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# Nutrient Consumption in India: Evidence from a Village Study

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# Nutrient Consumption in India: Evidence from a Village Study*

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**ABSTRACT**

Adequate nutrition is one of the basic requirements for survival and is generally regarded as a core dimension in any evaluation of well-being. In the context of India, a country with high prevalence of poor nutrition, there is a dearth of nutrition studies with adequate coverage and comparability. Using primary data on food consumption from a village in a poorer state of India, we study the consumption of five key nutrients, namely, calories, protein, carbohydrate, calcium and iron. Investigating the determinants of nutrition intake, we find evidence of consumption smoothing. By correcting for potential endogeneity in both expenditure and consumption of subsidised food through the Public Distribution System (PDS) we demonstrate a causal link from expenditure and the availability of subsidised food grains to nutritional intake. We also find evidence that other individual characteristics such as gender and occupation have an important role to play as determinants of nutrition.

Key Words: Endogeneity, Macro nutrients, Micro nutrients, Nutrition, Public Distribution System, India

JEL Classification Number: I1, I38, O12, O53

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# 1 Introduction

Nutrition is universally regarded as a core dimension in any evaluation of well-being. *The Economist* (Feb. 18, 2012) reported, that nutrition is increasingly becoming the centre of policy initiatives both for governments and multi-lateral agencies. Britain's Department for International Development, for instance, is devoting more resources to nutrition, taking the share of nutritional related projects in its budget from less than four percent in 2010 to over 10 percent in 2015 (Development Initiative, 2017). The World Bank (2006) in a report makes a strong case for investing in nutrition, given the high returns. Despite this increasing interest in nutrition, for many developing countries, there is a dearth of detailed studies focussing on nutrient intake (Haddad et al., 2015). In the context of India, a country with high levels of stunting and wasting, recent national surveys on nutrition suffer from issues of comparability and lack of coverage particularly for regions with high nutritional deficiencies (John et al., 2015). This paper uses primary village-level data from a poor region in India to investigate both macro and micro nutrient consumption. Specifically, we study the consumption of three macro nutrients, calories, protein and carbohydrates, and two micro nutrients, calcium and iron. In addition to quantifying the level of nutritional intake in the village, we examine the causal factors that impact nutrient consumption.

India presents a rather puzzling case when it comes to nutrition. In an early pioneering study, going against the prevailing wisdom and using village-level data (ICRISAT) from India, Behrman and Deolalikar (1987) demonstrated that income elasticities of demand for macro and micro nutrients are close to zero. It implied that increases in income would not necessarily be translated into increased nutrient consumption. They attributed their findings to strong preferences for particular kinds of diets. Using nationally representative data from the National Sample Survey (NSS), Subramanian and Deaton (1996) found that the expenditure elasticity for calorie consumption varies between 0.3 and 0.5.[1] Analysing NSS data, Dreze and Deaton (2009) found that, contrary to popular expectations, while income had increased, calorie intake had declined over time. This held true across the board for all income categories. They explained this puzzle mainly in terms of a reduced need for calories arising from a shift towards more

[1] Using semi parametric methods on the ICRISAT data set, Roy (2001) found that income elasticity of calorie intake was small but positive.

sedentary jobs over time and overall improvement in health. Focussing on fats and proteins in addition to calories, Gaiha et al. (2013) provide an alternative hypothesis where decrease in demand for these nutrients is mainly due to decrease in the consumption of food products resulting from higher prices.

Given the diverging views in the literature on both the trends and determinants of nutrition in India, there is need for detailed micro level studies on nutrition to enhance our understanding in several ways. First, such micro level studies allow us to explore the specific problem in greater detail than is often possible in the case of national studies for a very large country such as India. Second, in studying the problem in a small area, it is often easier to identify the impact of the local social and cultural environment; the insights gained in this fashion may, in its turn, suggest hypotheses, which can be tested at the state or national level. It is in this spirit that we have collected primary data from the village of Mahidharpada in Odisha, India. Our research is also motivated by village studies in economics such as those undertaken by the LSE Palanpur Study Group (Himanshu et al. 2018, Lanjouw and Stern, 1998, Bliss and Stern, 1982), the ICRISAT village studies (Dercon et al. 2013, Behrman and Deolalikar, 1987) and Townsend's (2016) Thai village studies. Although one has to be cautious about drawing any general conclusions from village studies, they often capture the changes happening in the country at large. In the case of Palanpur, Stern (2017) claims that changes in India are reflected in the changes in the village, and long term study of the village helps in understanding the broader changes happening in India. Thus, while recognizing the limitations of village studies such as ours, we believe that they can serve as useful supplements for corresponding studies on a much larger scale.

We contribute to the existing literature in several ways. We believe that, after the initial set of papers, such as Behrman (1988a, 1988b), Behrman and Deolalikar (1987), which study nutrition at the village level using ICRISAT data, ours is the first paper to undertake a detailed analysis of the consumption of nutrients in a village in India. If village studies reveal interesting patterns and changes, then given the size and diversity of India it is imperative that we look beyond the initial established village studies and focus on less prosperous regions. The village we study is located in Odisha which is a state in eastern India with a very high level of poverty.[2] Between 2004-05 and 2009-10, Odisha experienced one of the greatest reductions in income poverty, as measured by the headcount ratio, among India states; during this period, the

[2]Based on the 2011 census of India, Odisha had a population of 41.94 million and is the 11th largest state in the country.

headcount ratio in Odisha declined from 57.2 percent to around 37 percent. The Government of Odisha has undertaken several policy initiatives such as the Targeted Public Distribution System (PDS), to improve nutrition among its citizens (see among others Shrivastava et al. 2017 and Gillespie et al. 2017). All these changes make it an interesting case to study.

Unlike some studies of nutrition, our interest here is not on estimating the demand for different nutrients; instead, we examine causal links between certain key variables, in particular, between household expenditure and PDS, and consumption of nutrition. It is generally accepted that income (or expenditure) is an important factor which influences nutrition (Burchi and Muro, 2016). But we are not aware of any micro level study in India, which explores the causal link between household expenditure and the consumption of nutrients. Though Odisha has seen significant improvement in the implementation of the PDS between 2004 and 2010 (Khera, 2011a, 2011b), we have not been able to find any systematic study of the impact of PDS on nutrition for Odisha. At the national level, the findings have been mixed, with Kochar (2005) claiming that PDS provided food has no impact on nutrition and Kumar et al. (2012) showing a positive and significant impact of PDS on nutrition.

To the best of our knowledge, ours is the first study to demonstrate a causal connection from key variables such as household expenditure and PDS, especially to nutrition in the context of micro level studies in India. We correct for potential endogeneity issues by using standard Instrumental Variable (IV) methods. While the IV method is well established, we have not found any application of IV in this context before. In addition, we have undertaken several robustness checks, to establish the role of other household and individual characteristics, such as gender, occupation, and caste of the household, in determining the consumption of macro and micro nutrients. Our analysis reveals some interesting results on how household and individual characteristics impact nutrition, which are different from the results in existing literature.

As recognised by Subramanian and Deaton (1996), there is a difference between nutrient intake and nutrient availability. While our sample is not nationally representative as in the NSS, unlike NSS which is based on purchase data, we have focussed on direct consumption. Thus, for example, a household might have purchased 40 kilograms of rice but might have consumed only 20 kilograms of rice. What we have documented is the latter figure of 20 kilograms. Purchase-based data, on the other hand, may include food items that are purchased for other purposes such as gifts to others; also purchase-based data may include food stored and consumed in a period different from the period during which the actual purchase is made.[3] Further the focus at the village level has allowed us to take into account consumption of particular types of food which are specific to the region. For instance, we have documented substantial consumption of leafy vegetables such as amaranthus virdis (leutia saag) and pulses such as horse gram (kolatha) which although quite common in this region, is not consumed widely elsewhere.

The plan of the paper is as follows. In Section 2 we discuss in detail the data that we have collected and some broad descriptive statistics. The following section provides a brief description of our notations, and how we calibrate the different nutrients. Section 4 presents our estimation strategy and examines the results of our analysis. In this section we also discuss the evidence of the causal impact of key variables on nutrient consumption using the IV method. Section 5 considers two robustness checks; one based on quantile regressions and the other using adult equivalence scales which take in to account some aspects of intra-household distribution. Section 6 concludes with a few brief remarks and some directions for future research.

## 2 Data and Descriptive Statistics

Mahidharpada is situated in eastern Odisha, a relatively prosperous part of the state, with the state capital, Bhubaneswar, in the North and the commercial city of Cuttack in the South. The village consists of 136 households. We were able to collect the food information for 134 households, with 776 people covered by the survey.[4] The average size of the household is 5.8. The village has three broad subgroups, based on caste lines – (i) "Schedule Castes" (SC), (ii) "Other Backward Castes" (OBC) and (iii) "Other Hindus" (OH), with SC being the dominant group with 81 households and the rest spread between OBC and OH. Slightly less than 80 percent of the households are headed by males. Mahidharpada is not an affluent village, with the main occupation in the village being wage labourers. The survey in this village was conducted between November and December 2011. We collected detailed information on living

[3] Although we have made it clear to each household head that we want the consumption data, given our 30 day recall (which we discuss in the next section), there is a possibility that they have reported the purchase data.

[4] We had information for 135 households but one of the households did not cook after the death of the only female member of the household. They mostly ate away from the house. Hence we decided to drop that household from our analysis.

standards including food consumption using a questionnaire that we developed.[5]

The food consumption data was based on a 30 day recall. Among the two main data sets used to study nutritional intake in India, the NSS has moved to a 7 day recall period from a 30 day recall, and the ICRISAT data is based on 24 hour recall. Short recall periods may have better accuracy in terms of the consumption people have undertaken, however, they may carry a lot of noise (Strauss and Thomas, 1995). In a rural context, we felt that the 30 day recall period may work better in two respects. First, some of the food items may not be consumed every week. For instance, non-staple food such as meat may be consumed bi-weekly, which under a 7 day recall would go unreported depending on which week the survey takes place. Second, weekly consumption might be more prone to idiosyncratic shocks of unemployment or sickness, particularly in a rural area where many of the households are daily wage earners and have no insurance. Therefore, we decided on a 30 day recall to collect the consumption information.

We have collected information over 55 food items across 11 food categories. For each food item we gathered information on the household's consumption of the quantity and expenditure over the preceding 30 days including both market and non-market transactions. Besides the consumption of food purchased in markets, we have taken three types of non-market transactions into account: (a) consumption of food received in exchange of other goods or labour rendered, (b) consumption out of home grown stock and (c) consumption of food picked free from fields and communal lands. Drawing on our broad observations in the village, we found that high per capita consumption of cereals and pulses are not surprising since many households rely on just these two food types as their only staple. Hence, in order to filter out extreme values in food consumption, we focus on the food categories of vegetables and dairy products. We decided to drop households from our sample which have reported per capita consumption for vegetables and dairy products greater than 20 kgs per month. As a result we had to trim our data from 134 households to 131 households. In terms of individuals, our sample now is of 766 individuals down from 776 in our raw data.

Table 1 below provides a broad picture of the demographics of the village after all the exclusion criteria have been applied.

[5] Given the detailed amount of information that was required and the general levels of literacy, each household was assisted by a research assistant.

Table 1: Demographics based on Caste and Gender of the Head of the Household

| | | Caste of the Head | | | Gender of the Head | |
|---|---|---|---|---|---|---|
| | Other Backward Castes | Other Hindu Castes | Schedule Castes | Total | Female | Male |
| Males | 58 | 58 | 167 | 283 | 38 | 245 |
| Females | 65 | 75 | 183 | 323 | 69 | 254 |
| Male Child | 12 | 7 | 54 | 73 | 7 | 66 |
| Female Child | 15 | 17 | 55 | 87 | 22 | 65 |
| Total (Individuals) | 150 | 157 | 459 | 766 | 136 | 630 |
| Total (Households) | 26 | 24 | 81 | 131 | 27 | 104 |

The average size of the household now is around 5.8, with 4.6 adults and 1.2 children where anyone 12 year old or less is considered a child and the rest as adults.[6] The modified sample had lost two female-headed households and one male-headed household, thus slightly reducing the overall proportion of female to male headed households in the sample from around 27 percent to 26 percent. Out of the three households that we dropped from further analysis, two are from OH (upper caste) and one from OBC. As before, SC are the dominant group followed by OBC and OH both of which have similar level of presence. The dominant occupation in the village remains wage labourers. Around 27 percent of the households and 23 percent of the individuals rely on subsidised food provided by the PDS. In terms of caste, around 65 percent of the PDS reliant households are SC and 33 percent are OBC. Rest of our analysis will be based on this modified sample.

Table 2 below provides the descriptive statistics for household consumption of the different food categories in the last 30 days.

As is evident from Table 2, cereals and vegetables constitute the bulk of food consumption. Given food preferences in Odisha, rice constitutes the major component of consumption within cereals. On average, the cereal consumption in our survey is around 11 kgs per month for each individual, with median consumption of around 10 kgs. At the all India level, for rural areas, Dreze (2007) reported that average cereal consumption per month in 2000-2001 was 12.5 kgs. Based on a primary survey conducted in 2011 for 144 households, Khera (2011c) finds the

[6] This is similar to the average in our original data set of 5.79.

Table 2: Monthly Food Consumed by Households

| | Mean | Median | Standard Deviation | Max | Min |
|---|---|---|---|---|---|
| Cereals (Kg) | 10.98 | 10.00 | 4.41 | 25.00 | 2.92 |
| Pulses (Kg) | 1.39 | 1.00 | 1.23 | 9.25 | 0.00 |
| Vegetables (Kg) | 7.06 | 5.80 | 3.97 | 19.67 | 1.57 |
| Fresh Fruits (Kg) | 1.26 | 0.89 | 1.30 | 10.10 | 0.00 |
| Dry Nuts (Kg) | 0.07 | 0.00 | 0.29 | 2.50 | 0.00 |
| Sugar Gur Salt (Kg) | 1.28 | 1.00 | 0.82 | 5.20 | 0.29 |
| Spices (Kg) | 0.31 | 0.24 | 0.22 | 1.35 | 0.04 |
| Dairy Products (Kg) | 1.75 | 0.67 | 2.89 | 18.20 | 0.00 |
| Edible Oil (Kg) | 0.52 | 0.38 | 0.45 | 2.63 | 0.07 |
| Meat Eggs and Fish (Kg) | 0.61 | 0.47 | 0.58 | 4.00 | 0.00 |
| Beverages (Kg) | 0.06 | 0.03 | 0.12 | 0.94 | 0.00 |
| Pan Tobacco and Intoxicants (Kg) | 0.24 | 0.14 | 0.34 | 2.88 | 0.00 |

per capita cereal consumption in Odisha under 7 day recall to be around 15.8 kgs. For rural areas in Odisha, Ray (2007) finds that total per capita cereal consumption for 2002 over 30 days is around 14.3 kgs. In that study, Odisha was one of the highest among Indian states for cereal consumption, second only to Bihar. Ray (2007) also finds that in 2002 per capita mean monthly consumption of vegetables and fruits is around 7.8 kgs, whereas meat, fish and eggs are 0.8 kgs. Our data on the other hand shows that per capita monthly vegetables and fruit consumption is around 7.1 kgs and 1.27 kgs respectively, with median consumption around 5.2 kgs and 0.9 kgs respectively. For meat, fish and eggs we find that the monthly average consumption is 0.61 kgs, with median consumption around 0.47 kgs. Thus, the amount of food consumed in the village, is around 10 to 20 percent lower than statewide and countrywide averages. This difference may be because of the longer recall periods used in our survey. We know that people under report their consumption when longer recall period is used.

# 3 Calibration of Nutrient Consumption

Since we are interested in the consumption of nutrients, we index the five nutrients of calorie, protein, carbohydrate, calcium, and iron as 1, 2, 3, 4, and 5, respectively. We calibrate the level of nutrient consumption for each household in the village using the information on the amount of food consumed along with how much nutrient a specified quantity of each of these food items provides.

In general terms, let $N$ be the set of all persons (including children) in the village. Suppose there are $K$ food items. From MedIndia (www.medindia.com), we have, for every food item, information regarding the amount of each of the five nutrients that a person can get from one unit of that food item.[7] For every food item $k$ ($k = 1, 2, ..., K$) and for every nutrient $j$ ($j = 1, 2, ..., 5$), let $r_{jk}$ denote the amount of nutrient $j$ that an individual derives from one unit of food item $k$. Suppose household $h$ daily consumes $a_{hk}$ units of food item $k$. Then household $h$ daily consumes $a_{hk}.r_{jk}$ units of nutrient $j$ from the consumption of food item $k$. The total daily consumption of nutrient $j$ by household $h$ is given by $b_j^h = \sum_{k=1}^{K} a_{hk}.r_{jk}$. The per capita daily consumption of nutrient $j$ by household $h$ will be $b_j^h/n_h$, where $n_h$ is the number of members in household $h$. Based on these steps we calibrate the per capita daily consumption of macro and micro nutrients in this village.

For macro nutrients, carbohydrate and protein the unit of measurement is in grams (gms) and for calories it is in kilo calories (kcal); for the micro nutrients, calcium and iron, it is milligrams (mgs). In our calibrations of nutrition we have not considered two food groups - beverages and intoxicants. The main reasons are, first, most of the nutrition comes from other food groups and second, attributing the nutrition from beverages and intoxicants to the whole household would be problematic as these items are usually consumed by adults, with intoxicants being consumed mainly by men. The next table provides the summary statistics for the daily per capita consumption of the five nutrients that we are interested in.

Table 3: Descriptive Statistics of per capita Daily Nutrition

| | Mean | Median | Standard Deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| Calorie (Kcal) | 1945.65 | 1757.96 | 786.64 | 4104.53 | 699.53 |
| Protein (gm) | 52.22 | 45.79 | 25.34 | 149.95 | 16.04 |
| Carbohydrate (gm) | 376.83 | 350.77 | 145.34 | 826.40 | 117.00 |
| Calcium (mg) | 380.80 | 289.73 | 271.48 | 1461.61 | 58.09 |
| Iron (mg) | 13.89 | 10.46 | 9.35 | 64.60 | 2.85 |

The daily per capita mean consumption of calories in our village is around 1950 kcal and protein is around 52 gms. Dreze and Deaton (2009), who estimate that for 2004-05, in rural areas of India the daily per capita mean calorie consumption was 2047 kcal and protein was 55.8gms. Kumar et al. (2012) report that in rural India for 2009-10, the daily per capita calorie

[7] We have checked that the nutritive values are in line with Gopalan et al. (2014) which is widely used in the literature.

and protein consumption was 2147 kcal and 59 gms respectively. As with food consumption, the average nutrient values in our data are around five to ten percent below the reported national averages.

We also find that the per capita median consumption is lower than the per capita mean consumption, implying the strong influence of the upper tail of the nutrient distribution on the mean. To understand what is happening with the tails of the distribution let us focus on calorie consumption, which mainly is generated by cereals. Among the top five households in terms calorie consumption, we have an average per capita consumption of 20 kgs of cereals (which is mainly rice), while for the bottom five households it is 4 kgs. In terms of household characteristics, two of the top five households are female headed and three are male headed, with three of the households belonging to SC and two of them are OH. On the other hand, among the lowest five households, all of them are male headed household, and only one belongs to the OH with the rest belonging to SC. Average household size is 9.6 in the bottom five compared to 4.2 for the top 5 households. Interestingly, both the top and bottom five households have one household that receive subsidised rice through PDS.

# 4 Results and Analysis

## 4.1 Estimation Strategy: Determinants of Nutrient Consumption

To understand the determinants of nutrient consumption, we run a set of regressions based on per capita daily nutrient consumption as the dependent variable and a set of control variables as our independent variables. Our analysis is done at the individual level, rather than at the household level. We consider both individual and household level covariates and we use the same covariates for the regressions for all nutrients. In our data we don't have intra-household allocation of food hence we mainly work with per capita values. However, we undertake robustness check where we partially account for the potential distribution within the household.

Although our analysis is done at the individual level, both our dependent variable and most of our covariates are household level information which implies that variation at the individual level may be limited. As a result standard errors will have bias, which we correct using clustered standard errors. Thus for our estimation strategy, we use standard OLS regression with clustered standard errors. The estimated equation for nutrient $j$, is given by

$$\ln(y_{ij}) = \alpha_j + \beta_j \ln(E_h) + \delta_j \ln(S_h) + \lambda_j X_{ij} + \varepsilon_{ij} \quad (1)$$

where $y_{ij}$ is the daily per capita nutrient consumption, $E_h$ is the daily per capita total expenditure in the household, $S_i$ is the daily per capita level of subsidised food grain received by the household from PDS, and $X_{ij}$ represents a vector of household and individual level variables which comprise of the caste, gender and age of the household head, and gender and occupation for each household member. Since there are three castes in the village, we have two caste dummies, one for OH and another for OBC, with the SC as the base category. For the gender for both the head of household and individual members, we have taken female-headed households as the base category. In terms of occupation, we have one dummy for those involved in farming and wage labour, with the rest of the occupations, such as artisans, business, paid employment and others, as a base category.

In investigating the determinants of nutrient consumption, one of the key variables is income. Since we do not have any earnings information, we have used expenditure as the proxy for income, as has been done elsewhere in the literature (Subramanian and Deaton,1996). Our expenditure includes expenditure on food and non-food items. In particular, for non-food items we consider expenditure on clothes, personal items, small household appliances, insurance, vacations, health and fuel. We do not consider expenditure on jewelry and social functions as part of the overall expenditure. This is because these expenditures happen as lump sums and are usually planned in advance. They are generally not part of an everyday household budget. For food expenditure where the food item has been secured by the household through non-market transactions, we have asked the household for an imputed value of the expenditure. In some cases, where they did not provide such value we have used the prevailing market prices to construct the expenditure on the relevant food item.[8] Although most of our estimated expenditure comes from marketed transactions, we felt that it was important to include non-marketed transactions as some of the food items are procured free from the village commons.

The other information that we have is the amount of subsidised rice each household received from the Public Distribution System (PDS) of India. The aim of the PDS is to provide

[8] For the same item, the prices paid by the households varied. We considered the average price when constructing the imputed value.

subsidised food including grains, lentils and cooking and lighting oil. Except for a short time, the PDS programme in India has provided universal coverage.[9] However, most of the research so far finds that the PDS programme has little or no effect. The effects considered range from the impact on childrens' weight to reduction of poverty. In our analysis we use the log of daily per capita level of PDS rice. Note that owing to lack of information we do not include subsidised food items, apart from rice, received by the household. From the conversion tables, we know that the main impact of rice is on the macro nutrients, and, therefore, if we observe any impact of PDS on nutrition, it will be mainly on the macro nutrients.[10]

Our next set of covariates capture information related to the household head and individual members. Pujari (2004) found that for Odisha socioeconomic and demographic factors including occupational status and household size were important in explaining household consumption of different types of food. A key factor in socioeconomic status, particularly in rural areas is caste. The customs and preferences of households, which may depend on caste, can influence their consumption for certain kinds of foods and thus nutrients (Ilaiah, 1996, p.26). In the Palanpur village study, Himanshu et al. (2018) found a clear difference between the castes in terms of nutrient consumption. Thus, we control for caste of the household head in our regressions. Note that all the members of the household will belong to the same caste as the head of the household.

There is strong evidence of gender differences in terms of nutrition. In the Palanpur studies, Sinha (2011) using anthropometric measures finds that males did relatively better than females in terms of nutrition. We control for gender using a dummy for each household member. However, head of the household can also have an important say in the food consumption of the household. In particular, Panda (1997) finds that in Odisha female-headed households spend less on high quality food. Thus, independently of food expenditure and other factors, we control for gender of the household head to see if that matters for nutrient consumption.

Food consumption patterns might also be influenced by the human capital of the head of the household. We would expect that more educated household heads may be better informed about the virtues of a more balanced and nutritious diet. Unfortunately we do not have data for the education levels of the head of the household. We try to capture human capital by the age of the head of the household. In doing so, we are intuitively capturing the knowledge

[9] See Kochar (2005) for details about the coverage of PDS in India.

[10] Each 100gms of Rice would generate 341Kcal of calories, 6gms of protein, 79gms of carbohydrate, 9mg of calcium and 1mg of iron.

people gain through life experiences over time. [11] In the literature (Kumar et al., 2012; Behrman and Deolalikar, 1990) the age of the head of the household is taken as a determinant of nutrition. Although we do not take into account the age of each member, one may argue that age itself can be a determinant of nutrition if households with more younger individuals consume different amounts and types of nutrients compared to households with mainly older adults. To capture that younger individuals may consume different amounts than adults, we will undertake robustness analysis using adult equivalence.

We also differentiate each individual in terms of occupational categories by using a dummy variable to control for their occupational status. The occupational dummy takes a value one if the individual works as a farmer or wage labourer, with the rest of the occupations being the base category. Our intuition is that farmers and wage labourers probably focus on more calorie-intensive foods such as carbohydrates rather than calcium or iron rich food. Kumar et al. (2012) find a difference in nutrient consumption depending on whether the head of the household works in the agricultural sector or not. It also ties in with Dreze and Deaton's (2009) claim that sedentary lifestyles impact the consumption of nutrients if we interpret our occupational dummy variable as distinguishing between sedentary and non-sedentary lifestyles.

## 4.2 Regression Analysis

In this section we estimate the determinants of daily per capita nutrient consumption. Household level determinants such as expenditure and PDS consumption is also assessed in terms of daily per capita. The standard regressions along with cluster standard errors for each nutrient are presented in Table 4.[12]

The regressions results from Table 4 show interesting patterns. For all macro and micro nutrients the expenditure elasticity of nutrient consumption is positive and strongly significant. Thus, for every one percent increase in per capita expenditure, the per capita consumption of

[11] There are two types of human capital which are intuitively relevant here: (a) formal education in schools/ colleges, which is likely to make an individual more informed about the roles of different nutrients in promoting good health and the amounts of different nutrients present in different types of food; and (b) informal learning through life experience, which may give even a person without formal education an intuitive idea about what types of food promote good health. Age serves as a reasonable proxy of (b).

[12] We have undertaken the standard diagnostics checks, particularly for multicollinearity. The variance inflation factor (vif) value is very low, indicating no multicollinearity.

Table 4: Determinants of per capita daily nutrient consumption (based on OLS regressions with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log per capita Daily Expenditure | 0.574*** | 0.699*** | 0.500*** | 0.943*** | 0.747*** |
| | (0.046) | (0.045) | (0.053) | (0.081) | (0.070) |
| Log per capita Daily PDS quantity | 0.754** | 0.628** | 0.760** | 0.214 | 0.540 |
| | (0.308) | (0.282) | (0.339) | (0.461) | (0.445) |
| Other Hindu Caste (Dummy) | -0.108 | -0.046 | -0.181** | -0.097 | -0.075 |
| | (0.071) | (0.067) | (0.087) | (0.135) | (0.117) |
| Other Backward Castes (Dummy) | 0.025 | 0.030 | 0.028 | 0.040 | 0.035 |
| | (0.061) | (0.070) | (0.066) | (0.122) | (0.116) |
| Gender of Head (Dummy) | -0.083 | -0.136** | -0.094 | -0.081 | -0.137 |
| | (0.052) | (0.061) | (0.062) | (0.108) | (0.100) |
| Age of Head | 0.002 | 0.001 | 0.002 | -0.003 | -0.005 |
| | (0.002) | (0.002) | (0.002) | (0.004) | (0.003) |
| Gender Individual (Dummy) | -0.023 | -0.017 | -0.026* | -0.021 | -0.027 |
| | (0.014) | (0.015) | (0.016) | (0.024) | (0.023) |
| Occupation Individual (Dummy) | 0.076** | 0.045 | 0.093*** | -0.032 | 0.011 |
| | (0.031) | (0.031) | (0.034) | (0.062) | (0.068) |
| Constant | 5.591*** | 1.621*** | 4.214*** | 2.914*** | 0.410 |
| | (0.213) | (0.174) | (0.254) | (0.324) | (0.320) |
| N | 766 | 766 | 766 | 766 | 766 |
| R-Squared | 0.627 | 0.697 | 0.513 | 0.613 | 0.527 |
| F-stat | 27.806 | 43.082 | 14.983 | 23.265 | 17.300 |

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

calories increases by 0.57 percent, that of protein increases by 0.70 percent, carbohydrates increases by 0.50 percent, calcium increases by 0.94 percent, and iron consumption increases by 0.75 percent. Although the expenditure elasticities of nutrient consumption are substantial, they are less than one except for calcium.[13] This indicates that for each percentage change in expenditure, nutrient consumption changes by less than a percent. On the other hand, it also means that if expenditure is reduced by one percent, the reduction in nutrient consumption would be less than one percent. Taken together they imply consumption smoothing of nutrients.

In terms of the impact of PDS on nutrition, we find that the elasticity is positive and significant for macro nutrients at the five percent significance level. For micro nutrients on the other hand, although the elasticity is positive, it is not significant. Given that in our data, households consume rice from the PDS stores, one percent increase in rice provided by PDS would yield 0.75 percent increase in per capita consumption of calories, 0.63 percent increase in protein and 0.76 percent increase in carbohydrates. The main nutrients from rice are calories and carbohydrates. Thus, it is not a surprise that an increase in PDS rice does not have a significant impact on the micronutrients. What is surprising is that for the main nutrients that comes with rice such as calories and carbohydrates, the impact of PDS rice on the consumption of those nutrients is bigger than that of expenditure. One plausible reason could be that while one percent increase in expenditure leads to a less than one percent increase in food consumption, a one percent increase in PDS consumption reflects a one percent increase in direct food intake. Note also that all of our households, except one, has a 'ration card' - which is needed to access PDS goods. Hence access to subsidised food itself may not really play a role for nutrition, but what seems to matter is the actual quantity of subsidised food.

In addition, there are several other interesting results that emerge. We consider two gender variables as determinants of nutrient consumption. We control for gender of each individual, and also control for the gender of the head of the household. At the individual level, females consume statistically significant higher amounts of calories and carbohydrates relative to males. It implies that in households with higher calorie and carbohydrate consumption there is a greater proportion of females relative to males. This difference does not seem to be arising owing to age difference between the genders since they are very similar in our data with the average age of all females around 31 while for all males it is 32. At the household level, female-

[13] For all the five nutrients, we tested whether (coefficients for Expenditure), $\beta_{Expenditure} = 1$. We fail to reject the null for Calcium.

headed households consume higher amounts of protein compared to male-headed household. From the raw data, it seems on an average female-headed household consume more of high protein food which are pulses, and meat, eggs and fish.[14] These results do not necessarily imply that females in general or female-headed households are better off nutritionally per se. The regression result holds after controlling for expenditure and other covariates. Thus, what it indicates is that, if the households were similar with respect to other covariates, then females and female-headed households will have a higher consumption of some of the macro nutrients. Intuitively, this result makes sense since evidence shows that female members of the household are more concerned about the overall well-being of their members (Behrman et al. 1999). There are, however, no differences for the micro nutrients based on gender.

When it comes to caste, we observe that controlling for other variables, OH caste (upper caste) has statistically significant lower consumption for carbohydrates compared to the SC.[15] Investigating further why this may be the case, we find that upper castes on average consume around 10 percent less of cereals compared to SC but they do consume more pulses and vegetables. Thus it might indicate some differences in tastes and preferences for food. While age can be considered a possible factor, there is not much difference between the average age of SC at 30 and average age of OH at 32. Although, the average age of OBC are higher at 34, they do not have any statistically significant impact on consumption of nutrients by virtue of their caste. However, for all nutrients other than carbohydrates, there is no impact of caste. Hence, it is not a robust determinant of nutrition.

Similarly, we find no statistically significant difference in nutrient consumption based on the age of the head of the household. This is in line with some of literature such as Behrman and Deolalikar (1990) who do not find age of the household head to have any effect at all on nutrient consumption. However, we should note Kumar et al. (2012) find that the consumption of macro nutrients increases with the age of the household head.

When it comes to occupation at the individual level, we do find that those who work as farm and wage labourers consumes a higher amount of macro nutrients which is statistically

[14] Female-headed households consumption of meat eggs and fish are 0.68 kg per capita over 30 days, while the same figure for male-headed households is 0.60 kg. For pulses, female-headed households consume 1.82 kgs per capita while male-headed household consume 1.30 kgs per capita. However, per capita median consumption for females are lower than males for both these two categories of food. Thus, as is shown in the appendix, quantile regression on the median, does not show any difference based on gender of the household head.

[15] This does not necessarily mean that upper caste Hindus consume less than other castes. In terms of the raw data, compared to SC, upper caste Hindus consume more of macro and micro nutrients; OBC consumes more of macro nutrients and less of micro nutrietnts compared to upper caste Hindus.

significant, relative to the rest of the occupational groups. In fact for calorie and carbohydrate, the statistical significance is at one percent level. Intuitively it implies that those in sedentary jobs consumes less of macro nutrients relative to those in non-sedentary jobs, thus lending more evidence towards Dreze and Deaton's (2009) claim that shift towards non-sedentary jobs has resulted in lower calorie consumption in India over the years.

## 4.3 Identification: IV Approach

While the regression analysis demonstrates some interesting patterns, there is a possibility of endogeneity in two of our variables of interest. There can be endogeneity issues between expenditure and consumption of nutrients, as consumption of nutrients itself can impact income and expenditure through improved productivity (Strauss and Thomas, 1998; Deolalikar, 1988). This interdependence between nutrient consumption and income (or expenditure) can in fact lead to poverty traps (Imai et al. 2014; Dasgupta and Ray, 1987). The endogeneity with respect to PDS consumption arises from the possibility that nutrient intake itself might influence the amount of PDS rice bought. The intuition here is that, if nutritional intake is more than adequate, then there would be less demand for PDS rice since typically the quality of the rice under PDS is not high (Khera 2011c). Unobserved factors such as distance of the household from village markets and ration shops, and health shocks, might also influence both the amount of PDS rice bought and intake of nutrients. We correct for both sources of endogeneity using an instrumental variable (IV) approach.

We use an asset index as an IV for expenditure. Our survey asks households about their ownership of 16 assets and durable goods.[16] The maximum number of assets in our sample owned by any one household is 16 and the minimum amount is 1. The median number of total assets is 5 and the mean is slightly higher at 5.7. We have taken the total number of assets each household owns as the IV for expenditure. This is akin to taking a count of the assets and has been used as an IV in the literature (Filmer and Scott, 2011). Further, to maintain the same structure as we have done for expenditure in our previous models, we have taken the log of per capita daily total assets as the IV for the log of daily per capita expenditure.[17] Our intuition here is that the assets would be strongly correlated with income and expenditure.

[16] The assets we take in to consideration are: house, bicycle, sewing machine, generator set, electric fan, black and white television, colour television, mixer grinder, air cooler, clock or watch, chair or table, cot, telephone, cell phone, fridge freezer, pressure cooker, computer.

[17] Given that assets are essentially a stock, we have run our IV estimations using the log of per capita total assets as the IV for the log of daily per capita expenditure. Our broad results remain the same.

Therefore, the covariance of expenditure and asset index is not zero.

At the same time we do not think that the number of assets would be correlated with the consumption of nutrients. The primary argument is that the purchase of assets typically had been undertaken in previous periods, therefore ownership of assets will not be able to influence current consumption of nutrients. While it is plausible that some of these assets are bought by incurring debts which would have a negative impact on nutrient consumption, there are very few credit facilities for the small consumer durables that we have focussed on. We also do not have any evidence from our survey that households have incurred debts to finance these consumptions. In our sample, there are 26 households who borrowed money; they borrowed mainly for agricultural and business purposes, marriages, and house improvements.[18] Another problematic possibility might be that assets are being sold to finance current food consumption. While that is plausible, it does not impact on the exogeneity of our IV because what we use as an IV are the current assets the households own. Given that the assets are in the households ownership, it could not have been sold or leveraged to buy more food. Hence, we can be reasonably confident that the exclusion restriction holds.

We use the consumption of kerosene for lighting purposes as an IV for our PDS variable. Out of the 131 households, 68 households have electricity, while the rest have to rely on other means for lighting and primarily kerosene is used for that purpose. PDS shops provide highly subsidised kerosene, which can be used both as a cooking and lighting fuel (Khera 2011c, Clarke, 2014). Specifically we use the log of the daily per capita consumption of kerosene for lighting purposes. Our intuition here is that greater the per capita consumption of kerosene, more would be the requirement for kerosene for lighting purposes. Hence it will be more likely that a household will visit the PDS shop to procure the subsidised fuel. If the household is accessing the PDS shop for its kerosene needs, it is highly probable they will access subsidised rice from the PDS shop too. Hence we expect there to be a strong correlation between rice consumption from PDS shops and kerosene consumption. In our data, 130 out of 131 households used kerosene over the last 30 days for lighting purposes, with an average consumption of 2.9 litres per household.[19] Further we find that those who use the PDS Rice also have a higher usage

[18] There were 28 households which borrowed money in the last 5 years but two households have paid back any outstanding loans.

[19] There are 29 households which use kerosene as a fuel for cooking purposes with an average consumption of 2.9 litres per household per month.

of kerosene compared to those who do not.[20]

To conform to the requirements of an IV, we propose that, while kerosene consumption may be related to our PDS variable, it is unrelated to the nutritional intake per se. We expect that lighting from oil lamps help people become more functional in the dark, but in general, in the village we do not see any evidence of oil lamps leading to people undertaking more activities which will impact their nutrient requirements. Most of the activity happens in the village during day times. Further, we haven't seen any evidence from the literature which indicate that kerosene could be a determinant of nutrient consumption. Thus, our exclusion restriction is satisfied in this case.

The IV estimations are done using two stage least squares (2SLS), with clustered standard errors.[21] Table 5 below reports the second stage of the regression results.

Before discussing the results of the second stage regression, let us examine the first stage regression results and tests, all of which are cluster robust.[22] For the first stage regression of log of per capita total daily expenditure we find that among the excluded variables, the coefficient of total assets is positive and significant but kerosene consumption is not. Similarly for the first stage regression on the log of per capita daily consumption of subsidised rice we find that kerosene consumption is positive and significant while household assets although positive is not significant. This is captured in the under-identification tests such as Kleibergen-Paap LM test where Chi Sq(1) is 10.05 and significant at 1 percent. Hence the instruments used in the estimation are relevant.

However, we still need to check whether our instruments are weak. Given that we have multiple endogenous regressors and our estimates are cluster robust, the valid test is the Kleibergen-Paap Wald F statistics which is 6.92 (Andrews et al. 2018). The relevant Stock Yogo weak IV critical value for 10 percent maximal IV size is 7.03 and the critical value for 15 percent maximal IV size is 4.58. Given that our Kleibergen-Paap Wald F statistics is close to was 7.03, we can infer that while our IVs are weak, the size of the bias is not extremely high. Further, we argue, this weakness mainly arises for the PDS endogenous variable and the associated IV

[20] The mean usage of kerosene for each household who buy PDS rice is 3 litres per month and those who do not buy PDS rice is 2.7 litres. This difference is significant and positive at 1 percent level of significance.

[21] We have also run the regression using limited information maximum likelihood (LIML) approach, however, there is very little difference between LIML estimators and the reported 2SLS estimators.

[22] We provide the first stage regression results in the Appendix.

Table 5: Determinants of per capita daily nutrient consumption using IV (based on 2SLS regressions with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log per capita daily Expenditure | 0.575*** | 0.699*** | 0.460*** | 1.028*** | 0.662*** |
| | (0.093) | (0.090) | (0.103) | (0.149) | (0.133) |
| Log per capita daily PDS quantity | 3.303*** | 2.750*** | 3.502*** | -0.936 | 2.637* |
| | (1.179) | (1.035) | (1.292) | (1.306) | (1.484) |
| Other Hindu Caste (Dummy) | -0.023 | 0.025 | -0.070 | -0.173 | 0.034 |
| | (0.091) | (0.087) | (0.110) | (0.145) | (0.132) |
| Other Backward Castes (Dummy) | -0.025 | -0.011 | -0.010 | 0.031 | 0.026 |
| | (0.078) | (0.086) | (0.081) | (0.154) | (0.118) |
| Gender of Head (Dummy) | -0.019 | -0.082 | -0.025 | -0.109 | -0.085 |
| | (0.070) | (0.075) | (0.082) | (0.110) | (0.115) |
| Age of Head | 0.001 | 0.001 | 0.001 | -0.002 | -0.006 |
| | (0.003) | (0.002) | (0.003) | (0.004) | (0.004) |
| Gender Individual (Dummy) | -0.005 | -0.002 | -0.005 | -0.032 | -0.008 |
| | (0.017) | (0.017) | (0.020) | (0.024) | (0.024) |
| Occupation Individual (Dummy) | 0.061* | 0.032 | 0.076* | -0.022 | -0.005 |
| | (0.037) | (0.036) | (0.041) | (0.061) | (0.073) |
| Constant | 5.442*** | 1.504*** | 4.203*** | 2.679*** | 0.593 |
| | (0.382) | (0.366) | (0.428) | (0.644) | (0.600) |
| N | 766 | 766 | 766 | 766 | 766 |
| F(8,119) | 10.858 | 15.096 | 6.165 | 12.577 | 7.908 |
| Chi Sq (2) (Endogeneity test) | 9.04** | 7.40** | 7.54** | 1.30 | 2.72 |

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

First stage Sanderson-Windmeijer Weak Identification test F(1,119)=31.52*** for log per capita daily expenditure and F(1,119)=12.47*** for log per capita daily PDS quantity.

Kleibergen-Paap F-Test (Weak-Identification) is 6.92. Corresponding Stock-Yogo weak IV test critical values: 10 percent maximal IV size: 7.03 and 15 percent maximal IV size: 4.58.

of kerosene consumption. The Sanderson-Windmeijer multivariate F test of excluded variables of log of per capita daily assets is F(1,130)=31.52 and for log per capita daily consumption of kerosene, F-test is F(1,130)= 12.47, both of which are significant at 1 percent level. Thus the value of the F-test for log per capita daily expenditure is higher than that of log per capita daily PDS consumption. In addition, we also conduct endogeneity tests (Chi Sq. (2)) for each second stage regression of the five nutrients. The endogeneity tests in Table 5 show that there are statistically significant differences in the coefficients between IV and OLS regressions only for the macro nutrients. Hence, the analysis of the results from the IV method is mainly concentrated on the macronutrients.

As before, the expenditure elasticity of nutrient consumption is positive and significant at one percent for all the nutrients, with the expenditure elasticity of consumption for all nutrients except calcium, less than one. The expenditure elasticity for the IV results are very similar to the standard OLS results in Table 4. When it comes to PDS, our IV results show that the PDS elasticity for macro nutrient consumption is positive and significant. Compared to the OLS results they are now significant at five percent level. However the elasticities levels are much higher than our standard regression result show. For instance, with calorie consumption, the PDS elasticity under standard regression is 0.75 while under IV based estimation it is 3.30. The large increase in the elasticity is indicative of the fact that kerosene consumption is a weak instrument for PDS rice consumption. This typically means that the covariance between the endogenous regressor and the excluded variable is low (Andrews et al. 2018). In our context this implies that the covariance between kerosene consumption and PDS consumption is low, which can happen if for some sub-group of our sample the kerosene and PDS consumption move in opposite direction. This is indeed the case where SC, who are the majority in our sample, have a lower consumption of PDS relative to OBC, however, when it comes to kerosene consumption we find that on an average the SC consume more than OBC.

From Table 5 it is clear that expenditure and PDS consumption are the main two variables which have significant impact on nutrition. Among the other factors which capture both household and individual level characteristics we find that individuals in non sedentary occupations consume more of calories and carbohydrates relative to those in other occupations. In summary, although our IVs are weak, in the presence of endogeneity issues it is less biased compared to OLS estimates. The results from the IV analysis two clear causal links: i) from expenditure to nutrition and (ii) from PDS rice consumption to macro nutrients.

# 5 Robustness Checks

## 5.1 Adult Equivalence

While per capita consumption of nutrients treats every member of the household the same, we know that the food consumption of children and adults are very different. Given that we don't have intra-household allocation of food in our data, one way to capture the within household distribution is through the notion of adult equivalence (see Deaton, 2003).[23]

Suppose the number of persons in household $h$ is denoted by $n_h$ of whom $n'_h$ are adults and $n_h - n'_h$ are children. Since we do not know the intra-household distribution of the quantities of food items consumed, we assume that all adult members in a given household consume the same amount of each food item and each child in a given household consumes a fraction $\gamma$ of what an adult of the same household consumes of each food item. The consumption of nutrient $j$ per "adult-equivalent" in household $h$ can be written as, $b_j^h/[n'_h + \gamma(n_h - n'_h)]$. Thus, the consumption of nutrient $j$ for each person $i$ in household $h$ is given by $y_{aj}^h = b_j^h/[n'_h+\gamma(n_h-n'_h)]$ for adults and $y_{cj}^h = \gamma b_j^h/[n'_h + \gamma(n_h - n'_h)]$ for children. Similarly, if we consider $Ex^h$ as the total expenditure of household $h$, then the expenditure for person $i$ in that household is $E_a^h = Ex^h/[n'_h + \gamma(n_h - n'_h)]$ for adults and $E_c^h = \gamma Ex^h/[n'_h + \gamma(n_h - n'_h)]$ for children. Thus, for adult equivalent expenditure, we implicitly assume that the share of expenditure of children and adults in food and non-food items are the same. For our purposes we consider $\gamma = 0.5$, which implies that a child's consumption of a nutrient is half of an adult's consumption of that nutrient in the household to which the child belongs.

The mean adult equivalent consumption of calorie is 2150 kcal, protein is 58 gms, carbohydrate is 418 gms, calcium is 418 mgs and iron is 15 mgs. These are higher than the per capita values reported in Table 3. They reflect a more realistic allocation of food within the household. Table 6 below shows the adult equivalent regressions, based on the previous covariates, with clustered standard errors.

The expenditure elasticity of nutrient consumption is positive and significant for all nutri-

[23] According to Deaton (2003, p.146), "Even when households consist of adults and children, welfare is often assessed by dividing expenditures by household size, as a rough-and-ready concession to differences in family size. However, such a correction does not allow for the fact that children typically consume less than adults, so that deflating by household size will understate the welfare of people who live in households with a high fraction of children." In this paper, we follow what Deaton (2003, p.149) calls the "arbitrary approach" in calculating equivalence scale, which has been widely used.

Table 6: Determinants of Daily Nutrient Consumption per Adult Equivalent (based on OLS regressions with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log daily Expenditure per adult equivalent | 0.655*** | 0.762*** | 0.593*** | 0.972*** | 0.804*** |
| | (0.038) | (0.038) | (0.044) | (0.068) | (0.060) |
| Log daily PDS quantity per adult equivalent | 0.963*** | 0.786*** | 1.001*** | 0.285 | 0.686* |
| | (0.302) | (0.268) | (0.330) | (0.439) | (0.411) |
| Other Hindu Caste (Dummy) | -0.119* | -0.055 | -0.193** | -0.102 | -0.084 |
| | (0.069) | (0.068) | (0.084) | (0.135) | (0.120) |
| Other Backward Castes (Dummy) | 0.008 | 0.016 | 0.008 | 0.033 | 0.023 |
| | (0.065) | (0.074) | (0.069) | (0.124) | (0.120) |
| Gender of Head (Dummy) | -0.074 | -0.129** | -0.083 | -0.078 | -0.131 |
| | (0.052) | (0.061) | (0.063) | (0.108) | (0.100) |
| Age of Head | 0.002 | 0.001 | 0.002 | -0.003 | -0.004 |
| | (0.002) | (0.002) | (0.002) | (0.004) | (0.003) |
| Gender Individual (Dummy) | -0.046*** | -0.034** | -0.053*** | -0.026 | -0.042* |
| | (0.016) | (0.016) | (0.018) | (0.025) | (0.024) |
| Occupation Individual (Dummy) | 0.154*** | 0.102*** | 0.183*** | -0.013 | 0.060 |
| | (0.032) | (0.032) | (0.035) | (0.066) | (0.071) |
| Constant | 5.260*** | 1.367*** | 3.837*** | 2.801*** | 0.179 |
| | (0.184) | (0.156) | (0.218) | (0.287) | (0.286) |
| N | 766 | 766 | 766 | 766 | 766 |
| R-Squared | 0.707 | 0.755 | 0.621 | 0.664 | 0.599 |
| F-stat | 67.716 | 99.105 | 42.322 | 39.271 | 32.520 |

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

ents. For every one percent increase in expenditure per adult equivalent, we find that per adult equivalent consumption of calories increases by 0.66 percent, per adult-equivalent protein consumption increases by 0.76 percent, per adult-equivalent carbohydrate consumption increases by 0.60 percent, per adult-equivalent calcium consumption increases by 0.97 percent, and per adult-equivalent consumption of iron increases by 0.80 percent. As before, the impact of expenditure is substantial on nutrient consumption. For all the nutrients other than calcium, the coefficients of expenditure are less than one, suggesting consumption smoothing for the adult equivalent case too.[24] The elasticities for all nutrients are greater in the adult-equivalent regressions than in the per capita case. Note that while the adult equivalent adjustment, scales up both the consumption of nutrient as well as the expenditure, it only does so for households with children.

As in the regressions based on the per capita case, we find the impact of PDS on the consumption of macronutrients is statistically significant, however the elasticities are much higher. In addition, we test for the hypothesis that the coefficient of the PDS elasticity of nutrient consumption is equal to one and we find that we cannot reject that hypothesis. Therefore, a percentage change in the PDS provided rice will lead to a one percent change in the consumption of macro nutrients.

For the other covariates, we have very similar results as before. At the individual level, we find that females have a higher consumption compared to males for all nutrients except calcium, and the differences are statistically significant. We also find that female headed households have higher consumption compared to male headed households for protein. In terms of caste, we find that OH consume lower calories and carbohydrates compared to SC. As previously, the occupational status does play a role in terms of nutrient consumption, and we find that non-sedentary occupations consumes more of macro nutrients relative to those in sedentary occupations. Thus, the results found under the per capita case are strengthened when we take into account intra-household distribution through adult equivalence.

## 5.2 Quantile Regressions

As a part of further robustness checks, we undertake quantile regressions for several different percentile levels of nutrient consumption. In particular our interest is in the bottom half of the

[24] As before, we had separately tested the hypothesis that the coefficient of expenditure in the regressions for the adult equivalent case, $\beta_{Expenditure} = 1$.

distribution of nutrients. In 2011, when our data was collected, 37 percent of the population of Odisha was below the poverty line. To explore the determinants for similar levels of nutrient distribution we present the quantile regression results for the 35th percentile below, where the covariates are the same as before.

Table 7: Determinants of per capita daily nutrient consumption (based on quantile regression at 35th percentile with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log per capita daily Expenditure. | 0.555*** | 0.720*** | 0.424*** | 1.048*** | 0.775*** |
| | (0.058) | (0.080) | (0.059) | (0.097) | (0.130) |
| Log per capita daily PDS quantity | 0.935** | 0.811 | 1.090* | 0.954* | 0.304 |
| | (0.372) | (0.682) | (0.640) | (0.512) | (0.621) |
| Other Hindu Caste (Dummy) | -0.113 | -0.029 | -0.122 | -0.150 | -0.066 |
| | (0.079) | (0.122) | (0.116) | (0.271) | (0.198) |
| Other Backward Castes (Dummy) | 0.083 | 0.105 | 0.091 | 0.093 | 0.068 |
| | (0.093) | (0.106) | (0.143) | (0.105) | (0.157) |
| Gender of Head (Dummy) | -0.095 | -0.128 | -0.137 | -0.018 | -0.201* |
| | (0.085) | (0.152) | (0.092) | (0.116) | (0.119) |
| Age of Head | 0.000 | -0.000 | 0.001 | -0.005* | -0.006 |
| | (0.002) | (0.004) | (0.003) | (0.003) | (0.005) |
| Gender Individual (Dummy) | 0.000 | -0.000 | -0.001 | 0.000 | -0.000 |
| | (0.014) | (0.025) | (0.025) | (0.022) | (0.036) |
| Occupation Individual (Dummy) | 0.022 | -0.000 | 0.078 | -0.000 | 0.029 |
| | (0.035) | (0.049) | (0.049) | (0.039) | (0.055) |
| Constant | 5.624*** | 1.458*** | 4.359*** | 2.415*** | 0.265 |
| | (0.245) | (0.322) | (0.279) | (0.318) | (0.581) |
| N | 766 | 766 | 766 | 766 | 766 |
| R-Squared | 0.618 | 0.691 | 0.495 | 0.604 | 0.525 |

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Broadly, the results remain consistent with what we have seen before. The coefficient of the expenditure term is positive and significant for all nutrients. As before, expenditure elasticity of consumption for all other nutrients is less than one, except for calcium, for which it is equal to one. The coefficient for PDS, is positive and significant for calorie and carbohydrate only, instead of all macro nutrients. This observation is true for the bottom quantiles too. The result is driven by the fact that households towards the bottom of the nutrient distribution consumes relatively more of PDS rice compared to other food, unlike those towards the top of the distribution. For instance, consider the calorie distribution where the per capita calorie consumption at the 35th percentile is around 1500 kcal. For households above the 35th percentile (in terms of calories) the per capita monthly consumption of pulses and vegetables on average is almost double those below the 35th percentile.[25] However, when it comes to PDS rice, the average per capita monthly consumption of households above and those below the 35th percentile is quite similar.[26] Thus, the gap in the food consumption between the households towards the top of the distribution and those towards the bottom of the distribution is some what mitigated by PDS rice consumption. We find a similar story if we consider the carbohydrate distribution.

The other household level and individual level covariates do not play much role when it comes to nutrient consumption. We do notice some statistically significant impact of household characteristics such as age and gender of the household head on iron and calcium respectively. However, these effects are not robust across other nutrients and more importantly they are not robust for other percentiles.

We investigated whether the results for expenditure and PDS rice consumption that we find for the 35th percentile also hold other quantiles.[27] For the quantile regression on the 25th percentile, for instance, none of these household and individual level characteristics are statistically significant. For the quantile regression at the median, our analysis show that unlike what we find for the bottom part of the distribution, for the median (and top half) of the nutrient distribution, the main impact on nutrient consumption comes from expenditure. Consumption of PDS rice along with other household and individual characteristics does not have any statistically significant impact. It is, thus,clear from our analysis that those who are at the bottom of the nutrient distribution are receiving and benefiting from the PDS provided subsidised rice.

# 6 Concluding Remarks

The main purpose of this paper was to undertake a thorough study of the consumption of nutrients in a village in eastern India. The underlying motivation was that detailed micro

[25] For households above the 35th percentile in terms of calories, the average per capita monthly consumption of pulses is 1.93 kgs and for those below the 35th percentile it is 0.62 kgs.

[26] Households above 35th percentile consume around 5.4 kgs PDS rice per month, whereas those below consume on average around 10.6 kgs of PDS rice per month. However, the average size of households is much higher in the households towards the bottom of the distribution. Hence, the average per capita monthly consumption in household above the 35th percentile is 1.77 kgs and those below the 35 percentile is 1.59 kgs.

[27] We present the results of the median regression and the 25th percentile in the appendix.

studies might reveal some interesting patterns which might be missed in a broader study using aggregate level data. Using information on food consumption from primary data, we constructed for the village, information on the consumption of five key nutrients of calories, proteins, carbohydrate, calcium and iron. We focussed on the determinants of consumption of these five nutrients.

Some broad results emerge from our analysis. First, from our analysis it is evident that household expenditure has a positive and significant impact on both macro and micro nutrients and the impact is robust. So any increase in expenditure will lead to an increase in nutrient consumption. This is very different from previous results, both in the sense that we establish causality and that we find the per capita expenditure elasticities for the five nutrients to be significantly higher, ranging from 0.50 to 0.94. Second, we find a positive and significant impact of PDS consumption mainly on macro nutrients. It is not a surprise since the only PDS food item we consider is rice and in our data cereals (of which rice is the main component) are the highest contributor to all the macro nutrients. The positive and significant impact is also found when we establish a causal link from PDS consumption to macro nutrients, which has not been explored in the literature before.

Using quantile regressions, we find that the positive impact of PDS is mainly at the bottom third of the nutrient consumption distribution, where it should be. Thus it indicates effective targeting of the people through PDS. There is broad evidence (see Khera 2011a) that during our survey period Odisha was one of those states in India which really improved their PDS in terms of the quantity of subsidised food grains disbursed and the timeliness of the disbursement. This improvement in PDS in Odisha is clearly reflected in the impact of the PDS provided rice on nutrition in the village. It also demonstrates that, as has been observed in other village studies, such as, Palanpur (see Himanshu et al. 2018), the village we study, Mahidharpada, is a microcosm of the changes happening in wider Odisha.

In addition, our results indicate PDS elasticity of nutrient consumption is greater than one. Thus, a one percent increase in the consumption of PDS rice will have a much greater impact on nutrition than a one percent increase in expenditure. The difference between expenditure elasticity and PDS elasticity of nutrient consumption, however, does not automatically imply that direct provision of food through PDS is preferable to a direct cash transfer, if the goal is to improve nutritional intake. This is because there are huge inefficiencies in PDS, where for every one rupee worth of food grains reaching the poor, the government spends Rs. 3.65

(Planning Commission, 2005). Even if the leakages are reduced, as has been the case in Odisha, the PDS elasticity has to be substantially higher than the expenditure elasticity for one to prefer PDS to cash transfer as an instrument for improving people's nutritional intake.

In terms of other covariates we find that individual characteristics play a more significant role than household level characteristics. Our broad results indicate under some specifications females do better in terms of nutrition compared to males, and individuals in non-sedentary occupations consume more of macro nutrients than other occupation groups. Further, we do not observe much role of caste or gender or age of the head of the household in determining nutrition. If there is any little evidence with regards to these household level determinants, it is that upper castes consumes less of carbohydrates compared to the scheduled castes. It should be recalled that these results are obtained after controlling for various other factors such as expenditure of the household and access to PDS rice. In general, the impact of household and individual characteristics on nutrient consumption is not robust under various regression specifications.

One can obviously argue that some of these results might be unique to our sample. While we acknowledge that these results are based only on one village, the fact that the results are in some cases very different from the existing literature indicates that village level micro studies can provide some unique insights. We need further investigation to understand whether similar results emerge in other village studies and, if so, why we observe different patterns at more aggregate level studies.

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# A Appendix

Table A.1: First Stage Results of the IV Regression

| | Log per capita daily Expenditure | Log per capita daily PDS quantity |
|---|---|---|
| Log per capita daily Assets | 12.982*** | -0.319 |
| | (2.236) | (0.261) |
| Log per capita daily kerosene consumption | 3.149 | 2.462*** |
| | (3.529) | (0.686) |
| Other Hindu Caste (Dummy) | 0.176 | -0.009 |
| | (0.136) | (0.011) |
| Other Backward Castes (Dummy) | 0.069 | 0.030* |
| | (0.151) | (0.016) |
| Gender of Head (Dummy) | 0.031 | -0.010 |
| | (0.088) | (0.015) |
| Age of Head | -0.002 | 0.000 |
| | (0.004) | (0.000) |
| Gender Individual (Dummy) | 0.013 | -0.006 |
| | (0.030) | (0.004) |
| Occupation Individual (Dummy) | -0.017 | -0.001 |
| | (0.048) | (0.007) |
| Constant | 2.861*** | -0.007 |
| | (0.263) | (0.033) |
| N | 766 | 766 |
| R-Squared | 0.363 | 0.193 |
| F-stat | 9.852 | 4.365 |

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.2: Determinants of per capita daily nutrient consumption (median regression with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log per capita daily Expenditure | 0.616*** | 0.735*** | 0.512*** | 0.997*** | 0.836*** |
| | (0.060) | (0.074) | (0.063) | (0.142) | (0.152) |
| Log per capita daily PDS quantity | 0.660 | 0.389 | 0.637 | 0.338 | 0.576 |
| | (0.427) | (0.637) | (0.431) | (1.040) | (0.696) |
| Other Hindu Caste (Dummy) | -0.184* | -0.150 | -0.148 | 0.014 | -0.013 |
| | (0.111) | (0.201) | (0.094) | (0.228) | (0.147) |
| Other Backward Castes (Dummy) | 0.113 | 0.063 | 0.092 | 0.113 | 0.130 |
| | (0.074) | (0.123) | (0.069) | (0.143) | (0.109) |
| Gender of Head (Dummy) | -0.078 | -0.198 | -0.133** | -0.032 | -0.121 |
| | (0.121) | (0.207) | (0.067) | (0.170) | (0.128) |
| Age of Head | 0.000 | 0.000 | 0.000 | -0.003 | -0.003 |
| | (0.002) | (0.004) | (0.002) | (0.004) | (0.003) |
| Gender Individual (Dummy) | -0.026 | -0.003 | -0.053* | -0.000 | -0.003 |
| | (0.024) | (0.028) | (0.028) | (0.033) | (0.034) |
| Occupation Individual (Dummy) | 0.081* | 0.024 | 0.110** | 0.000 | 0.018 |
| | (0.046) | (0.068) | (0.046) | (0.071) | (0.052) |
| Constant | 5.514*** | 1.666*** | 4.314*** | 2.617*** | -0.061 |
| | (0.314) | (0.277) | (0.255) | (0.638) | (0.536) |
| N | 766 | 766 | 766 | 766 | 766 |
| R-Squared | 0.615 | 0.688 | 0.506 | 0.608 | 0.520 |

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: Determinants of per capita daily nutrient consumption (based on quantile regression at 25th percentile with clustered standard errors)

| | Calorie | Protein | Carbohydrate | Calcium | Iron |
|---|---|---|---|---|---|
| Log per capita daily Expenditure | 0.543*** | 0.701*** | 0.438*** | 1.073*** | 0.682*** |
| | (0.062) | (0.103) | (0.069) | (0.120) | (0.106) |
| Log per capita daily PDS quantity | 0.945** | 0.852 | 1.358*** | 0.403 | 0.760 |
| | (0.440) | (0.856) | (0.425) | (0.939) | (0.590) |
| Other Hindu Caste (Dummy) | -0.115 | -0.099 | -0.168 | -0.189 | 0.064 |
| | (0.082) | (0.193) | (0.170) | (0.288) | (0.208) |
| Other Backward Castes (Dummy) | 0.077 | 0.083 | 0.018 | 0.112 | 0.115 |
| | (0.075) | (0.111) | (0.089) | (0.146) | (0.138) |
| Gender of Head (Dummy) | -0.091 | -0.026 | -0.051 | -0.058 | -0.180 |
| | (0.071) | (0.094) | (0.135) | (0.146) | (0.194) |
| Age of Head | 0.002 | 0.001 | 0.002 | -0.005 | -0.007 |
| | (0.002) | (0.003) | (0.003) | (0.004) | (0.005) |
| Gender Individual (Dummy) | 0.000 | 0.000 | -0.000 | 0.000 | -0.000 |
| | (0.015) | (0.024) | (0.023) | (0.026) | (0.033) |
| Occupation Individual (Dummy) | 0.013 | -0.000 | 0.047 | -0.000 | 0.092 |
| | (0.032) | (0.038) | (0.052) | (0.037) | (0.059) |
| Constant | 5.543*** | 1.358*** | 4.151*** | 2.338*** | 0.385 |
| | (0.257) | (0.371) | (0.358) | (0.415) | (0.473) |
| N | 766 | 766 | 766 | 766 | 766 |
| R-Squared | 0.616 | 0.680 | 0.491 | 0.607 | 0.514 |

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.