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Impact of Temperature on Children’s Nutrition: A Comparative Study of Three Ecological Regions of Nepal

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Abstract: Nutrition obtained during the growth period of childhood significantly influences long-term well-being and overall productivity, ultimately contributing to the economy of a society. However, weather shocks can wreak havoc by damaging crops, changing yields of important crops and disrupting market access, which directly impacts the food intake of both adults and children. When these adverse events occur during childhood, short term and long term inadequacy in nutrition as well as disease incidence can cause malnutrition leading to stunted growth and cognitive impairment that may persist into adulthood, affecting the labor market and increasing health expenditure. To address this issue, we derive causal relationships between temperature changes and weight-to-height z score in the three ecological regions of Nepal; Mountains, Hills, and Terai (flatland). We find that there is a positive and significant impact of temperature on children's weight-to-height z score in the Terai region. An increase of 20 percent in the average growing degree days leads to 1 standard deviation growth in weight-to-height z score. This relation remains consistent in households where the head of households are involved in agriculture or salaried employment in the Terai region of Nepal.

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1. Introduction

Ensuring a well-rounded diet that includes essential nutrients and minerals is crucial during a child's formative years. It not only impacts their physical well-being but also plays a significant role in their mental development. Research indicates that children facing hunger or illnesses in their early years can experience enduring physiological repercussions (Barker, 1990, Martins et al, 2011) contributing to academic struggles, increased dropout rates, and limited employment opportunities (Young, 1996, Almond and Currie, 2011, Hoddinoth et al, 2013, Phalkey et al, 2015). Despite substantial global efforts, there is still a concerning number of children under the age of five who are too thin for their height (referred to as 'wasting'). In 2022, approximately 45 million children globally fell into this category, with over half of them residing in South Asia (Joint Malnutrition Estimates, 2022). Wasting can occur due to a complex interplay involving poverty, disease, caregiving practices, and dietary patterns, all of which vary depending on the context (Harding et al, 2018). All these factors prevent children from attaining sufficient nutrition in their early years which not only jeopardize their individual potential but also extends to far-reaching effects on labor productivity, impeding economic advancement, and potentially perpetuating intergenerational effects.

There is growing evidence that temperature and precipitation shocks affect consumption of micronutrients. It changes the yields of important crop sources of micronutrients, alters the nutritional content of a specific crop (Smith and Myers, 2018, Nelson et al, 2018), and influences decisions to grow crops of different nutritional value (Burke and Lobell, 2010). This exacerbates the heightened susceptibility of children to wasting, especially in low-income and lower-middle income countries where it is already a growing concern. Furthermore, due to their immature physiology and metabolism (Ahdoot et al, 2015), children are at higher risks of suffering from diseases such as respiratory diseases, malaria and diarrhea caused by air pollution, high temperature, frequent and irregular rainfalls (Bunyavanich et al, 2003, Sheffield and Landrigan, 2010). This has direct implications on nutritional intakes and can lead to child morbidity and mortality (Hasegawa et al, 2016, Troeger et al, 2018). While food availability and accessibility are widely studied in the climate literature, the impact of climate change on proper utilization of food remains understudied (Burke and Lobell, 2010). Therefore, in this paper, we focus on children's nutrition in the face of the inevitable challenges posed by climate change.

We study the effects of temperature and precipitation shocks on the weight-to-height z scores of children in the three distinct agro-ecological regions of Nepal: Mountains, Hills, and

Terai (lowlands). All regions have varying climates due to altitudes ranging from 700 meters in the Terai region to 8,848 meters in the Mountain region. Since most of the literature in this area are focused in Sub-Saharan Africa (Hirvonen et al, 2015; Thiede and Gray, 2020; Antilla-Hughes et al, 2021; Amondo et al, 2023) where temperatures are extreme, we utilize the unique features of Nepal with varied climatic conditions, to look at whether the effects persist in rising yet temperate weather extremes across the regions. This also assists us in determining the effectiveness of nationwide programs in countries with different topographies, and see whether it is important to tailor to suit specific populations. Furthermore, we attempt to understand the mechanisms through which weather variability affects nutrition.

This research is carried out by combining the Policy and Science for Health, Agriculture and Nutrition (PoSHAN) annual surveys of households with children less than 5 years old, collected across the three regions in Nepal from 2013–2016, with the average temperature and precipitation data at district level. We exploit the exogenous shock – weather variation in wards across years to form causality between fluctuations in weather and its impact on children's nutrition using fixed effects. Since the relation between temperature and the crop outcomes is non-linear (Schlenker and Roberts, 2009); Lobell et al, 2011); Zhao et al, 2017), we utilize a widely adopted measure in agriculture called Growing Degree Days (GDD) to better understand the mechanisms affecting children's nutritional intake. Growing Degree Days (GDD) is the sum of truncated degrees on a given day between two boundaries suitable for the crops to grow, and Harmful Degree Days (HDD) measure the days when the temperature exceeds the optimum level.

Unlike existing literature, we find that rising temperature does not have a negative impact rather a positive effect on the weight-to-height z score in the Terai region. The results in the other regions remain insignificant. A 1°C increase in average temperature shifts the weight-to-height z-score by 0.15 standard deviation from the mean in the Terai region. This is consistent with temperature anomalies which are deviations from the long-term average from 1979–2016. The positive linkage may exist because contrary to existing literature, the average temperature used in this paper does not surpass the conventional extreme temperatures found in the other studied regions. On the other hand, average precipitation and long-term average precipitation does not have any significant effect in any of the regions. There is no significant difference in the outcome for male and female children.

Since the relationship between average temperature and weight-to-height z score is non-linear, we use another measure, Growing Degree Days, to study this impact. We find that there is a positive association between Growing Degree Days and children's weight-to-height z score, and a negative impact of Harmful Degree Days on children's weight-to-height z score in the

Terai region. The relation remains true for households involved in agriculture and salaried occupations. This supports our hypothesis that agriculture is an influential pathway through which weather affects weight-to-height z score. We find that a 100-units increase in Growing Degree Days shifts weight-to-height z score by 0.22. Likewise, a 10-unit increase in Harmful Degree Days creates a negative shift in weight-to-height z score by 0.27 standard deviation. Therefore, even though extreme temperatures above 35 degree Celsius is not common, if the trend of rising temperature continues, there are high chances that children in the Terai region will become malnourished.

Contrary to the expectation that poorer households would engage in consumption smoothing during challenging times (Deaton, 1991), empirical studies (Hoddinott, 2006; Carter and Lybbert, 2012) find that, in the face of drought losses, impoverished households are more likely to hold onto their assets, while wealthier families opt for asset liquidation to maintain consumption stability. This illustrates the risk-averse behavior that the poorer households have, molded by the knowledge and resource constraints they face. The decision to disrupt consumption in an attempt to safeguard productive assets in the short term can have an irreversible impact on the growth and development of children (Alderman et al., 2006). Furthermore, parents choosing to reduce their food intake to provide more for their children contributes to diminished productivity, creating a detrimental cycle of impoverished workers unable to generate sufficient income to obtain the necessary calories for productivity—a phenomenon known as the 'efficiency wage hypothesis' (Berhman et al., 2004). Put differently, parents' decisions can have an intergenerational effect on shaping poverty for future generations.

Most of the literature in the growing field of climate change and children's nutrition are targeted in warmer African countries and typhoon-prone coastal countries. Antilla-Hughes et al (2021) find that warmer El Niño conditions predict worse child undernutrition in the developing countries, but better outcomes in areas where precipitation is positively affected by warmer ENSO (El Niño Southern Oscillation). Randell, Gray and Grace (2020) show that higher temperatures in utero and more rainfall during the third trimester are positively associated with severe stunting in Ethiopia. Likewise, Thiede and Gray (2020) show that delay in monsoon onset during the prenatal period is associated with reduced child height among children aged 2-4 years in Indonesia. Maccini and Yang (2009) find that higher rainfalls in early childhood lead to improved health outcomes, educational attainment, and socio-economic status for infant girls in Indonesia. Conversely, in Bangladesh, those exposed to the 1998 extreme flood showed lower height-for-age z-scores than unaffected children (Ninno and Lundberg, 2005). Hirvonen et al (2015) find no significant effect of drought in child undernutrition.

We contribute to the existing literature by focusing our study on a landlocked country with three distinct topographies and varying yet temperate climatic conditions where the temperature rarely exceeds 35 °Celsius. This offers a unique perspective into the effects of climate change in the same country but different climatic conditions. By incorporating longitudinal data rather than cross-sections, we present more concrete and robust results of the impact on nutritional outcomes. We also add to the existing literature of temperature's non-linear relationship on agriculture (Schlenker and Roberts, 2009; Lobell et al, 2011; Zhao et al, 2017) by studying its second-order effects on children's weight-to-height z score. We show that agriculture is one of the pathways through which temperature affects children's nutritional outcome.

2. Conceptual Framework

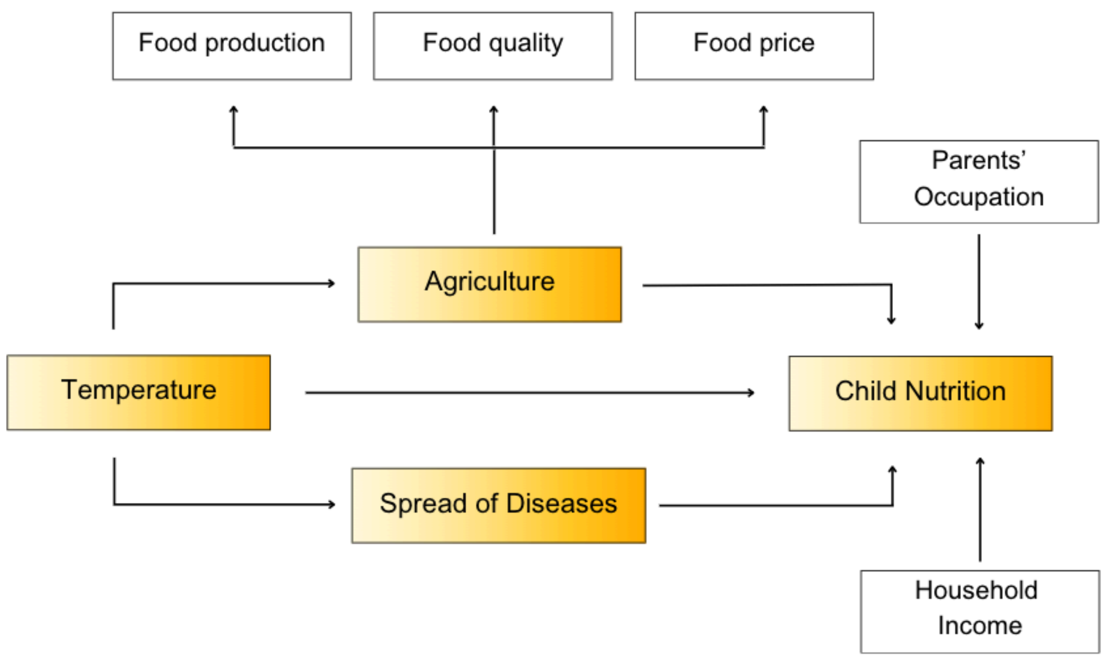

Figure (i) Directed Acyclic Graph (DAG) showing the relationship between temperature and child nutrition, and the pathways through which they are related.

The pathways through which temperature can affect children's nutrition are illustrated in Figure (i). Extreme temperatures can directly affect children's nutrition and health from heat exhaustions, dehydration, thermal stress-induced loss in appetite, diarrhea and respiratory diseases. Agriculture and vector-borne diseases are the indirect pathways that we take into consideration in this study that influences children's nutritional outcomes. From the literature, we know that increases in temperature across a certain point has a negative impact on crop yields. This then directly influences the diets of children as food availability depends on the crops grown and sold in the market. Additionally, a study (Smith and Myers, 2018) has found that increase in concentration of CO2 in the atmosphere reduces nutritional content of important crops such as rice, wheat, and corn. This directly impacts the growth and development of children in countries where those food crops are the main staple of their diet. Thus, the link between temperature and children's nutrition becomes very important to understand especially because of its long-term consequences on children's well-being. Additionally, insects such as mosquitoes thrive in hot weather, which means increase in heat also causes easy spread of vector-borne diseases such as malaria, dengue, and lyme disease. This may harm the immune system of children who are affected.

3. Data

3.1 Nepal Context

Nepal is a landlocked country in South Asia with an area of 147,516 km^2, bordered by India and China. There are three main geographical regions in the country: Mountains, Hilly, and Terai region. The Mountain region has an elevation from 3,000m to 8,848m and covers 15% of the total area of the country. The Hilly region occupies 68% of the country, and falls in between the Mountain and Terai region. And the Terai region ranges 700-1000m, and covers 17% of the whole country. Figure (ii) shows the map of Nepal with the districts in the dataset highlighted. In the dataset, the minimum average temperature in the Mountains is -0 °Celsius, and the maximum average temperature in the Terai region goes up to 25 °Celsius.

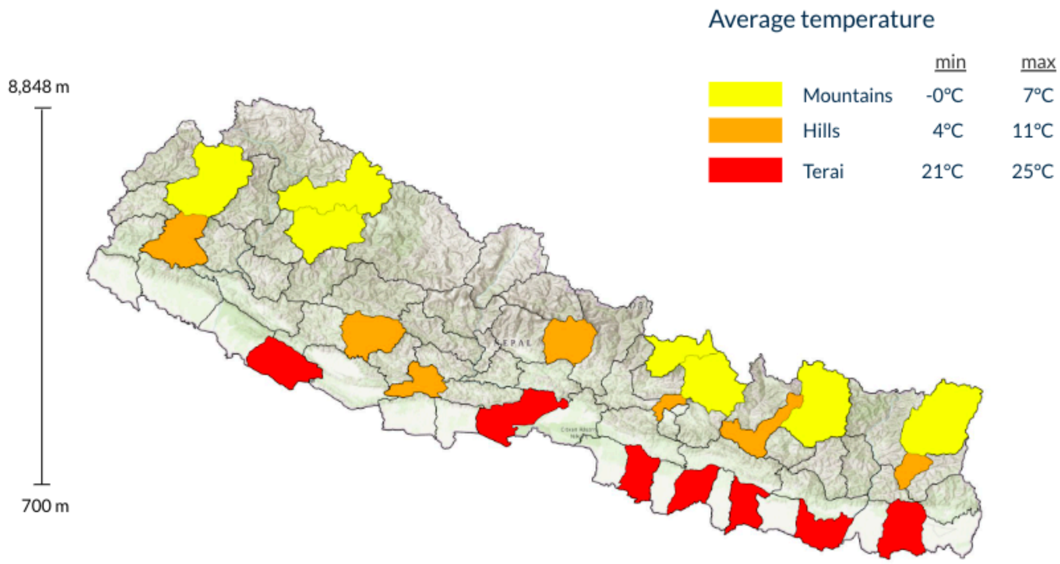

Figure (ii) Map of Nepal shows the districts included in the dataset with the range of average temperature in the three ecological regions: Mountains, Hills, and Terai in the year 2016.

3.2 Household Survey Data

This study examines three waves of the Policy and Science for Health, Agriculture and Nutrition (PoSHAN) annual surveys of households with children less than 5 years old, collected in 21 districts across each agro-ecological zone (mountain, hills and flatlands) in Nepal from 2013-2016. It is collected at community, household, and individual level and consists of components that link agriculture, nutrition, and health. Systematic random sampling was used to initially select 7 VDCs/districts in every agro-ecological zone and later 3 wards were selected from each VDC resulting in 63 clusters/wards where we use fixed effects (Figure iii) (refer to Klemm et al., 2018 for the design of data collection). Kathmandu is the smallest district in the dataset with 395 km^2 area and Mugu is the largest district in the dataset with 3,535 km^2 area.

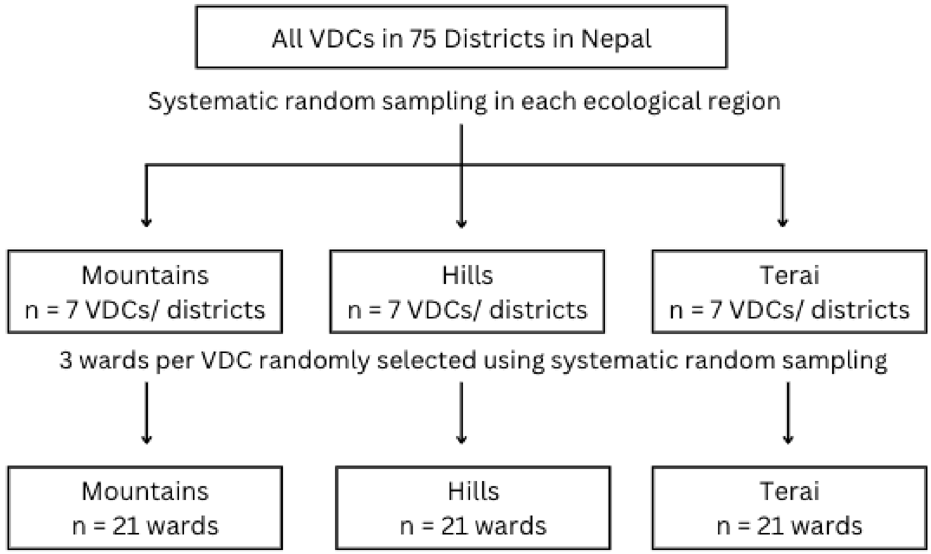

Figure (iii) Random household selection process: Out of 75 districts, 7 VDCs/districts in every agro-ecological zone were selected and from those districts, 3 wards were selected resulting in 21 wards in each of the ecological regions.

3.3 Weather Data

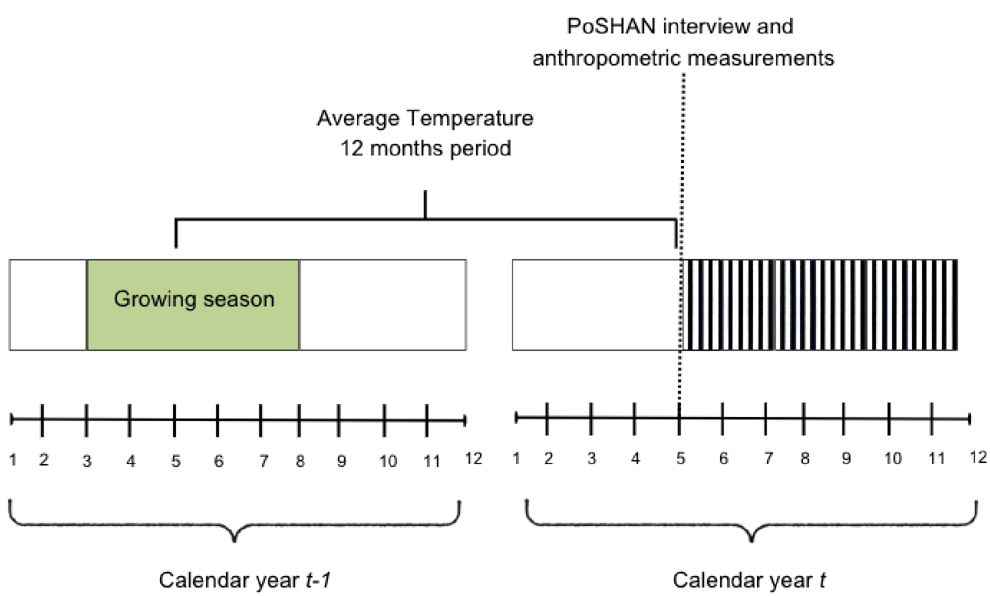

Figure (iv) Weather Calendar: Average Temperature Data collected 12 months prior to the survey data collection. Growing season is from March-August. Survey data were collected starting May.

The monthly average and maximum temperature and precipitation data were extracted from 2013–2016 at Level 2 (district) from European Centre for Medium-Range Weather Forecasts's updated ERA5 gridded climate dataset. Due to confidentiality of the dataset, we do not have information on the location of the wards. However, since the districts are small in area, we only expect minimal temperature variation between the wards within the same district. The highest temperature in the years 2013, 2014 and 2016 was 30.68 °Celsius in the district Banke that lies in the Terai region of Nepal. On the other hand, the lowest temperature was -12.16 °Celsius in the district Mugu in the Mountain region. We take the averages of the 12-months period before May when the survey was collected and merge them with the survey dataset by the district.

Papers such as Schlenker and Roberts (2009), Lobell et al (2011), Zhao et al (2017) use non-linear models to show that increasing temperatures have severe impacts on the yields of major crops. They use Growing Degree Days (GDD) as an indicator of the sum of truncated degrees on a given day between two boundaries suitable for the crops to grow, and Harmful Degree Days (HDD) that measure the days when the temperature exceeds the optimum level. In this paper, we use the bounds for paddy as rice is a staple in Nepal and its bounds cover optimal temperature for crops such as wheat, maize, millet which are other staple crops in the country. The optimal temperature for paddy to grow is between 10 and 35 degree Celsius, so temperatures of 5°C, 12°C, 15°C, 30°C, and 36°C in a given day would result in 0, 2, 5, 20, and 25 growing degree days, respectively. And any temperatures above 35°C would count to HDD. Both GDD and HDD are calculated using daily mean temperature from the previous year's growing season from March to August.

3.4 Anthropometric Measurements

To exhibit the nutritional shocks due to high caloric needs during early age, we use anthropometric measures such as weight-to-height z score (Alderman and Heady, 2018). Weight-to-height z score measures wasting, defined as a child being too thin for their height, that results from either rapid weight loss or the failure to gain weight (UNICEF, 2022). Anthropometric z-scores describe how far an individual's measurement is from the reference populations' median value. Z-scores that fall outside of the normal range indicate a nutritional issue (undernutrition or overweight). If a z-score is outside the normal range, its distance from the median indicates the severity of the nutritional issue; the further away, the more severe (Cashin and Oot, 2018). Children who have weight-to-height z score less than 2 standard deviations fall into moderately wasted category and those with z score less than 3 standard deviations are severely wasted (UNICEF, 2022).

Amongst the 18,000 observations of preschool children in 2013, 2014 and 2016 altogether, we see a progressive trend in weight-to-height z score (see Appendix II). 19.23 percent of children were out of moderately and severely wasted category by 2016 in comparison to 2013. However, 13 out of 100 children were still moderately and severely wasted in 2016. Because of the massive 2015 April Earthquake in Nepal, survey data were not completely collected during that year so we have decided to leave out the year 2015. Since we use fixed effects across time and wards, any consistent differences caused by the earthquake are eliminated.

5. Specification

In order to examine the relation between temperature and children's nutrition, we firstly use average temperature as the weather variable to see whether or not there is an effect on children's weight-to-height z score. Following that, we replace the weather variable with maximum temperature, Growing Degree Days (GDD), Harmful Degree Days (HDD), and the deviation from the long-trend average temperature and precipitation from 1979-2016, to further investigate the relation and mechanism through which temperature can have an effect on children's weight-to-height z score. We form a causal relationship by controlling for both spatial and temporal invariant factors using the standard fixed effects Ordinary Least Squares regression model (Dell et al, 2014; Hsiang, 2016). The following regression model is used to find the impact on nutritional outcomes:

$$Y_{it} = \beta_0 + \beta_1 W_{it} + \tau X_i + \mu_i + \theta_t + \varepsilon_{it} \quad \ldots\ldots \text{ eqn (i)}$$

Y_{it} is the dependent variable that represents children's weight-to-height z score. W_{it} is the weather variable. We replace the weather variable with average temperature, maximum temperature, Growing Degree Days (GDD), Harmful Degree Days (HDD), and the deviation from the long-trend average temperature and precipitation from 1979-2016, to see whether the association remains constant or not. For all the regressions, we control for time-invariant variables using μ_i ward-fixed effects and θ_t year-fixed effects. X_i is a vector of controls for child and household-specific characteristics such as child age, child sex, number of children, mother's age, mother's education, and wealth index. Due to data limitation, we are unable to use household-fixed effects which would provide more precise results. However, since households in a given ward share similar socioeconomic status, culture and tradition, access to infrastructures, education, schools, markets, we believe using ward-level fixed effects controls for all the time-invariant factors that are present at the ward level affecting children's nutritional status. And with time-fixed effects, we are able to explore the causal impact of temperature as a random exogenous shock on children's weight-to-height z score.

6. Results and Discussion

In Table 1, Outcome A, B, and C presents the results for equation (i) with different regressors where in Outcome A, the independent variable is average temperature, in Outcome B, the independent variable is maximum temperature, and Outcome C is the results with long-term average temperature z score as the independent variable. With ward level fixed effects, we find that there is no statistically significant relationship between the different variations of temperature and children's weight-to-height z score in the Mountains and Hilly region. All the coefficients for the regressions remain positive, but are statistically insignificant. There is a positive and significant relationship in the Mountains Region with district-fixed effects, however this does not provide a precise result as there are variations in weight-to-height z score of children, food availability and preferences, elevation, and cultural differences across wards within the same district that district-fixed effects does not take into account.

We find positive and significant impact of temperature on children's weight-to-height z score in the Terai region, and these results remain consistent with district as well as ward-level fixed effects. A degree Celsius increase in the average temperature leads to a positive increase of 0.15 standard deviation in the weight-to-height z score of the children, suggesting that increasing temperature is beneficial for the growth of children in the Terai region. This may be because the increasing temperature is better suited for the crops to grow, so there is more food availability and utilization. We use maximum temperature in Outcome B and find that a degree Celsius increase in the average of maximum temperature increases weight-to-height z score by 0.08 standard deviation. In Outcome C, we find similar results in reference to the long-term mean and standard deviation of temperature in a district for all 12-month periods from 1979 to 2016.

It shows that the weight-to-height z score increases by 0.058 standard deviation in the Terai region. Outcome A and Outcome B are consistent at 1% significance level.

	Weight-to-height z score					
	Mountains		Hills		Terai	
	(1)	(2)	(3)	(4)	(5)	(6)
Outcome A: Avg temperature	0.111	0.144**	0.103	0.093	0.154***	0.131**
	(0.069)	(0.044)	(0.112)	(0.055)	(0.044)	(0.056)
Outcome B: Max temperature	0.110*	0.136***	0.068	0.057	0.081***	0.068*
	(0.055)	(0.036)	(0.081)	(0.037)	(0.024)	(0.034)
Outcome C: Avg temperature	0.0747	0.107**	0.037	0.034	0.059**	0.049*
z score (1979-2016)	(0.061)	(0.042)	(0.034)	(0.031)	(0.017)	(0.023)
Ward FE	Yes		Yes		Yes	
District FE		Yes		Yes		Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2537	2537	3948	3948	9805	9805

* p<0.10, ** p<0.05, *** p<0.01

Table 1: Outcome A shows the effect of average temperature during the year on weight-to-height z score. Outcome B shows the same effect using maximum temperature instead of average. Outcome C shows the effect of deviation from long-term weather average (1979-2016) temperature on weight-to-height z score. Columns (1), (3), (5) are coefficients with ward and year fixed effects, and Columns (2), (4), (6) have district and year fixed effects. Controls include child age, child sex, number of children, mother's age, mother's education, and wealth index. Standard errors clustered at ward level.

In Table 2, we substitute temperature variables with Growing Degree Days and Harmful Degree Days as our independent variables to examine whether the positive effects on the weight-to-height z score can be inferred from agriculture and suitable climatic conditions for the crops to grow. Table 2 shows a positive relation in the Mountain region but it is statistically insignificant. The growing degree days has a negative but statistically insignificant effect on children's weight-to-height z score. And we find that there is a significant and positive effect of growing degree days on children's weight-to-height z score in the Terai region. Conversely, we find that harmful degree days for temperatures over 35°C have a negative impact. A 100-units increase in growing degree days lead to 0.212 standard deviations increase in the weight-to-height z score in the Terai region, meaning a 20 percent increment in the average growing degree days leads to 1 standard deviation gain in weight-to-height z score. On the other hand, a 10-unit increase in Harmful Degree Days has a negative effect of 0.25 standard deviation on the weight-to-height z score.

	Weight-to-height z score		
	(1)	(2)	(3)
	Mountains	Hills	Terai
Growing Degree Days	0.000597	-0.000358	0.00212***
	(0.00151)	(0.00110)	(0.000750)
Harmful Degree Days	0	0	-0.0254*
	(.)	(.)	(0.0136)
Ward FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	2505	3911	9750
Mean GDD	617.02	1621.73	2464.18
Mean HDD	0	0	1.68

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2: Impact of growing degree days and harmful degree days on weight-to-height z score using ward and year fixed effects. Controls include child age, child sex, number of children, mother's age, mother's education, and wealth index. Standard errors clustered at ward level.

We further discover that the positive effects of growing degree days remain significant for households that are involved in agriculture or salary employment in the Terai region (Appendix III). This shows that children born in families who are farmers seem to become healthier with increases in growing degree days and diminishing harmful degree days. Likewise, since Terai is the main region for food production catering to the needs of the whole country, most of the salaried occupations are also directly related to agriculture. Therefore, children who have a direct association with agriculture benefit from the increasing temperature. The positive results may also be because the temperature that we use in this paper rarely exceeds the harmful degree days which are common in regions where previous literature has been conducted. Although extreme temperatures above 35 degree Celsius is not common yet in Nepal, if the trend of rising temperature follows the global trend, there are chances that children in the Terai region will become malnourished.

From the literature (Antilla-Hughes et al, 2021), we know that there is a positive relationship between average temperature and children's weight-to-height z score up to a certain point. Likewise, the relation between growing degree days and crop yields also remains positive to a certain level (Schlenker and Roberts, 2009). However, since this relation is non-linear, eventually after a point, there will be a dip on the weight-to-height z score due to extreme increase in the temperature. Due to data limitation, we are unable to investigate the tipping point up to which the temperature has a positive impact on the weight-to-height z score. So, we cannot assure at what level the temperature will become harmful for crop yields, affecting children's growth. For future research, we would use a larger dataset with all the districts in the regions for a longer timespan and examine whether the existing relationship remains. Furthermore, we do not take into account any adaptation or coping mechanisms that households may be adopting to prevent the effects of temperature. Some other limitations are: (i) Measurement errors that might occur from survey data, (ii) We are unable to get granular detail on household effects since we use fixed effects at ward level, and (iii) We have not included survey data from 2015 because of the April 2015 earthquake. The effects of which we believe will be mediated by time fixed effects.

7. Robustness Check

Since we run our regression models separately for each of the ecological regions that have uneven observations, an additional step would be to look into whether or not the differences of the main variables remain statistically significant. As shown in Table (3), we find that the differences between the three ecological regions are statistically significant.

Weight-to-height z score	
Avg temperature	-0.6158

	(0.043)
Hilly Region # Avg temperature	0.2928**
	(0.786)
Terai Region # Avg temperature	0.1145***
	(0.040)
Maximum temperature	-0.0439
	(0.030)
Hilly Region # Max temperature	0.1747***
	(0.056)
Terai Region # Max temperature	0.0737**
	(0.029)
Avg temperature z score	-0.0478
	(0.031)
Hilly Region # Avg temperature z score	0.1451***
	(0.037)
Terai Region # Avg temperature z score	0.0663***
	(0.024)
Ward FE	Yes
Year FE	Yes
Observations	16,288

* p<0.10, ** p<0.05, *** p<0.01

Table 3: Results showing interaction of region with different regressors. Controls include child age, child sex, number of children, mother's age, mother's education, and wealth index. Standard errors clustered at ward level.

7. Conclusion

We use a dataset that spans for three years to study the impact of temperature shocks on children's nutritional outcomes in Nepal. Distinct from the prevailing literature, we find a positive relationship between temperature variations and children's nutritional outcome, suggesting that the current impacts from global warming and climate change may not entirely be destructive and that there are positive effects from the increasing temperature on the physical wellbeing of children in the Terai region, especially those living in households involved in agriculture. This also suggests that national adaptation programs designed to mitigate the impact of climate change should be localized. Factors such as climatic conditions, topography, local culture and practices, and parents' education and occupation, need to be taken into consideration at a local level to avoid counteractive outcomes.

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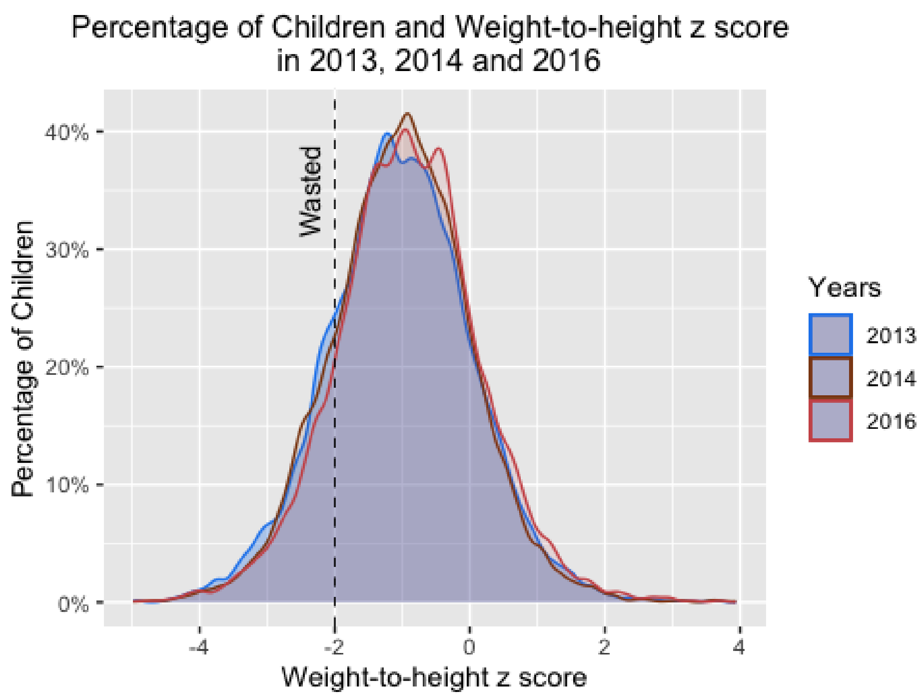
Appendix

Appendix I: Summary Statistics

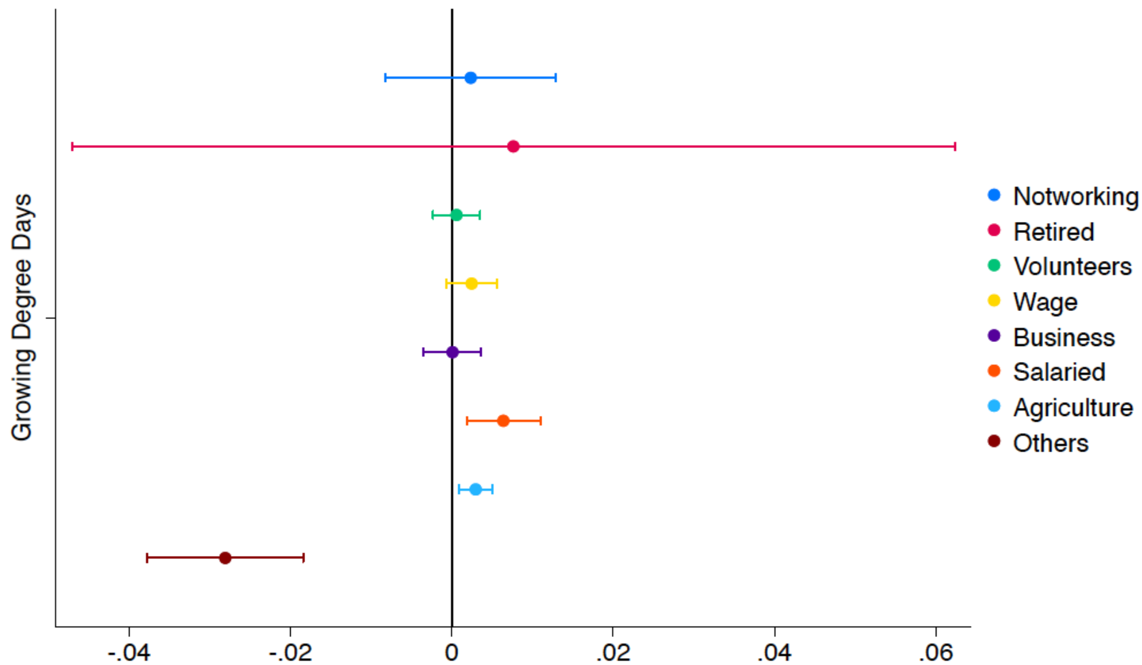
Region	**N**	**Mean**	**SD**	**Min**	**Max**
Mountain					
Weight-to-height	2537	-.620	1.003	-4.97	3.94
Avg temperature	2862	2.837	2.683	-.232	7.007
Avg precipitation	2862	4.367	1.419	2.738	8.015
Max temperature	2862	8.047	2.712	4.705	12.491
Avg temp z score	2862	0.415	0.689	-.431	1.557
GDD	2862	617.020	347.866	0	1332.49
HDD	2862	0	0	0	0
Child age	2862	35.518	19.631	0	74
Mother’s education	2862	3.317	4.986	0	17
Hilly					
Weight-to-height	3947	-.603	1.036	-4.98	3.68
Avg temperature	4359	15.953	2.853	6.107	19.498
Avg precipitation	4359	6.728	1.602	4.131	11.291
Max temperature	4359	20.900	2.957	10.637	24.677
Avg temp z score	4359	0.691	0.603	-.307	1.816
GDD	4359	1620.291	183.660	1383.089	1971
HDD	4359	0	0	0	0
Child age	4359	33.428	19.588	0	74
Mother’s education	4359	2.338	4.107	0	17

Terai					
Weight-to-height	9804	-1.230	0.997	-4.94	3.72
Avg temperature	11098	23.572	0.814	21.481	24.961
Avg precipitation	11098	4.155	0.936	2.798	6.155
Max temperature	11098	29.084	1.070	26.605	30.679
Avg temp z score	11098	.831	1.149	-.402	2.612
GDD	11098	2464.114	86.259	2228.227	2572.221
HDD	11098	1.677	1.997	0	4.516
Child age	11098	34.469	19.983	0	75
Mother's education	11098	1.205	3.031	0	17

Appendix II: Trend of children's weight-to-height z score in 2013, 2014, and 2016



Appendix III: Coefficient plot showing the relationship between growing degree days and children's weight-to-height z score by the head of household's occupation.



Growing Degree Days
-.04
-.02
0
.02
.04
.06
Notworking
Retired
Volunteers
Wage
Business
Salaried
Agriculture
Others