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The U.S. Government's Global Hunger & Food Security Initiative

Altitude and Child Linear Growth in Nepal

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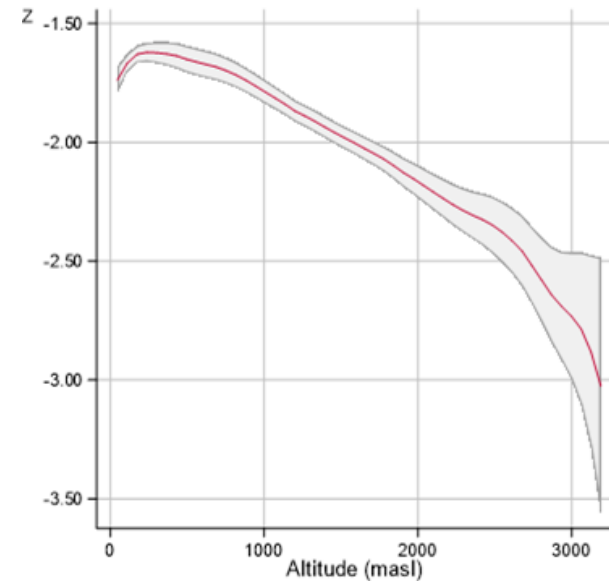
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MOTIVATION

- In Nepal, children at high altitudes exhibit restricted linear growth compared with children at lower altitudes. Why?
- Easy to imagine how this relationship may be confounded; substantive relationship would matter, though.
- We examine the role of potential confounders (wealth, maternal health, remoteness) in this relationship



HAZ by Altitude



DATA

- Data come from 2006, 2010, 2016 Demographic and Health Surveys (DHS); analysis done at child level (n=8,824)
- Includes HAZ, altitude averaged by survey cluster, and household characteristics.
- Both HAZ and altitude highly variable; means both out of region of serious concern; large SD's indicate many children at low HAZ or high altitude, however.

Table 1: Descriptive statistics

Variable	Min.	Mean	Max.	SD
HAZ	-5.96	-1.79	4.99	1.35
Altitude (km· above sea level)	0.05	0.79	3.19	0.73
Female indicator	0	0.49	1	0.5
Age (months)	0	29.78	59	17.1
Hill zone indicator	0	0.31	1	0.46
Mountain zone indicator	0	0.08	1	0.27
Mother highest ed: primary	0	0.18	1	0.39
Mother highest ed: secondary	0	0.25	1	0.43
Mother highest ed: higher	0	0.07	1	0.25
Wealth index value	-162.36	-17.61	393.19	88.24
Access to safe water	0	0.74	1	0.44
Smoke fuel used in house	0	0.84	1	0.37
Urban indicator	0	0.3	1	0.46
Mother's BMI	14.02	20.81	43.29	2.98
Quality-weighted road density	0	340.59	4408.57	439.61
District distance to Kathmandu (km)	0	351.06	775.71	203.26



BASELINE RESULTS

Table 2: Baseline Results (SE's in parentheses)

Dependent variable:

	HAZ (1)	HAZ (2)	HAZ (3)
Altitude	-0.277*** (0.020)	-0.214*** (0.027)	-0.219*** (0.028)
Household Controls	NO	YES	YES
Remoteness Controls	NO	NO	YES
Constant	-1.569*** (0.021)	4.143*** (1.560)	4.111** (1.600)
Observations	8,824	8,824	8,824
R ²	0.022	0.245	0.246
Adjusted R ²	0.022	0.241	0.241

- Proceed in three stages: additive models, polynomial models, interaction models.
- In baseline additive models, altitude coefficient is consistently large and significant.
- Coefficient changes by a limited amount as household, and then remoteness, controls are added.



NONLINEAR RESULTS

- Expect larger marginal effects at high altitudes, so we fit nonlinear specifications (polynomial and discrete kasl. bin interactions).
- Marginal effects larger at high altitudes in both, but based on F-test, no different from baseline specification.
- No strong evidence of need for nonlinear specification

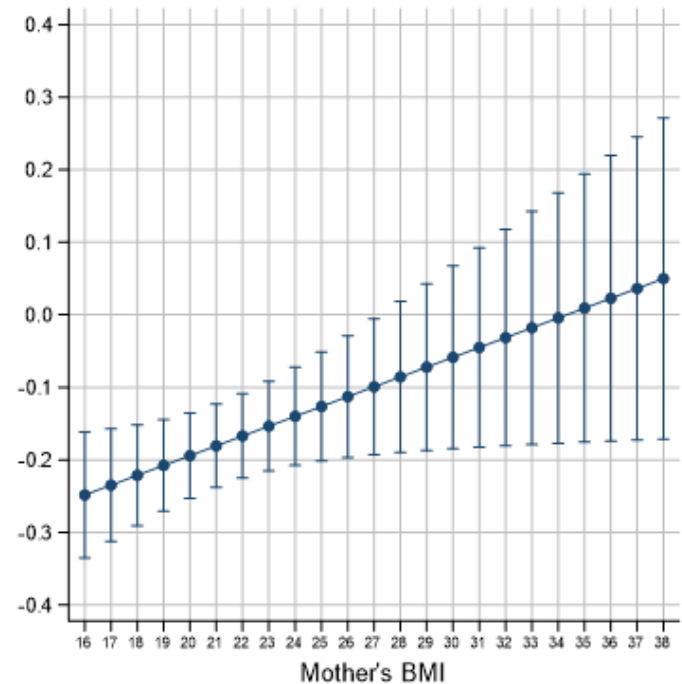
Table 3: Nonlinear Altitude Specifications

Dependent Variable: HAZ		
Altitude	-0.502*** (0.161)	-0.309*** (0.080)
Altitude^2	0.295** (0.138)	
Altitude^3	-0.077** (0.033)	
1-2 Kasl.		-0.176 (0.137)
2-3 Kasl.		1.176** (0.490)
3+ Kasl.		10.803 (8.043)
AltitudeX1-2 Kasl.		0.205* (0.118)
AltitudeX2-3 Kasl.		-0.444* (0.228)
AltitudeX3+ Kasl.		-3.485 (2.627)
Controls	ALL	ALL
Constant	4.001** (1.611)	3.888** (1.617)
Observations	8,824	8,824
R ²	0.246	0.247
Adjusted R ²	0.242	0.242



INTERACTION RESULTS

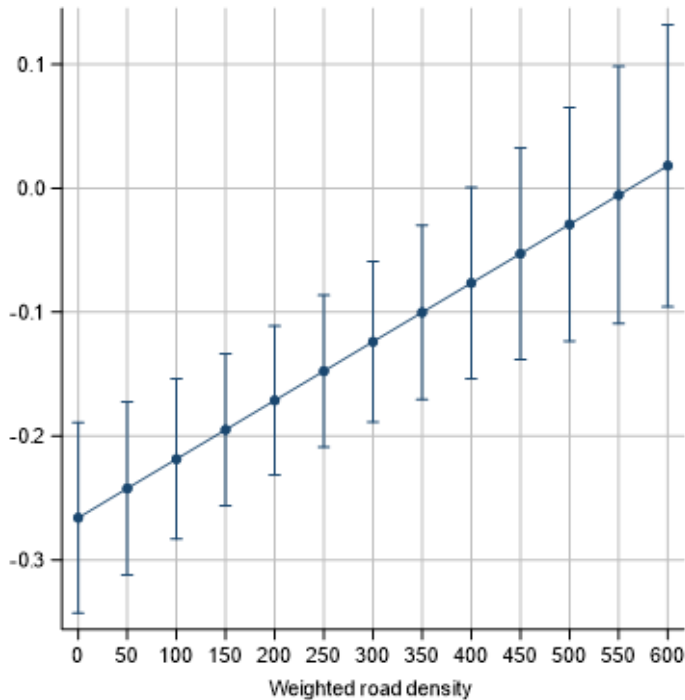
- Finally, interact altitude with several plausible mediators.
 - Household wealth index value
 - Mother's BMI – proxy for health/food environment
 - Quality-weighted road density – measure of infrastructure.
- Including these variables additively does not explain away altitude coef., but perhaps they weaken HAZ-altitude relationship.



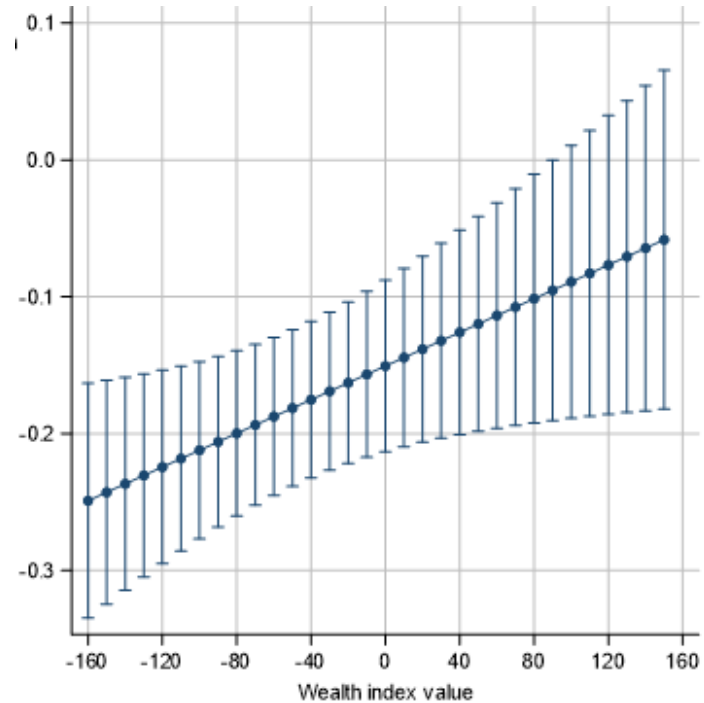
Predicted marginal effect of altitude on HAZ by mother's BMI



INTERACTION RESULTS II



Marginal effect of altitude on HAZ by quality-weighted road density



Predicted marginal effect of altitude on HAZ by household wealth index value



DISCUSSION

- At high levels of mediators, altitude effect substantially reduced; in the case of infrastructure, it goes away entirely.
- Altitude maintains large negative marginal effect even under these specifications, so it is not explained away.
- Not obvious that moving these variables to high values is feasible solution, especially in the case of infrastructure.
- Overall takeaway: even accounting for mediation, children at high altitude are at particular risk for malnutrition, but this is at least partially due to a lack of resources and infrastructure.



ADDITIONAL TOPICS

Several issues that may matter, but we cannot analyze:

- Household food access/dietary diversity: we lack data on these important topics, and on the agricultural environment more broadly; maternal BMI is a partial proxy, but is very noisy.
- Micronutrient deficiencies: zinc and iron deficiencies can reduce linear growth, and zinc deficiency in soil can cause it in food. Evidence that this is particularly relevant in the Terai; see Bevis et al. (2019).
- Unobserved boron toxicity could also contribute; reduces growth and is possible in these areas, but difficult to get data.



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