DO MATERNAL SPOT FEEDING PROGRAMS EFFECT BIRTH WEIGHT? EVIDENCE FROM ANDHRA PRADESH AND TELANGANA IN INDIA

A Thesis

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by

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ABSTRACT

The erstwhile state of Andhra Pradesh became the first state in India to provide one full meal per day to pregnant woman as a part of the supplementary nutrition program of the Integrated Child Development Services in 2013. The objective of the program is to fight maternal undernutrition by providing hot cooked meals at the *Anganwadi* center, in addition to direct administration of iron and folic acid supplements. I use two rounds of National family health survey of India to create a panel of cohort born from 2012 to 2018 and apply quasi- experimental methods to evaluate the impact of the given program on birth weight. Specifically, I use difference-in-difference model and event study design. Overall, I find a significant and positive effect of the program, with a 35- 44 grams improvement in birth weight and 3-3.5% lower probability of low birth weight babies, with the program's effect concentrated in rural and poor households Given the importance of first 1000 days of life, including in-utero, the one full meal program for pregnant woman presents a scalable model for fighting the stubborn rates of maternal and child undernutrition in India.

BIOGRAPHICAL SKETCH

Sumedha Minocha is interested in maternal and child health, especially from the perspective of food systems and public policies. Her research interest is motivated by six years of work experience, during which she traveled across rural parts of India and studied problems in agriculture and nutrition, using econometric tools on data collected through primary surveys as well as secondary data available through national surveys. Sumedha firmly believes that policy-oriented research should be grounded in reality and must be communicated in a simple way.

To this end, Sumedha has worked with a team of nutritionists at St. John's Research Institute in Bangalore, where she studied the supply and demand of quality foods in Indian diets, especially protein-rich foods. She has also worked on the scope of food fortification in India. Prior to that, she worked with the International Food Policy Research Institute in New Delhi, where the projects that she was involved in focused on the role of agricultural technologies in farmer risk management and income security. In terms of her educational background, Sumedha has completed her master's in economics from Madras School of Economics and bachelor's in economics from Delhi University. Sumedha is currently pursuing PhD in Applied Economics and Management at Cornell University as a Tata Cornell Institute (TCI) scholar.

Dedicated to my partner and daughter.

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LIST OF ABBREVIATIONS

ICDS: Integrated Child Development Services

SNP: Supplementary Nutrition Program

THR: Take Home Ration

HCM: Hot cooked meal

AWC: Anganwadi Center

IFA: Iron and Folic Acid

AP: Andhra Pradesh

OFM: One full meal

NFHS: National Family Health Survey

DID: Difference-in-difference

ITT: Intention-to-treat

LIST OF KEYWORDS

Nutrition, Birth weight, Low birth weight, Pregnant woman, Pregnancy, One full meal, Hot cooked meal, Maternal spot feeding, Supplementary Nutrition, Andhra Pradesh, Telangana, India

1. Introduction

The first 1000 days of life including in-utero is the most crucial period for shaping a child's growth and development. Poor nutrition during pregnancy has long-term adverse consequences on physical and cognitive development of children, their productivity and future earnings. Failure to provide nutrients such as protein, iron, zinc, iodine, folate and longchain polyunsaturated fatty acids during this critical period may result in lifelong deficits in brain and nervous system function despite subsequent nutrient repletion in later life (1,2). The physical effects of maternal undernutrition are reflected in adverse birth outcomes including increased risk of premature deliveries, small-for gestational age babies and infant mortality (1,3).

India's maternal nutritional indicators are amongst the poorest in the world. The prevalence of anemia was 57% amongst women in reproductive age and 52% amongst pregnant women in 2019- 2021 (4). Nearly 19% of women in reproductive age had a Body Mass Index which was below normal (<18.5 kg/m^2) during the same time period (4). The intergenerational effect of poor maternal nutrition is reflected in adverse birth outcomes and children's nutritional status. In 2019-21, every third child was stunted, every third child was underweight and every fifth child was wasted (4). This is not surprising as the percentage of low birth weight (LBW) babies (<2500 grams) was 18% while Infant mortality rate was 35 in 2019-21 (4).

A social protection program to combat the problem of maternal and child malnutrition in India is the integrated child development services (ICDS). It is a self-selective nutrition and health based government program targeted towards pregnant and lactating women, adolescent girls and children under 6 years of age. One of the core components of ICDS is supplementary nutrition program (SNP), either provided as take home rations (THR) or hot cooked meals (HCM), depending on the target group and geography, in addition to provision of nutritional supplements.

Other services under ICDS include immunization services, health check-ups, growth monitoring, and nutrition and health counselling, which are provided through village or municipality based *Anganwadi* centers (AWC) or child care centers. In this paper, I study a SNP targeted towards pregnant women, examining its causal impact on a key marker for lifetime health effects- infant birth weight.

Depending on the Indian state, supplementary nutrition for pregnant and lactating women is either provided as THR or HCM. While THR is a fortified mix of ready to cook food that are taken back home for consumption, HCM is a freshly cooked meal consumed at the AWC. The introduction of HCM for pregnant and lactating women has been more recent in several states, mainly as a replacement to THR. This is because of the criticism that the nutrient content of THR is insufficient as well as that it is being shared with other household members (5). In addition to food, supplements are also provided on the spot or to take home. For example, pregnant women are provided iron and folic acid (IFA) supplements in several Indian states.

The erstwhile state of Andhra Pradesh (AP)[1] was the first state to have introduced HCM as one full meal (OFM) per day for pregnant and lactating women under the *Indiramma Amrutha Hastham Program* in 2013 (5). Additionally, the program also involved direct administration of IFA supplements. The program was initially implemented at a sub- district level in the AWC of selected ICDS projects. The program was scaled up further in more ICDS centers, with the total coverage of around 50% in 2014, and finally universalized in Telangana in 2015, post its carvation out of AP, whereas the rest of AP universalized the program in 2017 (6). The program was renamed as *Arogya Lakshmi* in Telangana thereafter.

[1]Andhra Pradesh was bifurcated into Telangana and the residuary Andhra Pradesh state on 2 June, 2014

To build evidence base on OFM served to pregnant women in AP and Telangana, I use quasi- experimental methods to study the program impact on birth weight and LBW (<2500 grams). The children's data from the fourth and the fifth wave of India's National Family Health Survey (NFHS-4 and NFHS-5) provides a unique opportunity for creating a panel of cohort born from 2012 to 2018. The timings of program implementation and expansion is apt for using a difference-in-difference (DID) model on this data. Specifically, I compare the within- state difference in birth outcomes between younger birth cohorts exposed to the program and older cohorts not exposed to the program across the treated states (AP and Telangana) and control states bordering AP and Telangana (Odisha and Tamil Nadu) where THR is provided as supplementary program. Since eligibility does not determine participation in the program, the DID estimates provide Intention-to-treat (ITT) effects of the program. I also extend the DID model to account for different phases of program expansion, as well as to understand the interacting effects with state. Last, I apply the event study design leveraging a greater variation over time, other than across states. This also helps in formally testing for parallel trends.

My study makes several contributions. This is the first study to evaluate the causal impact of OFM program on birth weight and LBW for pregnant women in India, almost a decade post the inception of the program. The outcome variables that I use aligns well with one of the stated objectives of the program. Birth weight has been extensively evaluated for a nutrition based program in United States called Women, Infants and Children (WIC), but not in the context of India (7). However, certain conditional cash transfer programs targeted towards mothers in India, for example the *Indira Gandhi Matritva Sahyog Yojana*, have evaluated this particular outcome (8). My study adds to the body of literature on food and health based programs for women and children, especially the role of supplementary nutrition during pregnancy in India (9). There is also much interest in policy circles in shifting away from in-kind support to cash transfers with limited data backed evidence on the impact of the former; my study helps in filling that gap by building evidence on SNP in general and OFM program in particular.

The OFM program has a widespread reach amongst pregnant and lactating women in AP and Telangana. For example, the scheme cover overs 360,000 pregnant women in Telangana and many more lactating mothers, while the cost of the program is roughly Rs 24 ($0.3) per person (6,10). The meals usually consist of a diversified basket of food including milk, eggs, vegetables, amongst other foods, in addition to direct administration of supplements. The aim of the program is to fulfil more than 40% of the daily requirement of calories, protein and calcium intake of the target population, much higher than the center recommended guideline.

I find a significant and positive impact of the program with 35- 44 grams overall improvement in birth weight. I also find that the OFM program decreases 3-3.5% probability of LBW babies. The positive effect of the program is true for several specifications of the econometric models used for the evaluation. The parallel trends in average birth weight and LBW between the treatment and control states prior to the introduction of OFM program confirms the causal nature of the estimates. Robustness checks by applying DID on subsamples of wealth quintile and area of residence indicate that the effect is concentrated amongst the poor households residing in rural area, lending confidence to my estimates.

The rest of the paper is organized as follows: section 2 provides the background and anticipated effects of the program, section 3 describes the data used, section 4 states the empirical strategy, section 5 presents the results, followed by discussion and conclusion remarks in section 6.

2. Background

The ICDS is one of the flagship programs of the Government of India providing a package of multisectoral interventions for early childhood care and development. Since its inception in 1975, the ICDS has evolved over the years resolving issues of eligibility criteria, coverage, and uptake. The center mandated the universalization of the program in 2006. With only one-third of the villages having at least one AWC in 1992-93, the coverage was scaled to 91 percent of all villages in 2004-05 (11). Despite the expansion, the utilization of services was initially low; 76.4% of mothers in rural areas reported that they did not receive any services at AWC during pregnancy in 2004- 05 (12). This has gradually reduced to 40.1% in 2015-16 and 25.2% in 2019-21 (4,13). Currently, the program has a reach of about 82 million children under 6 years of age and over 19 million pregnant and lactating woman (14).

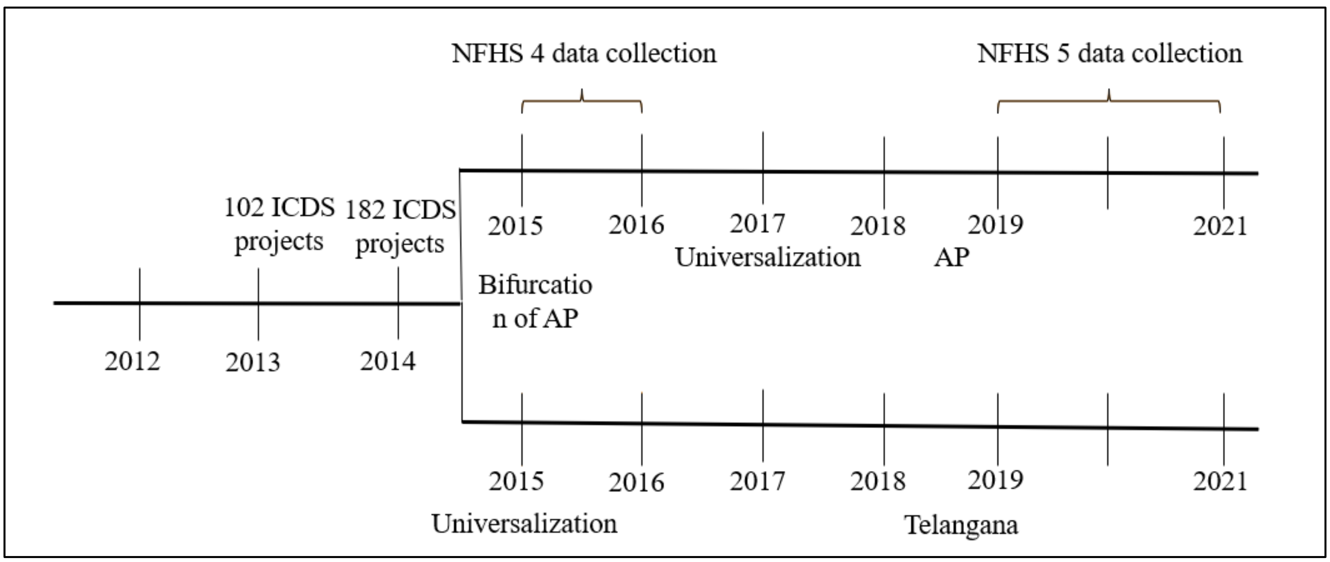
The primary objective of the supplementary nutrition component of the ICDS is to bridge the gap between the Recommended Dietary Allowance (RDA) and the Average Daily Intake (ADI). The program cost is shared equally by the state and central government, and some states supplement additional funds for the program (15). The center provides the broad guidelines for the per beneficiary cost and macronutrient content of the food, however, the implementation of the program varies by state. For example, the center recommends a per beneficiary cost of Rs 7 for pregnant and lactating woman but the state of Telangana spends Rs 24 per beneficiary, which is one of the well- performing states in terms of ICDS (16,17). The center recommends a minimum provision of 600 calories and 18-20 grams of protein during pregnancy and lactation (16). However, the procurement of raw material, quality checks, menu, and preparation is up to the discretion of the state.

Limited literature exists on the supplementary nutrition provided to women, focusing on children instead, mostly finding positive effects of the program. Jain (2015) finds that children who receive supplementary nutrition every day are about 1 cm taller than those who do not receive supplementary nutrition (11). Mittal and Meenakshi (2019) conclude that ICDS in Bihar resulted in higher intakes of calories, protein, and iron, for older children who benefit from cooked meals, however, they do not find an impact on Vitamin A intake (11). Also, for younger children whose mothers are given THR, they do not find evidence that the ICDS improved intake of calories or any other nutrients. These studies found that the uptake of supplementary nutrition in children is associated with household demographics and accessibility to the AWC (11,18). Chakrabarti et al (2019) found a positive improvement through expansion in coverage and greater inclusivity of the SNP as well as other services provided at ICDS, although the poorest and disadvantaged castes are still not adequately served in some of the states (14).

Since the beginning of the program, supplementary nutrition for pregnant and lactating women was provided in the form of THR, which is a fortified energy dense ready to cook premix such as *halwa, khichadi* or *upma,* taken back home for consumption. In an analysis of the nutrient composition of THR provided in Odisha, Uttar Pradesh and Rajasthan, Schwartz et al (2018) found that although it met the center recommended guideline for energy, protein and fat content, it fell short of several micronutrients such as folate, vitamin C, vitamin A, iron, calcium and zinc, essential during pregnancy and lactation (19). Since it is taken home for consumption, another common problem noted with THR is that of sharing with other family members (20).

Recognizing these problems, the erstwhile state of AP replaced THR with HCM for pregnant and lactating women in 2013. *Indiramma Amrutha Hastham Program* demonstrates the commitment of the erstwhile state of AP in fighting maternal and child malnutrition through provision of a wholesome meal or OFM each day. The program was introduced in 102 high-risk[2] ICDS projects of the 387 ICDS projects at the sub-district level in January 2013 (5). The program was scaled in December 2013 to 63 additional ICDS projects (21). Post the bifurcation of erstwhile AP into current AP and Telangana in June 2015, Telangana fully scaled up the program in December 2014 renaming it *Arogya Lakshmi Program* (22). AP scaled up the program in the remaining ICDS projects in January 2017 (23). At present, the program targets all pregnant and lactating women in more than 90,000 AWC across AP and Telangana. The program timings along with NFHS data collection timeline is presented in **Figure 1.**

Figure 1: OFM Program and Data Collection Timeline



The OFM consists of cooked grains (rice, wheat, or millets), *dal* (cooked lentils or pulses), vegetables or fruits, milk and egg. The meal provides a total of 1000-1200 calories, 32- 37 gm protein, 501- 578 mg calcium in AP and Telangana, much more than the recommendation of the center (17,24). The aim is to provide more than 40% of the day's requirement of calories, protein and calcium. In addition, the program also involves direct administration of 90+ IFA tablets. The

[2]High risk ICDS projects was based on poor maternal and child health indicators

per beneficiary meal cost has also gradually increased since its inception from Rs 15 to Rs 24 in AP and Telangana. The program aims to reduce maternal anemia and mortality as well as incidence of LBW babies and infant mortality, channelized through higher enrollment of mothers in AWC (24). The other stated program objectives are ensuring that food supplied is consumed by only the mothers rather than the whole family, enhancing the quality and acceptability of meals, and ensuring regular health checkups and immunization. The program blends well with the scope of ICDS services, providing a complementary effect in reducing maternal and child undernutrition.

After its implementation in erstwhile AP, the OFM program gained popularity and was introduced in several other states of India, namely Chhattisgarh, Gujarat, Madhya Pradesh, Uttar Pradesh, Karnataka, and Maharashtra. Kachwaha et al (2021) synthesized the available literature on OFM, noting the similarities and variations in the program elements (6). The program is quite similar across states in terms of provision of a diversified meal, however, the unique feature of AP and Telangana is inclusion of eggs and milk. Some of the states like Chhattisgarh and Madhya Pradesh continued providing THR along with HCM. Uttar Pradesh and Madhya Pradesh discontinued the program after the pilot phase. In terms of the objectives, AP, Telangana and Karnataka categorically state the goal of improving maternal and child health indicators, whereas other states focus on intermediary goals like increasing registration, attendance and health check-ups in AWC.

Kachwaha et al (2021) also found six studies that evaluated this program in different states; most of the studies were mixed method studies and lacked a comparison arm (6). Nevertheless, these studies do find meaningful outcomes. For example, Sethi et al (2019) found enhanced dietary diversity (>6 food groups) of 57%-59% and high consumption of eggs and milk (74%-96%) in their cross- sectional evaluation of 360 pregnant and lactating women consuming hot cooked meals in AP and Telangana in 2016 (10). An ethnographic study in Karnataka found that mothers who consumed these meals for >75 days experienced improved weight gain (average 10.27 kgs from the 1st to 3rd trimester), increase in hemoglobin (average 0.52% from the 1st to 3rd trimester) and delivered babies with nearly 10 grams higher birth weight (25).

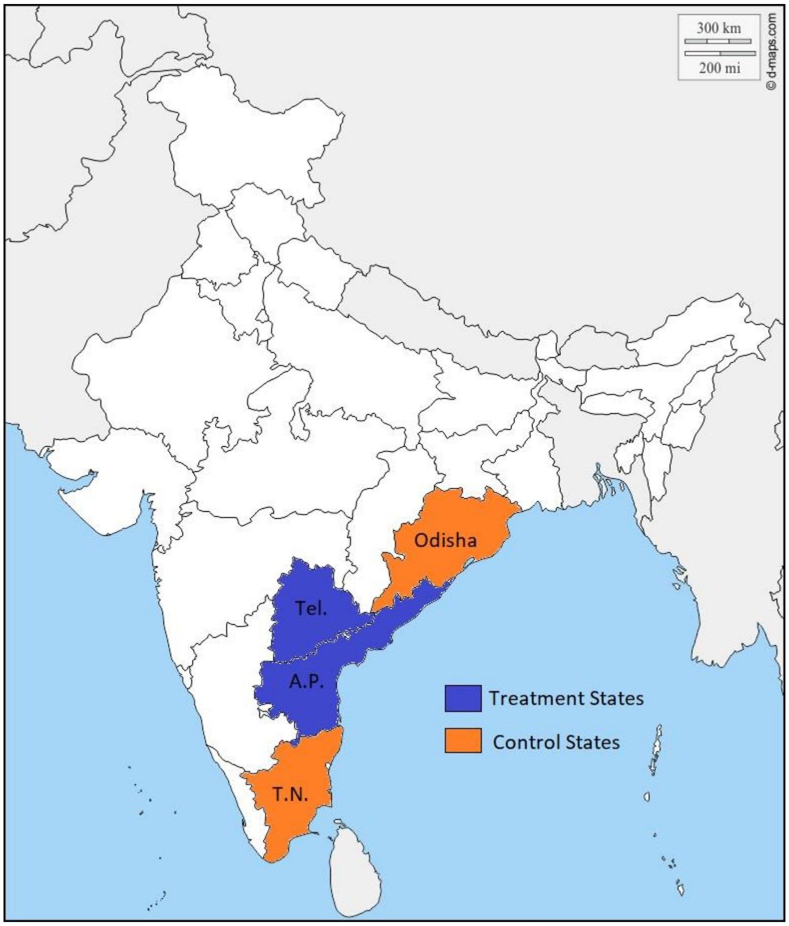
A-priori, I anticipate the OFM program to have a positive or no impact on the birthweight. I also expect this effect to be concentrated in rural areas and amongst poor households, given that these subsamples are likely to be more resource constrained with poor diets so are expected to get maximum gains from the program. However, I do not expect the program to have any negative impact. The positive change is anticipated because the nutrient composition provided through this program is almost double that of center recommended guidelines, which I assume was previously provided through the THR. The unique feature of the program is addition of milk and egg in the diet, which are nutrient dense foods rich in calcium and protein. Eggs are also rich in choline, which is significantly associated with fetal growth and development (26). The direction of the impact also depends on the substitutability and complementary with other meals. If the target population is consuming these meals over and above their status-quo consumption, then it should result in larger gains. The role of non- food pathways through group based behavior change as well as improved service delivery are other complementary channels that can contribute towards a positive impact (27). Despite these mechanisms, failure of food focused nutrition programs is not unheard of. Multiple pathways and their interactions with each other determine child health. The role of environment and women’s empowerment cannot be understated in this context. Hence, it wouldn’t be surprising if the program had no impact on birth outcome.

3. Data & Summary Statistics

The data for this paper was obtained from the fourth and fifth wave of National Family Health Survey (NFHS) conducted in 2015-16 and 2019-21 respectively, freely available for download (28). This is a cross-sectional survey that follows a multi-stage stratified sampling design, covering all states and union territories of India (13). The lowest level of geographical identifier is the district. The survey interviewed more than half a million households in each round; I focus on the children's dataset which contains data of children born five years before the survey took place and later in each round. Depending on the timings of the survey in each state, this implies that the data covers birth cohort of children born between 2010 to 2016 in the fourth wave and 2014 to 2021 in the fifth wave.

I retained four states for the analysis- AP, Telangana, Tamil Nadu and Odisha. The latter two share a border with AP and Telangana respectively, having similar diets as well as well-functioning ICDS, as is the case with the treatment states. Hence, Tamil Nadu and Odisha were considered as control states for the analysis. **Figure 2** provides a map for the treatment and control states for a geographical context. Although Karnataka, Maharashtra and Chhattisgarh could also have been chosen based on the above-mentioned criteria, however, these states introduced HCM between 2015- 2017 either as a pilot program in selected ICDS projects or as a universal program, hence are not appropriate controls.

Figure 2: Map of India with treatment and control states



Abbreviations: Tel.: Telangana, A.P.: Andhra Pradesh, T.N.: Tamil Nadu

To make the children's sample balanced across cohorts and states, I trim the data in two ways. Firstly, I drop the cohort which had incomplete data for a given year, which occurred because of the timings of the survey. For example, if the survey for the fourth wave was conducted from January to July 2016 for a given state, then it would cover half of the cohort born in 2016 as well as 2011, both of which were dropped for the main analysis. Secondly, I drop the entire cohort if the data for it was not available across all the states. This created a balanced panel data structure from 2012 to 2018 for the treated and control states. There was no case of overlapping cohorts between the two rounds, as far as the given states are concerned. The only exception to the above-mentioned procedure was the cohort born in the year 2015 in the state of Tamil Nadu, which had data for only half of the cohort, but retained for the analysis.

Although the program was initiated in 2013, however, I do not expect it to have any effect on the 2013 birth cohort. This is because the program targeted only 1/4th pregnant women in the state, moreover, given that a typical pregnancy lasts for 9 months, the first batch of infants fully exposed to the program in-utero would have been born in September 2013. Even if I conservatively assume two trimesters of in-utero exposure, which is when the weight gain starts accumulating, only half of the cohort would have been exposed to the program. Hence, I consider the cohort born in 2014 as the post treatment group. Note that the program was also scaled to around 50% in 2014.

Within the children's data, my main variable of interest, birth weight (as a continuous variable) is based on either written health record or mother's memory recall. I drop missing observations, if the birth weight was not known by the mother or if the child was not weighed at birth, which consisted of less than 3% of the sample. **Figure 3** presents these statistics for the treatment and control states. I also drop extreme values of birth weight, greater than 7500 grams and less than 1000 grams. Since a high percentage of birth weight is based on memory recall, misreporting could be a possible issue, leading to biasness in the estimates. Hence, I consider another outcome variable for the analysis, LBW, categorized as less than 2500 grams. However, this variable could also be biased around the cut-off value. **Figure 4** and **Figure 5** presents the trend of birth weight and percentage of LBW in the treatment and control states. Based on the graph, I firstly, confirm parallel trends for the outcome variables in the pre-intervention period from 2012 to 2013, which is formally test later in the paper. Secondly, the graph indicates a divergence in the outcome variables in the post intervention period, from 2014 onwards, indicating that the program had an impact. However, these differences are in grams, so may or may not translate into large gains when I do more formal testing.

Figure 3: Type of Birth weight recall

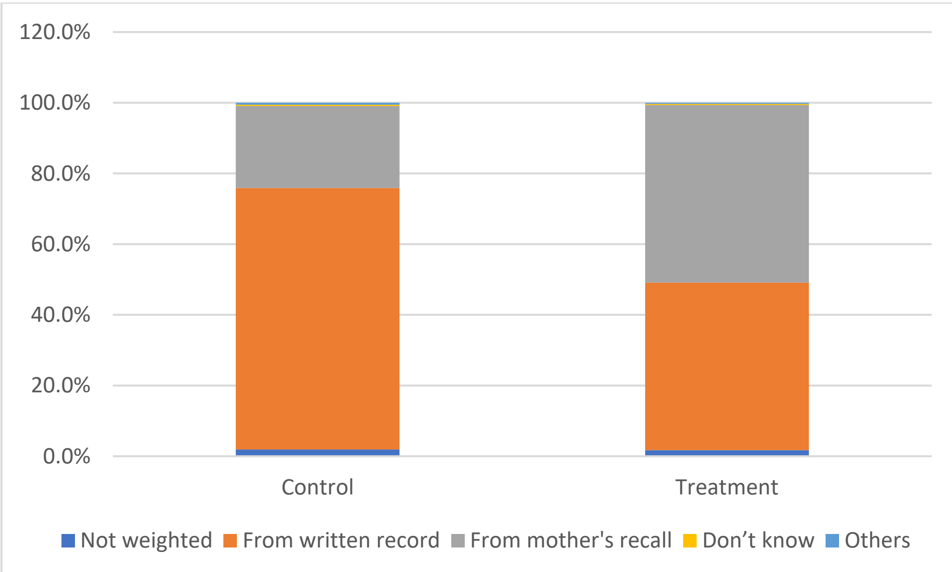


Figure 4: Trend in Birth weight (in grams)

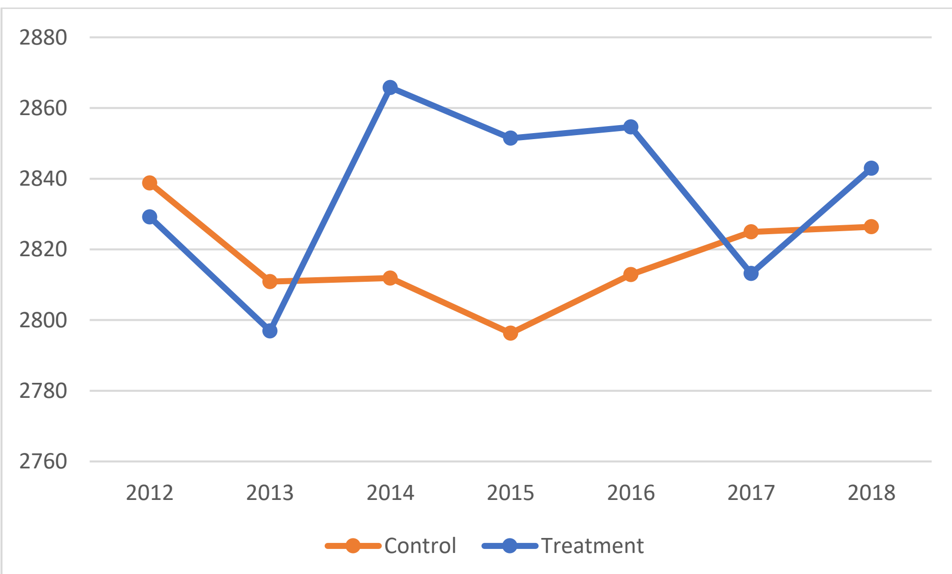
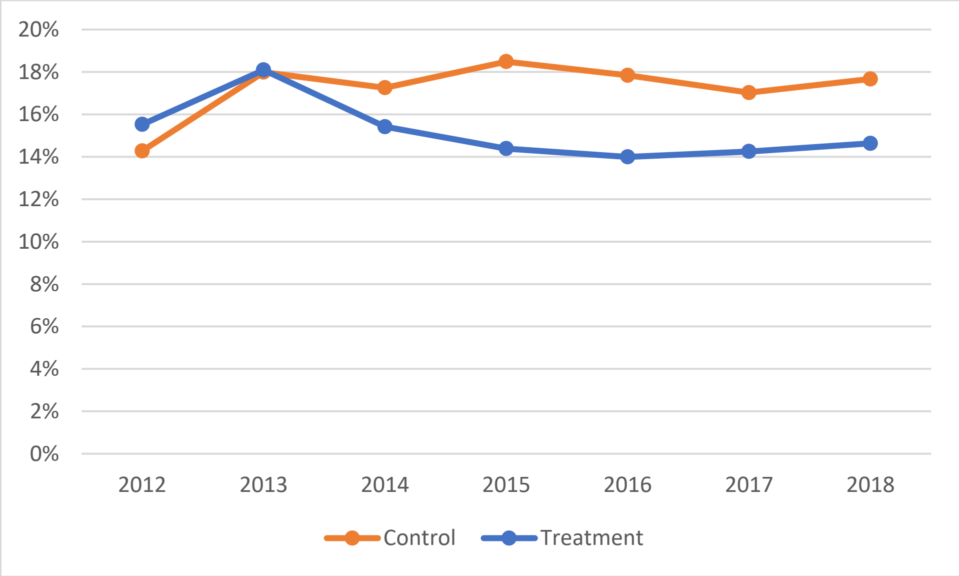
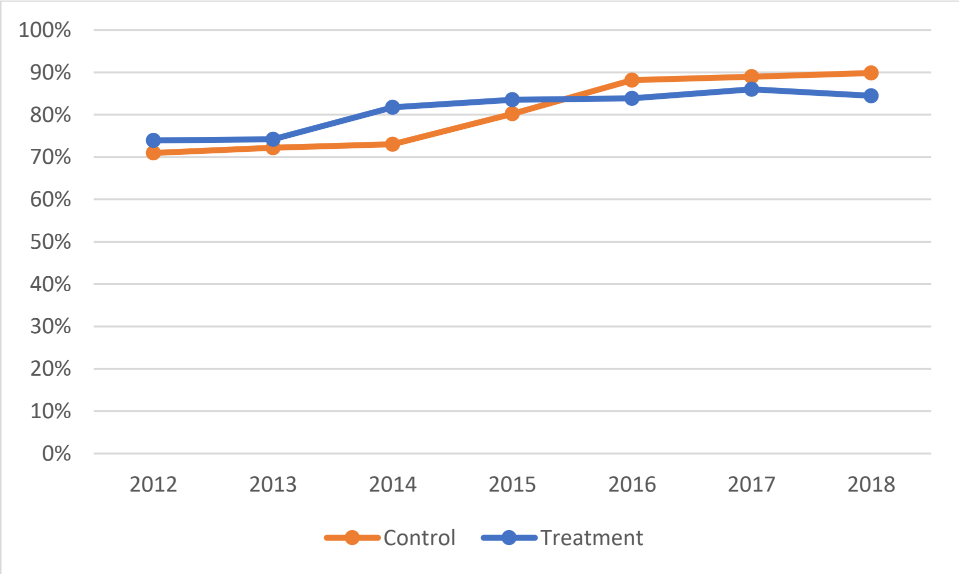


Figure 5: Trend in prevalence of Low Birth weight



To understand the participation in SNP during pregnancy, I merge the above-mentioned sample of children's data with their mother's data. **Figure 6** presents the trend for participation in SNP, finding that participation has increased in both the treatment and control states.

Figure 6: Participation in Supplementary Nutrition Program during pregnancy



Other variables used for the main analysis are mothers education level and age as well as the child's sex and birth order. So was household demographics from the household data.

Specifically, I use the type of residence (rural/urban), state-based wealth quintile, household religion, household caste, type of toilet used, and type of cooking fuel used. Dummy variables are created for type of residence as rural, for the five wealth quintiles, for religion as Hindu and for caste as scheduled caste, scheduled tribe or other backward classes. From the type of toilet used, I create a variable on the improved sources of sanitation which were non shared toilet facilities categorized as flush toilets to piped sewer systems, septic tanks, and pit latrines; ventilated improved pit/ biogas latrines; pit latrines with slabs; and twin pit/composting toilets (13). Use of electricity, LPG, or biogas were considered as clean cooking fuel, which was created as another variable (29). The "non de jure" or non- usual residents are dropped from the analysis. There were also 3% missing observations for mother's age, which were also dropped from the analysis.

For the robustness check on subsamples of wealth quintiles, I classify poor households as the bottom three wealth quintiles and non-poor households as top two wealth quintiles, representing 62% and 38% children respectively. However, the classification results in missing standard errors for the main analysis because of the problem of single sampling unit in a few stratum. Therefore, such stratum is identified and reassigned to the closest stratum. There are 12 such cases. Also, the subsample by type of residence classified as rural and urban children represents 65% and 35% respectively of the total sample whereas the subsample by type of weight recall, based on written record and mother's recall represents 66% and 34% of the total sample. The latter also results in missing standard errors, hence, these stratum are reassigned to the closest stratum. The summary statistics for important variables during baseline period (average of 2012 and 2013) is presented in **Table 1**. The final sample consists of 31224 observations with 59.2% and 40.8% in control and treated group respectively.

Table 1: Summary Statistics

	Control	Treatment
% with residence in rural area	64%	61%
% with improved sanitation	42%	46%
% with clean fuel	53%	65%
% hindu as religion	91%	82%
% with caste as SC, ST or OBC	92%	83%
% mothers with no education	13%	19%
Mean age of mother	24.78	23.20
% of girl child	50%	48%
Mean birth order	1.75	1.76

3. Empirical Strategy

Given that the objective of the paper is to identify the impact of OFM program on birth weight through exposure during pregnancy, an ideal approach is a random assignment of the eligible population to the program and estimate average differences between the two groups (30). The initial introduction of the program in selected ICDS projects presents an ideal identification strategy through comparison of the AWC centers exposed to the program and those which were not exposed to the program. However, given that the lowest geographical identifier is the district, the second best approach is a quasi (or natural) experimental method, which mimics a randomized allocation setting under reasonable conditions. One common approach is the difference-in-difference (DID) model, which controls for biases arising because of both time varying factors as well as self- selection into the program (30).

I elicit intention-to-treat (ITT) effects of OFM program on the birth weight and LBW by comparing the children that were eligible for the program and those that were not eligible for the program along two dimensions: first by comparing treated and control states and second by taking the difference between eligible and ineligible cohorts within each state. The following regression equation is used to specify the DID model:

$$Y_{ist} = \alpha_1 + \alpha_2 \, OFM_{ist} * Post_{ist} + \delta X_i + \gamma_t + \eta_s + e_{ist} \quad (1)$$

where Y_{ist} is the birth outcome of interest for child i in state s at time period t, OFM_{ist} is the treatment indicator variable which takes the value of 1 if the child belongs to the treated state and 0 otherwise, $Post_{ist}$ is the post treatment time indicator which takes the value of 1 for eligible cohorts and 0 otherwise, and X_i are the household, mother and child specific controls. Household controls include dummies for improved sanitation, clean cooking fuel, religion as hindu, caste as scheduled case, scheduled tribe or other backward classes, and wealth quintiles. Mother's characteristic include her education level and age at the time of child's birth whereas child's characteristics include the sex and the order of birth. I include fixed effects for state η_s and cohort γ_t. Two birth outcomes are evaluated, birth weight as a continuous variable and LBW as a dichotomous variable (where <2500 grams==1). I use linear regression for the former and probit regression for the latter. The coefficient of the interaction term, given by α_2 is the main parameter of interest which gives the DID estimate of the ITT effect of OFM on the birth outcomes.

In the second specification, I expand the time frame to encompass the full scale up of the program in 2015 in Telangana and 2017 in AP, modifying equation 1 as follows:

$$Y_{ist} = \alpha_1 + \alpha_2\, OFM_{ist}*Post_{is2014} + \alpha_3\, OFM_{ist}*Post_{is2015} + \alpha_4\, OFM_{ist}*Post_{is2017} + \delta X_{ist} + \gamma_t + \eta_s + e_{ist} \quad (2)$$

Where $Post_{is2014}$, $Post_{is2015}$ and $Post_{is2017}$ are the post treatment time indicators which take the value of 1 for cohorts born in 2014, 2015 and 2016, and 2017 onwards respectively. The rest of the variables are as explained in equation 1. The coefficient of the interaction terms, given by α_2, α_3 and α_4 are the main parameters of interest which gives the estimate of the ITT effect of the OFM programs on the birth outcomes.

To examine the differential impact between AP and Telangana when the full scale up happened in each state, I modified the specification 2 as follows:

$$Y_{ist} = \alpha_1 + \alpha_2\, OFM\_AP_{ist}*Post_{is2014} + \alpha_3\, OFM\_Tel_{ist}*Post_{is2014} + \alpha_4\, OFM\_AP_{ist}*Post_{is2015} + \alpha_5\, OFM\_Tel_{ist}*Post_{is2015} + \alpha_6\, OFM\_AP_{ist}*Post_{is2017} + \alpha_7\, OFM\_Tel_{ist}*Post_{is2017} + \delta X_{ist} + \gamma_t + \eta_s + e_{ist} \quad (3)$$

The coefficient of the interaction terms captures the program effect in AP and Telangana in different years.

The key identifying assumption underlying the validity of DID is parallel trends i.e. the trends in the birth outcomes in the absence of treatment would have been the same in both the treated and control groups. Since this is not directly testable, I instead check if the trends in the pre-intervention periods were similar based on the birth outcomes of the cohort which were ineligible for the program. I extend the analysis to an event study design, which also makes sense because nutrition based programs that target the fetus are likely to take time to have an impact both because the results are driven by accumulated benefits during pregnancy as well as that implementation issues are likely to slow down the process in such programs. In practice, event study design implies incorporating cohort or year effects (which I already incorporated in the above mentioned regressions) and cohort effects interacted with treatment, given as follows:

$$Y_{ist} = \alpha_1 + \alpha_2 \, OFM_{ist}*\gamma_{2013} \ldots\ldots\ldots\ldots + \alpha_7 \, OFM_{ist}* \gamma_{2018} + \delta X_i + \gamma_t + \eta_s + e_{ist} \quad (4)$$

If the interactions in the pre intervention period are insignificant, then the assumption for parallel trends is satisfied.

I re-run specification (1) on subsamples of area of residence and wealth quintile for conducting robustness checks. If the program has a positive impact, I anticipate it to be concentrated in rural areas and amongst poor households. This is because these households are more likely to have poor diets, and hence, benefit the most from the program. I also re-run specification (1) on subsamples of type of birth weight recall, based on written record or mother's recall.

4. Results

Table 2 presents the results for all the specifications with birth weight as the outcome variable. The estimates of the basic DID model (specification 1) suggest a significant and positive impact of the OFM program, commensurate to an improvement of 35- 44 grams in birth weight. As is evident from the results of specification (2), the effect is concentrated in the initial years of program implementation and expansion, with an improvement of 46- 69 grams. Equally, the results of specification (3) suggest that AP drives this effect, experiencing an improvement greater than 100 grams. The results of the event study design (specification 4) confirms the assumption of parallel trends given that the interaction term for treatment state and year 2013 is insignificant. It also confirms that as far as birth weight is concerned, the gains of the program is during the initial years of program implementation.

Table 3 presents the results for all the specifications with LBW as the outcome variable, which is a dichotomous variable. The estimates of the DID model (specification 1) suggest a significant and positive impact of the OFM program; it decreases 3-3.5% probability of LBW babies as calculated from the marginal effects from the probit model. However, as opposed to my findings from birth weight, specification (2) suggests these effects to be concentrated in the years when the program was universalized. Also, these gains occur in both the treatment states (specification 3). The event study design confirms the assumption of parallel trends as well as breaks the program effect for each year, finding that the program reduces 3-5% probability of LBW babies for different years.

Table 4 and **5** presents results from the robustness checks where I re-run specification (1) on subsamples of area of residence and wealth quintiles. I find evidence for the program effect to be concentrated in rural area, equivalent to an improvement of 40-47 grams in birth weight and

4% lower probability of LBW babies. The results from subsample of wealth quintiles suggest that the effect is concentrated amongst poor households (bottom 3 wealth quintiles), equivalent to an improvement of 49-64 grams in birth weight and 4.7- 4.8% lower probability of LBW babies. **Table 6** presents the results from the sub sample analysis by type of birth weight recall. I find weak evidence for birth weight to be driven by mother's recall and LBW to be driven by written record.

Table 2: Linear regression results with birth weight as outcome variable

	Birthweight							
	Specification (1)		Specification (2)		Specification (3)		Specification (4)	
OFM*Post 2013							-5.21	-14.24
							(30.08)	(28.80)
OFM*Post 2014	43.7**	35.43*	61.083**	64.88**			58.61**	58.13**
	(19.8)	(18.87)	(26.67)	(25.79)			(29.62)	(28.74)
OFM_AP*Post 2014					109.75***	97.09***		
					(33.98)	(33.49)		
OFM_Tel*Post 2014					2.01	25.88		
					(37.19)	(35.18)		
OFM*Post 2015			57.52**	46.13**			62.61**	42.76
			(23.44)	(22.58)			(29.76)	(29.23)
OFM_AP*Post 2015					80.32***	66.36**		
					(29.59)	(28.96)		
OFM_Tel*Post 2015					29.83	21.06		
					(31.88)	(29.37)		
OFM*Post 2016							47.92	36.23
							(31.41)	(30.17)
OFM*Post 2017			19.55	6.71			-1.013	-17.94
			(23.96)	(22.76)			(30.46)	(29.83)
OFM_AP*Post 2017					32.95	18.87		
					(30.53)	(29.88)		
OFM_Tel*Post 2017					4.71	-6.98		
					(32.62)	(29.42)		
OFM*Post 2018							34.97	18.89
							(31.65)	(30.14)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household, maternal & Child Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Significance level: *** 1%, ** 5%, *10%*

Table 3: Probit regression results for low birth weight (less than <2500 grams) as an outcome variable

	Low Birth Weight (<2500 grams)							
	Specification (1)		Specification (2)		Specification (3)		Specification (4)	
OFM*Post 2013							-0.015 (0.020)	-0.007 (0.020)
OFM*Post 2014	-0.137*** (0.053)	-0.139** (0.055)	-0.022 (0.019)	-0.025 (0.019)			-0.029 (0.020)	-0.029 (0.020)
OFM_AP*Post 2014					-0.053** (0.025)	-0.049** (0.025)		
OFM_Tel*Post 2014					0.016 (0.025)	0.005 (0.025)		
OFM*Post 2015			-0.042*** (0.016)	-0.041*** (0.016)			-0.050** (0.020)	-0.041** (0.020)
OFM_AP*Post 2015					-0.041** (0.02)	-0.042** (0.020)		
OFM_Tel*Post 2015					-0.043** (0.020)	-0.041** (0.02)		
OFM*Post 2016							-0.047** (0.021)	-0.044** (0.021)
OFM*Post 2017			-0.034** (0.015)	-0.033** (0.015)			-0.039* (0.020)	-0.033 (0.020)
OFM_AP*Post 2017					-0.034* (0.019)	-0.033* (0.019)		
OFM_Tel*Post 2017					-0.035* (0.020)	-0.034* (0.02)		
OFM*Post 2018							-0.043** (0.020)	-0.04** (0.02)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household, maternal & Child Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Significance level: *** 1%, ** 5%, *10%*

Table 4: Regression results by type of residence

	Birth weight				Low Birth weight			
	Rural		Urban		Rural		Urban	
	Specification (1)		Specification (1)		Specification (1)		Specification (1)	
OFM*Post 2014	47.42**	40.09*	43.21	43.79	-0.0393**	-.0417**	-0.0274	-0.0284
	(22.77)	(22.54)	(35.86)	(34.78)	(0.0163)	(0.0163)	(0.0230)	(0.0227)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household, maternal & child Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Significance level: *** 1%, ** 5%, *10%*

Table 5: Regression results by wealth

	Birth weight				Low Birth weight			
	Poor		Non-poor		Poor		Non-poor	
	Specification (1)		Specification (1)		Specification (1)		Specification (1)	
OFM*Post 2014	62.08***	48.76**	12.21	12.94	-0.0487***	-0.0473**	-0.0101	-0.014
	(23.73)	(22.91)	(33.31)	(32.24)	(0.0167)	(0.0167)	(0.0209)	(0.0208)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household, maternal & child Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Significance level: *** 1%, ** 5%, *10%*

Table 6: Regression results by type of weight recall

	Birth weight				Low Birth weight			
	Written record		Mother's recall		Written record		Mother's recall	
	Specification (1)		Specification (1)		Specification (1)		Specification (1)	
OFM*Post 2014	34.19	22.14	54.28*	60.01	-.1455**	-0.1366*	-0.1009	-0.1405*
	(25.62)	(24.06)	(32.48)	(31.49)	(0.0707)	(0.0725)	(0.0809)	(0.0855)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household, maternal & child Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Significance level: *** 1%, ** 5%, *10%*

5. Discussion & Conclusion

In this paper, I evaluate the ITT effect of OFM program on birth weight and LBW (<2500 grams) in erstwhile AP, now AP and Telangana, where the program was introduced for the first time in India for pregnant women in 2013. Take home rations were replaced by provision of a diversified hot cooked meal consumed at the AWC, other than direct administration of IFA tablets. The prominent feature of the program was regular provision of egg and milk in the meals. The aim of the program was to fulfill more than 40% of caloric, protein and calcium requirements during pregnancy. I find a significant impact of the program on the given birth outcomes post 2014. The OFM program results in 35- 44 grams improvement in birth weight. I also find that the OFM program decreases 3-3.5% probability of LBW babies. Since the program was initially implemented in selected ICDS centers and not all eligible population would have likely participated in the program, the given estimates are conservative and represent lower bound of effects.

The results with birth weight as the outcome variable suggests that the effect is driven by the period between 2014 to 2016. However, with LBW as the outcome variable, I find that the effects are spread out across the years. Although the program was introduced in 2013, it initially covered 102 ICDS projects out of 387 ICDS projects, additionally the first cohort with full exposure during pregnancy was born from September 2013 onwards. The year 2014 saw an expansion in the coverage of the program, while the program was fully scaled up in Telangana and AP in 2015 and 2017 respectively. Yet the results suggest that the effect was concentrated in the state of AP during the initial years of the program, as far as birth weight is concerned. One explanation of this could be that the initial years focused on high risk ICDS centers, with poor maternal and child malnutrition indicators, as is the case with most government programs. However, the dip in the trend of birth weight post 2017 is perplexing and unanticipated. For LBW, the effect is not only spread across years but also across the two treatment states. One interpretation of the result could be that moving from LBW to appropriate weight was realized with each year of the program as a gradual process, but beyond that, the benefits of weight gain were concentrated in AP and during initial years.

The data on SNP participation during pregnancy shows that it has gradually increased from 73% to 84% from 2012 to 2018 in the treatment states, which is likely to contribute to the positive effects. However, the data does not tell other aspects of the program such as frequency of participation in SNP in each trimester, different food items consumed as a part of the meal, and consumption of IFA tablets. The NFHS only sheds light on some of these indicators and that too with respect to the last pregnancy, hence, this data could not be analyzed. In this context, it is difficult to comment on implementation and access issues with the provision of meals and supplements, however, given that the program's effect is concentrated in the rural and poor households, shows that the program is successful in reaching to the likely vulnerable population groups. The program results in 40-47 grams in birth weight and 4% lower probability of LBW babies in rural areas. The poorest households (bottom three wealth quintiles) experienced an improvement of 49-64 grams in birth weight and 4.7- 4.8% lower probability of LBW babies. The results also indicate that the improvement in birth weight is driven by data based on mother's memory recall whereas the lower probability of LBW is driven by written health card, although the evidence for it is weak. A possible issue with the subsample of data based on mother's memory recall is that the ratio of sample size between treatment and control state is disproportionate, given by 3:7.

ICDS works as a package of interventions so that the changes in the SNP came along with changes in other components such as strengthening of nutrition and health counselling, monitoring of weight gain, and greater incentives to Anganwadi staff. Given that the prime focus of the program was provision of meal and supplementation so it popularly came to be called One full meal or maternal spot feeding, but my study is a comprehensive evaluation of the program rather a specific component. Disentangling the effect of the program is beyond the scope of the present study, but I can postulate that the food component is the main driver of the effect and other program aspects complement it, given the program motivation.

Although the importance of the first 1000 days of life is widely recognized as a critical window of opportunity, until more recently the policy dialogue was mostly focused on child growth after birth rather than in-utero. However, it is agreed that earlier the intervention, better is the effect on long term child health. The last decade saw not only changes in SNP but also introduction of non-food programs for pregnant women in India like the conditional cash transfer program. Evaluation of these studies found a mixed record as far as health outcomes are concerned but more tangible changes in health service use (8). In terms of the international evidence, several studies have shown that pregnant women who participate in food focused supplementary nutrition program for Women, Infants, and Children (WIC) in United States give birth to healthier infants than those who do not participate, although WIC is not a universal program so not directly comparable (14).

Even for food and nutrition based programs, it needs to be understood that the etiology of pregnancy is complex; birth outcomes are determined by multiple pathways other than nutrient consumption. In the context of India, the role of environment, particularly water, sanitation, and indoor pollution is often highlighted as an impediment to better child health through suboptimal absorption of nutrients (3). Basu et al (2022) found that the choice of cooking fuel and subsequent indoor air pollution has a significant impact on under-five and neonatal mortality (29). Although I added these factors as control variables in the regression specifications, but the negative externality of these factors is often felt beyond the household level. These environmental issues are often stated as a barrier for bringing about a transformative impact on child health outcomes, despite large scale policy efforts. A 35- 44 grams improvement in birth weight that I found through the OFM program is a meaningful impact, given the complex interplay of factors in determining child growth, including the growth in utero. Also, my paper reflects that the changes are not only small in magnitude but the process of change itself is gradual.

An important caveat of my study is the lack of a pure control group without any intervention. Since the OFM program in erstwhile AP is a replacement to THR and that the bordering states have THR as SNP, I don't have a pure control without any intervention. In this sense, the results reflect the effect of OFM as compared to THR, which in principle was providing some form of nutrition despite the problem of sharing and insufficient nutrient content. I am also limited by the data in understanding the nuanced characteristics of the program, which restricts me in suggesting policies for improving the program. For example, trimester wise data on consumption of IFA and diet recall for the food consumed at the AWC, home and other sources will shed a greater light on the program characteristics. Another data limitation is that my main variable of interest is partly based on memory recall, hence, misreporting can be a possible issue. Heaping around 500 grams is another problem with birth weight data. Unisa et al (2022) suggest that LBW is likely to be underestimated when missing data as well as heaping at 2,500 grams are highly prevalent (31). However, Subramanyam et al (2010) point out the importance of birth weight data from NFHS for epidemiologic research in the absence of other sources (32). Since

NFHS 5 was partly collected during the COVID pandemic, another related issue could be biasness in the results because of COVID related deaths. The quality of data collected during this round may also have suffered. In so far, amongst the states considered for analysis, Tamil Nadu is the only state which collected part of the data from November 2020 to March 2021, otherwise the data was collected pre-COVID outbreak.

Despite the caveat and challenges, this is the first study to evaluate the causal impact of OFM program on birth weight and LBW in two Indian states. Moreover, my study shows that the OFM program succeeds in fulfilling one of the program objectives of improving child anthropometric measures. More studies are needed to rigorously evaluate if the program meets it's other stated goals, as well as unraveling the underlying mechanisms that drive the program. From a policy perspective, the one full meal program for pregnant woman presents a scalable model for fighting maternal and child malnutrition in India.

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