Antecedents and Spatial Variation of the Dual Burden of Childhood Stunting and Underweight in India: A Copula Geoadditive Modelling Approach

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Motivation

- India has one of the highest burdens of childhood undernutrition in the world.
- Current estimates $\Rightarrow$ 36% stunting, 17% underweight & 6% wasting among under 6 children.
- Extant research: analysis of antecedents & spatial heterogeneity for each of these metrics separately.
- Above dimensions can be significantly correlated in a particular population $\Rightarrow$ valuable insights regarding penetration and spread of dual burdens of malnutrition.
- Proposed research: quantification of spatial distribution and critical drivers of the dual burden of stunting and underweight using copula-geoadditive modeling approach.

Methodology

- Copulas $\Rightarrow$ separate marginal model specification of responses from the joint distribution governing their dependence structure.

- $Y_{is}(Y_{iu}) = 1(0)$ if i^{th} child is stunted (underweight) $\Rightarrow$

  $$P(Y_{is} = 1, Y_{iu} = 1|\boldsymbol{x}_{is}, \boldsymbol{x}_{iu}) = C(P(Y_{is} = 1|\boldsymbol{x}_{is}), P(Y_{iu} = 1|\boldsymbol{x}_{iu}); \nu)$$

  $C : [0,1]^2 \to [0,1]$: copula function, ν : copula parameter $\Rightarrow$ quantifies stunting-underweight association.

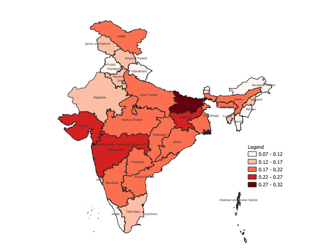
- Copula geoadditive models accommodates the following effects:
  - Linear as well as flexible, non-linear effects of predictors.
  - Within-region (unstructured) & between-region (unstructured) spatial effects of stunting & underweight.
  - Spatial heterogeneity in the copula parameter.

- Non-linear effects $\Rightarrow$ thin-plate regression splines; structured spatial effects $\Rightarrow$ Markov random-field smoother.

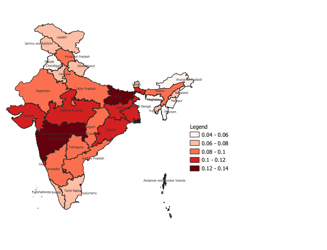
Results

- CGM was applied on data from 1,04,021 children from National Family Health Survey-5 (NFHS-5) dataset.
- χ^2 test $\Rightarrow$ significant stunting-underweight association.
- Significant spatial heterogeneity in dual burden of stunting and underweight $\Rightarrow$ highest (lowest) prevalence in eastern & western states (northern & southern states).
- Significant between-state variation in underweight $\Rightarrow$ lowest in north-east, highest in central and western India.
- Boys, low birthweight, normal delivery, no prenatal checkup, maternal short-stature & underweight, anemia $\Rightarrow$ significantly higher odds of stunting & underweight.
- Child age, age at first birth & duration of breast feeding $\Rightarrow$ significant non-linear association with stunting and underweight.

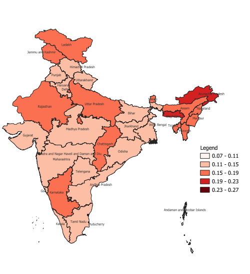
Joint probability maps



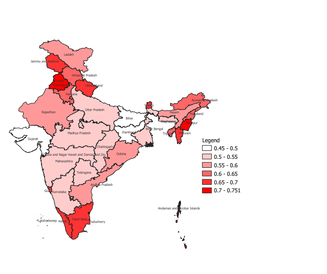
a) Joint probability of a child being stunted as well as underweight



b) Joint probability of a child *not* being stunted but underweight



c) Joint probability of a child being stunted but *not* underweight



d) Joint probability of a child *not* being stunted as well as underweight

Non-Linear Associations

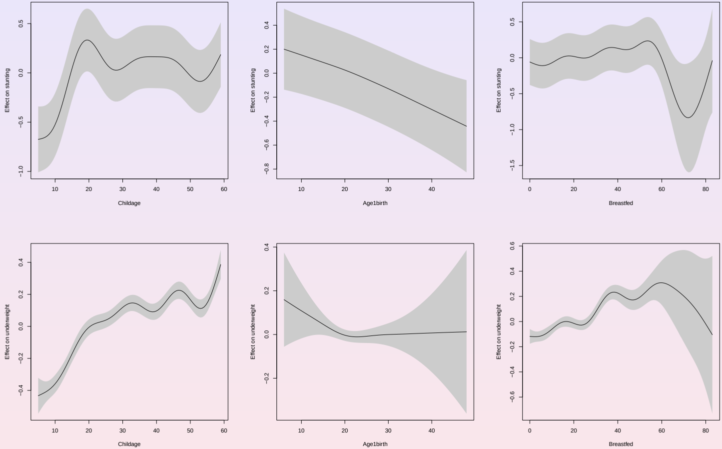


Figure 1: Estimated non-linear effects of child age, maternal age at first birth and duration of breastfeeding on the likelihood of stunting (top row) and underweight (bottom row). Shaded regions correspond to 95% confidence bands

Discussion

- One of the largest studies that jointly models the dual burden and geographical variation of stunting & underweight in India.
- Moderately strong stunting-underweight association and significant spatial heterogeneity in this association across India.
- Significant within-state variation in the prevalence of stunting & underweight $\Rightarrow$ district-specific analysis.
- Necessity of a nuanced, region-specific nutritional intervention plan to effectively tackle childhood undernutrition in India.


Thank You