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Costs, Cost-Sharing, and Cost Drivers of a Home Visiting Program

The Case of PADIN in Brazil

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Abstract

Home visiting programs have demonstrated potential for tackling early deficits in children's cognitive, language, motor, and social-emotional skills, but little is known about their costs or how much the costs may vary across contexts. Using an ingredients-based approach for measuring all components of a program's costs, this study employs administrative data, survey data, GIS data, and interviews to estimate the costs for a state-run home visiting program implemented in municipalities in Ceará, Brazil—the *Programa de Apoio ao Desenvolvimento Infantil* (PADIN, or *Child Development Support Program* in English). Estimates suggest that the annual cost per child of the PADIN program was BRL 1,597 (USD 438) for 10 months of implementation in 2018. The top three cost elements are compensation for the home visitors (27 percent of total costs), compensation for state-level personnel providing technical assistance and supervision (23 percent), and compensation for municipal-level supervision (14 percent). The assembled cost data also suggest that municipalities make significant financial contributions to the program, bearing on average 38 percent of the costs of implementation. Finally, the cost data gathered for this analysis illuminate deficiencies in the current administrative data used to monitor program implementation and the need for more careful and more deliberate tracking of spending. An analysis based solely on financial records of the program would have overestimated total costs by 27 percent but also completely missed costs for key resources such as the cost of municipal-level supervisory personnel borne by the municipalities. These discrepancies underscore the importance of using the ingredient-based method to capture actual resource use.

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Costs, Cost-Sharing, and Cost Drivers of a Home Visiting Program: The Case of PADIN in Brazil

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I. Introduction

Investments that occur during children's early years are critical for determining their entire trajectory of human capital accumulation, including their education, physical and mental health, and earnings as adults (Almond and Currie, 2011; Bailey et al, 2021; Gertler et al, 2014; and Walker et al, 2022). Likewise, early deficits in child development tend to persist or even amplify as children age and enter school (Hamadani et al, 2014 and Schady et al, 2015). In a number of small-scale trials across multiple countries, home visiting programs have demonstrated potential for tackling early deficits in children's cognitive, language, motor, and social-emotional skills (Jensen et al, 2021; Jeong et al, 2021; and Jervis et al, 2023).

Little is known, however, about the costs of these programs in which trained staff make frequent door-to-door visits to counsel parents of young children and demonstrate how they can incorporate cognitive and social-emotional stimulation activities for children into their daily routines and reduce the use of harsh methods for discipline. Studies that report costs rarely document their estimation methods or data sources, and estimates suggest a wide range, with weekly home visiting programs costing from USD 12 per child per month in India (Grantham-McGregor et al., 2020) to approximately USD 160 per child per month in Rwanda (Desmond, 2019).

This study estimates the costs for a state-run home visiting program in Ceará, Brazil – the *Programa de Apoio ao Desenvolvimento Infantil* (PADIN, or *Child Development Support Program* in English) – implemented by the state's Department of Education. Obtaining accurate cost estimates for a decentralized program like PADIN in which the state designs a program and provides fixed per-capita funding for municipalities to implement is particularly challenging, as cost data collection must occur at both the central and decentralized levels. Using an ingredients-based approach for measuring all components of a program's costs (Levin et.al, 2018), we use administrative data, survey data, GIS data, and interviews to estimate total annual costs per child, the degree of cost sharing between the state government and municipal governments, and breakdowns by expenditure category. The ingredients-based approach requires us to capture all the quantities and prices for each input or resources used to implement the program, in contrast to approaches that start with budgets that are aggregated by very general categories (such as personnel or equipment) and that may not reflect actual expenditures. Other studies have found substantial differences between this kind of "micro-costing" approach and those that solely rely on aggregated administrative records or reference-based pricing (Frapier et al, 2015; Chorozoglou et al, 2023).

We also document the extent of heterogeneity in cost, cost sharing, and determinants of cost observed across municipalities implementing the program. If implementing jurisdictions must spend a

significant amount of their own funds on state programs and if this cost-sharing is not made explicit from the onset, then program sustainability can be jeopardized if municipalities cannot consistently raise sufficient funds to implement the program. Moreover, though per-capita state funding for PADIN is equal across municipalities by design, if municipalities can top-up spending, then the program itself can widen pre-existing inequalities across municipalities to the extent that municipalities that spend more on the program also spend more on other investments in young children.

We estimate that the annual cost per child of the biweekly PADIN program, when implemented for 10 months of the year, is BRL 1,597 in 2018 or USD 438. The top three cost elements are compensation for the home visitors (27 percent of total costs), compensation for state-level personnel providing technical assistance and supervision (23 percent), and compensation for municipal-level supervision (14 percent). Thus, frontline workers only accounted for less than one-third of the program, which is consistent with other costing studies that find front-line personnel to account for a third or less of costs in early childhood development programs (Gustafsson-Wright, Boggild-Jones, and Gardiner, 2017).

Our results also suggest that though the program had been spearheaded by the state, municipalities make significant financial contributions to the PADIN program. On average, they bear 38 percent of the costs of implementation. There is substantial variation in this cost sharing, ranging from 22 to 52 percent of the costs of implementation across all municipalities in the sample. The data required to estimate costs also shed light on variation in implementation across municipalities. For example, different municipalities spend very different amounts on supervision, both because they purchase varying amounts of supervisors' time (ranging from 25 to 100 percent of their total time) and because they compensate supervisors differently (ranging from BRL 700 to BRL 4,575 per month, equivalent to USD 192 to USD 1,253).

Finally, we use the cost data gathered for this analysis to assess the completeness of administrative data for costing purposes and to estimate discrepancies between the costs implied from program financial records and costs estimated using the ingredients-based approach. Data from the Online Monitoring System, for example, could not be used to determine very basic information, such as the number of home visitors employed in each municipality or the number of families served. Data on these indicators were available but deviated unrealistically from program design and what was tracked by PADIN personnel and municipal offices. Though transportation accounted for a non-trivial proportion of total costs (10%), little current administrative source of data could be used to estimate the transportation costs of the home visiting program, as records tended to group them with all transportation-related costs incurred by all programs of the municipal Education Secretariats. Our data from surveys of municipal supervisors suggest that in many cases, transportation costs of the PADIN program are borne by the home

visitors themselves, as more than half of the surveyed supervisors reported that home visitors in their municipalities use their own vehicle for commutes without any additional compensation.

A comparison of our cost data and the data found in financial records underscores the value of using the ingredients-based method to capture actual resource use. When calculated based solely on financial records from both state and municipal governments, the unit cost estimate of the program would be 27 percent higher than the estimate obtained through ingredient-based methods and multiple rounds of data validation. An examination of more disaggregated costs indicates this average discrepancy masks the occurrence of both cost overestimates and cost underestimates. While financial records implied transportation costs that were 3.9 times higher, they also would have undervalued the cost of supervision and frontline workers by 40 percent.

The rest of this paper is structured as follows: The next section provides some background on the PADIN program, while Section III describes the multiple sources of data and methods used to estimate costs of the program. Section IV presents our findings on PADIN's cost structure and cost drivers and illustrates the drawbacks in relying on only one data source to estimate costs. Section V concludes.

II. The PADIN home visiting program

Started and led by the Ceará state government since 2017, the PADIN program targets rural households benefitting from the Bolsa Familia cash transfer program that have children under the age of 47 months. The program uses home visits to improve parental attachment and help below-poverty line families create a home environment that fosters language, cognitive, and social emotional skills, as well as healthy physical development. College educated home visitors (known as *agentes de desenvolvimento infantil* (ADIs) or child development agents) visit families twice a month to engage with mothers and their children in early stimulation activities and to encourage parents to continue trying out these activities at home. The families are also invited to participate in community meetings, usually once a month, to reinforce messages from the home visits.

As a state initiative, PADIN is overseen by the State Secretariat for Education (SEDUC) and Centers for Regional Coordination of Education Development (CREDE). These units were responsible for designing the program and its operational framework and overseeing its implementation. The state government transfers funds with a fixed transfer per eligible family meant to cover the compensation for the home visitors and supervisors (compensation for home visitors and supervisors is labeled as "scholarships" rather than salaries). The state government also organizes training for the home visitors and provides in-kind program assets, such as the learning materials that are used by the home visitors to demonstrate play-based stimulation activities and that are left with families for their use until the next visit.

Of 184 municipalities in Ceará, 34 municipalities and 2 districts in the state capital adopted the program in 2017. In 2018, the program expanded to 48 municipalities (with each district counted as a municipality). These municipalities all fall into the highest quintile of poverty incidence in the state. Participating municipalities must identify eligible families and recruit supervisors and home visitors. They also must ensure the availability of physical spaces for community meetings and PADIN team meetings and provide technical assistance for planning program activities, monitoring, and evaluation.

III. Data and methods

We aimed to estimate costs for all 32 municipalities that had adopted PADIN in 2017 and had maintained implementation in 2018,[2] using the "ingredients method" of Levin et al. (2018) to estimate all costs associated with the PADIN program. Rather than starting with large categories of expenditure, such as personnel or travel, and matching these to budgets and expenditures, the ingredients method first involves making a list of all the activities and resources required to make a program happen (for example, training of supervisors and home visitors, transport for training, pedagogical kits for families, supervision, transportation for home visits) and then further breaking these into (i) the *quantities of inputs* that go into the activities and resources (for example, one supervisor working half time for a year) and (ii) the *prices associated with these inputs* (for example, the salaries of the supervisors). The approach aims to capture all resources needed to keep the program running regardless of who is paying. In a program like PADIN, not only would resources potentially come from the state government and participating municipalities, but communities may also bear some costs if community meetings that require effort from volunteers are built into the program.

From 2018 to 2019, we assembled multiple data sources both to draw up an exhaustive list of activities and resources and to identify the quantities and prices of each input. Because the program was implemented by both the state and individual municipal governments, there was no single source of information that would capture all activities and resources associated with the program. We had to make site visits to observe the program under implementation, interview state- and municipal-level personnel managing the program, conduct a survey among municipal officials, and obtain program monitoring data collected separately by the state PADIN team and the state-level Online Monitoring System.

[2] The 32 municipalities in our sample include Amontada, Ararendá, Barroquinha, Boa Viagem, Capistrano, Choró, Croatá, Graça, Granja, Ipueiras, Irauçuba, Itapiúna, Itarema, Itatira, Martinópole, Miraíma, Moraújo, Morrinhos, Mucambo, Novo Oriente, Pereiro, Quiterianópolis, Reriutaba, Salitre, Santana do Acaraú, Santana do Cariri, Tamboril, Tarrafas, Trairi, Tururu, Uruoca and Viçosa do Ceará. In all exhibits, we labeled municipalities with a number between 1 and 32 to protect the identity of survey respondents since there were only 1-3 respondents with specific roles per municipality. The raw data provided in the reproducibility package has also been anonymized.

Table 1 describes the cost structure of the program and indicates which ingredients we did not cost. Just from this structure alone, it is apparent that municipal governments play a large role in implementing the PADIN program and must use some of their own resources for program implementation. There also appears to be considerable leeway for municipalities to spend more on certain ingredients, such as supervisors' compensation or transportation. Community costs primarily comprise the time volunteers spend traveling to and assisting in community meetings. The opportunity cost for parents to travel to and attend these meetings is negligible, as most are held on weekends.

We did not monetize the time of some support personnel in the municipal office, transportation costs for community meetings, or the amortized costs of venues for community meetings and office spaces for PADIN team meetings. The costs of these ingredients were expected to be minimal compared to the resources we did account for, while tracking down the data to estimate costs for these ingredients would be time consuming. Support personnel indirectly include technical staff (such as the municipal secretary, IT technicians, psychologists, nurses, speech therapists, nutritionists, and pedagogy specialists), administrative personnel (such as those in human resources), and teams dedicated to specific building functions (such as receptionists, security or doorman, kitchen staff and cleaning staff). While these personnel are required for the work of the entire municipal office to run smoothly, interviews indicated that on average, such staff dedicates up to only two days per year to support the PADIN program. When these two days of costs are distributed across all children in a municipality, the cost per child would be negligible. Likewise, community meetings were meant to be a walkable distance from families' homes, resulting in minimal transportation cost for families. The transportation cost for home visitors to attend community meetings is also minimal when distributed across all families served.

Data sources

Table 2 lists each data source we used to measure program costs at the state, municipality, and community levels. In addition to collecting financial records at the state level, a local enumerator traveled to each of the 32 municipalities with a structured questionnaire to interview supervisors and other key personnel working on the PADIN program at the municipality level. During these interviews, we collected information on time-use and salaries of personnel (for example, how much time they spent on PADIN versus other social programs), compensation, training, and community meetings. Supervisors from 20 municipalities provided itemized expenditure reports on food and supplies.[3]

[3] Although all municipal expenditure reports cover the categories of office supplies and food, only 11 municipalities included items related to transportation. Since many reports cannot clarify whether the transportation costs are specific to the PADIN program or apply to the entire secretariat, we excluded these transportation costs from the main analysis. However, we used them to calculate the cost estimates that rely solely on financial records, as shown in Figure A6 in Appendix A.

When multiple data sources were available for a particular ingredient, we used the source that exhibited overall better quality. For example, the numbers of home visitors documented in the interview data from supervisors and the M&E data were consistent for all municipalities except for one, while the information recorded in the Online Monitoring System substantially and unrealistically diverged from the other sources (see Figure A1 in Appendix A). For this ingredient, we adopted the M&E record. Lacking a reliable list of all children served from the Online Monitoring System (see Figure A2 in Appendix A), we used the number of home visitors, their target caseload (10 families), and the assumption that 95 percent of households had only one age-eligible child and 5 percent had two to calculate the total number of children served. Likewise, when 2018 data on program implementation lacked coverage (for example, for neighborhood locations of participating families), we used data from 2019. We preferred actual incurred expenses and disbursements over budgeted costs and verified incurred expenses with the program's financial manager.

When data were missing for an ingredient in a particular municipality, we imputed values either using the average of all municipalities or the most comparable municipality. For example, we substituted the gross salary of the supervisor in one municipality with the gross salary reported by the supervisor in a nearby municipality because these two municipalities are similar in size and share a border. Thus, we assumed the supervisor positions in the two municipalities would have comparable job responsibilities and compensation. Because nearly all municipalities indicated in the survey that they incurred costs for office supplies and food, when 12 municipalities did not provide their monthly expenditure reports, we assigned them the average monthly per child costs of office supplies and food calculated for the 20 municipalities that did provide itemized data.

State-level costs. For all state-level costs, we primarily relied on financial records of the PADIN program and evenly distributed costs across all children participating in the program in the state. Interviews with state-level program personnel and supervisors were used to address any outliers or discrepancies across state-level records.

Municipal-level personnel. To estimate personnel costs at the municipal level, we relied on the supervisor survey implemented in all 32 sample municipalities. To determine supervision costs for the PADIN program, we used the reported percentage of supervisor time dedicated to the program and valued it using supervisors' self-reported gross monthly salary. Four municipalities also reported providing

additional compensation for home visitors to supplement the monthly payment of BRL 420 (equivalent to USD 115) from the state.[4]

Transportation. Transportation spending as self-reported by the supervisors at the municipalities, however, is unlikely to accurately reflect the true transportation costs of the program. Interviews with supervisors suggested that in more than half of all municipalities, home visitors arranged their own transportation to the homes of participating families and received no compensation for travel expenses; in a quarter of municipalities, they arranged their own transportation and received cash compensation.[5] Less than 10 percent of supervisors reported that home visitors used municipality-owned vehicles. When household neighborhoods are plotted on a map, however, there are municipalities that do not provide travel assistance or compensation even when families are situated well beyond walking distance from the municipal office. To address this problem, we also estimated transportation costs to provide a more accurate account of what resources are needed for implementation, as it may not be realistic in the medium- to long-run to rely on home visitors to pay for work-related travel.

To compensate for limited records related to transportation use by the home visitors, we mapped neighborhoods of participating households and used GIS software to estimate the travel time and road distance between these neighborhoods and the municipal office, under the assumptions that the municipal administrative building that hosted the local PADIN office was the starting point for any trip to a neighborhood and that a home visitor could visit up to four families within the same neighborhood on a single trip (see Appendix B for more details). When the distance between the municipal office and the neighborhood was less than 2 kilometers, we assumed home visitors could walk and not incur any transportation costs, while we assumed motorbikes could be used for distances between 2 and 10 kilometers and shared cars for distances exceeding 10 kilometers.

Training. Training costs incurred by the municipalities include compensation for supervisors' accommodation and per diems for home visitors to attend sessions that were organized outside their municipality. We relied on the supervisor survey to determine the extent to which supervisors and home visitors were compensated for any costs incurred during training.[6] Because training does not fully depreciate each year but personnel do leave the program, we had to make some assumptions to estimate

[4] Four municipalities provided additional compensation for home visitors, with this supplement ranging from BRL 98 (equivalent to USD 27) to BRL 532 (equivalent to USD 146) per month.
[5] Cash compensation for home visitors' travel ranged from BRL 23 (equivalent to USD 6) to BRL 317 (equivalent to USD 87) per month.
[6] Among all 32 municipalities surveyed, 17 reported providing accommodation compensation for supervisors and 6 reported offering per diems for home visitors when they traveled to another municipality or city to participate in initial and ongoing training sessions.

annual training costs. Specifically, we spread the costs for supervisors' initial training over five years and the costs for home visitors over two years.

Food and supplies. The expenses related to office supplies and food provided for community meetings and home visits were estimated based on itemized monthly expenditure reports submitted by 20 municipalities. We aggregated the costs of items within the office supplies and food categories on a monthly basis and calculated the average across all months with available data.

Costs borne by communities. To estimate costs borne by the community, we obtained the frequency of community meetings and volunteer involvement for each municipality from the survey and assumed a duration of 3 hours for each community meeting based on our communications with the PADIN team. When a municipality reported volunteer involvement in community meetings in the survey, we used guidance from PADIN staff to infer that half of the meetings in that municipality featured one volunteer who dedicated 4 hours to support a single community meeting (organizing the space and preparing and distributing food). We used Brazil's minimum wage in 2019 as the opportunity cost for volunteers' time spent on community meetings.

Estimation

To make costs comparable across municipalities serving different numbers of families, we express our cost estimates as monthly unit costs – specifically, as the cost per child per month. We primarily report the monthly cost per child since home visiting programs do not always operate throughout the entire year, and the duration can vary from one program to another. For state-level spending, we evenly distribute costs across all 5,303 children served by the 48 municipalities implementing PADIN in 2018. When a resource was meant to be used over multiple years, we divided its cost by the number of months of potential use to apportion an estimate of monthly cost. We used the 2018 official exchange rate of 3.65 between Brazilian reals and US dollars to convert the estimated costs in Brazilian reals into US dollars.

To arrive at an estimate of total monthly costs per child in a municipality *j*, we summed the monetized value of all ingredients attributed to a child, regardless whether the ingredients are funded by the state, municipality and community, using equations (1) to (4):

$$Total\ monthly\ cost\ per\ child_j = \frac{S^{yearly}}{10 \times \sum_{j=1}^{48} N_j^{child}} + \frac{M_j^{monthly}}{N_j^{child}} + \frac{C_j^{monthly}}{N_j^{child}} \quad (1)$$

where

S^{yearly} is the total yearly cost borne by the state;

$M_j^{monthly}$ is the total monthly cost borne by the municipal government in municipality j;

$C_j^{monthly}$ is the total monthly cost borne by the community in municipality j; and

N_j^{child} is the number of children served in municipality j.

Because state-level costs were measured only on an annual basis and the program runs for 10 months of the year, we divide the total yearly cost borne by the state by 10 months to obtain a monthly cost. To estimate state-level training costs, the cost of training per person per day was multiplied by the total of number of training sessions (4) and the training session duration (2 days).

$$S^{yearly} = L^s + (\sum_{j=1}^{48} N_j^{SV} \times p^{SV} \times 10) + (\sum_{j=1}^{48} N_j^{HV} \times p^{HV} \times 10) + (\sum_{i=1}^{486} p_i^{Trainee} \times 4 \times 2) + \left(\sum_{j=1}^{48} p_j^{Kit}\right) + F^s \quad (2)$$

where

L^s is the total cost of state personnel in one year;

N_j^{SV} is the number of supervisors in municipality j;

p^{SV} is the monthly compensation for supervisors paid by the state;

N_j^{HV} is the number of home visitors in municipality j;

p^{HV} is the monthly compensation for home visitors paid by the state;

$p_i^{Trainee}$ is the organizational cost of training sessions per session per day for trainee i[7];

p_j^{Kit} is the price of the pedagogical kits; and

F^s is the total cost of food provided at the training sessions.

Likewise, to calculate municipal monthly costs, the costs of inputs that are reported annually (for example, the number of training days attended) are divided by 10.

[7] In 2018, 486 trainees participated in the training, including supervisors, home visitors and staff from SEDUC and CREDE.

$$M_j^{monthly} = \left(N_j^{SV} \times W_j^{SV} \times E_j^{SV}\right) + \left(N_j^{HV} \times W_j^{HV}\right) + \frac{\left(N_j^{SV} \times T_j^{SV} \times p_j^{T_{SV}}\right)}{10} + \frac{\left(N_j^{HV} \times T_j^{HV} \times p_j^{T_{HV}}\right)}{10} + O_j^M + TS_j^M + F_j^M \quad (3)$$

where

W_j^{SV} is the monthly gross salary that supervisors received over and above the payment from the state;

E_j^{SV} is percentage of supervisors' time dedicated to the PADIN program;

W_j^{HV} is the additional compensation for home visitors from the municipality;

T_j^{SV} is the number of training days that the supervisor attended in a single year (see Appendix B);

$p_j^{T_{SV}}$ is the daily accommodation compensation for supervisors to attend out-of-town training;

T_j^{HV} is the number of training days that home visitors attended in a single year (see Appendix B);

$p_j^{T_{HV}}$ is the daily per diem for home visitors to attend out-of-town training;

O_j^M is the average monthly cost of office supplies;

TS_j^M is the monthly transportation cost for home visitors to complete the designated home visits; and

F_j^M is the monthly food cost for community meetings.

Based on guidance from PADIN team staff, if a supervisor reported the involvement of volunteers, we assumed that volunteers assisted half of the community meetings and contributed 4 hours of their time for each meeting.

$$C_j^{monthly} = \begin{cases} N_j^{CM} \times 0.5 \times 4 \times p^{min}, & Volunteer\ involvement \\ 0, & No\ volunteer\ involvement \end{cases} \quad (4)$$

where

N_j^{CM} is the number of community meetings held in a month in municipality j; and

p^{min} is the hourly minimum wage in Brazil in 2019.

IV. Results

A. Costs of the PADIN program

Using equations (1) through (4) and our estimates of their components, we estimate the annual cost per child for the PADIN program, with 10 months of implementation, to be BRL 1,597 in 2018, equivalent to USD 438. As shown in Table 3, personnel costs account for 64 percent of the total program cost. This includes home visitors for implementation (27 percent), state-level personnel for program design, training organization, supervision, and technical assistance (23 percent) and municipal-level supervision (14 percent). Transportation for home visits and food for training sessions and community meetings each contribute about 10 percent to the total cost, followed by teaching kits, supplies and training. Cost associated with volunteers' time is negligible, so we have omitted it from subsequent analyses. Table 4 shows the monthly and annual quantities and prices of the ingredients used at both the state and municipal levels.

Figure 1 presents total cost per child per month with a breakdown by funding source – the state and the municipality. State spending amounts to approximately BRL 99 per child per month (equivalent to USD 27), with 40 and 36 percent of this, respectively, going towards compensation for home visitors and remuneration for the PADIN coordination team at the State Secretariat for Education and the Regional Coordination of Education Development (see Figure A3 in Appendix A for a breakdown of state-spending by ingredient).

On average, municipalities shouldered 38 percent of the financial cost required to sustain the daily operations of the PADIN program, which is equivalent to an average of BRL 60 per child per month.[8] This proportion ranges from 22 percent to 52 percent (See Figure A4 in Appendix A) or from BRL 28 to BRL 108. We found no significant correlation between municipal spending and the municipality's GDP per capita, suggesting that wealthier municipalities do not necessarily spend more (see Figure A5 in Appendix A). Without additional information (namely, data on the variation in program effectiveness or children's developmental deficits across municipalities), it is not possible to determine whether the variation in municipal spending reflects differences in effort, efficiency, needs, or uncommitted budget. No matter the cause - despite the standardization of the provision of home visitors,

[8] Financial costs do not include community contributions. The calculation of the average municipal cost across all municipalities accounts for variations in the number of families and children served by each municipality. As a result, this number represents a weighted average of cost per child per month across all 32 municipalities, with the weights proportional to the number of children served in each respective municipality.

state support, training, and teaching kits - families and children across various municipalities experience very different levels of resource intensity in the PADIN program.

The breakdown of costs by funding source for each program ingredient (Figure 2) also demonstrates that the municipality is responsible for key elements of the program, as they are the sole or primary funder for supervision and transportation. This breakdown also makes evident that the combined cost associated with supervision and the involvement of state personnel in the program exceeds spending on frontline personnel like the home visitors.

To investigate the proximate causes underlying the differences in program cost across municipalities, we examine variation across municipalities for each ingredient separately. Figure 3 presents a "heat map" for the major ingredients of the PADIN program, restricted solely to municipal expenditure. Darker colors represent greater cost. The more color variation within an ingredient, the more variation in cost there is across municipalities. Supervision and transportation appear to drive much of the cost of the program that is borne by municipalities, which is consistent with the program's reliance on municipalities for these activities.

The data also suggest that some part of the variation in cost across municipalities stems from variation in implementation. First, in Figure 3, we see that the per-child costs of supervision and transportation vary considerably across municipalities. Second, when we break down the variation in supervision costs into two components – the amount of time that supervisors spend on the program and the gross salary that municipalities provide supervisors over and above the fixed transfer from the state – we find a sizable range across municipalities for both components (Figure 4).

According to the design of PADIN, supervisors are responsible for supervising program activities in their assigned municipalities. They hold weekly meetings with home visitors, prepare monthly and annual monitoring reports, and coordinate with other departments and partner institutions serving the same population. Beyond these duties, some supervisors also take on roles outside the PADIN program and can serve as a principal or teacher in a school or as literacy coordinator.

Figure 4 plots the percentage of time supervisors devote to the PADIN program against their gross monthly salary. While there is a cluster of municipalities in which supervisors devote all their time to the PADIN program, the data reveal a sizable range, from 25 percent of a supervisor's working hours to 100 percent.[9] There is also a large range in the gross salaries that supervisors received outside the PADIN scholarship – from BRL 700 (equivalent to USD 192) to BRL 4,575 (equivalent to USD 1,253)

[9] There is also a cluster of reported level of effort at 50 percent.

per month, as self-reported by supervisors – even though supervisors have similar qualifications across municipalities.

Other data collected to cost the program indicate variation in implementation across municipalities. For example, the design of the PADIN program calls for home visitors to visit each family twice a month. In practice, 27 municipalities adhered to this frequency, while 5 municipalities reported weekly visits, making the average family 2.3 visits per month with each visit lasting 63 minutes. The frequency of community meetings also varied: while three municipalities only organized community meetings once every six months or bi-monthly, twelve municipalities managed to hold community meetings twice per month, or even four times per month. Fifteen municipalities offered community meetings once per month following the program design, while two municipalities did not have a clear standard but had approximately 10 meetings in the previous year.

B. Data quality

For a few program ingredients, we had multiple sources of data. For example, we asked supervisors to report on compensation for the travel required for home visitors to implement the program. We also plotted the neighborhoods of participating families and municipal offices on a map and used fuel costs, amortized vehicle costs, travel distances, and commute times (See Appendix B) to estimate the costs associated with visiting households, assuming that home visitors would visit up to four households in a neighborhood on the same workday.

Figure 5 demonstrates the importance of interrogating program reported costs with other sources of data. For almost all municipalities, there is a discrepancy between transportation costs estimated from the supervisor survey and transportation costs measured using GIS data and the prices of fuel and vehicles. In all but four municipalities, the self-reported costs are far below the costs estimated using the ingredients method to break costs into their constituent quantities (distance and travel times) and prices. The average discrepancy is BRL 14 (equivalent to USD 4) per child per month and ranges from BRL 0.13 to BRL 42 (equivalent to USD 12). Thus, relying solely on self-reported data from program personnel would lead to underestimates of the transportation costs associated with the program. These discrepancies also provide a measure of the extent to which home visitors themselves incur costs stemming from program implementation.

Similarly, other data required to estimate costs, such as the number of home visitors and children served in each municipality, were collected from three different sources (supervisor survey, M&E reports of the program, and the Online Monitoring System). Figures A1 and A2 in Appendix A present discrepancies among the data sources and suggest that records from the Online Monitoring System do not

accurately reflect program implementation. Because these records tend to inflate the number of home visitors per municipality and undercount the number of children served, relying on these records for this basic information could lead to substantial overestimates of the cost of the PADIN program.

Our analysis also underscores the importance of using an ingredient-based method to accurately capture the actual utilization of resources. If we rely on the financial records collected from both state and municipal governments, the cost per child per month would be BRL 203 (equivalent to USD 56) (see Figure A6 in Appendix A). This is 27% higher than our estimate, which was derived from the ingredients-based method and multiple rounds of data validation. At the state level, the costs of scholarships for supervisors and home visitors were lower in financial records than our estimates, whereas the costs for teaching kits were higher. These two discrepancies nearly balance each other out. At the municipal level, additional compensation for supervisors and home visitors was not recorded. The transportation cost estimated from the municipal itemized expenditure reports is almost five times our estimated transportation cost. This discrepancy arises because many municipalities included the expenses for vehicle rental, maintenance, and fuel for the entire secretariat, rather than solely for the implementation of the PADIN program.

V. Conclusions

This study assembled data from surveys, administrative and financial records, and spatial data to estimate costs for the PADIN home visiting program, a state-led initiative in Ceará, Brazil. Findings suggest total annual costs of BRL 1,597 in 2018 or USD 438 per child for 10 months of implementation. After adjusting for the length of the intervention, our estimate of cost per child per month (USD 44) is similar in magnitude to costs calculated for home visiting programs that provide weekly home visits for approximately 10 months or above, such as China REACH (USD 47), Reach Up and Learn in Colombia (USD 48), Reach Up and Learn in India (USD 12), Reach Up and Learn in Jamaica (USD 66), Cuna Mas in Peru (USD 27), and Reach Up in the República Bolivariana de Venezuela (USD 37) (see Appendix C). The top three cost components of PADIN include compensation for the home visitors (27 percent of total costs), compensation for state-level personnel (23 percent), and compensation for supervision (14 percent).

A breakdown of costs by funding source suggests that although PADIN is a state-level program, municipalities bear a non-trivial proportion of the costs of implementation - an average of 38 percent of total costs. The assembled cost data also suggest substantial variation both in per-child spending across municipalities and in program implementation with the highest cost municipality spending three times more than the amount per child spent by the lowest cost municipality. Thus, though the state equalizes

per-capita spending on frontline workers by paying the salaries of the home visitors and provides significant technical assistance, municipalities choose to augment or not augment this funding and thus spend very different amounts per child.

Similarly, the analysis revealed that home visitors themselves had to bear the transportation costs associated with the program in half of all municipalities. Because transportation is an essential element of program implementation, this financing arrangement may limit the pool of home visitors that can be recruited and may threaten program sustainability.

This costing exercise also revealed the limitations of relying on a single data source to cost program elements and the importance of using the ingredients method to break costs into their constituent prices and quantities. Some administrative records (data from the Online Monitoring System, for example) did not consistently report basic program elements such as the number of home visitors assigned to a municipality or the number of children served. Similarly, transportation costs reported by supervisors in a survey and documented in expenditure reports diverged substantially from costs estimated using travel distances and prices associated with fuel and vehicles. Thus, lessons for future costing exercises would be to use the ingredients-based method (or activity-based costing) and rely on multiple sources of data.

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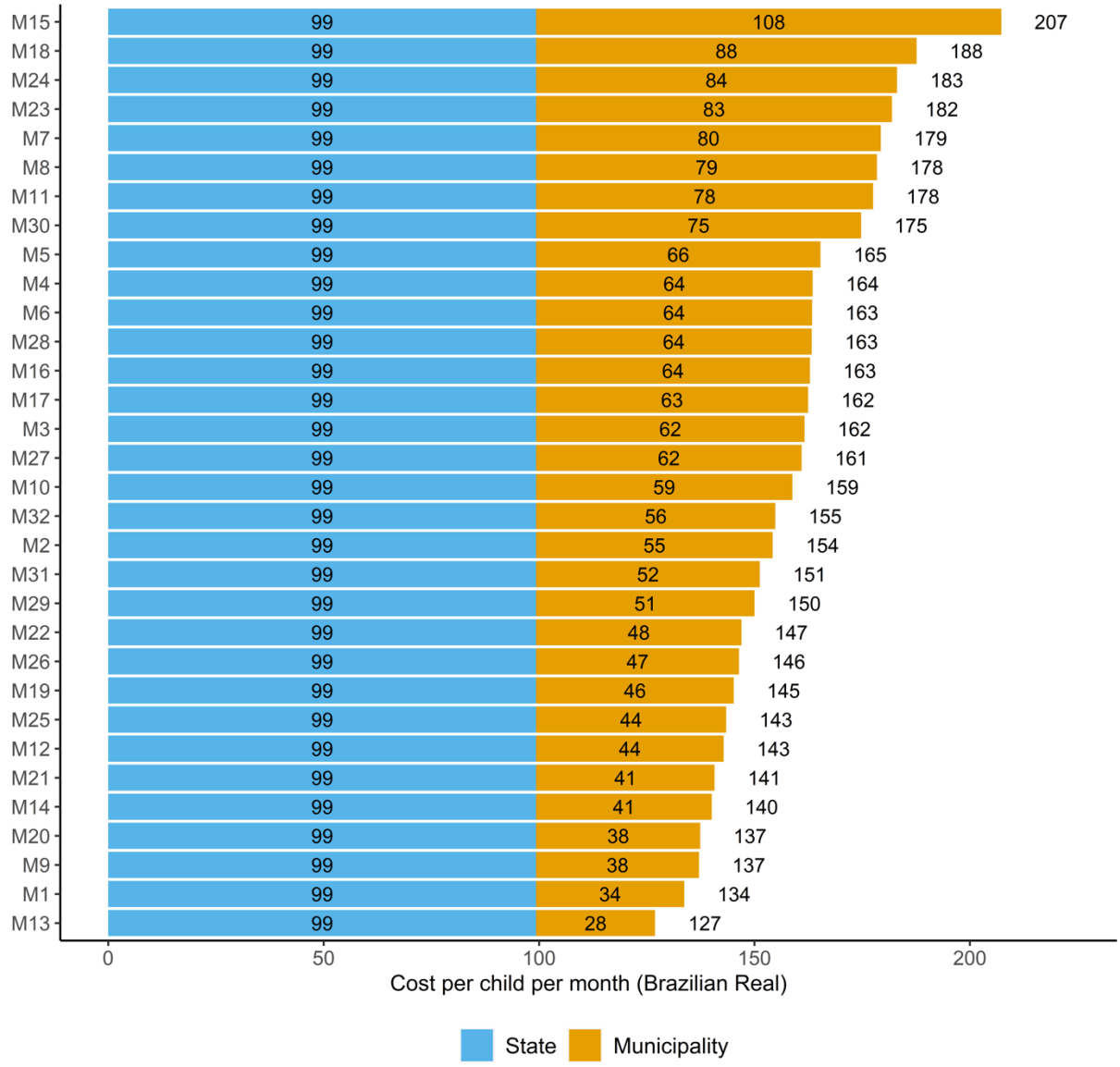
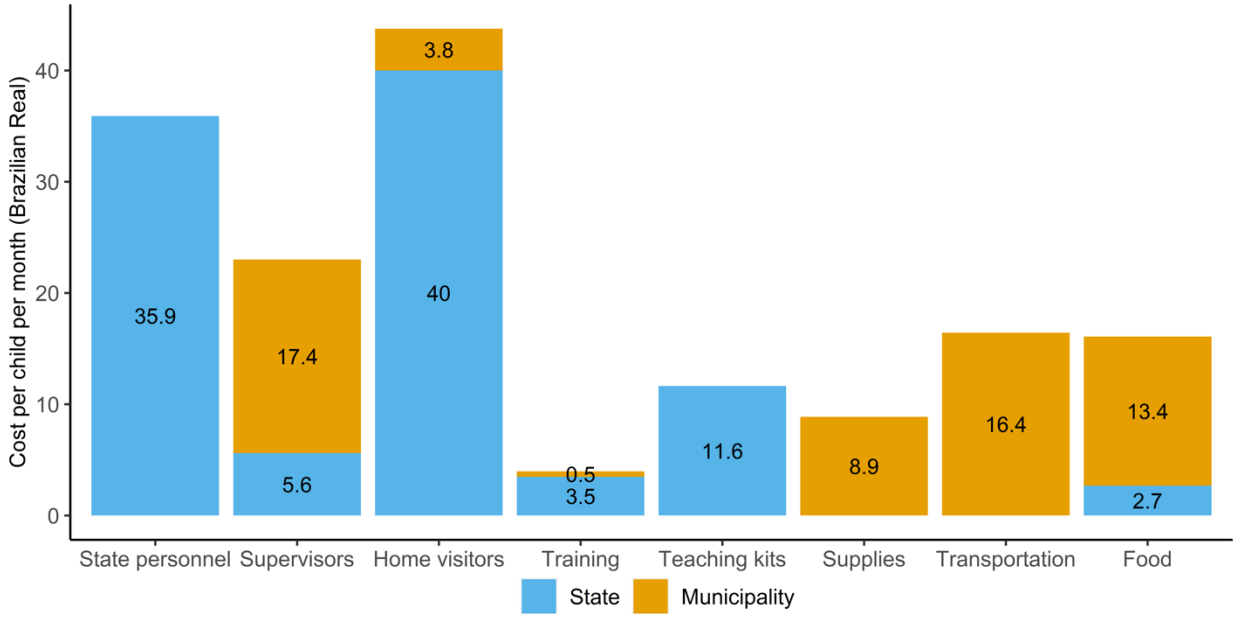
Figures

Figure 1. Cost per child per month, by funding source



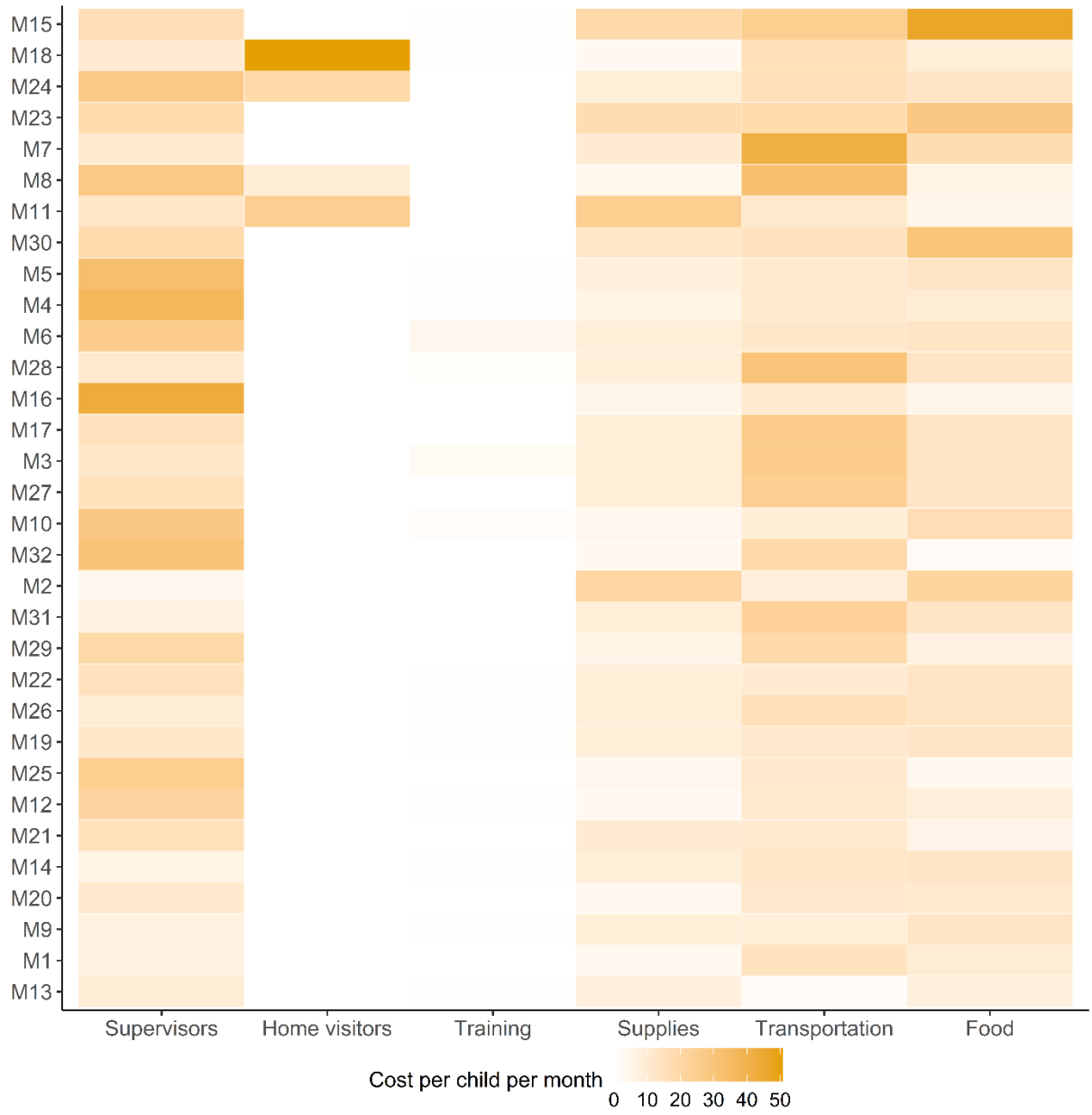
*Note*s. Cost estimates have been derived from administrative data, survey data, GIS data, and interviews, and represent the cost per child per month to provide the PADIN services in 2018. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents.

Figure 2. Cost per child per month, by ingredient and funding source



*Note*s. Cost estimates have been derived from administrative data, survey data, GIS data, and interviews, and represent the cost per child per month to provide the PADIN services in 2018. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents.

Figure 3. Decomposition of cost per child per month borne by municipalities, by ingredient

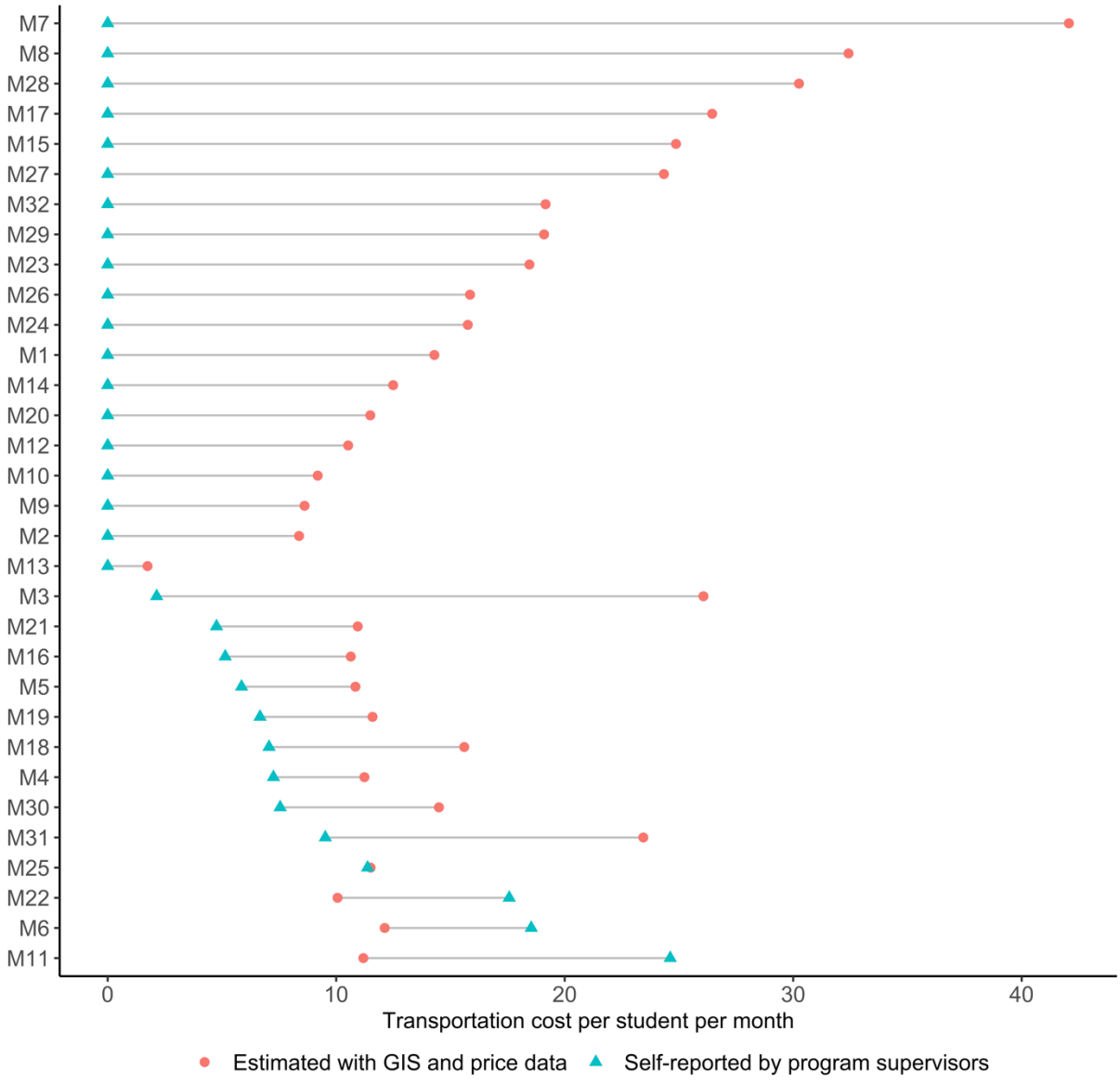


*Note*s. Cost estimates have been derived from administrative data, survey data, GIS data, and interviews, and represent the cost per child per month to provide the PADIN services in 2018. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents.

Figure 4. Supervisors' gross salary and time dedicated to the PADIN program

*Note*s. Data on supervisors' time and compensation come from a survey conducted with supervisors in sampled municipalities. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents.

Figure 5. The discrepancy between self-reported and transportation costs estimated with the ingredients method



*Note*s. The self-reported transportation cost was based on information provided by program supervisors in a survey implemented in all 32 sample municipalities. The estimated transportation cost used GIS data and data on the prices of fuel and vehicles. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents.

Tables

Table 1. The cost structure of the PADIN program, by funding agency and ingredient

	State government	Municipality government	Community
State personnel	PADIN team in SEDUC and CREDE		
Program supervisors	Scholarships for supervisors	Supervisors' time dedicated to PADIN, compensated by the municipality	
Home visitors	Scholarships for home visitors	Additional compensation for home visitors	
Municipal Secretariat of Education supporting personnel		Municipal Secretariat personnel's time dedicated to technical assistance*	
Training	Organizational cost of training sessions	Accommodation compensation for supervisors and per diem for home visitors to travel outside of the municipalities to attend training sessions	
Materials for visits	Pedagogical kits		
Supplies		Office supplies necessary for community meetings and home visits	
Transportation		For home visitors to conduct home visits; For home visitors and families to attend community meetings*	
Food	Food for training sessions	Food for community meetings, lunch for home visitors during home visits, snacks for celebratory gatherings	
Venues		Physical spaces for community meetings, PADIN team meetings and other activities*	
Volunteers' time			Volunteers' time to facilitate the organization of the community meetings

*Note*s. Items marked with an (*) were not costed.

Table 2. Data sources

	Data source	Data collection method	Year
State	1. PADIN financial spreadsheets on personnel, training, and food	Provided by SEDUC	2016 – 2018
	2. Reported training cost and information on facility use	Email exchanges with the PADIN team in SEDUC	2018 - 2019
Municipality	1. Responses to a survey that elicits information on key personnel's time use and salaries, transportation mode, frequencies of training for supervisors and home visitors, and frequency of community meetings for parents	In-person interviews among supervisors in 32 municipalities	2018
	2. Itemized monthly expenditure reports for office supplies and food	Submitted by supervisors in 20 municipalities	2018
	3. Monitoring and evaluation (M&E) data, including the number of supervisors and home visitors by municipality	Provided by SEDUC for 32 municipalities	2018
	4. The number of participating families by neighborhood, home visitor and municipality	Provided by SEDUC for 29 municipalities in 2018 and 32 in 2019	2018 - 2019
	5. Publicly available sources on the purchase cost of vehicle, unit price of fuel, fuel economy of cars and motorbikes, and the number of years vehicle last	Websites and reports on transportation in Brazil (see Appendix B for more details)	2018 - 2019
	6. Records from Online Monitoring System	Provided by SEDUC for 48 municipalities	2018
	7. Municipality statistics (area, population size, and GDP per capita by municipality)	Official website[10] of the government statistical institute IBGE	2018
Community	Records of community meetings and involvement of volunteers	Interviews with supervisors in 32 municipalities	2018
Other	Official exchange rate between Brazilian reals and US dollars (period average)	International Monetary Fund, International Financial Statistics	2018

*Note*s. SEDUC = State Secretariat for Education.

[10] https://cidades.ibge.gov.br/

Table 3. Monthly and annual cost per child by ingredient

Ingredient	Monthly cost per child		Annual cost per child		% out of total
	In BRL	In USD	In BRL	In USD	
State personnel	36	10	359	98	22%
Supervisors	23	6	230	63	14%
Home visitors	44	12	438	120	27%
Training	4	1	40	11	2%
Teaching kits	12	3	116	32	7%
Supplies	9	2	89	24	6%
Transportation	16	5	164	45	10%
Food	16	4	161	44	10%
Volunteers	0.07	0.02	0.75	0.20	0.05%
Total	160	44	1597	438	100%

*Note*s. The monthly and annual cost per child for providing PADIN services in 32 sampled municipalities in 2018 were estimated using administrative data, survey data, GIS data, and interviews among program administrators at both the state and municipality levels. Costs are reported in 2018 Brazilian reals (BRL) or 2018 USD. The 2018 official exchange rate of 3.65 between Brazilian reals and US dollars was used to convert the estimated costs in Brazilian reals into US dollars.

Table 4. Monthly and annual quantities and prices of ingredients

Panel A. State-level inputs for serving 5,135 children in 48 municipalities.

Ingredient	Quantity	Unit	Monthly cost (in BRL)			Annual cost (in BRL)		
			Price	Total	Cost per child	Price	Total	Cost per child
State personnel	24	FTE	7683	184389	36	76829	1843888	359
Supervisors	48	FTE	600	28800	6	6000	288000	56
Home visitors	489	FTE	420	205380	40	4200	2053800	400
Training	3888	Person*course*day	4.6	17885	3	46	178848	35
Teaching kits	48	Kit	1245	59754	12	12449	597536	116
Food	5135	Beneficiary	2.7	13760	3	27	137600	27
Total				509967	99		5099672	993

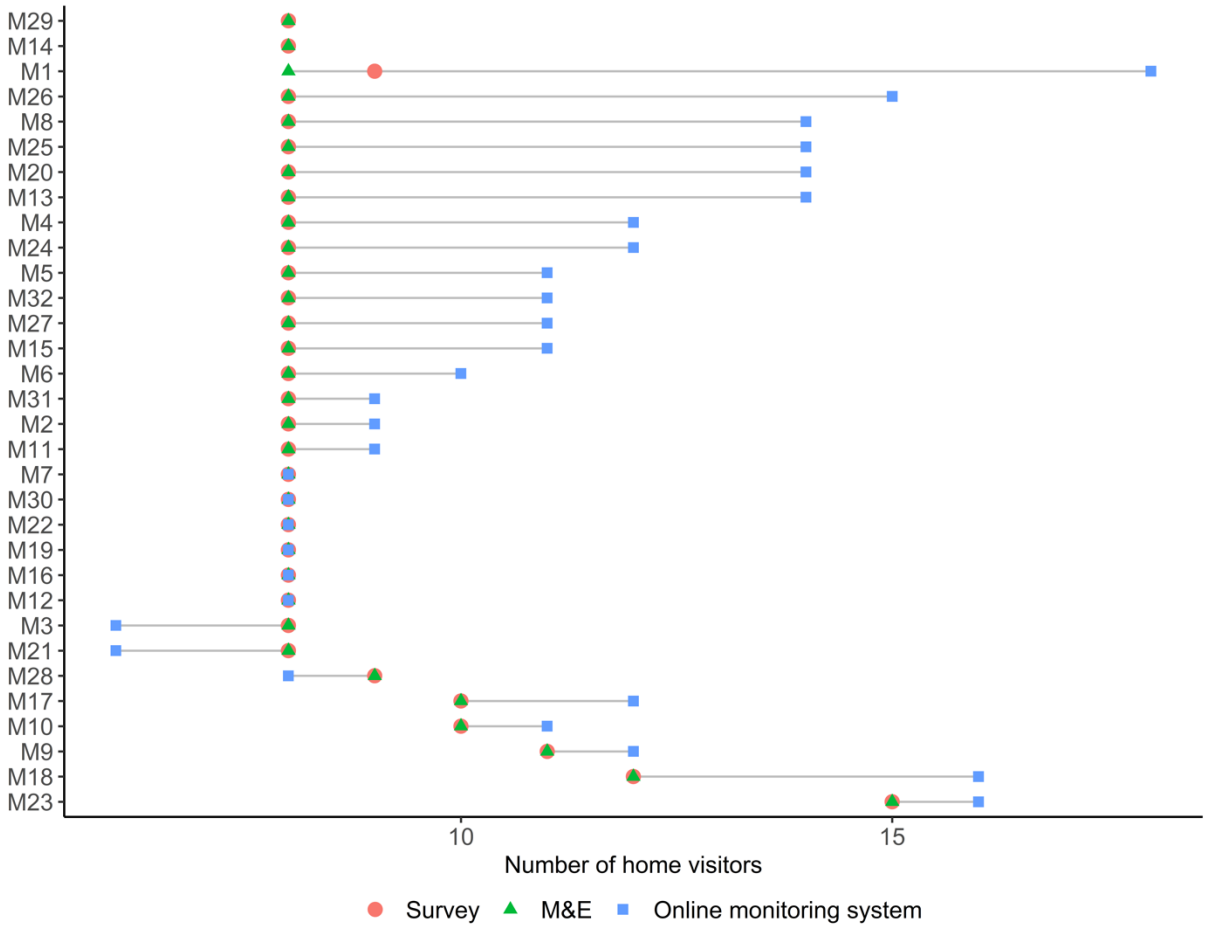
Panel B. Municipal-level inputs for serving 2,888 children in 32 sampled municipalities.

Ingredient	Quantity	Unit	Monthly cost (in BRL)			Annual cost (in BRL)		
			Price	Total	Cost per child	Price	Total	Cost per child
Supervisors	22	FTE	2285	50229	17	22852	502287	174
Home visitors	275	FTE	39	10836	4	394	108360	38
Supervisors' training	18	Day	65	1187	0.4	649	11870	4
Home visitors' training	10	Day	22	232	0.1	222	2318	1
Food	2888	Beneficiary	13	38709	13	134	387087	134
Office supplies	2888	Beneficiary	9	25609	9	89	256088	89
Motorbikes	29	Motorbike	131	3795	1	1309	37948	13
Cars	38	Car	606	23036	8	6062	230362	80
Fuel	4586	Liter	4.5	20635	7	45	206350	71
Total				174267	60		1742669	604

*Note*s. FTE = Full-Time Equivalent. The monthly and annual cost per child for providing PADIN services in 32 sampled municipalities in 2018 were estimated using administrative data, survey data, GIS data, and interviews among program administrators at both the state and municipality levels. Costs are reported in 2018 Brazilian reals (BLR).

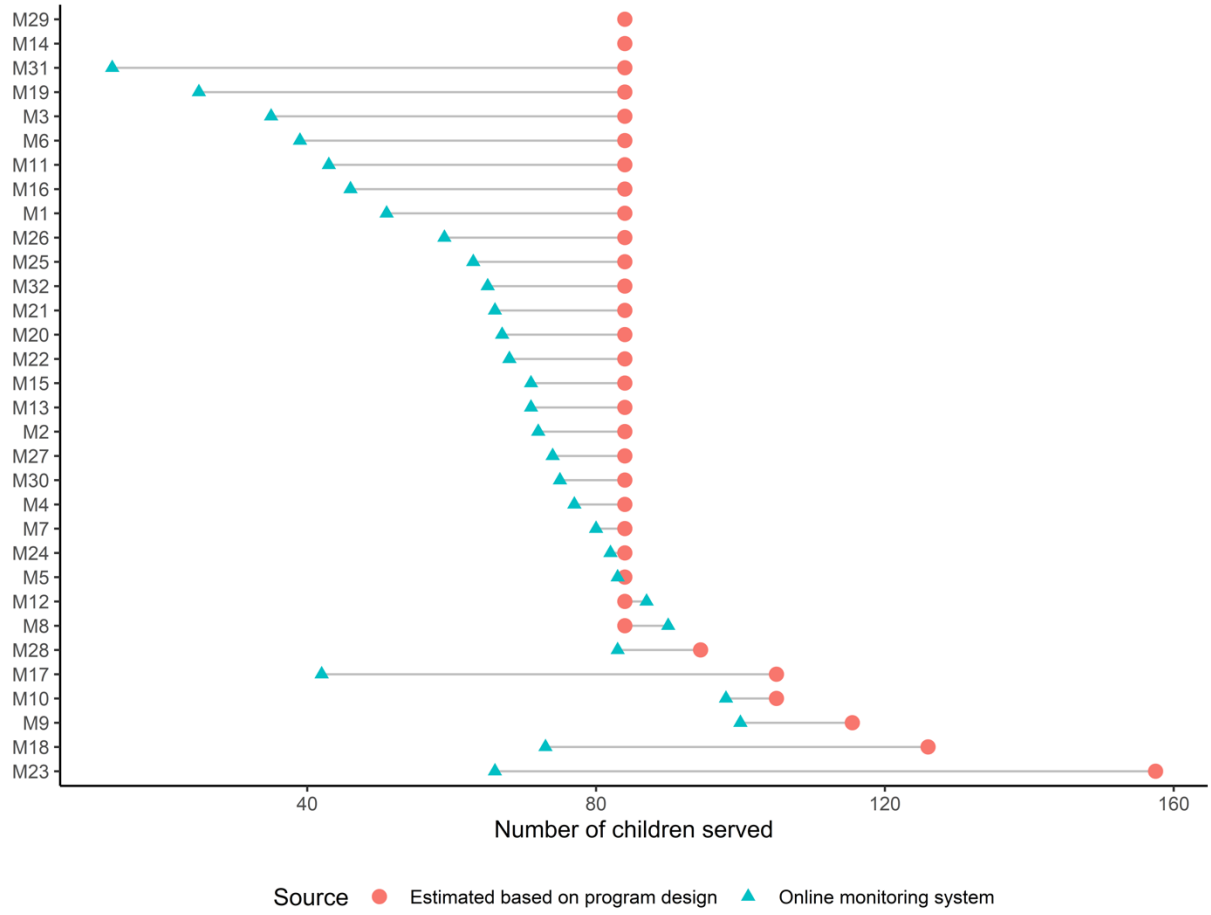
Appendix A. Additional figures

Figure A1. Number of home visitors, by data source



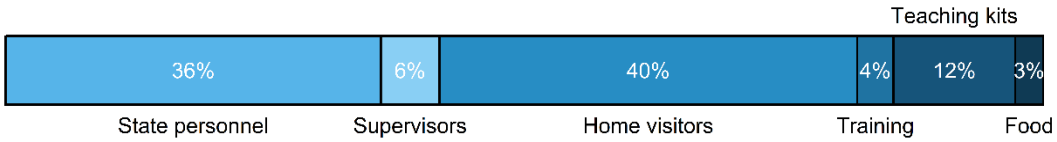
Notes. Data on the number of home visitors were retrieved from a survey conducted with program supervisors, Monitoring and Evaluation (M&E) data provided by the PADIN team in SEDUC, and the online monitoring system respectively. Information for M14 and M29was missing when data were retrieved from the Online Monitoring System in June 2023.

Figure A2. Number of children served, by data source



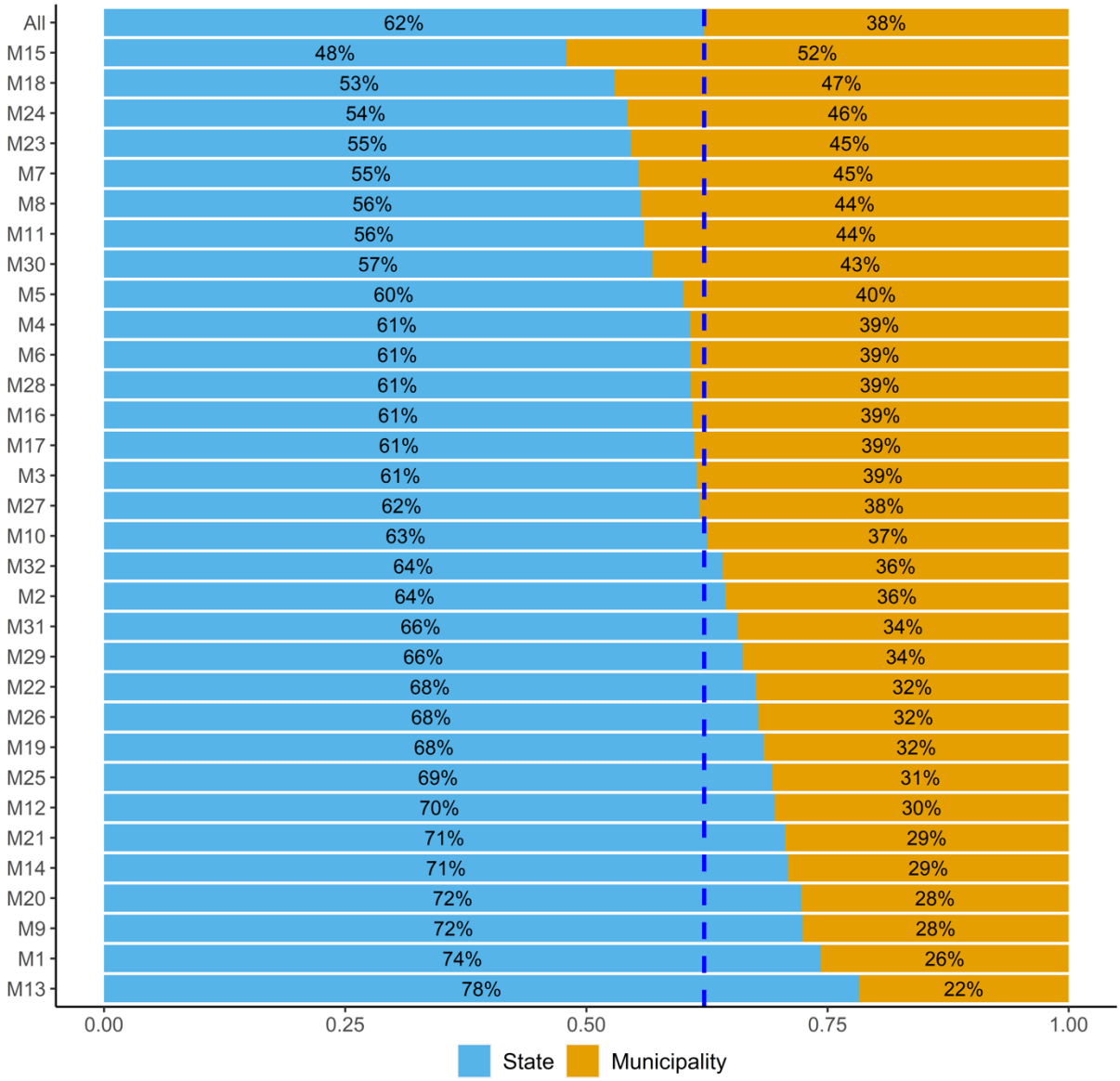
Notes. Estimates of the number of children served were based on program design. These are contrasted with the number of children served retrieved from the online monitoring system. Information for M14 and M29 was missing when data were retrieved from the Online Monitoring System in June 2023.

Figure A3. State costs of the PADIN program, by ingredient (percentage of total state costs)



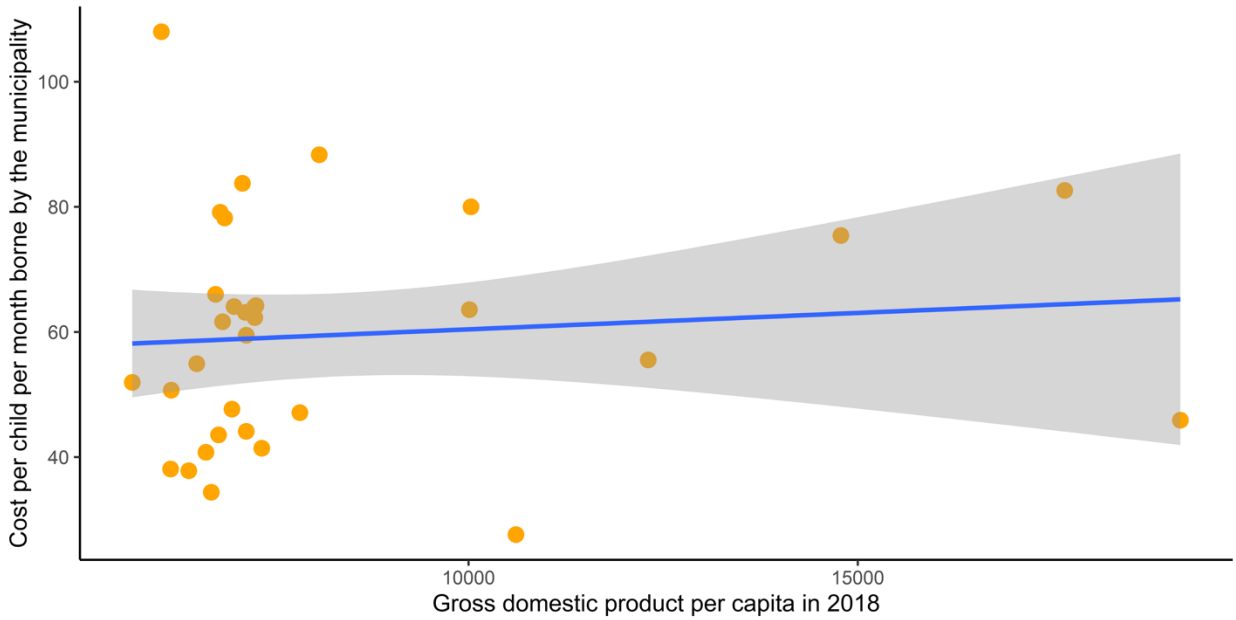
Notes. Costs borne by the state were estimated based on the PADIN financial spreadsheets provided by the PADIN team in SEDUC, as well as through email exchanges with them. The state personnel cost covers the salaries and bonuses of 24 professionals who are responsible for recruiting and training supervisors and home visitors, developing content, coordinating, and organizing training sessions.

Figure A4. Cost per child per month borne by funding source (percentage of total program costs)



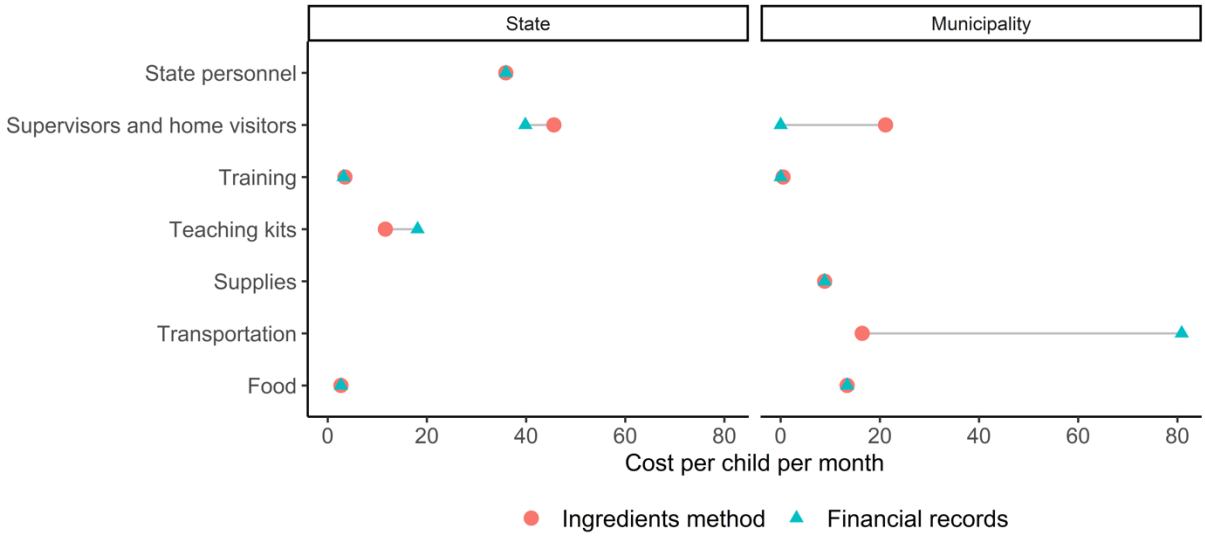
Notes. The calculation of the cost distribution by funding source used administrative data, survey data, GIS data, and interviews. The municipalities have been anonymized and labelled with a random number between 1 and 32 to protect the identity of survey respondents. The calculation of the average municipal cost across all municipalities (percentage of total costs depicted by the dashed vertical line) accounts for variation in the number of families and children served by each municipality. Thus, the average proportion of municipal costs presented as "All" represents a weighted average across all 32 municipalities, with the weights proportional to the number of children served in each municipality.

Figure A5. Correlation between Gross Domestic Product (GDP) per capita and cost per child per month borne by the municipality



Notes. Cost per child per month borne by the municipality was estimated using administrative data, survey data, GIS data, and interviews. The gross domestic product per capita by municipality was retrieved from the official website of the government statistical institute IBGE (https://cidades.ibge.gov.br/).

Figure A6. Deviation in the estimated cost per child per month (in BRL) from financial records compared to our estimate using the ingredients-based method



Notes. The cost per child per month estimated using the ingredients method used administrative data, survey data, GIS data, and interviews. Meanwhile, the cost per child per month estimated using the financial records relied on the financial records provided by the PADIN team in SEDUC and the itemized monthly expenditure reports submitted by supervisors in 20 municipalities.

Appendix B. Methodological details on training and transportation costs

1. **Training cost at the municipal level**

T_j^{SV}, the number of training days that the supervisor attended in a single year in municipality j, includes 5 days of initial training amortized over 5 years and the number of ongoing training days in one year reported by the supervisor in municipality j.

T_j^{HV}, the number of training days that home visitors attended in a single year, includes 5 days of initial training amortized over 2 years and the number of out-of-town ongoing training days attended by home visitors in one year, as reported by the supervisor in municipality j;

2. **Transportation costs**

To estimate the transportation costs associated with home visits, we gathered data on the number of households served in each neighborhood, placed neighborhoods on a geo-coded map of Brazil, and used Geographic Information System (GIS) techniques to simulate household locations within neighborhoods and estimate travel distance and travel time from these households to the corresponding municipal administrative office, the local headquarters of the PADIN program.

Mapping households and municipal offices

We geocoded the neighborhoods of families participating in the program (as destinations) and the municipality's administrative buildings (as origins). Administrative buildings for all 32 municipalities were successfully located using the Google Maps API. Out of the 821 neighborhoods listed in PADIN records, 757 were located within the correct municipality using three geocoding services: Open Street Map, Pelias, and Google Maps. We omitted from the analysis 64 neighborhood locations recorded for participating families, as these locations could not be located using any of these three services.

Because the exact locations of the households could not be shared with us for data privacy reasons, we used their neighborhood locations to impute their distance and travel time from the municipal office. To do this, we matched the destination neighborhoods to census tracts provided by the Brazilian government and randomly sampled potential locations corresponding to the number of visited households within a given neighborhood, using a built-up dataset from the Facebook High Resolution Settlement Layer. With those randomly sampled locations, we created a map of "simulated" household locations.

Estimating travel distances and times

Leveraging Mapbox Directions API, we estimated travel distance and travel time between each simulated household location and the administrative building of the municipality. Distances under 2 kilometers were designated for walking. For distances between 2 and 10 kilometers, we assumed home

visitors would travel by motorbike.[11] Beyond 10 kilometers, we assumed home visitors would employ shared cars for their commutes. To the extent that travel would not be optimally coordinated across locations and home visitors in practice, our estimates of transportation cost are conservative.

Projecting a transportation profile for each municipality

Because we lacked precise locations of households within neighborhoods, we used the simulated dataset of travel distances and travel times for each home visitor, neighborhood, and municipality to create *transportation profiles* for each municipality. This profile indicates the number of households assigned to each transportation mode, along with their average travel distance and travel time. Specifically, using the simulated dataset, we calculated the percentage of households in each municipality that could be reached via walking, motorcycling, or car sharing, and further computed the average travel distance and travel time for each transportation mode. These percentages were then multiplied by the total number of households actually served in each municipality, resulting in the number of households allocated to each transportation mode (See equation B.1).[12]

$$HH_{kj} = HH_j \times \frac{\sum_{v=1}^{V}\sum_{d=1}^{D} \widehat{HH_{dkvJ}}}{\sum_{k=1}^{3}\sum_{v=1}^{V}\sum_{d=1}^{D} \widehat{HH_{dkvJ}}} \qquad (B.1)$$

where

HH_{kj} is the number of households reached by transportation mode k in municipality j;

HH_j is the number of households served in municipality j;

$\widehat{HH_{dkvJ}}$ is the number of households in neighborhood d of municipality j visited by home visitor v using transportation mode k, as estimated from the simulated household location data; and

V and D are the upper bounds of the sequences of home visitors and neighborhoods respectively.

Estimating the average number of households visited per trip

[11] The version of Mapbox Directions API we used did not support estimating travel time and travel distance for motorbike transportation. To address this, we specified the "driving-traffic" mode within Mapbox Directions API (that is, driving with consideration for traffic conditions) for households located beyond the 2-kilometer walking radius. Because road usage and traffic conditions for both motorbikes and cars should be similar, this strategy should provide a reasonable estimate for motorbike journeys.

[12] The simulated household locations accounted for 84 percent of total households served across all 32 municipalities. In one municipality, neighborhood information was available for only 3 out of the 80 households served. Similarly, in another municipality, the simulated dataset covered only 21 percent of program households. Consequently, the transportation cost estimates for these municipalities might be less accurate compared to those municipalities that provided more comprehensive data.

To account for the potential for home visitors to cluster home visits within the same neighborhood, we used the duration of home visits reported by the supervisors (on average 63 minutes per visit) to set the maximum number of households a home visitor could visit during a typical trip to a neighborhood given that all households may not be available to meet on the same day. We set this number at 4 visits per day. Using the simulated dataset, for each neighborhood and each transportation mode, we computed the number of trips necessary for the home visitor to commute to the neighborhood to complete one cycle of home visits (See equation B.2). We rounded the division up to be conservative.

$$\widehat{TR_{dkvJ}} = \left\lceil \frac{\widehat{HH_{dkvJ}}}{4} \right\rceil \tag{B.2}$$

where

$\widehat{TR_{dkvJ}}$ is the number of trips required by home visitor v to complete one cycle of family visits in neighborhood d of municipality j using transportation mode k, as estimated from the simulated household location data.

We aggregated the number of households and trips for each home visitor across all neighborhoods that they serve during one cycle of home visits. We then summed the households and trips for all home visitors by transportation mode. By dividing these two sums, we obtained the average number of households a home visitor visits on a typical trip for each transportation mode (See equation B.3)[13].

$$\overline{HH_{kJ}} = \frac{\sum_{v=1}^{V} \sum_{d=1}^{D} \widehat{HH_{dkvJ}}}{\sum_{v=1}^{V} \sum_{d=1}^{D} \widehat{TR_{dkvJ}}} \tag{B.3}$$

where

$\overline{HH_{kJ}}$ is the average number of households visited by a home visitor on a typical trip in municipality j when using transportation mode k.

Similarly, we calculated the average travel distance per trip and the average travel time per trip for each transportation mode in a municipality (See equations B.4 and B.5).

[13] Notably, home visitors are also likely to group home visits in adjacent neighborhoods together. However, due to a lack of information about the proximity of neighborhoods and the feasibility of traveling between them within a day, we were unable to account for this scenario. Consequently, the calculated average households visited per trip might be slightly underestimated, resulting in a relatively conservative estimate of the transportation cost.

$$\overline{DIST_{kJ}} = \frac{\sum_{v=1}^{V}\sum_{d=1}^{D}\widehat{DIST_{dkvJ}}}{V \times D} \quad (B.4)$$

where

$\overline{DIST_{kJ}}$ is the average distance a home visitor travels on a typical trip in municipality j when using transportation mode k; and

$\widehat{DIST_{dkvJ}}$ is the travel distance for home visitor v to conduct a trip to neighborhood d of municipality j using transportation mode k, as estimated from the simulated household location data.

$$\overline{TIME_{kJ}} = \frac{\sum_{v=1}^{V}\sum_{d=1}^{D}\widehat{TIME_{dkvJ}}}{V \times D} \quad (B.5)$$

where

$\overline{TIME_{kJ}}$ is the average travel time a home visitor spends on a typical trip in municipality j when using transportation mode k; and

$\widehat{TIME_{dkvJ}}$ is the travel time for home visitor v to conduct a trip to neighborhood d of municipality j using transportation mode k, as estimated from the simulated household location data.

Pricing out cars, motorbikes and fuels

We proceeded to estimate the required quantity of cars and motorbikes necessary to conduct the estimated number of trips. Subsequently, we estimated the fuel cost for motorbikes and cars. After that, we derived the monthly cost from the initial purchase cost of those cars and motorbikes. The steps are described as followed.

First, with the number of households allocated to each transportation mode and the average number of households visited per trip, both of which were estimated in the preceding steps, in conjunction with the frequency of home visits reported in the survey, we were able to compute, for each transportation mode, the necessary number of trips required to fulfill the designated number of home visits to all households served (rounded up as shown in equation B.6), as well as the total travel distance covered in round trips (equation B.7) and the aggregate travel time (equation B.8).

$$TR_{kj} = \left\lceil HH_{kj}/\overline{HH_{kJ}} \times F_j^{VT} \right\rceil \quad (B.6)$$

where

TR_{kj} is the total number of trips required to complete the designated home visits to all served households in municipality j using transportation mode k; and

F_j^{VT} is the frequency of home visits per month in municipality j, as self-reported from the survey.

$$DIST_{kj} = \overline{DIST_{kj}} \times 2 \times TR_{kj} \quad (B.7)$$

where

$DIST_{kj}$ is the total travel distance covered in round trips in municipality j using transportation mode k.

$$TIME_{kj} = \overline{TIME_{kj}} \times 2 \times TR_{kj} \quad (B.8)$$

where

$TIME_{kj}$ is the total travel time spent by home visitors to fulfill all designated home visits in municipality j using transportation mode k.

Second, we estimated the cost of fuel and vehicles for each mode of transportation to account for the total travel distance and travel time. Regarding fuel cost, we converted the total travel distance into liters of gasoline required, using the fuel economy figures for cars and motorbikes in Brazil. Average fuel consumption was 7.5 liters of gasoline per 100 kilometers for cars in 2019[14], and 2.9 liters for motorcycles that are similar to a 125 c.c. Fan model in 2013/2014[15]. Subsequently, we multiplied the liters of gasoline by the price of fuel, BRL 4.5 per liter in 2019[16], to calculate the overall fuel costs for both cars and motorbikes (see Equation B.9). The fuel cost estimation for cars might be slightly conservative, as we assumed that two home visitors would share a car for a trip but we did not halve the fuel cost, allowing for coverage of the commute between the neighborhoods served by these two home visitors in some capacity.

$$COST_j^F = \sum_{k=2}^{3} \frac{DIST_{kj}}{100} \times E_k \times p^F \quad (B.9)$$

where

[14] This is the fuel economy of light-duty vehicles in Brazil for 2019, published by International Energy Agency as part of Global Fuel Economy Initiative 2021.
[15] The fuel economy of motorbikes was extracted from a study conducted in Curitiba, State of Paraná, Brazil. The State of Ceará is in the northeastern coast of Brazil, while Paraná is located in the south.
[16] According to data published by the National Agency for Petroleum, Natural Gas and Biofuels in Brazil, the average consumer price of gasoline C in Ceará is BRL 4.5 per liter in 2019.

$COST_j^F$ is the total cost of fuel used in municipality j;

E_k is the fuel economy (i.e., liters of gasline needed per 100 kilometers) for transportation mode k, where $k = 2$ refers to motorbiking and $k = 3$ refers to car sharing with traffic; and

p^F is the price of fuel per liter.

Regarding the cost of vehicle, we made the assumption that home visitors would use cars or motorbikes provided by the municipality. In the case of motorbikes, we further assumed that if a home visitor needed to use a motorbike to visit a neighborhood, the particular motorbike would not be used by another home visitor on the same day. The cumulative usage time for motorbikes across all home visitors in a municipality is derived from a combination of the total travel time in round trips and the total time spent on home visits (Equation B.10). To estimate the latter, we factored in the average duration of a home visit and the frequency of such visits in each municipality, as reported in the survey.

$$UsageTime_{kj} = TIME_{kj} + \ HH_{kj} \times DUR_j^{VT} \times F_j^{VT} \qquad (k = 2, 3) \tag{B.10}$$

where

$UsageTime_{kj}$ is cumulative usage time of vehicles for transportation mode k in municipality j; and

DUR_j^{VT} is the average duration of a home visit in municipality j, as reported by the supervisor in the survey.

We then converted the cumulative usage time into day counts. Our assumption was that a single motorbike can be used for up to 15 days in a month, allowing for some flexibility to coordinate schedules. As a result, the number of motorbikes required by a municipality would be calculated by dividing the day count by the maximum days a motorbike can be used (i.e., 15 days), rounded up to the nearest whole number (see Equation B.11).

$$Motor_j = \left\lceil \frac{UsageTime_{kj}}{15} \right\rceil \qquad (k = 2) \tag{B.11}$$

where $Motor_j$ is the number of motorbikes needed in municipality j.

The initial purchase cost of a commonly used, light motorbike in Brazil, such as a 125 c.c. Fan model, was reported as BRL 5,600 in 2013[17]. We adjusted this price to 2019 BRL to account for the

[17] The procurement cost of a 125 c.c. Fan model motorbike was also extracted from the study conducted in Curitiba, State of Paraná, Brazil. This price was corroborated by other online resources, including a motorbike discussion post published around the same time as the study.

inflation[18] and then amortized it over a 5-year period. The estimated monthly cost of a motorbike is approximately BRL 131. Consequently, the overall monthly cost for motorbikes, which the municipality is expected to cover instead of home visitors as is the case in most municipalities now, is obtained by multiplying the total number of motorbikes by its monthly cost (Equation B.12).

$$COST_j^M = Motor_j \times p^M \tag{B.12}$$

where

$COST_j^M$ is the monthly cost of motorbikes in municipality j; and

p^M is the monthly cost of motorbikes.

The estimation of the cost for cars follows the same logic as that for motorbikes, with two exceptions (see equation B.13). One difference is that the cumulative car usage day count, as calculated for motorbikes, was halved to reflect the assumption that two home visitors would share a car during a trip. The second difference is that the market price of a commonly used, compact sedan in Brazil, such as the Volkswagen Gol, totaled BRL 36,373 in 2019[19]. The monthly cost of a car would be BRL 606 after spreading the purchase cost over a five-year period.

$$COST_j^C = \left\lceil \frac{UsageTime_{kj}}{2\times 15} \right\rceil \times p^C \qquad (k = 3) \tag{B.13}$$

where

$COST_j^C$ is the monthly cost of cars in municipality j; and

p^C is the monthly cost of cars.

Last, the total transportation cost is the combination of fuel cost and vehicle costs (equation B.14).

$$TS_j^M = COST_j^F + COST_j^M + COST_j^C \tag{B.14}$$

where TS_j^M is the monthly cost of transportation in municipality j, as shown in equation (3).

[18] According to the World Databank, the Consumer Price Index (CPI) for Brazil was 119.4 in 2013 and increased to 167.4 in 2019.

[19] In 2019, we used Numbeo.com to estimate the procurement cost of a new Volkswagen Gol car. Given its low cost, we conservatively assumed a lifespan of 5 years. The production of the Volkswagen Gol was discontinued in 2022 and subsequently replaced by the Volkswagen Polo. As of 2023, the Manufacturer's Suggested Retail Price (MSRP) for the Polo is approximately BRL 100,000.

Appendix C. The costs of home-visiting programs

Table C.1 Cost per child per month of home visiting interventions

Country	Program	Modality of intervention	Length of intervention (in months)	Age of target child population	Year	Cost per child per month in 2018 US dollars	Ingredients method used	Study
Biweekly home visits								
Brazil	PADIN	Biweekly home visits and community meetings	10	0 to 47 months	2018	$ 43.80	Yes	This study
Weekly home visits								
China	China REACH	Weekly home visits	21	10 to 24 months	2015	$ 46.59	Unknown	Zhou et al., 2023
Colombia	Reach-Up and Learn	Weekly home visits with play demonstrations and micronutrient sprinkles given daily	18	12 to 24 months	2010-2011	$ 47.98	Unknown	Attanasio et al., 2014
India	Reach-Up and Learn	Weekly home visits	24	7 to 16 months	2015-2017	$ 11.92	Yes	Grantham-McGregor et al., 2020
Jamaica	The Jamaican Reach Up and Learn	Weekly home visits	24	9 to 24 months	1987–1989	$ 66.36	Unknown	Zhou et al., 2023
Peru	Cuna Mas	Weekly home visits	24	0 to 36 months	2013-2015	$ 26.95	Unknown	Araujo et al., 2021
Rwanda	Sugira Muryango	Weekly home visits	3	6 to 36 months	2018	$ 157.07	Yes	Desmond, 2019
Venezuela	Reach Up	Weekly home visits and weekly group sessions	9	0 to 36 months	2021	$ 37.07	Yes	Wilton et al., 2023
Monthly visits								
India	The Sustainable Program Incorporating Nutrition and Games, or SPRING	Monthly home visits	24	0 to 24 months	2015-2018	$ 6.21	No	Kirkwood et al., 2023
Niger	Niger Safety Nets Project	A monthly village assembly, a monthly small-group meeting, and a monthly home visit	18	6 to 59 months	2013-2015	$ 4.23	Unknown	Premand et al., 2016

The cost estimates in the table above result from an exercise to harmonize costs across different parenting programs that varied in their frequency, duration, year of implementation, and program participation. Estimates reported in papers were the starting point. To ensure comparability, we made the following adjustments to the reported cost estimates:

- When costs were reported on a per-targeted-child basis, we used the program's participation rate to convert these figures to a cost per participating child.
- Reported annual costs per child were converted to monthly costs by dividing the annual amount by 12.
- The total cost estimates for the entire intervention were divided by the intervention's duration (in months) to determine the monthly cost per child.
- Unless otherwise specified, we assumed costs were reported in USD in the first year of implementation. We then used the Consumer Price Index to adjust these costs to 2018 USD values.

Studies were considered to have used the ingredient-based method if they: i) specified it in the methods section, or ii) disaggregated the ingredients and reported the quantities. If it was obvious that the cost data were only extracted from financial records, we considered that the ingredient-based method was not used for the cost analysis.

There are several caveats to consider before using the table to compare programs.

- **Visit frequency**: PADIN was designed to offer biweekly home visits. In contrast, other programs either had weekly or monthly home visits. The cost per child per month for home visiting programs is not strictly proportional to the frequency of visits. This is because certain one-time setup costs, like personnel time for content development, training, and supervision, are incurred upfront regardless of visit frequency.
- **Validity**: The comprehensiveness and rigor of the cost analyses across programs vary significantly. Some studies utilized the "ingredients method", while others solely relied on program budgets.

Combined intervention costs: The reported costs for some interventions, such as "Reach-Up and Learn" in Colombia, "Reach Up" in Venezuela, and the "Niger Safety Nets Project", represent a combined sum for home visits and other supplementary interventions. Based on the information provided in the studies, we could not isolate the cost of the home visits alone.

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