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How undernourished are Indians really? A critical assessment of indicators and scope for improvement

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ABSTRACT

Food and nutritional security re-emerged as a major challenge facing developing countries since the global food, fuel and financial crises in 2008. A wide variety of approaches are used to gauge the status of food insecurity at global, national, household and individual levels. However different indicators often provide a diverseset of estimates and a contrasting picture owing to the nebulous concept of what constitutes food insecurity and the differences in measurement approaches adopted. In this paper, we briefly review the most commonly-adopted approaches used by researchers for assessing food and nutritional insecurity. These include FAO's prevalence of undernutrition indicator, household-based consumer expenditure surveys (CESs), and anthropometric measures used in evidence-based and policy-oriented research.

We also assess the prevalence of nutritional deficiency in India in terms of the macronutrients at the national levelusing the latest CES data (2011-12). We complement our analysis with anthropometric measures to assess the link between food intakes and nutritional outcomes. Finally,we conduct the multivariate analysis using a multilevel modelling framework to examine the relative importance of particular covariates and geographical contextual factors in determining the different measures of food and nutritional security. We highlight that applying uniform norms for a geographically and ethnically diverse country like India is inappropriate. We conclude there are serious limitations to measuring undernutrition solely through calorie intake; and argue that a multi-dimensional approach incorporating anthropometric measures and a multilevel modelling framework is required to better measure and understand the underlying causes of undernutrition. Keywords: Undernutrition, Food security, Multilevel modelling

Keywords: Opium poppy, remote sensing, yield bias correction

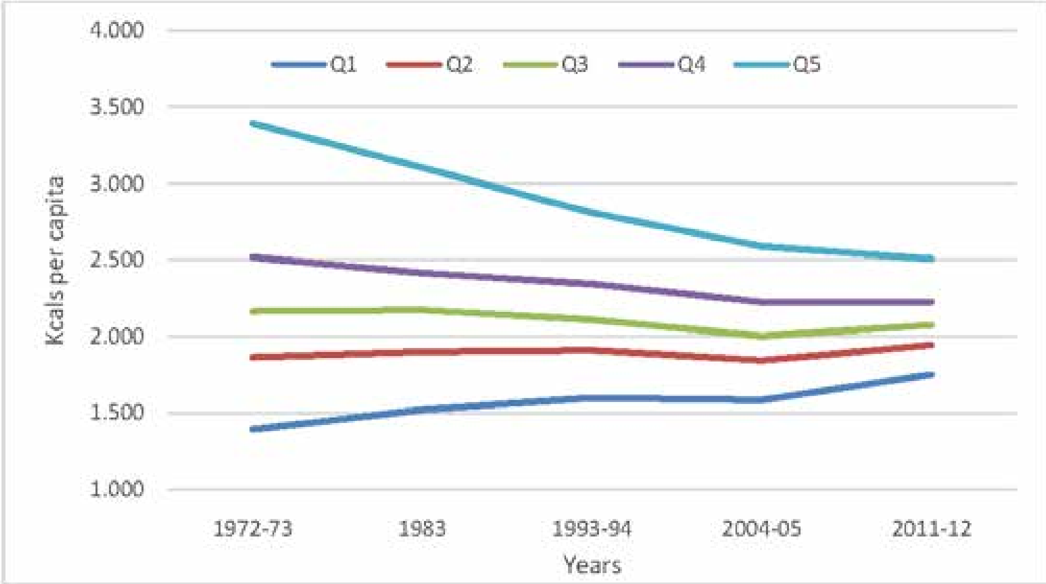
PAPER

1. Introduction

India is home to nearly 25% of the undernourished population in the developing world, and consequently, global undernutritionis highly sensitive to the prevalent situation in that country. Interestingly, total per capita calorie consumption in India has declined over the past three decades despite rising incomes over the same period. However, within income classes, our analysis (using various rounds of the National Sample Survey (NSS) data shown in Figure 1 belowreveals that overtime caloric intakes of poor Indians (two lowest quintile economic groups) has grown, albeit slowly,and for the rich (higher quintile groups) it has declined progressively since1972-73.

In this paper, we analyse alternative measures of undernutrition in India and undertake our own modelling of caloric intakes using multilevel analysis. The paper is organized as follows. The next section critically reviews the most commonly-adopted approaches used for assessing food and nutritional insecurity. Section 3 provides a comparison between calorie intakes and anthropometric outcomes in India using the most recently available survey data. Section 4 presents the multilevel modelling analysis of caloric intakes, wherein weexamine the relative importance of particular covariates and regional contextual factors. The last section summarizes the key findings of the study highlightingthe key policy implications.

Figure 1 - Trends in per capita calorie consumption across economic classes (quintiles) in rural India



Source:Authors' own estimation using NSS data.

2. Review of the existing approaches

A number of coexisting indicators are being used to infer on the state of food security and undernutrition at global, national, household and individual levels. Unfortunately, these different indicators tend to be used independently of each other and usually are seen as alternatives by the end-user. We briefly discuss below the main attributes of these indicators.

FAO's prevalence of undernutrition (PoU) indicator is the most widely-acknowledged indicator used in food security debates. It is based on three critical parameters: mean quantity of calories available in a country for human consumption, inequality in access to those calorie intakes and mean minimum age-sex specific calorie requirements of that population. FAO has been publishing this indicator annually as a 3-year average in its State of Food Insecurity in the World (SOFI) publications.The method has been widely criticised in policy circles as it measures food availability rather than food consumed. Notwithstanding recent improvements, FAO'sestimation method still suffers from some key non-remediable problems in the accurate assessment of food security. These include itsconsideration of being based on minimum activity levels whichistoo simplistic an assumption for developing countries where majority of the workforce is involvedin heavy manual labour. It is incapable of capturing the impact of short-term price and economic shocks whose frequencies have been increasing in the recent past. Also, as an aggregate measure,it is still unable to assess the nutritional status of households/ individuals and identify them.

Another commonly used approach is that of nationally representative household-level CES which contain a detailed component on food quantities consumed at the household level. The quantities consumed are converted to obtain estimates of nutrient consumption which can then be compared with the age-sex-activity specific requirement cut-offs to identify the households with undernourished individuals. The use of a non-parametric household survey approach is considered to be an improvement over FAO's aggregate measure as it helps to undertake multilevel targeting and monitoring within countries as it captures the demographic structure of the household population itself; and also has the ability to evaluate the dietary diversity and macronutrient status*. However, a problematic issue is that it does not capture the intra-household allocation of commodities. Also, data surveys are not undertaken on a regular basis and are computationally intensive and expensive both in terms of financial and technical resources. In addition, food eaten away from home, wastage, losses and non-food use within the households are not adequately captured across these surveys. Further, survey measures suffer from non-sampling errors due to misreporting, incomplete questionnaire forms and issues of telescoping and recall bias.

While the previous two indicators focus on macro level, another widely-acknowledged approach to measure food insecurity is the use of anthropometric indicators such as wasting (low weight for height), stunting (low height for age) and underweight (low weight for age; Body Mass Index (BMI) less than 18.5 for adults). This approach measures nutritional outcomes at the individual level. A key positive feature of anthropometric indicators is that they are simple, accurate and relatively cheaper to compute. They evaluate the nutritional outcomes at the individual level and thus can be used to determine intra-household allocation, for targeting interventions and monitoring them across age and gender traits in a population. These indicators directly connect to the development status of a population (Pelletier 1994; Deaton and Dreze 2009). However, the methods for measurement of nutritional outcomes in the adult population can be problematical due to the lack of consensus on the global reference standard for such population. Anthropometric failures might occur due to reasons such as manifestation of diseases, prolonged illness etc. that are completely uncorrelated with food insecurity. Also, such an approach does not identify the nutrients causing poor anthropometric status.

Given the merits and demerits of each of the approaches, one can conclude that there is no picture-perfect yardstick to measure undernourishmentas each method contributesas different pieces of the broader food insecurity puzzle. Accordingly,we argue it is time to link the household survey approach with the anthropometric surveys such that the outcomes of both approachescan be used in a mutually-reinforcing and complementary manner to provide a multi-dimensional insight into undernutrition issues. For instance, if the overall vital health indicators are weakening while that of anthropometric status are improving then it is suggestive of the fact that the available resources should be directed towards primary health care, disease prevention and other social support facilities rather than boosting up food supplies. Here, adopting a multi-dimensional approach becomes critically important for policymakers in assessing country-level food security and hunger and poverty-related issues. Attention in the following sections turns to these issues.

3. Calculation and comparison between prevalence of undernutrition and prevalence of underweight in India

In this section we compare and contrast PoU measures of undernutrition with anthropometric measures of underweight using the most recently available datasets in order to highlight differences between these two approaches and its implications for policy. We estimate prevalence of undernutrition (PoU) using the unit-level NSS data from 61st Round (NSS-61) for the period 2004-05 covering 1,24,680 households and the 68th round (NSS-68) for the period 2011-12covering 1,01,662 households. The nutrient intake of an individual is calculated using the quantity of each food item consumed by each household which is converted into its nutrient equivalent content of calories. We calculate PoU on the basis of the recommended dietary allowances (RDAs) as given by the Indian Council of Medical Research-National Institute of Nutrition (ICMR-NIN). A household was considered to be calorie deficient if its actual total calorie consumption was less than the calorie required for that household given the age, sex, activity status of household members as per RDAs (Chand and Jumrani, 2013).This computation uses the RDA levels for moderate activity in rural areas and assumes sedentary lifestyles in urban areas. PoU is estimated as proportion of people living in households that are not consuming threshold energy intakes. We present PoUfor major states in Table 1 below. We also present the prevalence of underweight by utilising the National Family Health Survey 2004-05(NFHS-3); a household survey which provides information on health-related matters. The survey covers 1,24,384 females (aged 15-49 years) and 74,369 males (aged 15-54 years) across 29 states. NFHS-3 collected information on height and weight of women and men which is then used to calculate BMI - calculated as weight in kilograms divided by height in meters squared (kg/m2). The WHO classification of underweight for adults is defined as the cut-off point where BMI ↓ 18.5; and used to define thinness or acute undernutrition. We also present preliminary results for a limited number of statesreleased thus far from the most recent NFHS-4 survey (2015-16). The prevalence of underweight among major statesis also presented in Table 1.

Although NFHS and NSS surveys are not strictly comparable owing to the different time periods,Table 1 servesto demonstrate the considerable differences that exist between PoU and BMI measuresof malnourishment when data is disaggregated at the regional level.These most striking differences are in the rural settingwhere states such as Kerala and Tamil Nadu have a PoU of 78% and 84%, respectivelyin 2004-05and are well above the all-India average; compared with a prevalence of underweight (using BMI measure)of 21% and 32% (for 2005-06) respectively, which sits below the all-India average. By the same token, states such as Bihar and Uttar Pradesh have PoU in the rural areas well below the all-India average for 2004-05, whilst in terms of BMI measures, those two states have prevalence rates of underweight (for 2005-06) well above the all-India average. Of particular concern here is insignificant correlation between the rank ordering of states ranked by BMI and those ranked by PoU. Moreover, whilst underweight prevalencehas fallen considerably between 2004-05 to 2015-16, based on preliminary NFHS-4 survey results, this has not been reflected in any significant reduction in PoU over the periods 2004-05 and 2011-12indicating that the differences between the two measures are widening overtime.

To have a state such as Kerala with human development index approaching that of a developed country status having one of the highest PoU in India questions the validity in the uniform application of calorific thresholds in India. India is a subcontinent withconsiderable ethno-physiological differences in its population across regions; differences in public health infrastructure and other social determinants impacting on health (inequalities) such that in some regions people can survive more effectively on lower calories; and differences in climatic and topographical conditions requiring differing calorie expenditure. In light of the above, there is an important role for multilevel analysis of caloric intake to play in setting the minimum calorie norms for different regions or states of India. We now explore this issue.

*In this study, we have analysed all the macronutrients but only the results for calories have been presented due to the word limit.

Table1: *Prevalence of underweight (BMI) and prevalence of undernutrition (PoU) in India by major states for rural and urban areas*

	Proportion of BMI<18.5 (NFHS-3; 2005-06) (15-49 years)		Proportion of BMI<18.5 (NFHS-4; 2015-16 (Recent preliminary data) Women (15-49 years)			Men (15-49 years)			PoU (NSS-61) 2004-05		PoU (NSS-68) 2011-12	
State	Rural	Urban	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Rural	Urban
JAK	29.03	19.01							52.57	31.05	49.12	31.33
HMP	30.92	19.74							52.07	32.89	37.96	37.21
PUN	20.34	18.46							58.78	48.5	53.67	46.84
UTC	32.80	19.45	20.0	15.5	18.4	18.5	12.5	16.1	58.18	36.93	35.67	34.11
HAR	34.23	22.85	18.2	12.2	15.8	12.9	9.0	11.3	55.53	53.91	61.11	51.63
RAJ	41.78	30.57							54.90	50.79	51.66	46.88
UTP	39.41	28.86							53.92	49.62	60.25	61.45
BIH	40.59	31.9	31.8	22.2	30.4	26.9	18.9	25.4	58.31	43.17	63.13	46.84
ASM	37.31	29.32							69.72	51.74	77.55	60.68
WBG	43.11	23.30	24.6	14.0	21.3	20.3	19.0	19.9	69.11	62.41	69.53	63.88
JHK	44.36	29.98							67.62	36.13	62.78	53.47
ORS	40.52	27.45							69.51	51.19	66.99	54.51
CHG	43.99	28.72							74.64	53.03	73.34	53.32
MAP	44.61	32.27	31.8	20.6	28.3	31.1	22.5	28.4	76.15	60.05	63.20	59.84
GUJ	42.65	27.18							77.89	59.91	81.67	55.76
MHR	42.06	27.05	30.0	16.8	23.5	23.7	14.5	33.5	80.51	74.44	68.90	62.00
ANP	37.00	22.08	20.3	11.5	17.6	16.5	11.5	14.8	76.93	62.14	64.85	50.37
KAR	40.12	25.43	24.3	16.2	20.7	18.4	14.2	16.5	85.59	65.24	77.03	67.13
KER	21.15	16.50							77.99	64.07	79.92	67.03
TAN	32.17	22.74	18.5	10.9	14.6	14.3	10.7	12.4	84.02	67.19	81.05	64.77
All-India	**34.62**	**23.40**							**68.03**	**59.35**	**66.08**	**58.71**

Source: Authors' own calculations utilising NFHS-3 unit-level data, Census of India data and NFHS-4 state level fact sheets for proportion of underweight for 15-49 age group; NSS-61 and NSS-68 surveys.

4. Multi-level modelling of calorie consumption

4.1 Data and methods

We now turn our attention to investigating the differing characteristics governing calorie consumption itself and use multi-level modelling to explore regional differences. We utilise the most recent NSS-68 (2011-12) CES to establish our mode1 (see earlier). We use the natural logarithm of total caloric intake as the dependent variable and incorporate a number of individual-level variables into the modelling framework. These include: monthly per capita expenditure (MPCE) as a proxy measure of economic status; MPCE2; household size; household employment activity (self-employed as reference); ration card (no card as reference); maximum education of household head (illiterate as reference); interaction effect between education*MPCE; socio-religious (Hindu-general as reference); quintiles (hectares) of land possession (first quintile as reference); sex of household head (male as reference). A multi-level regression model was used to estimate the impact of various factors affecting nutrient (i.e. calories) intakes. The model is written as follows:

$$Y_{ijk} = \alpha + \sum_m \beta^m X_{ijk}^m + u_k + v_{jk} + e_{ijk} \qquad (1)$$

- Y_{ijk} – log per capita calorie intake of household i nested in j^{th} neighbourhood/first stage unit(FSU) and k^{th}state
- X_{ijk}^m –fixed component – where superscript m represents number of covariates
- u_k – intercept effect of k^{th}state
- v_{jk} – intercept effect of j^{th} neighbourhood (FSU) nested in k^{th}state

... e_{ijk} – residual error of householdi nested in j^{th} FSU nested in k^{th} state

The model shown in equation 1 contains a fixed component which has a separate intercept (x) and a slope parameter (b^m) estimating the effects of a one unit change in the covariates on y_{ijk}. The remaining terms in right hand side (random components) in equation 1 capture the independent effect of geographical space as an independent explanatory factor - in terms of the impact of the state, and the neighbourhood nested within the state. The advantage of multi-level modelling approach is that it allows the intercepts to vary with respect to states and FSUs to account for the macro-level unobserved contextual factors at the stateand neighbourhood level, beyond household-level attributes. Thus the intercept for a given state and neighbourhood can be expressed as $x + u_k$ and $x + u_k + v_{jk}$ respectively. We generate two regression models – both for rural and urban areas. All econometric analyses were conducted using Stata 13.

4.2. Results

Table 2 below presents the results of regression model for both rural and urban settings. As expected, we observe there is a highly significant and positive relationship between calorie intake and MPCE in both rural and urban settings; and this positive relationshipappears to be non-linear and diminishing in nature as evidenced by the negative coefficients for $MPCE^2$.

Table 2 - Multilevel model for calorific intakes in India, 2011-12, using NSS-68 survey

Parameters	Rural (R)		Urban (U)	
	Coefficients	CI (at 95%)	Coefficient	CI (at 95%)
Logarithm of MPCE	1.135***	(1.071;1.199)	1.094***	(1.013;1.175)
Logarithm of MPCE^2	-0.033***	(-0.36;-0.031)	-0.030***	(-0.033;0.027)
Household (HH) size	-0.018***	(-0.019; -0.017)	-0.026***	(-0.027;-0.025)
HH activity type:reference- self employed				
Non-agriculture(R); Regular wage/salary earning (U)	-0.192***	(-0.024; -0.014)	-0.001	(-0.005; 0.004)
Regular wage/salary earning (R); Casual labour (U)	-0.029***	(-0.034; -0.023)	0.015***	(0.008; 0.022)
Casual labour in agric. (R)	0.006**	(-0.002; 0.0127)	NA.	NA
Casual labour in non-agric. (R)	-0.009***	(-0.015;-0.002)	NA	NA
Others (R&U)		(-0.037; 0.020)	0.000	(0.008;0.008)
Ration card type: reference - no card)				
Antyodaya	0.103***	(0.094;0.113)	0.104***	(0.089;0.120)
BPL	0.079***	(0.073;0.085)	0.079***	(0.072;0.086)
Others	0.052***	(0.046;0.057)	0.039***	(0.033;0.045)
Maximum education HH head: reference - illiterate				
Literate	0.170*	(-0.001;0.341)	0.605***	(0.344;0.867)
Primary-Middle	0.277***	(0.154;0.400)	0.670***	(0.476;0.863)
Secondary plus	0.439***	(0.318;0.560)	0.890***	(0.707;1.074)
12+ years of education and above	0.373***	(0.233;0.512)	1.060***	(0.861;1.250)
*Interaction effect – education*log MPCE*				
Literate*logarithm of MPCE	-.016**	(0.030;-0.001)	-0.053***	(-0.075; -0.030)
Primary-middle*logarithm of MPCE	-.026***	(-0.037; -0.016)	-0.060***	(-0.076; -0.043)
Secondary plus*logarithm of MPCE	-.041***	(-0.052; -0.031)	-0.080***	(-0.095; -0.064)
12+ years of educ. and above*logarithm of MPCE	-.038***	(-0.049; -0.025)	-0.110***	(-0.110; -0.778)
Social status: reference- Hindu (general)				
Muslim	-0.013***	(-0.019; -0.006)	0.004	(-0.003;0.012)
Christianity	-0.003	(-0.016;0.009)	-0.002	(-0.017;0.012)
Sikh	0.024	(0.005;0.042)	0.008	(-0.010;0.026)
Hindu (SCs)	-0.001	(-0.006;0.036)	0.006*	(-0.000;0.014)
Hindu (STs)	0.007*	(-0.001;0.014)	0.17**	(0.004;0.030)
Others	0.005	(-0.016;0.026)	-0.017*	(-0.035;0.001)
Land-ownership (in hectares): reference - first quintile				
Second quintile	0.002	(-0.005;0.007)	NA	NA
Third quintile	0.016***	(0.010;0.022)	NA	NA
Fourth quintile	0.034***	(0.028;0.041)	NA	NA
Fifth quintile	0.043***	(0.36;0.050)	NA	NA
Sex of HH Head: reference - male				
Female	0.016***	(0.011;0.22)	0.018***	(0.012;0.025)
Constant	-0.990***	(-1.38; -0.600)	-1.001***	(-1.510; -0.502
Random Effects				
State Level - ICC	0.147	(0.842;0.243)	0.107***	
State/FSU - ICC	0.328	(0.270;0.393)	0.299***	

***, ** and * refer to 1%, 5% and 10% significance levels, respectively
ICC – Intra-class correlation; NA- not applicable

Consistent with the empirical literature, our model results reveal a negative relationship between household size and calorie intake reflecting possible scale economies in food preparation.Education on its own has a positive effect on caloric intake in both the settings. Interestingly,the interaction effect Education*log MPCE shows that its impact gets smaller with improvements in the economic status of Indian households. Of significance, at very high levels of MPCE, education actually starts showing a negative effect on caloric intake; a phenomenon that is particularly pronounced in urban areas.

As expected, people who possess any kind of ration card were likely to have a higher caloric intakecompared to the non-cardholder reference category; and those with a greater subsidy entitlement were more likely to have higher consumption of calories. Landholding size is positively associated with caloriewith this variable not being applicable in urban areas. With regards to socio-cultural characteristics, with only a few exceptions, there was little statistical variation across groups in calorie intake. Our estimation results also show that in comparison to the male-headed households, female-headed households are likely to have higher intakes of calorie in both rural and urban settings. With regardsto occupational categories in the rural areas, most households'occupational activitieshave a lower propensity to consume calories compared to the reference category of households who wereself-employed in agriculture, reflecting differences in physical activity across occupations. In the urban setting, casual labourers had higher propensity to consume calories relative to self-employed.

Of particular interest is the random component of our multilevel modelling for examining independent effect of region on calorie intakes. We find that in rural settings, about 33% of the total unexplained variation in log of per capita calorie intakes is explained by our random components - 15% by states and 18% by neighbourhoods (measured by the intra-class correlation, ICC). In case of urban settings, states explain around 11% of the total residual variance and neighbourhood around 20%. In Figures 2 and 3 below, states are ranked in terms of the impact of state-level unobserved factors influencing calorie consumption. We confine our discussion to the 20 major states of India which are modelled as intercept shifts in the propensity of calorie intakes along with their confidence intervals (95%) and are shown in the figures below as caterpillar plots. In rural areas, after allowing for individual household covariates, households belonging to states such as Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, and Gujarat lie below the Indian average in calorie consumption. In contrast states such as Bihar, Jharkhand, Uttar Pradesh, and Orissa as well as mountainous states such as Uttaranchal, Himachal Pradesh and Jammu and Kashmir all laywell above the Indian average in calorie consumption. A similar pattern of regional differences also exists in the urban settings (Figure 3). The important issue here is that,besides household-level characteristics, unobserved contextual factors at the regional level play a significant role in determining calorie intakes across India. In this context, it becomes important to disentangle these regional-level effects in order to more appropriately inform policy matters relating to undernutritional issues.

Figure 2 - State level random effects in calorie intakes: rural areas

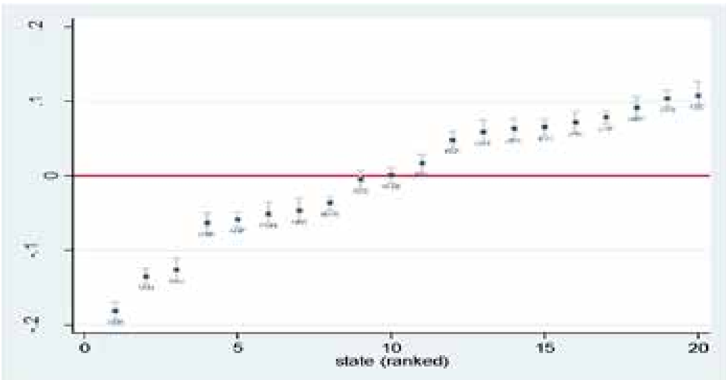
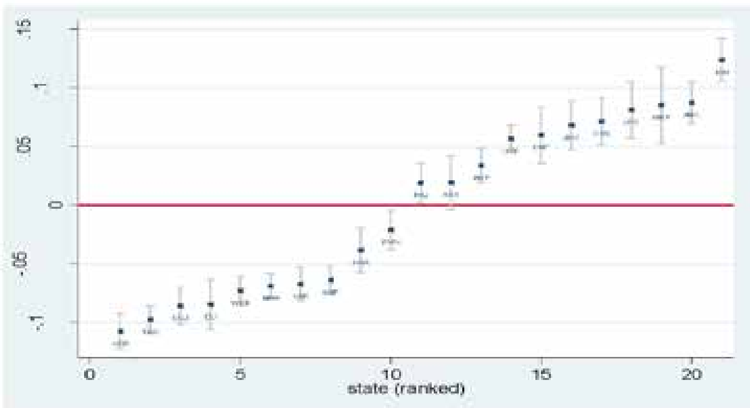


Figure 3 - State level random effects in calorie intakes: urban areas



5. Conclusion

Using the most recently available surveys on calorie consumption and BMI, this paper shows there is considerable divergence between PoU and anthropometric methodsand consequently there is the need to adopt a multi-dimensional approach tomeasuring food and nutritional insecurity in order to inform policy in India. In recognition of this, we undertook multilevel analysis to model caloric intakes. Our results show that in addition to household level characteristics, unobserved contextual factors at the regional level play a significant role in determining calorie intakes across India. The extent to which these regional differences are due to factors such as, physiological differences reflecting different ethnicities across regions, differences in climatic/topographical conditions and consequent differing physical activities and calorie requirements, or differences in public health infrastructure and other social support and consequent differing calorie requirements to maintain minimal health, is unclear. What is clear, is that imposing a uniform calorie threshold across all of India, irrespective of region, in order to measure prevalence of undernutrition is inappropriate and leads to misinformed policy. As an imperative, more research is required into understanding contextual factors contributing to spatial differences in minimum calorie requirements necessary for maintaining good health. This paper makes an initial contribution to understanding these issues.

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