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Growing Together

The Importance of a Large Early-Life Social Inclusion Program on Neonatal Health Outcomes in Latin America*

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Abstract

We estimate the impact of participation in *Chile Crece Contigo* (ChCC) on neonatal health outcomes. ChCC is the Government of Chile's flagship early-life health and social welfare program, targeted to the most vulnerable and lowest income social groups, with a particular aim of fostering inclusion and human capital development starting *in utero*. Using a newly-generated administrative database linking all births occurring between 2002 and 2010 (2 million births to 1.3 million mothers) with an indicator of whether each mother was a program beneficiary, we find that this targeted social program had significant effects on birth weight, the proportion of low birth weight babies, and the proportion of premature births. What's more, we validate micro-level between-mother estimates with difference-in-difference estimates based on time-varying program roll-out at the sub-national level. Taken together our estimates suggest that program participation increased weight at birth by 12 or 13 grams, at an estimated public cost of $18 per gram. These estimates are comparable to those observed in a developed country setting and have important efficiency and equity implications for a developing economy. We show that program participation closed the prevailing early life health gap between targeted program participants and richer non-participants, and that they imply considerable changes in cognitive achievement in the long-run.

JEL codes: H23, O15, I14, H43, O38, H51.

Keywords: Public health; neonatal health; social security; efficiency; early life investments.

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1 Introduction

The importance of early life health over the entire life course of an individual has been extensively recognised in the economic (and non-economic) literature (Almond, Currie and Duque, 2017; Almond and Currie, 2011*b*; Barker, 1990). This has lead to considerable investments in fetal and infant health in a wide range of contexts (see, among many others, discussion in Bitler and Karoly (2015) with reference to the USA and Bharadwaj, Løken and Neilson (2013) applied to Chile).

An important motivation of these early-life health policies owes to the dynamic complementary between the efficiency of investments in health early in life and investments later in life. In an influential series of papers, Heckman and Cunha (2007); Cunha and Heckman (2009); Cunha, Heckman and Schennach (2010) argue that early-life remedial investments are not only efficient, but equality promoting. This has lead, at times explicitly, to policies targeting early-life health outcomes as a basic column of the social safety net across the developed and the developing world.[1]

Such early-life health policies are particularly important in the context of Latin America. Many Latin American countries are characterised by irregular, rather than universally poor, infant health outcomes (Belizán et al., 2007). Indicators are particularly sub-standard among socially isolated groups, including low-income households, rural communities, and indigenous people. These early-life health differentials are only magnified over the life course of individuals, partially explaining the emergence of significant gaps in adulthood in education, salary, and morbidity and mortality. This has been documented in the Chilean context, where divergence of outcomes at a very young age (birth weight) have important effects on adacemic achievement up to 18 years later (Bharadwaj, Eberhard and Neilson, forthcoming).

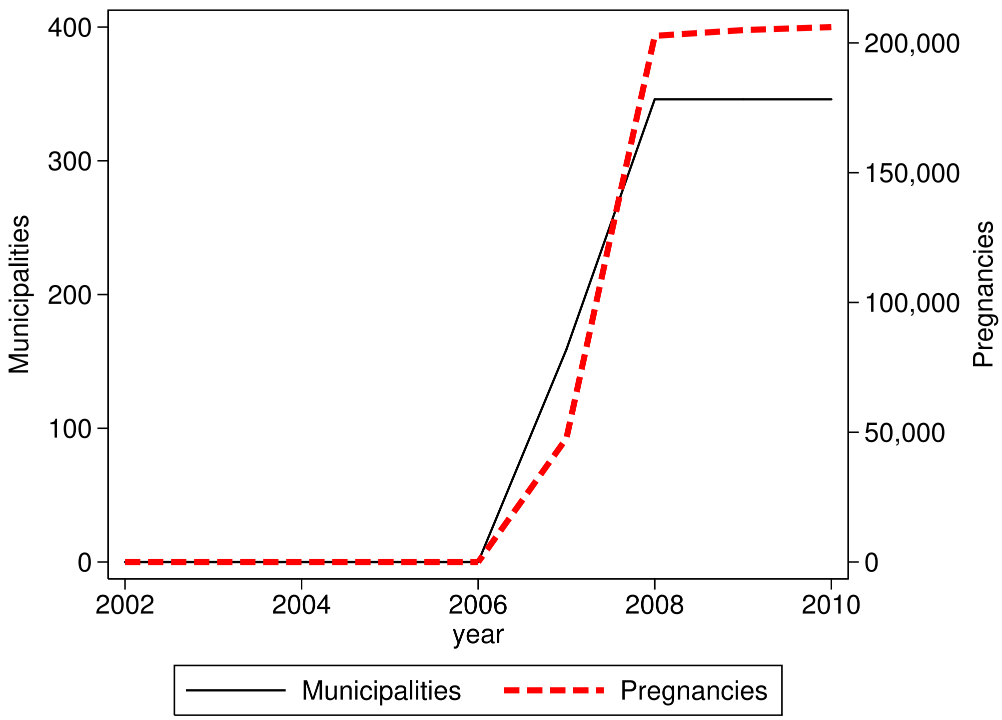
The importance of investment in health—and early-life health in particular—as a driver of individual and national outcomes in the developed world has been flagged in various dimensions. Influential work points to the importance of health as a determinant of equality within countries (Deaton, 2003), and document the long-shadow of early life insults to health in the developing world (Currie and Vogl, 2012). The social determinants of health starting *in utero* have lead to the recent design and implementation of many large, targeted early life social safety-net programs throughout Latin America and the developing world. (Monteiro de Andrade et al., 2015).

In this paper we propose to estimate the impact of one such large-scale, national-level health program explicitly designed to target early-life health in vulnerable groups. This program: *Chile*

[1] For example, in the context of Chile Crece Contigo—the policy we propose to examine in this paper—the policy's design explicitly references Heckman and Carneiro (2003) as support for the implementation of a large-scale early-life social program (see the official materials in Arriet et al. (2013)).

Crece Contigo (hereafter ChCC) was implemented in Chile in 2007, offering a basket of services, information and basic supplies to all children enrolled in the public health system.[2] As well as a transversal series of benefits, an additional series of means-tested benefits were provided to families classified as part of the 60% of most vulnerable families, with additional benefits for those who were classified as part of the 40% of most vulnerable families. ChCC also has a stated aim of addressing divergent health outcomes in socially excluded groups, releasing materials in both Spanish and native indigenous languages, given the well-documented health disparities among indigenous people across the world, and in Chile (Anderson et al., 2016).[3,4]

Figure 1: Timing of Program Rollout and Coverage



NOTES TO FIGURE 1: The first program rollout occurred in June of 2006, with the remainder of municipalities joining in the second rollout in Abril of 2007. All coverage figures are based on ChCC administrative records.

The ChCC program was rolled-out progressively from June of 2007. In the first year the program covered 159 of Chile's 346 municipalities, before being extended to all municipalities in

[2]The Chilean health system consists of a private and public stream and users nominally choose between public or private care. An associated monthly payment is automatically deducted from all formal salaries as a previsional payment. This payment is either made to the public health insurance (FONASA) or a private health insurer known as an ISAPRE. Any individual unable to pay contributions is covered by the public FONASA system. The private system is consderably more costly in terms of out of pocket costs. Recent administrative data suggests that 76% of the population is covered by public care. Nationally, 67% of beds are in the public system and the remaining 33% are in the private system (Departamento de Estadísticas E Información de Salud, Ministerio de Salud, 2016).

[3]Chile's population is 4.58% indigenous, the majority of whom are Mapuche, and this group has been documented as having poorer birth, neonatal and child health outcomes (Anderson et al., 2016).

[4]In order to provide an idea of the program's scope, we provide a brief list of program benefits in appendix A1 of this paper.

mid-2008. Program participation among pregnant women also increased in line with geographic coverage. In figure 1 we plot administrative figures of program usage over the life of the program. In 2010 the program covered greater than 200,000 pregnancies nationwide.[5] In terms of total cost, ChCC is one of the largest health programs in Chile. Recent figures (which we discuss in slightly more detail in section 5 of this proposal) suggest that ChCC spending currently accounts for almost 1% of the national budget.

Despite the size and scope of ChCC, few rigourous or well identified studies have been conducted on the program's effectiveness, and none, as far as we are aware, have examined the policy's effect on birth outcomes or survival during the first year.[6] In this we take advantage of newly matched administrative data to conduct the first such study, drawing identification from two (different) sources: the first, the within-mother variation in exposure produced across siblings around the date of the policy's introduction, and the second, the geographic and time variation in municipal-level participation. The first strategy allows us to estimate a mother fixed effects model (at the individual level), and the second a difference-in-difference specification at the municipal level.

Our results suggest that this program has considerable effects on neonatal health in Chile. Depending on the specification examined, we find that the effect of program participation on birth weight is between a 12 and 13 gram increase, with this being particularly important when considering the reduction of the proportion of low birth weight babies. Similarly, we observe a reduction in the frequency of premature births. Given the large coverage of the ChCC program, these results are noteable in national level averages, and appear to *eliminate* the birth weight differential between the poorer program participants and the less-poor non-participants.

To put the program's effects in context, we calculate the inferred cost of producing a gram of birth weight, and the implications of this to educational attainment later in life. When combined with the cost of running Chile Crece Contigo, our estimates suggest that the government spends around \$18 per gram of birth weight—a figure that is comparable to other large neonatal health programs, even in developed countries (such as the US Food Stamp Program). What's more, given the well-known positive effects of birth weight on later life outcomes, we estimate that as an *upper bound* cost, each \$1200 spent on Chile Crece Contigo results in an additional 0.1 standard deviation of educational attainment on later life test scores. These results suggest that targeted public health and social welfare programs can have large impacts in developing and emerging economies, and that these impacts may last much longer than the period in which an individual

[5] According to vital statistics data, in 2010 there were 250,643 live births. We note however that a pregnancy will be contained in the ChCC administrative data plotted in figure 1 even if the mother miscarries or a fetal death is recorded.

[6] As well as searching the economics literature, we conducted a search on PubMed using the keywords "Chile Crece Contigo" AND "Child Health" OR "Chile Crece Contigo" AND "Neonatal Health" OR "Chile Crece Contigo" AND "Birth weight" OR "Chile" AND "Neonatal Health" over the span 2006 to 2014 (ie after the design of the program).

is enrolled in the program.

In what remains of this paper we briefly describe the newly generated data that we will work with which provides universal coverage of births and ChCC usage, discuss the proposed estimation strategies to determine the impact of ChCC on neonatal health, discuss estimated results, and in closing estimate the efficiency of public spending on this program, benchmarking against other public neonatal health programs, as well as the estimated value of imporvements in health at birth in Chile.

2 Data

We have worked with the Chilean Ministry of Social Development and Ministry of Health (MDS and MS respectively for their initials in Spanish) to link administrative data on all births in the country with an indicator of whether each mother was enrolled in ChCC during pregnancy (as well as the vulnerability score of each mother, which impacts the degree of benefits they will receive). As each person in Chile has a unique national identity number, this has been used to link mothers and children between administrative databases. Given data privacy laws in Chile we have signed a confidentiality declaration to protect all individual level data with identifying features, however are able to release anonymised registers at the micro-level (refer to appendix B for further details). The resulting data set is a unique universal source of information on births in Chile which will allow us to estimate the impact of the program, unlike other data sources on ChCC which are small and do not cover pre- and post-reform time periods.

We match all births occurring between 2002 and 2010 with their siblings, and, from 2007 onwards, whether the mother participated in ChCC during gestation. This results in a sample of 1,917,085 births occurring to 1,241,514 mothers. Of these births, 32.6% of mothers participated in ChCC for at least one of their births. Vital Statistics data in Chile covers greater than 99% of all births, and coverage is stable over time. We focus on the period of 2001 to 2010 in order to have a sufficient pre-ChCC and post-ChCC window for analysis, though below discuss a number of consistency checks we run using a shorter pre-program window. Further deatils on the Chilean Vital Statistics Data can be found in Bharadwaj, Løken and Neilson (2013).

This data allows us to observe a range of human capital measures at birth. These include the weight of the baby, the baby's length in centimetres, and the gestational length as recorded at birth. These measures have been consistently shown to have large and long-lasting effects on health and well-being (Almond and Currie, 2011*a*). Although Apgar and head circumference are measured at birth in Chile, they are not currently available in administrative data. Along with measures of health immediately at birth, we are able to follow babies over 1 year of life to observe their survival at one year. Using the same unique national identity number which is assigned at birth, we can match each child in the birth register with any deaths under 1 year of age in the mortality register in order to measure infant mortality.

Table 1: Summary Statistics: Birth and Chile Crece Contigo Data

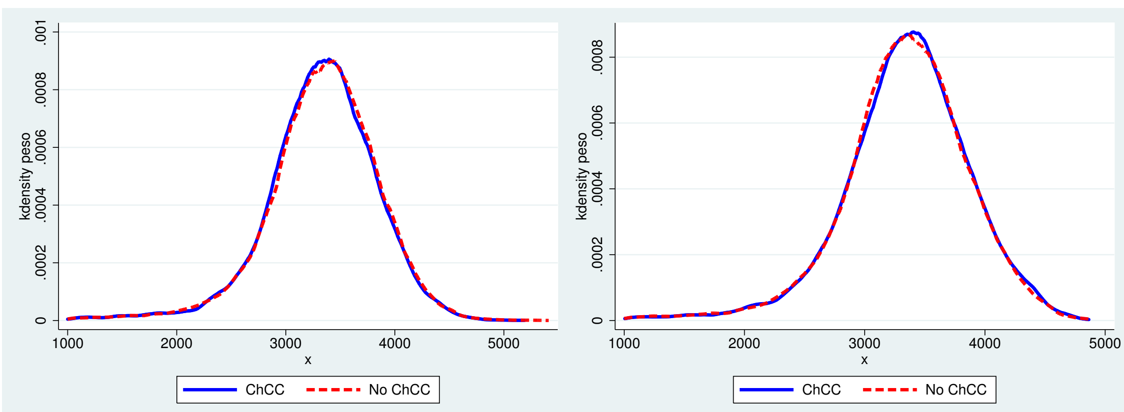
	N	Mean	Std. Dev.	Min	Max
Panel A: Individual-Level Data					
Birth weight (grams)	1912573	3327.45	539.30	500.00	5000.00
Gestation (weeks)	1910932	38.59	1.74	25.00	44.00
Low Birth Weight (< 2,500 grams)	1912573	0.06	0.23	0.00	1.00
Premature (< 37 weeks)	1910932	0.07	0.25	0.00	1.00
Year of Birth	1917085	2006.57	2.30	2003.00	2010.00
Mother Ever Participated in ChCC	1917085	0.15	0.35	0.00	1.00
Mother's Age (years)	1915322	27.08	6.81	14.00	49.00
Surviving Children	1916934	1.96	1.13	0.00	15.00
Panel B: Municipal-Level Data					
Birth weight (grams)	31805	3345.73	174.30	686.00	4868.00
Gestation (weeks)	31805	38.69	0.56	26.00	42.00
Low Birth Weight (< 2,500 grams)	31805	0.05	0.07	0.00	1.00
Premature (< 37 weeks)	31805	0.06	0.08	0.00	1.00
Year	31842	2006.51	2.29	2003.00	2010.00
Municipality Participating in ChCC	31842	0.31	0.46	0.00	1.00
Early Adporting Municipality	31842	0.52	0.50	0.00	1.00
Mother's Age (years)	31833	26.69	2.35	14.00	45.00
Surviving Children	31842	2.02	0.41	0.67	9.00
Number of Births	31842	60.21	93.69	1.00	787.00

NOTES: All births from 2003 to 2010 are included in the estimation sample. Panel A presents individual-level statistics for all births. Birth weights greater than 5,000 grams or less than 500 grams are removed from the sample, as are reported gestational times of less than 25 weeks or greater than 45 weeks. Panel B presents municipal level averages collapsed to municipality and month× year cells. ALl municipalities which have at least one birth in a given month have an observation (there are 345 municipalities in Chile). The number of births in each cell is presented in the last row.

In table 1 we provide summary statistics of principal health indicators at birth, as well as rates of participation in Chile Crece Contigo by mothers. Panel A documents full micro-level data, largely in agreement with values observed in vital statistics data observed else where. The average birth weight in the population is approximately 3,300 grams, geation is on average 38.6 weeks, and 6 and 7% of births are low birth weight or premature (respectively). In administrative data from 2003 to 2010 15% of mothers are observed to ever participate in Chile Crece Contigo, though this value is considerably lower than actual participation rates once the program was implemented, as the program only began running from June of 2007 onwards (ie births ocurring in 2008 and onwards). In panel B we provide similar summary statistics, however now using averages in municipal by month cells. In Chile there are 345 municipalities (the third level administrative district), and as we discuss further below, using municipal-level variation in program roll-out we can estimate the effects of Chile Crece Contigo on average birth outcomes. In general municipal level averages line up with individual level data. In the final line of table 1 we observe that there is considerable variation in the size of municipalities. Depending on the municipality, the number of births per months ranges from as low as 1 birth (conditional on there not being 0 births) to as high as 787 births.

In figure 2 we examine the full distribution of birth weights split by those who eventually participated in ChCC and those who never participated. These are presented entirely *before* the program's implementation in figure 2a. In this figure we observe that the distribution of birth weights for those who eventually used ChCC (the solid line) was slightly lower than the corresponding distribution for those who never used ChCC. These distributions are statistically distinguishable using traditional tests, and is particularly noticeable between approximately 2,500 and 3,000 grams. We document similar distributions, however now based on the post-ChCC time period in figure 2b. In this case we now observe the reverse pattern: the ChCC user distribution appears to be shifted to the right of the non-ChCC distribution, suggesting that babies born to ChCC participants now have *better* neonatal health measures than non-participants.

Figure 2: Birthweight Distributions Pre- and Post-Program Implementation



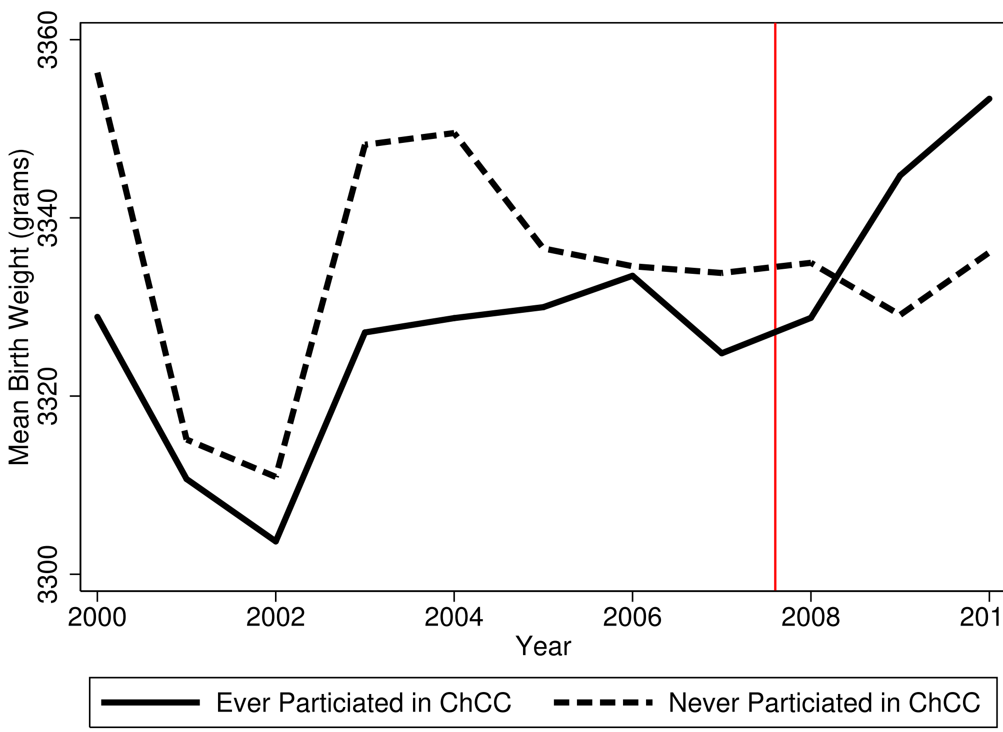
(a) Birthweights Pre-ChCC

(b) Birthweights Post-ChCC

Notes to figure 2: Densities are plotted using an Epanechnikov kernel with a bandwidth of 5 grams. Each panel separates distributions by whether the mother *ever* participates in Chile Crece Contigo. Panel (a) displays only pre-ChCC time periods, while panel (b) displays only post-ChCC time periods. In both cases, Kolmogorov-Smirnov tests reject equality of distributions (in different directions).

Finally, in figure 3 we examine time series of average birth weights for the same two groups. We display a vertical solid line to indicate the first roll-out period of ChCC, meaning that expected impacts should be noted only ∼9 months following this point. Using yearly averages it does appear that there is an increase in birth outcomes among users following the reform, and approximately parallel trends in the pre-reform period. These illustrative trends are suggestive that Chile Crece Contigo may have had significant impacts on health at birth, which is something that we go on to test more formally in the following sections.

Figure 3: Program Roll-out (early and late adopters)



NOTES TO FIGURE 3: Yearly averages are taken for all mothers who have ever participated in Chile Crece Contigo (although pre-2007 the program was not yet implemented) and all mothers who have never participated. The vertical solid line indicates the beginning of the ChCC program.

3 Methodology

3.1 Estimating the Impacts of ChCC

Given the rich data available, we propose to follow two estimation strategies to take advantage of different identifying features inherent in data and the implementation of ChCC. The first is an individual-level specification using variation within mothers over time. We propose to estimate:

$$InfantHealth_{ijt} = \beta_0 + \beta_1 ChCC_{jt} + \boldsymbol{X_{ijt}\beta}_x + \phi_t + \mu_j + \varepsilon_{ijt} \tag{1}$$

where $InfantHealth$ refers to a measure of health at birth of child i born to mother j at time t. We will construct a panel of mothers and their children, and our variable of interest is $ChCC_{jt}$. This measures for each mother at time t whether she participated in Chile Crece Contigo, and under typical (fixed effect) panel assumptions, β_1 identifies the effect of participation on infant health. We include maternal fixed effects μ_j and year fixed effects ϕ_t, as well as a series of time-varying controls for mothers including birth order dummies and mother's age at birth dummies. Identification takes advantage of the fact that there are mothers who (a) participated in ChCC and had births both before and after the introduction of the policy, and (b) never participated in the policy and also had births both before and after the policy's introduction. As well as estimating this specification with our full data (2000-2010), we will run a number of consistency checks using tighter windows to ensure that results aren't driven by children born at very different maternal ages or birth orders, as well as augment mother time-varying controls $\boldsymbol{X_{ijt}}$ to include age at birth and birth order fixed effects for both ChCC participants and non-participants separately.[7]

Our principal outcome measures of $InfantHealth$ consist of birth weight in grams, low birth weight (<2,500 grams), birth length in centimetres, gestation time in weeks, prematurity ($<$ 37 weeks gestation), and infant mortality. Given that we propose to use various outcome measures and a single indepedent treatment variable we will correct for multiple hypothesis testing. We briefly return to this point in the following subsection.

Our second strategy is a traditional difference-in-differences (DD) model in which we take advantage of the time-varying roll-out of the policy by geographic area. As discussed above, ChCC was first implemented in 159 municipalities before later being implemented across the entire country. If ChCC had a significant effect on early-life child health outcomes in socially excluded groups we should see that outcomes first improve in the early treatment municipalities,

[7] We are also able to control for a number of other individual-level covariates including maternal education, however in our main specification do not propose to include this control given that ChCC explicitly aims to ensure that young mothers who are still enrolled in education finish their studies, and hence education is likely a bad control.

and only later improve in the late adopting areas. We thus propose to estimate:

$$InfantHealth_{ct} = \alpha_0 + \alpha_1 ChCC_{ct} + \boldsymbol{W_{ct}\alpha}_w + \phi_t + \lambda_c + \eta_{ct} \quad (2)$$

where $InfantHealth$ is now an average for each municipality c in year t. The variable $CHCC_{ct}$ is a binary treatment measure indicating if the program was available in the municipality 40 weeks prior (to account for gestation), and we include full municipality and year fixed effects. If implementation of the policy were completely random, α_1 should give us the unbiased effect of ChCC on infant health measures. However, as we may be concerned that early adopting municipalities with better infrastructure were following different trends over time, we propose to include a series of time-varying controls for health infrastructure $\boldsymbol{W_{ct}}$, and in supplementary regressions also examine the robustness of results to municipal-specific linear time trends. Despite these considerations, we note that there is no particularly notable geographic clustering of early- and late-adopted municipalities, even within metropolitan areas such as Santiago (refer to figure 4 overleaf to observe the variation in roll-out by area). As is typical, we will cluster standard errors by municipality (346 municipalites) to account for the well-known time-dependence in unobserved stochastic errors by geographic area (Bertrand, Duflo and Mullainathan, 2004; Cameron and Miller, 2015).

These two proposed strategies are based on different identifying assumptions[8], and indeed, estimated effects should be diluted considerably at the municipal-level given that only a subset of a municipality enrolls in ChCC. However we can provide a rough comparison and consistency check of the effects if we inflate α_1 to account for partial enrollment at the municipal level. We propose to conduct this comparison, following the methodology described in Almond, Hoynes and Schanzenbach (2011) who conduct a similar adjustment in examining the roll-out of the Food Stamp Program at the municipal level in the United States.

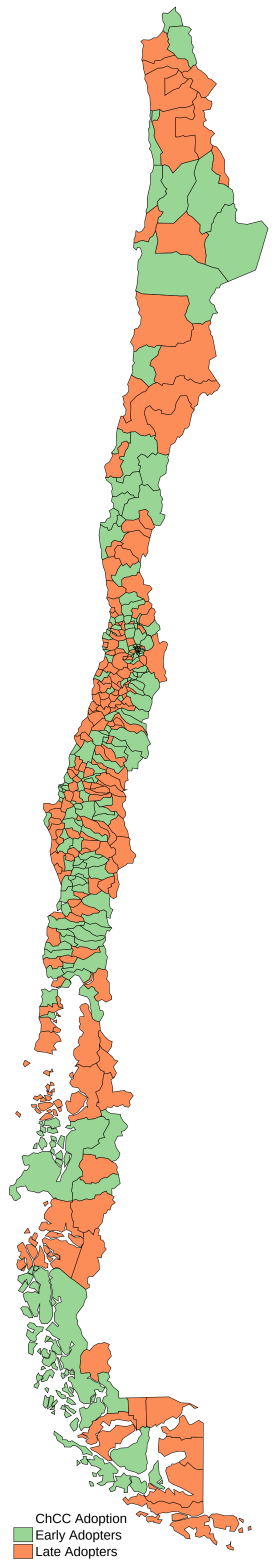
3.2 Inference, Robustness Strategies and Extensions

In order to run a consistency check on DD results we propose to estimate a full event study. This event study is a test in the style of Granger (1969). We will examine precisely when indicators diverge between early and late treatment areas, estimating the following specification:

$$\begin{aligned} InfantHealth_{ct} &= \gamma_0 + \sum_{k=1}^{6} \gamma_k^{lead} ChCC_c \times 1\{Year = -k\} \\ &+ \sum_{l=1}^{4} \gamma_l^{lag} ChCC_c \times 1\{Year = +l\} \phi_t + \lambda_c + \nu_{ct}. \end{aligned} \quad (3)$$

[8]Strict (conditional) exogeneity for the family panel specification in equation 1 and parallel trends for the DD specification in equation 2.

Figure 4: Program Roll-out (early and late adopters)



NOTES TO FIGURE 4: Chile consists of 346 municipalities ("*comunas*") which are the lowest geographic administrative level. ChCC roll-out started with 159 municipalities in June 2007 (chosen due to the availability of infrastructure) and then was rolled out to the remaining municipalities in April of the following year. Early adopters are marked in green and late adopters are marked in red.

Here we interact a series of indicator variables indicating policy implementation leads ($-k$) and lags ($+l$). If the difference between early and late implementing states only emerge when the policy is implemented, there should be no differential impact in any of the lead terms, suggesting an individual and joint test that each of the γ^{lead} terms are equal to zero.

Secondly, in order to ensure adequate size in all hypothesis testing, we will correct for mulitple testing in each of models 1 and 2. As described previously, we will examine 6 dependent variables in each case. In naive regressions we will be considerably more likely to reject null hypotheses at a fixed level given that we are conducting multiple tests. As such, we will apply Romano and Wolf (2005)'s stepdown hypothesis testing algorithm which fixes the Family Wise Error Rate at a set level α. This hypothesis correction technique is considerably more powerful than older techniques such as Bonferroni or Holm, and is increasingly used in the social science literature (see for example Gertler et al. (2014)). Similarly, it is more correct than setting False Discovery Rates at a fixed level given the relatively small number of multiple tests. We will employ the algorithm available in Clarke (2016).

Finally, along with regressions examining birth weight, and low birth weight we are able to observe the effects of the policy over the entire range of the birth weight distribution, to examine precisely where effects are observed (if effects are observed). In order to do so we propose to estimate specifications 1 and 2 using quantile regression. We will do this for the various (approximately) continous outcomes available, namely birth weight, length at birth, and gestational length.

4 Results

4.1 Individual-Level Estimates with Mother Fixed Effects

Estimates based on mother fixed effects are presented in table 2. We present fixed effects estimates in each case also controlling for mother's age and birth parity fixed effects which may vary around the reform date. Identification is thus driven by changes in birth outcomes between siblings born before and after their mothers began participating in Chile Crece Contigo, compared with similar time siblings occurring to never-participating mothers. In each case we cluster standard errors by mother to account for the correlation of stochastic errors within a family over time.

Results are presented for birth weight, the likelihood that a birth is low birth weight (less than 2,500 grams), total gestational length, and the likelihood of prematurity (birth at less than 37 weeks). Both LBW and prematurity are frequently used measures, and associated with a range of poor health outcomes later in life (Almond, Chay and Lee, 2005). We observe large signficant effects on birth weight and on gestational lengths, suggesting that participation in Chile Crece Contigo impacted these two outcomes. However, we do not observe significant effects on low birth weight or the probability of being born prematurely in this specification.

Table 2: Estimated Program Effects with Mother Fixed Effects

	(1) Birth Weight	(2) LBW	(3) Gestation	(4) Premature
Chile Crece Contigo	13.107***	0.001	0.065***	-0.003
	[3.444]	[0.002]	[0.012]	[0.002]
Constant	10.733***	-0.001***	0.042***	-0.002***
	[0.000]	[0.000]	[0.000]	[0.000]
Observations	1506198	1506198	1504887	1504887
R-Squared	0.000	0.000	0.000	0.000
Mother Fixed Effects	Y	Y	Y	Y
Age Fixed Effects	Y	Y	Y	Y
Birth Order Fixed Effects	Y	Y	Y	Y

Estimation sample consists of all mothers who have at least one child on either side of the ChCC reform. Refer to table 1 for summary statistics for each variable. All specifications cluster standard errors by mother. * p<0.10; ** p<0.05; *** p<0.01.

The effect sizes observed for birth weight and gestational weeks are considerable. An effect of 13 grams is equivalent to approximately 0.5% of the mean birth weight in Chile over the time period examined, and similar to the reported effects of large successful programs world wide. For example, recent evidence suggests that participation in the Food Stamp Program in the United States, one of the largest and most costly social security programs, increases birth weight by approximately 20 grams (Almond, Hoynes and Schanzenbach, 2011). Similarly, participation in the supplementary nutrition program for Women, Infants and Children is estimated to increase birth weight by around 17-30 grams (Hoynes, Page and Stevens, 2011; Rossin-Slater, 2013).

These first results suggest that targeted social-security programs can have considerable effects on early-life human capital in an emerging country context. Below we turn to an alternative estimation strategy and a series of placebo and consistency checks to examine the plausibility of these estimates.

4.2 Municipal-Level Estimates

Estimates based on municipality and time-varying exposure to the Chile Crece Contigo program are presented in table 3. As described in the methodology section, identification is driven by the differential roll-out to pilot (159) and non-pilot municipalities (186), with municipal specific factors being captured by municipality fixed effects. Given that roll-out was timed by month, we generate municipal by month averages for birth weight, LBW, gestation and prematurity, as well as counts of the total number of births, which we use to weight our principal specifications.

Results from table 3 once again suggest large and significant effects of Chile Crece Contigo from this alternative identification strategy. The estimates on birth weight (column 1 without maternal age and parity controls, or column 2 with these controls) suggest that after ChCC's arrival, average birth weights at the level of the municipality increased by 7.5 grams. While this is smaller than the value estimated in table 2, this is expected given that only a proportion of each municipality is ever enrolled in the program. If we follow Almond, Hoynes and Schanzenbach (2011) and inflate estimates using participation rates to arrive at an approximate individual-level estimate, this suggests values of approximately 12 grams[9], in quite close agreement with our mother fixed effects estimates displayed in the previous subsection.

In turning to weighted municipal-level estimates we *do* observe significant impacts on the frequency of low birth weight births and premature deliveries. For LBW babies, we see a reduction of 0.5 percentage points, which is equivalent to nearly a 10% reduction. Similarly, with premature deliveries we see a reduction of 0.4 percentage points, or approximately a 7% reduction in these pregnancies after the implementation of ChCC.

We examine the plausibility using a series of placebo tests. These placebo tests use the same early and late municipality groups, however assigning the placebo reform date to a period entirely *before* the arrival of Chile Crece Contigo. Thus, if there is no general prevailing difference between the two groups of municipalities we should observe that all placebo tests based on pre-reform dates lead to insignificant estimates of the effect of the placebo treatment on birth outcomes.

These results are displayed in figure 5. Each point estimate and confidence interval corresponds to a placebo reform starting in the early municipalities at the date displayed on the x-axis, and rolling out to the remaining municipalities 9 months later (as occurred in the true reform). We use all time periods for which full coverage is available, until arriving to the date of the true reform (indicated by the red dotted line in the figures). We observe that in nearly all cases placebo reforms lead to smaller and statistically insignificant estimates. In the case of tests using birth weight, we observe one statistically significant result in the placebo tests (of approximately 40), and none when examining low birth weight. The effects of the reform only begin to be observed when approaching the true reform date, reaching their maximum estimates when the true reform dates are used.

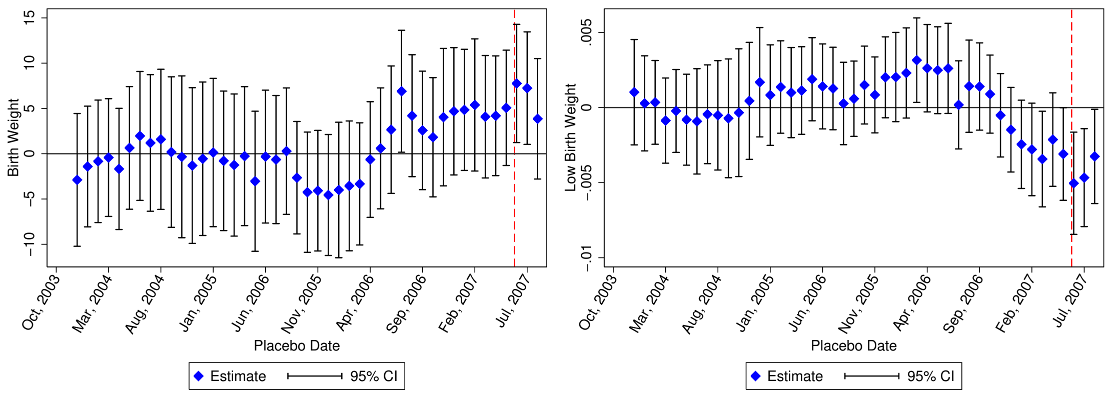
[9] This is calculated using average municipal participation rates of 65.1% among pregnant women, and so for the birth weight result in column 1 the estimated inflated effect is given as $7.695/0.651 = 11.82$ grams.

Table 3: Difference-in-Difference Estimates using Municipal Variation in Coverage

	Birth Weight		Low Birth Weight		Gestation		Premature	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Municipality Participating in ChCC	7.652*	7.847**	-0.003**	-0.003*	0.023	0.023	-0.002	-0.002
	[3.892]	[3.929]	[0.001]	[0.001]	[0.018]	[0.018]	[0.002]	[0.002]
Constant	3344.816***	3272.469***	0.050***	0.036***	38.811***	39.310***	0.055***	0.027***
	[4.317]	[13.550]	[0.002]	[0.005]	[0.012]	[0.043]	[0.002]	[0.006]
Observations	43675	43674	43675	43674	43676	43675	43676	43675
R-Squared	0.241	0.243	0.047	0.048	0.334	0.338	0.100	0.101
Time-Varying Controls		Y		Y		Y		Y

Estimation sample consists of all municipal-level averages for each month between 2003 and 2010 for all women. Low birth weight refers to the proportion of births under 2,500 grams, and premature refers to the proportion of births ocurring before 37 weeks of gestation. Each cell is weighted using the number of births in the municipality and month, and all specifications include municipality and time (Year × Month) fixed effects. * p<0.10; ** p<0.05; *** p<0.01.

Figure 5: Placebo Tests for Municipal-Level Difference-in-Differences



(a) Birth weight placebo

(b) Low birth weight placebo

Notes to figure 5: Placebo tests consist of (falsely) assigning the initiation of the ChCC program during the pre-program period for the early and late adopters. In each case the estimates and 95% confidence intervals displayed correspond to the estimated effects of ChCC on early life outcomes if the early adoption municipalities adopted in the month displayed on the x-axis, and the late adopters adopted 8 months later (as was the case with the true adoption). The actual adoption date was in June of 2007, and so the true estimates (ie estimates from table 3) correspond to those indicated by the red vertical line. The left-hand panel presents placebo tests for birth weight, while the right-hand panel presents tests for the proportion of low-birth weight babies.

4.3 Robustness and Extensions

In our principal specification we use weighted regressions, time and municipal fixed effects, and infer exposure to the reform by subtracting 9 months from the date of birth. We examine a number of specifications to determine the robustness of these results to alternative measures and specifications.

Firstly, as we observe the precise day of birth as well as the gestation length in weeks, we can estimate the exact day of conception, and generate exposure to Chile Crece Contigo as any pregnancy conceived after the program's implementation. In table 4 we replicate our main municipal-level results from table 3, however now measuring exposure using conception rather than birth dates. In this table we observe that all results hold, and indeed appear to be if anything slightly larger. Our estimates for birth weight are now 7.9 grams on average in each municipality, which when inflated to give individual level estimates suggests an impact of 12.15 grams.

We present additional results in appendix tables documenting estimates without municipal-specific population weighting, and where we augment equation 2 to include municipality-specific linear time trends. In both cases we find largely similar results, with comparable effect sizes.

Table 4: Difference-in-Difference Estimates using Municipal Variation in Coverage

	Birth Weight		Low Birth Weight		Gestation		Premature	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ChCC	7.912**	7.760**	-0.005***	-0.005***	0.019	0.019	-0.004**	-0.004**
	[3.330]	[3.330]	[0.002]	[0.002]	[0.013]	[0.013]	[0.002]	[0.002]
Constant	3347.102***	3294.334***	0.053***	0.035***	38.719***	39.221***	0.060***	0.031***
	[4.082]	[14.996]	[0.002]	[0.006]	[0.016]	[0.048]	[0.002]	[0.006]
Observations	29368	29367	29368	29367	29332	29331	29332	29331
R-Squared	0.384	0.385	0.264	0.264	0.484	0.487	0.305	0.306
Time-Varying Controls		Y		Y		Y		Y

Estimation sample consists of all municipal-level averages for each month between 2003 and 2010 for all women. Low birth weight refers to the proportion of births under 2,500 grams, and premature refers to the proportion of births ocurring before 37 weeks of gestation. Each cell is weighted using the number of births in the municipality and month, and all specifications include municipality and time (Year × Month) fixed effects. * $p<0.10$; ** $p<0.05$; *** $p<0.01$.

Finally, throughout the paper we have estimated our main specifications using four (related) measures of human capital at birth. Despite the fact that we are testing multiple hypothesis tests with a single independent variable (Chile Crece Contigo exposure), we have not corrected for this in baseline hypothesis testing. As such, we examine the results' robustness to Romano and Wolf (2005)'s stepdown algorithm which fixes the Family Wise Error Rate. Even when using this (demanding) criterion to test the significance of results we observe that the estimated effects of ChCC remain. For example, in our main difference in difference results p-values associated with each of the four outcome variables when using Romano Wolf testing are 0.0434, 0.0876, 0.1833 and 0.1833 (in order of decreasing significance), compared to 0.0225, 0.0351, 0.0978 and 0.1288 in naive tests. All in all, these results suggest that participation in the Chile Crece Contigo social security program had economically and statistically important effects on neonatal health outcomes.

5 Efficiency of Public Healthcare Spending

Chile Crece Contigo is the flagship early life health program in the Chile, and one of the largest social safety net programs of any type in the country. It is also one of the most important early life health programs in a middle or lower-middle income country setting worldwide (Richter et al., 2017). As such considerations of efficiency in public health care spending are of considerable importance. As we describe in table 5, spending on ChCC is approaching 1% of the fiscal budget per year, documenting the importance of this policy nation-wide. Using the current exchange rate, spending on ChCC in 2010 was approximately USD 330 million.

Table 5: Spending on ChCC as a Portion of National Spending

Year	Spending (ChCC)	Spending (National)	Percent
2007	67,903,331	17,883,154,418	0.380
2008	126,446,362	20,650,579,217	0.612
2009	159,660,473	23,406,879,324	0.689
2010	214,505,550	25,651,969,793	0.836

All values are displayed in 1000s of Chilean pesos. All national spending values are taken from the corresponding yearly budget, and ChCC spending is compiled from the ChCC final reports (Arriet et al., 2013).

To provide a broader consideration of the program's impacts and efficiency given public investment, we calculate the inferred cost of producing one gram of birth weight through this policy. In order to do so we compare the total cost of the pre-natal portion of Chile Crece Contigo with the total grams of birth weight produced by the policy. In order to estimate the total costs, we assign pro-rata costs by years in the program. Given that the prenatal component is approximately 1 of 5 years of coverage, we assume that one fifth of costs are apportioned to this sector. In order to calculate the total birth weight gained due to the program, we use our preferred estimate of approximately 12 grams from table 3. Using these values, as well as the total number of pregnant women covered per year, the inferred cost of a gram of birth weight is approximately 12,000 Chilean Pesos[10] (or based on the current exchange rate, approximately 18 US dollars. Interestingly, this value is similar in magnitude to that calculated from the US Food Stamp Program and The WIC program (Clarke, Oreffice and Quintana-Domeque, 2017).[11]

While this value benchmarks the efficiency of the ChCC program compared to other early life health programs, it provides less context on the implications of these costs for social spending and development outcomes within the country. In order to put these estimates in context, we can ask how investments in birth weight compare to the *returns* to birth weight in the country. In Chile there are a number of well-identified estimates of the value of birth weight to later-life education, with significant and long-standing observed impacts Bharadwaj, Løken and Neilson (2013); Bharadwaj, Eberhard and Neilson (forthcoming). Using a similar within family estimation strategy as proposed in specification 1 of this paper, Bharadwaj, Eberhard and Neilson (forthcoming) estimate that a 10% increase in weight at birth increases child test scores by 0.05 standard deviations. Using our estimates from above, these values imply that each additional standard deviation improvement on test scores costs 809,000 Chilean Pesos, or approximately 1200 USD. What's more, these estimates are clearly a lower bound. While birth weight is a well known determiniant of educational attainment, birth weight is also known to impact labour market outcomes (Johnson and Schoeni, 2011*b*; Cook and Fletcher, 2015; Behrman and Rosenzweig, 2004; Rosenzweig and Zhang, 2013; Case, Fertig and Paxson, 2005), the prevalence of chronic morbidities (Barker, 1995; Almond and Mazumder, 2005; Johnson and Schoeni, 2011*a*), mortality (van den Berg, Lindeboom and Portrait, 2006), and a range of psychological outcomes (Fletcher, 2011).

6 Conclusion

We examine the importance of a large early life social safety net program in a middle income country. This program—Chile Crece Contigo—is one of the largest social programs in Chile,

[10]This value is calculated using the costs, the total estimated impact, and the number of program recipients as:

$$\text{Inferred Cost} = \frac{\frac{1}{5} \times 20,650,579,217,000}{13 grams \times 161,834} = 12020.52 pesos/gram$$

[11]In ongoing work we are collecting data to generate comparison values from early life health programs in other Lower Middle Income Countries and Middle Income Countries. Examples of such programs from within Latin America include Plan Nacer (Argentina) and Qali Warma (Peru).

reaching more than 150,000 pregnant women each year, and accounting for nearly 1% of the national budget. Using newly generated administrative data matching all births with a program participation indicator, as well as time and geographical variation in program roll-out, we are able to combine a number of estimation strategies leading to plausibly causal effects under varying assumptions.

We document, firstly, that this program has considerable effects on neonatal health in Chile. Depending on the specification examined, we estimate that the program participation increases birth weight between 12 and 13 grams, reduces the probability of being low birth weight by up to 10% and reduces premature births by as much as 7%. What's more, it appears to eliminate the birth weight differential between the poorer program participants and the less-poor non-participants. Results appear to agree quite well whether working with between-mother micro-level estimates, or difference-in-difference estimates based on program roll-out nation-wide.

Combined with the cost of running Chile Crece Contigo, our estimates suggest that the government of Chile spends approximately $18 per gram of birth weight—a figure that is comparable to other large neonatal health programs, even in developed countries. What's more, given the well known positive effects of birth weight on later life outcomes, we are able to estimate that as an *upper bound* cost, each $1200 spent on Chile Crece Contigo results in an additional 0.1 standard deviation of educational attainment on later life test scores. All told this paper suggests that public investments in early life health in developing and emerging economies have considerable returns when well targeted and well designed, and that these impacts may propogate through the economy long after birth and program implementation.

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Appendices

A Appendix Figures and Tables

Table A1: List of ChCC Policy Benefits

Element (Program)	Benefit or Service
Massive Education	Weekly radio program "Creciendo Juntos" with national coverage Chile Crece Contigo TV in waiting rooms of public health centres "Fono Infancia" a free phone line providing support and information Provision of children's books, and prenatal music CDs
Socio-emotional Development	Gestation and birth guide "beginning to grow" Prenatal care protocol: check-ups Prenatal care support: fortified food, information Educational support for pregnant mother and partner (4 sessions) Personalised birth support, favouring rapid skin contact with mother Integral puerperal and breastfeeding support
Newborn Support Program	Pack for safe attachment and clothing (multiple goods) Pack for basic care and stimulation (mulitple goods) Pack with crib/corral (multiple goods) Integral care for newborn in neonatal and pediatric units Regular health controls focused on integral development Health controls for vulnerable or developmentally delayed children
Means-Tested Elements	Access to technical support for children with any type of disability Guaranteed free access to "sala cuna" Guaranteed free access to nursery school Guaranteed access to "Chile Solidario" Support to finish education (mothers) Support for labour market insertion (families) Improvement of living conditions (families) Mental Health Attention Family dynamic attention (focused on domestic violence) Judicial support

Table A1: Difference-in-Difference Estimates using Municipal Variation in Coverage (Unweighted)

	Birth Weight		Low Birth Weight		Gestation		Premature	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Municipality Participating in ChCC	4.876	5.345	-0.004	-0.004	0.042*	0.041*	-0.005*	-0.005*
	[6.613]	[6.556]	[0.003]	[0.003]	[0.022]	[0.022]	[0.003]	[0.003]
Constant	3362.840***	3276.501***	0.052***	0.043***	38.881***	39.304***	0.057***	0.039***
	[9.767]	[20.904]	[0.004]	[0.010]	[0.028]	[0.066]	[0.004]	[0.010]
Observations	43675	43674	43675	43674	43676	43675	43676	43675
R-Squared	0.073	0.079	0.019	0.019	0.102	0.106	0.030	0.031
Time-Varying Controls		Y		Y		Y		Y

Estimation sample consists of all municipal-level averages for each month between 2003 and 2010 for all women. Low birth weight refers to the proportion of births under 2,500 grams, and premature refers to the proportion of births ocurring before 37 weeks of gestation. Results display unweighted averages by municipality and month, and all specifications include municipality and time (Year × Month) fixed effects. * p<0.10; ** p<0.05; *** p<0.01.

Table A1: Difference-in-Difference Estimates using Municipal Variation in Coverage (with trends)

	Birth Weight		Low Birth Weight		Gestation		Premature	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Municipality Participating in ChCC	5.224	5.276	-0.002*	-0.002*	0.017	0.017	-0.002	-0.002
	[3.457]	[3.481]	[0.001]	[0.001]	[0.013]	[0.014]	[0.002]	[0.002]
Constant	3342.374***	3267.383***	0.051***	0.038***	38.816***	39.303***	0.056***	0.030***
	[3.927]	[12.604]	[0.002]	[0.005]	[0.011]	[0.038]	[0.002]	[0.006]
Observations	43675	43674	43675	43674	43676	43675	43676	43675
R-Squared	0.264	0.266	0.056	0.057	0.371	0.374	0.111	0.113
Municipal-Specific Trends	Y	Y	Y	Y	Y	Y	Y	Y
Time-Varying Controls		Y		Y		Y		Y

Estimation sample consists of all municipal-level averages for each month between 2003 and 2010 for all women. Low birth weight refers to the proportion of births under 2,500 grams, and premature refers to the proportion of births ocurring before 37 weeks of gestation. Each cell is weighted using the number of births in the municipality and month, and all specifications include municipality and time (Year × Month) fixed effects. * p<0.10; ** p<0.05; *** p<0.01.

B Data Agreement

We provide the full confidentiality agreement between the principal investigator of this project (Clarke) and the Ministry of Social Development (previously known as Ministry of Planification) and the Ministry of Health. This agreement is displayed in full overleaf.

NOTE: This is suppressed for filesize limits on paper submission.