.22)
N	1,581,394	65,233	192,162	229,208	101,639	276,804	12,190	250,067	4479
Gestation (weeks)	39.06 (1.69)	39.14 (1.73)	39.21 (1.70)	39.15 (1.71)	39.14 (1.72)	39.07 (1.70)	39.02 (1.76)	39.00 (1.67)	38.85 (1.66)
N	1,570,863	65,233	192,162	229,208	101,639	276,804	12,190	250,067	4479
<i>Control variables</i>									
Male	0.51 (0.50)	0.52 (0.50)	0.51 (0.50)	0.51 (0.50)	0.52 (0.50)	0.51 (0.50)	0.51 (0.50)	0.51 (0.50)	0.51 (0.50)
Birth order	1.80 (0.97)	1.71 (0.88)	1.74 (0.91)	1.79 (0.96)	1.81 (0.94)	1.85 (1.00)	1.89 (1.07)	1.80 (1.00)	1.84 (1.04)
Birth month	6.47 (3.37)	6.51 (3.37)	6.50 (3.37)	6.43 (3.38)	6.43 (3.38)	6.41 (3.37)	6.44 (3.38)	6.41 (3.37)	6.38 (3.42)
Mother's age	28.25 (5.03)	27.10 (4.49)	27.38 (4.63)	27.85 (4.77)	27.81 (4.76)	28.28 (5.12)	27.39 (5.28)	28.47 (5.29)	26.77 (5.26)
Years of education	13.47 (3.04)	12.71 (2.70)	12.73 (2.82)	13.15 (2.90)	12.98 (2.91)	13.49 (3.06)	12.36 (3.13)	13.81 (3.13)	12.96 (3.11)
<i>Mother's place of birth</i>									
Québec	0.82 (0.38)	0.91 (0.29)	0.85 (0.36)	0.86 (0.35)	0.84 (0.37)	0.84 (0.37)	0.69 (0.46)	0.80 (0.40)	0.96 (0.19)
RoC	0.04 (0.19)	0.02 (0.15)	0.03 (0.16)	0.03 (0.18)	0.03 (0.18)	0.04 (0.20)	0.05 (0.21)	0.04 (0.20)	0.03 (0.16)
Other	0.14 (0.35)	0.07 (0.25)	0.13 (0.33)	0.10 (0.31)	0.13 (0.33)	0.12 (0.33)	0.26 (0.44)	0.16 (0.36)	0.01 (0.11)
<i>Language at home</i>									
French	0.83 (0.37)	0.91 (0.28)	0.81 (0.39)	0.86 (0.35)	0.81 (0.39)	0.84 (0.37)	0.67 (0.47)	0.83 (0.37)	0.92 (0.27)
English	0.10 (0.31)	0.06 (0.23)	0.13 (0.33)	0.09 (0.29)	0.11 (0.31)	0.1 (0.3)	0.11 (0.32)	0.11 (0.31)	0.04 (0.21)
Other	0.06 (0.24)	0.03 (0.17)	0.06 (0.24)	0.05 (0.22)	0.08 (0.27)	0.06 (0.25)	0.21 (0.41)	0.06 (0.23)	0.04 (0.19)
<i>Marital status</i>									
Married or common-law	0.87 (0.34)	0.68 (0.47)	0.70 (0.46)	0.88 (0.33)	0.87 (0.34)	0.90 (0.3)	0.87 (0.33)	0.91 (0.29)	0.90 (0.3)
Single	0.05 (0.22)	0.00 (0.03)	0.00 (0.03)	0.05 (0.21)	0.05 (0.21)	0.07 (0.26)	0.10 (0.31)	0.07 (0.26)	0.09 (0.29)
Missing	0.08 (0.27)	0.32 (0.47)	0.30 (0.46)	0.08 (0.26)	0.09 (0.28)	0.02 (0.15)	0.02 (0.15)	0.02 (0.14)	0.01 (0.11)
N	1,584,066	65,800	193,906	229,212	101,641	276,986	12,198	250,142	4479

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. Multiple births as well as children whose birth weight was under 500 g or whose gestation was under 25 weeks of gestation are also excluded.

Looking at the outcome variables, we find that birth weight increases over time (from 3335 to 3397)¹⁰ while gestation is fairly stable and even slightly decreasing (from 39.2 to 39.0). 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 LCSCs participating in the program (+73 versus +29). While this suggests a positive impact of the OLO program, clearly the increase is not restricted to LCSCs participating in the program. Technological changes and modifications to other safety net programs that have an impact on 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.

4. 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 follows:

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

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 fixed effects for year 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). The

¹⁰ These are the average birth weights for all observations for the 1986–1989 period versus the 1998–2001 period.

Table 3

Orthogonality of the rollout to maternal characteristics.

Dependent variable	OLO (δ)	
	(1)	(2)
	FE	FE + X_{it}
Mother's age	0.077 (0.060)	0.041 (0.040)
Mother's education (years)	0.075* (0.036)	0.067 (0.034)
Quebec born mother	-0.002 (0.007)	-0.003 (0.006)
French speaking mother	0.003 (0.004)	0.003 (0.003)
First birth	0.001 (0.003)	0.000 (0.003)
Male	-0.002 (0.002)	-0.002 (0.002)

Note: N=1,548,066. Shows the impact of the program on maternal characteristics. Set 1 includes only year and LCSC dummies. Set 2 also includes our main control variables (except those used as the dependent variable). LCSC clustered standard errors are in parentheses. Significance is denoted using asterisks: *** is p<0.01, ** is p<0.05, and * is p<0.1.

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 confounding factors, including child and family characteristics X_{it} . More specifically we include the following controls: male (dummy), maternal age categories (16 or less, 17 to 35, above 35 omitted), years of education dummies, months of birth¹¹ 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, Rest of Canada–RoC, other omitted).

In some specifications, we also have the OLO_{ct} dummy interact 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 as follows:

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

where OLO_{ct}^1 equals 1 if the LCSC c is running the OLO program for the first year in time t , and 0 otherwise, and the same logic holds for OLO_{ct}^2 to OLO_{ct}^4 while the term OLO_{ct}^5 equals 1 if the LCSC c 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.

Four outcome variables are used: birth weight, LBW dummy (equal to 1 for birth weights under 2500 g), weeks of gestation, and preterm dummy (equal to 1 for gestation periods of fewer than 37 weeks). As mentioned above, birth weight is a key indicator of health at the time of birth and has been shown to influence health and socioeconomic outcomes in later life. 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.

5. Results

Before proceeding to the results, we first check that the program rollout is orthogonal to changes in maternal characteristics. In theory, mothers could change their area of residence to become eligible for the program, so we want to make sure that selective manipulation of treatment status is not a serious concern. Table 3 shows the estimates of our baseline model (Eq. (1)) on maternal characteristics. In specification 1, only the fixed effects are included, while specification2 also includes our main control variables (except those used as the dependent variable). Clearly, the program is not correlated with maternal characteristics as none of the estimates are significant once the controls are included.

Fig. 3 shows the evolution of maternal characteristics over time, where $t = 0$ marks the year prior to the implementation and $t = 1$ marks the implementation year. Since the rollout takes place over many years, we need to aggregate multiple implementation periods. First, we aggregate the data by implementation year. For example, LCSCs joining the program in 1996 are aggregated together to form the OLO group, and all other LCSCs (those who joined prior to or after 1996) are aggregated together to form the control group. This gives us the evolution of the characteristics over time for LCSCs joining in 1996 versus all others, with 1996 being set to $t = 1$. We then repeat this exercise for each year between 1986 and 1999. Second, we aggregate over all implementation periods. As a result, in Fig. 3¹² each LCSC is eventually included in the control group since each LCSC eventually serves to control for underlying trends in our empirical approach. We find that the trends in maternal and infant characteristics are extremely similar and that there are no jumps around the discontinuity point. Maternal age and years of education increase over time in both groups. The percentage of French speaking mothers and the percentage of female infant is stable in both groups, while the percentage of Québec born mothers and the percentage of first birth decreases in both groups. The percentage of Québec born mothers is higher in OLO LCSCs at first, but eventually becomes identical in both groups. This variation is, however, not significant as shown in Table 3. 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.¹³

Our identification strategy also relies on the assumption that control and treated LCSCs share a common trend in the outcome variables. Fig. 4 shows the descriptive evolution of mean birth weight, LBW, gestation and preterm. Prior to the program, birth weight is on average smaller in treated LCSCs but follows an upward trend similar to that of control LCSCs. As of $t = 1$, the gap between treated and control LCSCs is almost completely eliminated, and then vanishes as of $t = 2$. This suggests a progressive impact of the program. The effect on birth weight is mirrored by a decreased probability of delivering an LBW baby. Again the trends preform are similar and may even suggest a slight increase in the gap between the two groups. As of $t = 1$, the gap is completely eliminated. For gestation (measured in weeks), both the treatment and control groups show a slightly negative trend over time. There are no apparent significant differences suggesting a positive or negative impact of the program. This is also true for the probability of delivering preterm. This is not surprising given that gestation is measured very imprecisely (in weeks) and that

¹² We give the same weight to each implementation cohort even if some cohorts include many more LCSCs than others to ensure that each fiscal year is weighted equally in any given t . We aggregate cohorts with fewer than three LCSCs to avoid over representation of small cohorts.

¹³ This is reasonable given the cost of moving compared to the monetary value of the OLO program (about \$543 in 2008).

¹¹ Season of birth has been shown to affect birth outcomes (Currie and Schwandt, 2013).

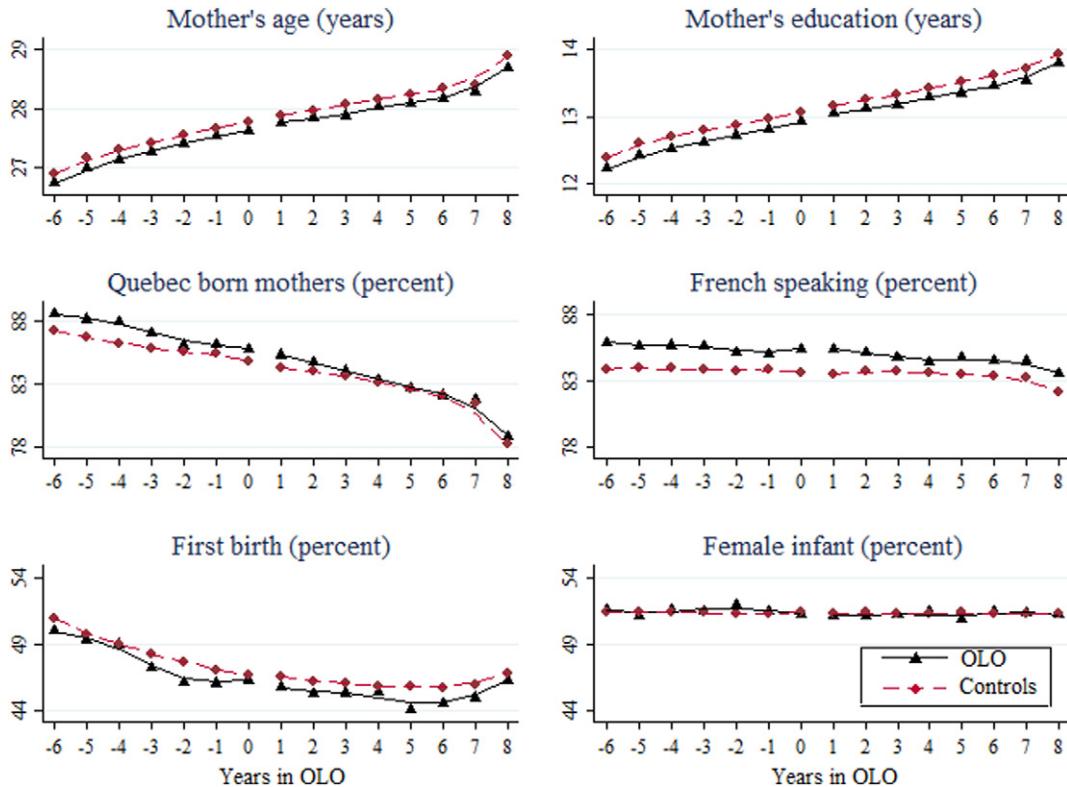


Fig. 3. Individual characteristics by treatment status. Note: This figure shows the trends in individual characteristics by treatment status over time. We use triangles for OLO and circles for the controls, and $t = 0$ marks the last year prior to observing treated OLO babies.

the apparent impact on birth weight is relatively small. Indeed, from Fig. 4, we could expect the intention-to-treat (ITT) to be about 10 g. We discuss the TOT below. 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.

5.1. Birth weight and low birth weight (LBW)

Table 4 presents the estimates of the impact of the OLO program on birth weight and LBW (top panel), and on gestation and the probability of delivering preterm (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). In columns 1 and 4, we include year dummies (ρ_t) and LCSC dummies (ϑ_c) only, while we additionally include the child and family characteristics (X_{it}) in columns 2 and 5. In columns 3 and 6, we add LCSC specific trends. First, we estimate both models using the full sample to which we have access that covers all births between 1986 and 2008 (Table 4). Second, we estimate both models using only birth records between 1986 and 2004 (Table A.1 in the Appendix). Since most of the OLO program implementation took place between 1986 and 1999, this shorter 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.

Improving the birth weight outcome is one of the primary objectives of the OLO program. It is expected that, through improved proteins and caloric intakes, babies of disadvantaged mothers should attain a more desirable weight. Since we do not identify which babies are treated by the program and which are not, Table 4 reports the 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 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, and between 2006 and 2008. 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. By 2008, it is 8.0%, with a high of 9.0% in 2006. 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 slightly higher afterward as the program progresses. Therefore, the average treatment effect is weakly significant and suggests an increase in birth weight of the order of 76.2 g (column 1: 5.636/0.076) if we do not control for child and family characteristics, and 69.8 g (column 2: 5.306/0.076) 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: 75.1 and 69.9 g ($p < 0.05$) for our specifications without and with controls respectively. Finally, the inclusion of LCSC specific trends is in line with our previous results and suggests an increase of 75.9 g ($p < 0.01$, column 3: 5.768/0.076).

The progressive impacts suggest that during the first year the estimated effect (δ_1) is positive but not significant. As time progresses the impact increases and eventually reaches 121.6 g (column 2: 9.239/0.076) when we control for X_{it} (and 142.8 g (column 3: 10.851/0.076) when we include LCSC specific trends). These effects are not only large (larger than those estimated by Hoynes et al., 2011, for WIC), they are also significant ($p < 0.05$). One interpretation is

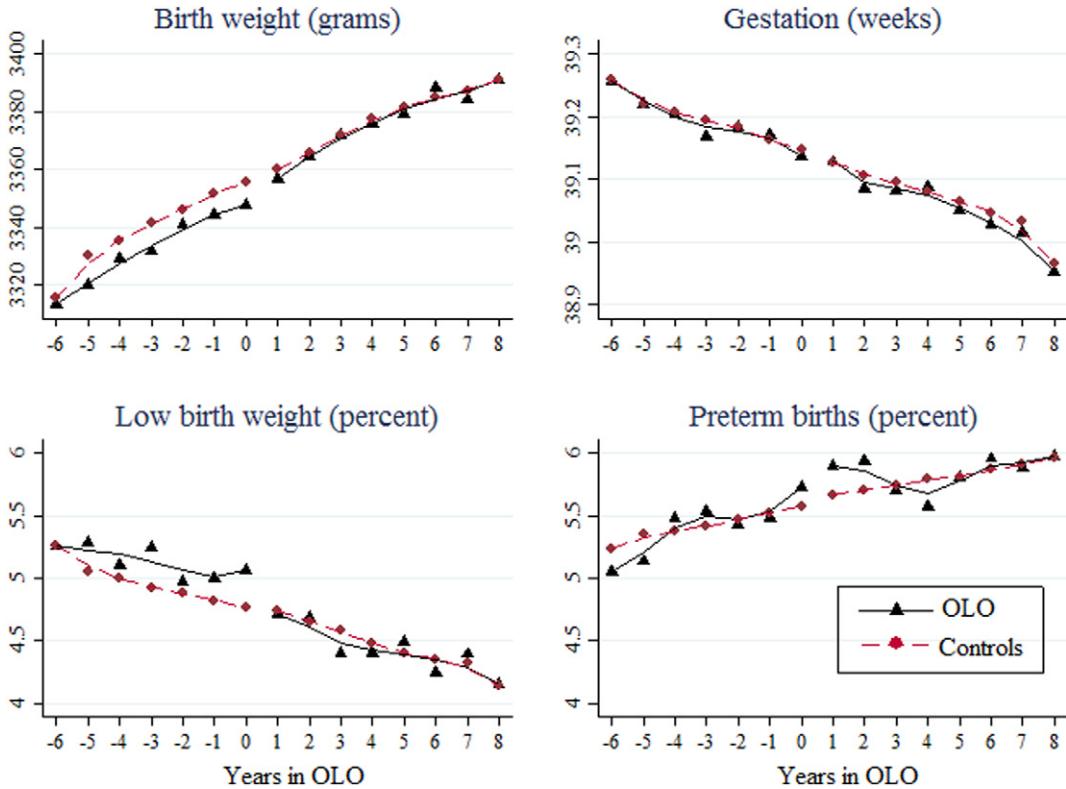


Fig. 4. Outcomes by treatment status. Note: This figure shows the trends in the outcome variables by treatment status over time. Again we use triangles for OLO and circles for the controls, and $t = 0$ marks the last year prior to observing treated OLO babies.

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 LCSCs. 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.

We now turn to the probability of delivering an LBW baby (under 2500 g). The results suggest that the program decreases the probability of having an LBW baby by 0.27 percentage point across the entire population, or that participation in the program decreases the probability by 3.6 percentage points for the treated group (column 6: $-0.270/0.076$). This effect is not only positive but highly significant, and holds across all specifications. Again the progressive effects suggest that in the first year the program has a smaller effect, but eventually reaches 0.30–0.32 percentage point, which implies that participating pregnant mothers have a probability of delivering an LBW baby that is 4.1 percentage points lower (column 6: $-0.315/0.076$). Since the 2500 g threshold marks a point where the likelihood of having birth defects leading to chronic health conditions is 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.

5.2. Gestation and preterm

Increasing the number of weeks of gestation also contributes to improving the health of the newborn. The bottom panel of Table 4 presents the ITT effects of the OLO program on weeks of gestation

(left panel) and the probability of delivering preterm (right panel). These 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 0.21 week (column 2: $0.016/0.076$), which is about 1.5 days. This effect is small but comparable to other findings in the WIC literature. Once we include the LCSC specific trends this effect, however, becomes virtually zero. 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 delivering preterm (under 37 weeks). We find that the probability decreases following the introduction of the program but the effects are generally not significant. We find that the probability of delivering preterm decreases by between 0.17–0.18 percentage point (columns 5 and 6) across the entire population, or that participation in the program decreases the probability of delivering preterm by between 2.2–2.4 percentage points for the treated group. Looking at the progressive effects, we find that the effect is generally increasing over time, but the pattern is not stable.

5.3. Robustness checks

In this section, we test the robustness of our main results. For convenience, Table 5 presents the estimates from our benchmark specification (3) in the first column of each of our four outcomes.

To further address the selection concern we additionally include postal codes fixed effects (specification 4). Given that postal codes

Table 4

Estimated impacts (ITT).

	Birth weight (grams)			Low birth weight (percentage points)		
	(1)		(2)	(1)		(2)
	FE	FE + X_{it} + trends	FE + X_{it}	FE	FE + X_{it}	FE + X_{it} + tends
OLO (δ)	5.636*	5.306*	5.768***	-0.259***	-0.247***	-0.270***
	(2.978)	(2.818)	(2.188)	(0.081)	(0.077)	(0.077)
Year 1 (δ_1)	3.258	2.819	3.746*	-0.184*	-0.169*	-0.201**
	(2.781)	(2.583)	(2.219)	(0.097)	(0.094)	(0.094)
Year 2 (δ_2)	6.483*	5.969*	7.253**	-0.233**	-0.216**	-0.252**
	(3.412)	(3.313)	(2.853)	(0.097)	(0.095)	(0.098)
Year 3 (δ_3)	4.633	4.763	6.050**	-0.350***	-0.346***	-0.379***
	(3.501)	(3.352)	(2.686)	(0.103)	(0.101)	(0.109)
Year 4 (δ_4)	9.340**	8.976**	10.361***	-0.321**	-0.312**	-0.343***
	(4.230)	(4.070)	(3.435)	(0.127)	(0.122)	(0.126)
Year 5 (δ_5)	9.769**	9.239**	10.851***	-0.315**	-0.302**	-0.315**
	(4.145)	(3.892)	(3.166)	(0.123)	(0.118)	(0.128)
N	1,581,394	1,581,394	1,581,394	1,581,394	1,581,394	1,581,394
Gestation (weeks)						
	(1)			Preterm (percentage points)		
	FE	FE + X_{it} + trends	FE + X_{it}	FE	FE + X_{it}	FE + X_{it} + tends
	0.011	0.010	0.010	-0.185	-0.168	-0.181**
OLO (δ)	(0.014)	(0.014)	(0.875)	(0.113)	(0.111)	(0.082)
Year 1 (δ_1)	0.012	0.010	0.012	-0.193*	-0.175	-0.204**
	(0.013)	(0.012)	(0.888)	(0.109)	(0.107)	(0.087)
Year 2 (δ_2)	0.008	0.007	0.007	-0.050	-0.030	-0.053
	(0.015)	(0.015)	(1.093)	(0.139)	(0.137)	(0.121)
Year 3 (δ_3)	0.005	0.004	0.002	-0.166	-0.155	-0.167
	(0.017)	(0.017)	(1.229)	(0.149)	(0.148)	(0.126)
Year 4 (δ_4)	0.022	0.021	0.018	-0.396**	-0.385**	-0.385***
	(0.019)	(0.018)	(1.412)	(0.156)	(0.154)	(0.129)
Year 5 (δ_5)	0.017	0.016	0.002	-0.274	-0.254	-0.170
	(0.023)	(0.023)	(1.580)	(0.192)	(0.186)	(0.134)
N	1,570,863	1,570,863	1,570,863	1,570,863	1,570,863	1,570,863

Note: Shows the estimated impacts of the OLO program on birth weight, the probability of delivering a low birth weight baby (<2500 g), gestation and the probability of delivering preterm. 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 two different specifications. Set 1 includes only year and LCSC dummies. Set 2 includes year and LCSC dummies, and the following control variables: male (dummy), 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). Set 3 additionally includes LCSC specific time trends. LCSC clustered standard errors are in parentheses. Significance is denoted using asterisks: *** is $p < 0.01$, ** is $p < 0.05$, and * is $p < 0.1$.

represent extremely small geographical areas (19 households on average), these can account for a number of fixed characteristics of households within the same postal code. We find that our results are generally comparable. We find a positive impact on birth weight of 82.3 g (column 2: 0.016/0.076) and a reduction in the probability of LBW of 3 percentage points (column 6: -0.228/0.076). On gestation, the results are slightly more significant, with a positive impact on gestation of 0.5 week or 3.7 days (column 2: 0.013/0.076) and a reduction in preterm births of 3.1 percentage points (column 6: -0.236/0.076).

We mentioned above that some LCSCs never joined the OLO program during our observation period. Mothers in these LCSCs were generally younger, less educated and more likely to be a single parent. To ensure that our results are not driven by the inclusion of this group, specification (5) excludes all births in LCSCs that never joined the OLO program. Again, our benchmark results are comparable to these. We find a positive impact on birth weight and a reduction in the probability of LBW. On gestation, we again find no significant effects, but the coefficients are of similar magnitude. The overall impact on preterm birth is also comparable.

Finally, our last specification (6) includes multiple births. Our main results are comparable whether we include multiples births

(6) or not (3). They are slightly smaller in magnitude when multiple births are included.

In sum, we find that our results are robust to the inclusion of postal code fixed effects, the exclusion of non-participating LCSC, or the inclusion of multiple births.

5.4. Distributional effects

While our main results are able to capture a shift in the average birth weight and around the 2500 g threshold, refining our understanding of the distributional impact of the program is essential to estimating the cost benefits of the program.

Table 6 shows the impact of the program at various points of the birth weight distribution: under 750 g; 750 to 999 g; 1000 to 1499 g; 1500 to 1999 g; 2000 to 2499 g; and more than 2499 g. The coefficients across one row sum to one since a reduction in one part of the distribution must be paralleled by an increase somewhere else in the distribution. Our results suggest a net positive gains in the percentage of babies reaching the fair weight threshold of 2500 grams. In each other birth weight category, we find a net negative impact of the program. This implies that the program led to a shift of the entire

Table 5

Robustness checks.

	Birth weight (grams)				Low birth weight (p.p.)			
	(3)	(4)	(5)	(6)	(3)	(4)	(5)	(6)
OLO (δ)	5.768*** (2.188)	6.256*** (2.158)	5.479** (2.181)	5.556** (2.293)	-0.270*** (0.077)	-0.228*** (0.087)	-0.257*** (0.077)	-0.260*** (0.094)
Year 1 (δ_1)	3.746* (2.219)	3.999 (2.614)	3.570 (2.208)	2.432 (2.46)	-0.201** (0.094)	-0.152 (0.107)	-0.191** (0.094)	-0.160 (0.106)
Year 2 (δ_2)	7.253** (2.853)	8.146*** (2.808)	6.967** (2.851)	6.877** (2.97)	-0.252** (0.098)	-0.232** (0.112)	-0.239** (0.098)	-0.223* (0.127)
Year 3 (δ_3)	6.050** (2.686)	6.340** (2.925)	5.627** (2.679)	7.127*** (2.693)	-0.379*** (0.109)	-0.339*** (0.119)	-0.363*** (0.109)	-0.406*** (0.127)
Year 4 (δ_4)	10.361*** (3.435)	11.083*** (3.176)	9.730*** (3.426)	11.069*** (3.753)	-0.343*** (0.126)	-0.283** (0.128)	-0.321** (0.125)	-0.371** (0.153)
Year 5 (δ_5)	10.851*** (3.166)	10.955*** (3.257)	9.890*** (3.138)	10.204*** (3.576)	-0.315** (0.128)	-0.282** (0.129)	-0.285** (0.127)	-0.263* (0.156)
N	1,581,394	1,581,394	1,552,055	1,619,730	1,581,394	1,581,394	1,552,055	1,619,730
Gestation (weeks)				Preterm (p.p.)				
	(3)	(4)	(5)	(6)	(3)	(4)	(5)	(6)
OLO (δ)	0.010 (0.875)	0.013* (0.717)	0.009 (0.880)	0.007 (0.959)	-0.181** (0.082)	-0.236** (0.096)	-0.180** (0.082)	-0.110 (0.100)
Year 1 (δ_1)	0.012 (0.888)	0.014 (0.868)	0.011 (0.891)	0.005 (1.014)	-0.204** (0.087)	-0.245** (0.117)	-0.203** (0.087)	-0.101 (0.112)
Year 2 (δ_2)	0.007 (1.093)	0.012 (0.923)	0.006 (1.098)	0.003 (1.188)	-0.053 (0.121)	-0.123 (0.127)	-0.052 (0.121)	0.032 (0.141)
Year 3 (δ_3)	0.002 (1.229)	0.009 (0.988)	0.001 (1.237)	0.004 (1.259)	-0.167 (0.126)	-0.257* (0.134)	-0.169 (0.127)	-0.130 (0.139)
Year 4 (δ_4)	0.018 (1.412)	0.022** (1.049)	0.016 (1.421)	0.018 (1.468)	-0.385*** (0.129)	-0.422*** (0.14)	-0.386*** (0.129)	-0.344** (0.155)
Year 5 (δ_5)	0.002 (1.580)	0.011 (1.056)	0.001 (1.587)	-0.001 (1.684)	-0.170 (0.134)	-0.258* (0.144)	-0.170 (0.134)	-0.046 (0.166)
N	1,570,863	1,570,863	1,541,669	1,609,017	1,570,863	1,570,863	1,541,669	1,609,017
FE+ X_{it} +trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Postal code fixed effects	No	Yes	No	No	No	Yes	No	No
Excluding Non-participants	No	No	Yes	No	No	No	Yes	No
Including multiple births	No	No	No	Yes	No	No	no	Yes

Note: Shows the estimated impacts of the OLO program on birth weight, the probability of delivering a low birth weight baby, gestation and the probability of delivering preterm. Set 3 is our benchmark specification and includes the same control as in Table 4. Set 4 uses postal code fixed effects. Set 5 excludes LCSC never participating in the OLO program. Set 6 includes multiple births. Clustered standard errors are in parentheses. Significance is denoted using asterisks: *** is $p < 0.01$, ** is $p < 0.05$, and * is $p < 0.1$.

birth weight distribution, but with much smaller impacts in the left tail of the distribution.

More specifically, we find that the program reduced the number of babies (in the overall population) weighing under 750 g by 0.014 percentage point and the number weighing 750 to 999 g by 0.016 percentage point. There are also 0.024 percentage point fewer babies

of 1000 to 1499 g and 0.053 percentage point fewer babies of 1500 to 1999 g. The vast majority of the net positive gain of 0.27 percentage point in the number of babies reaching at least 2500 g comes from a reduction of 0.164 percentage point in the number of babies weighing 2000 to 2499 g. These effects show that the OLO program mainly had an impact on infants who would, without the program,

Table 6

Distributional impacts on birth weight.

	Birth weight intervals (grams)					
	<750	750–999	1000–1499	1500–1999	2000–2499	>2499
OLO (δ)	-0.014 (0.009)	-0.016 (0.014)	-0.024 (0.022)	-0.053 (0.031)	-0.164** (0.067)	0.270*** (0.077)
Year 1 (δ_1)	-0.026*** (0.010)	-0.018 (0.017)	-0.018 (0.031)	-0.045 (0.041)	-0.094 (0.083)	0.201** (0.094)
Year 2 (δ_2)	-0.011 (0.010)	-0.004 (0.018)	-0.005 (0.027)	-0.048 (0.039)	-0.184** (0.081)	0.252** (0.098)
Year 3 (δ_3)	-0.004 (0.013)	-0.027 (0.018)	-0.028 (0.028)	-0.078 (0.045)	-0.242*** (0.090)	0.379*** (0.109)
Year 4 (δ_4)	-0.007 (0.014)	-0.015 (0.019)	-0.056** (0.028)	-0.029 (0.046)	-0.237** (0.107)	0.343*** (0.126)
Year 5 (δ_5)	-0.016 (0.014)	-0.012 (0.018)	-0.004 (0.034)	-0.029 (0.051)	-0.254** (0.101)	0.315** (0.128)

Note: N=1,581,394. Shows the estimated impacts in percentage points of the OLO program on key birth weight intervals using set 3 (our benchmark specification) and includes the same controls as in Table 4. LCSC clustered standard errors are in parentheses. Significance is denoted using asterisks: *** is $p < 0.01$, ** is $p < 0.05$, and * is $p < 0.1$.

Table 7

Distributional impacts on gestation.

	Gestation intervals (weeks)			
	<28	28–36	37–41	>41
OLO (δ)	−0.018 (0.014)	−0.163** (0.079)	0.268** (0.110)	−0.087 (0.082)
Year 1 (δ_1)	−0.040** (0.018)	−0.164 (0.084)	0.243** (0.114)	−0.038 (0.089)
Year 2 (δ_2)	−0.008 (0.017)	−0.044 (0.117)	0.128 (0.148)	−0.076 (0.094)
Year 3 (δ_3)	−0.004 (0.020)	−0.163 (0.123)	0.295 (0.163)	−0.127 (0.113)
Year 4 (δ_4)	−0.004 (0.022)	−0.381*** (0.127)	0.675*** (0.178)	−0.290** (0.122)
Year 5 (δ_5)	−0.018 (0.022)	−0.153 (0.130)	0.472** (0.201)	−0.302** (0.151)

Note: N=1,570,863. Shows the estimated impacts in percentage points of the OLO program on key gestation intervals using set 3 (our benchmark specification) and includes the same controls as in Table 4. LCSC clustered standard errors are in parentheses. Significance is denoted using asterisks: *** is p<0.01, ** is p<0.05, and * is p<0.1.

have had a birth weight between 2000 and 2499 g but who – thanks to the program – reached the fair weight threshold of 2500 g. It also shows that much smaller infants (below 1000 g) also benefited from the program and reached higher birth weights.

Table 7 shows the distributional impact of the program on gestation. We find that the program reduced the probability of delivering preterm. This effect is mirrored by an increase in the probability of carrying a baby to term (37 to 41 weeks). Interestingly, although not significant, the program appears to have also reduced the probability of carrying a baby post-term (42 weeks or more), and slightly reduced the probability of extreme immaturity (under 28 weeks).

5.5. Discussion

We find strong evidence of a positive impact of the OLO program on birth weight and a negative impact on the probability of LBW. The average impact on birth weight is of the order of 69.8 g. While this is two times larger than comparable estimates for the WIC program (29 g, Hoynes et al., 2011), it is, however, smaller than the 107 to 146 g 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 successful 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 four individual nutrition counseling sessions. The OLO program relies more on group counseling and fewer sessions. Both the OLO and WIC programs devote a similar fraction of their total costs to administration and counseling. 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 counseling, there is a possibility that the estimated impacts do not result from better nutrition, but from behavioral changes resulting from counseling. For example, counseling 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, Abrevaya, 2006). Understanding the mechanisms by which prenatal nutrition programs may work has seldom been done in this literature. Exceptions are Rossin-Slater (2013) and Bitler and Currie (2005). Bitler and Currie (2005) estimate the relationship between WIC participation and prenatal care. Rossin-Slater (2013) 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 period. Using Eq. (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, and consuming over-the-counter drugs or prescription medications during pregnancy. It also provides information on the type of prenatal care received (from a doctor or not) and the presence of diabetes and high blood pressure during pregnancy.

Our results, presented in Table 8, 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-Slater (2013) 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 everyone¹⁴ 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-Slater, 2013).

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.

Table 8

Average impact on maternal behavior and health.

	Set 1		Set 2		
	Coef	s.e.	Coef	s.e.	N
Diabetes	−0.02	(0.03)	−0.03	(0.03)	2556
High blood pressure	0.00	(0.03)	0.01	(0.02)	2556
Prenatal care by a doctor	−0.00	(0.03)	0.00	(0.03)	2555
No prenatal care	0.01	(0.02)	0.01	(0.02)	2555
Smoking	−0.01	(0.04)	−0.00	(0.04)	2556
Alcohol	0.01	(0.04)	0.02	(0.04)	2555
Prescription medication	0.03	(0.04)	0.03	(0.04)	2555
Over the counter drugs	0.00	(0.04)	0.00	(0.04)	2555
Trend + CLSC	Yes		Yes		
Maternal characteristics	No		Yes		

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.

¹⁴ In Canada, health care is mostly free at the point of use, since the billing and reclaiming of health care costs by 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.

Table 9

Average neonatal cost by birth weight in Canada.

Birth weight intervals (grams)	Avg. neonatal hospital costs (\$)	OLO (p.p.)	Avg. cost savings (\$)	OLOS (p.p.)	Avg. cost savings (\$)
<750	117,806	-0.0142	16.78	-0.0164	19.3
750–999	89,751	-0.0159	14.24	-0.0117	10.54
1000–1499	42,133	-0.0236	9.92	-0.0037	1.56
1500–1999	15,952	-0.0526	8.39	-0.0289	4.60
2000–2499	4617	-0.1640	7.57	-0.2540	11.73
≥ 2500	952	0.2702	2.57	0.3146	3.00
Savings (ITT)			54.33		44.72
Savings per treated child (TOT 7.6%)	714.91			588.43	

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

6. Program cost and benefit analysis

Underweight babies drive important neonatal hospital costs and carry a greater risk of malformation leading to chronic health conditions. Studies on the effects of prenatal health on subsequent human capital and health find substantial effects (e.g., Almond and Currie, 2011a, Black et al., 2007, Currie and Hyson, 1999, Oreopoulos et al., 2008). Our results suggest that the OLO program increases the birth weight of babies of treated mothers and decreases the probability of delivering LBW babies. More specifically, we showed above that the probability of delivering an LBW baby for the overall population decreased by 0.27 percentage points on average due to the program.

Table 9 shows the neonatal costs by birth weight categories (<750; 750–999; 1000–1499; 1500–1999; 2000–2499; ≥2500). In order to assess the neonatal cost savings of the OLO program, we use the estimates reported in Table 6. As mentioned above, we find that the probability of delivery diminishes in each of the categories except for the ≥2500 category, where it increases. Multiplying the average neonatal hospital cost by the average ITT effect by category allows us to infer the average neonatal hospital cost savings of the program. Using the participation rate (7.6%), we find a total neonatal cost savings per treated infant of \$715 (reference year 2005). If we use the effects of the program in the long run (5 years or more, OLOS), we find a total cost savings per treated infant of \$588. A lower bound estimate using today's percentage of treated infant (9.0%) would be \$497.

In 2008, the total program cost was \$7.057 million¹⁵ and the number of treated babies was about 13,000. This implies a program cost per baby of the order of \$543 (equivalent to \$509 in 2005).¹⁶ Therefore the average neonatal cost savings (average or long run) outweigh the cost of the program. If we use our most conservative estimates, the cost of the program, however, outweighs the average neonatal cost savings over the period by \$46. While we account for the full cost of the program, our savings fail to account for the long-term benefits associated with increased birth weight and the cost of

rehospitalization in the first year of life, which is known to be higher for babies whose birth weight is under 2500 g.

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) – as well as cognitive development, educational attainment and earnings (Almond and Currie, 2011b). The link between infant health at the time of birth and adulthood outcomes has seldom been 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 and importance of the long-term impacts of infant health at birth is scarce and leads to a wide range of estimates but all point to a positive impact on adulthood outcomes (e.g., Almond et al., 2005, Bartley et al., 1994, Behrman and Rosenzweig, 2004, Black et al., 2007, Case et al., 2005, Currie and Hyson, 1999, Oreopoulos et al., 2008). Studies with twins of the same cohorts (Behrman and Rosenzweig, 2004, Black et al., 2007, Figlio et al., 2014, Oreopoulos et al., 2008, Royer, 2009) 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 2.0%¹⁷ which would imply a positive impact on high school completion of about 0.18 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 wages equals the discount rate, we find that over a 35-year-long career the program would lead to an expected additional revenue of \$339 per 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 would be concentrated among those graduating from high school. Combined with the neonatal cost savings, this clearly 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 represent only a fraction of the benefits of the program. Clearly the program is cost effective.

¹⁵ The program cost includes all costs related to the program paid by the Canada Prenatal Nutrition Program (CPNP) 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 (Bitler and Currie, 2005), at \$49 per month for 7 months (\$343). We use the 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 (0.77 USD; 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 (5.306) divided by the percentage of treated children (0.076) divided by the average birth weight (3352 g) in Québec during the period.

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

7. 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 WIC program, it evaluates a more targeted¹⁹ 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 by the OLO program on birth weight and the probability of delivering a fair weight baby: treated babies gain 70 g on average and are 3.6 percentage points less likely to be LBW. We also find that prematurity decreased by 2.2 percentage points and gestation increased by 1.5 days, but these effects are generally not significant. Our estimated effects on birth weight and LBW are larger than comparable estimates of the WIC program (29 g; Hoynes et al., 2011), but smaller than results reported in Higgins et al. (1989). While the OLO program provides a specific food basket that may better ensure the proper nutrition of pregnant mothers, counseling sessions vary by LCSC and may not be as effective as the individual sessions recommended by Higgins. counseling 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 have an impact on maternal health and behavior during pregnancy or on 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 rates 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 rehospitalization and the lifetime costs of chronic health conditions related to LBW). The estimated effects found in this paper may not be generalizable 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 most 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.²⁰ These should be the focus of future research.

¹⁹ WIC currently serves 53% of all infants born in the United States (<http://www.fns.usda.gov/wic/about-wic-wic-glance>), while OLO serves less than 15% of all infant born in Québec.

²⁰ Hoynes et al. (2012) study the impact of the FSP 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 who practice Ramadan fasting have lower test scores.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.labeco.2016.05.003>.

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