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Food Transfers and Child Nutrition: Evidence from India's Public Distribution System†

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India's National Food Security Act of 2013 (NFSA) led to one of the biggest expansions in food transfers in history, affecting over 500 million people. We use plausibly exogenous variation created by the NFSA to estimate the effect of food transfers on child nutrition. Using individual panel data across eight states in India over five years, we find that increased transfers significantly reduced stunting. The food transfers increased wage incomes and improved dietary diversity. Our results suggest that, in the states we study, the NFSA prevented approximately 1.8 million children from being stunted (*JEL* I12, I18, I38, J13, O12)

Undernutrition in early life is a critical public health concern in developing countries. Infants and children are particularly vulnerable, as the risk of morbidity and mortality from undernutrition is highest in children under five years of age (Black et al. 2013). Child undernutrition delays cognitive development, lowers human capital accumulation, productivity, and earnings in adult life, thereby contributing to the intergenerational transmission of poverty (Sudfeld et al. 2015; Victora et al. 2008; Currie and Almond 2011; McGovern et al. 2017). Worldwide, about 150 million children under the age of five are affected by stunting. India accounts for about 30 percent of the stunted children in the world, and within India an estimated 36 percent of young children are stunted.

Food transfers and subsidies are perhaps the world's most ubiquitous social safety nets, providing nutritional assistance to about 1.5 billion people worldwide. More than 75 percent of low- and middle-income countries use in-kind food transfer programs as part of their social protection portfolio (World Bank 2015, 2018). Public support for food transfers is partly motivated by the argument that they have beneficial long term effects on child nutrition and development.

However, it is not obvious that food transfers alone improve child nutrition. For instance, the effect of food transfers on calorie intake may be low, either because the transfer crowds out other food purchases or because households choose to sell

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the transfer to generate cash. Furthermore, food transfers often focus on providing subsidized staple crops, which may cause households to substitute away from more nutritious foods, potentially worsening child malnutrition (Jensen and Miller 2011).[1] Moreover, even if household food consumption improves on aggregate, households may fail to direct extra consumption toward children. Therefore, credible evidence of a large-scale positive effect of food transfers on child nutrition is limited.

In this paper, we estimate the effect of food transfers on child undernutrition in the context of India's Public Distribution System (PDS)—the world's largest program of subsidized food transfers and India's most far-reaching social safety net. The PDS program provides highly subsidized rations of staple food to the poor through a network of over 500,000 fair price shops. The program provides assistance to more than 800 million people, making it one of the world's largest social transfer programs of any kind. The PDS accounts for 60 percent of India's social assistance budget, in 2019–2020, costing about Rs 1.8 trillion (US$26 billion), about three times as much and covering about eight times as many people as the better studied National Rural Employment Guarantee Act (NREGA). By estimating the effect of the PDS, we provide evidence for the performance of food transfers at a very large scale.

Our empirical strategy exploits variation in PDS transfers generated by the National Food Security Act (NFSA) of 2013. This policy substantially expanded PDS entitlements for the average recipient and was hailed at the time as the biggest ever expansion of the "right to food" in the world. In particular, the NFSA created a binding mandate that states provide 5 kg of grains to eligible individuals at a price of no more than 3 Rs/kg for rice and 2 Rs/kg for wheat (NFSA 2013). Before NFSA, states had discretion over the prices and quantities they offer to PDS beneficiaries. After NFSA, all states had to comply with a new national minimum mandate.

This provision created two sources of variation in the transfer value of PDS entitlements. The first source of variation is at the state level. States with pre-NFSA prices or quantities that fell short of the mandate had to expand their subsidies, while states that were already in attainment with the mandate did not. Eligible households who lived in nonattainment states thus saw their PDS entitlements expand more than households in attainment states. The second source of variation is determined by household size, stemming from the NFSA's requirement that PDS rations be calculated on a per individual basis. Before the NFSA, many states calculated rations on a per household basis, allocating a fixed amount of grain to each eligible household regardless of size. In those states, the switch to per individual allocation led to a greater expansion of PDS entitlements for large households relative to small ones.

In addition to the variation created by the NFSA, we exploit a third source of household-level variation stemming from the fact that some households have PDS ration cards at baseline and some do not. Households who do not have a ration card are not directly affected by the PDS reform and serve as an internal control group that allows us to better estimate and control for unobserved location-specific shocks.

We aggregate these three sources of variation into a household-specific measure of the value of PDS entitlements before and after the NFSA, using detailed information

[1] This also relates to the "malnutrition puzzle" in India, where calorie consumption has stayed constant or even declined when income increased (Deaton and Drèze 2009).

on state-level PDS entitlements on quantity and prices collected from personal fieldwork and government records. Our empirical analysis combines this policy information on PDS entitlements with individual and household panel data on ration cards, household size, and state of residence from ICRISAT's "Village Dynamics in South Asia" panel (VDSA). The VDSA panel data cover 30 villages spread across 8 states in India between 2010 to 2015. This data allows us to generate a precise measure of the value of a household's PDS entitlement that a household h is entitled to receive in state s in time t as a function of household's baseline characteristics (state of residence, household size, and ration card). All three sources of variation are combined into this household-specific measure of PDS entitlement value, which we use to estimate the effect of PDS transfers on child malnutrition in a regression with individual and year fixed effects.

The fact that, within the same state, households with different sizes and eligibility status are affected differently by the NFSA reform allows us to further control for a wide set of unobserved time-varying shocks by including state-by-time, household-size-by-time, and ration-card-by-time fixed effects. Identification in these regressions follows the same logic as a "triple-difference" approach, based on comparing households observed in the same state and same year whose PDS transfers were affected to different extents by the NFSA.

Our empirical strategy addresses a number of other challenges introduced by the details of the implementation of the NFSA. These include states that "overshot" the NFSA mandate and expanded their PDS entitlements by more than would have been necessary to come into attainment, and other states that were slow to implement the mandate. To deal with these issues, we instrument for actual entitlements with counterfactual "target" entitlements that would have existed if states had done the bare minimum to comply with the NFSA mandate at the time it was ratified. We also show that outcomes of households who benefited more/less from NFSA were on parallel trends in the years leading up to the reform.

Our core analysis shows that PDS transfers significantly reduced stunting in children aged 0 to 5 years. The magnitude of the effect is largest for infants 0 to 2 years, consistent with a large literature that emphasizes the significance of the first 1,000 days of life—a critical window in which to intervene to prevent stunting (Bundy et al. 2018; de Onis and Branca 2016). We find no impacts on weight-based indicators, and on the prevalence of overweight or obesity among adults.

We then validate that the expansion of PDS transfers led to a large increase in nutritional intake among beneficiary households. An increase in PDS transfer value of 30 rupees per capita per month led to an increase in daily per adult equivalent calorie intake of 167 kcal of energy intake, 4.3 grams of protein intake and 4 g of fat intake. Importantly, while PDS only subsidizes staple grains, we find that an increase in PDS transfers improves dietary diversity and "crowds-in" the consumption of nutrient-dense foods, with a large increase in animal proteins from milk and meat. A possible explanation for this crowd-in is that the decrease in out-of-pocket expenditure on staple foods frees up household food budgets and allows them to shift expenditure to more nutrient-dense foods. Consistent with this explanation, we find that PDS transfers increase the share of the food budget spent on animal proteins while decreasing the share spent on grains. The magnitude of increase in nutrient intake is large enough to explain our core finding of a reduction in stunting, consistent with an extensive literature in nutritional science (Murphy and Allen 2003; Roberts and Stein 2017; Pimpin et al. 2019). For instance, using the estimates from a recent meta-analysis Pimpin et al. (2019), we show that the estimated increase in animal protein intake alone could explain much of the observed increase in child height.

We next examine the effect of PDS transfers on labor income. We find that increased transfers led to an increase in daily wages and total wage income at the household level, improving the welfare of poor households who are typically net labor suppliers.[2] The increase in total wage income is large relative to the size of the transfer: A 1 rupee increase in the value of the PDS transfer led to approximately 1.2 additional rupees in wage income. These results are consistent with recent evidence that cash transfers can increase the incomes of recipient households by more than the amount of the transfer through a labor market mechanism (Carneiro et al. 2021). This additional "second-round" effect on household welfare may partly explain the large effect of food transfers on stunting in our context. We find that an increase in food transfers of 30 rupees per capita per month, the size of the post-NFSA increase for the average household in our sample, led to a 36 rupees per capita increase in wage income, which is equivalent to 7 percent of total consumption for a household in the poorest quintile. The same increase in transfers led to a 7.2 percentage point reduction in the proportion of children who are stunted.

Our final set of results shows that the effect of PDS transfers on child stunting are particularly large during years with a low rainfall, a climate shock associated with increased child undernutrition. These results suggest that a nutrition-sensitive safety net like the PDS supports food security, making child nutrition outcomes less sensitive to local climate shocks.

Our results contribute to the academic literature in several ways. First, they provide early evidence that food transfers alone can reduce child stunting in developing countries. Previous work by Han, Kim, and Park (2021) finds that food vouchers can reduce child stunting, but only when combined with nutrition education in the form of behavioral change communication (BCC). The same study finds no evidence that food vouchers alone can reduce stunting. Similarly, Olney et al. (2018) finds that food-based assistance reduces child stunting only when food assistance is combined with supplementation of corn-soy blend and a BCC component. Ahmed, Hoddinott, and Roy (2019) find no evidence that food transfers can reduce stunting, either by themselves or in combination with BCC. These studies are part of a recent literature suggesting that social transfers have limited effects on child nutrition unless they are combined with behavioral change communication (Olney et al. 2018; Carneiro et al. 2021; Han, Kim, and Park 2021; Ahmed, Hoddinott, and Roy 2019; Field and Maffioli 2021). Consistent with this evidence, Tarozzi (2005) finds that an increase in the price of PDS food in a single state, Andhra Pradesh, had no effect on child anthropometric

[2] This effect is consistent with a health productivity mechanism in which improved nutrition increases labor productivity. Alternatively, the wage increase could be due to a general equilibrium effect. We find evidence that an increase in PDS transfers led to a small decrease in the number of days worked per month, which may reflect a reduction in labor supply that could lead to an increase in wages in the local labor market.

measures. In contrast, our results suggest that food transfers alone can lead to substantial reductions in stunting without any complementary intervention.[3]

Second, we add to the recent evidence that labor market responses can reinforce the effects of social transfers on undernutrition. Carneiro et al. (2021) show that cash transfers caused new mothers to increase labor supply, generating additional income beyond the transfer income itself. We document that food transfers can cause an increase in daily wages and total wage income, which also has substantial positive "second-round" effects on household welfare.

Third, we contribute to the literature on the impacts of climate shocks on undernutrition by showing that food transfers can have larger effects on child nutrition during years with negative climate shocks. Extensive research has shown that extreme weather events such as droughts substantially increase child stunting, particularly for rural agricultural households who rely on rain-fed agriculture as their source of income (Cooper et al. 2019; Helldén et al. 2021; Hoddinott and Kinsey 2001; Alderman, Hoddinott, and Kinsey 2006). Moreover, climate models suggest that extreme weather events, such as droughts, will increase in frequency and severity as a result of climate change (Dai 2013), posing a severe risk to child nutrition and anthropometric outcomes. Our results imply that food transfers can play an important role in mitigating the negative impact of climate shocks on child nutrition.

Finally, our paper provides novel evidence on the effectiveness of the Public Distribution System, the world's largest food transfer program. Previous work on the PDS system was constrained by a dearth of plausibly exogenous variation in PDS transfers at the household level and often relied on variation in market prices of non-PDS grain to identify changes in PDS transfers. For instance, Kochar (2005) studied the effect of a nationwide increase in the generosity of PDS transfers in the late 1990s and found only marginal increases in caloric intake. Similarly, Kaushal and Muchomba (2015) found that a later increase in PDS subsidies in 2002 had no effect on nutritional intake, and Kaul (2018) found that PDS subsidies had a small positive effect on food consumption. Tarozzi (2005), Kishore, and Chakrabarti (2015) and Krishnamurthy, Pathania, and Tandon (2017) studied effects of state-level changes to PDS policies. These previous studies significantly improved our understanding of the effects of the PDS system but were limited by the potential endogeneity between state-level policies or market prices and unobserved shocks to nutritional outcomes, a limitation our analysis sidesteps.[4]

[3] Our results also relate to the large literature on the effects of cash transfers on child nutrition in developing countries. Studies in this literature generally find mixed or null effects, and a few studies find unintended negative effects on obesity and risks of noncommunicable diseases (Manley, Gitter, and Slavchevska 2013; de Walque et al. 2017; Hawkes et al. 2020).

[4] Moreover, previous work was constrained by lack of data on PDS ration cards and PDS entitlements. Most previous studies of the PDS have relied on repeated rounds of cross-sectional data from the National Sample Survey Organization (NSSO) before 2011–2012, which does not contain consistent information on whether a household has a PDS ration card nor on the size of their PDS entitlement. This makes it difficult to precisely measure household-level access to food transfers and may lead to attenuation bias. To identify beneficiaries, previous studies either imputed ration cards (Kochar 2005; Kaushal and Muchomba 2015; Krishnamurthy, Pathania, and Tandon 2017) or assumed that households reporting any purchase from the PDS were beneficiaries (Kaul 2018). Some studies sidestep this issue and examine only the exposure of marginal changes in PDS subsidy (Tarozzi 2005; Kishore and Chakrabarti 2015). Furthermore, earlier studies relied on actual PDS consumption rather than PDS "entitlements" due to the difficulty in observing state-level policy changes in entitlements. In contrast, the information on ration card status contained in our data, and detailed information on state-level PDS entitlements collected

Our paper advances this literature by using the NFSA as a source of plausibly exogenous variation that allows us to estimate the effect of PDS transfers while controlling for a wide range of unobserved geographic and household-level shocks. To our knowledge, our study is the first to examine the effects of the large increases in PDS transfers generated by the NFSA—one of the biggest expansions of food transfers in history, affecting over 500 million people. Our results suggest that PDS transfers led to large improvements in nutrient intake and sizable reductions in child stunting. In the eight states we study, which cover about 41 percent of India's population, our back-of-the-envelope estimates suggest that the PDS expansion following the NFSA prevented 1.8 million children from being stunted.

I. Institutional Background

The Indian Public Distribution System (PDS) is one of the largest social programs in the world, and the largest social program in India, accounting for almost 1 percent of the country's GDP (costing approximately US$10 billion in 2016 (Government of India 2017)). The PDS has been in existence since before India's independence. It was initially established as a rationing system by the British government during World War II to ensure workers in a few urban centers received food (Nawani 1994). In the early 1970s, the PDS evolved into a social program with the primary objective of providing food security to vulnerable households. Since then, the PDS has been the primary social program for food security in India.

In 1997, the Indian central government reformed the PDS from a universal system to a targeted program that supported the poor, using a system of household-level allocations based on ration cards. This system was expanded in 2002 and further reformed by the National Food Security Act (NFSA) in 2013. This section describes the basic structure of the PDS system since 2002, and gives a brief outline of the changes brought about by the NFSA. More details about how these changes shape our identification strategy are given in Section III.

A. *Basic Structure of the PDS System*

The PDS is based on a system of ration cards that the government issues to households below the poverty line, which entitle them to receive a set quantity of food grains at a fixed price. There are two main types of ration cards: Below Poverty Line (BPL) and Anthodaya Anna Yojanaa (AAY).[5] BPL cards are targeted to households below the poverty line, while AAY cards are reserved for the poorest of the poor who are disadvantaged in other ways, such as widows, the disabled, or the elderly. Ration cards are allocated through a two-step process involving central and state governments. First, the central government uses census data to determine the number of BPL and AAY households to be covered under the PDS in each state. State

from personal fieldwork and government records, allows us to precisely calculate each household's PDS entitlement based on state-level policies.

[5] There is also a third type of ration card—Above poverty Line (APL)—for households above the poverty line. APL cardholders in general do not receive any food grains, and food allocation for APL households is on an ad hoc basis. We focus our attention on the ration cards that are entitled to receive PDS rations: BPL and AAY.

governments then use proxy means tests to allocate ration cards among their population. For example, during the pre-NFSA period 2002–2013, the central government estimated that the state of Bihar had 6.5 million households below the poverty line, of which 2.5 million were determined to be AAY. Accordingly, the state issued 4 million BPL cards and 2.5 million AAY cards based on a proxy means test that consisted of a series of exclusion restrictions (for example, households that owned more than five acres of land or an automobile were ineligible).[6] As identification of households is based on census data, ration cards in most states are not updated regularly (Saxena 2009; Drèze and Khera 2010).

Every year, the central government supplies state PDS systems with subsidized grain through an agency called the Food Corporation of India (FCI), which procures rice and wheat from farmers across the country and stores it in government-operated warehouses. The FCI offers grain to states at a uniform subsidized price called the central issue price, up to a maximum quantity that depends on the number of eligible households in the state. In the pre-NFSA period, the central issue price was 5.65 Rs/kg for rice and 4.15 Rs/kg for wheat for BPL households. The maximum quantity offered to a state was 35 kg of grain per month per household with a ration card.[7] The central issue price and quantity allocations from the center to the states remained constant during the pre-NFSA period, for both BPL and AAY cardholders.

State governments choose how much grain to buy from the FCI, up to the maximum offered quantity, and distribute it through a network of over 500,000 retail outlets known as fair price shops, each serving a large village or a cluster of villages. With a fair price shop in almost every village in India, the PDS is the most far reaching of all social safety nets in the country.[8] At the fair price shop, beneficiaries with a ration card are allowed to purchase up to a fixed quantity of food grains at a fixed price, both set by the state government.

Before the NFSA, states had substantial discretion over the prices and quantities they offered to ration cardholders. A number of states chose to offer PDS grains at prices below the central issue price. For instance, Jharkhand offered rice to BPL households at a price of 1 Rs/kg. The cost of this additional discount was borne by the state budget, since the revenues of the fair price shops were smaller than the outlays to the FCI. Moreover, states were also free to sell PDS grains at prices above the central issue price. This was only true for sales to BPL households. For AAY households, the central government mandated that states had to sell the full allocation of 35 kg per household at a price no higher than the central issue price. For instance, pre-NFSA, the state of Bihar offered PDS rice to BPL households at

[6] States had some flexibility in deciding the precise nature of the proxy means test used to allocate ration cards. For a more detailed account of ration card identification and allocation, see Saxena (2009)

[7] For example, since Bihar had 4 million households with BPL cards, it was entitled to a monthly maximum of 140,000 metric tons for BPL households at 5.65 Rs/kg for rice and 4.15 Rs/kg for wheat (4 million BPL households $\times$ 35 kg). States were also allowed to issue more ration cards and cover more beneficiaries than the number of households determined to be eligible by the center, by procuring additional food grains from sources other than the FCI. For instance, pre-NFSA, Andhra Pradesh issued 16.2 million BPL ration cards, compared to 4.1 million below poverty-line households identified by the center. Furthermore, some states, such as Maharashtra and Orissa, use fair price shops to provide food rations to households above the poverty line at a higher price, on an ad hoc basis, based on the availability of food grains.

[8] In 2011, there were 506,198 PDS ration shops (Government of India 2011b) in 597,608 inhabited villages (Government of India 2011a). The coverage increased to 532,000 ration shops by 2016 (Government of India 2016).

a price of 7 Rs/kg, compared to the central issue price of 5.65 Rs/kg. Quantity entitlements of PDS grain also varied across states. There was also substantial variation in how states calculated quantity entitlements. The most generous state, Jharkhand, allocated 35 kg of total grain to every eligible household, while Gujarat only allocated 18 kg. Furthermore, some states calculated quantity entitlements at the individual level (Andhra Pradesh and Karnataka), while the rest calculated them at the household level.

B. *National Food Security Act*

In 2013, the Indian central government passed the National Food Security Act (NFSA), which guaranteed a minimum quantity of food grains at affordable prices to every eligible person in India. The NFSA, labelled as the biggest ever expansion of the "right to food" in the world, created a "legal entitlement" to food for PDS beneficiaries (NFSA 2013) and increased the central government's outlays on the program by as much as 25 percent (or Rs 230 billion) from the previous fiscal year (Government of India 2014). Importantly, the NFSA increased the central government's generosity of PDS allocations to the state governments: the central issue price was reduced to 3 Rs/kg for rice and 2 Rs/kg for wheat, and the quantity allocations from center to state was switched to an allotment of 5 kg per eligible individual. The switch to individual-level allotment was directed toward bringing about greater equity in food grain allocation for larger households. The NFSA retained the pre-NFSA entitlements for the AAY households at 35 kg/HH at a price no higher than the central issue price. In addition, APL households were not entitled to receive any food grains and were excluded under NFSA.

Crucially for our analysis, the NFSA created a binding legal mandate that states provide at least 5 kg of grains to eligible individuals at a price of no more than 3 Rs/kg for rice and 2 Rs/kg for wheat. This mandate forced states to pass through central issue prices and quantities to beneficiaries. As a result of this provision, states whose PDS systems were less generous than envisioned by the NFSA had to expand their entitlements to come into attainment with the mandate. In addition, the provision forced states to calculate PDS entitlements on a per individual basis, where most states had previously calculated them on a per household basis. In those states, the switch to individual-level entitlements led to a greater expansion of PDS entitlements for large households relative to small ones. In principle, the switch to individual-level could have led to a decrease in entitlements for small households. However, in practice, this was largely outweighed by the overall increase in the price and quantity mandates. Our data suggest that 72 percent of BPL households experienced an increase in PDS entitlements after NFSA and only 3.6 percent of households experienced a decrease in PDS entitlements.

The central government provided some flexibility to the states in implementing NFSA. While the NFSA was being drafted and debated in the parliament, several states raised concerns that the NFSA might limit the prevalent PDS systems that were more generous than the NFSA mandate (Banik 2016). Consequently, the final enactment of the NFSA allowed states that had more generous PDS systems than the NFSA mandate to keep their entitlements unchanged (NFSA 2013). States also had some discretion on when to implement NFSA, though most states had implemented the reform's main provisions by the start of 2014. Our empirical strategy, described in the next section, ignores state-level variation in the date of implementation of the NFSA provisions, to avoid concerns about endogenous timing.[9]

II. Data

We use the new wave of ICRISAT's panel study Village Dynamics in South Asia (VDSA). These data contain longitudinal information on 1,300 households comprised of 7,000 individuals from July 2010 to June 2015 (VDSA 2015). Households were randomly selected from 30 villages spread across 8 states in India: Andhra Pradesh, Bihar, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, and Orissa.[10] Four villages were selected from each state (except Madhya Pradesh, from which two were selected) to represent the agroclimatic conditions in India's semiarid and humid tropical regions. The geographical locations of the villages are shown in Supplemental Appendix Figure A1. Households in each village were randomly selected to represent four landholding classes: large, medium, small, and landless. All 30 villages have a PDS fair price shop.

Table 1 presents summary statistics at baseline. The VDSA data sample is primarily focused on smallholder farmers in rural and impoverished regions and may not cover all types of households. About 78 percent of the sample households depend on agriculture for their livelihood. Although VDSA is not a representative sample, many of the VDSA sample characteristics, including household expenditures, household calorie and nutrient intake, child stunting rates, are comparable to rural India averages. For example, the daily per adult equivalent consumption in the VDSA sample was 2,560 kcal of energy, 67 g of protein, and 49 g of fat. These numbers are comparable to national rural averages from the most recent round of NSSO in 2011–2012, which showed daily per capita consumption of 2,233 kcal, 60.7 g of protein, and 46 g of fat (NSSO 2014). Similarly, the monthly per capita expenditure in the VDSA sample was Rs 1,144, which is comparable to the national rural average of Rs 1,430, based on the NSSO round in the 2011–2012 period (NSSO 2014). Furthermore, the VDSA sample's child stunting rate of 38.7 percent is broadly similar to national stunting rates in rural India of 41 percent for children under 5 reported in the National Family Health Survey 2015–2016.

Attrition is minimal in the ICRISAT data. Before NFSA, we observe 1,683 children and adolescents with anthropometrics and age data, and among these individuals only about 151 children and adolescents are not observed after NFSA. Unbalance on individual anthropometric data is most likely related to the individual not being present in the household at the time of data collection, rather than

[9] While the NFSA mandated a time limit of one year for the states to implement the provisions, the deadline was extended several times due to delays in implementation (Puri 2017). The political alignment between the center and state governments also played a role in when the states enacted NFSA (Jakobsen 2019). States that were of the same political party as the central government (such as Karnataka and Maharashtra) more readily adopted NFSA, while state governments that were of the opposition party (such as Gujarat) were more restrained in adopting NFSA.

[10] Two villages are in Telangana, a state formed in 2014. As our dataset begins before the formation of the new state, and for the purpose of consistency, the two villages in Telangana are considered as Andhra Pradesh.

Table 1—Summary Statistics

	Beneficiaries	Nonbeneficiaries	Total
Anthropometrics (children aged 0 to 5yrs)			
Height-for-age z-score (HAZ)	−1.582	−1.354	−1.485
	(1.581)	(1.618)	(1.600)
Stunting	0.405	0.361	0.387
	(0.491)	(0.481)	(0.487)
Household nutrient intake (HHs with children 0 to 5 yrs)			
Energy (daily kcal/person)	2,530.1	2,603.2	2,560.3
	(659.0)	(730.9)	(690.5)
Protein (daily grams/person)	65.2	70.0	67.2
	(18.3)	(20.3)	(19.3)
Fat intake (daily grams/person)	44.2	55.7	49.0
	(21.4)	(25.9)	(24.1)
Household expenditures (in rupees per capita per month)			
Total expenditures	1,047.7	1,278.7	1,144.0
	(697.2)	(885.6)	(789.5)
Food expenditures	583.7	705.9	634.6
	(233.8)	(295.7)	(268.2)
Nonfood expenditures	454.4	554.2	495.7
	(545.6)	(656.6)	(596.1)
Household consumption quantity (in kgs per capita per month)			
Rice and wheat (excluding PDS)	6.8	10.3	8.3
	(5.1)	(6.0)	(5.8)
Rice and wheat (from PDS)	4.9	0.8	3.2
	(3.3)	(2.1)	(3.5)
Household labor outcomes			
Household wage earnings	984.7	708.8	871.9
(rupees/month per capita)	(785.9)	(752.4)	(784.2)
Individual wages (rupees/day)	180.4	198.5	186.8
	(100.9)	(107.6)	(103.7)
Household market labor supply	39.6	33.4	37.4
(days/month)	(23.9)	(19.4)	(22.6)
Household characteristics			
Household size	5.9	6.1	6.0
	(2.4)	(2.6)	(2.5)
Landholding size (in acres)	3.4	5.7	4.4
	(4.1)	(7.8)	(6.1)
Education of head (in years)	3.7	6.8	5.0
	(4.2)	(4.8)	(4.7)

Notes: This table reports summary statistics of the ICRISAT's VDSA data that corresponds to the baseline period before 2013. "Beneficiaries" refers to households that possess a PDS ration card, "Nonbeneficiaries" refers to household without a PDS ration card, and "Total" refers to the entire sample. Market wages and wage earnings are trimmed at the top 5 percent of the distribution. Expenditures are deflated using rural CPI general index with 2010 base year (CSO 2014), and represent 2010 real value per capita per month. Standard deviations are reported in parentheses.

households dropping out (less than 4 percent of households attrited from the panel after NFSA). Nonetheless, we validate that attrition is uncorrelated to the expansion in PDS transfers after NFSA in Supplemental Appendix Table A1.

We construct our main outcomes with individual-level anthropometric data on height, weight, and arm circumference, as well as individual characteristics such as age and gender. All of these data are collected annually at the beginning of the panel year in July. For the household-level analysis, we use household-level data on item-wise consumption, collected monthly. We convert food consumption quantities and expenditures into their nutrient content (calorie, protein and fat) using the nutrient value of Indian food items, based on NSSO (2014) and Gopalan, Rama Sastri, and Balasubramanian (1991). We identify PDS beneficiary households using their ration card status at baseline in 2009 (we use baseline status to avoid bias from potentially endogenous changes in ration card status). Price data used to calculate the value of the PDS transfer come from the price schedule in the VDSA data and correspond to a comparable variety of PDS rice and wheat. For the labor market analysis, we aggregate the individual-level data on labor supply and wages collected every month to the household-level, and trim the top 5 percent of wages to remove outliers that may be due to misreporting.

Our main outcome of interest is a stunting indicator, defined as a height-for-age z-score (HAZ) under -2 standard deviations of the WHO guidelines (WHO 2006). A HAZ value of -1 indicates that, given sex and age, a child's height is one standard deviation below the median child in her age/sex reference group. We also construct indicators for severe stunting that equals one if $HAZ < -3$, and an indicator of moderate stunning that equals one is $-3 \leq HAZ < -2$. We also report the direct effects on HAZ and on additional measures of child malnutrition, including weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), and mid-upper-arm circumference-for-age z-score.

One limitation of the VDSA data is that it did not collect exact information on individuals' day or month of birth. As a result, age is only measured in full years, e.g., a child aged 2 years and 6 months is recorded as age 2. This introduces measurement error in the z-score calculation, since we use the reference population for the exact reported age, but children may actually be several months older. In principle, this may lead us to underestimate the amount of stunting in the sample, since the reference population is younger than the sample population. However, our estimated stunting rate in the sample of children under 5 is 38.7 percent, which is close to national estimates of the stunting rate of 41 percent in rural India in 2015, which suggests that we do not substantially underestimate stunting. Since age measurement is unlikely to be correlated with the NFSA-induced change in PDS transfers, it should not lead to bias in our estimates. Furthermore, our preferred measure of stunting is binary, with a threshold close to the center of the distribution, which makes our estimates less susceptible to outliers created by mismeasured ages. We also confirm that our results are robust to using the height-for-age z-score as the outcome, though these estimates are noisier due to the larger influence of outliers and measurement error.

Table 1 presents summary statistics at baseline. We find stunting rates of 38.7 percent in children under 5 years old. Supplemental Appendix Figure A2 shows the distribution of height-for-age z-scores at baseline.[11] Nutrient intake on average is adequate in this setting and meets the minimum recommended levels: At baseline, the average daily per adult equivalent consumption was 2,560 kcal of energy, 67 g of

[11] Only 1.6 percent of children were overweight, suggesting that undernutrition is more of a concern than the double burden of malnutrition in the VDSA study population. Undernutrition among adult women in the study sample is also high. About 31 percent of adult women aged 18 to 49 are underweight (BMI $<$ 18.5) and only 1.4 percent are obese (BMI $>$ 30).

protein, and 49 g of fat. The minimum levels of per capita daily calorie, protein, and fat intake for our sample household's age and gender composition is 2,257 kcal, 50 g of protein, and 30 g of visible fat, based on the dietary guidelines for moderate work from the Indian Council of Medical Research (ICMR). While nutrient intake in the VDSA sample households meets the minimum guidelines on average, only about 17 percent of households always meet the calorie requirement over the entire sample period, and only about 34 percent of households always meet their protein requirement, which suggests that many households experience periods of poor nutrition.

The household's average labor supplied to the market (including all members in the household) is 41 person-days per month at an average daily wage rate of 187 Rs/day. Most of the beneficiaries in the sample are landless agricultural laborers and small farmers who work in the casual nonfarm labor market. Non-beneficiaries include medium and large farmers and individuals who are employed in the formal sector with a salaried job.

Rainfall data are from the Indian Meteorological Department, measured at a high spatial resolution of 0.25 degree $\times$ 0.25 degree grid cells (Pai et al. 2014). Daily rainfall data for the ICRISAT villages are obtained by mapping the village coordinates to each grid cell. No two villages are located in the same grid cell, and hence our rainfall measure varies by village. In this study, we use the z-score of rainfall quantity relative to the village's 60-year average as a measure of the rainfall shock.

III. Empirical Strategy

Table 2 shows how PDS entitlements were calculated in all eight states in our sample before and after the NFSA. As shown in column A, before NFSA, states had substantial discretion over PDS prices and quantities, with rice prices ranging between 1 Rs/kg in Jharkhand and 7 Rs/kg in Bihar, and quantity entitlements varying between 18 kg per household in Gujarat and 35 kg per household in Jharkand. Most states calculated quantity entitlements at the household level, the exception being Andhra Pradesh and Karnataka, which calculated them at the individual level.

As explained previously, the NFSA created a binding mandate that forced states to provide at least 5 kg of grains to eligible individuals at a price of no more than 3 Rs/kg for rice and 2 Rs/kg for wheat. This provision created substantial variation in PDS transfers based on complex interactions between four variables: state, time, household size, and eligibility (ration card) status. Eligible households in some states saw their transfers increase more than in others, depending on the state's baseline PDS policies. Among eligible households in the same state, the size of the increase further varied by household size, but more so in some states than others, again depending on baseline PDS policy.

In particular, our empirical strategy exploits three sources of variation:

- State-level variation based on NFSA mandate: States whose pre-NFSA prices or quantities fell short of the mandate had to expand the generosity of their PDS transfers, while states who were already in attainment of the mandates did not. Eligible households who lived in nonattainment states thus saw their PDS entitlements expand more than eligible households in attainment states.

Table 2—State-Level PDS Policy Changes

		PRE-NFSA (A)		POST-NFSA (B)		NFSA Target (IV) (C)	
	Item	Quantity	Price	Quantity	Price	Quantity	Price
				Oct. 14			
Andhra Pradesh[a]	Rice	4 kg/indv (Max of 20 kg/HH)	1 Rs/kg	6 kg/indv (No ceiling)	1 Rs/kg	5 kg/indv	1 Rs/kg
	Wheat	No wheat ration					
				NFSA–Feb. 14			
Bihar	Rice	15 kg/hh	7 Rs/kg	3 kg/indv	3 Rs/kg	3 kg/indv	3 Rs/kg
	Wheat	10 kg/hh	5 Rs/kg	2 kg/indv	2 Rs/kg	2 kg/indv	2 Rs/kg
Gujarat[b]	Rice	5 kg/hh	3 Rs/kg	No changes		1 kg/indv	3 Rs/kg
	Wheat	13 kg/hh	2 Rs/kg			4 kg/indv	2 Rs/kg
Jharkhand	Rice	35 kg/hh	1 Rs/kg	No changes		No changes	
	Wheat	No wheat ration					
				Anna Bhagya Yojana July 13			
Karnataka[c]	Rice	4 kg/indv	3 Rs/kg	30 kg/hh	1 Rs/kg	4 kg/indv	3 Rs/kg
	Wheat	1 kg/indv (Max 25 kg/HH)	3 Rs/kg	3 kg/hh	3 Rs/kg	1 kg/indv	2 Rs/kg
				NFSA–Feb. 14			
Maharashtra	Rice	10 kg/hh	6 Rs/kg	2 kg/indv	3 Rs/kg	2 kg/indv	3 Rs/kg
	Wheat	15 kg/hh	5 Rs/kg	3 kg/indv	2 Rs/kg	3 kg/indv	2 Rs/kg
				NFSA April 2014			
Madha Pradesh[d]	Rice	2 kg/hh	4.5 Rs/kg	1 kg/indv	1 Rs/kg	1 kg/indv	3 Rs/kg
	Wheat	18 kg/hh	3 Rs/kg	4 kg/indv	1 Rs/kg	4 kg/indv	2 Rs/kg
				Feb. 13			
Orissa	Rice	25 kg/hh	2 Rs/kg	25 kg/hh	1 Rs/kg	No changes	
	Wheat	No wheat ration					

Notes: NFSA targets assume that all states complied with the mandate in March 2013, when NFSA was officially ratified by the Indian Union Cabinet (NFSA 2013; Parliament of India 2014; USDA 2013; The Hindu 2013).

[a] Andhra Pradesh (AP) decreased rice price to 1 Rs/kg in November 2011. AP split into two states in 2014, namely Telangana and AP. In October 2014, Telangana increased rice quantity entitlement to 6 kg/member, and in April 2015, AP increased the quantity entitlement to 5 kg/member.

[b] Gujarat enacted NFSA in 2016, which is not captured in our study time frame.

[c] Karnataka reduced wheat price to Re 1/kg in October 2013 under the Anna Bhagya Yojana.

[d] Madhya Pradesh (MP) introduced Mukhyamantri Annapurna Scheme in July 2013 and reduced rice price to 2 Rs/kg and wheat price to 1 Rs/kg. In February 2014, MP further reduced rice price to 1 Rs/kg.

Sources: Information on state-level PDS entitlements pre- and post-NFSA (columns A and B) comes from author's fieldwork and government records. The NFSA target IV (column C) is based on the counterfactual scenario that assumes that each state only expanded by the minimum amount needed to comply with NFSA mandate.

- Within-state variation by household-size based on NFSA's switch to per individual entitlement: Before the NFSA, many states calculated rations on a per household basis, allocating a fixed amount of grain to each eligible household regardless of size. In those states, the switch to per individual allocation benefited large households relative to small ones.
- Household-level variation based on ration cards: Some households had PDS ration cards at baseline and some did not. Households who did not have a ration card were unaffected by the PDS reform and serve as an internal control group.

We combine these three sources of variation to construct a precise measure of PDS transfer value T_{hst} that a household h is entitled to receive in state s at time t as a function of household baseline characteristics (state of residence, household size and ration card).

We use this variation to estimate the effect of food transfers on child stunting and other related outcomes in a set of fixed effects regressions that includes individual and year fixed effect. The fact that, within the same state, households with different sizes and eligibility status are affected differently by the NFSA reform, allows us to further control for a wide set of unobserved time-varying shocks, by including state-by-time, household-size-by-time, and ration-card-by-time fixed effects.

The state-by-time fixed effects absorb all cross-state differences in the expansion of the average PDS transfer after the NFSA and control for time-varying. The household-size-by-time and ration-card-by-time fixed effects control for any time-varying effects of the other sources of identification, household-size, and eligibility. After controlling for the full set of two-way fixed effects, our estimates are only identified by the higher-order interactions of state, time, PDS eligibility, and household size.[12] Identification in these regressions thus follows the same logic as a "triple-difference" approach, based on comparing of households observed in the same state and same year whose PDS transfers were affected to different extents by the NFSA.

The next two subsections describe the two sources of variation generated by the NFSA in more detail. We then continue by describing how we aggregate this variation into a household-level measure of the value of PDS entitlements before and after the NFSA, and how we use this variation in our instrument. Finally, we describe the regression equations that allow us to estimate the effect of PDS entitlements on undernutrition outcomes of children.

A. *State-Level Variation Generated by the Price and Quantity Mandates*

The left panel in Figure 1 shows the time series of the PDS rice prices offered to BPL households by the eight states in our data. The graph shows that states for which PDS prices were initially above 3 Rs/kg decreased their prices to meet the NFSA targets. For instance, the states of Bihar and Maharashtra reduced their prices from 7 Rs/kg and 6 Rs/kg to the mandated price of 3 Rs/kg. The figure shows that the price mandate was binding; by the beginning of 2014, all states had reduced their PDS rice prices to 3 Rs/kg or less.

Figure 1 also shows that most states that were already in attainment with the mandate continued with their existing entitlements. For instance, Jharkhand and Andhra Pradesh, whose PDS rice price was already below the new mandate at 1 Rs/kg, left the price unchanged. An exception is the state of Karnataka, where the pre-NFSA rice price was 3 Rs/kg, and so it was therefore already in attainment with the mandate. Nevertheless, Karnataka voluntarily reduced its PDS rice price to 1 Rs/kg.

[12] Note that the other two-way interactions—state-by-ration-card, state-by-household-size, and ration-card-by-household-size—are all subsumed by the household fixed effects. (We measure ration card status and household size in the baseline year, so these variables do not change over time.)

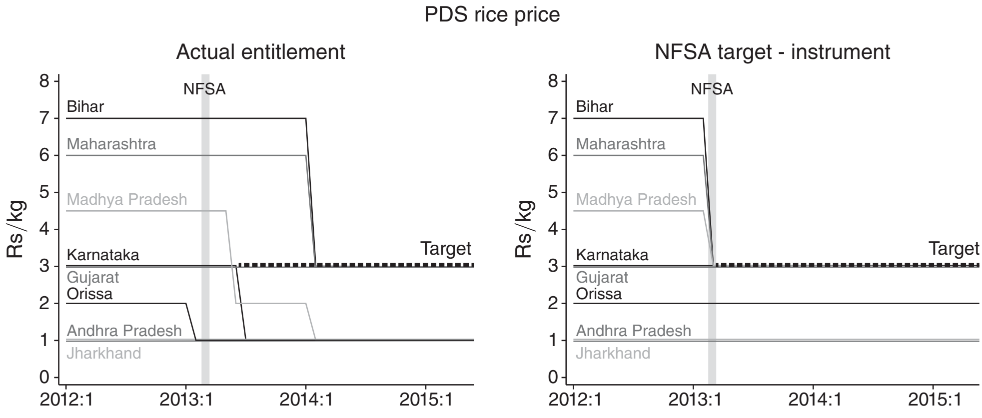

Figure 1. State-Level Variation in PDS Rice Price

Notes: The left panel shows the actual entitlement, and the right panel shows the counterfactual NFSA target (instrument). The solid lines denote PDS rice prices in Rs/kg for BPL households in the eight states in the ICRISAT panel. The dashed vertical line denotes NFSA target price of 3 Rs/kg. The horizontal shaded line denotes the time of NFSA approval. Information on state-level PDS entitlements (left panel) comes from author's fieldwork and government records. The NFSA target (right panel) is based on the counterfactual scenario that assumes that each state only expanded by the minimum amount needed to comply with the NFSA price mandate.

The figure further shows that some states that were initially out of compliance with the mandate expanded their entitlements more than necessary. For instance, Madhya Pradesh reduced its PDS rice price from 4.5 Rs/kg to 1 Rs/kg, even though a reduction to 3 Rs/kg would have sufficed to comply with the mandate.

The voluntary expansions of state PDS programs sometimes coincided with state elections, which could bias our estimates by introducing correlation between entitlements and unobserved determinants of food security.[13] To address this concern, our empirical strategy instruments actual PDS entitlements with counterfactual entitlements that would have existed if every state had expanded the program by the bare minimum necessary to comply with the NFSA mandate. The right panel of Figure 1 shows the evolution of counterfactual rice prices. As shown in the graph, we assume that states already in attainment with the price mandate, such as Jharkhand and Andhra Pradesh, made no changes to PDS prices. We further assume that states that voluntarily lowered their prices beyond NFSA targets, such as Madhya Pradesh and Karnataka, only lowered their prices to 3 Rs/kg for rice and 2 Rs/kg for wheat, the highest prices that comply with the mandate. Finally, we assume that all states complied with the mandate in March 2013, when NFSA was officially ratified by the Indian Union Cabinet (NFSA 2013; Parliament of India 2014; USDA 2013; Parsai 2013), ignoring state-level variation in the timing of the reform's implementation.

[13] For instance, the first executive decision by the Chief Minister of Karnataka in 2013 was to introduce Karnataka's own PDS program "Anna Bhagya Yojana," fulfilling an election promise of reducing the price of PDS rice to 1 Rs/kg (Deccan Herald 2013*b*). Similarly, the chief minister of Madhya Pradesh introduced the "Mukhyamantri Annapurna Scheme" as part of his election manifesto, and reduced the price for PDS rice to 1 Rs/kg (Deccan Herald 2013a).

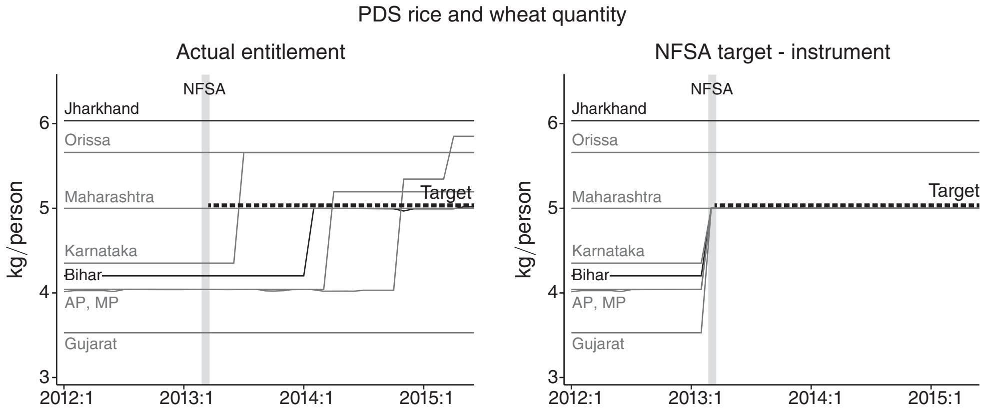

Figure 2. State-Level Variation in PDS Quantity

Notes: Left panel shows the actual entitlement and right panel shows the counterfactual NFSA target (instrument). The solid lines denote PDS quantity in kg/person for BPL households in the eight states in the ICRISAT panel. The dashed vertical line denotes NFSA target quantity of 5 kg/person. The horizontal shaded line denotes the time of NFSA approval. Information on state-level PDS entitlements (left panel) comes from author's fieldwork and government records. The NFSA target (right panel) is based on the counterfactual scenario that assumes that each state only expanded by the minimum amount needed to comply with NFSA quantity mandate.

Figure 2 shows the analogous variation created by state-level compliance with the NFSA quantity mandate. The left panel shows the evolution of per capita quantity entitlements over time. As shown, six of the eight states in our sample initially had entitlements below the NFSA mandate of 5 kg per capita. Five of these states raised their entitlement to comply with the NFSA mandate. The exception is Gujarat, which waited until 2016, after the end of our period of observation, to bring its quantity entitlement in line with the NFSA mandate. Jharkhand and Orissa, the two states in which quantity entitlement already exceeded 5 kg per capita, left their entitlements unchanged.

As with the price mandate, several states expanded their entitlements beyond the level necessary to comply with the NFSA mandate, specifically Karnataka and Andhra Pradesh. As before, we construct counterfactual PDS entitlements that ignore these voluntary expansions beyond the NFSA mandate. Thus we assume that states that voluntarily increased their quantity entitlements beyond the NFSA target level, such as Karnataka and Andhra Pradesh, instead did the bare minimum to reach compliance (column B in Table 2). To construct these counterfactuals, we assume that all states changed their entitlement to 5 kg per individual. States whose entitlements were already above 5 kg are assumed to have left their entitlements unchanged.

An additional complication comes from the fact that the NFSA mandated 5 kg of grains per individual, but let states decide how this total would be split between rice and wheat. To calculate our counterfactual entitlements based on compliance with the NFSA mandate, we assume that states kept their proportional split between rice and wheat approximately constant as they expanded entitlements. For instance, Bihar's pre-NFSA entitlement was 15 kg/household of rice and 10 kg/household of wheat. We therefore assume that Bihar complied with the NFSA mandate by moving to a post-NFSA entitlement of 3 kg/individual of rice and 2 kg/individual of wheat. For details, see Table 2, which shows actual and counterfactual price and quantity entitlements for all states in our sample.

B. *Within-State Variation Generated by the Switch to Individual Entitlements*

A second source of variation for our empirical strategy comes from the NFSA's provision that PDS entitlements be calculated at the individual level instead of the household level. As shown in Table 2, column A, six out of the eight states in our sample calculated entitlements entirely at the household level pre-NFSA, regardless of household size. The two remaining states, Andhra Pradesh and Karnataka, calculated entitlements on a per individual basis, but imposed a maximum ceiling per household. After the NFSA, all states had to calculate entitlements entirely at the individual level, providing 5 kg of grain per person, without regard to household size. The switch to per individual allocation benefited larger households at the expense of smaller ones.

The left panel of Figure 3 shows the time-path of per capita entitlements for households of different sizes. Initially, smaller households have more generous per capita entitlements than larger ones, a consequence of the per household allocation formula used by most states. After the NFSA, households of all sizes receive approximately equal per capita allocations, as the entitlements are now calculated per individual. Consequently, post-NFSA, the quantity entitlements increased substantially for large households (by around 2 kg/person as shown in Figure 3), whereas they remained the same and reduced only slightly for small households. Therefore, post-NFSA, quantity entitlements increased to a greater extent for large households relative to small ones.

As with the state-level price and quantity mandate, compliance with the individual allotment provision was not perfect, and households of different sizes still have slightly different average PDS entitlements after NFSA took effect. This is because certain states, such as Karnataka, negotiated an exception with the central government that allowed them to calculate entitlements at the household level even after the NFSA took effect. As before, we deal with the issue of noncompliance by calculating entitlements under the counterfactual of full compliance with NFSA provisions. The right panel of Figure 3 shows these counterfactual entitlements, which change to 5 kg per capita for all households immediately after NFSA was ratified in 2013.[14]

C. *Calculating the Value of PDS Transfers*

We aggregate the variation generated by the NFSA into a household-specific measure of PDS transfer value. We begin by calculating the price and quantity of

[14] One possible reason why the central government let Jharkhand and Orissa continue to calculate entitlements at the household level is that their average pre-NFSA entitlement was above 5 kg per capita, even though it was less than that for some large households. To test robustness to our definition of compliance with the mandate, we construct an alternative set of counterfactual entitlements, for which we assume that states in which the average pre-NFSA entitlement was above 5 kg per capita were considered in attainment. Estimates based on this counterfactual instrument are very similar to those of our baseline definition of compliance.

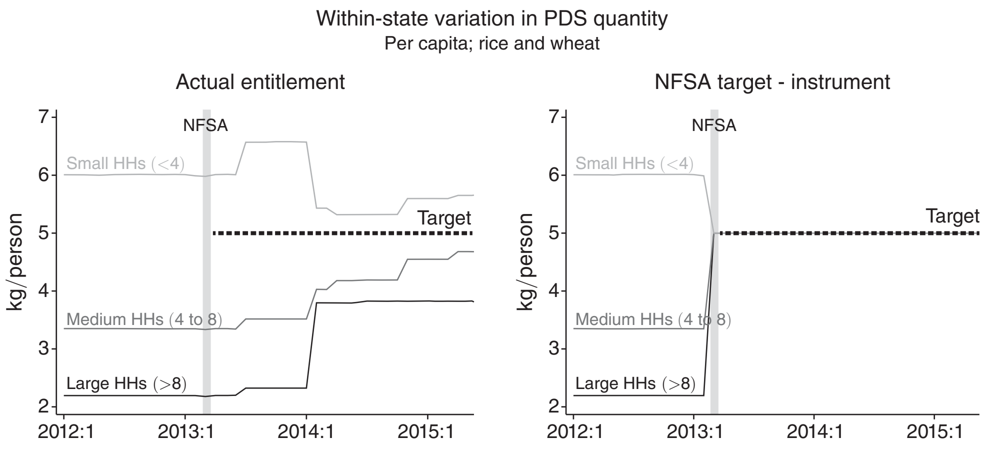

Figure 3. Within-State Variation in PDS Quantity

Notes: The left panel shows the actual entitlement, and the right panel shows the counterfactual NFSA target (instrument). The solid lines denote PDS quantity in kg/person for small, medium, and large BPL households in the ICRISAT panel. Households with less than four members are denoted as small, between four and eight members are denoted as medium, and those with more than eight members are denoted as large. The dashed vertical line denotes NFSA target quantity of 5 kg/person. The horizontal shaded line denotes NFSA approval. Information on state-level PDS entitlements (left panel) comes from author's fieldwork and government records. The NFSA target (right panel) is based on the counterfactual scenario that assumes that each state only expanded by the minimum amount needed to comply with NFSA quantity mandate.

PDS grain the household was entitled to in a given year, based on the household's baseline characteristics (ration card status, household size, and state of residence) and the state-level PDS policy active in that year. We then quantify the value of the transfer by calculating the product of quantity entitlement and price discount (difference between the market and PDS price).[15]

$$T_{hst} = \overbrace{Q_{hst}^{pds\ rice}\left[\bar{P}^{Market\ rice} - P_{hst}^{pds\ rice}\right]}^{Rice} + \overbrace{Q_{hst}^{pds\ wheat}\left[\bar{P}^{Market\ wheat} - P_{hst}^{pds\ wheat}\right]}^{Wheat}. \tag{1}$$

The variables Q_{hst}^{pds} and P_{hst}^{pds} are the PDS quantity and price entitlements for household h in state s in month t. These entitlements are a function of the PDS policy in the household's state of residence s at time t as well as the household's size and ration card status. To address the concern that household characteristics may be affected by the NFSA reforms, or that households may have migrated in response to reforms, we calculate Q_{hst}^{pds} and P_{hst}^{pds} using household characteristics measured at

[15] Measuring the generosity of PDS subsidies in terms of their implicit transfer value is valid if the subsidized amount is inframarginal, so that consumption of staple cereals is more than what is provided by the PDS. Our data suggests that this is generally the case for households in our sample. The average household in our data consumes 48 kg of staple cereals as compared to a maximum of 35 kg of grains per household provided by the PDS. All of our sampled households consume more staples than their PDS ration in given month.

baseline: household's ration card status in 2010, and average household size in the period of 2010–2012.[16] We set $T_{hst} = 0$ for households who do not have a ration card. All prices are adjusted for inflation using the Consumer Price Index for Rural India using 2010 as the base year, so that T_{hst} reflects the real value of the transfer at constant 2010 prices.

The market price $\bar{P}^{Market}$ is defined as the national average market price in India before 2013. The national average market price was 22 Rs/kg for rice ($= \bar{P}^{Market\ rice}$) and 15 Rs/kg for wheat ($= \bar{P}^{Market\ wheat}$). We use a constant, national average to avoid endogeneity between grain prices in a state and the state's PDS policies. We further use the baseline average before 2013 to avoid endogeneity from the effect of the NFSA on grain prices. Thus, our measure of the price is designed to be exogenous to baseline state PDS policies, as well as policy changes induced by the NFSA. Our measure T_{hst} might be a slight underestimate of the true value of the transfer for two reasons. First, it is possible that PDS transfers can lead to a decrease in local consumer prices (Cunha, De Giorgi, and Jayachandran 2019). We explore this issue in Supplemental Appendix A1. We find no evidence that an increase in PDS transfers led to reductions in local market prices of rice and wheat, though our analysis likely lacks the statistical power to detect effects of small to moderate size. Second, it is possible that PDS transfers can have an additional insurance value against price fluctuations (Gadenne et al. 2021). We show that PDS transfers can protect anthropometric outcomes during drought conditions, when food prices tend to be high, consistent with an insurance effect in Section VII. If households value this insurance effect, the true value of the transfer may be higher than the value of T_{hst} calculated at constant prices. The true value would be a function of the household's ability to store food and their risk aversion and would be difficult to estimate. Our estimates should thus be interpreted as the effect of a 1 rupee increase in the direct value of the transfer at constant prices.[17]

As discussed previously, some states "overshot" the NFSA mandate and expanded their PDS entitlements by more than would have been necessary to come into attainment, while other states were slow to implement the mandate. This introduces potential endogeneity between policy changes and unobserved determinants of food security. For example, states that experienced negative shocks to food security among poor households may have expanded their PDS program earlier and more extensively than states that did not experience such shocks, leading to a correlation between changes in PDS policies and food security shocks that could bias our estimates. To avoid this endogeneity, we instrument for actual entitlements

[16] We use baseline ration card status for two reasons. First, we only observe ration card status for all 5 years in the 12 East India villages; in the 18 semiarid topic villages, we only have ration card status in 2010. Second, one might be concerned that changes in ration card status might be induced by the NFSA, although we see limited evidence that this might be the case in the East Indian villages where 92 percent of the households retained their status, while 5 percent gained a ration card and 2 percent lost their ration card status.

[17] To illustrate the calculation of the transfer value in equation (1), take the example of a household of six people in Bihar in 2012. This household received 15 kg of rice at 7 Rs/kg and 10 kg of wheat at 5 Rs/kg. The national average market price was 22 Rs/kg for rice and 15 Rs/kg for wheat. These numbers yield a price discount of 15 Rs/kg for rice and 10 Rs/kg for wheat and a transfer value of Rs 325 ($T_{hst} = 15 \times 15 + 10 \times 10$). After the NFSA reforms, the same household received 18 kg of rice at 3 Rs/kg and 12 kg of wheat at 2 Rs/kg, adding up to a transfer value of Rs 498 ($T_{hst} = 18 \times 19 + 12 \times 13$).

with counterfactual "target" entitlements, $\tilde{T}_{hst}$, that would have existed if states had done the bare minimum to comply with the NFSA mandate at the time it was ratified:

$$\tilde{T}_{hst} = \overbrace{\tilde{Q}_{hst}^{pds\ rice}\left[\bar{P}^{Market\ rice} - \tilde{P}_{hst}^{pds\ rice}\right]}^{Rice} + \overbrace{\tilde{Q}_{hst}^{pds\ wheat}\left[\bar{P}^{Market\ wheat} - \tilde{P}_{hst}^{pds\ wheat}\right]}^{Wheat}. \tag{2}$$

In this equation, the PDS prices and quantities, $\tilde{Q}_{hst}^{pds}$ and $\tilde{P}_{hst}^{pds}$, are calculated based on a counterfactual scenario in which each state only expanded PDS entitlements by the minimum amount needed to comply with NFSA mandates. These counterfactual target entitlements are shown in column C of Table 2. For example, Andhra Pradesh expanded its PDS entitlement to 6 kg of rice per eligible individual, while the NFSA only required an entitlement of 5 kg per individual. The target quantity entitlement for Andhra Pradesh, $\tilde{Q}_{hst}^{pds}$, is therefore 5 kg per individual.

The counterfactual further assumes that all states implemented the NFSA reform immediately after its official cabinet approval in March 2013, and thus ignores variation in the timing of implementation, which may also be endogenous to local conditions. Thus, $\tilde{Q}_{hst}^{pds}$ and $\tilde{P}_{hst}^{pds}$ change to their post-NFSA values in March 2013, regardless of when the state actually implemented the reforms.[18]

Figure 4 displays the relationship between changes in the target transfer value $\tilde{T}_{hst}$ and changes in the actual transfer value T_{hst} between the pre- and post-NFSA periods. Each scatter point represents a state-by-household-size cell. The marker shapes denote three household size categories: small households of fewer than four members, medium households between four and seven members, and large households with more than seven members.[19] The marker colors denote how a state's pre-NFSA PDS entitlements compared to the new NFSA mandates: States that were in attainment with both the price and quantity mandates are shown in green, states that were out of attainment with both mandates are shown in red, and states that were out of attainment with only the quantity mandate are shown in blue.

The graph clarifies the main sources of variation that form the basis of our empirical strategy. First, states that were already in attainment with the NFSA mandates did little to expand their PDS entitlements, so their observations are found close to the intercept (green markers). States that were out of attainment expanded their entitlements, but this expansion benefited larger households more than smaller ones (red and blue markers). Because of this, the markers of large households in those states are found further to the top right of the graph, those of medium households in the

[18] The cross-state variation in the timing of implementation is small. All states except one complied with the price mandate by February 2014 (as shown in Figure 1) and the quantity mandate by October 2014 (as shown in Figure 2). The exception was Gujarat, which was already in attainment with the price mandate but did not comply with the quantity mandate until 2016, after the end of our period of observation. This delay in full implementation was due to a political disagreement between the central government and Gujarat's state government, which was led by the opposition party and thus more restrained in adopting NFSA.

[19] In Figure 4, we use the household-size categories for ease of visualization. To calculate the entitlements and transfer values in equations (1) and (2), we use the exact household size at baseline.

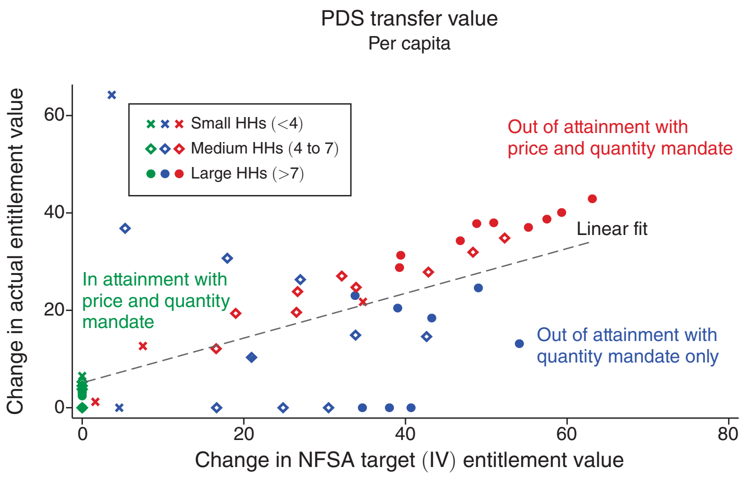

Figure 4. Variation in PDS Transfer Value

Notes: This graph presents a scatter plot of post-NFSA changes in NFSA target value (Instrument) against changes in actual entitlement value for BPL households in the eight states in the ICRISAT panel. The actual transfer value T_{hst} is defined as the product of quantity entitlement and price discount, described in equation (1), based on the actually existing state-level PDS policy before and after NFSA. The NFSA target value $\tilde{T}_{hst}$ is based on a counterfactual scenario in which each state only expanded PDS entitlements by the minimum amount needed to comply with NFSA mandates, as described in Section III. Transfer values are in 2010 rupees per capita. Each scatter point denotes a state-by-household size cell. The marker shapes denote three household size categories: small households of fewer than four members are shown as cross, medium households between four and seven members are shown as diamonds, and large households with more than seven members are shown as solid circles. The marker colors denote how a state's pre-NFSA PDS entitlements compared to the new NFSA mandates: States that were in attainment with both the price and quantity mandates are shown in green, states that were out of attainment with both mandates are shown in red, and states that were out of attainment with only the quantity mandate are shown in blue. Grey dashed line denotes the linear fit values between changes in NFSA target value and the actual entitlement value.

middle, and those of small households in the bottom left. The graph also shows considerable variation across states within households of the same size, which largely depends on how far out of attainment with the different mandates the state was (the size of the gap between the state's pre-NFSA policy and the NFSA mandate is not shown on the graph but is also an important factor in the variation).

The graph shows that the variation in entitlements is fairly complex, driven by the interaction between household size and the precise details of a state's pre-NFSA policy. This makes it useful for our analysis, since it allows us to obtain precise estimates of the effect of PDS transfers even after controlling for a fine-grained set of fixed effects at the state-by-time, household-size-by-time, and ration-card-status-by-time level.

D. *First Stage*

Table 3, panel A contains the first-stage results at the individual level. The results show that the relationship between NFSA target entitlement and actual PDS entitlement is strong, with an F-stat above 300. Results are robust to more conservative

Table 3—First Stage

	Transfer entitlement value				
	(1)	(2)	(3)	(4)	(5)
Panel A. Individual level					
NFSA target value (IV)	0.844	0.846	0.869	0.858	0.865
	(0.045)	(0.048)	(0.045)	(0.036)	(0.034)
Individual and year FE	X	X	X	X	X
State by year FE		X	X	X	X
Hhsize-year FE			X	X	X
Rationcard-year FE				X	X
Hhchar-year FE					X
F-stat	350.2	306.7	365.3	583.1	635.1
Observations	2,118	2,118	2,118	2,106	2,103
Panel B. Household level					
NFSA target value (IV)	0.860	0.863	0.896	0.894	0.898
	(0.043)	(0.046)	(0.046)	(0.037)	(0.045)
Household and month FE	X	X	X	X	X
State by month FE		X	X	X	X
Hhsize-month FE			X	X	X
Rationcard-month FE				X	X
Hhchar-month FE					X
F-stat	400.2	357.6	375.0	570.3	389.6
Observations	72,290	72,290	72,170	72,170	71,031

Notes: The table reports coefficients of first-stage regressions of PDS entitlement value on NFSA target value. The unit of observation in panel A is at the individual-year and panel B is at the household-month. The PDS entitlement value (T_{hst}) refers to actual household-level entitlements values based on the current year's state-level PDS policies and baseline household size and ration card status, as described in equation (1), Section IIIC. NFSA target value ($\tilde{T}_{hst}$) refers to the counterfactual entitlements assuming that all states expanded PDS entitlements just enough to comply with the NFSA mandates, as described in equation (2), Section IIIC. PDS transfer value (T_{hst}) and the NFSA target value ($\tilde{T}_{hst}$) are measured in real per capita rupees. For the specification that controls for the interaction between observed household characteristics and time fixed effects, the set of baseline household characteristics include caste, occupation, and education of household head. Standard errors reported in parentheses are clustered at the village level.

fixed effects that control for unobserved time-varying shocks to households with different observed characteristics (columns 2–5). Overall, these results show that the NFSA mandates generated substantial variation in household-level PDS entitlements, which allows us to use the NFSA target mandates as an instrumental variable.

Furthermore, in Table 4 we validate that the more generous state-level PDS entitlements reached eligible households and led to increased consumption of PDS grains at lower prices. Panel A shows the estimated effects of NFSA targets on actual PDS entitlements. These results suggest that states largely implemented the NFSA's mandates. A 1 kg increase in the NFSA quantity target increases a household's actual entitlement by 0.78 kg. Similarly, a 1 Rs/kg decrease in the NFSA target price reduces the household's PDS price entitlement by 0.58 Rs/kg. Taking price and quantity entitlements together, a 1 rupee increase in the value of the NFSA target increases the actual entitlement value by 0.85 rupee.

TABLE 4—VALIDATION OF PDS TAKE-UP

	Entitlement		
	Quantity (kg)	Price (Rs/kg)	Transfer value (in 2010 Rs)
Panel A. Effect of NFSA target on entitlement			
NFSA target	0.776	0.578	0.849
	(0.076)	(0.039)	(0.054)
F-stat			245.4
Observations	72,290	69,451	72,290
	Actual consumption		
	Quantity (kg)	Price (Rs/kg)	Transfer value (in 2010 Rs)
Panel B. Effect of entitlement on consumption			
PDS entitlement	0.485	0.444	0.684
	(0.093)	(0.116)	(0.107)
Observations	72,290	64,716	72,290

Notes: The table reports estimates from regressing NFSA target value on PDS entitlement in panel A and PDS entitlement value on PDS consumption in panel B. Each coefficient estimate is from a separate regression with column heading as outcome variable and row heading as the regressor variable. PDS entitlement refers to actual household-level entitlements calculated based on the current year's state-level PDS policies, baseline household size, and ration card status, as described in equation (1), Section IIIC. NFSA target value refers to the counterfactual entitlements assuming that all states expanded PDS entitlements just enough to comply with the NFSA mandates, as described in equation (2), Section IIIC. Unit of observation is household-month. Each regression is estimated with household and consecutive month fixed effects.

Panel B shows estimates of the effects of changes in PDS entitlements on actual consumption of grains from PDS fair price shops, based on food consumption data from the ICRISAT panel. The results show that changes in state-level PDS policies were largely passed through to beneficiaries. A 1 kg increase in a household's PDS entitlement led to a 0.48 kg increase in consumption of PDS grains. A 1 Rs/kg decrease in a household's price entitlement reduced the household's purchase price of PDS grains by 0.45 Rs/kg. Finally, a 1 rupee increase in the value of a household's entitlement led to a 0.68 rupees increase in the value of the realized PDS transfer, calculated as the difference between the cost of the household's consumption of PDS grain and the value of the same quantity of grain at current market prices. Note that the relationship between the entitlement value and actual value received is less than 1 and is not necessarily due to program leakage. First, there is measurement error in our instrument, since we base the target value on ration card status and household size at baseline, to avoid concerns about endogeneity. If these variables changed after baseline, the household's actual entitlement will be different from our calculated target value. Second, as noted above, there was both noncompliance and overcompliance in state-level policy changes. For instance, some states did not immediately decrease their PDS prices to meet the NFSA mandates, while others decreased their prices more than necessary to meet the mandate. Thus, this coefficient would be substantially less than 1 even if every household received exactly the amount of PDS grain they were entitled to.

IV. Effect on Child Undernutrition

A. *Estimating Equation*

We use the PDS transfer values described in the previous section to estimate the impact of PDS transfers on child undernutrition with the following equation:

$$Y_{ihst} = \beta_1 T_{hst} + \delta_{st} + \mathbf{X}'_{ihst}\gamma + \alpha_i + \lambda_t + \epsilon_{ihst}, \tag{3}$$

where Y_{ihst} represents the anthropometric status of child i in household h, state s, and year t. This variable is measured annually in July. The variable T_{hst} is the household's average PDS transfer value over the previous 12 months. For instance, for $t = 2014$ the outcome Y_{ihst} is the child's stunting status in July 2014, while T_{hst} is the household's average PDS transfer value between July 2013 and June 2014. The coefficient β_1 can thus be interpreted as reflecting the effect of one year of exposure to increases in PDS entitlements. Standard errors are clustered at the village level. We also show results for specifications that cluster standard errors at the state level.

Note that the PDS transfer value, (T_{hst}) reflects the value of transfer the household was entitled to, not the amount it actually received. As shown in Table 4, a 1 rupee increase in entitlement (T_{hst}) was only associated with a 0.68 rupee increase in the value of the subsidy received. Our estimates should thus be interpreted as reflecting the effect of an exogenous 1 rupee increase in PDS entitlement, not the effect of receiving an additional 1 rupee of transfer, which is likely to be higher than our estimates. In addition, our estimate may also reflect indirect effects of the entitlement increase. For example, village-level increases in the average PDS entitlement may have led to a decrease in the price of non-PDS grain. To test for the presence of this type of local general equilibrium effect, we also estimate a specification that controls for village-by-time fixed effects (columns 3 and 4 in Table A2). Including these fixed effects does not substantially change our estimates, which suggests that local general equilibrium effects are not a major component of the effect of increased PDS entitlements.

The coefficients α_i and λ_t are individual and year fixed effects. The parameter δ_{st} denotes a set of state-by-year fixed effects. Our baseline specification also includes household-size-by-time and ration-card-by-time fixed effects, which are included in the vector of time varying variables $\mathbf{X}_{ihst}$. The state-by-time fixed effects eliminate all cross-state variation in the expansion of PDS after the NFSA. Our estimates are thus only based on comparisons of households observed in the same state and same year whose PDS transfers were affected to different extents by the NFSA. The household-size-by-time and ration-card-by-time fixed effects control for any time-varying effects of the other sources of identification, household-size and eligibility.

After controlling for the full set of two-way fixed effects, our estimates are only identified by the higher-level interactions of state, time, PDS eligibility, and household-size.[20] Identification in these regressions thus follows the same logic as a

[20] Note that the other two-way interactions—state-by-ration-card, state-by-household-size, and ration-card-by-household-size—are all subsumed by the individual fixed effects.

"triple-difference" approach, based on comparing households observed in the same state and same year whose PDS transfers were affected to different extents by the NFSA. To further test the robustness of our estimates, $\mathbf{X}_{ihst}$ also includes interactions between time fixed effects and other baseline household characteristics (caste, occupation and education of household head), which control for shocks that differently affected households with different characteristics.

As discussed above, the PDS transfer value (T_{hst}) is instrumented with its target value based on the NFSA mandates, $(\tilde{T}_{hst})$. [21] Our estimates thus reflect a Local Average Treatment Effect (LATE) on PDS-eligible households in the states that complied with the NFSA mandates (since these are the compliers with the instrument). Fortunately for our analysis, most states complied with the NFSA mandates to a large extent. All states except one complied with the price mandate by February 2014 (as shown in Figure 1) and the quantity mandate by October 2014 (as shown in Figure 2). The exception was Gujarat, which was already in attainment with the price mandate but did not comply with the quantity mandate until 2016, after the end of our period of observation. For the purposes of our analysis, Gujarat is thus likely a "never-taker" whose effect is not reflected in our IV estimates.

B. *Effect on Child Stunting*

For our main analysis, we consider the early childhood period from age 0 to 5 years. We also conduct heterogeneity analyses on infants 0 to 2 years old. To estimate the effects on nutritional status on children, we focus on stunting, a well-validated measure of chronic malnutrition (Prendergast and Humphrey 2014). We also report the direct effects on HAZ and on additional measures of child undernutrition, including weight-based indicators and mid-upper arm circumference.

Table 5 reports estimates of equation (3) for the impact of PDS transfers on stunting in children aged 0 to 5 years. These results show that an increase in the PDS transfer value decreases the likelihood of stunting. Based on the coefficient estimates in column 1, a 100 rupee per capita increase in PDS transfer value translates to a 21 percentage points decrease in the prevalence of stunting. The estimates remain statistically significant with standard errors clustered at the state level, accounting for a small number of clusters using a wild-bootstrap method.

To interpret the economic significance of the estimates, we consider a policy experiment of increasing the PDS entitlement value by 30 rupees per capita per month—an amount equivalent to the PDS expansion for an average PDS beneficiary in our data and about 4 percent of monthly consumption expenditure for a household in the poorest quintile. Based on the coefficient estimates in column 1, a 30 rupees per capita increase in transfer value decreases stunting prevalence by 7 percentage points and an associated 95 percent CI range between -1.2 percentage points to -13 percentage points. In comparison to the baseline sample mean of stunting rate

[21] In addition to our IV specification, we also report reduced-form estimates from regressing child stunting outcomes directly on the instrument target NFSA target value $(\tilde{T}_{hst})$ in Supplemental Appendix Table A3 and validate that the reduced-form estimates are consistent with our main specification with instrumented regressions.

Table 5—Effect of PDS Transfer Value (in Rs 100) on Children from Age 0 to 5 Years

	Stunting (1)	Stunting moderate (2)	Stunting severe (3)	HAZ (4)
PDS transfer value	−0.216	−0.183	−0.033	0.298
(IV : NFSA target value)	(0.087)	(0.073)	(0.045)	(0.153)
Age # year FE	X	X	X	X
State # year FE	X	X	X	X
HH-size group # year FE	X	X	X	X
BPL status # year FE	X	X	X	X
HH-char # year FE	X	X	X	X
State cluster bootstrap p-value	0.025	0.073	0.320	0.027
Observations	1,305	1,305	1,305	1,305
Baseline mean	0.387	0.199	0.187	−1.485
Change from PDS expansion (in level)	−0.071	−0.061		0.098
Change from PDS expansion (in %)	−18.5%	−30.3%		6.6%

Notes: The table presents estimates of IV regressions of individual stunting and height-for-age z-score (HAZ) on PDS transfer value, instrumented by NFSA target value. PDS transfer value and NFSA target value are expressed in units of 100 rupees. The construction of PDS transfer value and NFSA target value are described in equations (1) and (2) in Section IIIC, respectively. All regressions include individual and consecutive year fixed effects. The unit of observation is the individual-year. Stunting $= 1$ if $HAZ < -2$; Moderate stunting $= 1$ if $-3 < HAZ < -2$; Severe stunting $= 1$ if $HAZ < -3$. HAZ is winsorized at the top and bottom 2.5 percent of the distribution to remove outliers that may be due to misreporting. Weak IV F-stats represent Kleibergen-Paap (2006) rk Wald statistic. Standard errors reported in parentheses are clustered at village level. The wild-cluster bootstrap p-value for clustering standard errors at the state level is calculated using the Webb six-point distribution, as described in Cameron and Miller (2015).

at 39 percent, the expansion of the PDS program decreases stunting prevalence by 18.6 percent.

To assess the magnitude of these results, we perform a back-of-envelope calculation that extrapolates our estimates to the aggregate level. The rural population of under-five children in the six states in our sample that expanded their PDS after the NFSA reform was 33.6 million in the 2011 census and approximately 25.3 million of the children lived in households below the poverty line that benefited from the NFSA expansion. These six states cover about 41 percent of India's population.[22] Assuming that the NFSA reform led to a reduction in stunting by 7 percentage points among rural children, our estimates therefore imply that the PDS expansions after NFSA prevented 1.8 million children ($= 0.07 \times 25.3$) from being stunted.

One should note that this effect is unlikely to reflect a "pure" effect of 30 rupees of additional consumption of PDS grains. We show in Section VI that the increase in PDS transfers following the NFSA led to a significant increase in the daily wages of recipients. This labor market effect caused an increase in the expenditure of poor households that was similar in magnitude to the "first-round" effect of the transfer.

[22] The six states that expanded the PDS program after NFSA in our study are Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh and Maharashtra. Based on the Food Grain Bulletin government report, as of 2016, about 256 million rural people in the expansion states were below the poverty line and thus eligible for PDS transfers. About 9.9 percent of the population were in the age group 0–5 in the 2011 census. Using these numbers, we calculate the approximate number of rural children exposed to the NFSA to be 25.3 million ($= 256 \times 0.099$).

Table 6—Effect of PDS Transfer Value (in Rs 100) on Children Height by Age Group

	Stunting (1)	HAZ (2)
PDS transfer (IV: NFSA target value)		
X age 0 to 2	−0.279	0.422
	(0.104)	(0.187)
X age 3 to 5	−0.118	0.102
	(0.106)	(0.203)
Age # year FE	X	X
State # year FE	X	X
HH-size # year FE	X	X
BPL status # year FE	X	X
HH-char # year FE	X	X
Observations	1,305	1,305

Notes: This table presents heterogeneous effects by age group from IV regressions of individual stunting and height-for-age z-score (HAZ) on PDS transfer value, instrumented by NFSA target value, interacted with age-group category. PDS transfer value and NFSA target value are expressed in units of 100 rupees. The estimation includes children 0 to 5 years. The construction of PDS transfer value and NFSA target value are described in Section III. All regressions include individual and consecutive year fixed effects. The unit of observation is the individual-year. Stunting $= 1$ if $HAZ < -2$. HAZ is winsorized at the top and bottom 2.5 percent of the distribution to remove outliers that may be due to misreporting. Standard errors reported in parentheses are clustered at village level.

Consistent with a second-round labor market effect, we show in Section V that a 1 rupee increase in PDS transfers increases food expenditures by more than 1 rupee. We show below that an increase in PDS transfers led to a substantial increase in consumption of high quality foods like meat, dairy, and legumes, which are not sold by the PDS. This finding is consistent with the hypothesis that our estimates partly reflect second-round effects that operate through the labor market.

Columns 2 and 3 in Table 5 show that program effects on stunting are primarily driven by reductions in the likelihood of moderate stunting. Based on the coefficient estimates in column 2, a 30 rupee increase in transfer value decreases moderate stunting by 4.8 percentage points [95 percent CI range of −0.93 percentage points to −10.1 percentage points], a 30 percent reduction from the pre-NFSA mean. Consistent with the reductions in stunting, column 4 in Table 5 shows that increases in PDS transfer led to an improvement in height-for-age z-score. In particular, the coefficient estimates in column 4 suggest that a 30 rupee increase in transfer value improves height-for-age z-score by 0.10 standard deviation [95 percent CI range of −0.0004 to 0.21], an increase of about 6.7 percent from the pre-NFSA mean.

Next, we explore whether the increase in PDS transfers had heterogeneous effects on stunting by age and gender. Table 6 reports effects on stunting and HAZ by age group 0 to 2 years and 3 to 5 years. The coefficient estimates in Table 6, column 1 show that an increase in PDS transfers decreases the likelihood of stunting for children, with a larger effect on infants 0 to 2 years. Similarly, the results in column 2 show that the heterogeneous effects on HAZ are concentrated on infants 0 to 2 years. These results are consistent with a large literature that emphasizes the significance of the first 1,000 days of life, a period of fast linear growth during which a child's development is highly sensitive to nutritional intake (Black et al. 2013; de Onis and Branca 2016). Furthermore, our heterogeneity results are consistent with the idea that the first 1,000 days are a "window of opportunity" for reducing stunting, during which food transfers of modest size can have substantial positive impacts (Ruel and Alderman 2013). Lastly, we find that the effect of PDS transfers on stunting is broadly similar for boys and girls. The point estimates reported in Supplemental Appendix Table A4 are slightly higher for boys, but the difference in effects between girls and boys is small and not statistically significant (bottom of Table A4).

C. *Robustness Tests*

The identifying assumption of our estimator is that changes in the value of transfers generated by the national NFSA mandate were uncorrelated with unobserved shocks to child anthropometric outcomes. In other words, households who benefited more from the NFSA reforms—i.e., larger households and households in states that were forced to expand entitlements—should be on the same trend as households who benefited less or were unaffected by the reforms. We test this assumption in two ways. First, we estimate an event-study specification that tests how nutritional outcomes of children who benefited more versus less from the NFSA reform evolved prior to the reform. We find no evidence for differential trends in HAZ and stunting rates of children in the time periods before the NFSA reform. Lastly, we validate that our estimates are not confounded by changes in other government social programs, including the NREGA and the Midday Meal scheme.

Parallel Pre-trends.—We now directly test for violations of the parallel trends assumption by examining trends in the outcome in the years leading up to the NFSA reform. First, we test for nonparallel pre-trends by including a one-year lead of the PDS transfer value in the estimation of equation (3). As with the contemporaneous transfer value, we instrument the lead transfer value with the lead target value based on NFSA mandates. The results in Table 7 show that the coefficients associated with the lead are small in magnitude and statistically insignificant. These results show no evidence of preexisting trends in child nutritional outcomes before the enactment of NFSA.

To visually examine pre-trends in anthropometric outcomes, we also estimate an event-study specification. To do this, we calculate a household-specific treatment intensity by taking the difference between the household's transfer target value before and after NFSA $(\Delta\tilde{T}_{ht}))$. We then estimate a reduced-form, event-study regression by interacting the treatment intensity with a set of indicators for time periods before and after the NFSA reform:

$$(4) \qquad Y_{iht} = \sum_{p=-3}^{p=1} \beta_p \left[\Delta\tilde{T}_h\right] \cdot \mathbf{1}_{\{t=p\}} + \delta_{st} + \mathbf{X}'_{ihst}\gamma + \alpha_i + \lambda_t + \epsilon_{iht}.$$

In this equation, Y_{iht} is the stunting or HAZ of child i in household h and year t. $\Delta\tilde{T}_h$ is the change in PDS entitlements that household h experienced as a result of the NFSA reform. The regression includes the same set of controls as our

Table 7—Robustness Test for Parallel Trends Using Lead of PDS Transfers

	Baseline		Leads test	
	Stunting	HAZ	Stunting	HAZ
PDS Transfer value	−0.216	0.298	−0.213	0.275
(IV: NFSA target value)	(0.087)	(0.153)	(0.083)	(0.140)
Lead of PDS transfer value			0.013	0.122
(IV: Lead of NFSA target value)			(0.169)	(0.339)
Age # year FE	X	X	X	X
State # year FE	X	X	X	X
HH-size # year FE	X	X	X	X
BPL status # year FE	X	X	X	X
HH-char # year FE	X	X	X	X
Observations	1,305	1,305	1,303	1,303

Notes: This table presents the robustness of the main results on stunting to pre-trends. Columns 1 and 2 present the baseline estimates of IV regression of stunting and height-for-age z-score (HAZ) on PDS transfer value, instrumented by NFSA target value. Columns 3 and 4 further control for the lead of the PDS transfer value, instrumented by the lead of NFSA target value. Unit of observation is individual-year. PDS transfer value and NFSA target value are expressed in units of 100 rupees. All regressions include individual and consecutive year fixed effects. Stunting $=$ 1 if $HAZ < -2$. HAZ is winsorized at the top and bottom 2.5 percent of the distribution to remove outliers that may be due to misreporting. Standard errors reported in parentheses are clustered at village level.

baseline specification in equation (3): state-by-time fixed effects and a vector of household-specific time varying fixed effect. Note that this regression is based on the change in the household's transfer target value, $\tilde{T}_{ht}$ (the instrument used to estimate equation (3)), so that the estimates reflect a reduced form effect.

Figure 5 plots the β_p coefficient along with their 95 percent confidence intervals, with the period of NFSA implementation ($p = 0$) as the omitted category. The β_p coefficients estimate how nutritional status changed for children in households whose PDS entitlements increased strongly due to NFSA relative to households whose entitlements increased weakly or not at all. These changes are estimated relative to the omitted period in 2013, the year NFSA was implemented. The coefficients associated with the pre-NFSA time periods are close to zero and there is no sign of an upward or downward trend. This suggests that households who were more/less strongly affected by NFSA were on parallel trends with respect to unobserved determinants of child nutritional outcomes in the period leading up to the reform. The coefficients only deviate from zero in 2014, the year after NFSA, with a drop in stunting. Similarly, Supplemental Appendix Figure A3 shows no trends pre-NFSA and a jump in HAZ after NFSA. Taken together, the event-study estimates in Figure 5 and the lead test results in Table 7, provide no evidence for a violation of the parallel trends assumption that underlies our estimates.

Robustness to Other Welfare Programs.—As a first robustness test, we explore possible correlations between increases in PDS transfers and other government welfare programs including Midday meals, NREGA, subsidized public health insurance, scholarships and relief loans. We utilize the limited available data on government benefits received by each household, and estimate the effect of households' PDS entitlement on the benefit values received by the same household

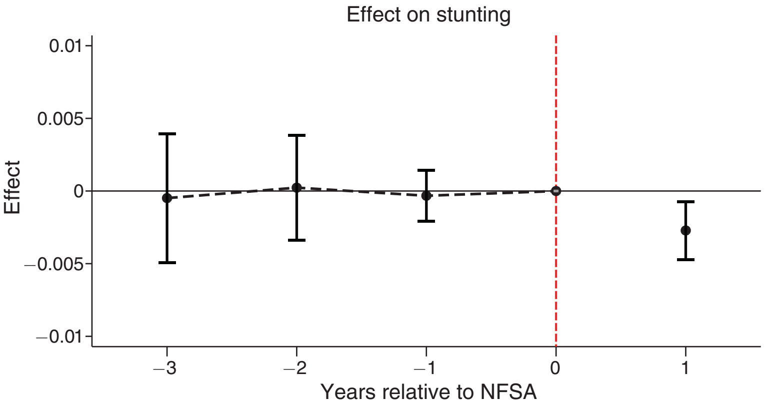

Figure 5. Effect of PDS Transfer on Stunting

Notes: This graph shows event study coefficients from estimating equation (4) along with their 95 percent confidence intervals. As described in Section IVC, equation (4) is a reduced form regression of child stunting on an interaction between treatment intensity ($\Delta\tilde{T}_{ht}$) and one-year time periods relative to NFSA, with the period of NFSA implementation as the omitted category. The household-specific treatment intensity ($\Delta\tilde{T}_{ht}$) is the difference between the household's NFSA target value before and after NFSA. Note that this regression is based on the change in the household's transfer target value, $\tilde{T}_{ht}$ (the instrument used to estimate equation (3)), so that the estimates reflect a reduced form effect. The regression includes the same set of controls as our baseline specification: state-by-time fixed effects and a vector of household-specific time-varying fixed effects.

from welfare programs, in a regression that controls for household and time fixed effects.[23] The estimates, reported in Supplemental Appendix Table A8 are small and statistically insignificant. We thus find no evidence that increases in PDS entitlements from NFSA were correlated with changes in benefits from other welfare schemes received by the same households. In Supplemental Appendix Table A7, we also show that our estimates are robust to controlling for state-level NREGA policy interacted with BPL status, which suggests that our estimates are not confounded with changes in NREGA that may have differentially affected BPL households.

An additional confounding factor could be changes in minimum support prices (MSP) of rice and wheat. MSPs are support prices at which the government procures from farmers to be distributed to the PDS systems. In principle, an increase in MSPs that is correlated with the increase in household-level PDS transfers could bias our estimates. We believe that this is unlikely to be the case for several reasons. First, while MSPs have increased steadily over time, their rate of growth was largely constant at 4–5 percent during our period of observation, and there is no evidence that MSPs increased as a result of NFSA (Government of India 2016). Second, the bulk of the food grain procurement through MSPs in India is from the northwest surplus regions of Punjab and Harayana (about 60–70 percent). Among the eight

[23] Unfortunately, the availability and quality of the data on government receipts is not ideal. First, this data is not reported for the 12 East India villages. In the available data from 18 villages in semiarid tropics, the value of benefits received from most programs are imputed (for instance, the value of midday meals or health insurance benefits) and represent approximate values, pointing to considerable measurement error. For these reasons, we regard the results as tentative, providing suggestive evidence on the association between the value of PDS transfers and other social programs.

Table 8—Effect of PDS Transfer Value (in Rs 100) on Child Weight and MUAC (Age 0 to 5)

	log of weight	WAZ	Underweight	WHZ	Wasting	log of MUAC	MUAC-for-age z-score
PDS transfer value	0.043	0.241	−0.237	−0.023	0.016	0.038	0.274
(IV : NFSA target value)	(0.030)	(0.209)	(0.071)	(0.186)	(0.062)	(0.035)	(0.383)
Age # year FE	X	X	X	X	X	X	X
State # year FE	X	X	X	X	X	X	X
HH-size group # year FE	X	X	X	X	X	X	X
BPL status # year FE	X	X	X	X	X	X	X
HH-char # year FE	X	X	X	X	X	X	X
Observations	1,570	1,517	1,517	1,314	1,314	1,546	1,360

Notes: This table presents coefficients and standard errors from instrumented regression of PDS transfer value, with NFSA target value as the instrument, on weight-based indicators and mid-upper arm circumference (MUAC) of children aged 0 to 5 years. PDS transfer value and NFSA target value are expressed in units of 100 rupees. Unit of observation is individual-year. All regressions include individual and consecutive year fixed effects. Underweight $= 1$ if $WAZ < -2$; Wasting $= 1$ if $WHZ < -2$. Standard errors reported in parentheses are clustered at village level.

states in our data, five states had no or minute levels of procurement (less than 1 percent) during the study period, and no states accounted for more than 10 percent of procurement (Government of India 2016). Third, contrary to an expected increase in prices due to the MSP, we find no evidence on the effects on PDS transfers on local market prices. These results are reported in Supplemental Appendix Table A11, and discussed in Supplemental Appendix Section A1. Lastly, we find no significant program effects on medium and large farm households, who would most likely benefit from increased MSPs. On the contrary, we find large and significant effects for landless households who are least likely to benefit from increased MSPs. These results are reported in Supplemental Appendix Table A5.

D. *Effects on Other Anthropometric Outcomes, Adolescents and Adults*

We now explore whether the expansion in PDS transfers had an effect on weight-based indicators and mid-upper arm circumference (MUAC) of children aged 0 to 5. In particular, we use data on weight, height, mid-upper arm circumference, and age to construct z-scores of weight-for-age, weight-for height, and MUAC-for-age using the WHO child growth standard (WHO 2006). We also construct indicators for underweight and wasting, that equals 1 if WAZ and WHZ is under 2 standard deviations, respectively. Table 8 shows that the expansion of PDS transfers decreased the likelihood of underweight in children. These results further validate the magnitude of stunting reductions estimated in Section IV, as underweight is a composite measure of stunting and wasting. Table 8 also shows that increases in PDS transfers had limited impacts on other weight-based anthropometrics and MUAC. Previous studies have also found null effects of transfers on weight-based indicators of children, for example, Carneiro et al. (2021) and Filmer et al. (2023). Although weight reflects more recent changes in dietary intake, weight-based measures of children may be sensitive to seasonal variation and recent illnesses.

Table 9—Effect of PDS Transfer Value (in Rs 100) on Nutrition Status of Adult Women and Men

	BMI	Underweight	Overweight	Obese
Panel A. Adult women (18 to 30)				
PDS transfer value	0.326	−0.113	0.004	0.001
(IV: NFSA target value)	(0.135)	(0.051)	(0.016)	(0.006)
Observations	1,518	1,576	1,576	1,576
Baseline mean of outcome	19.87	0.37	0.06	0.01
Panel B. Adult women (18 to 49 yrs)				
PDS transfer value	0.226	−0.029	0.023	0.009
(IV: NFSA target value)	(0.160)	(0.025)	(0.028)	(0.015)
Observations	4,241	4,482	4,482	4,482
Baseline mean of outcome	20.38	0.32	0.12	0.02
Panel C. Adult men (18 to 49 yrs)				
PDS transfer value	−0.017	−0.016	−0.019	0.001
(IV: NFSA target value)	(0.139)	(0.038)	(0.009)	(0.003)
Observations	4,225	4,361	4,361	4,361
Baseline mean of outcome	20.42	0.28	0.09	0.01

Notes: This table presents coefficients and standard errors from instrumented regression of PDS transfer value, with NFSA target value as the instrument, on BMI and weight of adult women and men. PDS transfer value and NFSA target value are expressed in units of 100 rupees. Unit of observation is individual-year. All regressions include individual and consecutive year fixed effects and the same set of controls as our baseline specification: state-by-time fixed effects and a vector of household-specific time-varying fixed effects. Child-bearing age 18–30 years is determined from the age distribution of mothers in the data—less than 2 percent of mothers are older than 30 years. Underweight $= 1$ if $BMI < 18.5$; Overweight is $BMI > 25$; Obese $= 1$ if $BMI > 30$. Pregnant woman observations are excluded from the estimations. Standard errors reported in parentheses are clustered at village level.

We further explore whether increases in PDS transfers led to changes in the nutritional status of older children and adolescents (ages 6 to 19 years). Our estimates, reported in Supplemental Appendix Table A6, show that increases in PDS transfers had limited impact on the prevalence of stunting for older children and adolescents. These results are consistent with a limited scope of improvement in height among adolescents, highlighted in the nutrition literature. The results also relate to new evidence that shows that height is not an equally good indicator of long-term health at different ages, particularly for adolescents (Aurino et al. 2023). We find no effect of PDS transfers on weight-based indicators of older children, except that MUAC improved for children aged 6 to 10 years.

Lastly, we examine whether PDS transfers led to changes in the nutritional status of adult men and women, measured in terms of BMI. These results, reported in Table 9, show that increases in PDS transfers did not lead to changes in those who were overweight or in obesity in adult women and men. Rather, PDS transfers may have marginally improved the BMI status of adult women and decreased the likelihood of being underweight, especially among women of childbearing age, as shown in panel A of Table 9. These results imply that the concern of unintended effects of social transfers on obesity and noncommunicable disease risks may not hold in this setting (Hawkes et al. 2020). One possible reason could be that a substantial proportion of adult women in our study sample (about 34 percent) were undernourished at baseline, and few were at risk of obesity.

V. Effect on Nutritional Intake

We now estimate how an increase in PDS transfer affects the nutritional intake of recipient households. An objective of this analysis is to explore whether the increase in nutritional intake is large enough to be consistent with the magnitude of stunting reductions estimated in Section IV. To do this, we estimate the following regression:

$$Y_{hst} = \beta_2 T_{hst} + \delta_{st} + \mathbf{X}'_{ihst}\gamma + \alpha_h + \lambda_t + \epsilon_{hst}, \tag{5}$$

where Y_{hst} is a nutritional intake variable (such as staple cereal consumption, consumption of other food items, calorie and nutrient consumption, etc.) for household h, in state s and month t. Variable T_{hst} is the household's PDS transfer value, and α_h and λ_t are household and month fixed effects. Both Y_{hst} and T_{hst} are observed at monthly intervals. As before, we instrument the PDS transfer value T_{hst} with its target value based on the NFSA mandates, $\tilde{T}_{hst}$.[24] To ensure consistency and comparability with the estimates on stunting, we restrict the sample to households with children 0 to 5 years old, which make up about 27 percent of the VDSA sample. Results remain similar if we include all the sample households. Standard errors are clustered at the village level.

The coefficients α_h and λ_t are household and month fixed effects. As before, in equation (3), our baseline specification includes state-by-year fixed effects (δ_{st}) and a vector of household-specific time-varying variables $\mathbf{X}_{ihst}$ that includes household-size-by-time, ration-card-by-time fixed effects, and baseline household characteristics (caste, occupation, and education of household head)-by-time fixed effects. Therefore, the identification of the household-level estimates in equation (5) are analogous to equation (3), which are based on comparisons of households observed in the same state and same year for whom the PDS transfers were affected to different extents by the NFSA.

Columns 1 and 2 of Table 10 report estimates for monthly expenditures and quantity consumed for different food items, and represent monthly per adult equivalent values. Columns 3–5 report estimated effects on daily calorie, protein, and fat intake of the corresponding food items, and represent daily per adult equivalent values. The nutrient values are obtained from converting food consumption quantities and expenditures into their nutrient content, using the nutrient value of Indian food items based on Gopalan, Rama Sastri, and Balasubramanian (1991). The food items in Table 10 are classified based on their food group, such as staple cereals, animal proteins, plant proteins, fruits and vegetables, and fats. The estimates on total food consumption are reported at the bottom of Table 10.

As before, to interpret the economic significance of the estimates, we consider a policy experiment of increasing the PDS transfer value by 30 rupees per capita per month—an amount equivalent to the PDS expansion for an average PDS beneficiary in our data and about 4 percent of monthly consumption expenditure for a household in the poorest quintile. As before, these effects should not be interpreted

[24] In Table 3, panel B, we validate that first stage of the relationship between NFSA target entitlement and actual PDS entitlement, observed at monthly intervals, is strong with an F-stat above 300.

Table 10—Effect of PDS Transfer on Food Consumption

	Value (in 2010 Rs)	Quantity (in grams)	Energy (kcal)	Protein (mg)	Fat (mg)
	(1)	(2)	(3)	(4)	(5)
Staple cereals					
PDS grain	0.019	17.138	1.961	49.321	3.991
	(0.006)	(5.330)	(0.615)	(14.705)	(1.253)
Staples except PDS	0.096	6.341	0.728	21.241	2.110
	(0.076)	(4.554)	(0.522)	(13.706)	(1.497)
Animal proteins					
Milk and milk products	0.299	14.915	0.488	19.575	34.326
	(0.080)	(4.806)	(0.155)	(6.170)	(10.853)
Meat	0.084	0.502	0.019	4.174	0.538
	(0.029)	(0.232)	(0.009)	(1.614)	(0.182)
Eggs	0.012	0.003	0.011	0.925	0.925
	(0.005)	(0.002)	(0.006)	(0.445)	(0.445)
Vegan proteins					
Pulses	0.124	2.974	0.342	22.814	1.076
	(0.023)	(0.521)	(0.060)	(3.973)	(0.667)
Fruits and vegetables					
Fruits and vegetables	0.255		0.297	9.211	2.483
	(0.042)		(0.068)	(2.143)	(0.394)
Fats					
Oils	0.143	2.470	0.736	−0.061	81.804
	(0.032)	(0.372)	(0.112)	(0.048)	(12.422)
Other foods					
Coarse cereals	0.031	3.271			
	(0.019)	(1.450)			
Sugar	0.063	2.408			
	(0.016)	(0.575)			
Other food items	0.193				
	(0.037)				
Meals outside	0.119				
	(0.040)				
Total food	1.449		5.564	144.778	138.596
	(0.189)		(0.808)	(21.238)	(20.482)

Notes: Each cell in this table reports coefficient and standard errors from a separate regression of PDS transfer, with NFSA target value as the instrument, on household consumption outcomes, as specified in equation (5). Columns 1 and 2 report estimates for monthly per adult-equivalent expenditures and quantity consumed for different food items. Columns 3–5 report estimated effects on daily per adult-equivalent intake of calorie, protein, and fat of the corresponding food items. The nutrient values are obtained from converting food consumption quantities and expenditures into their nutrient content, using the nutrient value of Indian food items based on Gopalan et al. (1991). Unit of observation is household-month. All regressions include household and consecutive month fixed effects, and the same set of controls as our baseline specification: state-by-time fixed effects and a vector of household-specific time-varying fixed effects, as specified in equation (5). Sample is restricted to households with children aged 0 to 5 years. The number of observations of each regression ranges between 31,500 to 33,000. Other food items include condiments (spices (salt), beverages (tea/coffee), bread, biscuits, prepared sweets, etc). Standard errors reported in parentheses are clustered at village level.

as reflecting only the direct effect of the 30 rupee increase on transfer size. We show, in Section VI, that the increase in PDS transfers led to a significant increase in the wage income of recipients. This labor market effect led to an additional 36 rupee increase in wage income, so that the total increase in a household's available food budget was approximately 66 rupees.

First, the results on staple cereals in Table 10 show that a more generous PDS transfer increases the total quantity of staple cereals consumed, primarily driven by increased consumption of PDS grain. The estimates on energy intake show that the most significant amount of calories are derived from grains from the PDS ration shop. Based on the coefficient estimates, a 30 rupee increase in PDS transfer value increases PDS rice and wheat consumption by 514 g per month per adult equivalent, which translates to an increase in calorie intake of 59 kcal per day per adult equivalent. These results validate that the increased generosity of PDS transfers brought about by the NFSA led to higher consumption of PDS grains at lower prices. Lastly, we find no effect of PDS transfers on consumption quantities and expenditures of staple cereals sourced from market purchases and home production, and can rule out a decrease in consumption quantity by more than 74 g per month per adult equivalent.

The estimated results on non-staple foods show that a more generous PDS transfer improves consumption of diverse foods, with a large increase in animal protein intake from milk and meat. Based on our estimates, a 30 rupee monthly per capita increase in PDS transfer translates to an increased monthly per adult equivalent consumption of milk and milk products by 447 g, of meat by 15 g, and of eggs by 0.09 g. These quantities translate to increased daily per capita protein intake of 587 mg sourced from milk and milk products, 125 mg from meat, and 27.8 mg from eggs. Overall, animal protein intake increased by 0.74 g per day (about a 10 percent increase from baseline animal protein intake of 7.5 g). In addition, PDS transfers also increase consumption of vegan proteins, primarily through pulses. Based on our estimates, a 30 rupee monthly per capita increase in PDS transfer increases intake of pulses by 89 g, which translates to an increase in vegan protein intake by 0.68 g (about a 9 percent increase from baseline vegan protein intake of 7.5 g). Furthermore, PDS transfers increase intake of oils and fruits and vegetables. Similarly, the results for expenditure values shows that PDS increases expenditures on all food items, with the largest increase in expenditures on animal proteins from milk and meat.

In aggregate, PDS transfers increased total household intake of energy, proteins, and fat. Based on the coefficients on total food, a 30 rupee monthly increase in PDS transfer led to an increase in daily per adult equivalent calorie intake of 167 kcal of energy intake, 4.3 g of protein intake, and 4.1 g of fat intake. We further explore substitutions in household food budget shares in Supplemental Appendix Table A9. The advantage of focusing on budget shares is that it provides a diet quality measure independent of changes in total food expenditures. These results show corroborative evidence that households decrease their out-of-pocket expenditure on staple foods, and shift their food budgets to increase expenditure on higher quality, more nutritious foods, primarily animal proteins. Thus, though PDS transfers consist entirely of staple grains, we find that their expansion improved dietary diversity and "crowded-in" the consumption of nutritious non-staple foods, most notably animal proteins.[25]

[25] In order to compare our estimates on calorie and nutrient intake with the previous literature, we compute elasticities with respect to PDS transfer value and expenditures. These estimations, reported in Supplemental Appendix Table A10, are estimated in log-log form and thereby limit the sample to beneficiary households with a nonzero PDS transfer value. The estimated elasticity of the total calorie intake with respect to the PDS transfer value is 0.265 and is larger than previous estimates: 0.11 in Kaul (2018), 0.06 in Kochar (2005), −0.003 and statistically insignificant in Kaushal and Muchomba (2015). One possible reason for a higher estimate in this study could be the

Moreover, PDS transfers increase total food expenditures. Based on the coefficients on total food, a 1 rupee increase in transfer value led to 1.45 rupee increase in food expenditures, though the coefficient is not significantly different from 1. Thus, we cannot reject the hypothesis that households spend the entirety of the additional PDS transfer value on food, consistent with a strong "flypaper" effect.[26] However, these results could also be explained by the presence of "second-round" multiplier effects of food transfers on local labor markets or private food markets (Carneiro et al. 2021; Cunha, De Giorgi, and Jayachandran 2019). We show, in Section VI, that the increase in PDS transfers after NFSA led to a significant increase in labor income. This effect caused an overall increase in the budgets of poor households that was similar in magnitude to the "first-round" effect of the transfer. If households spent some of this additional income on food, a 1 rupee increase in PDS transfers could have led to a more than 1 rupee increase in food expenditure.

A. *Is the Increase in Nutritional Intake Consistent with the Reduction in Stunting?*

Overall, the effects on household food consumption suggest that the PDS transfers substantially improves nutrient intake, particularly of animal proteins. These results are consistent with our main finding of stunting reductions in children, as protein-rich foods are an essential component of food intake that promotes linear growth. An extensive literature in nutrition and medicine has shown that proteins from animal sources such as milk, meat and eggs are associated with improved linear growth (Murphy and Allen 2003; Roberts and Stein 2017; Shapiro et al. 2019).[27]

In terms of the magnitude of improvements in nutrient intake, our estimates above suggest that a 30 rupee increase in PDS transfers increased daily per adult equivalent consumption of total calories by 167 kcal, total protein intake by 4.3 g and animal protein intake by 0.74 g, implying an increased intake of 4.2 g of animal protein per 1,000 kcal ($= (0.7/167) \times 1{,}000$). Our previous estimates from Table 6 suggest that the same amount of transfer increased the HAZ of children by

inclusion of nonmarginal expansions in the PDS program, post-NFSA. However, the estimated calorie expenditure elasticity in this study (0.268) is slightly less than previous estimates: 0.37 in Behrman and Deolalikar (1987) using the old wave of the three ICRISAT villages, 0.45 in Subramanian and Deaton (1996) with a range of 0.3 to 0.5 using Indian data, and studies reviewed in Strauss and Thomas (1995).

[26] Studies have highlighted several possible rationales for the salient effects of food transfers on food consumption, including mental accounting (Hastings and Shapiro 2018), intra-household bargaining (Breunig and Dasgupta 2005), insurance against price risk (Gadenne et al. 2017), and resource-constrained environments (Hoddinott, Sandström and Upton 2018). Therefore, there are many possible channels through which food transfers such as the PDS may have larger effects on food consumption. However, identifying these mechanisms is beyond the scope of this paper, due to the lack of data availability of an exogenous unearned income source (such as a cash transfer) during our study period.

[27] Proteins from animal sources contain essential amino acids that stimulate insulin-like growth factors (IGF-1), leading to rapid linear growth and cognitive development via the mTORC1 pathway (Parikh et al. 2022; Semba et al. 2016). In addition, animal source foods are rich sources of multiple micro nutrients (such as zinc, iron, iodine, magnesium, calcium, B-vitamins, vitamin A, and vitamin D) that supply essential components and regulate processes involved in growth and development (Neumann, Harris, and Rogers 2002; Michaelsen et al. 2009). Among animal source foods, milk has been specifically and repeatedly shown to exert an important influence on linear growth in undernourished population (Millward 2017; Herber et al. 2020; Dror and Allen 2011; Hoppe, Mølgaard, and Michaelsen 2006). In addition to the nutritional benefits from consuming individual foods, consumption of diverse foods that contain a wide range of micronutrients has been show to be an important determinant of linear growth and stunting reductions in multiple settings (Arimond and Ruel 2004; Headey, Hirvonen, and Hoddinott 2018).

0.10 standard deviations and reduced stunting by 7 percentage points [95 percent CI range of -1.2 percentage points to -13 percentage points]. These magnitudes of stunting reduction are broadly consistent with the estimated increase in nutrient intake, in light of the nutrition literature on the effects of protein supplementation on child growth outcomes. For instance, a recent meta-analysis by Pimpin et al. (2019) of 19 randomized controlled trials, including 11,098 infants and children, showed that food-based animal protein supplementation increased height-for-age *z*-score of children. While the magnitude of HAZ effects varied by the level of protein dose in each trial, the meta-analysis found that a weighted-average dose of 2.87 grams of animal protein per 1,000 kcal regular diet increased HAZ by a magnitude of 0.06 standard deviations [95 percent CI range of 0.02 to 0.10]. Based on these numbers, our estimated effect of an increase of 4.2 g of animal protein per 1,000 kcal would increase HAZ by 0.098 standard deviations ($= 0.06 \times 4.7/2.87$). Thus, the increase in animal protein intake alone could explain our observed gains in child height-for-age of 0.10.[28] Similarly, Iannotti et al. (2017) show that an egg a day for six months, equivalent to 7 grams of protein, increased height-for-age *z*-score of children ages 6 to 9 months by 0.63 standard deviations [95 percent CI range of 0.38 to 0.88]. These numbers suggest that our estimated increase in animal protein of 4.2 g per day would lead to an increase in height-for-age of 0.37 standard deviations, substantially larger than the effect we observe. While these calibration exercises rely on simplifying assumptions, they demonstrate that a large gain in height of the magnitude we observe or larger should not be unexpected based on the observed increase in animal protein.

The magnitude of our estimated effects are also broadly consistent with previous studies that find positive effects of transfers on child height and household nutrient intake. For instance, Olney et al. (2018) and Jensen et al. (2016) show that a program in Guatemala that combined nutritional education with food assistance improved household consumption and consequently reduced stunting. The program, which provided households with food assistance equivalent to 347 kcal and 10.6 g of protein per day per capita, increased children's HAZ by 0.19 standard deviation [95 percent CI range of 0.032 to 0.347] and reduced stunting by 11.10 percentage points. Similarly, Ahmed, Hoddinott and Roy (2019) show that a program that combined cash transfers with a behavioral change communication (BCC) component, which increased household energy intake by 220.4 kcal/day per capita and protein intake by 8.2 g/day per capita, increased children's HAZ by 0.25 standard deviations [95 percent CI range of 0.091 to 0.40] and reduced stunting by 7.8 percentage points [95 percent CI range of 1.9 percentage points to 13.7 percentage points].

[28] It should further be noted that the meta-analysis by Pimpin et al. (2019) estimated the effect of increased protein intake while holding total calorie intake constant. In our case, PDS transfers increased both protein intake and total calorie intake, so we would expect them to have a larger effect. The increase of 0.098 standard deviations in HAZ that we calculated from meta-analysis should therefore be considered a lower bound. Either way, our estimates are not statistically distinguishable from the increase suggested by the meta-analysis and should therefore not be unexpected based on the increase in nutrition (the lower bound of our 95 percent CI is an increase of 0.02 standard deviations, which is substantially below the increase suggested by the meta-analysis).

Our estimates suggest that a 30 rupee increase in PDS transfers increased calorie and animal protein intake by roughly half the amount of the programs studied by Olney et al. (2018); Jensen et al. (2016); Ahmed, Hoddinott and Roy (2019), and also improved anthropometric outcomes by about half as much, suggesting that our estimated dose-response relationship is in line with the previous literature. Furthermore, our estimate of a stunting reduction of children by 7 percentage points and associated 95 percent CI range of the estimate [-1.2 percentage points to -13 percentage points] falls largely within the 95 percent confidence intervals of several recent studies that looked at the effect of social transfers on stunting, including Carneiro et al. (2021) [95 percent CI range of -0.7 percentage points to -10.5 percentage points], Field and Maffioli (2021) [95 percent CI range of -0.4 percentage points to -8.7 percentage points], and Ahmed, Hoddinott and Roy (2019) [95 percent CI range of -1.9 percentage points to -13.7 percentage points].

VI. Effects on Wage Earnings

In addition to their direct effect on food consumption, food transfers can impact child outcomes through potential "second-round" effects on wage earnings.[29] For instance, previous research has shown that social transfers can have substantial additional effects on households by increasing their labor incomes (Bandiera et al. 2017; Fink, Jack, and Masiye 2020; Carneiro et al. 2021). To explore the possibility of labor market effects of PDS transfers, we estimate equation (5) on households' labor market outcome (wage earnings, wages, and labor supply). As before, in equation (5) labor market outcomes and PDS transfers are observed at monthly intervals. Our analysis of labor supply and wage earnings focuses on the number of days worked outside of the household and the earnings generated by that work. For this analysis, we use the full sample of individuals and denote the labor supply and earnings of individuals who do not work as zero. Our measure of labor supply and earnings thus captures both the decision to work and number of days worked (extensive and intensive margins). Our analysis of the wage restricts the sample to individuals that report participation in the labor market.

The results in Table 11 show that an increase in PDS transfers led to an increase in household wage earnings and an increase in market wages. Based on the coefficient estimates in column 1, a 1 rupee increase in transfer value led to an increase in households' per capita wage income by 1.21 rupees. These results suggest that PDS transfer may increase the household's wage incomes by a magnitude of 0.21 more than the value of the transfer. Column 2 shows that an increase in PDS transfers increases daily market wages, consistent with an increase in household wage earnings. Based on the coefficient estimates, a 30 rupee increase in transfer value increases daily market wages by approximately 3.2 rupees ($= 30 \times 0.108$) or 1.7 percent of the pre-NFSA mean.

[29] In the context of rural markets, food transfer may affect local consumer prices (Cunha, De Giorgi, and Jayachandran 2019). We explore the "second order" price effects of PDS transfers in Supplemental Appendix Section A1.

TABLE 11—EFFECT OF PDS TRANSFER ON LABOR MARKET OUTCOMES

	Wage earnings	Wages	Labor supply
PDS transfer value	1.212	0.108	−0.051
(IV: NFSA target value)	(0.553)	(0.054)	(0.014)
Observations	54,479	42,054	57,322
Mean of outcome	910 Rs/month	183 Rs/day	36 days/month

Notes: The table presents estimates of IV regressions of household wage earnings, daily wages, and household labor supply on PDS transfer value, instrumented by NFSA target value. Unit of observation is household-month. All regressions include household and consecutive month fixed effects, and the same set of controls as our baseline specification: state-by-time fixed effects and a vector of household-specific time-varying fixed effects, as specified in equation (5). Labor supply and wage earnings are measured as the number of days worked per month outside of the household and the earnings (in real per capita rupees) generated by that work. Market wages represent daily wages measured in Rs/day. Wage earnings is measured in real per capita rupees, market wages represent daily wages measured in Rs/day, and labor supply is measured in number of days per month. Market wages and wage earnings are trimmed at the top 5 percent of the distribution to remove outliers that may be due to misreporting. The results are robust to trimming the wage distribution at different thresholds and to using the entire distribution. Standard errors reported in parentheses are clustered at village level.

The increase in household wage earnings and wages is consistent with a health productivity mechanism in which improved nutrition increases labor productivity (Strauss and Thomas 1998). Alternatively, the wage increase could be due to an equilibrium effect. Column 3 shows that an increase in PDS transfers led to a modest reduction in the number of days worked outside the household of about 4 percent. However, we have no information on the number of hours worked per day, so we cannot estimate the effects of PDS transfers on total labor supply.[30] It is thus possible that a reduction in labor supply caused local wages to rise as an equilibrium response in the local labor market (Rosenzweig 1988). Either way, the wage increase is larger on magnitude than the reduction in labor supply, so that PDS transfers led to a substantial increase in total wage income. Overall, our key result that PDS transfers improved wage earnings are consistent with those of Carneiro et al. (2021), who found that cash transfers improved earnings of beneficiary mothers, and thereby increased overall resources for the household.

VII. Effects during Climate Shocks

Climate change and extreme climate events are widely acknowledged to be a major threat to child nutrition, particularly for agrarian rural households who rely

[30] It is possible that the reduction in days worked is offset by an increase in the number of hours worked per day, which could potentially explain the increase in the daily wage in a way that is consistent with a health productivity effect. Based on the coefficient estimates, a 30-rupee increase in transfer value led households to decrease their days worked by about one day per month ($1.5 = 30 \times 0.05$), or 4 percent. These results are consistent with previous estimates on the labor supply effects of social transfers. For instance, our estimate for a transfer size equivalent to 10 percent of household consumption translates to a reduction of 6 percent in market labor supply that falls within the 95 percent confidence interval estimated in Banerjee et al.'s (2017) meta-analysis of six randomised controlled trials of conditional cash transfers. The same estimate, in comparison to sample mean of total labor supply (including domestic, self-employment, and market) of 109 days/month, translates to a reduction of 1.3 percent ($= 1.5/109$) in total labor supply.

on rain-fed agriculture (Helldén et al. 2021). A bad rainfall may result in lower crop yield and higher food prices, worsening food security and nutrition for vulnerable households, thereby exacerbating child malnutrition outcomes. Several studies have documented large increases in child stunting during periods of droughts (Hoddinott and Kinsey 2001; Alderman, Hoddinott, and Kinsey 2006; Phalkey et al. 2015; Cooper et al. 2019). Food transfers may be effective at protecting against these adverse effects by providing nutritional assistance during times of food insecurity and income shortfalls (Ruel and Alderman 2013). Moreover, food transfers can provide an additional insurance against price risk, as the effective value of food transfers rise together with local food prices in response to agricultural production shocks (Gadenne et al. 2017). A nutrition sensitive safety net like the PDS could thus mitigate the negative effects of climate shocks on child nutrition by improving food security during periods of production or income shortfalls. If this is true, we would expect the effect of PDS on child nutrition to be particularly large in years with negative climate shocks.

We test this proposition by considering how increased PDS transfers affect the way child malnutrition responds to rainfall shocks. The ICRISAT villages provide a unique setting to test this proposition, where a majority of households are vulnerable to rainfall shocks (Giné, Townsend, and Vickery 2008; Jacoby and Skoufias 1997; Rosenzweig and Binswanger 1993). We use rainfall quantity during the monsoon season (June to September) as a measure of climate shock. For ease of interpretation, we use the standardized z-score of monsoon rainfall in the estimations.[31]

We estimate whether increases in PDS transfers led to larger reductions in child stunting during climate shocks by considering an interaction model similar to equation (3), with an added interaction between PDS transfer and rainfall quantity:

$$(6) \qquad Y_{ihst} = \beta_4 T_{hst} + \beta_5 R_{vt} + \beta_6 R_{vt} T_{hst} + \delta_{st} + \mathbf{X}'_{ihst}\gamma + \alpha_i + \lambda_t + \epsilon_{ivt},$$

where R_{vt} is the standardized z-score of rainfall quantity during the rainy season (June to September) in village v in the previous year t. As noted in equation (3), the anthropometric status of children is measured annually in July. Accordingly, the variable R_{vt} corresponds to the annual rainfall in the previous year. For instance, for $t = 2014$ the outcome Y_{ihst} is the child's stunting status in July 2014, while T_{hst} is the household's average PDS transfer value between July 2013 and June 2014, and R_{vt} is the z-score of rainfall quantity during the rainy season of the crop year 2013, between June 2013 and September 2013. Standard errors are clustered at the village level. The coefficient β_6 can be interpreted as the degree to which PDS transfers can attenuate the adverse effects of rainfall shocks on child malnutrition.

The results of this estimation, reported in Table 12, suggest that the effect of PDS transfers on child stunting is particularly large during years with less rainfall. The estimates in column 2 suggest that a shortfall in monsoon rainfall increases

[31] The z-score of monsoon rainfall can be interpreted as the number of deviations from the village's 60-year average monsoon rainfall. For instance, in our data, the 60-year, village-specific average monsoon rainfall is 790 mm and the average standard deviation is 395, therefore a monsoon rainfall z-score of -1 corresponds to precipitation of 395 mm less than that village average.

TABLE 12—EFFECT OF PDS TRANSFER (IN Rs 100) ON CHILD HEIGHT AT DIFFERENT LEVELS OF MONSOON SHOCK

	Stunting		HAZ	
	(1)	(2)	(3)	(4)
PDS transfer	−0.211	−0.167	0.269	0.167
(IV–NFSA value)	(0.090)	(0.088)	(0.161)	(0.161)
Rainfall quantity	−0.034	−0.081	0.189	0.296
(z-score)	(0.036)	(0.040)	(0.110)	(0.134)
PDS transfer × RF quantity		0.099		−0.228
		(0.029)		(0.093)
Observations	1,305	1,305	1,305	1,305

Notes: This table reports coefficients and standard errors from instrumented regressions of stunting and HAZ on PDS transfer value (with NFSA target value as the instrument) interacted with rainfall quantity (z-score). PDS transfer value and NFSA target value are expressed in units of 100 rupees. All regressions include individual and consecutive year fixed effects and the same set of controls as our baseline specification: state-by-time fixed effects and a vector of household-specific time-varying fixed effects, as specified in equation (3). Rainfall quantity refers to standardized z-score of rainfall quantity with respect to the village mean and standard deviation. In our data, the 60-year village-specific average monsoon rainfall is 790 mm, and the average standard deviation is 395, therefore a monsoon rainfall z-score of -1 corresponds to precipitation of 395 mm less than that village average. The unit of observation is the individual-month. Standard errors in parentheses are clustered at the village level.

stunting, consistent with earlier work (Hoddinott and Kinsey 2001). The interaction term suggests that PDS transfers mitigate this effect. Based on the coefficient estimates in column 2, a 100 rupee increase in PDS transfer when rainfall quantity is 2 SD below the long-run mean decreases stunting by 36 percentage points ($= -0.167 - 2 \times 0.099$). However, when rainfall quantity is 1 SD above the long-run mean, a 100 rupee increase in PDS transfers decrease stunting only by 7 percentage points. The same estimates imply that, for a PDS program expansion of 30 rupees per capita per month reduces stunting by 12 percentage points ($= 36 \times 0.33$) when rainfall is 2 SD below the mean, whereas the reduction in stunting is 2.3 percentage points when rainfall is 1 SD above the mean.

Overall, our results show that the effect of PDS transfers on stunting reductions are particularly large during years with low rainfall. These results suggest that a nutrition-sensitive safety net like the PDS can enhance food security and thus make child nutrition outcomes less sensitive to production shocks. As climate change continues and is expected to increasingly threaten food security and nutrition outcomes of children and vulnerable households, the results from this study suggest that food transfers can play an important role in mitigating the adverse effects of climate shocks on child nutrition.

VIII. Conclusion

India has one of the highest proportions of undernourished children in the world. In 2019, 37.3 percent of Indian children under the age of five were estimated to be stunted and at risk of failing to achieve their genetic potential for physical and cognitive development. Stunting in children has long-term consequences on poverty, human capital, and health. According to some estimates, childhood stunting in India alone costs billions of dollars every year in productivity and lost earnings (Akseer et al. 2022). Understanding the efficacy of social programs in addressing the problem of undernutrition and stunting is critical for development policy worldwide, as effective investments in early childhood nutrition can have substantial long-term effects on economic growth and productivity (Hoddinott et al. 2008).

We have estimated the effect of India's PDS program on child undernutrition. We studied the expansion in PDS food transfers precipitated by the National Food Security Act (NFSA)—hailed at the time as the biggest ever expansion of "right to food" in the world. The welfare impacts of the NFSA are striking in many dimensions. The expansion of PDS transfers significantly reduced stunting in children. The magnitude of this effect was largest for infants 0 to 2 years old, consistent with the critical window of the first 1,000 days of life during which a child's development is highly sensitive to nutritional intake. Furthermore, we find marked improvements in household dietary diversity and nutrient intake, particularly of animal proteins, consistent with our main finding of stunting reductions. The NFSA expansion also had important "second round" impacts on wages. Daily wages and total wage income at the household level increased, improving the welfare of poor households, who are typically net labor suppliers. The magnitude of the increase in wage earnings was more than the amount of the transfer itself and may partly explain the large effects of food transfers on stunting in our context. Finally, the expansion in PDS transfers led to larger reductions in stunting during years with a low rainfall shock, suggesting that PDS transfers may play an important role in mitigating the adverse impacts of climate shocks on child undernutrition. Overall, our results suggest that food transfers can lead to large improvements in nutritional outcomes of children in poor households.

Our results have important implications for the Indian policy debate around the effectiveness of the NFSA and the PDS. The PDS has been criticized on the grounds that the program is poorly targeted, does not reach the intended beneficiaries, and hence may have little impact on household nutrient intake and child nutrition. Furthermore, critics contend that PDS encourages only "empty calories," and thus may crowd-out more nutritious food items and not improve dietary diversity, thereby worsening undernutrition outcomes. Our results suggest that these criticisms are not generally valid. We find that PDS expansions that followed NFSA effectively reached the intended beneficiaries and had large positive impacts in our study sample. Our back-of-the-envelope calculations that extrapolate our estimates to the aggregate level suggest that the PDS expansions from NFSA, prevented approximately 1.8 million children from being stunted.

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