D4N 2023
Delivering for Nutrition in South Asia
Equity and Inclusion
2.11.2023
Speaker picture-in-picture

Temperature and children's dietary diversity

Evidence from India

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Introduction

- **More hot days, warmer temperatures, and frequent droughts** are expected to impact agricultural systems and human health (Meehl et al., 2007).
- **Children are not only physically more vulnerable** than adults to the **direct effects** of extreme heat, and droughts but also to the **indirect effects** of a rise in temperatures such as **conflicts, vector-borne diseases, economic dislocation, undernutrition, and migration** (Banerjee & Maharaj, 2020; Currie & Deschênes, 2016).
- A growing body of literature evaluates how a rise in temperature affects children's health and nutrition. Existing empirical evidence highlights that increase in temperature:
  - **Increases infant mortality rates, preterm birth, stunting and wasting rates**, and
  - Decreases **birth weight**.

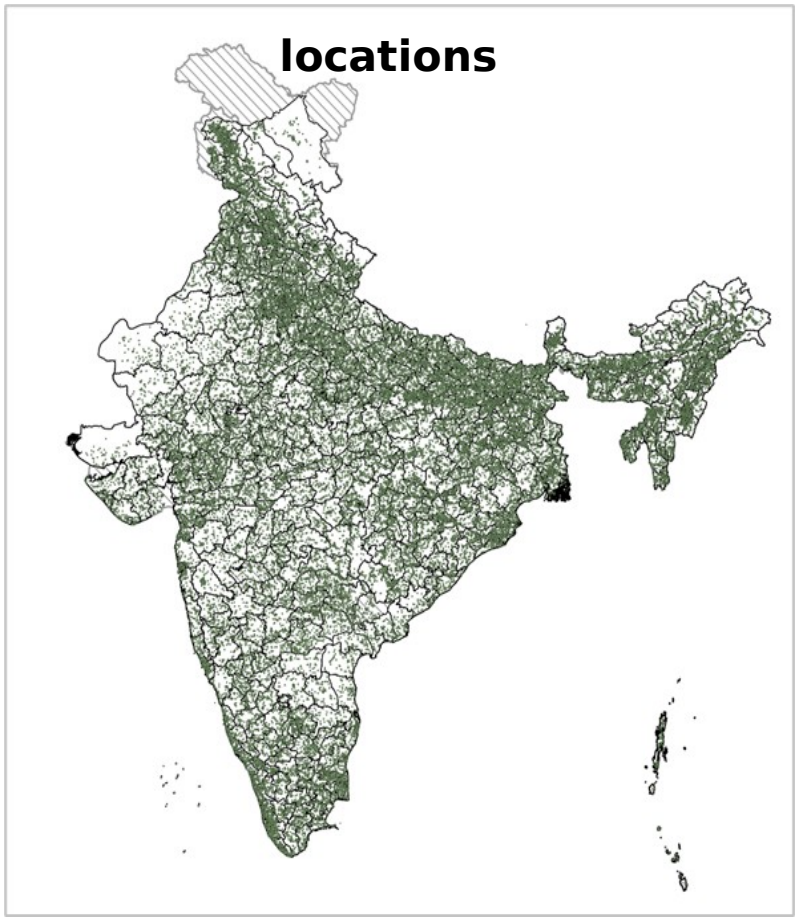
Temperature-dietary diversity relationship

Pathways	Description
Reducing the availability of homegrown produce	✓ Reduction in yields of crops, livestock, and fisheries. ✓ Increased prevalence of pests and diseases could result in food loss and morbidity of farm animals
Reducing income	**1. An income effect:** ✓ Reduction in consumption of purchased items: reduction in calorie consumption or substitution of healthy food items towards inferior but cheaper food. **2. Price instability effect:** ✓ shortages in local food supplies which could raise prices and increase the volatility of food prices. Affordability of nutritious meals. **3. Labor market effects:** ✓ Non-agricultural income could increase household income and therefore improve access to nutrition and diverse diets. ✓ If reallocation towards low labor productivity activities that serve as a residual source of employment could increase poverty and reduce access to healthy diets.
Altering women's time use	✓ Influence women's availability of time for child feeding and care practices, which could directly affect the immediate causes of undernutrition
Increase exposure to disease	✓ Increased incidence of water-borne illnesses like diarrhea, cholera, and typhoid and vector-borne illnesses like malaria, dengue, and chikungunya, which could cause children to lose their appetites and reduce the body's ability to absorb and utilize nutrients

Data

Description	Data Source
1. Survey data	
✓ Household and children's data	• Demographic Health Survey (DHS) for India, conducted in 2015-16 and 2019-20 . • Pool data from 4,14,114 children between the ages of 6 and 23 months
2. Geospatial and satellite data	
✓ Weather (Climate Data Store-Copernicus)	• **Temperature :** ERA5-Land reanalysis dataset. • **Precipitation:** Global Precipitation Climatology Centre (GPCC) • Extracted monthly temperature and rainfall data from January 1989 to December 2021.
✓ Travel time	**Market access:** Gridded map of travel distance for every point on the globe given by Nelson et al., (2019).
✓ Road network	**Density of roads:** Global Roads Inventory Project (GRIP) (Meijer et al., 2018)
✓ Land cover	**Farming areas around a household:** Geo-Wiki hybrid land cover map (See et al.,2015).

DHS cluster locations



Source: DHS 2014-15 and 2019-20

Baseline Specification

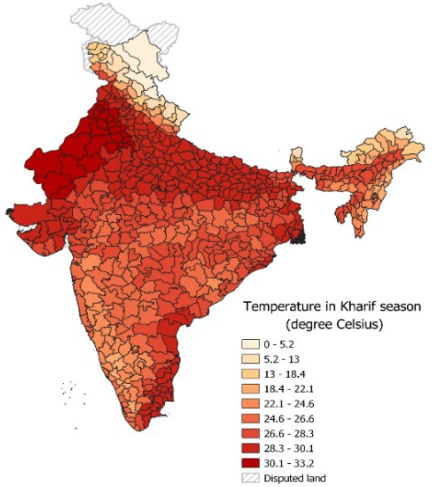
$$D_{i,d,t} = \beta_0 + \beta_1 Temp_{d,t} + \beta_2' \boldsymbol{C_{i,d,t}} + \beta_3' \boldsymbol{H_{i,d,t}} + \beta_4' \boldsymbol{G_d} + \beta_5 R_{d,t-1} + \beta_6' \boldsymbol{t_t} \times \boldsymbol{m_j} + \theta_s + \varepsilon_{1,i,d,t}$$

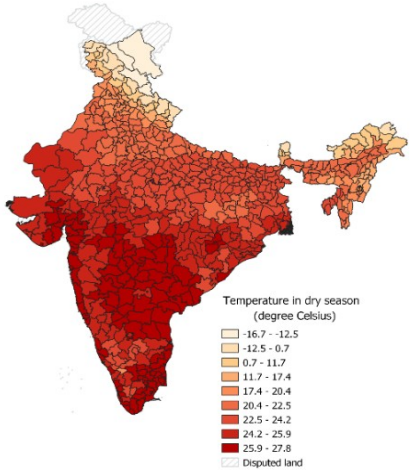
Variables	Description
Dietary diversity score of children (	calculated as the number of food groups (out of seven in total) consumed by a child in the last 24 hours.
Temperature (:	the average temperature (in Celsius) in the last three months within a 10-kilometer radius of the DHS cluster in which the child lives.
Child attributes and mother's traits (:	gender, age and birth order of child and mother's education level, mothers age at first birth, employment status, and whether she has antenatal care during pregnancy.
Household characteristics ():	household factors including religion, caste, family size, and wealth.
Geographical characteristics):	road density, access to markets (amount of time needed to reach the nearest population of 20,000 inhabitants) and household located in agricultural areas (percentage of area around a household covered by cropland)
Rainfall deviation previous Kharif season ():	deviation in rainfall within a ten-kilometer radius of the DHS cluster during the previous Kharif season (or wet season) from its long-term average to account for environmental shocks.
Seasonality in diet patterns	we include the month of the DHS survey, and a vector of interaction terms between the DHS survey year and the month of the survey.
DHS survey year and state fixed effects	Year FE controls for unobserved shocks common across survey years and state FE to account for time-invariant state level policies.

Given its size, India experiences significant spatial and temporal temperature variations

- ✓ Rabi/winter (RH) temperatures are high in regions of western and southern India, while temperatures fall in the northern and eastern parts.
- ✓ Kharif/monsoon (LH) temperatures are higher in regions of western, north-central, and southern coastal parts of India.

Average temperature during the wet and dry seasons in India

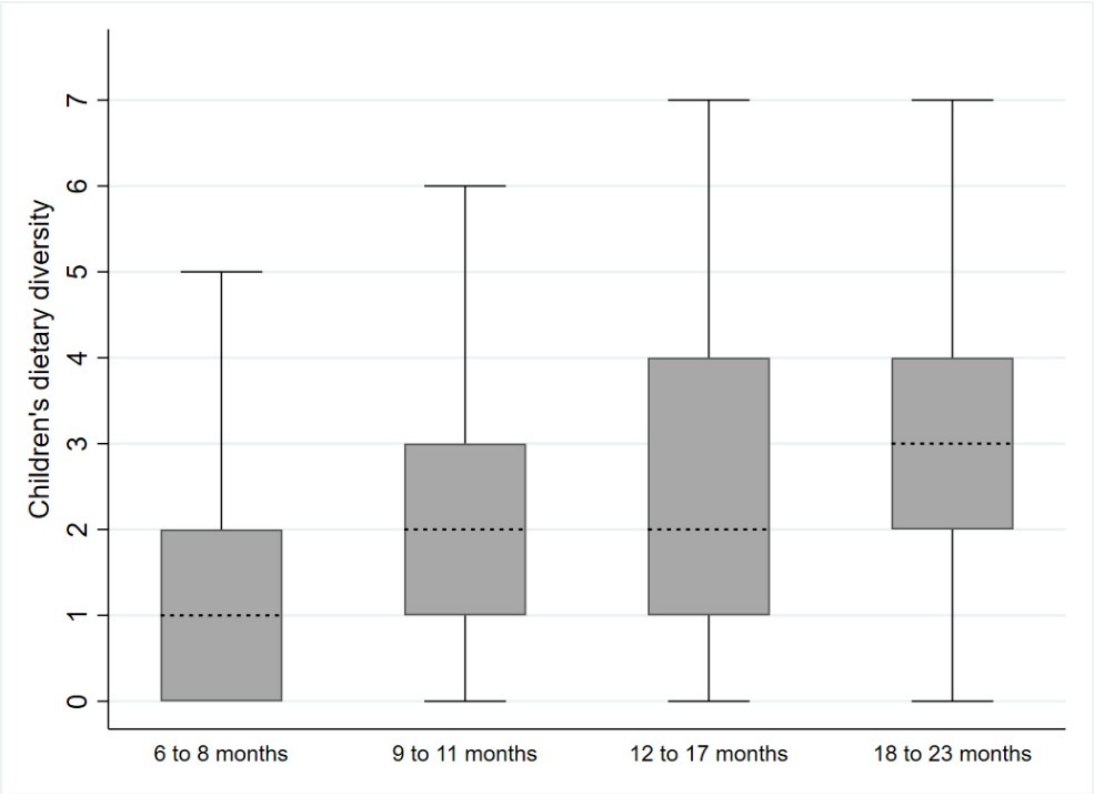




Dietary diversity of children in the age group of 6 to 23 months is low in India

- ✓ Children in this age group consumed **about 2 food groups** out of 7 food groups in the past 24 hours.
- ✓ Only about **23% of children** in this age group achieved the **minimum dietary diversity** (MDD) recommendation of at least 4 food groups.
- ✓ Even amongst the **older children (more than one and a half years)**, around **68% have not achieved the MDD** recommendation

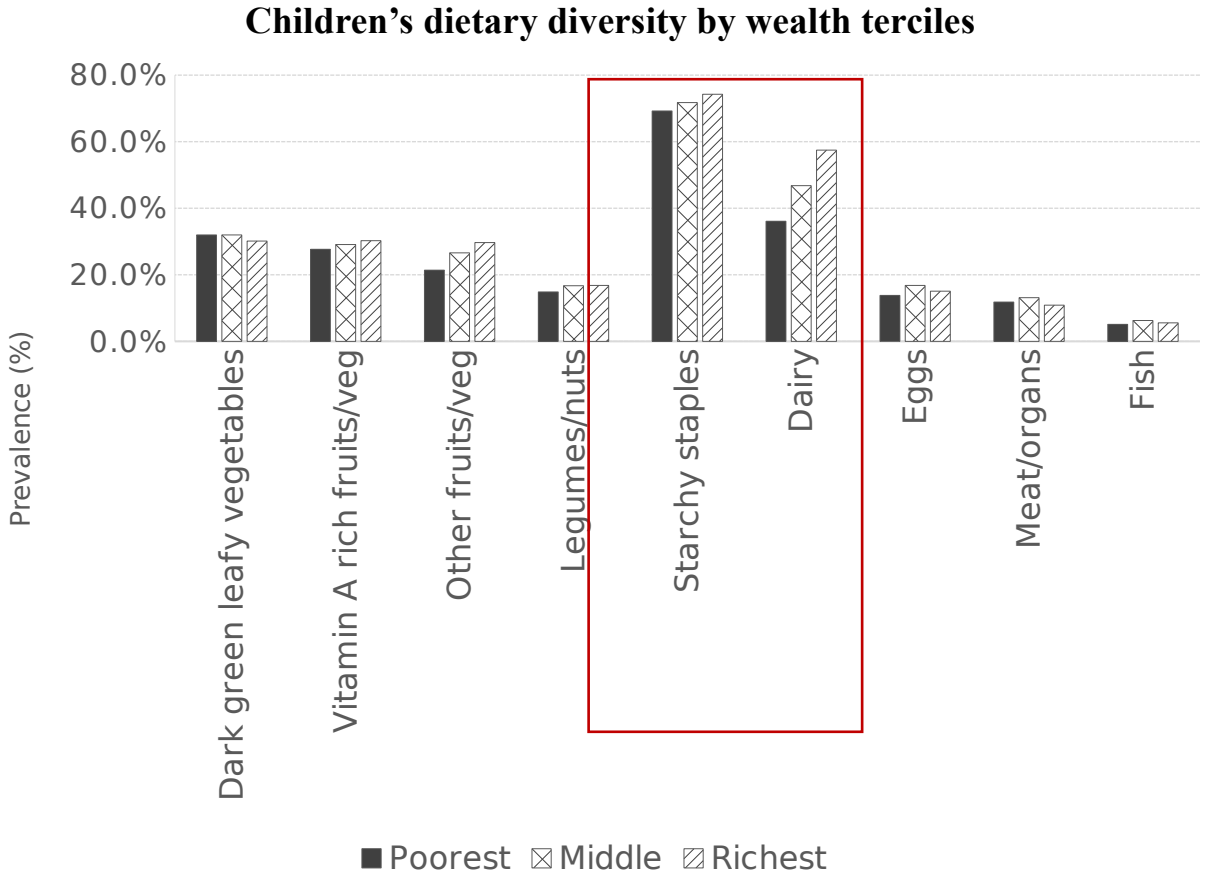
Children's dietary diversity by age groups



Source: Created by authors using data from DHS 2015-16 & DHS 2019-20

High incidence of starchy foods in children's diets, even amongst children from wealthier households

- ✓ Highest incidence of starchy staples across all age groups.
- ✓ Even among the wealthiest households, consumption of starchy staples is high.
- ✓ Consumption of meat, eggs, and fish is low for all age groups.
- ✓ Children from the wealthiest tercile of households consume less meat, poultry, eggs, and fish than children from middle-class households.
- ✓ Children from wealthy households tend to consume more fruits and vegetables, although the proportion of children who consume dark leafy vegetables somewhat declines with wealth.



Source: Created by authors using data from DHS 2015-16 & DHS 2019-20

Temperature is statistically significant and negatively associated with children's dietary diversity

- ✓ The Poisson coefficient can be interpreted as one more degree of temperature is associated with a 0.3% decrease in the number of food-group intakes.
- ✓ Here, we only analyze the overall effects without making assumptions about which mechanism may explain the link between high temperature and children's dietary diversity.

	(1)		(2)	
	Children's dietary diversity		Children's dietary diversity	
	OLS		Poisson	
	Coefficient	SE	Coefficient	SE
Temperature [a] (degree Celsius)	-0.008***	(0.002)	-0.003***	(0.001)
Child characteristics	Yes		Yes	
Household characteristics	Yes		Yes	
Geographical factors	Yes		Yes	
Rainfall deviation	Yes		Yes	
State fixed effects	Yes		Yes	
Survey month fixed effects	Yes		Yes	
Survey year fixed effects	Yes		Yes	
Survey month x survey year fixed effects	Yes		No	
Observations	4,14,114		4,14,114	
Average dietary diversity of a child	2.316			

[a] Average temperature in the last three months around a 10-km radius of the DHS cluster in which the child lives. [b] Terciles of wealth asset index. [c] Within a buffer zone of a 10-km radius around the DHS cluster, the totalroad density of all types of roads is calculated and then regions are classified as lowest, middle, and highest terciles of road density. d Travel time to the nearest population of 20,000. e Using a buffer of a 10-km radius around a DHS cluster centroid, we estimate the fraction of area that is classified as cropland. We then classify a region as areas with the lowest, middle, and highest terciles of agricultural land surrounding a household. f The rainfall anomaly index is measured as a standardized score of deviation of the previous year's Kharif season from historical averages within a 10-km radius of the household. Standard errors are clustered at the household level and presented in parenthesis. *** Significant at 1% level, ** Significant at 5% level, * Significant at 1% level.

The negative effect of temperature is disproportionately more amongst older children in the age group of 12 to 23 months, and children born in heat-prone areas have a lower heat-induced loss in dietary diversity

- ✓ The negative effect of temperature on children's dietary diversity is greater for children in the age group of 12 to 23 months than younger children in the age group of 6 to 12 months.
- ✓ Children who live in historically hotter places are better able to adjust to high temperatures.
- ✓ Heat stress has less of a negative impact on their diets than children who live in relatively colder regions

	(1) Children's dietary diversity		(2) Children's dietary diversity	
	Coefficient	**SE**	**Coefficient**	**SE**
Child is more than one year old x Temperature	-0.006***	(0.002)		
Hotter regions [a] x Temperature			0.008***	(0.002)
Controls included [b]	Yes		Yes	
State fixed effects	Yes		Yes	
Survey month fixed effects	Yes		Yes	
Survey year fixed effects	Yes		Yes	
Survey month x survey year fixed effects	Yes		Yes	
Observations	4,14,114		4,14,114	

[a c] Child characteristics such as gender, age, and birth order, and mother's traits, such as educational level, age of the mother and age at first birth, employment status, and whether she had any antenatal care during pregnancy are included as controls. We also control for household factors including religion, caste, family size, and wealth status. Geographic factors such as road density, access to markets, an agricultural area, and rainfall deviation are also controlled for. Standard errors are clustered at the household level and presented in parenthesis. Standard errors are clustered at the household level and presented in parenthesis. *** Significant at 1% level, ** Significant at 5% level, * Significant at 1% level. Hotter region is 1 if a given district's long-run average temperature is above the district median and is zero otherwise.

The negative effect of temperature on children's diets can be reduced by better access to market, roads and improved maternal education

- ✓ Children who live in neighborhoods with high road density have less of a negative impact due to temperature than children who live in areas with low road density.
- ✓ Children who live in areas with high market accessibility experience less negative impact from temperature on diets than children who live in areas with poor market accessibility.
- ✓ We find that maternal education can have a significant impact in moderating the harmful effects of temperature on children's diets

	(1)		(2)		(3)	
	Children's dietary diversity		Children's dietary diversity		Children's dietary diversity	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
High road density [a] x Temperature	0.003*	(0.002)				
High market access [b] x Temperature			.006***	(0.002)		
Maternal 1 to 6 years education x Temperature					0.000	(0.003)
Maternal 7 to 9 years education x Temperature					0.000	(0.003)
Maternal 10+ years education x Temperature					0.006**	(0.002)
Controls included [c]	Yes		Yes		Yes	
State fixed effects	Yes		Yes		Yes	
Survey month fixed effects	Yes		Yes		Yes	
Survey year fixed effects	Yes		Yes		Yes	
Survey month x survey year fixed effects	Yes		No		Yes	
Observations	4,14,114		4,14,114		4,14,114	

Conclusion

- ✓ We find that temperature rise has a significant and **negative effect** on children's diets.
- ✓ We also **find evidence of substantial heterogeneity in the temperature-dietary diversity** relationship across:
  - ❑ age,
  - ❑ geographical location,
  - ❑ access to roads and markets,
  - ❑ maternal education.
- ✓ From a policy perspective, this study suggests that:
  - ○ Investment in the development of rural infrastructure, such as roads and markets, can have significant advantages in reducing some of the adverse effects of climate change.
  - ○ Moreover, improving female literacy can have long-term intergenerational benefits, as well as help reduce some of the negative effects of the rise in temperature on children's diets.

Thank you