Seasonal Patterns of Acute Malnutrition and Climatic Variability: Evidence from Africa

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Undernutrition among children under five

• Stunting: 148.1 million (22.3%)
  • Low height-for-age
  • Result of chronic undernutrition
  • Associated with lower cognition, lower earnings, and increased morbidity in adulthood

• Wasting: 45 million (6.8%)
  • Low weight-for-height
  • Result of recent weight loss due to disease or acute food insecurity
  • Associated with increased mortality risk

Reconsidering nutrition survey timings

• Measurement dependent on cross-sectional surveys
  • JME data sources: LSMS, MICS, DHS, SMART surveys
    • “the primary source dataset contained 1100 data sources from 160 countries and territories”...
      “global estimates are highly representative of the majority of children across the globe for the
      most recent period”
    • Occur at the same time each year (physical accessibility, intentionally not seasonal)
    • Timing based on discrete categories such as pre-harvest vs post-harvest, dry vs wet
      season, or hunger/lean vs plenty seasons

• Does acute malnutrition follow the agricultural calendar? **Not always!**

• “Food first hypothesis”: malnutrition driven primarily by lack of food
  (Pelletier, 1995)

• “Seasons” designed around assumptions and computational constraints
  of previous decades
Seasonal acute malnutrition

- Statistics emphasize country-level prevalence, BUT...
- Knowledge gaps
  - Continuous seasonal pattern
  - Link to livelihoods
  - Environmental drivers
  \[\text{at subnational level}\]
- “Over 50% of studies [in African drylands] rely on 2–4 time points within the year and/or the inclusion of time as a categorical variable in the analysis” (Marshak et al, 2021)
Challenges

• How can we develop subnational models of wasting?
  • Text matching to known spatial references

• How can we accurately model a continuous outcome which is observed infrequently?
  • Multiple harmonic regression

• Can we introduce meaningful partitions (income, livelihoods, measures of wealth) to contextualize observed patterns?
  • Split sample and fixed effects across population subsets
Fuzzy matching of survey locations

- Systematically resolving similarities across languages
  - E.g. Nord vs. north vs. northern
- Allows for mixed order of geographic specificity, changing geographies
  - E.g. “gambia wuli basse” vs. “gambia basse” vs. “gambia upper river wuli”
- Some survey locations still require manual correction
  - E.g. D. I. Khan vs. Dera Ismail Khan region in Pakistan
Multiple Harmonic Regression

\[
\text{logit}(\text{Wasting}) = \beta_0 + \beta_1 \sin(2\pi \omega T) + \beta_2 \cos(2\pi \omega T) + \beta_3 \sin(4\pi \omega T) + \beta_4 \cos(4\pi \omega T) + \beta_5 T + \beta_6 T^2 + \beta_7 T^3
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unimodal (2\pi)</th>
<th>Bimodal (4\pi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Shift (\Theta)</td>
<td>(\Theta = \arctan(\frac{\beta_1}{\beta_2}))</td>
<td>-</td>
</tr>
<tr>
<td>Peak Timing (P_T)</td>
<td>If (\beta_2 &gt; 0) and (\beta_3 &gt; 0), (P_T = \Theta \left(\frac{M}{2\pi}\right))</td>
<td>Estimated arithmetically based on predicted seasonal curve</td>
</tr>
<tr>
<td></td>
<td>If (\beta_3 &lt; 0), (P_T = (\Theta + \pi)\left(\frac{M}{2\pi}\right))</td>
<td>(P_{T1} = \text{global maximum})</td>
</tr>
<tr>
<td></td>
<td>If (\beta_2 &lt; 0) and (\beta_3 &gt; 0), (P_T = (\Theta + 2\pi)\left(\frac{M}{2\pi}\right))</td>
<td>(P_{T2} = \text{local maximum})</td>
</tr>
</tbody>
</table>

Seasonal wasting in North African drylands

Finding: largest wasting peak is associated with highest temperatures; smaller wasting peak occurs after peaks of rainfall + vegetation

Scaling up by combining data

- Koppen climate classifications (Beck, 2018)
- Global rainfall modality (Knoben, 2019)
- Based on grid cells with population > 0 (GPW v4, SEDAC, 2018)
- Wasting outcomes: SMART + DHS + MICS

Map of DHS cluster locations (1999 – 2020) overlaid on map of Koppen climate zones
Ongoing challenges

• Spatial data availability
  • MICS, LSMS: no spatial data
  • Warehousing of SMART

• Nutrition surveillance

• Relevant drivers
  • Food prices/affordability?
  • Livelihood changes?
Towards seasonality as a basic driver of acute malnutrition

Thank you! Questions?

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Local vs. livelihoods-based calendars

Sources: (left) Young, H. & Ismail, M.A. 2019. *Complexity, continuity and change: livelihood resilience in the Darfur region of Sudan*. Disasters, 43(S3): S318–S344; (right) FEWSNET