Journal of Population Economics
https://doi.org/10.1007/s00148-019-00761-6

ORIGINAL PAPER

Growing together: assessing equity and efficiency in a prenatal health program

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Received: 4 March 2019 / Accepted: 20 November 2019 / Published online: 20 February 2020

Abstract

We study the acting mechanism of an early-life social safety net program and quantify its impact on child health outcomes at birth. We consider both the equity and efficiency implications of program impacts and provide a metric to compare such programs around the world. In particular, we estimate the impact of participation in *Chile Crece Contigo* (ChCC), Chile's flagship early-life health and social welfare program, using a difference-in-differences style model based on variation in program intensity and administrative birth data matched to social benefits usage. We find that this targeted social program had significant effects on birth weight (approximately 10 grams) and other early-life human capital measures. These benefits are largest among the most socially vulnerable groups but shift outcomes toward the middle of the distribution of health at birth. We show that the program is efficient when compared to other successful neonatal health programs around the world and find some evidence to suggest that maternal nutrition components and increased links to the social safety net are important action mechanisms.

Keywords Public health · Neonatal health · Social security · Efficiency · Early-life investments

JEL Classification H23 · O15 · I14 · H43 · O38 · H51

Responsible editor: Alessandro Cigno

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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 et al. 2017; Almond and Currie 2011a; Barker 1990). This importance justifies the central role that spending on infant and maternal health plays as a pillar of the social safety net in many countries (see, for example, discussion in Bitler and Karoly (2015) with respect to the USA) as well as considerable public spending focused on remedial investments to improve neonatal health outcomes (Almond et al. 2010; Bharadwaj et al. 2013). Influential work points to the importance of health as a determinant of equality within countries (Deaton 2003) and documents the long-shadow of early-life harms to health in the developing world (Currie and Vogl 2012). Recognition of the social determinants of health starting in utero has led to a burgeoning design and implementation of large targeted early-life social safety net programs throughout the developing world in places where previously such programs did not exist (Monteiro de Andrade et al. 2015).

An important motivation of these early-life health policies owes to the dynamic complementarity 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), and Cunha et al. (2010) argue that early-life remedial investments are not only efficient, but need not face equity–efficiency trade-offs implicit in later life remedial investments.

In this paper we study the equity and efficiency implications of a large targeted public health program. We examine the program *Chile Crece Contigo* (hereafter ChCC), a national-level multidimensional health program explicitly designed to target early-life health in vulnerable groups. ChCC was implemented in Chile in 2007, offering a basket of medical and social services, information and supplies to all expectant mothers enrolled in the public health system, as well as their children once they are born. As well as a transversal series of benefits available to all users of the public health service, an additional series of means-tested benefits were provided to families classified as part of the 60% most vulnerable in the country. 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 amongst indigenous people across the world, including in Chile (Anderson and Robson 2016).[1]

ChCC is the flagship early-life health program in Chile and one of the largest social safety net programs of any type in the country. It has been presented as a successful case of scaling-up development interventions in the recent Lancet Early Childhood Development Series (Richter et al. 2017) and has been replicated, largely unchanged, in other contexts.[2] Despite the size and scope of ChCC, as well as the

[1] 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 and Robson 2016).

[2] For example, Marroig et al. (2017) describe the program *Uruguay Crece Contigo*, which was designed following ChCC.

attention paid to its rollout and scale-up, few rigorous or well-identified studies have been conducted on the program's effectiveness, and none have examined the policy's effect on birth outcomes or survival during gestation. In this paper, we take advantage of the time-varying rollout of the program to different municipalities within the country, and the sharp (and pre-determined) expansion in the number of program beneficiaries to estimate the program's impact on early-life health in a continuous difference-in-differences style model. The headline results from our paper document that this program *has* been successful in improving neonatal health in Chile among program participants, suggesting that the attention paid to the program is warranted. We find that the effect of program participation on average birth weight is approximately a 10-g increase, and we observe some evidence to suggest that the program may also have reduced rates of fetal death and improved other health outcomes at birth.

Beyond mean impacts of the program, we are interested in studying the program's distributional impacts on the population of infants in Chile. ChCC is universally available in the public health system, but it has means-tested components designed to close health and developmental gaps that open early in life. In particular, in this paper we focus on two equity considerations related to ChCC's impacts. Firstly, we examine whether the program impacts the most vulnerable (poorest) population groups. This measure of vulnerability is captured by a publicly assigned score given to families based on average incomes, goods, and access to services that aims to capture socioeconomic well-being. Secondly, we examine where in the health distribution policy impacts are observed. It is important to note that these two notions of equity are quite different. The first captures whether program impacts are most substantial in the most economically disadvantaged families, while the second captures whether program impacts are most substantial among children born with more fragile health shocks. The design of the program explicitly targets the first condition (low socioeconomic level) but does not target the second condition.[3] In terms of the first consideration, we do find that ChCC has its largest effects among vulnerable (targeted) families and virtually null effects among non-targeted groups. In supplementary analysis using a discontinuity in benefit-targeting in the top two quintiles of the income distribution, we do not observe evidence of a discontinuous jump in infant health outcomes. This provides additional evidence to suggest that results are driven by families in lower income quintiles.

However, turning to the impact of ChCC across the distribution of health at birth, we find that the largest impacts come towards the middle of the distribution rather than among infants with the most fragile health stocks. While we do observe universally positive impacts of ChCC participation on both birth weight and weeks of gestation across their respective distributions, we estimate that these impacts do not become statistically significant until 2000 g and 36 weeks respectively and are largest when considering babies weighing 3500 g and born at full term. Together these

[3]Later in the paper we briefly document how these two conditions interact. In particular, we do not observe that the births occurring to members of a lower socioeconomic status have worse health stocks on average, given that their mothers are generally younger, and potentially have greater biological stocks.

results suggest that (at least ex ante) targeting poor health may be significantly more challenging than targeting vulnerable families. Nonetheless, we do recognise that health improvements even above the median have considerable long-term impacts (Royer 2009)

In terms of total cost, ChCC is one of the largest health or welfare programs in Chile. Recent figures suggest that ChCC spending currently accounts for almost 1% of the national budget. In terms of coverage, this program is substantial, reaching between 75 and 80% of all newborns in the country. To put the program's estimated effects in context, we calculate the inferred cost of producing a gram of birth weight and the implications for educational attainment later in life. When combined with the cost of running Chile Crece Contigo, our estimates suggest that the government spends around $11 per gram of birth weight—a figure that is comparable to other large successful neonatal health programs, including those in developed countries (such as the Special Supplemental Nutrition Program for Women, Infants, and Children, or WIC, in the USA). Our estimates suggest that ChCC is efficient when compared with other programs that explicitly target health at birth and that the cost per gram of birth weight is considerably lower than programs that do not explicitly target health at birth but that have been documented to have unintended positive impacts on these outcomes (such non-targeted programs include a poverty alleviation program in Uruguay and the Food Stamp Program in the USA). What's more, given the well-known positive effects of birth weight on later life outcomes, based on a back-of-the-envelope calculation we estimate that as an *upper bound* cost, each $2750 spent on ChCC results in an additional 0.05 standard deviations of educational attainment (as measured by later life test scores). These results suggest a common metric for considering the impact of early-life health programs across contexts. When linked to the literature on the long-run impacts of birth weight in Chile, these results also suggest that targeted public health and social welfare programs can have large impacts in developing and emerging economies, and these impacts should last much longer than the period in which an individual is enrolled in the program.

In this study we take advantage of administrative data from vital statistics and enrollment in public programs to conduct the first study of ChCC's impact *in utero*, drawing identification from two (different) sources. The first, and principal, method is based on temporal- and geographic variation in program intensity (due to varying rollout dates) in a difference-in-differences style setting. As a consistency check of these results, for a subset of women and children for whom linked administrative data is available, we observe the mother's use of public programs, and so exploit within-mother variation in exposure produced across siblings around the date of the policy's introduction.

Given that ChCC provides a basket of health and social support services to participants, after considering the net and distributional program impacts, we briefly examine the program's action mechanisms. We find suggestive evidence that prenatal nutritional supplements for mothers and increased linkages between families and the social safety net are important drivers of improvements of health at birth. All in all, the lessons from ChCC suggest that targeted health policies can have a substantial impact on birth outcomes of their intended recipients, but also point to remaining challenges in shifting very poor outcomes even with quite intensive investments. This paper offers new evidence on the relationship between public human capital investments and child's health in a country in the process of development, thus providing an important case to compare with a larger literature examining children based in higher income countries, where parental behaviours, availability of public programs, and the technology of the production function of child health are potentially quite different.

In what remains of this paper we briefly describe the ChCC program and the nature of its rollout, as well as the matched administrative data that allows us to link birth outcomes with ChCC usage and intensity. We 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 improvements in health at birth in Chile.

2 Background

2.1 Chile Crece Contigo

Chile Crece Contigo is a multidimensional early-life health program, targeting children from the first prenatal check-up during gestation, and following them through the first four years of their life. From 2018 onwards, this will be extended to the first seven years of life with the implementation of a mental health component. It is the Government of Chile's flagship social security program for children, reaching in some form approximately 75–80% of children in the country. The most comprehensive set of benefits are targeted to children from the 60% most vulnerable families.[4] ChCC is jointly implemented by the Ministry of Social Development, the Ministry of Health, the Ministry of Education, and the Ministry of Labour, and is delivered by a local network of public providers in each municipality (known as the Chile Crece Contigo Municipal Network).

The program was implemented gradually throughout the country, starting in June of 2007. The yearly expansion in program size, both in terms of total municipalities covered and the proportion of all births nationwide, is displayed in Fig. 1. In the first year the program covered 159 of Chile's 346 municipalities, before being extended to all municipalities in early-2008. We provide a description of the geographic dispersion of rollout in Appendix 1 Fig. 5. Early-implementing municipalities were not chosen at random, but rather were targeted given the availability of key infrastructure and the ability to manage the program in existing space in hospitals and health clinics (Arriet et al. 2013), explaining the earlier rollout to less-densely populated regions in the north and south of the country. Earlier-adopting municipalities were not necessarily those with better health infrastructure, but rather those not subject to space

[4] "Vulnerability" has historically been measured using a deterministic score assigned by government social workers, known as the *Ficha de Protección Social* (FPS), or Social Protection Score. Families with a FPS inferior to 13,484 points are classified as belonging to the 60% of most vulnerable households. Additional details of the FPS can be found in Herrera et al. (2010).

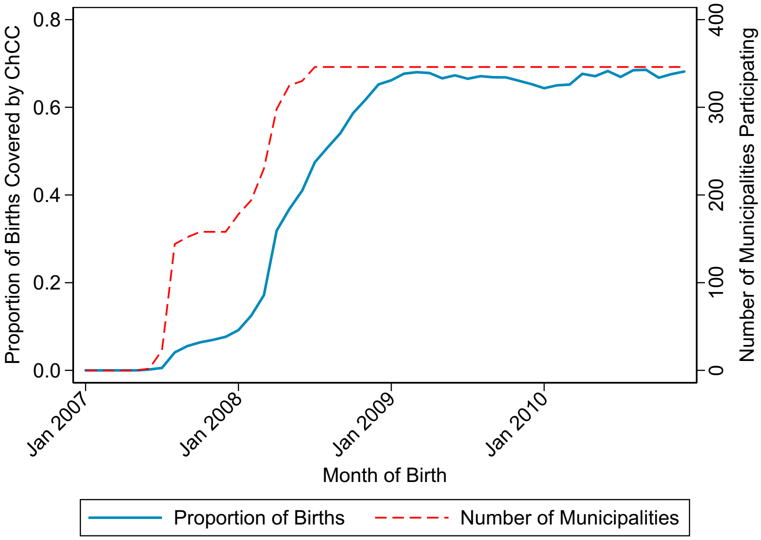


Fig. 1 Usage of gestational component of ChCC by month. Program usage by month and municipality, and proportion of all births covered nationwide is calculated from administrative data provided by the Ministry of Social Development. This captures the proportion of all mothers giving birth each month who participated in the prenatal components of ChCC prior to giving birth. The program did not exist prior to 2007. Additional details can be found in Section 3 of this paper. Geographic distribution of municipal rollout is provided in Appendix 1 Fig. 5

or capacity constraints in service provision. We return to discuss this below, and in Section 4 when outlining estimation strategies.

Program participation among pregnant women also increased in line with geographic coverage. The proportion of all births in Chile receiving at least some ChCC benefits during gestation are displayed as the solid line in Fig. 1. By the time ChCC was fully rolled-out, the program reached approximately 70% of all births nationwide, a figure which has remained quite steady over time. Any mother enrolled in the public health system will, by default, participate in ChCC as the program is an integrated part of prenatal check-ups and birth in the public health system. This mode of delivery of ChCC means that there is no explicit demand-side and individuals cannot opt out (unless they stop attending all public health check-ups), as all individuals enrolled in the public health service[5] automatically participate in ChCC from their first prenatal check-up, until the child "graduates out" of the program when entering the primary schooling system. Thus, program participation is entirely determined by

[5]The Chilean health system consists of a private and public stream and users nominally choose between public and private care. An associated monthly payment is automatically deducted from all formal salaries as a provisional 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 considerably 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 2016). Additional background is provided in Appendix 2.

the supply-side, which depends on each municipality's date of entry into ChCC and public health population, and implies that the program completely covers its objective population of women enrolled in the public health system. The program was institutionalised as a basic pillar of the Social Security system in 2009, with the approval of a law[6] guaranteeing its ongoing existence.

While program participation can thus be considered as pre-determined by an individual's status as covered by the public or private health systems, it is interesting to consider whether the nature of the municipal-level rollout is systematically related to individual characteristics. As discussed above, the program arrived to different municipalities within the country at different times depending on the municipality's ability to meet initial program demand. We are not aware of any policy documents describing exactly how this rollout was implemented[7] and as such we collect a number of municipal-level characteristics of each municipality in 2006, the year prior to ChCC's implementation. In Table 1 we regress each municipality's status as an "early adopter" (whether it adopted prior to September 2007 in the first wave of municipalities), and the number of months adopted by the time the program was fully rolled out, on each of these municipal-level characteristics. In columns 1 and 3 we observe some evidence to suggest that earlier adopters may differ on a number of observable characteristics: namely lower poverty rates, and a lower proportion of primary and tertiary educated mothers, a higher rate of teen births, and fewer residents with piped tap water. However, when we condition on regional fixed effects to capture general geographical clustering of outcomes and rollout, we observe relatively little evidence to suggest that there are systematic observable differences at baseline between early adopters and later adopters, with the exception of the proportion of residents who have a vulnerability score (a crude measure of the number of households accessing public programs). In no specification do we observe evidence to suggest that rollout obeyed political considerations such as the party of the mayors of each municipality. In general, while there is relatively little evidence to suggest that rollout was highly targeted to a large number of municipal characteristics, there are some differences between early and later adopting municipalities. As we lay out at more length in the methodology section of this paper, the validity of our estimates *does not* require that this rollout is conditionally as good as random, it simply requires that any characteristics which are correlated with municipal selection are not systematically correlated with improvements in health at precisely the same time that there is expansion in the municipal coverage of the ChCC program in a given municipality. We provide a number of tests of this later in this paper.

The program consists of two main pillars. The first is the Program Supporting Bio/Psycho/Social Development (PADBP), and the second is the Program Supporting New-Borns (PARN). The PADBP pillar begins at the first prenatal medical check-up, with the main goal of supporting fetal and child development by providing

[6] The Law 20.379 was passed unanimously by parliament on April 2nd, 2009 to "institutionalise the subsystem of integral protection of infancy, Chile Crece Contigo".

[7] However the Chilean Ministry of Social Development provided us with their records of the precise date of entry of each municipality into the program.

Table 1 Rollout of Chile Crece Contigo and Municipal Characteristics

	Early adopter		Adoption period	
	(1)	(2)	(3)	(4)
Residents with treated tap water	− 0.004**	0.000	− 0.026*	−0.001
	(0.002)	(0.002)	(0.014)	(0.014)
Residents using public health service	− 0.114	0.015	− 0.869	0.284
	(0.080)	(0.080)	(0.687)	(0.703)
Population receiving vulnerability score	−0.446	−0.968*	−3.983	− 8.860*
	(0.545)	(0.537)	(4.422)	(4.582)
Residents living in poverty	− 0.008**	0.001	− 0.049	0.026
	(0.004)	(0.004)	(0.031)	(0.033)
Transfers for education	−0.001	−0.001	−0.007	0.004
	(0.002)	(0.002)	(0.015)	(0.016)
Births to teen mothers	1.269**	0.315	7.191**	0.589
	(0.502)	(0.313)	(3.200)	(2.407)
Vote share obtained by mayor	− 0.058	− 0.121	− 1.241	− 1.588
	(0.239)	(0.213)	(1.970)	(1.812)
Mayor belongs to a left-wing party	0.028	0.007	0.302	0.247
	(0.078)	(0.068)	(0.636)	(0.579)
Mayor belongs to a right-wing party	0.095	0.080	0.578	0.592
	(0.064)	(0.063)	(0.542)	(0.533)
Mothers with primary education	− 2.747**	− 0.261	− 11.220	2.913
	(1.304)	(1.578)	(11.312)	(12.931)
Mothers with decondary education	−1.665	−0.601	−3.444	3.656
	(1.116)	(1.251)	(9.587)	(10.211)
Mothers with tertiary education	− 2.614**	− 1.111	− 12.246	− 4.096
	(1.194)	(1.362)	(10.538)	(11.257)
Constant	2.825***	1.335	17.253*	9.296
	(1.060)	(1.271)	(9.186)	(10.257)
Mean of dependent variable	0.408	0.408	6.730	6.730
Observations	341	341	341	341
R-squared	0.102	0.304	0.073	0.276

Columns 1 and 2 regress each municipality's early enrollment status (binary) on observable municipal characteristics at baseline (2006) using a linear probability model. Columns 3 and 4 regress the number of months each municipality was enrolled in the program by the time all municipalities had enrolled. Each independent variable is measured as the proportion of respondents in the municipality meeting the indicated condition, a binary variable for the mayor's party, or millions of Chilean pesos when referring to transfers of educational resources from the central government. Columns 2 and 4 additionally control for region fixed effects (for the 15 regions in the country). Municipal-level characteristics are drawn from electoral records, the National Service of Municipal Information (SINIM) and birth records from 2006. Heteroscedasticity-robust standard errors are displayed in parentheses. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

information and ongoing support in periodic check-ups, and in certain circumstances, home visits. The second program arm, the PARN, begins at the birth of the child. Among other things, this pillar provides a comprehensive kit of materials to all newborns born in the public health system including a crib, blankets, baby carrier, toys and didactic materials, clothing and sanitary products. In what remains of this section we provide a description of the components of the PADBP program, focusing only on the prenatal components. We focus on this program arm in more depth given that we examine ChCC's impact on health at birth, which can only respond to prenatal investments, rather than health after birth. We provide a more comprehensive discussion of the program, including both pre- and post-natal components, in Appendix 3 of this paper.

Prenatal components of ChCC The design of ChCC called for an increase in the amount of time spent on prenatal check-ups (with midwives in public health clinics) from 20 min per appointment to 40 min per appointment. The increased time was used on newly incorporated components, such as the application of standardised tests for pre-partum depression, social support programs, and information to encourage the participation of fathers or partners in preparations for having a child. ChCC targets 7 prenatal check-ups in public health centres. At the date of the first prenatal check-up, families are supplied with an information kit (in Spanish or one of five indigenous languages or regional dialects), as well as a (music) CD for prenatal stimulation. Any person meeting a set of pre-defined risk factors[8] receives an additional psycho-social evaluation to determine whether they are referred for immediate additional support. The ChCC program also delivers nutritional components to expectant mothers. This principally consists of a fortified powdered milk disbursed by the kilogram at local health centres. The formula of this product was changed during the ChCC program to more accurately meet the nutritional needs of pregnant women. We return to discuss mechanisms of the program's action in more depth later in the paper.

Along with these universal benefits, families flagged as pertaining to the 60% most vulnerable of the population receive a series of preferential benefits. These benefits begin at the first prenatal check-up with the definition of a personalised plan created between municipal health workers and families, as well as hour-long home visits from social workers and paramedical technicians.[9] Finally, vulnerable families are referred to the ChCC Municipal Network, which includes meetings with municipal workers offering information related to education and labour market programs where relevant, information regarding other government programs and community services, and eventually access to free child care. We conducted *in situ* (anecdotal) interviews with midwives and social workers involved in the program, who highlighted that the implementation of ChCC resulted in a considerable increase in the quality of prenatal

[8]These factors are as follows: a first prenatal check-up at 20 weeks or later, the pregnant women being aged under 18 years, having 6 or fewer years of primary education, insufficient family support, "rejection of the pregnancy", symptoms of depression, substance abuse, or any signs of intra-family violence.

[9]These home visits are not universally offered among the preferential group. Home visits are targeted to families with a greater number of risk factors as defined in ChCC materials handed out to local public health providers.

care offered, and the ability to easily refer families between institutions. We provide additional information regarding the scope and design of the program in Appendix 3. A comprehensive list of program benefits is available in Ministerio de Desarrollo Social (2014), and summarised in Appendix 3 Table 24.

2.2 Existing evidence on the impact of early-life programs on infant health

A well-established body of work—much in the economic literature—has documented the importance of public policies on indicators of health at birth and during gestation. These can be broadly split into two types of programs: those explicitly targeting infant health, and those with indirect impacts on infant health.

There is relatively less evidence on programs explicitly targeting infant health. Nevertheless, convincing evidence from the United States shows that publicly provided food and nutritional advice to pregnant mothers has considerable effects on birth outcomes. The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), has been shown to have appreciable impacts on health at birth (refer to Bitler and Karoly (2015) for a clear overview).[10] A number of policies directly designed to target health at birth exist in Latin America, though often rigorous evaluations have not yet been implemented. These include programs such as Plan Nacer (Argentina) and Uruguay Crece Contigo (Uruguay). One notable exception is a CCT from Bolivia. Celhay et al. (2016) identify a significant reduction in rates of stillbirth following receipt of a relatively small CCT. In Section 5.2 of this paper we benchmark the impacts of a range of early-life health programs such as WIC.

Evidence also exists on the impacts of non-targeted welfare policies on health at birth. Analysis from the USA suggests that the Supplementary Nutrition Assistance Program (Food Stamps) may increase birth weight by as much as 20 g (Almond et al. 2011), and unintended impacts on child health have also been identified from the Earned Income Tax Credit (Hoynes et al. 2015). Another series of papers documents the impact of receipt of conditional cash transfers on infant health, even when these transfers were not directly targeting these outcomes.[11] This includes the PROGRESA/Oportunidades program in Mexico (Barham 2011), and the PANES program in Uruguay (Amarante et al. 2016), both of which identify considerable impacts on survival or (a reduction) in poor health indicators at birth respectively.

2.3 Other social safety net programs in Chile

Chile Crece Contigo joined a number of other targeted social security programs in Chile. However, unlike other programs offered by the Ministry of Social Development, Chile Crece Contigo focuses exclusively on the early-life stages, and covers a large proportion of the population of Chile.

[10] There is also evidence suggesting public insurance expansions in the USA resulted in changes in prenatal health behaviours of mothers (Dave et al. 2018).

[11] A broad literature also studies the impact of transfers on fertility itself, rather than health outcomes at birth, for example Nandi and Laxminarayan (2016) in India and Malak et al. (2019) in Canada.

The Chile Solidario program is focused on poverty reduction, and is targeted to the most vulnerable 10% of the population. This program includes a cash transfer (which fades out over time) and a series of home visits. This program has been demonstrated to increase the take-up of employment programs, as well as participation in other public policies (Carneiro et al. 2014). Other programs targeted to families with children include the Subsidio Único Familiar, a subsidy for families with children, as well as a series of targeted scholarships and school meal programs. In each case, these policies are targeted to a more restricted group than ChCC recipients (Herrera et al. 2010). One component of the (targeted) component of ChCC is ensuring that vulnerable families are adequately enrolled in additional social policies for which they are eligible. We examine the potential link between ChCC usage and connection to the social welfare network more generally in Section 5.3 of this paper.

3 Data

Birth outcomes Vital statistics covering all births occurring in Chile are publicly available from 1990 until 2015 from the Ministry of Health. Additionally, data on fetal deaths occurring after 22 weeks of gestation are available from 2002 onwards. These vital statistics data cover greater than 99% of all births, and coverage is stable over time. In this paper we use the full universe of births and fetal deaths occurring between 2003 and 2010 (4 years pre- and post-ChCC), and match this with administrative data on ChCC usage in the gestational period provided by the Ministry of Social Development (MDS). These data allow us to calculate usage by month for each of the 346 municipalities of Chile.[12] The precise date of program rollout by municipality is also provided by the MDS.

These birth data allows us to observe a range of human capital measures at birth. These are 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 2011b). Although Apgar and head circumference are measured at birth and the mode of delivery is recorded (Caesarean section, vaginal or forceps-assisted) these variables are not currently available in administrative data. Along with measures of health immediately at birth, we are able to calculate rates of fetal death per live birth by combining fetal death registers with live birth registers. The recording of fetal deaths is consistent throughout the country, capturing all stillbirths observed by doctors or midwives (see for example Rau et al. (2017, p. 22), Bentancor and Clarke (2017, p. 2532) for additional details).

Administrative (micro-) data is collapsed at the municipal by month level, and matched with data on ChCC intensity by municipality and month. We match all births occurring between January of 2003 and December of 2010 (inclusive), surrounding the program's rollout. ChCC data is available from mid-2007 (the first date of

[12] Municipalities in Chile are the third level administrative district, and the lowest level of local governance, after provinces and regions. In Chile there are 346 municipalities, 54 provinces, and 15 regions.

program rollout) until 2010, and the pre-2007 period provides coverage of the pre-reform dates. This results in a sample of 1,917,085 births occurring to 1,241,514 mothers. When collapsed to the municipal level, this results in 31,842 municipal $\times$ month observations. The theoretical maximum number of observations is 346 municipalities $\times$ 8 years $\times$ 12 months (33,216 municipalities), but a number of smaller municipalities do not have births in each month.

In Table 2 we provide summary statistics of principal health indicators at birth, as well as rates of participation in Chile Crece Contigo by municipality and month. These summary statistics are unweighted; population weighted summary statistics are broadly similar. Municipal-level averages are largely in agreement with values observed in Vital Statistics data observed elsewhere (we also provide summary statistics at the level of births in Appendix 4 Table 26). The average birth weight in municipal averages is approximately 3350 g, gestation is on average 38.7 weeks, and 5 and 6% of births are low birth weight or premature (respectively). In administrative data from 2003 to 2010, 25% of mothers are observed to 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. Rates of usage of the program (only the gestational component) by time are displayed in Fig. 1. In Appendix 1 Fig. 6 we present the distribution of ChCC

Table 2 Summary statistics: birth and Chile Crece Contigo data

	N	Mean	Std. Dev.	Min	Max
Proportion enrolled in ChCC	31,842	0.24	0.36	0.00	1.00
Birth weight (g)	31,805	3346.28	174.44	686.00	4868.00
Low birth weight < 2500 g	31,805	0.05	0.07	0.00	1.00
Gestation (weeks)	31,806	38.66	0.60	24.00	42.00
Premature < 37 weeks	31,806	0.06	0.08	0.00	1.00
Length (cm)	31,806	49.47	0.88	30.00	56.00
Number of births	31,842	60.21	93.69	1.00	787.00
Rate of fetal deaths/1000 births	31,842	9.56	38.45	0.00	2000.00
Year of birth	31,859	2006.51	2.29	2003.00	2010.00
Mother's education	31,808	10.74	1.50	0.00	19.00
Mother's age	31,833	26.68	2.35	14.00	45.00
Proportion teen births	31,833	0.18	0.13	0.00	1.00
Number of children	31,842	2.02	0.41	0.67	9.00

Summary statistics are displayed for municipality by month averages for each month from January 2003 to December 2010. Averages are displayed for each municipality in which there is at least one birth in the given month. The average number of births by municipality and month is displayed above. There are 346 municipalities in Chile, and hence a maximum number of observations of 346 municipalities $\times$ 8 years $\times$ 12 months, or 33,216 municipality $\times$ month observations. The difference between this maximum and the observed number of observations are cases where no births occurred. Uncollapsed micro-data on births consists of 1,917,085 observations between 2003 and 2010. Additional details on this birth data is provided in Appendix 2. Proportion enrolled in ChCC refers to the average proportion of births in each municipality which were covered by ChCC in utero during the entire period of 2003–2010, and so is always zero prior to the implementation of ChCC in 2007/2008 usage by municipalities once the program was implemented. We observe considerable variation in program intensity by municipality, reflecting different rates of usage of the public (rather than private) health system by municipality within the country. In examining the number of births occurring in each municipality in Table 2 ("Number of Births") we also observe a large range in municipal size. Depending on the municipality, the number of births per month ranges from as low as 1 birth (conditional on there not being 0 births) to as high as 787 births. As we discuss below, regression estimates are consistently weighted by the number of births per cell. This weighting also accounts for a small number of strange cells, for example municipalities with very high rates of fetal death or adolescent births. These outliers occur in municipality by month cells in which only one birth occurred, and so result in extreme averages when expressed per birth. These do not drive regression results given the small number of births, and corresponding low analytic weight.

For a subset of births, we are able to match all siblings with mothers, as well as with the mother's participation in social programs. For these mothers we thus observe her full fertility history, as well as whether she participated in Chile Crece Contigo, and her social protection score, defining the degree of usage of ChCC for which she will be eligible (ie for means tested and general items, or only for general items). Approximately 50% of births are correctly matched to their mother. We thus use this matched micro-data sample as an auxiliary test of the main result. While this does not include the full universe of births used in the municipal-level analysis, the resulting data set is a unique source of information on births in Chile matched to the mother's take-up of social safety net programs. In Appendix 4 we discuss the match rates, as well as the characteristics of the matched and unmatched sample. The unmatched children were overwhelmingly matched with their father rather than their mother in the social registry, and so are excluded from micro-level analyses given the lack of information on the *mother's* usage of public programs, including, fundamentally, ChCC. We highlight that this imperfect match is not an issue for any regressions using all data at the level of the municipality, which are the principal regression results we focus on in this paper. This is only an issue for regressions based on maternal socioeconomic characteristics, such as regressions splitting by the mother's social vulnerability score.[13]

Chile Crece Contigo data Administrative data on ChCC usage as well as the exact date of rollout is provided by the Ministry of Social Development of Chile. As discussed in Section 2.1, program rollout occurred gradually, based on infrastructure availability, and is documented geographically in Appendix 1 Fig. 5. Administrative figures for intensity of program use are also provided by the Ministry of Social Development which record the proportion of births in each month and municipality which used at least some ChCC components at some point of their gestation. The trend in this measure over time was plotted in Fig. 1 of this paper. We also collect month-by-month figures describing the usage of a number of key program components from

[13] We also note that we could not match fetal death data to maternal socioeconomic characteristics, and as such, rates of fetal death are only considered in the main municipal-level regressions.

the Department of Health Information (DEIS) of the Ministry of Health. We return to discuss these data when examining the program's mechanisms of impact.

Finally, a number of municipal-level controls are collected. These data are drawn from the Municipal System of Municipal Information (SINIM), the Chilean Electoral Service (SERVEL), and directly from the birth registers. These measures are available yearly between 2003 and 2010, and include financial transfers to the municipalities for education, the proportion of residents in poverty and the proportion receiving a social vulnerability score, the proportion of residents with access to treated piped water in their home, the mayor's party and vote share when elected, as well as maternal education and the proportion of teen births (as documented in Table 1).

4 Methodology

Estimating the impact of ChCC We leverage the time-varying rollout and intensity of ChCC by municipality to estimate the following flexible difference-in-differences (DD) model:

$$InfantHealth_{ct} = \alpha_0 + \alpha_1 ChCC_{ct} + \boldsymbol{W}_{ct}\alpha_w + \mu_t + \lambda_c + \eta_{ct} \tag{1}$$

where $InfantHealth$ measures average birth outcomes for each municipality c in period t. In principal specifications, the unit of time is month by year. The variable $ChCC_{ct}$ is a treatment measure indicating the proportion of all births in each municipality and month which received coverage from the *Chile Crece Contigo* program during gestation. This measure is always 0 prior to the program implementation, and increases to reach approximately 75% of the population following the program's implementation. Given that the program was implemented in different municipalities at different times, we include full municipality and time (month $\times$ year) fixed effects as λ_c and μ_t respectively. The measure of $ChCC$ depends on program rollout as well as the proportion of a municipality which is enrolled in the public health system. This share is largely fixed by municipality once a municipality reaches its steady state of program use, and is higher in municipalities with a larger proportion of low-income households.[14] While we could use a simple binary measure for $ChCC$ availability in specification 1, this is practically challenging, given that there is considerable variation in actual usage of ChCC for different time periods and municipalities, and replacing the continuous intensity variable with a binary availability variable results in much less identifying variation. Nonetheless, we present this

[14] All women enrolled in the public health system who become pregnant automatically participate in ChCC. In Appendix 1 Fig. 3 we document the proportion of the country enrolled in the public health system, and observe a declining trend prior to ChCC's implementation. In Appendix 1 Table 10, we test formally whether ChCC actually convinced people to participate in the public health system, which would complicate our empirical strategy, however find no evidence that this is the case. In Appendix 1 Fig. 8 we present scatter plots of the level of municipal enrollment, and various municipal characteristics, where, unsurprisingly, higher ChCC usage is associated with greater poverty shares and vulnerability (conditional results were documented in Table 1).

specification as an appendix model. Similarly, we present an appendix specification where we instrument $ChCC_{ct}$ with lagged usage in the same municipality, to examine the possibility that our continuous ChCC measure captures program demand rather than program availability, and a specification where we interact average rates of ChCC usage in each municipality with treatment lags and leads, providing an event study specification.

Identification is drawn from the fact that considerable variation in ChCC coverage owes to the date that each municipality enters the ChCC program.[15] If implementation of the policy were completely random, α_1 will give the unbiased effect of ChCC participation on infant health measures. However, as documented in Table 1, we may be concerned that early-adopting municipalities with better infrastructure were following differential trends over time, we include a series of time-varying controls for health infrastructure and municipal development $\boldsymbol{W}_{ct}$, and in supplementary regressions also examine the robustness of results to regional and municipal time trends, and separate regional and municipal fixed effects for each year. We also estimate a specification to examine whether the date of rollout has a direct impact on early-life health outcomes *conditional* on the expansion in intensity of the program and find that it does not, providing further support for the identifying assumption (Appendix 1 Table 11). As is typical, we cluster standard errors by municipality (346 municipalities) to account for the well-known time dependence in unobserved stochastic errors by geographic area (Bertrand et al. 2004; Cameron and Miller 2015). We discuss a number of additional placebo checks below.

Our principal outcome measures of $InfantHealth$ are based on the available measurements recorded in vital statistics data, and consist of birth weight in grams, low birth weight (< 2500 g), birth length in centimetres, gestational time in weeks, prematurity (< 37 weeks gestation), and the frequency of fetal deaths. Given that we propose to use various outcome measures and a single independent treatment variable ($ChCC$), we correct for multiple hypothesis testing in a number of ways. Firstly, in order to ensure adequate size in hypothesis tests, we apply Romano and Wolf (2005)'s step-down hypothesis testing algorithm which controls the Family Wise Error Rate (FWER) at a set level α. This hypothesis correction technique is considerably more powerful than older FWER techniques such as Bonferroni or Holm, and is increasingly used in the economic literature (see for example Gertler et al. (2014)). This is also a more demanding correction than those corrections which control the False Discovery Rate of findings. Secondly, we construct a single index based on the full set of outcome variables which gives more weight to variables which provide the most independent variation. To construct this index we follow the procedure described in Anderson (2008), allowing us to examine the estimated effect of ChCC on a single outcome variable, where variables which provide more independent information are given larger weights in the index.

[15] Note that here the largest expansion in coverage is seen in the year around policy implementation. We could thus limit our analysis to a single year period of rollout, and we do so in alternative specification. There is however some variation in coverage in the post-treatment period, and the inclusion of a longer pre-treatment period allows greater power to estimate baseline health outcomes, and as such we generally work with the full sample of 2003–2010 data.

Alternative identification strategies While our main identification strategy takes advantage of the time-varying expansion of ChCC by municipality, we also estimate a child-level regression controlling for mother fixed effects leveraging within mother variation in policy exposure. For each mother in matched administrative data we observe all births occurring between 2003 and 2010, both before and after policy implementation. The inclusion of mother fixed effects thus allows us to capture all time-invariant unobservables of mothers correlated with program participation. We also include a number of time-varying controls, including maternal age and birth order fixed effects.

We estimate mother fixed effect models only as a robustness check rather than our main specification given that the match between children and mothers was not universal (while municipal-level regressions are based on complete vital statistics data). As discussed in Section 3, approximately 50% of births were correctly merged with data on their mother's use of public programs, while the remaining births were merged with the father's social program participation. We provide additional details regarding the precise mother FE specification to be estimated, as well as match rates and characteristics of matched and unmatched children in Appendix 4.

We use this same source of rich variation in maternal outcomes to estimate a regression discontinuity model based on the additional preferential program benefits targeted to vulnerable households. The targeting of ChCC is based on a social protection score (the "Ficha de Protección Social") which is assigned to families following an interview with a social worker, and which captures family vulnerability over a range of dimensions. Importantly, the cutoff is arbitrarily set, capping access to preferential services at families located above the 60th percentile of the vulnerability score. In particular, this equates to a score of 13,484 points (refer to Appendix 1 Fig. 10a for the distribution of scores assigned to all mothers observed in the birth records). Importantly, while there is a theoretical cutoff in the program's preferential benefits at this arbitrary point of the distribution of the social protection score, it would be very hard for individuals to systematically manipulate their score to be located on one side or the other of the cutoff, given that it is determined after an interview and based on an undisclosed (to the public) criterion.[16]

This suggests that the cutoff acts as an ideal setting for use in a regression discontinuity design, allowing us to determine whether the program targeting and preferential benefits have appreciable impacts on health at birth. It is important to note, however, that this test is a test of the *intensive* margin impacts of the program (more program inputs), rather than the *extensive* margin impacts of moving a larger population into the program. In Appendix 1 Fig. 10b we document that there is no considerable bunching at the program cutoff when implementing a McCrary (2008) density test. In formal implementations of the regression discontinuity test we estimate both

[16] In particular, the Ministry in charge of assigning this score states (to the public) that the score is based on income, the household's needs—which depend on the number of dependents meeting certain criteria such as disability or age ranges, and the household's access to a range of goods and services including health, education, vehicles, and housing. The precise formula for calculating the score is not disclosed.

parametric models where a separate quadratic polynomial is estimated on each side of the cutoff, and non-parametric local linear models, where the optimal bandwidth is calculated using Calonico et al. (2014)'s bias-corrected optimal bandwidth selector with a triangular kernel.

Placebo tests We observe monthly usage rates of ChCC during gestation for each municipality following the reform's implementation. This measure of usage by municipality and time is our independent variable of interest in main specification 1. In order to ensure that our estimates for α_1 are not simply capturing systematic differences between municipalities with varying implementation time and intensity of ChCC, we propose to conduct a series of placebo tests using lagged measures of the independent variable of interest.[17] Specifically, we estimate the following model:

$$InfantHealth_{ct} = \gamma_0 + \gamma_1^k ChCC_{c,t-k} + \boldsymbol{W}_{ct}\alpha_w + \mu_t + \lambda_c + \eta_{ct} \qquad \forall k \in 1, \ldots, 40. \tag{2}$$

Here, rather than regressing birth outcomes on ChCC usage among births in the same month, we regress outcomes at time t on on ChCC usage in month $t-k$, where k refers to the lagged quantity of months. Provided that improvements in birth outcomes are truly flowing from the program, rather than systematic differences between municipalities, we should see that lags of $ChCC_{ct}$ do not impact birth outcomes in future periods conditional upon municipal and time fixed effects.

Distributional effects of the policy Along with regressions examining birth weight, and gestational length, we are able to observe the effects of the policy over the entire range of these health distributions, to examine precisely where any average effects are observed. In our main specifications we examine the impact of ChCC on LBW and prematurity, but these cutoffs defined by medical standards are arbitrary. We can similarly consider outcomes across the entire support of the health measures at birth. We follow Rossin-Slater (2013), who undertakes a similar analysis of birth weight and the WIC program, in defining a range of binary variables which take the value of 1 if birth weight exceeds a certain weight, and zero otherwise, for points from 1000 to 5000 g. Similarly, we create binary measures for gestational length greater than w weeks, where w is set at 30–41 weeks. This allows us to determine if mean impacts vary throughout the distribution of health at birth, as we simply replicate Eq. 1, however now with the range of distributional variables, in place of $InfantHealth$. Once again in these specifications we report results both uncorrected for multiple hypothesis testing, and results accounting for the fact that with multiple outcomes, we are likely to over-reject the null hypothesis of a zero-reform impact.

[17] Frequently, identifying assumptions in DD-style models are tested by event study analysis, where treatment status is interacted with a full set of lags and leads. In the setting of this paper, where program usage is a continuous rather than binary measure, an event study is not suitable given the lack of binary treatment, and the fact that all municipalities are eventually treated. We thus proceed with the lagged placebo tests as described in this section.

5 Results

5.1 Program impacts

5.1.1 Headline effects

Baseline estimates based on municipality and time-varying exposure to the Chile Crece Contigo program are presented in Table 3. Estimates in this table are all produced by an archetypical DD model including ChCC coverage as the independent variable of interest, and municipality and month × year fixed effects. Standard errors are clustered by municipality.

Results from Table 3 suggest large and significant effects of the reform on birth weight and the rate of fetal deaths. As the independent variable is measured as the proportion of ChCC coverage in a municipality, an increase in 1 unit of this variable is equivalent to moving from 0 to universal ChCC coverage, or the mean impact of ChCC if the full population were treated. The mean impact of Chile Crece Contigo is estimated as a 10-g increase in birth weight. When examining the proportion of low birth weight babies, results suggest that ChCC brought about a reduction in these births by 0.2 percentage points; however, this is not distinguishable from 0 at the 10 percent level. When comparing the (statistically insignificant) point estimate to the absolute value of low birth weight births, this is approximately a 3.7% reduction. We find no impact of ChCC on size at birth, but do observe a small increase in gestational length of 0.24 weeks (though like low birth weight, this impact is not statistically significant). No statistically significant effect is observed when considering the proportion of premature births, though impacts are weakly negative (ie a reduction in premature births). Finally, in turning to fetal deaths, we observe a significant reduction, of 1.5 fetal deaths per 1000 live births following the program's implementation

Table 3 Difference-in-difference estimates using municipal variation in coverage

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Proportion of ChCC coverage	10.092**	− 0.002	0.004	0.024	− 0.002	− 1.530**
	(4.404)	(0.001)	(0.028)	(0.015)	(0.002)	(0.766)
Constant	3351.522***	0.054***	49.479***	38.705***	0.065***	4.892***
	(4.082)	(0.002)	(0.026)	(0.016)	(0.002)	(0.517)
Mean of dependent variable	3346.281	0.054	49.475	38.659	0.064	9.563
Observations	31,805	31,805	31,806	31,806	31,806	31,842
R-squared	0.261	0.051	0.451	0.278	0.095	0.056

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 2500 g, and premature refers to the proportion of births occurring before 37 weeks of gestation. Birth weight is measured in grams, Size is measured in centimetres, and Gestation is measured in weeks. Fetal deaths are measured as the number of fetal deaths per 1000 live births. 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. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

and expansion. Similar impacts have been documented with the rollout of universal health coverage in Brazil (Bhalotra et al. 2019).

We examine alternative specifications and controls in Table 4. Here rather than simply estimating a baseline DD model with time and geographic fixed effects, we add additional time-varying controls, region and municipal specific linear or quadratic time trends, region and municipality by year fixed effects, or alternative weights. Even in the most demanding specification which allows a separate fixed effect for each municipality in each year (346 $\times$ 8 fixed effects), estimates largely agree with those in the baseline DD model (10.09 versus 9.61 g). While split linear time trends by municipality reduce the coefficient slightly and increase the standard error, rendering the coefficient insignificant (t-statistic $=$ 1.34), identical models allowing split *quadratic* trends suggest a slightly larger (and significant) result of 11.8 g. The remaining effects are quite stable, with the exception of the estimated effect of ChCC on the rate of fetal deaths which no longer remain significant in certain fixed effect specifications. Throughout the paper we weight regressions by the number of births in each municipality by month cell, however In column 9 we document that results are robust when weighting by the number of pregnancies, proxied by the sum of all births and fetal deaths.[18] In some models, significant positive impacts are observed on birth size and significant reductions are observed in the proportion of low birth weight babies, but these are not consistently observed. If we estimate using trimester $\times$ municipality averages rather than month by municipality outcomes, estimates remain quite stable (Appendix 1 Tables 12 and 13). Similarly, if we limit our analysis period to only one year around the data of the reform, point estimates largely agree with those in Table 3, however are estimated with less precision (Appendix 1 Table 14).[19] The impacts on birth weight are not driven by municipalities with extreme averages. Results are virtually identical when winsorizing or trimming at the first and 99th percentiles (Appendix 1 Table 16).

Finally, we correct for multiple hypothesis testing in Appendix 1 Table 17. Panel A presents uncorrected and corrected p values where we account for the fact that we are prone to over-reject the null when testing the impact of ChCC on multiple outcome variables. Original p values come from estimates presented in Table 3, while corrected values follow Romano and Wolf (2005, 2016). This is a demanding correction, ensuring that no null hypotheses will be incorrectly rejected at a given size. In this case, we still observe a statistically significant effect on birth weight. When considering an index capturing infant health (where a positive value implies greater health), we observe that regressing the single infant health index on rates of participation in ChCC results in statistically significant impacts.

We examine the plausibility of identifying assumptions using a series of placebo tests. These placebo tests use the ChCC participation rates for each municipality, however assigning the placebo reform treatment to a period entirely *before* the

[18] This quantity is closer to the number of all women covered by ChCC, given that women who miscarry after a number of months would also have participated in the program.

[19] We also estimate an IV model for this one year period, where this ChCC intensity measure is instrumented by ChCC availability. Perhaps unsurprisingly given the shorter period and noisier IV estimates, these estimates are noisy (Appendix 1 Table 15).

Table 4 Alternative specifications: diff-in-diff estimates of program impacts

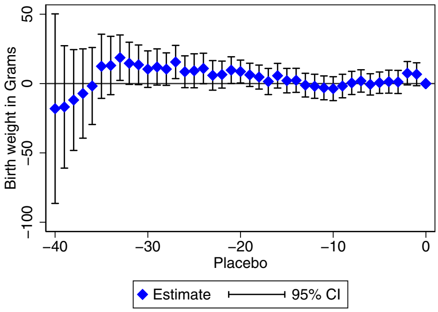
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Birth weight									
Proportion of ChCC coverage	10.092**	9.354**	9.204**	8.712**	8.088*	7.210	11.817*	9.613*	10.024**
	(4.404)	(4.550)	(4.394)	(4.204)	(4.321)	(5.382)	(6.021)	(5.289)	(4.402)
Panel B: LBW									
Proportion of ChCC coverage	− 0.002	− 0.002	− 0.002	− 0.003*	− 0.003*	− 0.001	− 0.003*	− 0.003	− 0.002
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Panel C: Size									
Proportion of ChCC coverage	0.004	0.011	0.014	0.030	0.033	0.022	0.051**	0.048**	0.004
	(0.028)	(0.028)	(0.026)	(0.026)	(0.026)	(0.025)	(0.023)	(0.024)	(0.028)
Panel D: Gestation									
Proportion of ChCC coverage	0.024	0.026*	0.008	0.018	0.020	0.003	0.017	0.024	0.024
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.017)	(0.015)
Panel E: Premature									
Proportion of ChCC coverage	− 0.002	− 0.002	− 0.000	− 0.001	− 0.001	0.001	− 0.000	− 0.000	− 0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Panel F: Infant mortality									
Proportion of ChCC coverage	− 1.530**	− 1.593**	− 1.203	− 0.607	− 0.677	− 1.943**	− 1.109	− 0.202	− 1.834**
	(0.766)	(0.783)	(0.787)	(0.812)	(0.824)	(0.943)	(0.933)	(0.938)	(0.813)
Municipal and time FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time-varying controls	N	Y	N	N	Y	N	N	N	N
Region time trends	N	N	Y	N	N	N	N	N	N

Table 4 (continued)

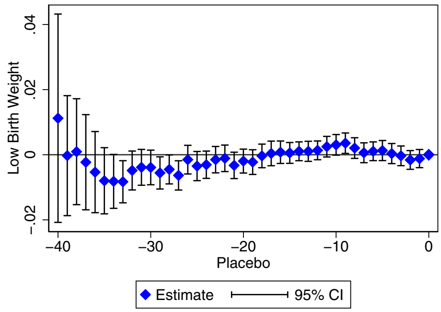
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Region × Year FEs	N	N	N	Y	Y	N	N	N	N
Municipal linear trends	N	N	N	N	N	Y	N	N	N
Municipal quadratic trends	N	N	N	N	N	N	Y	N	N
Municipal × Year FEs	N	N	N	N	N	N	N	Y	N
Weighting by pregnancies	N	N	N	N	N	N	N	N	Y

Each specification is estimated by DD using municipal-level averages by month, and weights for the number of observations in each cell. Column 1 replicates results from Table 3, and then columns 2–8 include additional controls, time trends, or fixed effects. Column 9 weights by the number of pregnancies, rather than births. Regions in Chile are the second-level administrative district, of which there are 15. Municipalities are within districts (analogous to states and counties in other countries), and there are 346 municipalities in Chile. In each case where time trends are included, these are split for pre- and post-reform periods. The most demanding specification (column 8) allows for a separate fixed effect for each municipality in each year under study, given that there are twelve observations for each municipality in each year. Time-varying controls are collected from the Government of Chile's National System for Municipal Information, and are available for each municipality in each year. These controls consist of total transfers for education and health, the proportion of each municipality enrolled in the public health system (FONASA), the proportion enrolled in school, a pre-determined poverty index calculated by the government, and the coverage of drinking water. Standard errors are clustered by Municipality. Refer to Table 3 for additional notes corresponding births had occurred. Thus, if there is no general prevailing difference in trends between municipalities with different rollout timing or intensity of ChCC usage, 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.

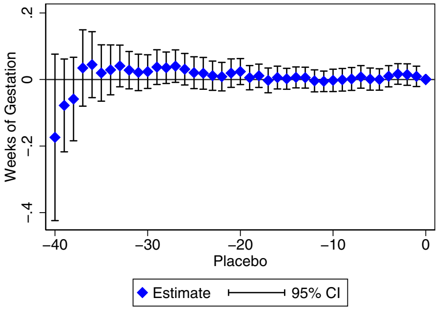
These results are displayed in Fig. 2. Each point estimate and confidence interval corresponds to a placebo reform lagged by the number of periods indicated on the x-axis. In general, the large majority of placebo tests indicate results which are not statistically distinguishable from zero. At times certain lags result in estimates which are significant at 95%; however, these generally occur with large time lags, when more observations are lost given lags in the placebo variable, and hence estimates are somewhat noisy. Across multiple placebo tests we reject 9 of 160 hypotheses at the 95% level, which is a rate of 0.056, quite close to the 0.05 expected rate of rejection. Additionally, in Appendix 1 Fig. 11 we present event study specifications, where *average* ChCC coverage in each municipality in the post-implementation period is interacted with full trimesterly lags and leads to the moment of program implementation. Fundamentally, we observe no significant difference in outcomes between municipalities with varying levels of ChCC usage *before* reform rollout, and observe that these differences emerge over time following rollout, particularly for birth weight, gestational



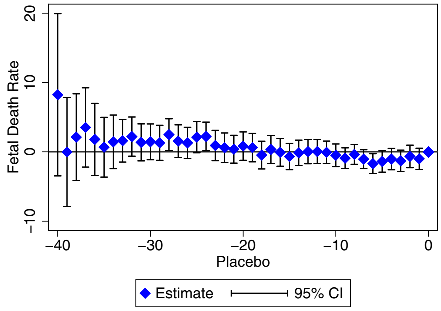
(a) Birth Weight



(b) LBW



(c) Gestation



(d) Fetal Deaths

Fig. 2 Placebo tests. Each point estimate and resulting confidence interval display the impact of a placebo test where the share of Chile Crece Contigo enrollees is lagged $j \in \{1, \ldots, 40\}$ months, where j is displayed on the horizontal axis. Each placebo test is estimated following the principal specification displayed in Table 3. Additional notes relating to each model can be found in Table 3 length, prematurity, and rates of fetal deaths. An additional test of the model's assumptions is provided in Appendix 1 Table 11. In this table we augment Eq. 1 to include the binary measure of availability of ChCC (as well as ChCC intensity), and observe that, once conditioning on the fact that rollout increases the availability of ChCC, the precise moment that the program becomes available (as measured by the implementation dummy) is not systematically related to health outcomes.

As discussed in Section 4, our measure of treatment intensity is usage of ChCC, which increases precipitously following the date of reform implementation. If we estimate using a binary measure of ChCC program availability, results are of the same direction, though frequently much less precisely estimated (Appendix 1 Table 18). For example, in the case of birth weight, we observe that for those individuals born when the program was available in utero (but for less than the full 9 months) that ChCC availability increases birth weight by 1.4 g, while for those individuals for whom ChCC was available during the entire prenatal period, birth weight is 3.3 g higher. These lower impacts are perhaps not surprising given that there is massive variation in usage of ChCC even when the program is available. This is observed in a temporal sense in Fig. 1, where usage expands considerably during 2007 and 2008, and also in a spatial sense in Appendix 1 Fig. 6. While the rate of use of ChCC when the program was available was 56.5% (when weighted by municipal population, or 60.6% without weights), certain municipalities have rates of usage lower than 20%, while others have rates of usage of nearly 100%. Despite the lower precision of results when simply using a binary available/non-available distinction, if these results are scaled up based on usage rates of ChCC (following Almond et al. (2011)), results are closer in magnitude to those reported in our main specification. For example, inflating the "ChCC Availability" estimate in Appendix 1 Table 18 to account for the fact that usage rates of ChCC where ChCC was available for less than the full pregnancy were 35.7%, results in an inflated estimate of approximately 4 g, while inflating the full availability estimate of 3.25 g with usage rates of 56.6% results in an estimate of approximately 6 g.

To address concerns that our (continuous) estimates displayed in Table 3 may reflect the decision to use ChCC rather than participation itself, in Appendix 1 Table 19 we present IV estimates, where participation in each municipality is instrumented by lagged participation rates. The logic behind these estimates is that while actual participation may reflect the decisions of the women who gave birth in a particular month, the participation rates of mothers in prior periods in the same municipality will be highly correlated with those of mothers in future periods, however will not reflect that actual characteristics of the precise group of mothers giving birth. In this case we observe that the first stage results presented in Appendix 1 Table 19 are strong, suggesting reasonably stable rates of usage of public care within municipalities over time, and second-stage IV estimates agree in sign and magnitude with those reported in Table 3, however with slightly inflated standard errors.

An alternative consistency check comes from estimates based on mother fixed effects for the matched sample, which are presented in Appendix 4 Table 27. We present fixed effects estimates in each case also controlling for mother's age and birth order fixed effects which vary around the reform date. Identification is driven by changes in birth outcomes between siblings born before and after their mothers began participating in Chile Crece Contigo, compared with similar timed siblings occurring to never-participating mothers. Once again, we observe that the effect of ChCC participation is large and statistically significant. In this case we *do* observe an impact on the size of the baby at birth, and the impacts on all other variables remain largely consistent with those estimated from municipal-level DD models. One exception is an unexpected positive coefficient on the LBW indicator, however when controlling for municipal and time fixed effects in Appendix 4 Table 28 this impact is not distinguishable from zero. The effect sizes observed for birth weight and gestational weeks are considerable. We estimate an effect of 19 g in mother FE models, 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 worldwide. For example, recent evidence suggests that participation in the Food Stamp Program in the USA, one of the largest and most costly social security programs, increases birth weight by approximately 20 g (Almond et al. 2011). Similarly, participation in the supplementary nutrition program for Women, Infants and Children is estimated to increase birth weight by around 17–30 g (Hoynes et al. 2011; Rossin-Slater 2013). Full discussion related to the mother FE models and results, as well as data match rates is provided in Appendix 4.

5.1.2 Program targeting and equity

While ChCC is universally accessible for any mother or family participating in the public health system, the degree of benefits associated with the program is means tested, and targeted more heavily to families identified as the most vulnerable. In Table 5 we estimate the impact of ChCC usage among targeted and untargeted groups. In particular, we present estimates considering families from different quintiles of the national “social protection score” which is used for targeting program benefits. In Panel A we examine the impact of ChCC use among the 20% most vulnerable of the population, which are both the targeted group, and the group most likely to receive the most intensive set of program inputs, in panel B we focus on the 40% most vulnerable (in early years, the targeted group was the 40% most vulnerable), in panel C we focus on the 60% must vulnerable (the full target group), and in panel D we examine the impact of ChCC usage in the non-targeted group (those with a Social Protection Score in the top 40%, or those without a Social Protection Score).[20] In these models we consistently use identical weighting and specifications as in Table 3, however subset only to particular population groups.[21]

[20] In practice, the means tested benefits also include a considerable discretionary component, beyond the simple cutoff score. For example, the home visit component of the program while only available for the 60% most vulnerable, was not available to the full vulnerable group given program demands, but rather was discretionarily offered by each local health centre based on perceived need and vulnerability (Ministerio de Desarrollo Social 2014).

[21] Such a sub-group analysis within difference-in-differences models has been conducted in a large number of papers. A number of such illustrative cases are Bhalotra and Venkataramani (2015), where heterogeneity is examined by race and gender, Almond et al. (2011) (heterogeneity by race), and Miller (2008) (heterogeneity by age). We follow this strategy, however in our case heterogeneity is examined by socioeconomic status.

Table 5 Impacts by vulnerability quintile

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature
Panel A: Quintile 1 (20% most vulnerable)					
Proportion ChCC coverage	16.779*	− 0.003	0.033	0.031	− 0.004
	(9.125)	(0.002)	(0.048)	(0.029)	(0.003)
Mean of dependent variable	3358.668	0.052	49.526	38.719	0.064
Observations	31,166	31,166	31,166	31,166	31,166
R-squared	0.251	0.069	0.496	0.284	0.142
Panel B: Quintiles 1–2 (40% most vulnerable)					
Proportion ChCC coverage	11.514	− 0.000	− 0.003	0.006	− 0.000
	(8.282)	(0.003)	(0.054)	(0.029)	(0.003)
Mean of dependent variable	3354.823	0.053	49.512	38.706	0.063
Observations	31,469	31,469	31,469	31,469	31,469
R-squared	0.294	0.075	0.542	0.326	0.157
Panel C: Quintiles 1–3 (60% most vulnerable)					
Proportion ChCC coverage	11.282	−0.000	−0.001	0.002	−0.000
	(7.966)	(0.002)	(0.053)	(0.029)	(0.003)
Mean of dependent variable	3352.508	0.053	49.504	38.698	0.064
Observations	31,558	31,558	31,558	31,558	31,558
R-squared	0.321	0.080	0.568	0.349	0.165
Panel D: Quintile 4+ (non-targeted)					
Proportion ChCC coverage	− 0.723	0.000	− 0.113**	− 0.019	− 0.002
	(8.491)	(0.003)	(0.054)	(0.031)	(0.004)
Mean of dependent variable	3323.043	0.056	49.395	38.532	0.066
Observations	27,578	27,578	27,580	27,581	27,581
R-squared	0.305	0.074	0.480	0.271	0.096

Identical specifications are estimated as in Table 3, however now each model is estimated using *only* observations which meet the criteria defined in panel headings. Classification of the 20%, 40%, and 60% most vulnerable is based on the Government of Chile's official scoring based on the *Ficha de Protección Social* (FPS, or Social Protection Score in English), which is used to classify the degree of benefits received by families in ChCC. The official cutoff for the 20% most vulnerable is a score of 8500 points or lower on the social protection score, and for the 40% and 60% most vulnerable is a score of 11,734 or 13,484 points or lower (respectively). Any mother with a score above 13,484 (or who has not applied for a score) is not in the targeted group. Additional discussion of the FPS is available in Herrera et al. (2010)

We observe that the impacts of the program are largest among those in the most vulnerable group, and smallest among those in the non-targeted group. In general, these estimates based on a split sample become less precise, however, a gradient in estimated impacts is observed in moving from more to less vulnerable groups, particularly when considering the impact on average birth weight. The impact of ChCC for the most vulnerable 20% is estimated at 16.8 g, while it is estimated as − 0.7 g among the non-targeted group.[22] Similar gradients in point estimates are observed in the probability of being low birth weight, size at birth, gestational length, and the likelihood of being premature, however none of these estimates are statistically distinguishable from zero.

These results are in line with ChCC's stated aim of closing early-life health gaps. Equity-promoting 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. In the Chilean context this has been documented, where divergence of outcomes at a very young age (birth weight) have important effects on academic achievement up to 18 years later (Bharadwaj et al. 2018). We return to this point in Section 5.2.

As discussed in Section 4, the targeting of preferential services in the ChCC program is based on a pre-defined cutoff point in the national social protection score. As such, this setting is well-suited for analysis using a regression discontinuity design when examining the *intensive* margin impacts of the program. We present basic RD plots for each outcome in Fig. 3, where the discontinuity is plotted at a Social Vulnerability Score of 13,484 points. In each case the sample consists of all births where children are matched to their mother's social program usage data (refer to Section 3 and Appendix 4 of this paper), in the period in which ChCC was implemented.

In descriptive plots we observe little evidence to suggest that there is a significant intensive margin program impact on any of the outcomes considered. In each case, if such an effect existed, we would expect that those children born to mothers just below the cutoff would have better health outcomes at birth. Graphical evidence does not suggest that this is the case, with polynomial fits of binned outcomes either suggesting similar outcomes on either side of the cutoff, or even marginal improvements on the upper side of the cutoff in the case of gestation. This result is not sensitive to the selection of the bin width used in the regression discontinuity plot (see for example Appendix 1 Fig. 12, where similar results are observed using finer bins).

We assess these descriptive results formally in Table 6. Here we estimate a regression discontinuity model, estimating the impact of being located just below the cutoff, and hence eligible for ChCC's preferential benefits. These results are in line with descriptive results in suggesting insignificant effects, both in parametric models where a separate quadratic polynomial is estimated on each side of the cutoff (panel

[22]These estimates *are* statistically distinguishable from each other at the 10% level. However it is worth noting that the estimated value of 16.8 among the 20% most vulnerable is not distinguishable from the estimated average value of 10.09 reported in Table 3.

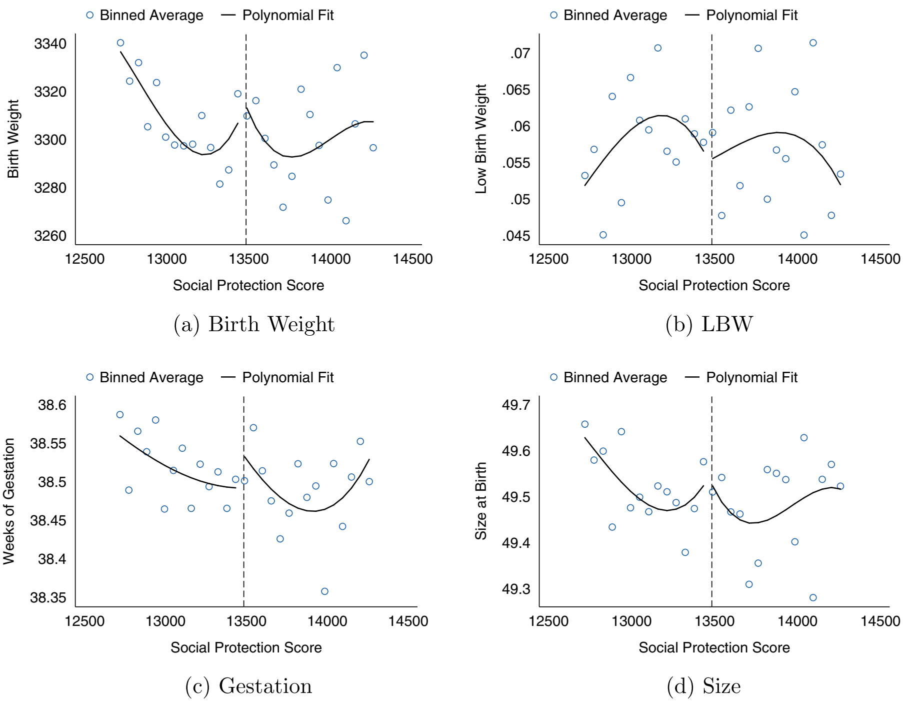


Fig. 3 Regression discontinuity plots at vulnerability score cutoff. Plots documented average health at birth based on the binned Social Protection Score of mothers. The vertical dashed line is drawn at 13,484 points, the cutoff for Chile Crece Contigo preferential services. Circles represent raw averages in bins (bins of 55 points are used), and solid lines represent a polynomial fit of these binned points. Formal tests of regression discontinuity models are provided in Table 6

A), and non-parametric bandwidth-optimal[23] local linear methods displayed in panel B. In both cases, we observe no significant impact of being located just below ChCC's preferential service threshold on any measures of health at birth.

Given the results in Table 6, it is important to consider why we observe a significant extensive margin impact (as in Tables 3, 4, and 5), but no intensive margin impact in regression discontinuity analysis. This owes to (at least) two facts. Firstly, we observe no increase in program usage at the cutoff point. In Appendix 1 Fig. 13 we document a similar regression discontinuity plot, however this time considering whether a mother actually participated in the program, and observe no significant reduction at the cutoff point. While this is not particularly surprising given that participation in ChCC is automatic if a mother is enrolled in the public health system, it documents that there is no encouragement effect in seeking ChCC based on the observed social protection score. Secondly, and more importantly, in general the preferential benefits targeted to the first three quintiles appear to be a de-jure regulation.

[23] Optimal bandwidth is calculated using Calonico et al. (2014)'s bias-corrected optimal bandwidth selector with a triangular kernel.

Table 6 Regression discontinuity estimates of preferential ChCC cutoff

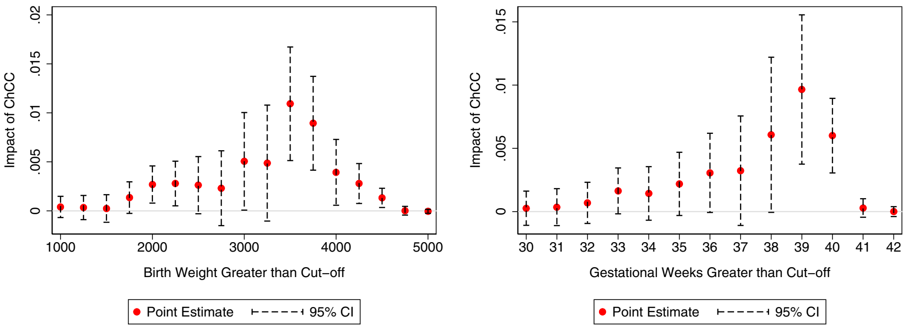
	Weight	LBW	Size	Gestation	Prematurity
	(1)	(2)	(3)	(4)	(5)
Panel A: Quadratic polynomial in running variable					
Discontinuity estimate	− 2.751	0.004	0.045	− 0.019	0.006
	(9.268)	(0.004)	(0.040)	(0.030)	(0.004)
Mean of dependent variable	3337.265	0.056	49.613	38.610	0.069
Observations	592,287	592,287	592,065	591,611	591,611
Panel B: Local linear with CCT optimal bandwidth					
Discontinuity estimate	− 2.237	0.004	0.017	− 0.024	0.007
	(10.187)	(0.004)	(0.047)	(0.034)	(0.005)
Mean of dependent variable	3302.352	0.058	49.492	38.501	0.067
Observations	38,888	40,457	37,105	36,646	41,264
CCT bandwidth	773.000	811.685	729.482	718.865	832.108

Panel A displays regression discontinuity estimates based on intensive margin program participation using a global polynomial estimate with a quadratic fit on either side of the cutoff to capture evolution of the running variable (the quadratic is allowed to vary on either side). Panel B displays local linear estimates based on Calonico et al. (2014). The optimal bandwidth is displayed in the bottom row of panel B, along with the number of observations located within this bandwidth of the cutoff. All estimates are based on the Social Protection Score cutoff point of 11,384 points

In practice, de facto, targeting of services is made at the level of the municipality, and is undertaken until municipalities reach their technical capacity. This is particularly notable in the case of home visits by midwives. There is considerable heterogeneity in levels of poverty by municipality, and as such, considerable heterogeneity in service demand. This impacts the ability of municipalities to reach all targeted households with the full range of preferential services. We document this using recent data in Appendix 1 Fig. 14, where the number of home visits during gestation per targeted families ranges from less than 1 to as high as 14, with a mean of around 1.4 visits per family.

5.1.3 Distributional effects

Mean impacts suggest that Chile Crece Contigo participation increases average birth weight by approximately 10 g and increases average gestational length by 0.024 weeks. However, in Table 3, we found relatively little evidence to suggest that these impacts reduce the probability of being born with low birth weight (< 2500 g) or premature (< 37 weeks). To examine further *where* the mean impacts of the policy are produced, in Fig. 4, we present estimates of the impact of ChCC at various points of the health distribution. In Fig. 4a we examine ChCC's impact on the likelihood that birth weight exceeds x grams, where $x \in \{1000, 1500, \ldots, 4750, 5000\}$, and in Fig. 4b we examine the likelihood that gestation exceeds x weeks, where $x \in \{30, 31, \ldots, 40, 41\}$. In these Figures we present a series of point estimates and



(a) Birth Weight (b) Gestation

Fig. 4 Policy impact across the health distribution. Point estimates and 95% confidence intervals are presented of the impact of Chile Crece Contigo on birth weight and gestational length at different points of the distribution. Each specification follows Eq. 1, however instead of using mean birth weight or gestational length in each municipality, uses the proportion of births exceeding determined cut-points of the distribution (displayed on the horizontal axis) as the dependent variable of interest. Panel **a** displays the estimates when considering birth weight, while panel **b** presents estimate for gestational length. For additional details, refer to notes to Table 3

confidence intervals which correspond to the estimates on $ChCC_{ct}$ from Eq. 1 where the outcome variable is infant health exceeding the indicated cutoff. It is important to note in this analysis that we are *only* considering impacts across the distribution of health at birth. This is quite different to the estimates in the previous subsection (Table 5) which considered impacts across the socioeconomic gradient.[24] The below results are thus cast as the estimated impacts for mothers at the mean with births of varying sizes/gestational lengths.

In Fig. 4a we observe that, although point estimates of the policy on birth weight are universally positive, estimated impacts are larger, and statistically less likely to be type I errors, at higher points in the birth weight distribution.[25] Estimates first become statistically significant at 2000 g, suggesting that ChCC has a small impact on increasing weight of quite low birth weight babies, before once again becoming statistically significant from about 3000 to 3500 g, which is quite close to the mean of the distribution (3346 g). The impact peaks at 3500 g, with the point estimate suggesting that participation in ChCC increases the likelihood of exceeding this barrier by as much as 1 percentage point. Quite a similar pattern is observed when

[24] It is of interest to note that on average, births to mothers in lower socioeconomic groups in these data *do not* appear to have lower health stocks (Appendix 1 Fig. 9) potentially reflecting lower average maternal age.

[25] Here once again we are testing many dependent variables on a single treatment variable, and so may expect that we will be prone to over-reject null hypotheses of a zero effect. When we correct each graph for multiple hypothesis testing using the Romano Wolf step-down procedure, inferential results are qualitatively similar (refer to Appendix 1 Table 20). While this may seem surprising given that we test many outcome variables, this is a result of the more efficient Romano Wolf procedure, which controls for the very high correlation between outcome variables (which are based on the same underlying variable) in this case given that its bootstrap re-sampling procedure respects correlations between outcome variables across models.

considering the impact of gestational length in Fig. 4b. While consistently positive impacts are observed across the gestational length distribution, these become largest at approximately the mean of the distribution (39 weeks) and remain considerable even at 40 weeks. It is worth noting that Chile Crece Contigo has targeted reductions in the rates of C-sections, which are extremely high in Chile, at approximately 50%, or 43% in the public health system, potentially partially explaining the increase in gestational length of full-term births. We return to this consideration further in Section 5.3 of the paper.

A possible alternative explanation of the relatively larger impacts towards the middle of the distribution and muted impacts towards the bottom of the distribution is that program participation may have an impact on scarring and on selection that cancel out. We have found some evidence pointing to the fact that ChCC reduces rates of infant mortality (Table 3). If the program induces selective survival among babies with relatively low health stocks, this selection effect may increase the incidence of LBW/premature babies in the population, even if the program itself reduces the incidence of such "scarring" conditions ceterius paribus. We examine this briefly in Table 7. In order to do so we follow Alderman et al. (2011) and an implementation in Bhalotra and Clarke (2019), considering the simulation of birth cohorts, under counterfactuals where surviving individuals owing to the program are removed from the sample, assuming that given proportions of these individuals would be LBW/premature. This allows us to examine how extreme selective survival must be to explain away the lack of result in these outcomes. In particular, we consider a case where we remove 16% of all fetal deaths from the sample in the *post-ChCC period only*, given that this is our baseline estimate of the impact of ChCC on fetal deaths (1.53 from Table 3 divided by 9.56 from Table 2). We then vary the proportion of these individuals who we assume would have been of low birth weight/premature, and calculate a new variable measuring the rate of babies born prematurely or with LBW in each case. In Table 7 we document how estimated impacts on these variables would change, ranging from 5% of selectively surviving births being assumed to be LBW/premature, to 100% of these birth being assumed to be LBW/premature (which provides an extreme bound). In each case, the dependent variable is multiplied by 100 for ease of visualisation Note that in the actual surviving population, 5–6% of births are LBW/premature. We observe that in both cases, the selectively surviving population would need to be considerably less healthy than the full population to imply significant program effects on LBW/prematurity. In the case of LBW, marginally significant impacts would be observed if at least 60% of all selectively surviving births would have been LBW, and in the case of prematurity, this value would need to be at least 80%. It is also noteworthy in both cases, that even under these quite extreme assumptions, the magnitude of the observed impact does not shift significantly.

Taken together with the findings from Section 5.1.1, these impacts point to the difficulty in shifting outcomes towards the very bottom of the health distribution at birth.[26] While we do find a small impact on some low birth weight categories,

[26]Investments in low birth weight babies, which are difficult to determine ex-ante, are also significant once the baby is born, and observed to be of low or very low birth weight. See Bharadwaj et al. (2013) for a discussion of public investments in very low birth weight babies in Chile.

Table 7 Scarring versus selection: simulating unselected birth outcomes

	5%	10%	25%	50%	60%	70%	80%	90%	100%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Low birth weight									
Proportion of ChCC coverage	− 0.216	− 0.219	− 0.227	− 0.240	− 0.245*	− 0.250*	− 0.256*	− 0.261*	− 0.266*
	(0.147)	(0.147)	(0.147)	(0.148)	(0.148)	(0.148)	(0.148)	(0.148)	(0.148)
Mean of dependent variable	5.305	5.303	5.295	5.282	5.277	5.271	5.266	5.261	5.255
Observations	31,805	31,805	31,805	31,805	31,805	31,805	31,805	31,805	31,805
R-squared	0.051	0.051	0.051	0.051	0.051	0.051	0.050	0.050	0.050
Panel B: Prematurity									
Proportion of ChCC coverage	− 0.223	− 0.226	− 0.234	− 0.247	− 0.252	− 0.257	− 0.262*	− 0.267*	− 0.273*
	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)	(0.158)
Mean of dependent variable	6.348	6.345	6.338	6.325	6.319	6.314	6.309	6.304	6.298
Observations	31,806	31,806	31,806	31,806	31,806	31,806	31,806	31,806	31,806
R-squared	0.095	0.095	0.095	0.095	0.095	0.094	0.094	0.094	0.094

Each regression uses the full sample of birth and fetal death data, but removes a portion of births in the post-ChCC period assumed to be "selectively surviving" due to ChCC. In each column it is assumed that $x\%$ of these selectively surviving births would have been of low birth weight (panel A) or born prematurely (panel B). The percentage assumed to meet this condition is indicated in column headers. In both cases the outcome variable (proportion of low birth weight and proportion of premature births) is multiplied by 100 for ease of visualisation. Means of dependent variables under each assumed counterfactual are indicated in the bottom row of each panel. All other details follow those in Table 3 we observe here that impacts are higher among larger babies. Work examining the impact of the WIC program from Rossin-Slater (2013) notes a similar pattern, with the largest impacts occurring at 3000–3500 g.[27] While this points to the challenge of improving birth outcome at the bottom of the health distribution, especially in large public programs such as ChCC, these improvements in birth weight even from the median of the birth weight distribution are certainly not trivial. Indeed, evidence from Royer (2009) suggests that returns to birth weight may actually be highest *above* the low birth weight cutoff. We turn to considerations relating to these returns, and returns of ChCC in particular, in the following subsections.

5.2 Program efficiency

5.2.1 External efficiency

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 Appendix 1 Table 21, 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 US $422 million, or 600 million in PPP-adjusted terms.

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 prenatal portion of Chile Crece Contigo with the total grams of birth weight produced by the policy. Information on the total costs of the program in each year included in this paper are compiled from government reports (Arriet et al. 2013). This breaks costs down by component, and we display all costs in Chilean pesos and in US dollars (PPP adjusted and unadjusted) in Appendix 1 Table 21. Based on this, we estimate that it costs US $111 for a single participant in the prenatal period of ChCC, based on the average PPP-adjusted cost in each of the 4 years laid out in Appendix 1 Table 21.[28] This value can then be compared with the average birth weight gain per birth to program participant of approximately 10 g (Table 3). All told, this suggests an average cost per gram of birth weight of $11 in PPP-adjusted terms (in non-PPP-adjusted terms this is even lower, at around $7).

[27] Rossin-Slater (2013) uses slightly broader distributional points, with estimates at each 500 g; however, the general pattern is very similar. It is important to note that such a finding is not universal in early-life public programs. Notably, Attanasio et al. (2013) find that the impact of a community nursery program in Colombia impacted child height much more at quintiles 10, 25 and 50 of the height distribution than at quintiles 75 and 90.

[28] We note that this refers to the marginal costs of the program. This will thus not include the costs of historical infrastructure investment, costs of non-program medical care during pregnancy, and so forth. These marginal costs are compared with the benefits from project participation, which also are marginal benefits.

In order to put these estimates in context, we can compare them to a series of successful early-life programs in other countries. In Table 8 we collect all estimates of the impact of early-life public programs on outcomes at birth where birth weight is available as an outcome, and where administrative data on birth outcomes are available. This results in a series of comparison programs. These are largely from the USA (WIC, the Food Stamp Program and the Earned Income Tax Credit); however, one estimate is also available for a CCT program from Uruguay (Amarante et al. 2016). It is important to note that not all of these programs actually target health at birth (in the same way that ChCC explicitly targets early-life health). Thus we can split the programs listed above into those which explicitly target health at birth (WIC and ChCC), and those which do not (PANES, FSP, EITC) but which have nonetheless been documented to have unintended impacts on early-life outcomes.

The estimated impact of each alternative program is drawn from the articles cited in the first column of Table 8. In most cases, these are presented as a single estimate,

Table 8 Costs and estimated impacts of selected early-life programs

Reference	Estimated impact	Cost per participant	Estimated cost per gram
Supplemental Nutrition Program for Women, Infants and Children (WIC, USA)			
Rossin-Slater (2013)	27.30 (7.98)	US $405	$14.8
Hoynes et al. (2011)	28.75 (15.13)	US $405	$14.1
PANES (Uruguay)			
Amarante et al. (2016)	30.83 (18.44)	US $918	$29.8
Supplemental Nutrition Assistance Program (FSP, USA)			
Almond et al. (2011)	8.96 (5.05)	US $1125	$125.6
	20.27 (6.89)	US $1125	$55.5
Earned Income Tax Credit (EITC, USA)			
Strully et al. (2010)	15.70 (1.211)	US $1558	$99.2
Hoynes et al. (2015)	9.95 (2.05)	US $1558	$156.6
Chile Crece Contigo (Chile)			
Our estimates	10.09 (3.37)	US $111	$11.0

Estimates from Hoynes et al. (2015) refer to single women with no more than a high-school education (the "high impact" group, with highest eligibility for policy use). Two estimates are presented for Almond et al. (2011) since their results are presented by race. The top line refers only to black mothers, while the bottom line refers only to white mothers. Estimates for black mothers are based on the most recent estimates presented by the authors in their Erratum. All US program costs are expressed in US dollars, and non-US program costs (Chile and Uruguay) are denoted in PPP-adjusted US dollars. PPP-adjusted costs are higher than non-PPP-adjusted costs, so this results in a conservative estimates of costs per gram. Similar estimates and additional calculation details are presented in Clarke et al. (2017) for the WIC and FSP only although in the case of Almond et al. (2011) estimates are presented separately for black and white mothers, so we report each estimate. Details on the cost per user are also generally drawn from various sources. In the case of the PANES program in Uruguay, the cost per user is reported by Amarante et al. (2016) as $102 per month in PPP-adjusted terms. In each case we infer the cost of the program by assuming 9 months of coverage, as this allows for consistent comparisons across programs. In the case of the WIC program, recent figures suggest that the cost of the program is quite stable at around $45 per month per participant (USDA 2017b), giving a 9-month cost estimate of $405 per participant. Similar estimates for the FSP suggest costs of approximately $125 per month per participant, or $1125 over the course of 9 months (USDA 2017a). Finally, costs from the EITC program are reported in Hoynes et al. (2015, their Appendix 1 Table 10).

These comparisons lead to a number of conclusions regarding the cost of producing birth weight in public programs, and the relative efficiency of different programs. Firstly, perhaps unsurprisingly, programs which explicitly target health at birth produce birth weight much more cheaply than non-targeted programs. The targeted programs (WIC and ChCC) range from anywhere between 2 and 15 times cheaper per gram of birth weight produced than non-targeted programs such as SNAP/FSP, the EITC or PANES in Uruguay. In general, it is likely reasonable to demand more of a program which aims to increase child health, so the increased costs among non-targeted programs should not be seen as a program inefficiency. Secondly, we note that ChCC produces birth weight in a comparatively efficient way, even when compared to WIC in the USA. Our back-of-the-envelope calculation of the cost of birth weight in Chile is US $11 per gram (PPP adjusted), compared with estimates of around US $14 per gram from the WIC program. As discussed above, this is then additionally more efficient than comparison non-targeted programs both in the USA and in Latin America.

5.2.2 Internal efficiency

Finally, while the value above 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 can be expected to map to *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 et al. 2013; Bharadwaj et al. 2018). Using a within family estimation strategy (similar to the strategy proposed as a specification check in Appendix 4), Bharadwaj et al. (2018) estimate that a 10% increase in weight at birth (250 g) increases child test scores by approximately 0.05 standard deviations (for language and math), and that these returns are quite stable between primary, secondary, and university entry exams. Using our estimates, as well as data on birth weights in Chile, we can thus back out the approximate amount required to be invested in ChCC to produce an additional 0.05 standard deviations of educational outcomes (performance, rather than attendance) for a single child.

While it is important to note that this is a back-of-the-envelope calculation, we highlight that the results are not premised on extrapolating the mean impact from ChCC of 10 g of birth weight to an increase of 250 g for a particular child. Bharadwaj et al. (2018) estimate the returns to birth weight using within-twin differences. Frequently these within-twin differences are small, and indeed the modal difference between twins in their histogram of birth weight differential among twins (their Fig. 2) falls between 25 and 50 g.

We combine Bharadwaj et al. (2018)'s estimate that a 250-g increase in birth weight maps into a 5% of a standard deviation increase in educational outcomes, with our estimates suggesting that that the cost per gram of birth weight produced by ChCC is \$11. This back-of-the-envelope calculation implies that the cost of 250 g of birth weight is approximately \$2750. Thus, this rough calculation suggests that for every \$2750 invested in the prenatal components of the ChCC program, performance on tests (compared with a static population) would increase by 5% of a standard deviation for the recipient child. Stated in another way, given that the cost per participant is estimated at \$111, the follow-on impact of this investment during the child's life is an increase in 0.2% of a standard deviation.[29] What's more, these costs are clearly an upper bound, as we ignore all other impacts of improvements in early-life health. While birth weight is a well-known determinant of educational attainment, birth weight is also known to impact labour market outcomes (Johnson and Schoeni 2011a; Cook and Fletcher 2015; Behrman and Rosenzweig 2004; Rosenzweig and Zhang 2013; Case et al. 2005), the prevalence of chronic morbidities (Barker 1995; Almond and Mazumder 2005; Johnson and Schoeni 2011b), mortality (van den Berg et al. 2006), and a range of psychological outcomes (Fletcher 2011).

5.3 Mechanisms

Currently, our headline estimate of an average impact of 10 g treats ChCC receipt as a black box. However, as discussed in Section 2.1, ChCC includes a range of provisions and services, which have been shown to work in other contexts. For example, provision of food to mothers during pregnancy has been shown to have large short- and long-term effects in the USA using data from the 1960s and 1970s (Almond et al. 2011; Hoynes et al. 2016). And Doyle (2017) documents medium-term improvements in cognitive and socio-emotional development of children in response to home visits to families and group education classes. In this section we consider five potential mechanisms of action to explain the impacts of ChCC. These are (i) a maternal nutrition component, (ii) a prenatal care component, (iii) a home visit component, (iv) a social connection component capturing links to the wider social safety net, and (v) a C-section component capturing potential reductions in rates of Caesarean section owing to the program. These potential mechanisms envelope the majority of ChCC components, with the exception of the prenatal educational component for parents, which, as we discuss below, is not included given problems with data availability.

[29] This is calculated as $\$111/\$2750 \times 5\% = 0.2\%$.

In order to assess the importance of different components we require data describing the usage of each component with variation ideally by month and municipality. Administrative data from the Ministry of Health of Chile describe usage of various health services by month and by Health Service for each month from 2001 onwards as part of their Summarised Monthly Statistics (REM). We thus collect in a consistent way all available indicators related to prenatal use of health services for the period under study. However, it is important to note that the data are not currently available at the municipal level, but rather by Health Service, which generally encompass various municipalities. In Appendix 1 Fig. 15 we show how municipalities are classified into Health Services, where each municipality is contained in only one Health Service. Using these data we are able to collect consistent reports of the number of prenatal check-ups, the number of home visits to pregnant mothers, the number of packages (kilograms) of fortified milk disbursed to expectant mothers, as well as the number of visits to Social Assistants at local health clinics. We thus cross our municipal-level data with *health service* level controls, where each mechanism is consistently measured as the average use of each component per pregnancy in the 9 months prior to each birth. In Appendix 1 Fig. 16 we display the evolution of the usage of these components over time. We additionally calculate a municipal by month measure of the rate of C-sections in the public health system. These are calculated from universal hospital discharge records, which record C-section, vaginal, and forcep births using ICD-10 codes. While we are not able to match these with the birth registers at a micro-level given a lack of published individual identifiers, we are able to use these records to calculate municipal-level aggregates in each month for the full period under study. Appendix 1 Table 22 documents DD regressions of ChCC's rollout on the prevalence of each postulated mechanism.

To examine the importance of different potential mechanisms, we augment Eq. 1, adding the vector of program usage variables to the specification in the following way:

$$birthweight_{cst} = \alpha_0^m + \alpha_1^m ChCC_{cst} + \boldsymbol{Mech}_{st}\gamma + \boldsymbol{W}_{ct}\alpha_w + \mu_t + \lambda_c + \eta_{cst}. \quad (3)$$

Here we add a subscript s to indicate health service given that the majority of the mechanism data is available at this level.[30] The vector of $Mech_{st}$ controls are clearly "bad controls" (Angrist and Pischke 2009) given that they are themselves outcomes of the ChCC program. However, we include these controls as a mechanism test as it allows us to examine the impact of ChCC on birth weight, *conditional* on a particular program component. We include different mechanism variables in a step-wise manner, and examine, conditional on each mechanism, how $\widehat{\alpha}_1^m$ compares to the original $\widehat{\alpha}_1$ estimate, allowing us to infer the proportion of the ChCC effect explained

[30] When a variable is collapsed at the level of municipality and health service, this results in identical levels and number of observations as when only collapsed at the level of municipality, given that each municipality is only found in one health service. In 2008, a single health service split into two, meaning that for a small number of observations, we are unable to calculate lags for the mechanism variables. The number of month $\times$ municipal observations in the original regression are 31,805, however when including municipal controls this health service split results in 31,760 observations. A number of small municipalities do not have hospital discharge records to calculate rates of C-section, resulting in a final sample of 30,738 observations.

by each particular mechanism. As the order in which we add the mechanisms in this process is arbitrary, we also calculate the Gelbach (2016) decomposition (for each outcome variable considered). This decomposition allows us to consistently apportion changes in the estimate of ChCC impact between the original $\widehat{\alpha}_1$ and $\widehat{\alpha}_1^m$ to each mechanism, by considering the impact of ChCC on each mechanism, and the impact of each mechanism on the outcome variable of interest.

Table 9 displays estimates of unconditional ChCC impacts, and the impact of ChCC conditional on the various proposed mechanisms. The baseline impact of 9.63 grams is slightly different (not statistically distinguishable) from the 10.092 g reported in Table 3 given the small number of observations without mechanism controls. We consistently compare conditional impacts with the 9.63 unconditional estimate to maintain fixed the estimation sample. Subsequent columns introduce particular mechanisms one-by-one. In column 2 we observe that an additional prenatal check-up is associated with a $\sim$ 6-g increase in birth weight. Column 3 includes controls for the original and updated formulation of fortified milk distributed to mothers (we provide full details related to fortified milk, and full mechanism data, in Appendix 3). We include two measures of average distribution during each mother's pregnancy, as well as a measure of distribution in only the third trimester, as this is potentially a sensitive period. In general we find quite inexact estimates of their impacts on birth weight, potentially also reflecting the lack of data availability at the finer municipal level. Additional columns of home visits and social safety net components are similarly imprecise, with the exception of enrollment of mothers in the Chile Solidario program, which is associated with a large positive impact on birth weight (comprehensive details and analysis of the Chile Solidario program is provided in Carneiro et al. (2014)). Additionally, increased rates of C-section, are associated with a large negative impact on birth weight.

Most interesting for the present analysis are the changes in the estimates of the impact of ChCC moving across columns. The estimated impact of 9.63 g in column 1 is reduced to 6.59 g in the final column, suggesting that the proposed mechanisms, even though measured noisily, can explain 32% of the full impact. At the foot of the table we provide two decompositions of these movements. The first row ("Explained Effect") calculates the percent of the movement in the effect from one column to another attributable to the particular mechanism. Here we observe that the mechanism which explains the largest proportion of the full impact in this setting is food supplementation (20.2%), followed by increased links to the social safety net (8.9%), and then home visits and reductions in the frequency of Caesarean sections.[31] The second row, displaying the cumulative explained effect, provides a cumulative sum of the ability of proposed mechanisms to explain Chile Crece Contigo's impact on birth weight, which reaches 31.6% of the full effect in the final column.

[31] There is a considerable medical literature on pregnancy inputs and birth outcomes. Among many others Kominiarek and Rajan (2016) indicate the importance of the nutritional status of mothers in pregnancy on fetal health outcomes, however Retnakaran et al. (2012) warn that an excess of maternal nutrients to the fetus increases the risk of macrosomia. Lu et al. (2003) question the efficacy of care in pregnancy in preventing premature births, instead pointing to the importance of ensuring the reproductive health of women throughout her whole fertile life, not only during pregnancy.

Table 9 Partial test of ChCC mechanisms

	(1) Base	(2) Home visits	(3) Supplements	(4) Prenatal care	(5) Social	(6) C-section
Proportion of ChCC coverage	9.630**	9.334**	7.453*	7.350	6.694	6.586
	(4.494)	(4.390)	(4.450)	(4.615)	(4.634)	(4.587)
Prenatal controls		5.874***	5.928***	5.893***	5.706***	5.216**
		(1.830)	(2.171)	(2.207)	(2.170)	(2.223)
Fortified milk (new formula)			1.302	1.276	1.276	1.176
			(1.076)	(1.105)	(1.092)	(1.096)
Fortified milk (original)			− 0.157	− 0.153	0.061	0.153
			(1.849)	(1.851)	(1.784)	(1.791)
Fortified milk (trimester 3)			− 0.523	− 0.523	− 0.686	− 0.612
			(1.159)	(1.159)	(1.120)	(1.128)
Home visits				1.692	2.489	1.169
				(10.998)	(10.972)	(10.735)
Social assistance					0.256	0.281
					(0.242)	(0.241)
Chile Solidario enrolment					13.514***	13.016***
					(4.865)	(4.869)
Rate of caesarean sections						− 24.777***
						(5.908)
Constant	3352.311***	3322.046***	3324.733***	3324.903***	3321.509***	3328.037***
	(4.118)	(10.970)	(11.306)	(11.433)	(11.470)	(11.573)

Table 9 (continued)

	(1) Base	(2) Home visits	(3) Supplements	(4) Prenatal care	(5) Social	(6) C-section
Explained effect		0.031	0.202	0.014	0.089	0.016
Explained effect (cumulative)		0.031	0.226	0.237	0.305	0.316
Mean of dependent variable	3345.753	3345.753	3345.753	3345.753	3345.753	3345.753
Observations	30,738	30,738	30,738	30,738	30,738	30,738
R-squared	0.265	0.265	0.265	0.265	0.266	0.266

Specifications replicate column 1 of Table 3, where birth weight is the dependent variable. All mechanism variables are available for each health service and month. One health service split into two in 2008, meaning that a small number of mechanism variables are not available where lagged measures are used. We consistently estimate without these observations so each column is comparable. Explained effect refers to the proportion of the baseline impact of ChCC which is explained away when conditioning on a particular mechanism, and the cumulative explained effect refers to the total explained effect summing all mechanisms. Additional details related to mechanisms and measurement are available in Section 5.3. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

It is important to note that this calculation is at best partial, as there are components which are hard to measure or not observed in publicly available data. Indeed, even when controlling for the full set of mechanisms, there is still 68.4% of the impact which we are unable to explain. For example, as discussed above, we do not observe group education usage over time, and measures like prenatal controls are potentially significantly under-reporting the true changes due to ChCC, given that prenatal controls approximately doubled in length and included a number of new and standardised components. Thus, measures of prenatal check-up coverage, while capturing ChCC's impact on extensive margin impacts, does not capture intensive margin impacts of additional time and additional components in a given check-up. In general, controlling for the absolute value of inputs over time will only allow us to capture impacts flowing from changes in component usage, and not capture any changes flowing from improved *quality* of inputs owing to ChCC. There are a range of other potential channels which have been documented in both the economic and non-economic literatures, which we are unable to observe in our data and which may influence fetal health, and be related to ChCC. These include, but are not limited to, maternal stress, maternal smoking and/or drinking, changes in income, changes in sleep patterns, and access to additional information/better practices (see for example Quintana-Domeque and Ródenas-Serrano (2014), Black et al. (2014), and Mazumder and Seeskin (2014)). Finally, in Appendix 1 Table 23 we present the alternative decomposition suggested by Gelbach (2016) which is based on the regression in column 5 of Table 9. Here we present the decomposition for each outcome measure in Table 3, and generally find that food supplements and increased linkages to the social safety net explain the largest proportion of (explainable) ChCC impacts on health outcomes at birth across other health outcomes, as was the case with birth weight.

6 Conclusion

We estimate the impact of a large early-life health and social inclusion policy, *Chile Crece Contigo*, on measures of infant health of enrolled children. This policy—explicitly designed to target differences in psychological, behavioural, and cognitive development of children in vulnerable households which open early in life—is found to have significant impacts on health at birth over a range of dimensions. Using municipal rollout and variation in intensity of use of ChCC in a difference-in-difference specification, we estimate that participation in ChCC increased weight at birth by 10 g on average. We also find an increase in the likelihood of reaching certain gestational lengths, and some evidence to suggest that the program increased the likelihood of fetal survival. These results are validated by a large (but not universal) sample of micro-data where within mother variation in program exposure is used to estimate the policy's impact on infants.

We find that this policy is both equity enhancing, as well as quite efficient when compared with other policies worldwide, and successfully acts as a manner to bring about human capital accumulation. The impacts are observed to be largest amongst the most vulnerable groups, which are specifically targeted to receive preferential transfers in the program. Combined with the cost of running ChCC, our estimates suggest that the government of Chile spends approximately \$11 per gram of birth weight—a figure that is comparable and slightly less than other large neonatal health programs, even when controlling for purchasing power. 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* (back-of-the-envelope) cost, each \$2750 spent on ChCC results in an additional 0.05 standard deviation of educational attainment on later life test scores. While this paper uses birth weight as a comparable metric across programs, it is not the only metric one could use to compare programs. For example, given the importance of improvements in birth weight for low birth weight babies in particular, alternative criteria could compare program impacts at sensitive points of the birth weight distribution, such as low birth weight or very low birth weight cutoffs.

In the case of ChCC, our estimates suggest that the program impacts are highest for babies with health stocks at birth *above* the median outcome. We observe that the mean program effect of 10 g largely comes from shifting children who were born weighing between 3500 and 4000 g, and for increasing gestational length at full term (weeks 39 and 40). While ChCC targets a much broader set of developmental outcomes than health at birth, and a lack of impact on birth weight at lower points of the distribution does not preclude significant impacts on other cognitive or non-cognitive outcomes, this suggests that large-scale early-life intervention programs should be just one component of a comprehensive social safety net targeting child health outcomes. Nonetheless, despite challenges of targeting and improving the health at birth of conceptions towards the bottom of the health distribution, the results in this paper suggest that all told, public investments in early-life health in developing and emerging economies can have appreciable mean impacts when well targeted and well designed, and that these impacts may propagate through the economy long after birth and program implementation.

Acknowledgements We are grateful to Rodrigo Alarcó n, Jeanet Leguas and Felipe Arriet of the Ministry of Social Development of Chile and Andrés Alvarez of the Ministry of Health for providing invaluable data linkages and other guidance. We thank Serafima Chirkova, Dolores de la Mata, Rudi Rocha, Gabriel Romero, the editor Alessandro Cigno, and three anonymous referees, as well as seminar audiences at UNU-WIDER Mozambique, Universidad de Chile, Universidad de Concepción, Chile, and Universidad de la República, Uruguay, for very useful comments and suggestions. We are grateful to Fresia Jara and team at Hospital San Juan de Dios for providing interviews and discussion regarding day-to-day program functionality.

Funding information This study was funded by CONICYT, FONDECYT (grant number 11160200), and CAF Development Bank's Research Program on Health and Social Inclusion in Latin America.

Compliance with Ethical Standards

Conflict of interest Author A (Clarke) has received some benefit from the policy under study in this paper ("Chile Crece Contigo") given that his children participated in the program as part of regular check-ups in the Chilean public health system. This participation was outside of the time period studied in this paper, and this has not impacted the research design or the conclusions of this paper. The authors declare that they have no other conflicts of interest

Disclaimer The results and views in this paper are our own. Any errors are our own.

Appendix 1. Tables and figures

Table 10 Test of FONASA coverage and ChCC rollout

	(1) Women	(2) Men	(3) All
Proportion of ChCC coverage	− 1710.965	− 2665.317	− 4376.359
	[2135.177]	[3063.904]	[5044.565]
Constant	52,395.850***	49,867.394***	1.02e+05***
	[2354.014]	[3045.407]	[5321.473]
Mean of dependent variable	18,456.73	17,749.62	36,206.27
Observations	23,502	23,502	23,502
R-squared	0.971	0.956	0.965

DD specifications are reported where birth outcomes are replaced by FONASA enrollees as the dependent variable. All remaining details follow specification 1. FONASA enrollment data is available at the municipal level from December of 2005 onwards, and so only the December 2005–December 2010 period is available for use in this regression

Table 11 Difference-in-difference estimates using municipal variation in coverage and a rollout indicator

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Proportion of ChCC coverage	10.891**	− 0.003	0.002	0.027*	− 0.002	− 1.214
	[4.471]	[0.002]	[0.031]	[0.016]	[0.002]	[0.795]
ChCC implemented	− 1.817	0.001	0.004	− 0.008	0.000	− 0.719
	[2.844]	[0.001]	[0.021]	[0.012]	[0.001]	[0.540]
Constant	3351.524***	0.054***	49.479***	38.705***	0.065***	4.893***
	[4.083]	[0.002]	[0.026]	[0.016]	[0.002]	[0.517]
Mean of dependent variable	3346.281	0.054	49.475	38.659	0.064	9.563
Observations	31,805	31,805	31,806	31,806	31,806	31,842
R-squared	0.261	0.051	0.451	0.278	0.095	0.056

All specifications follow Table 3, however now augment each specification to include a binary indicator of each municipality's participation status in Chile Crece Contigo (1 if participating, 0 if not). This switches on in the month × year period in which the municipality adopts ChCC. All other details follow specifications in Table 3. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 12 Summary statistics by trimester: birth and Chile Crece Contigo data

	N	Mean	Std. Dev.	Min	Max
Proportion enrolled in ChCC	10,826	0.26	0.36	0.00	1.00
Birth weight (g)	10,814	3345.85	128.57	686.00	4868.00
Low birth weight $<$ 2500 g	10,814	0.05	0.05	0.00	1.00
Gestation (weeks)	10,814	38.66	0.47	24.00	42.00
Premature $<$ 37 weeks	10,814	0.06	0.05	0.00	1.00
Length (cm)	10,814	49.47	0.69	30.00	55.00
Number of births	10,826	177.08	278.55	1.00	2217.00
Rate of fetal deaths/1000 births	10,826	9.20	27.09	0.00	1000.00
Year of birth	10,837	2006.51	2.29	2003.00	2010.00
Mother's age	10,824	26.69	1.72	15.00	44.00
Proportion teen births	10,824	0.18	0.09	0.00	1.00
Number of children	10,826	2.02	0.32	1.00	8.00

Summary statistics are displayed for municipality by trimesterly averages for each trimester from January 2003 to December 2010. Trimesters refer to January–March, April–June, July–September, and October–December. For additional notes, refer to Table 2 which provides summary statistics at the municipality by month level

Table 13 Difference-in-difference estimates with data collapsed by trimester

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Proportion of ChCC coverage	8.990*	− 0.002	− 0.011	0.015	− 0.003	− 1.261
	[5.076]	[0.002]	[0.035]	[0.018]	[0.002]	[0.917]
Constant	3351.931***	0.054***	49.481***	38.712***	0.063***	4.801***
	[3.093]	[0.001]	[0.021]	[0.013]	[0.001]	[0.342]
Mean of dependent variable	3345.855	0.054	49.470	38.655	0.064	9.201
Observations	10,814	10,814	10,814	10,814	10,814	10,826
R-squared	0.492	0.125	0.668	0.501	0.225	0.138

Estimation sample consists of all municipal-level averages for each quarter between 2003 and 2010 for all women. Refer to additional notes in Table 3, and summary statistics for each variable at the trimester by municipal level in Table 12. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$

Table 14 Difference-in-difference estimates based on the year surrounding rollout

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Proportion of ChCC coverage	9.224	− 0.001	0.075	− 0.008	− 0.001	− 0.361
	[9.841]	[0.005]	[0.058]	[0.039]	[0.005]	[1.978]
Constant	3317.709***	0.058***	49.301***	38.526***	0.072***	10.451***
	[3.765]	[0.002]	[0.021]	[0.015]	[0.002]	[0.875]
Mean of dependent variable	3338.017	0.054	49.335	38.615	0.065	9.705
Observations	3969	3969	3969	3969	3969	3975
R-squared	0.345	0.116	0.405	0.336	0.176	0.149

All specifications follow Table 3, however now use only the first year surrounding program rollout from June 2007 to June 2008. Refer to Table 3 for additional notes. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 15 Instrumental variables estimates based on the year surrounding rollout

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Proportion of ChCC coverage	28.585	− 0.011	0.164	− 0.030	− 0.005	− 0.695
	[22.621]	[0.011]	[0.132]	[0.097]	[0.012]	[5.300]
Constant	3374.729***	0.048***	49.294***	38.750***	0.053***	7.906***
	[4.612]	[0.002]	[0.027]	[0.022]	[0.003]	[1.189]
Mean of dependent variable	3338.017	0.054	49.335	38.615	0.065	9.705
Observations	3969	3969	3969	3969	3969	3975
R-squared	0.344	0.114	0.405	0.336	0.175	0.149

Observations consist of municipality by month cells for each municipality in the 12 months surrounding implementation (from June 2007). The participation of respondents enrolled in ChCC is instrumented by whether or not each municipality has begun participating in Chile Crece Contigo. 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. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 16 Examining robustness of impacts on birth weight to removal of extreme values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Winsorizing at 1st and 99th percentiles									
Proportion of ChCC coverage	10.022**	9.275**	9.081**	8.512**	7.868*	7.121	11.668*	9.364*	9.962**
	[4.379]	[4.525]	[4.364]	[4.176]	[4.293]	[5.338]	[5.960]	[5.192]	[4.377]
Panel B: Trimming at 1st and 99th percentiles									
Proportion of ChCC coverage	10.164**	9.396**	8.980**	8.223**	7.527*	6.808	11.406*	8.844*	10.115**
	[4.368]	[4.520]	[4.355]	[4.166]	[4.288]	[5.342]	[5.965]	[5.142]	[4.366]
Municipal and time FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time-varying controls		Y			Y				
Region time trends			Y						
Region × Year FEs				Y	Y				
Municipal linear trends						Y			
Municipal quadratic trends							Y		
Municipal × Year FEs								Y	
Weighting by pregnancies									Y

Each specification follows models documented in panel A of Table 4, however here examining robustness of the birth weight results to outliers. In panel A, average birth weight in each municipality (the outcome of interest) is Winsorized at the 1st and 99th percentiles implying that observations more extreme than these values are replaced with the values of these percentiles. In this case the full sample of 31,805 observations is used. In panel B, the sample is trimmed at the 1st and 99th percentiles, and so observations more extreme than these values are simply removed from the sample. In this case, the estimation sample consists of 31,169 municipality × year cells. In both specifications, average municipal birth weight ranges from a minimum of 2844 g to a maximum of 3825 g. Refer to Table 4 for additional notes

Table 17 Adjusting for multiple hypothesis testing

	Index	Original variables				
	Anderson Index	Birth weight	LBW	Birth size	Weeks gestation	Premature
Panel A: Municipal-level analysis						
p value (original)		0.0226	0.1356	0.8940	0.1168	0.1499
p value (corrected)	0.1011	0.0588	0.3137	0.8235	0.3137	0.3137
Panel B: Individual-level analysis						
p value (original)		0.0000	0.0839	0.0257	0.0000	0.5553
p value (corrected)	0.0479	0.0392	0.2549	0.0588	0.0196	0.7451

Corrected p values based on original variables are calculated using the Romano and Wolf (2005) technique to control the Family Wise Error Rate of hypothesis tests, implemented by Clarke (2016). The Anderson (2008) index converts the multiple dependent variables into a single dependent variable (index) giving more weight to variables which provide more independent variation. The specification of each regression follows Table 3 (panel A), and Appendix 4 Table 27 (panel B).

Table 18 Difference-in-difference estimates using municipal program availability

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
ChCC availability	1.443	0.000	0.005	0.000	− 0.000	− 1.098**
	[2.905]	[0.001]	[0.019]	[0.012]	[0.001]	[0.531]
ChCC availability ($\geq$ 9 months)	3.250	0.001	0.017	− 0.003	− 0.000	− 1.009
	[3.052]	[0.001]	[0.020]	[0.012]	[0.001]	[0.697]
Constant	3351.512***	0.054***	49.479***	38.705***	0.065***	4.894***
	[4.087]	[0.002]	[0.026]	[0.016]	[0.002]	[0.515]
Mean of dependent variable	3346.281	0.054	49.475	38.659	0.064	9.563
Observations	31,805	31,805	31,806	31,806	31,806	31,842
R-squared	0.261	0.051	0.451	0.278	0.095	0.056

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 2500 g, and premature refers to the proportion of births occurring before 37 weeks of gestation. Birth weight is measured in grams, Size is measured in centimetres, and Gestation is measured in weeks. Fetal deaths are measured as the number of fetal deaths per 1000 live births. 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. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 19 IV Estimates using lagged ChCC enrollment

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Second stage estimates						
Proportion of ChCC coverage	9.586	− 0.002	− 0.027	0.014	− 0.004	− 1.438
	[5.943]	[0.002]	[0.039]	[0.022]	[0.002]	[1.098]
First stage estimates						
Lagged ChCC coverage	0.701***	0.701***	0.701***	0.701***	0.701***	0.701***
	[0.021]	[0.021]	[0.021]	[0.021]	[0.021]	[0.021]
Observations	31,454	31,454	31,455	31,455	31,455	31,489
AP first stage (F)	1072.44	1072.44	1072.44	1072.44	1072.44	1071.79
AP first stage (p)	0.000	0.000	0.000	0.000	0.000	0.000

Difference-in-difference estimates are presented following the results of Table 3. However, here the Proportion of ChCC Coverage among births in a given month and municipality is instrumented with lagged ChCC coverage from the same municipality. The 2SLS results along with standard errors clustered by municipality are displayed in the top panel of the Table. The second panel documents the first stage results of regression ChCC coverage on its lagged value. The associated first stage F-statistic and its p value are documented at the foot of the table

Table 20 Correction for Multiple Hypothesis Testing in Distributional Estimates

Birth weight			Gestation		
Cutoff	Original p value	Romano Wolf p value	Cutoff	Original p value	Romano Wolf p value
1000	0.4592	0.6573	30	0.6905	0.7922
1250	0.5786	0.7493	31	0.6245	0.7822
1500	0.7191	0.8492	32	0.3666	0.5315
1750	0.0632	0.0639	33	0.0464	0.0370
2000	0.0014	0.0000	34	0.1695	0.2398
2250	0.0135	0.0060	35	0.0804	0.0739
2500	0.0737	0.0759	36	0.0539	0.0410
2750	0.2736	0.4116	37	0.2337	0.3417
3000	0.1169	0.1299	38	0.2651	0.3596
3250	0.2212	0.3487	39	0.0477	0.0370
3500	0.0056	0.0010	40	0.0005	0.0000
3750	0.0030	0.0000	41	0.5312	0.7493
4000	0.0221	0.0120	42	0.9967	0.9960
4250	0.0167	0.0070			
4500	0.0144	0.0060			
4750	0.9501	0.9281			
5000	0.4313	0.6573			

Unadjusted and multiple-hypothesis test adjusted p values are displayed corresponding to the estimates and standard errors displayed in Fig. 4. Unadjusted p values refer to the p value on ChCC in each regression where the outcome variable is birth weight or gestation exceeding the listed cutoff. Romano Wolf adjusted p values are based on a null re-sampled distribution as described in Romano and Wolf (2005). We re-sample using 1000 bootstrap samples

Table 21 Costs of ChCC per participant in gestational program

	2007	2008	2009	2010
Panel A: All amounts in 1000s of Chilean pesos				
Costs associated with PADBP	1,969,162	6,116,663	14,231,107	14,444,574
Costs Ministry of Planning	1,001,810	2,529,976	2,604,131	4,197,607
Massive Education program	20,000	195,640	261,462	196,624
Total prenatal development components	2,990,972	8,842,279	17,096,700	18,838,805
Total budget (ChCC)	67,903,331	126,446,362	159,660,473	214,505,550
Total budget/1000 (all Chile)	17,883,154	20,650,579	23,406,879	25,651,970
Total women participating during gestation	47,683	166,900	171,811	171,799
Proportion of all participants in pre-natal care	1	0.449	0.307	0.303
Cost per pre-natal participant	62,726	24,714	30,549	33,116
Panel B: All amounts in US dollars				
Costs associated with PADBP	3,702,025	12,288,376	22,257,451	28,470,255
Costs Ministry of Planning	1,883,403	5,082,722	4,072,861	8,273,483
Massive Education program	37,600	393,041	408,917	387,546
Total prenatal development components	5,623,027	17,764,139	26,739,239	37,131,285
Total budget (ChCC)	127,658,262	254,030,741	249,708,980	422,790,439
Total budget/1000 (all Chile)	33,620,330	41,487,013	36,608,359	50,560,033
Total women participating during gestation	47,683	166,900	171,811	171,799
Proportion of all participants in pre-natal care	1	0.449	0.307	0.303
Cost per pre-natal participant	$118	$50	$48	$65
Cost per pre-natal participant (PPP adjusted)	$192	$72	$87	$93

Costs per pre-natal participant are calculated by dividing the pro-rata total costs of prenatal development components by the total number of participants in the pre-natal period. Total prenatal development components are calculated as the sum of the costs of the PADBP program, fixed costs assigned to the Ministry of Planning, and the costs of the Massive Education program. Costs are assigned pro-rata to pre-natal versus non pre-natal components using the proportion of all participants which are in the pre-natal period, rather than during years 1–5. In the first year, the program only began in utero, so all costs are assigned to pre-natal development. Budget details are all compiled from the ChCC final reports (Arriet et al. 2013), and historic budget laws (for example Ministry of Finance, Government of Chile (2007)). Total participants during gestation as well as in the post-natal period are compiled from the Department of Health Statistics and Information from the Ministry of Health. PPP-adjusted costs are based on the World Bank's PPP conversion factor

Table 22 Impact of Chile Crece Contigo on pregnancy inputs

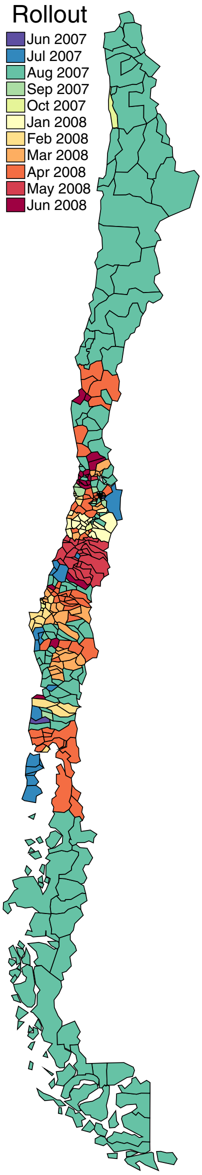
	(1) Home visits	(2) Supplement +	(3) Supplement	(4) Supplement 3	(5) Prenatal visits	(6) Social support	(7) Chile Solidario	(8) C-section
ChCC coverage	0.050	2.161***	1.291***	1.402***	0.092***	− 1.012*	0.059***	− 0.012
	[0.061]	[0.405]	[0.262]	[0.274]	[0.019]	[0.537]	[0.006]	[0.010]
Constant	5.153***	− 0.089	2.851***	4.591***	− 0.004	8.710***	0.167***	0.192***
	[0.051]	[0.061]	[0.121]	[0.141]	[0.004]	[0.621]	[0.004]	[0.008]
Mean of Dep. Var.	5.900	2.841	7.103	7.266	0.110	6.859	0.306	0.207
Observations	30,750	30,750	30,750	30,750	30,750	30,750	30,880	30,880
R-squared	0.914	0.954	0.894	0.878	0.853	0.636	0.619	0.563

Each regression shows the correlation between ChCC usage and different program components. Each variable with the exception of Chile Solidario refers to the average usage per birth in the 9 months prior to each birth, and is measured at the level of health service and month. One health service split in two in 2008, and hence lags are not available for a small number of areas in this period. Home visits refers to the number of integral visits to expecting mothers by a nurse or midwife, Supplement, Supplement + and Supplement 3 refer to Leche Purita, a fortified powdered milk drink given to pregnant women with an updated formula from 2008 onwards (+ refers to the new formula, 3 refers to the quantity given during trimester 3 only). Prenatal visits refer to controls with nurses, doctors or midwives at local health centres, Social support refers to all visits with Social Assistants, and Chile Solidario refers to the number of pregnant women giving birth each month who have at any point participated in Chile Solidario, a targeted social welfare program including a cash transfer. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

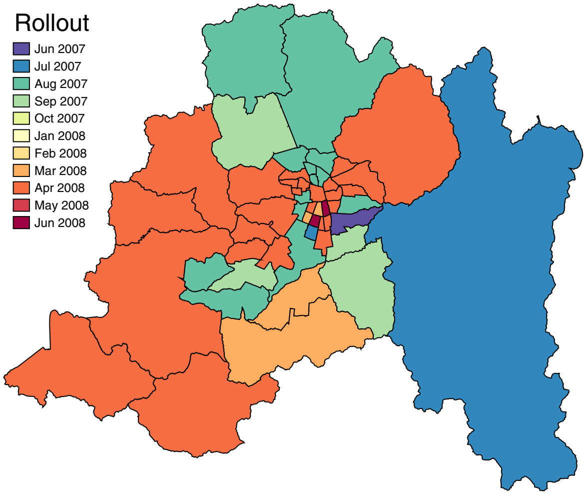
Table 23 Gelbach (2016) decomposition of ChCC mechanism

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature	(6) Fetal death
Decomposition of ΔChCC coverage						
Prenatal controls	0.263	– 0.000	0.002	0.002	– 0.000	0.025
	[0.351]	[0.000]	[0.003]	[0.002]	[0.000]	[0.030]
Food supplementation	1.884	– 0.000	0.005	0.009*	– 0.002***	0.003
	[1.152]	[0.000]	[0.012]	[0.005]	[0.001]	[0.266]
Home visits	0.109	0.001*	0.011	– 0.007	0.001	0.481**
	[0.983]	[0.000]	[0.007]	[0.005]	[0.000]	[0.216]
Social safety net	0.487	0.000	0.002	0.004***	– 0.000	0.038
	[0.387]	[0.000]	[0.003]	[0.002]	[0.000]	[0.069]
C-section rate	0.301	– 0.000	0.003	0.002	−0.000	0.002
	[0.276]	[0.000]	[0.003]	[0.002]	[0.000]	[0.011]
Total explained difference	3.045*	0.000	0.023*	0.011	– 0.002**	0.548**
	[1.587]	[0.001]	[0.012]	[0.007]	[0.001]	[0.243]
Observations	30,738	30,738	30,738	30,738	30,738	30,750

Each column displays the coefficient change decomposition developed by Gelbach (2016) for a different outcome variable. This decomposition considers the change in the estimated effect of ChCC from the baseline diff-in-diff model compared with that estimated in the full model where all proposed mechanisms are accounted for. The full change is given by , and this is decomposed into the portion owing to each of the four mechanisms discussed in Section 5.3. Full details of the decomposition and estimation of the variance-covariance matrix is provided by Gelbach (2016)



(a) Full Country



(b) Santiago Metropolitan Region

Fig. 5 Program rollout by date. Chile consists of 346 municipalities ("*comunas*") which are the lowest geographic administrative level with their own political administration. ChCC rollout started in June 2007, and reached 159 of the 346 municipalities in 2007 (chosen due to the availability of infrastructure) and then was rolled out to the remaining municipalities during 2008. Precise rollout dates are provided by the Ministry of Social Development of Chile. The full country is displayed in the left-hand panel, and only the Metropolitan Region of Santiago (from the centre of the country) is displayed in the right-hand panel

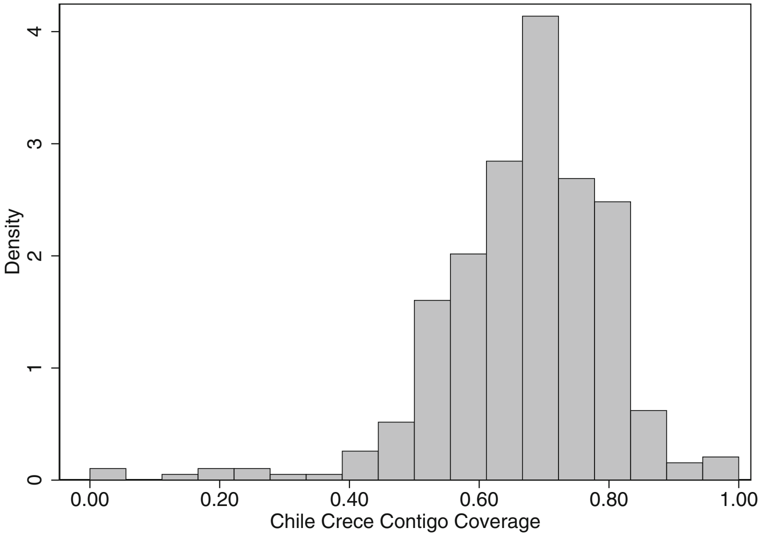


Fig. 6 ChCC usage in post-implementation period. The density of ChCC usage by municipality over the entire post-treatment period is displayed. Usage refers to the average proportion of all births in each municipality for which ChCC components were accessed by the mother during the gestational period. Usage data comes from The Ministry of Social Development's administrative data on public program use, and is averaged at the level of each municipality. Refer to Fig. 8 for additional details regarding municipal-level usage of ChCC components and municipal characteristics

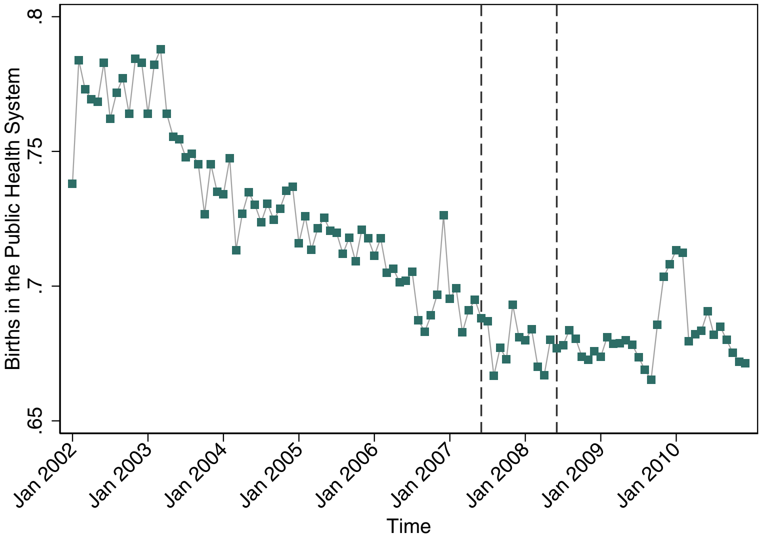
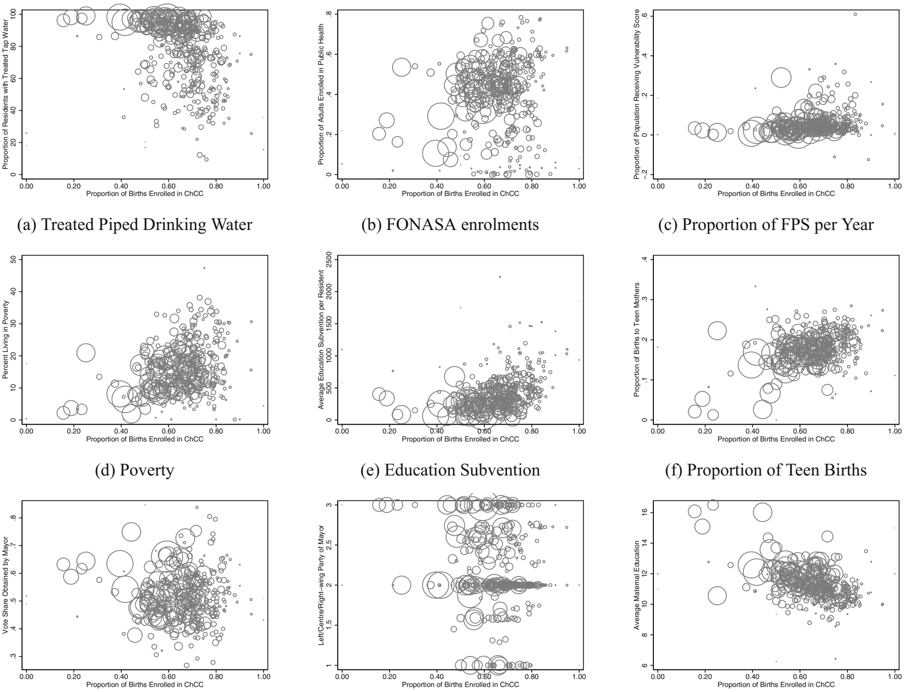


Fig. 7 Proportion of births attended in the public health system. Figures on the proportion of births in the public health system and all births nation-wide are provided monthly by the Department of Statistics and Health Information (DEIS) of the Ministry of Health of Chile. Monthly proportions are displayed for each month from January 2002 until December 2010. The first vertical dotted line is the beginning of ChCC rollout, while the second vertical dotted line is when ChCC reached the full country

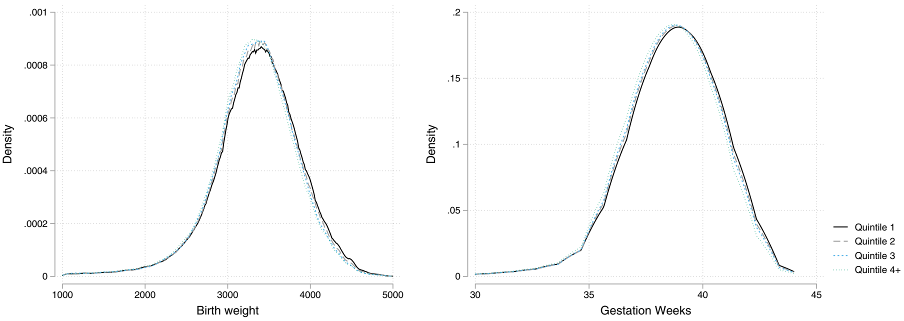


(a) Treated Piped Drinking Water (b) FONASA enrolments (c) Proportion of FPS per Year

(d) Poverty (e) Education Subvention (f) Proportion of Teen Births

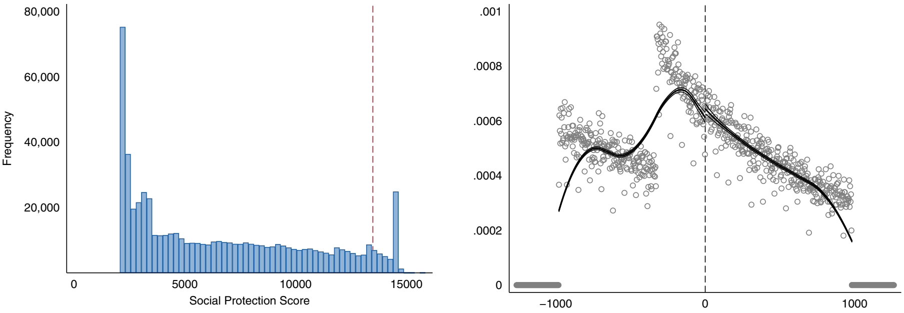
(g) Vote Share (Mayor) (h) Political Association (i) Maternal Education

Fig. 8 Municipal Characteristics and ChCC enrollment. Each panel presents the proportion of Chile Crece Contigo enrollees in each municipality after the introduction of the program along with municipal-level averages in a range of other social or political variables. In each case, ChCC enrollment is displayed on the horizontal axis, and alternative outcomes on the vertical axis. **a** Treated piped drinking water. **b** FONASA enrolments. **c** Proportion of FPS per year. **d** Poverty. **e** Education subvention. **f** Proportion of teen births. **g** Vote share (mayor). **h** Political association. **i** Maternal education



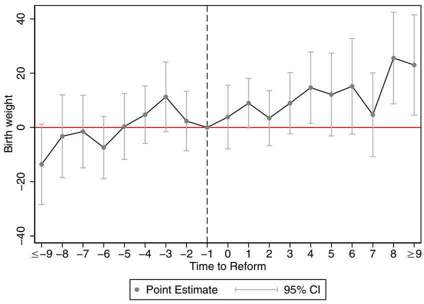
(a) Birth weight (b) Gestational Period

Fig. 9 Socioeconomic quintiles and health distributions at birth. Figures provide kernel density plots of birth weight (in grams) and weeks of gestation by quintiles of the Social Vulnerability Score. Quintile 1 is the most vulnerable, and quintiles 4 and above are grouped into a single plot. Means for birth weight are 3350 g, 3333 g, 3317 g, and 3298 g for quintiles 1, 2, 3, and 4+ respectively. Similar means for gestational period are 38.66 weeks, 38.61 weeks, 38.55 weeks, and 38.43 weeks. **a** Birth weight. **b** Gestational period

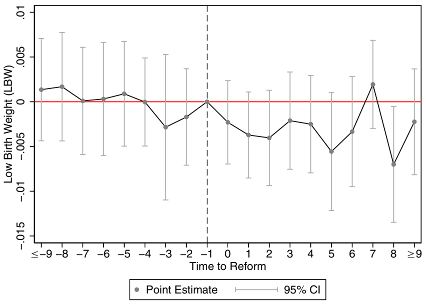


(a) Ficha de Protección Social: Density (b) McCrary Density Test

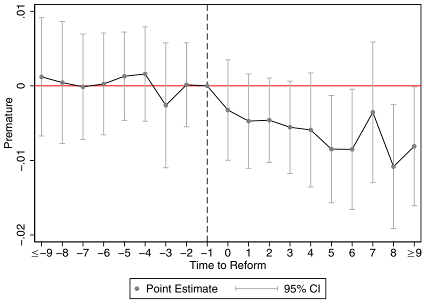
Fig. 10 Running variable (FPS) in RDD. Left-hand panel provides a histogram of all Social Protection Scores ("Ficha de Protección Social") for mothers matched to their children's birth records. The vertical dashed line indicates 13,484 points, the cutoff point for Chile Crece Contigo's preferential benefits. This is defined as the top-end of the third quintile of vulnerability scores, though these quintiles are defined on all recipients of a score in the country, not just mothers. The right-hand panel documents (McCrary 2008)'s density test around 13,484, documenting the dispersion of observations within 1000 points on either side of the cutoff



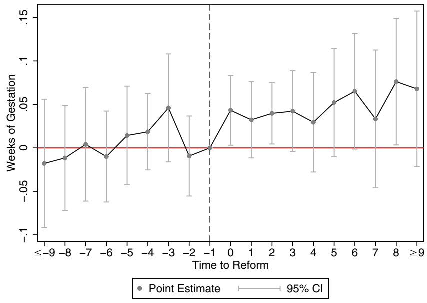
(a) Birth Weight



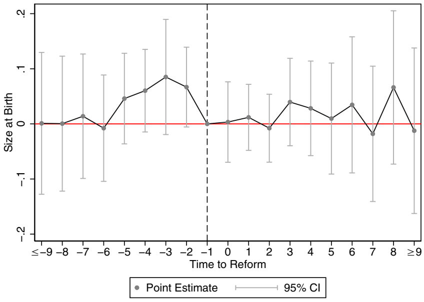
(b) LBW



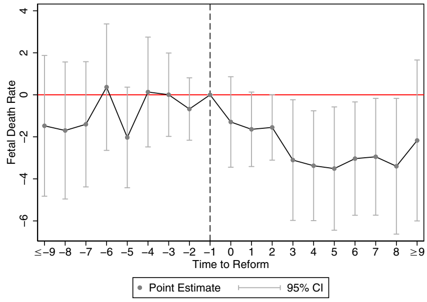
(c) Prematurity



(d) Gestation



(e) Size at Birth



(f) Fetal Deaths

Fig. 11 Event studies. Event studies present estimated models interacting ChCC treatment intensity with pre- and post-treatment indicators for each 3-month period pre- and post-reform. Here, the ChCC measure refers to average levels of ChCC use in the entire post-treatment period (to allow a constant treatment intensity for interaction), and this is interacted with indicators for the rollout of the ChCC program to each municipality. The precise specification is: $InfantHealth_{ct} = \alpha_0 + \sum_{j=-9}^{9} \beta_j 1\{\text{Time to Adoption} = j\}_t \times ChCC_c + \mu_c + \lambda_t + \varepsilon_{ct}$. As is standard, 1 period pre-treatment is the omitted reference group. Periods greater than 9 trimesters pre- or post-program are indicated in a single ≥ 9 term. **a** Birth weight. **b** LBW. **c** Prematurity. **d** Gestation. **e** Size at birth. **f** Fetal deaths

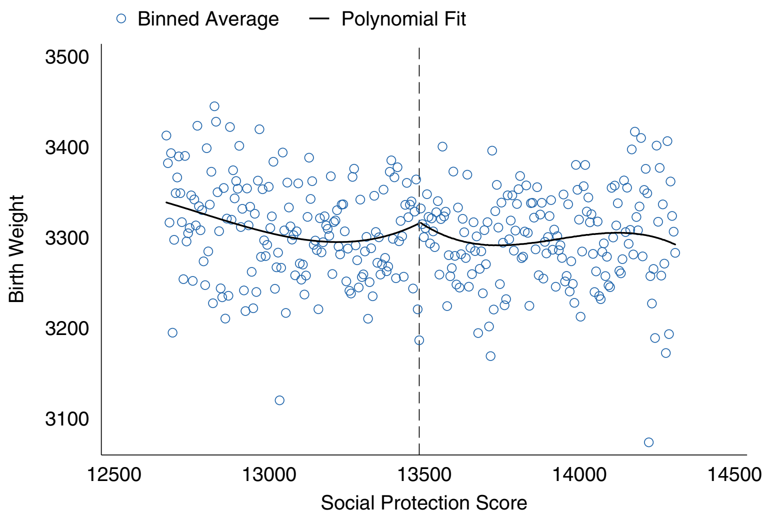


Fig. 12 Descriptive RD plot with smaller bins for Social Vulnerability Score (birth weight). Descriptive plot displays average birth weight outcomes in 5 point bins of the Social Protection Score, with a separate polynomial fitted on each side of the cutoff. This figure replicates Fig. 3a, however now using bins of 5 points, rather than 55 points, for the running variable

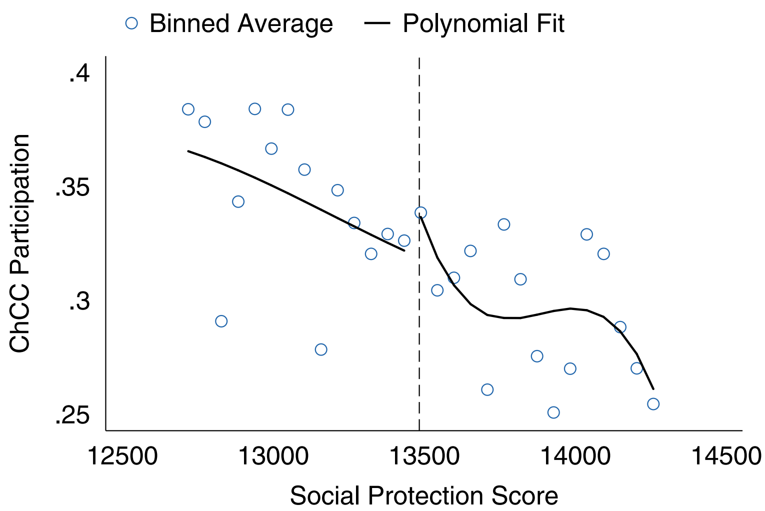


Fig. 13 Impact of FPS cutoff point on the probability of ChCC usage. Descriptive plot documents the probability that mothers are enrolled in the ChCC program around the official cutoff for the receipt of preferential benefits targeted at the bottom three quintiles of recipients of the Social Protection Score. When estimating a regression discontinuity specification in a local linear model with Calonico et al. (2014)'s optimal bandwidth, the additional likelihood of participating in ChCC when located just below the cutoff is 0.0065 (0.019) (coefficient and standard error)

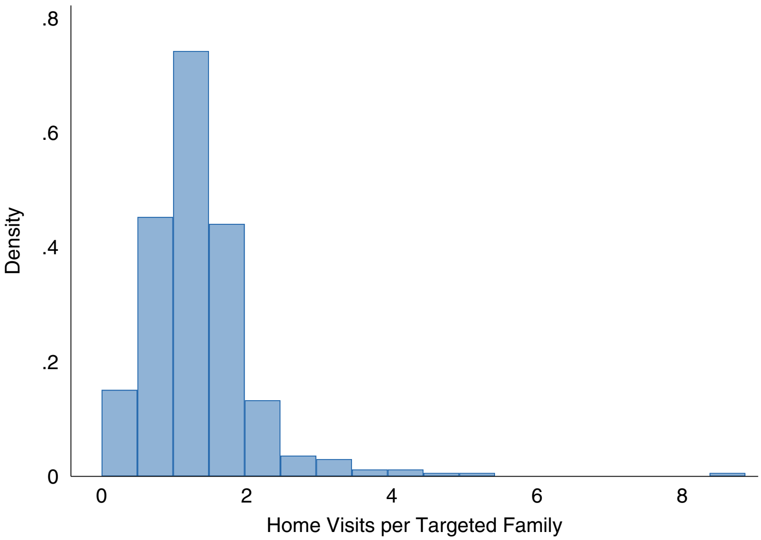


Fig. 14 Variation in Home Visit Intensity by Municipality. Histogram documents the average quantity of "Integral Home Visits" received by each targeted family per municipality in Chile in 2013. A value of 1 refers to a situation where (on average) each family flagged to require a visit based on ChCC's administrative criteria receives one visit during the gestational period. These data are averaged for each municipality, and are based on the year 2013 only. These data are released by the Ministry of Health (available at http://chcc.minsal.cl/indicadores/resultados/293) and are not available for earlier years. One small municipality with an average number of visits of 14.5 per flagged family was removed to simplify graphical presentation

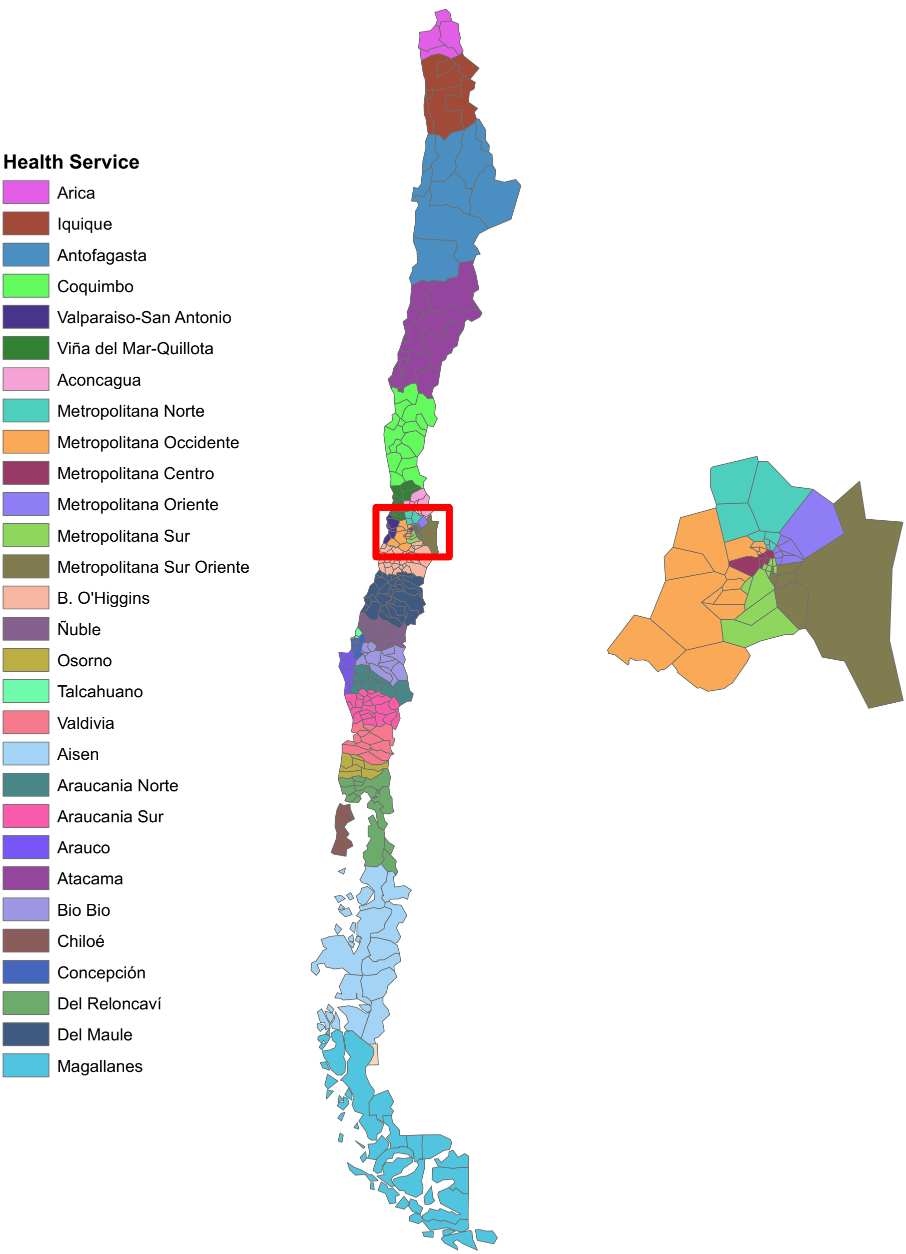
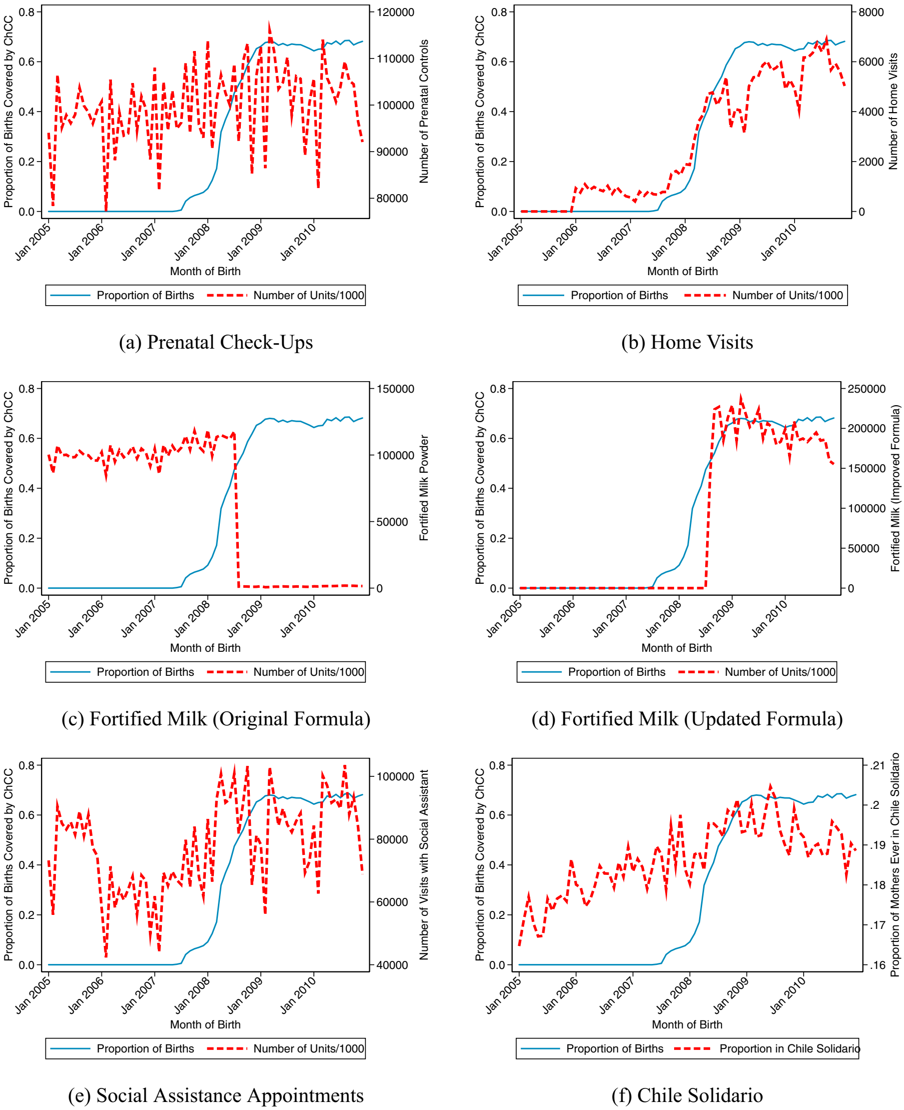


Fig. 15 Health Services and Municipalities. Municipalities are indicated by municipal boundaries, and health services are indicated by colours. Each of Chile's 346 municipalities belongs to one of 29 Health Services. The entire country is displayed at right, and the densely populated Metropolitan Region of Santiago is displayed at left



(a) Prenatal Check-Ups

(b) Home Visits

(c) Fortified Milk (Original Formula)

(d) Fortified Milk (Updated Formula)

(e) Social Assistance Appointments

(f) Chile Solidario

Fig. 16 ChCC rollout and pregnancy inputs disbursed. Solid blue line displays the rollout of ChCC and proportion of coverage of births as in Fig. 1. Dotted red lines display the total units of various components of the program disposed over time in whole of Chile. Each panel with the exception of Chile Solidario coverage in panel **f** presents the number of units divided by 1000. Additional discussion of variables and their measurement is provided in Section 5.3. **a** Prenatal check-ups. **b** Home visits. **c** Fortified milk (original formula). **d** Fortified milk (updated formula). **e** Social assistance appointments. f Chile Solidario

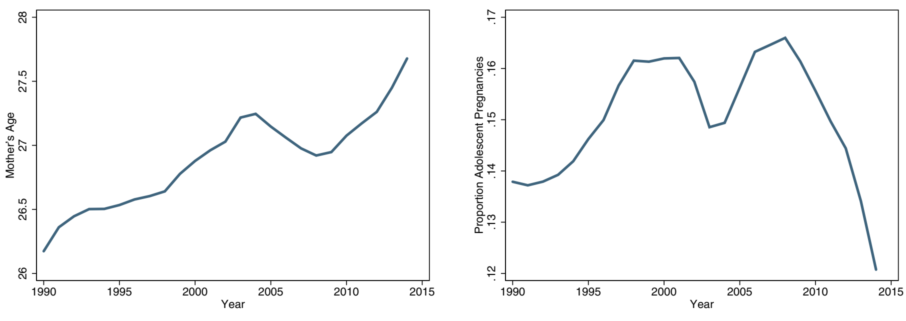
Appendix 2. Broader context: health system and birth outcomes chile

2.1 Birth outcomes and maternal characteristics

Following the return to democratic rule in 1990, full micro-data on all births in Chile has been available from the Ministry of Health's Department of Statistics and Health Information (DEIS). These vital statistics include each child's birth weight, weeks of gestation, and a number of characteristics of the mother and father (when the father is present). These data are recognised to be of high quality and very close to universal (see for example Mikkelsen et al. (2015)).

The average age of mothers in Chile has risen from slightly over 26 in 1990, to slightly under 28 in 2015 (Fig. 17). The average age of mothers increased constantly from 1990 until approximately 2004, before falling slightly, and ascending once again from 2009 onwards. This reduction in maternal age occurred during a considerable slow down in growth, and an uptick in the number of births each year (Fig. 18), in line with results suggesting countercyclicality in fertility. Panel b of Fig. 17 displays the proportion of teenage births (among all births), which rose until the early 2000s, began to fall until the growth slowdown in the mid-2000s, and has fallen sharply from 2007.

We display descriptive plots of average birth outcomes across time in Fig. 19. These indicators, particularly birth weight, improved sharply following the transition to democracy in the early 1990s, and the implementation of a considerable public health reform. Average birth weight increased by more than 60 g, and the proportion of low birth weight babies fell by a full percentage point (refer to panels Fig. 19a and b). From the year 2000 onwards, average outcomes have gradually worsened, in line with increases in maternal age.



(a) Mother's Age

(b) Proportion of Teenage Births

Fig. 17 Trends in Maternal Characteristics in Chile. Yearly averages of age and the proportion of all mothers aged under 20 years of age based on Ministry of Health (DEIS) micro-data covering all births in Chile between 1990 and 2015

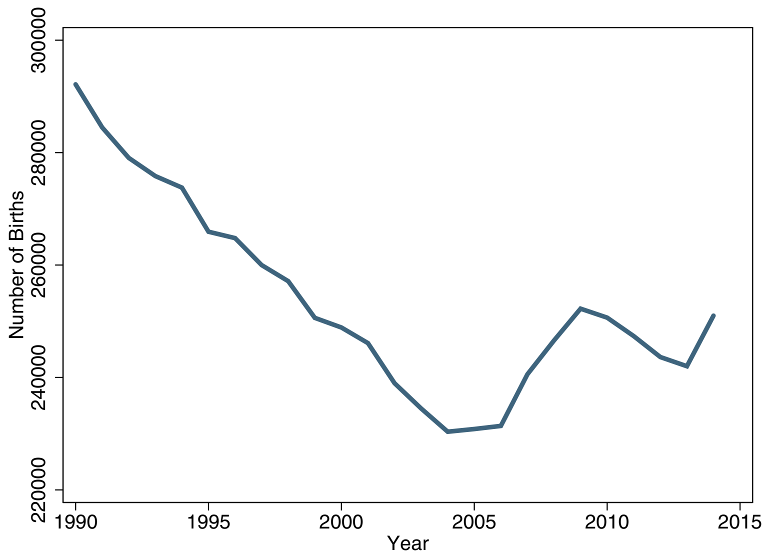


Fig. 18 Number of Births per Year

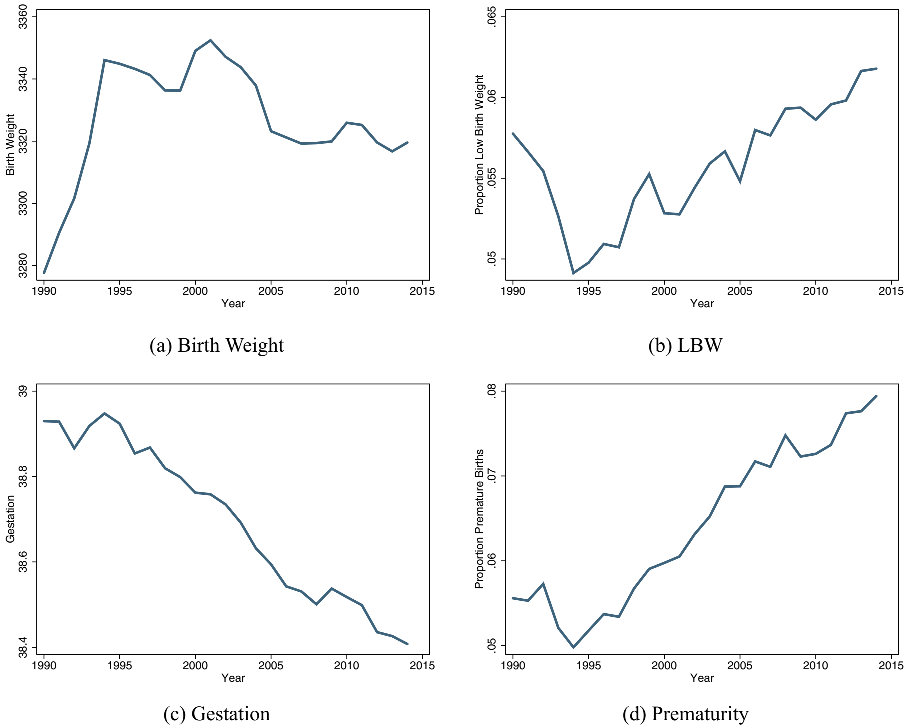


Fig. 19 Longer Term Trends in Birth Outcomes in Chile. Yearly averages of birth weight, the proportion of low birth weight births (< 2500 g), weeks of gestation, and the proportion of premature births (< 37 weeks) from Ministry of Health (DEIS) micro-data covering all births in Chile between 1990 and 2015

2.2 Prenatal health programs in Chile before ChCC

Prior to the implementation of ChCC, programs aimed at early childhood focused on health and education were already carried out in the country, separately.

With respect to the different health programs, the National Immunization Program (PNI) began in 1978, which is still in force at present. Its main objective is the reduction of morbidity and mortality, contributing to the reduction of infant mortality.

In 1987, the National Complementary Food Program (PNAC) was created, consisting of the delivery of milk to children under 6 years old and of food for pregnant women, delivered at primary care clinics. For the delivery of food, it must comply with health controls, controls for pregnant women and with the National Immunization Program.

In 1990, Chile ratified the Convention on the Rights of the Child, approved by the General Assembly of the United Nations, which promotes: non-discrimination, safeguarding the best interests, survival, development and protection of minors.

Since 1994 the government carries out the Program for the control of children Lower Respiratory Tract Infections (IRA, in Spanish), a campaign deployed every winter aimed at controlling these diseases.

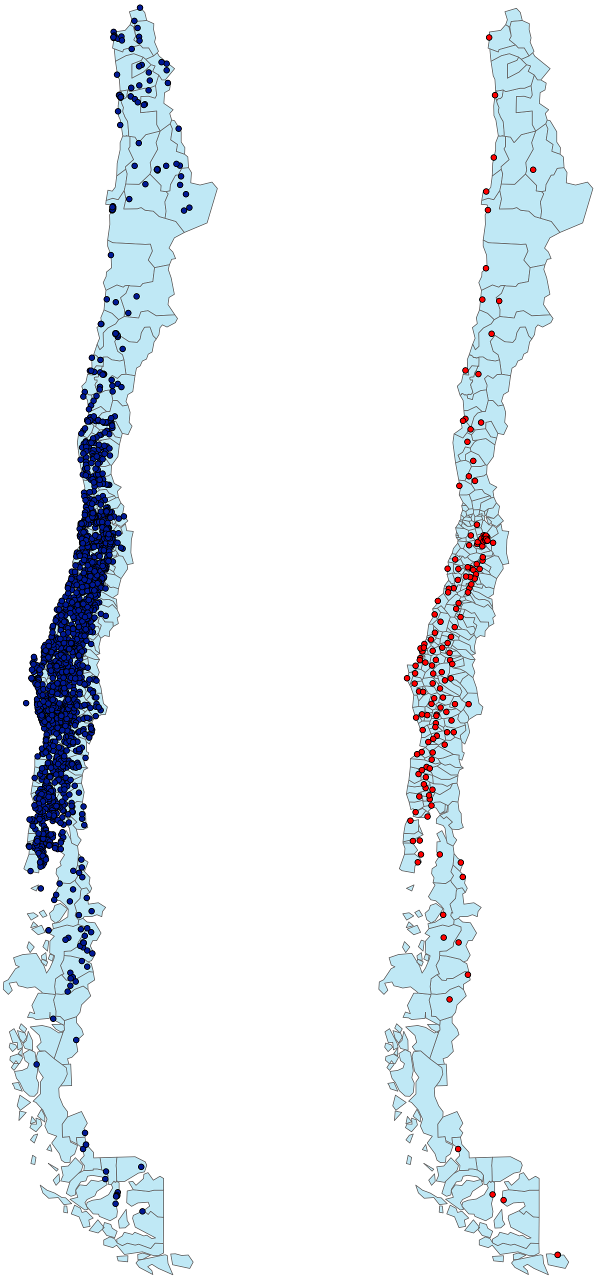
In particular with regard to pre-formal education, there are two institutions with the longest history in the country. On the one hand, the National Board of Kindergartens (JUNJI) is a state institution created in 1979. On the one hand, the INTEGRA foundation, created in 1991, is a private non-profit educational institution whose objective is the integral development of children from 3 months to 4 years old (although they also have kindergartens that offer kindergarten and pre-kinder), belonging to families of the first and second income quintile.

2.3 The Chilean health system

Primary care in the public health system in Chile is provided by municipal health centres which, among other things, provide prenatal appointments for pregnant mothers and families. These municipal health centres exist in each municipality in Chile (refer to Fig. 20a for geographic distribution). These health centres are distributed much more sparsely in less populated northern and southern regions of the country. Secondary and tertiary care are provided in hospitals which are located in each region of the country. Births attended in the public health centre are delivered in these hospitals. The geographical distribution of hospitals is displayed in Fig. 20b, where once again these are concentrated in the central region of the country where the largest population resides.

The health system in Chile is a mixed system,[32] which consists of a public and private systems. In administrative terms, the public system operates thanks to

[32]There is 3% of the population that is under the Ministry of Defense's insurance system, corresponding to the National Defense Fund of the Armed Forces (CAPREDENA) and the Carabineros (DIPRECA), which provide for the attention of officials of the Armed Forces and its charges.



(a) Health Clinics (b) Hospitals

Fig. 20 Geographic distribution of health centres and hospitals. Geo-referenced hospital and Health Clinic information from the Ministry of Health of Chile. All points represent public hospitals and health clinics the Sistema Nacional de Servicios de Salud (SNSS) that has autonomous services throughout the country, such as the Servicios Regionales Ministeriales (SEREMI), 29 Regional Health Services and the Servicio de Atención Primaria de Urgencia (SAPU). In this way, the Fondo Nacional de Salud (FONASA) is responsible for granting health care coverage as a financial institution with its own assets.

On the other hand, the private health system is composed of the Institutions of Provisional Health (ISAPRES). Currently there are 6 large private insurers and other smaller ones, that are empowered to capture and manage the mandatory health contribution of all formal workers that are not affiliated with FONASA, supplying the State in the granting and financing of health benefits.

Thanks to the contributions given to ISAPRES, they finance health services and the payment of medical licenses to their taxpayers. At present, the ISAPRES have achieved an increase in the supply and investment of private infrastructure in Chile. In addition, the main source of funding in ISAPRES is the contribution of its members, paying premiums based on the risks (sex and age) and their family responsibilities, thanks to an individual contract.

If an individual is enrolled in FONASA, they will be automatically assigned to one of the 4 groups depending on their disposable income, and their copayment will depend on this:

- Tranche/Section A: beneficiaries lacking resources to contribute, or in conditions of indigence (non-contributors).
- Tranche/Section B: Monthly taxable income less than or equal to $276,000 with co-payment equal to 0%.
- Tranche/Section C: Monthly taxable income greater than $276,000 and less than or equal to $402,960 with a copayment equal to 10% (with 3 or more family responsibilities is assigned to tranche B).
- Tranche/Section D: Monthly taxable income greater than $402,960 with a copayment equal to 20% (if 3 or more dependents, members in this group are assigned to tranche C).

The main difference between FONASA and ISAPRES is that FONASA is free or with low co-payments because the premiums do not depend on the risks or size of the family group, causing the state to make the largest contribution out of tax contributions.

The most recent data indicate the amount of the affiliated population in FONASA is 76% and in ISAPRE it is 18%.

Appendix 3. Additional program details and component data

Additional program details The full Chile Crece Contigo program covers children from before birth (officially from the first planned gestational check-up at week 14 of pregnancy) until early childhood. Initially, with the design and rollout of the program in 2007, the program ended at age 4, once children enter the first transition level to primary school.[33] More recent extensions mean the program now follows children up until the age of 8, with mental health treatment for children with mental health disorders aged between 5 and 8.

The original program designed for children aged up to 4 years consisted of 5 components and various sub-components. We lay these out below in Table 24. Component 1, which is targeted to pregnant mothers, is the only component which can potentially impact birth outcomes, as the remainder of the components are entirely delivered in the birth to 4 year period of life. The components below are universal, with the exception of component 1B and component 5, which are preferential components received by families flagged as being among the 60% most vulnerable based on a social protection score.

Each particular program item described in Table 24 consists of one or a series of check-ups, goods or other services. Each item also comes with a clear definition of how to deliver the item to the objective population, and key targets for public service workers. For example, Item 1A, Part i (pre-natal check-ups) specifies that 7 prenatal check-ups should be targeted in low-risk cases, and that the duration of these check-ups is 40 min. Particular check-ups also have their own requirements, such as specific diagnostic tests including the abbreviated psycho-social evaluation during the first and third trimester.

In this appendix we provide only a short summary of each component in Table 24. Full details regarding each component are available in the ChCC guide to services (Ministerio de Desarrollo Social 2014). Specific components targeted to vulnerable families consist of the generation of a personalised plan identifying availability of differential services, home visits lasting 1 h (which are targeted to families with specific risk factors), information related to other subsidies and local programs, and contact with local healthcare and social professionals. Additionally, all children in vulnerable families are guaranteed access to extended nursery and pre-school programs at no cost.

Data on program component coverage The examination of program mechanisms of action in Section 5.3 relies on data recording program components, and their coverage over time. As laid out in the paper, we collect these data from public monthly administrative health statistics data. In each case we calculate the average level of component use for each birth in the 9 months prior to birth. Averages are always calculated at the health service and monthly level. In a number of cases, we linearly extrapolate coverage by month *prior to 2005* only, given that data is not always available in 2003 and 2004. This period is entirely in the pre-program period, and time fixed effects also capture periods in which linear extrapolation is performed.

Fortified milk disbursed to pregnant women as part of the program was originally called “Leche Purita Fortificada” (*Purita* Fortified Milk). In 2008 this underwent a modification to better meet the dietary requirements of pregnant women, and was renamed to “Purita Mamá”. Purita Mamá thus replaced Leche Purita Fortificada,

[33] In Chile pre-primary education ends with the first and second levels of transition (or pre-kinder and kindergarten), which begin at ages 4 and 5 respectively. At age 6, children begin grade 1 of primary school.

Table 24 List of ChCC Policy Components and Phases

Component Name	Subcomponent Name	Program Item	Time-Period
1. Strengthening of Prenatal Development	A. Strengthening of Prenatal Care	i) Prenatal check-ups, establishment of link and detection of psychosocial risk factors	Weeks 14-40 Gestation
		ii) Receipt of gestational reading guides	
	*B. Integral Support for families in Psycho-Social Vulnerability	i) Design of individual health plan for pregnant mothers and families in psycho-social vulnerability	
		ii) Integral home visits for pregnant mothers in vulnerable situations	
		iii) Links with municipal ChCC Network in cases of vulnerability	
	C. Education for the Pregnant women and her partner or companion	i) Group or individual education for pregnant women and partner/companion. Cognitive and emotional support for birth and child-rearing	
2. Personalised Care During the Birth Process	A. Personalised care during childbirth	i) Integral care prior and during childbirth	At Birth
	B. Integral Care during the Postpartum period	i) Personalised integral support for the postpartum mother and infant	
		ii) Personalised cross-check of families bio-psycho social development	
		iii) Timely coordination with the primary health team	
	C. Newborn Support Program (PARN)	i) Education regarding the use of the PARN implements and early-life child-rearing	
		ii) Handout of basic implement set and educational material	
3. Integral Developmental Support for hospitalized children	A. Integral support for newborns in neonatal care	i) Integral evaluation; Developmental care plan; integration with families; hospitals open to families; prevention of neuro-developmental deficit; education and psycho-social interventions	0-4 Years
	B. Integral support for children in pediatric care	ii) Integral evaluation; Developmental care plan; Provision of space for education and play; Use of stimulation protocol; Helpful relationships built between health team and father/mother/carer	
4. Strengthening Integral Development of Children	A. Strengthening Child Health Checkups for Integral Development	i) Prenatal check-ups, establishment of link and detection of psychosocial risk factors	0-4 Years
		ii) Participation in Child Health checkups ("Niño/a sano")	
		iii) Check-ups with evaluation and follow-ups	
	B. Educational Interventions to support child-rearing	i) Group or individual education for development of parenting tools, "Nobody is Perfect" workshops	
*5. Support for Children in Vulnerable Situations	A. Strengthening of interventions for children in vulnerable situations, or developmentally delayed	i) Health support for children who are vulnerable, or developmentally delayed in integral components	0-4 Years
		ii) Health support for children with developmental deficit in integral components	
		iii)Integral home visits for families of children under 4 in vulnerable situations for their bio-psycho-social development	
		iv) Support module for infant development in health centres	

Notes: Components and sub-components are based on official Chile Crece Contigo guide to services (Ministerio de Desarrollo Social, 2014). Components or sub-components indicated with "*" are targeted components received only by means-tested groups.

although a very small number of batches of the original formula was still disbursed post 2008. In Table 25 we show the change in composition between the two types of dietary supplements. The guidelines issued by the Ministry of Health provide a clear description of how this milk should be disbursed to pregnant women. For those who begin pregnancy with normal weight, are overweight, or are obese, 1 kilogram of milk powder is given per month. For those women who begin pregnancy with an underweight diagnosis, 3 kg of milk powder is delivered per month (Gobierno de Chile, 2008). cutoff Measures of home visits refer to "Integral Home Visits" to pregnant women. Government reports highlight that Chile Crece Contigo has increased the frequency of home visits to pregnant mothers by around 500%. These home visits are targeted particularly to families identified as being in "psycho-social risk", which implies meeting the vulnerability cutoff, and also presenting a number of additional risk factors. Given that the demand for home visits varies considerably by income level of municipalities, the precise decision of which families to visit is made by

Table 25 Changes in composition of complementary nutrition component

Micronutrient	Units/portion	Purita Mamá	Purita Fortificada
Vitamin A	µg	120	50
Vitamin C	mg	35	14
Vitamin D	µg	1	0.6
Vitamin E	mg	7.5	0.1
Vitamin B_1	mg	0.4	0.06
Vitamin B_2	mg	0.4	0.24
Niacin	mg	4	0.12
Vitamin B_6	mg	0.5	0.06
Folate	µg	130	7.34
Vitamin B_{12}	µg	1.3	0.64
Vitamin B_5	mg	–	0.46
Calcium	mg	325	182.4
Iron	mg	–	2.0
Phosphorous	mg	291.5	155.2
Magnesium	mg	62.5	15.0
Zinc	mg	1.9	1.0
Copper	mg	–	0.08

All values come from Technical Guidelines for Leche Purita Fortificada (old formula) and Leche Purita Mamá (new formula). Each are described in terms of quantity of nutrients per recommended portion. In the new formula, the recommended portion is 25 g, versus a recommended portion of 20 g in the old formula

municipal health centres, where visits should be targeted to families with the largest number of risk factors. A complete discussion of the goals and recommendations for social workers completing home visits is provided in Gobierno de Chile (2009).

Remaining components such as prenatal check-ups and appointments with social assistants in local health centres are also reported in monthly health usage data. In this case the number of appointments completed are reported, and in Section 5.3 we calculate the average number of appointments per health service for a pregnancy in the 9 months prior to the birth.

Appendix 4. Maternal fixed effects

As a consistency check of the difference-in-difference results reported in the paper, we also undertake an analysis using the full matched micro-data observing each mother's participation status in ChCC. Identification is driven by variation within mother's exposure to the program over time. We estimate the following mother FE specification:

$$InfantHealth_{ijt} = \beta_0 + \beta_1 ChCC_{jt} + \boldsymbol{X}_{ijt}\beta_x + \phi_t + \mu_j + \varepsilon_{ijt} \tag{4}$$

where $InfantHealth$ refers to the same measures of health at birth as discussed in the body of the paper of child i born to mother j at time t.

The matched administrative data allows us to construct a panel of mothers and their children, and the independent variable of interest in 4 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, mother's age at birth dummies, and child year of birth dummies.[34] 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.

The matched mother and child data does not include the entire universe of births (we do use the entire universe of births in municipal-level regressions presented in the paper). As such, any estimated program impacts in the micro-level mother FE specification are at best suggestive of the average effects in the population. When matching vital statistics data with parental social program use data, approximately 50% of births were matched with fathers, rather than mothers, and in these cases we do not observe the mother's ChCC participation status. We thus restrict the analysis with mother FE only to the population of children matched with mothers, noting that it is not a representative sample, and as such not directly comparable to the municipal-level difference-in-difference regressions presented in the paper based on the entire universe of births. Nevertheless, it acts as a useful robustness check of the impact of ChCC based on different identifying assumptions.[35]

In Table 26 we present summary statistics of births to all mothers, births to mothers who were matched with their social program usage, and births to mothers who were not matched the mother's social program usage data. While their observable measures are largely similar, matched mothers appear to be slightly younger (26.91 versus 27.19 years), and have births with slightly better health indicators (3333 g of birth weight versus 3324 on average).

We present regression results using maternal fixed effects in Table 27. In this case identification is driven by mothers who have had more than one birth, and hence variation in program coverage. Despite the alternative methodology (and estimation sample) we observe results that are qualitatively similar to those reported using the municipal rollout to estimate program impacts. In this case we observe a larger impact on birth weight (19 g, versus 10 g), and significant impacts also when considering size at birth of each child. One result does not agree across specifications, and this is the estimate on the impact of ChCC on low birth weight children. In this specification we observe a weakly positive impact, while in the specification reported in

[34] 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 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. In supplementary analyses we augment the controls in 4 to examine the robustness of findings to alternative specifications.

[35] The two proposed strategies (the DD estimates in the body of the paper and the mother FE estimates in Appendices) rely on strict (conditional) exogeneity for the family panel specification in Eq. 4 and parallel trends for the DD specification in Eq. 1.

Table 26 Summary statistics: matched mother, child and social security data

	N	Mean	Std. Dev.	Min	Max
Panel A: All mothers					
Birth weight (g)	1,912,573	3327.45	539.30	500.00	5000.00
Low birth weight < 2500 g	1,912,573	0.06	0.23	0.00	1.00
Gestation (weeks)	1,910,932	38.59	1.74	25.00	44.00
Premature < 37 weeks	1,910,932	0.07	0.25	0.00	1.00
Length (cm)	1,911,391	49.47	2.49	30.00	60.00
Year of birth	1,917,085	2006.57	2.30	2003.00	2010.00
Mother's age	1,915,322	27.08	6.81	14.00	49.00
Proportion teen births	1,917,085	0.16	0.36	0.00	1.00
Number of children	1,916,934	1.96	1.13	0.00	15.00
Panel B: Matched mothers and children					
Proportion ever enrolled in ChCC	741,963	0.38	0.48	0.00	1.00
Birth weight (g)	740,393	3333.34	541.73	500.00	5000.00
Low birth weight < 2500 grams	740,393	0.06	0.23	0.00	1.00
Gestation (weeks)	739,707	38.64	1.76	25.00	44.00
Premature < 37 weeks	739,707	0.07	0.25	0.00	1.00
Length (cm)	739,913	49.50	2.50	30.00	60.00
Year of birth	741,963	2006.60	2.29	2003.00	2010.00
Mother's age	741,413	26.91	6.75	14.00	49.00
Proportion teen births	741,963	0.15	0.36	0.00	1.00
Number of children	741,918	1.96	1.14	0.00	15.00
Panel C: Unmatched mothers and children					
Birth weight (g)	1,172,180	3323.73	537.72	500.00	5000.00
Low birth weight < 2500 g	1,172,180	0.06	0.23	0.00	1.00
Gestation (weeks)	1,171,225	38.57	1.73	25.00	44.00
Premature < 37 weeks	1,171,225	0.07	0.26	0.00	1.00
Length (cm)	1,171,478	49.46	2.48	30.00	60.00
Year of birth	1,175,122	2006.55	2.31	2003.00	2010.00
Mother's age	1,173,909	27.19	6.84	14.00	49.00
Proportion teen births	1,175,122	0.16	0.37	0.00	1.00
Number of children	1,175,016	1.96	1.13	0.00	15.00

Summary statistics are presented for all births matched with the mother's participation in social programs. Summary statistics are presented for all years from 2003 to 2010. *Chile Crece Contigo* began in June of 2007, and so any mothers having all births prior to this date never participated in ChCC. For additional notes on variable definitions and comparison with the full universe of births (collapsed by municipality) refer to Table 2

Table 3 we observed a weakly negative impact. However, in Table 28 when we additionally include full time and municipal fixed effects, we observe that the result is no longer statistically distinguishable from zero, while remaining effects are largely unchanged. In panel B of Appendix Table 20 we present *p* values on the impact of

Table 27 Estimated program effects with mother fixed effects

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature
Participated in ChCC	19.395***	0.004*	0.049**	0.090***	− 0.001
	[4.534]	[0.002]	[0.022]	[0.016]	[0.002]
Constant	3074.884***	0.090**	48.412***	38.069***	0.124***
	[63.811]	[0.036]	[0.316]	[0.253]	[0.038]
Mean of Dep. Var.	3333.458	0.056	49.499	38.638	0.068
Observations	739,811	739,811	739,332	739,126	739,126
R-squared	0.018	0.002	0.022	0.012	0.002

Estimation sample consists of all births where the data link exists between the child and the mother's participation in social programs, including ChCC. Additional details regarding this procedure are provided in Appendix 4. In each case mother's fixed effects are included, and full fixed effects for mother's age at birth, child birth order, and child's year of birth are included. Standard errors are clustered by mother. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

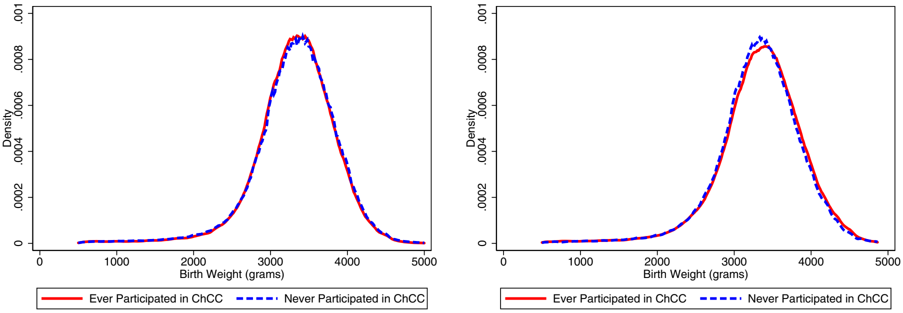
ChCC when correcting for multiple hypothesis testing. For birth weight, birth size, and gestational length we observe that results remain statistically distinguishable from zero when controlling for the family-wise error rate using Romano and Wolf's step-down correction.

Finally, we briefly examine distributional impacts of the program on health at birth, as examined in Fig. 4. In this case we simply examine descriptive evidence, considering the distribution of birth weight between program recipients and non-program recipients prior and posterior to the program's implementation. These are presented in Fig. 21, and we observe that in the pre-program period, the distribution of birth weight for recipient mothers is slightly below the corresponding distribution for non-recipient mothers, while post-program the reverse pattern is observed (both

Table 28 Maternal FE estimates with additional controls

	(1) Weight	(2) LBW	(3) Size	(4) Gestation	(5) Premature
Participated in ChCC	19.885***	0.003	0.056**	0.093***	− 0.002
	[4.598]	[0.002]	[0.022]	[0.016]	[0.002]
Constant	3078.607***	0.110***	48.100***	37.869***	0.149***
	[72.793]	[0.040]	[0.356]	[0.281]	[0.042]
Mean of Dep. Var.	3333.458	0.056	49.499	38.638	0.068
Observations	739,811	739,811	739,332	739,126	739,126
R-squared	0.023	0.006	0.027	0.017	0.006

Refer to notes in Table 27. All details of estimated specifications are identical; however, we now include year by month fixed effects, and fixed effects for municipality of birth. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$



(a) Birth weights Pre-ChCC

(b) Birth weights Post-ChCC

Fig. 21 Birth weight distributions pre- and post-program implementation. Densities are plotted using an Epanechnikov kernel with a bandwidth of 5 g. Each panel separates distributions by whether the mother *ever* participates in Chile Crece Contigo. Panel **a** displays only pre-ChCC s, while panel **b** displays only post-ChCC time periods. In both cases, Kolmogorov-Smirnov tests reject equality of distributions (in different directions)

differences are observed in the rejection Kolmogorov-Smirnov of tests of the equality of distributions). Interestingly, the distribution appears to be most shifted from around 2500–4500 g, providing some descriptive support of the distributional results documented in Fig. 4.

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