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An ecological study of the association between childhood stunting, water, sanitation, and protein access, 2001-20

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Stunted Growth

- Stunted growth impacts 22% of all children under 5 (2022 UN SDG report)
- Incidence highest in low-income nations (30.1% and 31.0% respectively in Africa and South-East Asia)
- The vast majority of stunted growth is likely attributable to EED

Environmental Enteric Dysfunction (EED)

Sub-clinical condition of the intestine marked by inflammation, villous blunting, and diminished epithelial barrier function.

Significant secondary effects including:

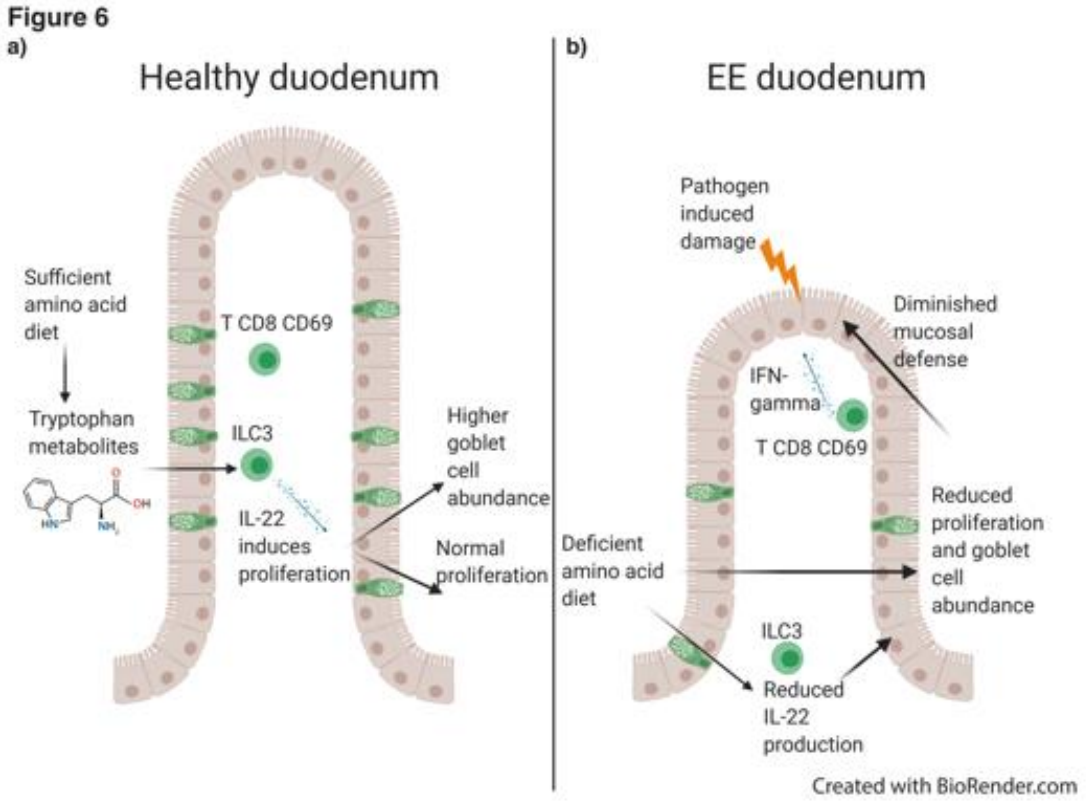
- Increased risk of metabolic syndrome
- Diminished oral immunity
- Increased risk of maternal and fetal complications in mothers with EED

EED and protein

Initially thought to be derived from increased fecal-oral exposure

Increasing evidence of significant contribution of protein deficiency

- Amino acid supplementation provides clinical benefit (Louis-August et al, 2019)
- Single cell study of Zambian adults points towards tryptophan deficiency as key factor (Kummerlowe, Wallach et al, 2022)
- *In Vitro* models are more effective when replicating protein deficiency (Bein et al, 2022)



Kummerlowe, Wallach et al, *Science Translational Medicine*, 2022

Animal protein and pediatric growth

Animal protein is the sole nutritionally complete protein source

Diverse plant based diets are equally healthy, but challenging to support for low-income families and nations.

Hypothesis: national availability of animal protein will also be a major predictor of stunting risk

Methods

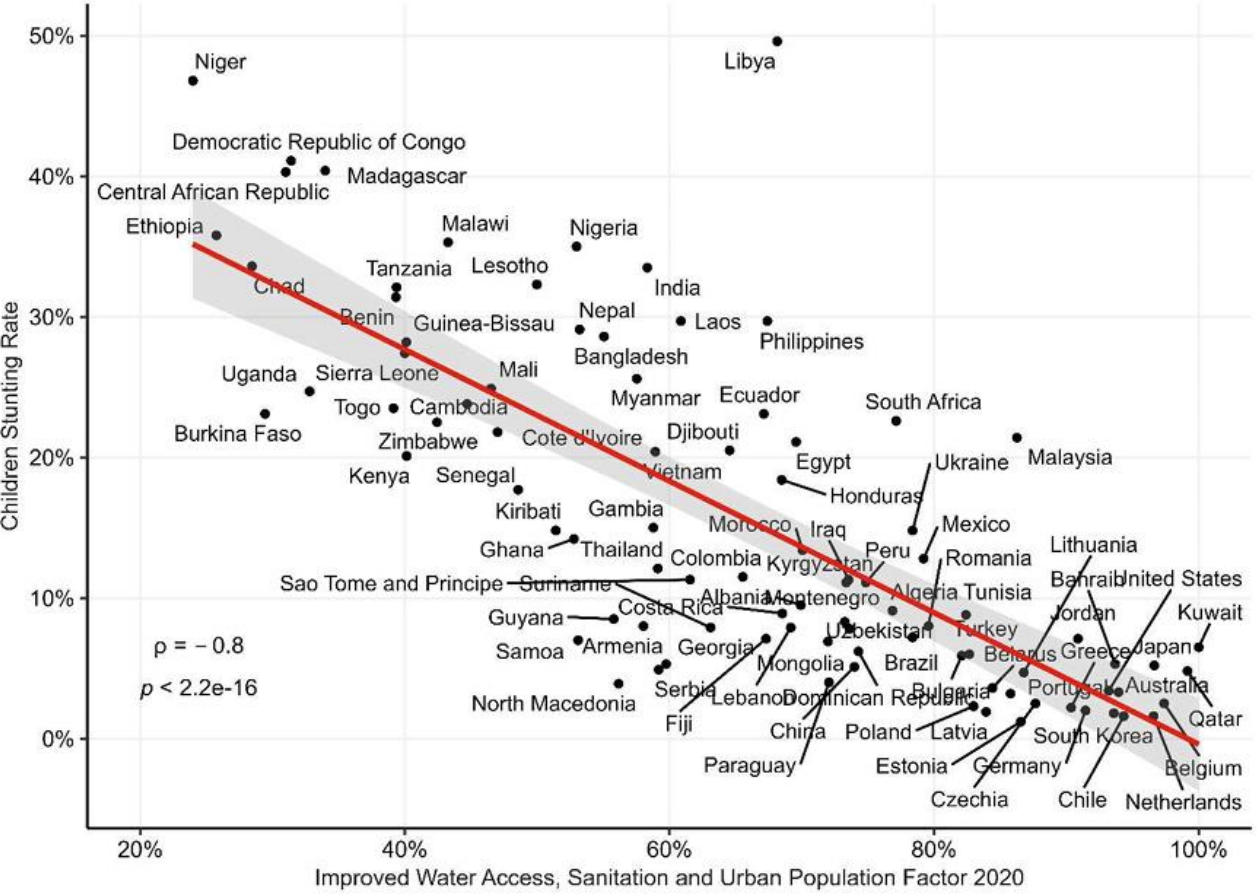
WHO data including 1836 observations from 94 countries in 2001-2020 where 80% of countries had data for all 21 years, and 96% of countries had data for at least half of the years.

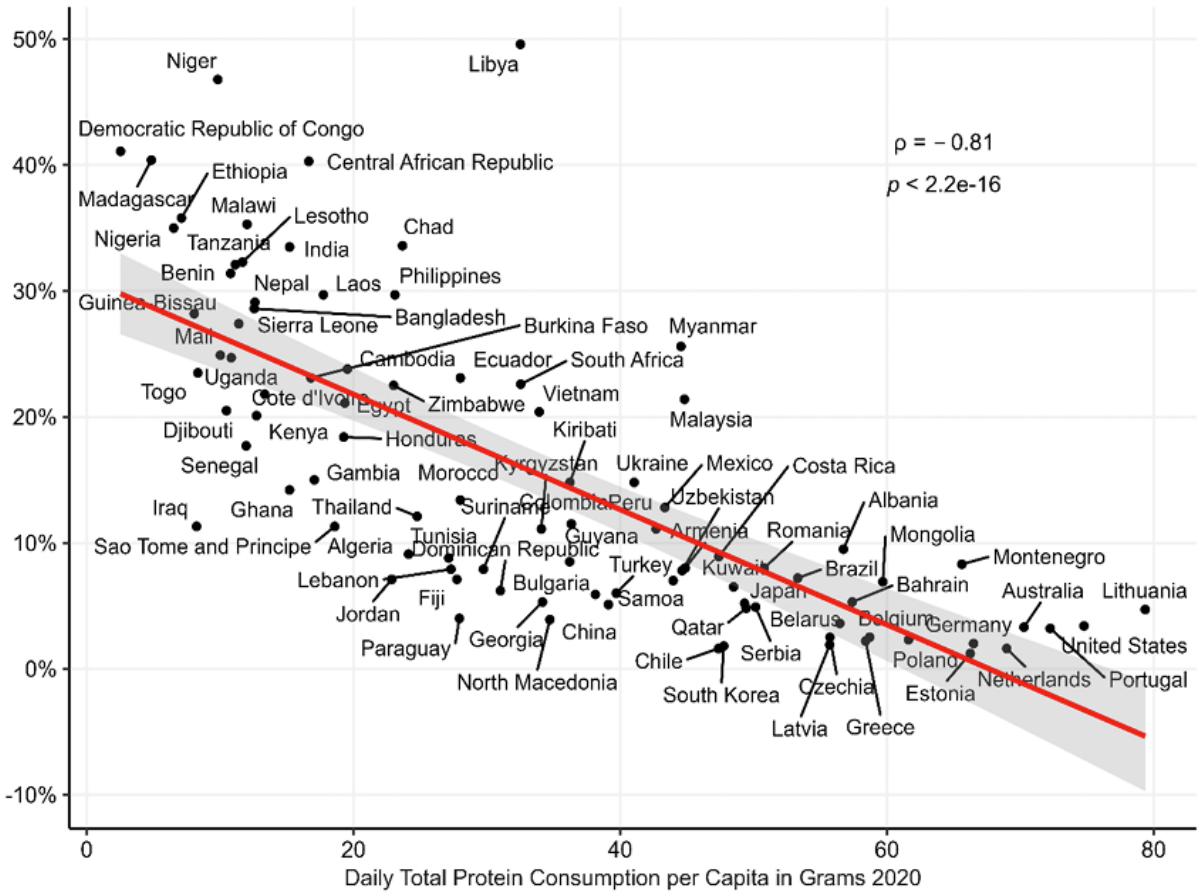
Bivariate: assessed the association between the percent of children with stunting and the percent of households with access to improved water and animal protein supply by estimating a non-parametric measure of association using Spearman's correlation of rank

Multivariate: We transformed our water and protein exposure variables into z-scores to put these different factors on the same scale. Regression coefficients represent the association between stunting and a 1 standard deviation change in the exposures. We assessed the association between children with stunting and households with access to improved water and animal protein supply using multilevel modeling using varying intercepts by country using the lme4 package in R.

- multilevel model accounts for the fact that each country has a different baseline percentage with stunting. We evaluated OLS and multilevel model regression assumptions through assessments of normality of residuals (e.g., residuals vs. fitted value plots) and autocorrelation plots and the Durbin-Watson measure of autocorrelation.

Bivariate analysis using animal protein reduces outliers at high rates of stunting





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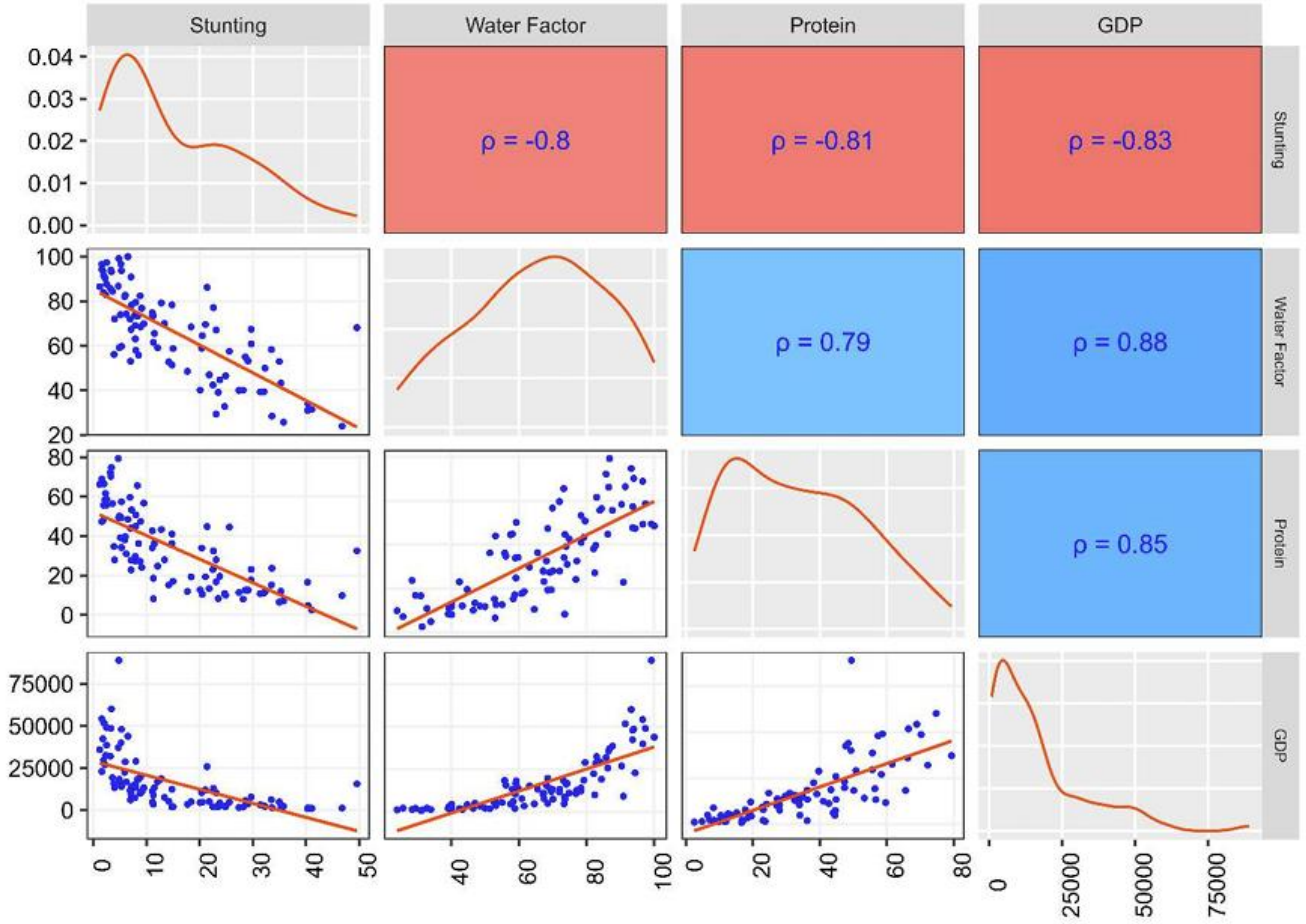
Results

Animal protein availability inversely associated with stunting

Equivalent association with water factor.

Figure 4: Association between percent of children under 5 years old with stunting (height z-score less than -2), percentage with adequate water/sanitation access, total daily animal protein supply in grams, and GDP in the most recent year 2020 (n=91 countries)



Conclusions

Ecological data reinforces existing mechanistic and outcome data

Additional supporting evidence for amino acid supplementation, or targeted supplementation to enhance full amino acid availability.

High mechanistic suspicion that tryptophan is the primary deficiency

Questions?

