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Effects of Nutrition Promotion on Child Growth in El Alto, Bolivia: Results from a Geographical Discontinuity Design

ABSTRACT Interventions that offer growth monitoring and nutrition counseling services to families with young children are one of the cornerstones of nutrition policy in developing countries. By raising caregivers' awareness and encouraging recommended feeding, health, and hygiene practices, these programs seek to improve children's growth, measured in terms of height and weight. We explore the effects of one such intervention that conducted home visits and community meetings with mothers of children under two years old in El Alto, a city of high poverty concentration in Bolivia. Project eligibility was limited to just over 400 households residing within a strictly defined geographical area. We exploit the resulting geographical discontinuity to identify impacts. Three years after the project started, we find that caregivers in the intervention area show substantial gains in health- and nutrition-related knowledge (0.327σ) and practices (0.273σ) relative to their peers just outside the project boundary. We find no detectable impacts on children's height, but observe a significant increase in the prevalence of overweight children. For contexts such as El Alto, with high prevalence of stunting and increasing risk of overweight in the same population, these results suggest that nutrition promotion interventions should reassess both content and behavioral change strategies to reduce stunting while concurrently preventing excess weight gain in children.

JEL codes: I15, J13, C93

Keywords: nutrition promotion; growth monitoring; regression discontinuity; Bolivia

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Child malnutrition still represents a major public health concern in many lower- and middle-income countries. However, what was mainly a problem of undernutrition in past decades, with high rates of stunting (low height for age) and wasting (low weight for height), is now a combined problem of high prevalence of stunting and anemia accompanied by an increasing risk of overweight and obesity.[1] The transition toward high energy-dense diets rich in sugar and fat, along with more sedentary lifestyles, is associated with increased weight gain among children. Childhood obesity, in turn, is associated with increased risks of adult obesity, which is linked to chronic health problems, including diabetes, cardiovascular disease, and cancer.[2]

Throughout Latin America and the Caribbean, the prevalence of stunting and wasting among children younger than five is on the decline. Regionally, the prevalence of stunting, an indicator of long-term deficits in nutrition and health, fell from 25.2 percent in 1990 to 10.7 percent in 2014. The prevalence of wasting, a measure of acute food insecurity and ill health, was just 1.1 percent in 2014, compared with an average of 8.2 percent for all developing countries worldwide. On the other hand, the prevalence of overweight children in Latin America and the Caribbean has experienced a steady climb, from 6.3 percent in 1990 to 7.6 percent in 2014.[3] These aggregate statistics hide important variations both between and within countries. High rates of stunting persist among many indigenous populations, in rural areas, and within certain low-income populations in fast-growing peri-urban areas. To improve nutrition outcomes and increase service coverage in these vulnerable population segments, home visit interventions that offer growth monitoring and nutrition counseling, often in combination with some form of group or community workshops, have been established throughout the region.

We evaluate a community child nutrition project in the city of El Alto, Bolivia, which aimed to prevent stunting and wasting among children in low-income households. The project was implemented between 2008 and 2011 by a local nongovernmental organization (NGO), which conducted monthly home visits in households with pregnant women and children up to the age of two years. Home visits consisted of growth monitoring (height and weight

1. Black and others (2013); Fernald and Neufeld (2007); Lobstein and others (2015); Popkin, Adair, and Ng (2012); Uauy and others (2008).

2. On the link between childhood and adult obesity, see Adair and others (2013) and Demerath and others (2009). On health risks, see Chan and Woo (2010).

3. World Health Organization (WHO), "Global Health Observatory Visualizations: Joint Child Malnutrition Estimates (UNICEF-WHO-WB)," 2015. Available online at apps.who.int/gho/data/view.wrapper.nutrition-1-7?lang=en (accessed 8 February 2016).

measurements) and health card registration for children, followed by counseling services to caregivers on recommended hygiene routines, diarrhea prevention, and nutritional practices. The project also organized monthly community meetings that included cooking classes and nutrition counseling for caregivers. Furthermore, the project lobbied local authorities to ensure a regular supply of micronutrients and nutrition supplements through the local health centers.

The intervention was implemented in a strictly defined geographical area. All households with pregnant women and children under two years old residing within the intervention area were offered home visit services (treatment group), while neighbors outside the intervention area were not (control group). The project collected an endline-survey in the second half of 2011, including 922 children aged six to forty-eight months in treatment and control households, with an effective survey response rate of 97.8 percent. Using a geographical discontinuity design to identify program impacts, we find that caregivers in treatment households demonstrate significantly more knowledge on health and child nutrition topics covered by the project. Treatment households also report significant differences in terms of health and nutritional practices. We find no evidence of effects on children's final nutritional status as measured by increased height for age, reduced stunting, or reduced wasting. We do, however, detect increases in average weight, as measured by weight for age, weight for height, and body mass index (BMI). While results on weight are somewhat sensitive to the model specification, our analysis shows that children in the treatment group are 12.5 percentage points more likely to be overweight (with a BMI-for-age z score of $> 2\sigma$) than their peers in the control group around the geographical boundary, which represents a relative increase of 245 percent.

Our review of the intervention's nutrition counseling and growth monitoring protocols offers some clues for explaining the project's unintended impact on weight gain. Messages intended to promote recommended feeding practices for children may have inadvertently encouraged the consumption of higher quantities of micro- and macronutrients without simultaneously eliminating excess calories from undesired fats and sugars and promoting physical activity. At the same time, monthly measurements of height and weight may have focused caregiver attention on short-term increases in weight as a sign of healthy growth, rather than on long-term changes in height, which are harder to perceive.

Our study complements a growing literature on the effects of growth monitoring and nutrition counseling interventions on anthropometric outcomes and caregiver knowledge, attitudes, and practices in developing countries.[4] Many of these studies analyze height and weight outcomes, but tend to concentrate on undernutrition (stunting, wasting, and underweight) and do not present measures of overweight and obesity among the analyzed outcomes. It is therefore difficult to assess whether interventions similar to the one studied here may have also posed a risk for excess weight gain among children in other country contexts.

While the community child nutrition project in El Alto was effective for knowledge acquisition and behavioral change related to hygiene routines and feeding practices, our results suggest that there may be scope for adjusting the intervention's content and behavioral change strategy. In populations such as El Alto, with coexisting risks of stunting and overweight, these adjustments would focus on transferring more of the intervention's informational content into effective behavioral change; eliminating or adjusting the frequency of growth monitoring in the home visit protocols; including messages and behavioral change strategies to encourage diversified diets, eventually including food replacement of bad calories for good ones; and promoting child health not only through domestic hygiene, but also through healthy lifestyle options that favor children's linear growth without explicitly focusing on weight- or calorie-related messages.[5] These modifications could be introduced through innovative pedagogic and communicational approaches and behavioral change strategies that engage the caregiver both cognitively and emotionally and consider the broader social and cultural context that influence the caregiver's decisions on nutrition-related practices.

The case study presented in this paper serves to illustrate the critical need for nutrition policies in Latin America and the Caribbean to address the upward trend in overweight children, even in low-income settings that maintain a high prevalence of stunting. Our results invite nutrition promotion programs to review the content and delivery of their interventions, particularly those that focus on feeding practices to reduce undernutrition and implement frequent growth monitoring. Even when following international best practices, this approach may involve the implicit or explicit promotion of excess caloric intake. As wasting in low-income populations becomes less prevalent, and obesity rates rise, nutrition promotion interventions should redirect their

4. Ashworth, Shrimpton, and Jamil (2008); Alderman (2007); Alderman and others (2009); Galasso and Umapathi (2009); Schaetzel and others (2008); Mayhew and others (2014); Monga and others (2008); Ruzita, Wan Azdie, and Ismael (2007); Shariff and others (2008).

5. Lobstein and others (2015).

efforts toward improving the nutritional content and diversification of diets, as well as promoting good hygiene and adequate levels of physical activity. Following recommended dietary guidelines, this could mean encouraging caregivers to ensure diversified diets with sufficient animal protein, fruits, and vegetables, eventually *replacing* high-energy processed foods loaded with fats and sugars.

Context and Intervention

Bolivia is an Andean country in South America with a population of more than 10 million inhabitants and an average per capita income of US$2,576.[6] Of the population, 43.4 percent live below the poverty line and 21.6 percent in extreme poverty, with pronounced rural-urban differences.[7] Despite remarkable progress in the past decades, Bolivia still suffers from one of the highest ratios of maternal mortality (311 out of every 100,000 live births) and infant mortality (50 out of every 1,000 live births) in Latin America, with birth complications, pneumonia, and diarrhea representing the three principal causes for the high infant mortality rate.[8]

According to the last Demographic and Health Survey (DHS) of 2008, acute malnutrition (as measured by weight for height) affects only 1.4 percent of children under five years, while stunting (as measured by height for age) continues to be a severe issue for public health policy in Bolivia, affecting 27 percent of this age group. Bolivia has the second highest rate of stunting in the region, following Guatemala. The national averages in Bolivia mask significant disparities among population subgroups. For example, stunting prevalence is significantly higher in rural areas, poor population segments, and households with less educated mothers. The stunting rate of children under five in the highland region is 34 percent, nearly three times higher than in the lowlands (12 percent). Another pressing concern in child nutrition in Bolivia is anemia: 61 percent of children under five suffer from anemia; among children up to two years of age, the rate ascends to 70 percent.[9] Both of these

6. The GDP per capita estimate is based on the World Bank Database and represents an average for the period 2009–2013.

7. UDAPE (2012).

8. All indicators based on DHS data from 2008 (Coa and Ochoa, 2009). This maternal mortality rate of 2008 is not officially confirmed and accepted by the Bolivian authorities. There are no official data on Bolivia's maternal mortality rate since 2003.

9. Coa and Ochoa (2009).

nutrition problems, stunting and anemia, in the first two years of a child's life are known to have severe long-term consequences in terms of cognitive development, learning achievement, and future labor productivity, even if they improve in later childhood years.[10]

Like many countries in the region, Bolivia increasingly suffers from the double burden of coexisting chronic stunting and overweight. Fully 50 percent of women of reproductive age in Bolivia are overweight or obese.[11] In the age group of fifteen to nineteen years, overweight or obesity affects more than 22 percent of women, and the rate increases with age. Furthermore, 9–10 percent of children in the six to eleven month range and 6–9 percent of children in the twelve to forty-seven month range are overweight.[12] Evidence indicates that obesity at the age of two years and above is associated with higher probabilities of obesity in adulthood and the related risks of chronic and degenerative diseases.[13] The health patterns described above at the national level hold for the city of El Alto and the corresponding department of La Paz, which presents the second highest anemia rate of children under five years old among the nine departments in the country (72 percent).[14]

The city of El Alto, with approximately one million inhabitants, is situated at 4,100 meters above sea level, in the direct vicinity of the country's seat of government, La Paz, in the altiplano highlands.[15] El Alto is the fastest-growing city in Bolivia due to high rural immigration and fertility rates. The city has the highest population density in the country, a poverty rate of 67 percent, and a population share of 86 percent that self-identifies as indigenous, mainly Aymara. The city's Eighth District, where the current study is located, belongs to the peri-urban southwest belt of El Alto. The area is characterized by high rural immigration and predominantly informal employment in the commercial, transportation, and small industry sectors. In 2003, a survey by the NGO Rural Andean Health Council (CSRA, its Spanish acronym) indicated that most families live in precarious housing conditions, referring to homes with adobe walls, up to two rooms, and lack of heating despite the year-round low temperatures. Homes are accessible mostly by dirt roads and do not have sanitation or waste

10. Grantham-McGregor, Fernald, and Sethuraman (1999a, 1999b); World Bank (2010).

11. Coa and Ochoa (2009).

12. Coa and Ochoa (2009). This definition considers children overweight at plus two standard deviations of the weight-for-height z score. A body mass index (BMI) measure of overweight and obesity is used in the remainder of the paper.

13. Freedman and others (1999); Chan and Woo (2010).

14. Coa and Ochoa (2009).

15. The constitutional capital of Bolivia is Sucre.

collection services. The same survey revealed that 71 percent of children aged twelve to twenty-three months had an incomplete vaccination scheme; 64 percent of children under two years old with diarrhea did not receive any oral rehydration treatment; and only 5 percent of the mothers reported applying adequate hand-washing practices.[16]

The principal government programs related to nutrition in Bolivia between 2008 and 2011 were the multisector program *Desnutrición Cero* (Zero Malnutrition in English) and its health sector component, as well as the conditional cash transfer program, *Bono Juana Azurduy* (BJA). *Desnutrición Cero* included a conditional incentive fund for municipal governments aimed at improving the coverage and quality of nutrition services by targeting vulnerable municipalities and promoting the provision of micronutrients (*Chispitas Nutricionales*), zinc, and oral rehydration therapy, with a focus on the first 1,000 days of life.[17] Persisting challenges in the sector include the operational management of its nutrition and health programs, coverage, coordination among programs in the health sector, coordination between public and private actors to guarantee an uninterrupted supply of micronutrients and food supplements (*Nutribebé*), and uncertainty about the effectiveness of some of the approaches adopted for health and nutrition promotion and behavioral change.[18]

The Community Child Nutrition (CCN) Project

The intervention studied here is the community child nutrition (CCN) project implemented by CSRA in El Alto.[19] CSRA ran the CCN project between May 2008 and March 2011. Through its census methodology, which maintained updated records of area residents in coordination with the health sector, the program identified pregnant mothers and newborn children in the intervention area as early as possible and incorporated them into the project. The project implemented monthly home visits and community meetings with the primary caregiver until the child was twenty-four months old.

16. Castrillo (2007).

17. The *Desnutrición Cero* municipal fund concentrated on vulnerable municipalities in rural areas with high levels of food insecurity and did not include the municipality of El Alto.

18. Morales, Pando, and Johannsen (2010).

19. The Rural Andean Health Council (*Consejo de Salud Rural Andino,* or CSRA) is an NGO with over thirty years of experience in the promotion of preventive healthcare models in Bolivia. Its established presence in the area of Senkata in District 8 facilitated the coordination with local health centers and the public health network to implement the project.

The CCN project implemented and complemented the country's main nutrition interventions described in the previous section, in particular the health sector component of *Desnutrición Cero* and the national nutrition protocols, using a community intervention model that was adapted to local conditions in El Alto. The project's main focus was the provision of growth-monitoring activities and health card registration, as well as counseling on hygiene and nutritional practices and behavioral changes that improve child nutrition. The project also worked with the municipal government to maintain an effective supply of micronutrients and food supplements by lobbying local authorities to include nutritional inputs in annual budget planning and distribution activities.

The intervention's conceptual model was based on an impact-oriented census methodology. From the outset, the project carried out a census through which information was collected on socioeconomic and health-related risk factors for every household in the intervention area. This information was used to identify families with young children or pregnant women and target the corresponding home visits accordingly. During the intervention, trained nurses and nurse assistants followed project protocols to run monthly home visits and community counseling activities in close coordination with the corresponding local health center. During the home visits, the mobile brigade measured and weighed children, provided counseling to their parents or to pregnant women on preventive health and nutrition measures, and promoted behavioral change toward better hygiene and age-adequate nutritional practices, including the incorporation of macronutrients such as animal protein in the children's diets. Home visits also promoted the consumption of micronutrients and food supplementation. Community meetings included cooking classes using locally available foods and reinforced key behavioral change messages in a group setting. However, the intervention lacked explicit messages on diversified diets, potential nutrient replacement, or general recommendations for physical activity. Families with other problems thought to affect nutrition status, such as domestic violence, were referred to existing public services, including educational, legal, or psychological support.

The theory of change that underlies this intervention model can be described as follows. Mothers receive counseling visits at home and attend group meetings, which include anthropometric measurements to monitor the weight and height of their children, nutrition counseling, and cooking classes. Mothers then receive nutritional supplements (*Chispitas Nutricionales* or *Nutribebé* or both), acquire knowledge, and learn strategies to improve domestic hygiene and child nutrition according to the individual household context. Mothers therefore apply adequate food intake during pregnancy, apply exclusive breastfeeding in children up to six months, and implement recommended complementary feeding practices after six months. Stunting, wasting, and anemia in children are thus prevented.

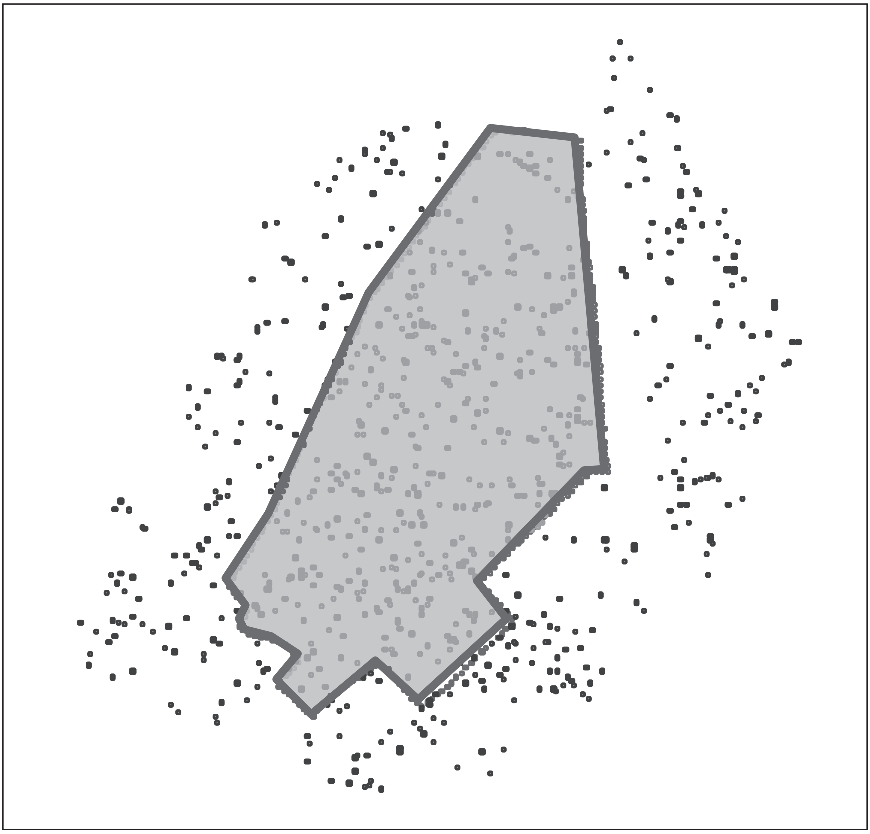
This causal chain was complemented and reinforced by preferential access to regular health checkups, vaccination visits, and health treatment at the local health center for project beneficiaries. Furthermore, the project lobbied and coordinated activities with the municipal government to enforce effective provision of micronutrients, macronutrients (*Nutribebé*), and oral rehydration sachets at the health centers. Complementary training sessions were held for the medical personnel at the health centers, aimed at strengthening the coordination between physicians and the NGO home visit brigades and ensuring the correct application of the respective norms and protocols during health checkups.

Empirical Strategy

To evaluate the impact of the intervention, we use a geographical discontinuity given by the project's well-defined limits that determined which households in the Eighth District of El Alto were eligible to participate. Geographical limits were established based on the project's operational capacity and the geographical proximity to the NGO's headquarters at the local health center. The geographical area includes sixteen neighborhoods in the Eighth Municipal District of El Alto, with a population of approximately 10,000 residents (2,040 households) out of a total population of approximately 48,000 inhabitants of the Eighth District. Limits were set at the beginning of the project in 2008, and the project operated exclusively within the project boundaries. Limits were established at the block level, typically bordering a major avenue or intersection, though in some cases limits were traced through residential areas. Figure 1 shows the project's geographical limits.

As explained in the previous section, the project conducted a census of households within the established boundaries, and all households with a pregnant mother or a child under two years of age were offered project services. Neighboring households in the city block across the street from the project limit were not offered services or admitted into the project, given the limited resources available. To identify project impacts, we take advantage of the

FIGURE 1. Geographical Limits and Study Area of CCN Project in El Alto, Bolivia[a]



a. The solid line indicates the geographical boundary of the CCN project. The project was implemented in the shaded area.

exogenous variation in treatment around the project's geographical boundary using a regression discontinuity (RD) framework.[20] The RD framework takes the location of a household on either side of the geographical discontinuity as quasi-random and assumes that households do not sort around the boundary based on the presence of the project (for example, by moving into the treatment area to gain access to the intervention). For the purposes of this

20. Hahn, Todd, and van der Klaauw (2001); Imbens and Lemieux (2008); Lee and Lemieux (2010). Keele and Titiunik (2015) propose a geographical regression discontinuity (GRD) design with two running variables to control for longitude and latitude.

paper, we consider all eligible households residing in the project area as the treatment group, while households in the immediate proximity but outside the project area are the control group.

Although the treatment assignment of the CCN project was not random, we argue that based on the nature of the intervention and characteristics of the study area, the well-defined geographical limit set by the project serves to create variation in treatment that approximates random assignment at the geographical boundary. For example, all households in the study area (both treatment and control) reside in the same district and share the same public services, including the district's main health center. As such, treatment and control households living on the project boundary are equidistant to health services. Regression models discussed below control for distance and for household and child characteristics.

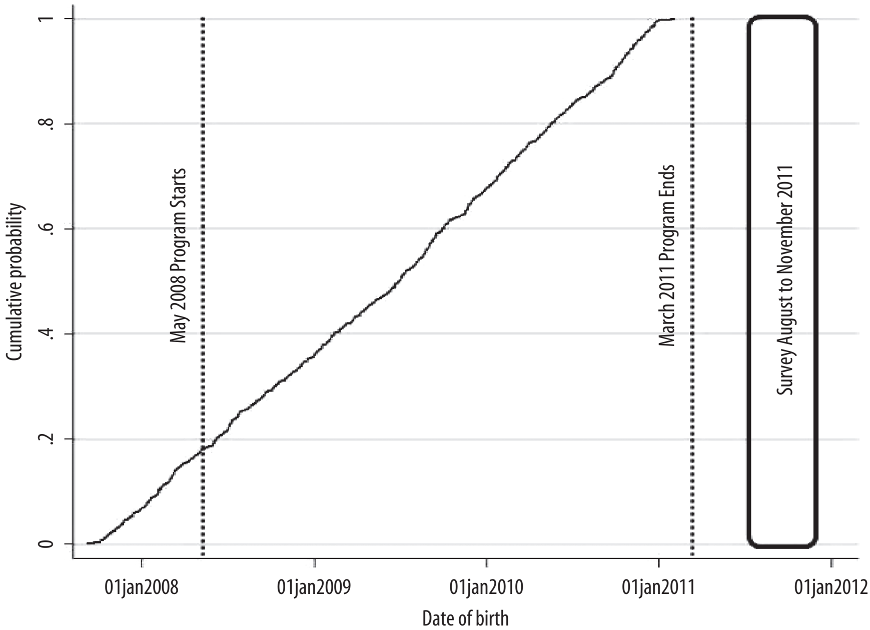
Data and Sample

To measure project impacts, we focus on the sample of households with children born between 1 October 2007 and 31 December 2010.[21] The endline survey was conducted between August and November 2011, meaning that children were between six and forty-eight months old at the time of the survey. Figure 2 shows the empirical distribution of birth dates for children in the study sample, with the oldest child born in October 2007. Fully 82.5 percent of children in the sample were born after the program started in May 2008. We also imposed a residency requirement of at least twelve months in the current location for the child or caregiver, to ensure a minimum exposure to treatment of one year. In the case of children younger than one, the mother or primary caregiver had to comply with the residency requirement and the child must have lived at the current location since birth.

The survey field procedure included a canvassing of households by an independent survey team. Field protocols established a pattern of surveys along the geographical limit of the intervention area, emanating outward and inward to balance sample sizes on each side of the boundary. The survey was collected by a survey team composed of nurses and nursing assistants, trained in the collection of household surveys and anthropometric measurements in young children. The survey team received a two-week training with the survey instrument and in the standardized use of electronic scales and

21. Two children born after 31 December 2010 (in January and February 2011, respectively) are included and were six months or older at the time of the survey.

FIGURE 2. Empirical Distribution of Children in Sample by Date of Birth



length and height boards. Surveyors practiced the correct calibration, use, and registration of anthropometric measures following World Health Organization (WHO) standards prior to the survey.[22] The effective survey response rate was 97.8 percent.

Household surveys included demographic and socioeconomic information, a basic health module, and education and employment sections for all household members. All women of reproductive age (fifteen to forty-nine) were interviewed about their birth history, prenatal care, delivery, and post-natal care for all pregnancies in the last ten years. The survey included nutrition-related knowledge and behavior questions for the caregivers of all children born between 1 October 2007 and 31 December 2010. Height and weight were collected for all children under the age of ten years residing in the household. In addition, data from the health cards of all children in the six to forty-eight month age range were collected either through a copy of the card provided during the household visit or through the clinical history number,

22. WHO (2008).

which could be linked to clinical records in the health center. Caregiver information was matched with the project's administrative records to determine project participation.

Given the importance of the distance-to-limit variable, all surveyors were trained in the use of global positioning system (GPS) devices. The survey recorded the latitude and longitude of each household in the survey, as well as coordinates of the project's geographical boundary and coordinates of all health centers in the area. Ultimately, the sample covered a census of eligible households in the intervention area and an equivalent number of survey-eligible households residing in closest proximity but outside the project's geographical limits. The maximum distance from the geographical limit was 0.45 kilometers (0.28 miles) in the treatment area and 0.68 kilometers (0.42 miles) in the control area. The complete sample is composed of 811 eligible households, 402 in the intervention area and 411 in the control, and includes 913 children in the age range of interest.

Health and Nutrition Knowledge and Practice Indexes

Following the project's theory of change described earlier, our analysis focuses on the impacts of the CCN project on measures of nutrition- and health-related knowledge and practices and final anthropometric outcomes of children. Nutrition and health knowledge and practice indicators followed international best practice adapted to the CCN project context, including questions on breastfeeding and complementary feeding, nutritional supplements, prevention and treatment of diarrhea episodes, risk signals during pregnancy and birth, and child healthcare during episodes of illness. The full set of indicators is presented in appendix tables A1, A2, and A3.[23] To resolve the multidimensionality inherent in a range of knowledge and practice indicators, we follow Kling and others in constructing aggregate indexes of the caregiver's knowledge and practices on health and nutrition.[24] Each index averages the components of equally weighted questions, as follows:

$$\text{INDEX}_i = \frac{\sum_{j=1}^{J} x_{ij}}{J},$$

where INDEX_i is the index score for household i; x_{ij} is the binary response for household i on question j with $x_{ij} = 1$ if the caregiver responded according to

23. The appendix is available online at www.cid.harvard.edu/Economia/contents.htm.
24. Kling, Liebman, and Katz (2007).

protocol and 0 otherwise; and J is the total number of items in the index. We construct separate indexes for knowledge- and behavior-related questions, with subindexes for nutrition and health and an aggregate score including both. We convert indexes to z scores as follows:

$$z\text{-INDEX}_i = \frac{\left(\text{INDEX}_i - \text{INDEX}_C\right)}{\text{SD}_C},$$

where z-INDEX$_i$ is the z score for INDEX in household i, INDEX$_C$ is the mean of INDEX in the control group, and SD$_C$ is the standard deviation of INDEX in the control group.

Identification Strategy

To identify project impacts, we run a standard regression discontinuity model in which the probability of treatment varies discontinuously at the geographical limit of the area of intervention. The basic regression specification is

$$(1) \qquad Y_i = \alpha + \beta_1 T_i + \beta_l \left(D_i - c\right) + \left(\beta_r - \beta_l\right) T_i \left(D_i - c\right) + \varepsilon_i,$$

where Y_i is the outcome of interest for a caregiver or child in household i, D_i is the distance from household i to the intervention area limit c, and T_i is a dummy variable equal to 1 for households located in the project area, that is for $D_i \geq c$, and 0 otherwise. β_l and β_r represent the relationship between the forcing variable (distance) to the left (l) and right (r) of the geographical limit, respectively, and ε_i is the error term. β_1 is the effect of the project. We normalized the distribution of distances from treatment and control households to the geographical boundary, with a distance of 0 at the limit. Distances from treated households to the intervention frontier are expressed in positive values, while distances from control households are transformed into negative values. For analysis of child-level anthropometric outcomes, we include controls for child age (month dummy variables), gender, and age*gender interactions in all models.

All results presented in the paper are from ordinary least squares (OLS) regression models (linear probability models in the case of binary outcome variables). In appendix tables A4–A7, we show results with alternative specifications of equation 1 for each outcome variable, testing robustness to bandwidth, confidence intervals, and functional form. First, we implement the optimal bandwidth estimator proposed by Imbens and Kalyanaraman for local linear estimators.[25] Second, we estimate equation 1 with robust confidence intervals proposed by Calonico, Cattaneo, and Titiunik.[26] We then estimate equation 1 using higher-order polynomials of D_i up to the fourth degree and a model controlling for caregiver characteristics (age, age squared, and highest level of schooling), household size in 2011, dwelling materials, and household assets. As a robustness check to rule out endogenous sorting around the geographical boundary, we estimate equation 1 limiting the sample to families that were residing in the same location prior to the start of the intervention in 2008 (about 70 percent of the sample). Finally, 17.4 percent of children in the sample were born prior to the program start date in May 2008. Given that these children had no or only partial exposure to the program during the critical prenatal and exclusive breastfeeding periods (pregnancy up to six months), we estimate equation 1 limiting the sample to children born after May 2008. For the most part, estimated coefficients are stable in terms of magnitude and significance across regression specifications. We discuss results that are sensitive to the regression specification on a case-by-case basis.

Results

Table 1 presents summary characteristics for treatment and control households. We test the difference in group means in the column labeled Difference, as well as a placebo regression discontinuity (RD) test of equation 1 on the full set of exogenous variables in the column labeled RD. The proportion of male children is higher in the control areas (54 percent) than in treatment areas (48 percent). This difference is statistically significant at the 10 percent level for the population mean, but is not significant at the geographical boundary in the RD model. The average age of children is just over twenty-six months and is balanced between the treatment and control groups. Caregiver characteristics are balanced in terms of age, indigenous, and marital status. Caregivers in the control group have an average of 0.47 years more education and 0.15 fewer children (difference in means significant at the 10 percent level), but this difference is not significant in the RD model. For a majority of exogenous household characteristics, there are no statistically significant differences in means or at the geographical boundary, including households' demographic composition, dwelling type (house, apartment, rooms, improvised dwelling), property tenure (household owned, rented or borrowed), and construction materials.

25. Imbens and Kalyanaraman (2012).
26. Calonico, Cattaneo, and Titiunik (2014).

TABLE 1. Descriptive Statistics[a]

Descriptive statistic	Treatment	Control	Difference	RD
Child characteristic	(*N* = 456)	(*N* = 457)		
Child is male = 1	0.48	0.54	–0.06*	–0.048
	(0.023)	(0.023)	(0.033)	(0.064)
Age in months	26.75	26.61	0.13	0.156
	(0.529)	(0.531)	(0.750)	(1.442)
Caregiver characteristic	(*N* = 402)	(*N* = 412)		
Caregiver's age in years	29.44	29.43	0.01	–0.875
	(0.335)	(0.345)	(0.481)	(0.924)
Caregiver's education in years	7.85	8.32	–0.47*	0.074
	(0.196)	(0.191)	(0.273)	(0.525)
Caregiver self-identifies as indigenous = 1	0.78	0.76	0.02	0.015
	(0.021)	(0.021)	(0.030)	(0.057)
Caregiver married or partnered = 1	0.92	0.92	0.00	–0.047
	(0.014)	(0.013)	(0.019)	(0.036)
Number of children	2.26	2.11	0.15*	0.164
	(0.060)	(0.053)	(0.080)	(0.153)
Household characteristic	(*N* = 402)	(*N* = 409)		
Household size	4.99	4.85	0.14	0.075
	(0.083)	(0.086)	(0.120)	(0.178)
Number of rooms in the dwelling	2.20	2.28	–0.08	–0.036
	(0.067)	(0.064)	(0.092)	(0.067)
Electricity connection inside the house = 1	0.99	0.99	0.00	0.008
	(0.005)	(0.005)	(0.007)	(0.014)
Access to piped water = 1	0.99	0.98	0.01	0.011
	(0.006)	(0.008)	(0.010)	(0.019)
Bathroom or latrine = 1	0.98	0.95	0.03**	–0.004
	(0.007)	(0.011)	(0.013)	(0.025)
Gas cylinder = 1	0.98	0.97	0.00	0.018
	(0.008)	(0.008)	(0.011)	(0.021)
Kitchen space used exclusively to cook = 1	0.88	0.88	0.01	–0.045
	(0.016)	(0.016)	(0.023)	(0.044)
Phone land line = 1	0.03	0.04	–0.01	–0.013
	(0.008)	(0.010)	(0.013)	(0.025)
Mobile phone = 1	0.94	0.90	0.04**	–0.018
	(0.012)	(0.015)	(0.019)	(0.036)
Gas stove for cooking = 1	0.97	0.97	0.00	0.005
	(0.008)	(0.009)	(0.012)	(0.023)
Radio = 1	0.87	0.89	–0.02	–0.081*
	(0.017)	(0.015)	(0.023)	(0.044)
Sound system = 1	0.38	0.40	–0.02	–0.027
	(0.024)	(0.024)	(0.034)	(0.066)
Television = 1	0.96	0.97	–0.01	–0.044*
	(0.010)	(0.008)	(0.013)	(0.025)
Refrigerator = 1	0.09	0.09	0.00	–0.090**
	(0.014)	(0.014)	(0.020)	(0.038)
Automobile = 1	0.22	0.20	0.02	–0.054
	(0.021)	(0.020)	(0.029)	(0.055)
Bicycle = 1	0.33	0.30	0.03	–0.019
	(0.023)	(0.023)	(0.033)	(0.063)

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
a. Table reports mean or proportion. Standard errors are in parentheses.

For the comparison of population means, exceptions are the presence of a bathroom or latrine and mobile phones, which have a slightly higher prevalence in the treatment group. Significant differences at the geographical limit are found for three assets (radio, television, and refrigerator). While the treatment assignment was not random, only two out of twenty-three (8 percent) independent variables collected in the survey show statistically significant differences in the population average at the 5 percent level, and only one variable is statistically different at the 5 percent level in the RD specification. These results lead us to believe that the group of control households along the geographical boundary is likely to deliver an appropriate estimate of the counterfactual when estimating project impacts.

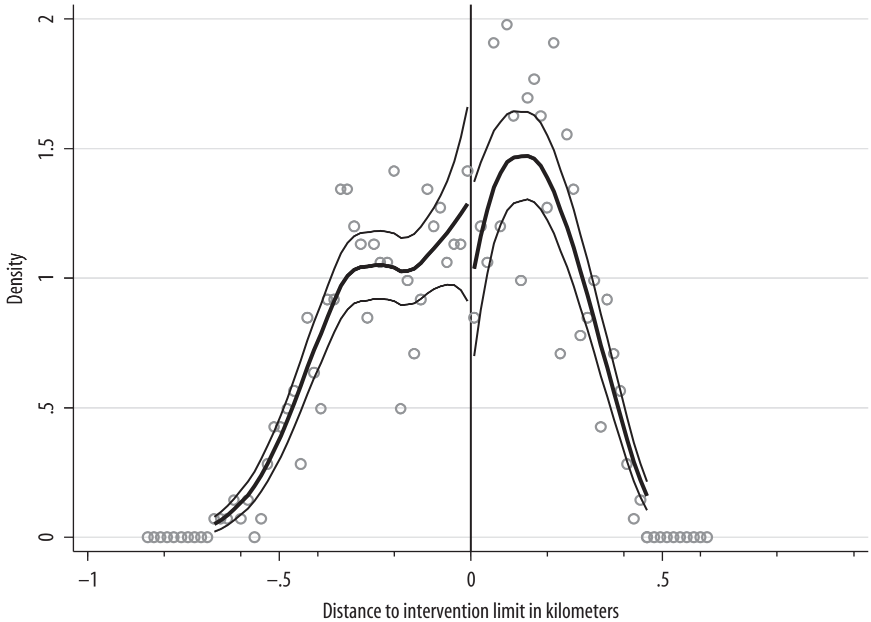
Treatment Assignment, Contamination, and Spillovers

The proposed geographical regression discontinuity design assumes that households do not manipulate the assignment variable (distance) and that households in the control group were not exposed to the intervention whether through imprecise application of the census area protocol by the project or through spillovers from treatment households sharing information with neighboring controls. With a maximum radius of 0.45 kilometer to 0.68 kilometer around the geographical boundary, treatment and control households reside in close proximity to one another. This proximity is advantageous in terms of comparability of households on either side of the boundary, but also poses potential risks in terms of both information spillovers and treatment contamination.

While dwelling location is arguably immutable, households (particularly those renting that face lower moving costs) might move from one area to another to seek project participation. We posit that based on the nature of the intervention, involving a modest time commitment of one monthly visit and no direct monetary or in-kind benefits, moving residences for the purpose of enrolling in the CCN project is unlikely. To test for sorting, figure 3 presents the results of a density smoothness test.[27] There is no evidence of a significant discontinuity in the density of observations around the geographical boundary. We additionally conduct robustness checks on our main outcomes by analyzing effects on the subgroup of households that have resided in their current dwelling since the beginning of the project in 2008 and as such are guaranteed to have not moved between areas. We find that results are robust to the residency requirement, suggesting that endogenous sorting at the geographical boundary is not a major risk to our identification of effects.

27. McCrary (2008).

FIGURE 3. Density Smoothness Test at Geographical Boundary[a]



a. Generated using the STATA routine "DCdensity" developed by McCrary (2008).

A second concern is contamination and spillovers, either from deviations in the treatment protocol by the CCN project staff or through interactions of neighbors sharing information on either side of the geographical limit. If such effects were to exist, they would tend to bias estimated impacts downward, so long as effects on caregivers and children in the control group go in the same direction as effects in the treatment group. To analyze treatment compliance and test indirectly for signs of contamination and spillovers, we analyze a series of indicators related to project participation and exposure, with results presented in table 2. Our strictest definition of project participation is the existence of a household growth monitoring folder in the CSRA administrative data, an indication that a household was effectively incorporated and treated by the project. Model 1 reports that only 3.6 percent of households in the control group have a growth monitoring folder, while this increases by 89.5 percentage points in the treatment group. That is, approximately 93 percent of households in the treatment area participated in the project according to administrative records.

TABLE 2. Household Project Participation[a]

Explanatory variable	*Registered by project (growth monitoring folder) = 1* (1)	*Ever received home growth monitoring visit = 1* (2)	*Participated in CCN project = 1* (3)	*Ever participated in community meetings = 1* (4)	*Participated in CCN project community meetings = 1* (5)
Treatment area = 1	0.895***	0.930***	0.957***	0.705***	0.606***
	(0.027)	(0.023)	(0.020)	(0.040)	(0.047)
Distance to boundary	0.054	0.079	0.036	0.057	0.022
	(0.066)	(0.056)	(0.049)	(0.098)	(0.113)
Distance * Treatment area	−0.020	−0.134	−0.106	0.249	0.010
	(0.116)	(0.099)	(0.086)	(0.171)	(0.199)
Constant	0.049***	0.053***	0.023*	0.028	0.015
	(0.019)	(0.016)	(0.014)	(0.027)	(0.032)
Summary statistic					
R squared	0.835	0.881	0.909	0.627	0.441
Control group mean	0.0367	0.0342	0.0147	0.0147	0.0098
Robust to specification[b]	Yes	Yes	Yes	Yes	No
Robust to bandwidth selection[c]	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.

*** Statistically significant at the 1 percent level.

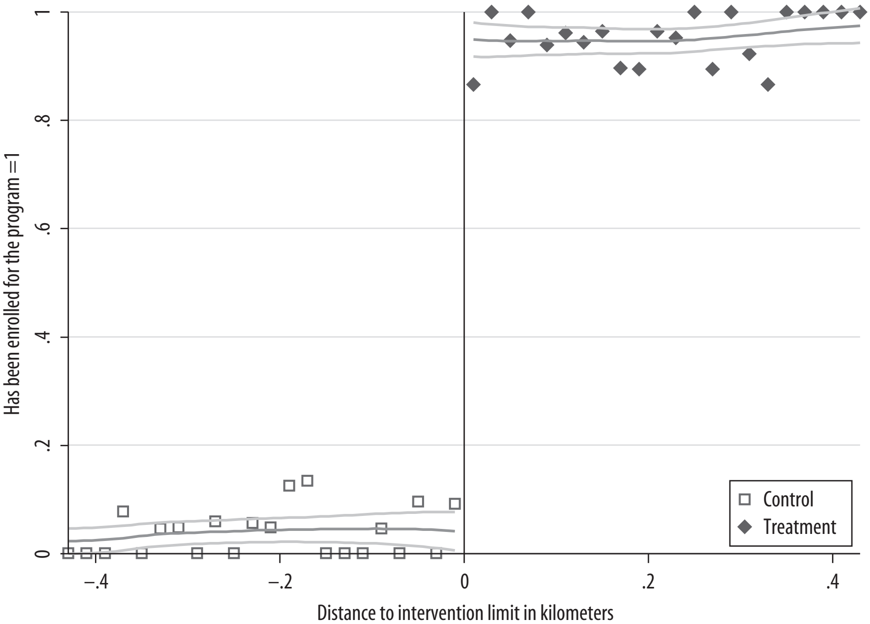
a. OLS regressions; $N = 811$. Treatment area = 1 indicates that the household is located within the intervention area (0 otherwise). Distance to treatment boundary is the minimum linear distance in kilometers from a household to the geographical intervention area boundary, calculated using GPS coordinates, centered at zero at the boundary; it is greater than 0 for households in the treatment area and less than 0 outside the treatment area. Standard errors in are parentheses.

b. Robustness checks are presented in online appendix table A4. These include regressions with higher-order distance polynomials degrees two through four, controls for household characteristics, and analysis of subsamples of households that reside in the same location since 2008 and the subsample of households with children born after May 2008.

c. Results are robust to nonparametric RD estimators proposed by Fujii, Imbens, and Kalyanaraman (2009), Imbens and Kalyanarman (2012), and Calonico, Cattaneo, and Titiunik (2014). Yes indicates that there is no statistically significant difference between treatment coefficients among specifications at the 10 percent level.

In models 2 through 5 of table 2, we analyze self-reported indicators of project participation collected during the survey. In model 2, caregivers were asked whether they had received some kind of home visit at any time in the past three years. While only 3.4 percent of the control group indicates a home visit of any kind, this increases by 93 percentage points in the treatment group, indicating that over 96 percent of households in the treatment area report at least one home visit in the past three years. Models 3 and 5 ask households about participation in the CCN project (home visit and community meeting components) by mentioning the project's name, while model 4 reports participation in any community nutrition meeting (independent of the implementing entity). In all cases, self-reported participation in CCN home visits in the control area is under 1.5 percent, and participation in CNN community meetings is just 0.09 percent. Furthermore, while treatment compliance remains high for the

FIGURE 4. Project Participation[a]



a. Scatterplot of program participation based on administrative records. The program's geographical boundary is centered at zero. Each bin represents the mean value of 2 percent of observations. The control group (squares) is to the left of zero and treatment group (diamonds) to the right of zero.

community meeting component, at 60 to 70 percent, it is below the rates of participation in the home-visit component. Results on project participation outcomes are highly stable and robust to bandwidth and regression specification, as shown in appendix table A4.

We present a graphical representation of program participation in figure 4, showing participation rates around the project's geographical limit (centered at zero). The horizontal axis represents distance around the geographical boundary, and each point depicts the proportion of households enrolled in the project based on administrative records for a bin of 2 percent of observations. We observe that participation rates are close to one for bins close to the geographical boundary in the treatment group (to the right of zero), while participation is close to nil in the control area (to the left of zero).

Taken together, these results from administrative data and self-reports suggest that treatment compliance within the geographical boundary was upward of 93 percent, while treatment contamination in control areas was very low. Furthermore, based on self-reports, it appears that caregivers in the control group did not participate in community meetings, which, unlike household visits, would have admitted individuals from outside the treatment area. While we cannot rule out that neighboring caregivers in the treatment and control areas shared information, any informational spillovers would bias estimated impacts downward to the extent that such information positively influences outcomes in the control group. As such, we argue that the conditions for identifying project impacts of the CCN project are likely to be satisfied, providing at least a lower-bound estimate of true project effects.

Impacts on Knowledge

Through home visits and community meetings, the CCN project delivered hygiene, health, and nutrition counseling meant to improve caregivers' knowledge and provoke behavioral change. Messages were delivered through oral communication with caregivers, printed materials such as posters, and demonstration exercises including growth and weight monitoring in the household and cooking lessons during community meetings. Topics covered included exclusive breastfeeding up to the age of six months and promotion of extended breastfeeding up to twenty-four months of age with simultaneous complementary feeding following age-appropriate dietary recommendations. Project health workers provided information on child health and nutritional care, including dietary recommendations, feeding practices, and information on diarrhea prevention (including domestic hygiene) and treatment (including zinc and oral rehydration sachets provided at the nearby health center). The counseling protocols on dietary recommendations also encouraged the use of nutritional supplements with micro- and macro-nutrients (*Chispitas Nutricionales* and *Nutribebé*) that are available through the local health centers.

The survey included a set of twenty-four nutrition and seventeen health questions designed to measure the caregiver's knowledge of core topics included in the CCN project curriculum (see appendix tables A1 and A2). We aggregate questions into a total knowledge index, with nutrition and health subindexes as described above. Table 3 presents average scores on the knowledge index between treatment and control caregivers, with an average correct response rate of 42 percent in the treatment group and 28 percent in the control group on all health and nutrition questions.

OLS results of the regression discontinuity model 1 are presented in table 4 and graphically in figure 5. Models 1–3 present results on the overall index,

TABLE 3. Health and Nutrition Knowledge and Practice[a]

Index	*Treatment*	*Control*	*Difference*
Knowledge	($N = 402$)	($N = 412$)	
Nutrition index	0.44	0.27	0.17***
	(0.009)	(0.007)	(0.012)
Health index	0.40	0.29	0.11***
	(0.008)	(0.008)	(0.011)
Global index	0.42	0.28	0.14***
	(0.007)	(0.006)	(0.010)
Practices	($N = 398$)	($N = 408$)	
Nutrition index	0.63	0.52	0.11***
	(0.012)	(0.012)	(0.017)
Health index	0.66	0.56	0.11***
	(0.009)	(0.008)	(0.012)
Global index	0.65	0.54	0.11***
	(0.008)	(0.008)	(0.011)

*** Statistically significant at the 1 percent level.

a. Table reports the mean value of caregivers' knowledge and practice indexes. Standard errors are in parentheses.

TABLE 4. Caregiver Knowledge Acquisition[a]

	Index			*Score (SD)*		
Explanatory variable	*Global (1)*	*Nutrition (2)*	*Health (3)*	*Global (4)*	*Nutrition (5)*	*Health (6)*
Treatment area = 1	0.128***	0.155***	0.100***	0.327***	0.403***	0.252***
	(0.019)	(0.022)	(0.021)	(0.048)	(0.059)	(0.052)
Distance to treatment boundary	0.090**	0.126**	0.054	0.271**	0.368***	0.175
	(0.045)	(0.053)	(0.051)	(0.117)	(0.142)	(0.126)
Distance * Treatment area	−0.133*	−0.195**	−0.070	−0.455**	−0.612**	−0.297
	(0.078)	(0.093)	(0.088)	(0.204)	(0.248)	(0.220)
Constant	0.303***	0.302***	0.305***	0.065**	0.087**	0.042
	(0.013)	(0.015)	(0.014)	(0.033)	(0.040)	(0.036)
Summary statistic						
R squared	0.212	0.222	0.113	0.206	0.214	0.112
Control mean	0.282	0.271	0.292	0.00	0.00	0.00
Robust to specification[b]	Yes	No	Yes	Yes	No	Yes
Robust to bandwidth selection[c]	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.

** Statistically significant at the 5 percent level.

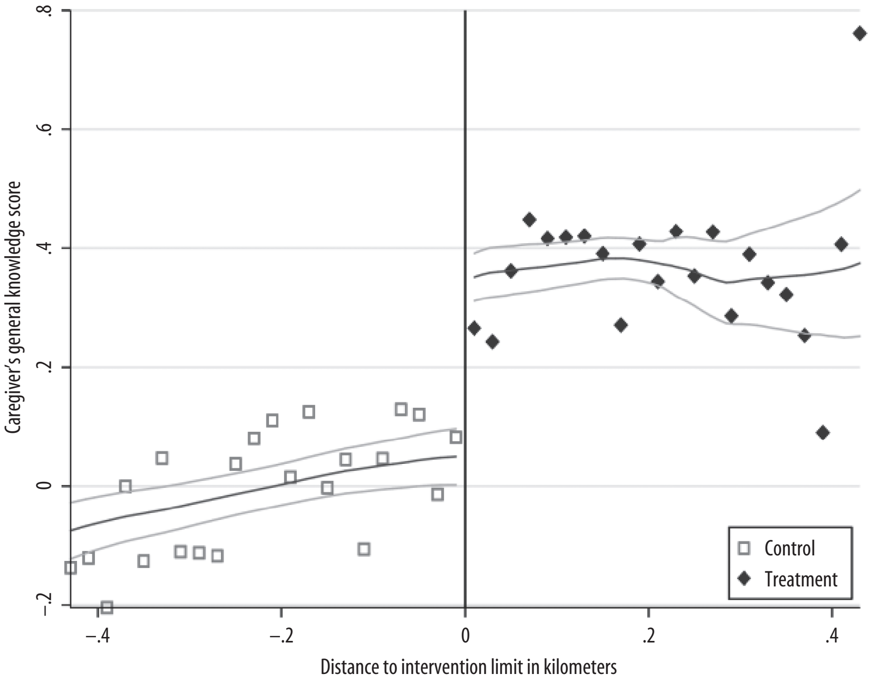
*** Statistically significant at the 1 percent level.

a. OLS regressions; $N = 814$. Treatment area = 1 indicates that household is located within the intervention area (0 otherwise). Distance to treatment boundary is the minimum linear distance in kilometers from a household to the geographical intervention area boundary, calculated using GPS coordinates, centered at zero at the boundary; it is greater than 0 for households in the treatment area and less than 0 outside the treatment area. Standard errors in parentheses.

b. Robustness checks are presented in online appendix table A5. These include regressions with higher-order distance polynomials degrees two through four, controls for caregiver and household characteristics, and analysis of subsamples of households that reside in the same location since 2008 and the subsample of households with children born after May 2008.

c. Results are robust to nonparametric RD estimators proposed by Fujii, Imbens, and Kalyanaraman. (2009), Imbens and Kalyanarman (2012), and Calonico, Cattaneo, and Titiunik (2014). Yes indicates that there is no statistically significant difference between treatment coefficients among specifications at the 10 percent level.

FIGURE 5. Scatterplot of Caregiver's Global Knowledge Score on Nutrition and Health[a]



a. Scatterplot of global knowledge *z* scores. The program's geographical boundary is centered at zero. Each bin represents the mean value of 2 percent of observations. The control group (squares) is to the left of zero and treatment group (diamonds) to the right of zero.

interpreted as the proportion of correct responses, while models 4–6 present the normalized *z* score in standard deviations. The CCN project increases the caregiver knowledge index by 12.8 percentage points (model 1). Impacts on the subindexes of nutrition and health are 15.5 and 10.0 percentage points, respectively. When scores are converted to normalized *z* scores, these effects represent increases of 0.327 standard deviations (σ) in the global knowledge score (model 4), 0.403σ for the nutrition subindex, and 0.252σ on the health subindex. All models are robust to specification tests except the nutrition subindex, and all models are robust to bandwidth selection (appendix table A5). Taken together, these results suggest that the CCN project had large and sustained impacts on intended knowledge acquisition and retention on behalf of beneficiary caregivers in regard to the core health and nutrition messages promoted by the project.

TABLE 5. Caregiving Practices for Child Nutrition and Health[a]

	Index			*Score (SD)*		
Explanatory variable	*Global* *(1)*	*Nutrition* *(2)*	*Health* *(3)*	*Global* *(4)*	*Nutrition* *(5)*	*Health* *(6)*
Treatment area = 1	0.111***	0.131***	0.096***	0.273***	0.292***	0.268***
	(0.021)	(0.033)	(0.023)	(0.050)	(0.076)	(0.059)
Distance to treatment boundary	0.005	−0.025	0.033	0.043	−0.047	0.129
	(0.051)	(0.079)	(0.055)	(0.121)	(0.183)	(0.143)
Distance * Treatment area	0.011	0.005	0.007	0.015	−0.007	0.014
	(0.090)	(0.139)	(0.097)	(0.211)	(0.320)	(0.249)
Constant	0.537***	0.513***	0.574***	0.016	−0.005	0.068*
	(0.014)	(0.022)	(0.016)	(0.034)	(0.051)	(0.040)
Summary statistic						
R squared	0.117	0.064	0.120	0.136	0.060	0.138
Control mean	0.536	0.515	0.556	0	0	0
Robust to specification[b]	Yes	Yes	Yes	Yes	Yes	Yes
Robust to bandwidth selection[c]	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.

*** Statistically significant at the 1 percent level.

a. OLS regressions; $N = 806$. Treatment area = 1 indicates that household is located within the intervention area (0 otherwise). Distance to treatment boundary is the minimum linear distance in kilometers from a household to the geographical intervention area boundary, calculated using GPS coordinates, centered at zero at the boundary; it is greater than 0 for households in the treatment area and less than 0 outside the treatment area. Standard errors in parentheses.

b. Robustness checks are presented in online appendix table A6. These include regressions with higher-order distance polynomials degrees two through four, controls for caregiver and household characteristics, as well as analysis on subsamples of households that reside in the same location since 2008, and the subsample of households with children born after May 2008.

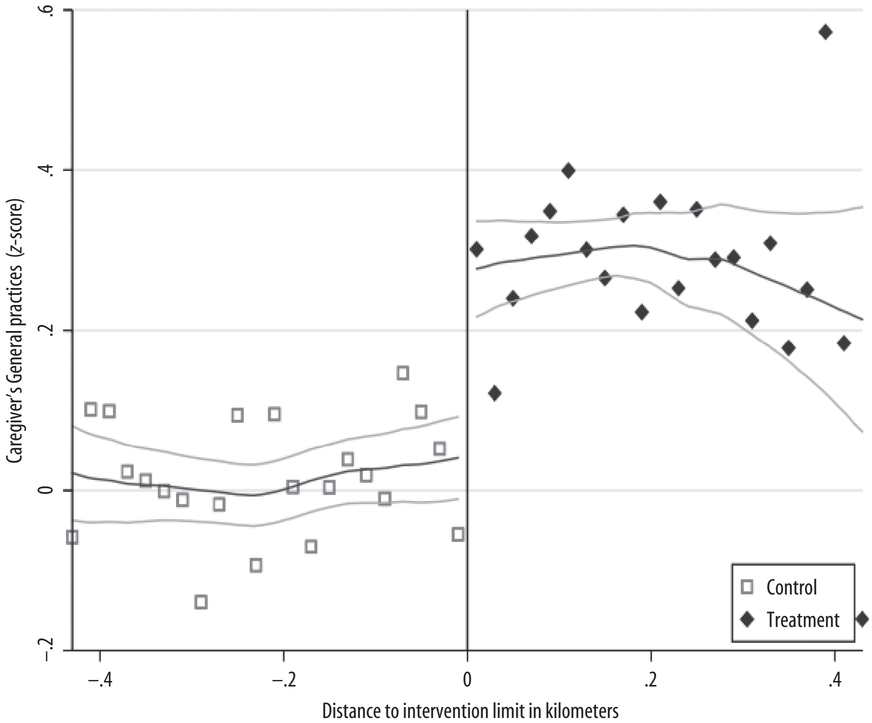
c. Results are robust to nonparametric RD estimators proposed by Fujii, Imbens, and Kalyanaraman. (2009), Imbens and Kalyanarman (2012), and Calonico, Cattaneo, and Titiunik (2014). Yes indicates that there is no statistically significant difference between treatment coefficients among specifications at the 10 percent level.

Impacts on Behavior

The CCN model aimed to improve health and nutritional outcomes in children by provoking changes in caregiver behavior with regard to nutritional and health practices. We measure self-reported nutrition- and health-related practices in the key areas motivated by the project, including exclusive and complementary breastfeeding, nutritional supplementation, domestic hygiene, and utilization of health services. The construction of behavior indexes follows the same procedure described earlier and used for knowledge. Behavior-related indexes are aggregated for all behavior questions (global index) and separately by nutrition and health subindexes. The detailed list of index components is presented in appendix table A3.

Results are presented in table 5, with a graphical representation in figure 6. As with knowledge, we observe that the CCN project significantly increases reported health and nutritional practices. The global practice index increases

FIGURE 6. Scatterplot of Caregiver's Global Practice Score on Nutrition and Health[a]



a. Scatterplot of global practice *z* scores. The program's geographical boundary is centered at zero. Each bin represents the mean value of 2 percent of observations. The control group (squares) is to the left of zero and treatment group (diamonds) to the right of zero.

by 0.273σ, while separate nutrition and health practices increase by 0.292σ and 0.268σ, respectively. These results suggest that the intervention was effective at altering caregivers' nutritional and health practices in general. However, the index does not explicitly analyze some other desired health practices, such as the caregivers' application of oral rehydration therapy in the case of diarrhea. In other specific practice areas, the captured improvements might not be large enough to achieve recommended doses, for example of micronutrients or nutrient supplementation. Furthermore, since the magnitude of the change in behavior is slightly smaller than the change in knowledge, the results suggest that knowledge acquisition may transfer only partially into behavioral change. As with previous results, estimated behavioral impacts are robust to bandwidth, confidence intervals, and specification, and they are largely stable in terms of magnitude and significance levels independent of the regression model or analysis subsample (appendix table A6).[28]

Impacts on Nutritional Outcomes

As discussed above, the intervention's theory of change sought to improve the caregiver's knowledge and behavior regarding child health and feeding practices, with the objective of improving children's physical development and reducing the risk of stunting and wasting. As such, the ultimate goal of the project was to improve children's health and nutritional status. To evaluate final impacts, we analyze anthropometric outcomes for all children under forty-eight months of age in the household.

We find no significant effects of the project on height, measured as the probability of stunting or the continuous height-for-age *z* score. A simple comparison of means in the treatment and control groups in table 6 shows that, on average, 23 percent of children in the treatment group are stunted compared with 24 percent of children in the control group. Furthermore, the average height-for-age *z* score is -1.25σ in the treatment group and -1.21σ in the control, also not statistically different. Table 7 shows regression results for equation 1 on anthropometric outcomes. There are no significant differences in the probability of stunting (model 1) or height-for-age *z* score (model 2) at the geographical limit. The results are robust to specification and bandwidth selection (appendix table A7). The result on height is presented graphically in figure 7, illustrating the absence of differences in children's height around the geographical boundary.

In terms of children's weight on the low end of the distribution, the proportion of underweight and wasted children in the population is low, with 2 percent in the treatment group and 3 percent in the control group (table 6). As with height, the project did not alter the probability of underweight, weight-for-age *z* score, or the probability of wasting (models 3 to 5 in table 7). Again, models are robust to bandwidth, specification, and subsample selection. On the other hand, the results suggest that measures of overweight may be significantly affected by the project.[29] Table 6 shows that at a descriptive

28. Specification tests in tables A5 and A6 for health knowledge and practice indexes show that the treatment coefficient falls below the 10 percent significance threshold in some of the higher-order polynomial specifications, though the overall direction and magnitude of the coefficient is unaffected.

29. We follow World Health Organization criteria for overweight, classifying children at risk of overweight as those with a BMI-for-age *z* score of over 1σ, overweight children as those with a BMI-for-age *z* score of over 2σ, and obese children as those with a BMI-for-age *z* score

TABLE 6. Child Anthropometrics[a]

Explanatory variable	*Treatment*	*Control*	*Difference*	N^T	N^C
Height-for-age *z* score (HAZ)	−1.25	−1.21	−0.04	453	456
	(0.050)	(0.058)	(0.076)		
Stunted = 1 (HAZ < −2)	0.23	0.24	−0.01	453	456
	(0.020)	(0.020)	(0.028)		
Weight-for-age *z* score (WAZ)	−0.26	−0.45	0.19***	449	452
	(0.045)	(0.045)	(0.064)		
Underweight = 1 (WAZ < −2)	0.03	0.05	−0.02	449	452
	(0.008)	(0.010)	(0.013)		
Weight-for-height *z* score (WHZ)	0.54	0.25	0.29***	450	451
	(0.052)	(0.051)	(0.072)		
Wasted = 1 (WHZ < −2)	0.02	0.03	−0.01	450	451
	(0.006)	(0.008)	(0.010)		
Body mass index z score (BMI *z* score)	0.72	0.42	0.30***	450	451
	(0.053)	(0.054)	(0.075)		
At risk for overweight = 1 (BMI *z* score > 1)	0.41	0.31	0.10***	450	451
	(0.023)	(0.022)	(0.032)		
Overweight = 1 (BMI *z* score > 2)	0.11	0.05	0.06***	450	451
	(0.015)	(0.010)	(0.018)		
Obese = 1 (BMI *z* score > 3)	0.01	0.00	0.01	450	451
	(0.005)	(0.003)	(0.006)		

*** Statistically significant at the 1 percent level.

a. Table reports mean or proportion. N^T and N^C are the number of observations in the treatment and control groups, respectively. Standard errors are in parentheses.

level, the average BMI *z* score in the treatment group is 0.72σ, significantly higher than the *z* score of 0.42σ in the control group. Thus, 41 percent of children in the treatment group are at risk for overweight, defined as a BMI-for-age *z* score of over 1σ, versus 31 percent in the control group, while 11 percent of children are classified as overweight (BMI z score of over 2σ) in the treatment group, versus just 5 percent in the control. The prevalence of

of over 3σ (WHO Child Growth Standards: 30 www.who.int/childgrowth/en/ (accessed August 2015). It is worthwhile to reflect on potential interpretation caveats of descriptive measures of "overweight" or "obesity." Considering that average height and weight patterns of Bolivian children might deviate from international WHO reference populations, increases in overweight prevalence based on WHO standards for BMI measures, as used in this study to define overweight and obesity thresholds, could be attributed perhaps not entirely "to excess bodyweight per se, but could be confounded by low[er] height for age" in the studied population, depending on its respective deviation in weight and height from the reference population (Lobstein and others, 2015, p. 2,513). This would be particularly relevant for descriptive indicators of BMI and weight-for-height that are based on height and weight data combined and interrelated within the same index. In the case of this study, which contrasts BMI in a treatment and control population controlling for potential confounders, it is nevertheless clear that the intervention of interest likely caused weight gains at the upper end of the weight distribution.

TABLE 7. Child Anthropometrics and Nutritional Status[a]

Explanatory variable	*Stunted = 1* (1)	*Height-for-age z score* (2)	*Underweight = 1* (3)	*Weight-for-age z score* (4)	*Wasted = 1* (5)	*Weight-for-height z score* (6)	*BMI z score* (7)	*Overweight = 1 (zbmi > 2)* (8)	*Obese = 1 (zbmi > 3)* (9)
Treatment area = 1	−0.019	−0.061	0.011	0.198	0.005	0.329**	0.355**	0.125***	0.015
	(0.058)	(0.154)	(0.026)	(0.128)	(0.021)	(0.146)	(0.153)	(0.037)	(0.012)
Distance to treatment boundary	0.115	−0.276	−0.101	0.105	−0.111**	0.269	0.293	−0.091	−0.031
	(0.139)	(0.369)	(0.062)	(0.309)	(0.051)	(0.352)	(0.367)	(0.090)	(0.028)
Distance * Treatment area	−0.228	0.761	0.048	−0.195	0.138	−0.777	−0.895	−0.079	0.034
	(0.240)	(0.638)	(0.107)	(0.531)	(0.088)	(0.603)	(0.630)	(0.154)	(0.049)
Constant	0.016	−1.484*	−0.014	−1.020	−0.016	−0.202	−0.148	−0.013	−0.004
	(0.301)	(0.799)	(0.134)	(0.661)	(0.110)	(0.752)	(0.786)	(0.192)	(0.061)
Summary statistic									
No. observations	909	909	901	901	901	901	901	901	901
R squared	0.098	0.134	0.090	0.162	0.090	0.153	0.148	0.112	0.142
Control mean	0.243	−1.213	0.0465	−0.449	0.0310	0.251	0.417	0.0510	0.00443
Robust to specification[b]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust to bandwidth selection[c]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.

** Statistically significant at the 5 percent level.

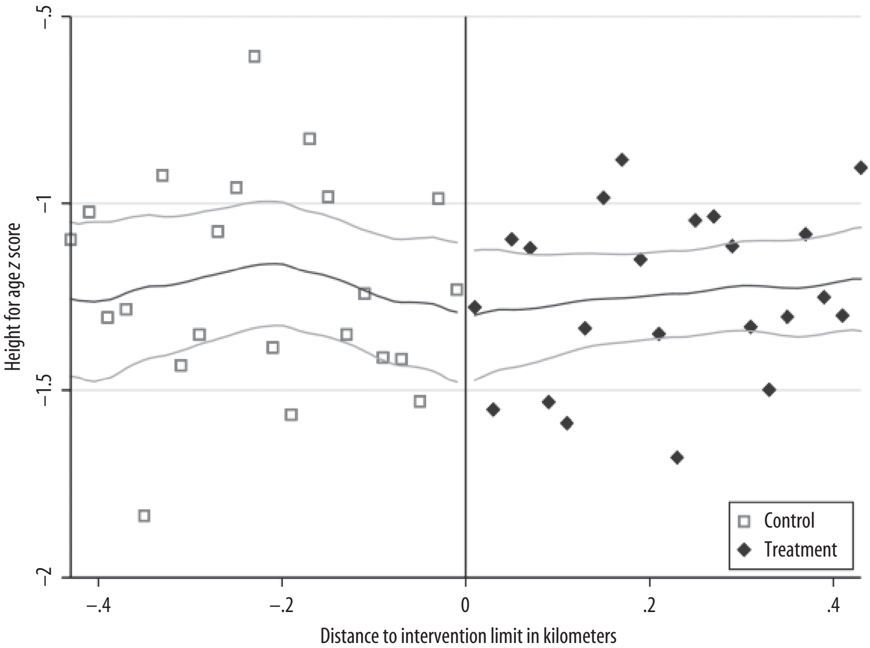
*** Statistically significant at the 1 percent level.

a. OLS regressions. Treatment area = 1 indicates that household is located within the intervention area (0 otherwise). Distance to treatment boundary is the minimum linear distance in kilometers from a household to the geographical intervention area boundary, calculated using GPS coordinates, centered at zero at the boundary; it is greater than 0 for households in the treatment area and less than 0 outside the treatment area. Standard errors in parentheses.

b. Robustness checks are presented in online appendix table A7. These include regressions with higher-order distance polynomials degrees two through four, controls for caregiver and household characteristics, as well as analysis on subsamples of households that reside in the same location since 2008, and the subsample of households with children born after May 2008.

c. Results are robust to nonparametric RD estimators proposed by Fujii, Imbens, and Kalyanaraman. (2009), Imbens and Kalyanarman (2012), and Calonico, Cattaneo, and Titiunik (2014). Yes indicates that there is no statistically significant difference between treatment coefficients among specifications at the 10 percent level.

FIGURE 7. Scatterplot of Children's Height-for-Age *z* Score[a]



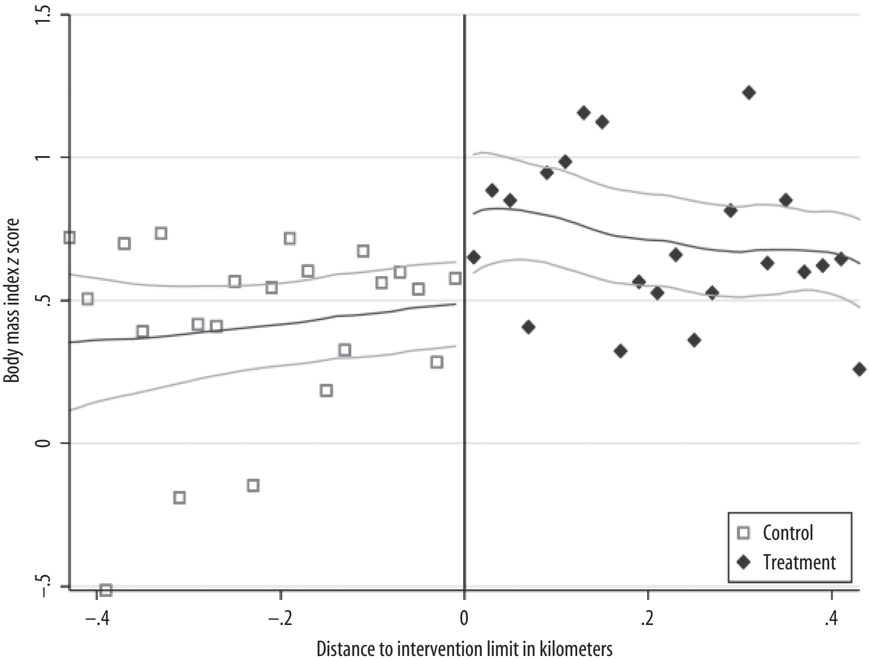
a. Scatterplot of height-for-age *z* scores. The program's geographical boundary is centered at zero. Each bin represents the mean value of 2 percent of observations. The control group (squares) is to the left of zero and treatment group (diamonds) to the right of zero.

obesity (BMI *z* score of over 3σ) in the study population is very low, at just over 1 percent in the treatment group and 0 percent in the control.

Regression results on weight are presented in table 7. The project increases the weight–for-height *z* score of beneficiary children by 0.329σ (model 6) and BMI *z* score by 0.355σ (model 7). This translates into significant effects on the probability of overweight (BMI *z* score of over 2σ) of 12.5 percentage points (model 8).[30] With a prevalence of overweight of 5.1 percent in the control population, this effect represents a relative increase of 245 percent in the prevalence of overweight for the treatment population. Finally, as discussed above, the prevalence of obesity (BMI *z* score of over 3σ) is very low, and we find a small and insignificant effect of the project (model 9). Results on weight

30. The analysis of risk for overweight (BMI z score of over 1σ) reveals a similar impact of 12.8 percentage points (not shown in the table).

FIGURE 8. Scatterplot of Children's Body Mass Index *z* Score[a]



a. Scatterplot of body mass index *z* scores. The program's geographical boundary is centered at zero. Each bin represents the mean value of 2 percent of observations. The control group (squares) is to the left of zero and treatment group (diamonds) to the right of zero.

are illustrated graphically in figure 8, which shows a discontinuous upward shift in the mean BMI *z* score of children in the treatment area. Unlike previous outcome indicators, the impacts on weight-related outcomes are more sensitive to specification tests. We find consistent and significant effects for some bandwidth and subsample robustness checks, but lose significance in many of the higher-order polynomial specifications (see appendix table A7, models 6–9).

Taken together, the analysis of anthropometric outcomes suggests that the CCN intervention did not affect children's height, the prevalence of stunting, or underweight, and in fact it may have put children at risk for increased weight gains, concentrated primarily in the range of 2σ to 3σ in BMI *z* score (using the standard threshold for overweight and obesity, respectively). Given limited sample sizes and the measurement error inherent in height and weight measurements, the results on weight are sensitive to some specification tests.

We therefore interpret the results as highly suggestive, though not definitive, evidence that the project caused undesired weight gains in the beneficiary population.

Conclusions

We study the effects of a community child nutrition project in the city of El Alto, Bolivia, which provided caregivers of children under two years old with health and nutrition counseling and growth monitoring through home visits and community meetings. Project eligibility was limited to households residing within a strictly defined geographical area, allowing us to exploit the resulting geographical discontinuity to identify project impacts. There is little evidence of project spillovers or contamination at the boundary, with over 90 percent treatment compliance in intervention areas and less than 4 percent participation in control areas, using our most conservative approximation of treatment exposure (one home visit in the past three years, whether provided by the project or other entities).

Approximately three years after the project was initiated, we find that caregivers in the intervention area show substantial gains in intended health and nutrition knowledge and practices relative to their peers in the control area just outside the project's geographical boundary. We find no detectable impacts on children's height-related outcomes, including height-for-age *z* score and the probability of stunting. Similarly, we find no effects on the probability of underweight children. However, we do find evidence of significant increases in weight for children in the treatment group, with an average increase of 0.355 standard deviations in the BMI-for-age *z* score. Children in the treatment area are 12.5 percentage points more likely to be classified as overweight.

Based on the high coverage levels of the CCN project and its substantial impacts on caregivers' knowledge and practices, the intervention model appears to be a promising vehicle for promoting behavioral change. However, caregivers may have inadvertently been led to implement recommended feeding practices related to the addition of desired nutrients without at the same time emphasizing the reduction of undesired ones and dietary diversification. Furthermore, through frequent anthropometric monitoring that highlights short-term weight changes relative to longer-term height gains, the growth monitoring component of the project may have rewarded and encouraged quick "success" in weight gain, interpreted as healthy growth. In contexts such as El Alto, with coexisting risks for stunting and overweight within the same population of children, our results suggest the need for focusing counseling messages not only on diet composition and feeding practices to promote healthy growth, but also on explicit food replacement, where necessary, and health and lifestyle practices that limit excess weight gain.

Based on these evaluation results, the project corrected and improved its design by implementing the following changes: eliminating growth and weight monitoring activities from the home visit protocol and instead training the local health center staff on how to correctly measure weight and height during routine health center visits by families; introducing explicit educational messages on dietary diversity and replacement of junk food; and implementing innovative pedagogic methods to increase the percentage of the acquired knowledge that is transformed into behavioral change and action.

Large swaths of populations in lower- and middle-income countries are experiencing demographic and economic trends similar to those in El Alto, Bolivia, including increasing urbanization, declining poverty, and widespread availability of cheap but high-energy and low-nutrient food options, such as edible oils and sugary beverages. The results presented in this study suggest that nutrition promotion interventions that focus on feeding practices and promote short-term weight gain could contribute, albeit unintentionally, to higher rates of overweight and obese children, with potentially detrimental long-term health and economic consequences. In contexts such as El Alto, the content of nutrition promotion interventions must be carefully designed and monitored to achieve the core objectives of reduced stunting (and wasting when present), while at the same time preventing overweight and obesity, especially in populations where both malnutrition challenges coexist.

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