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Climate, weather and child health in Burkina Faso

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Abstract

It is now clear that anthropogenic climate change is having a negative impact on human health. In this paper, we provide the first comprehensive assessment of the impact of climatic stressors on child health in Burkina Faso. We undertake a rigorous empirical analysis of the impact of climate and weather shocks on mortality, stunting (height-for-age *Z*-score) and wasting (weight-for-age *Z*-score), using Demographic and Health Surveys, combined with high-resolution meteorological data, controlling for household and individual covariates. We find robust evidence that both lifetime and short-term exposure to high temperatures and droughts have a negative impact on child health, as do increased temperature anomalies during crop seasons, suggesting a link between climate and health through domestic food production. Income and household wealth, access to electricity, sanitation and a health facility for childbirth negate some adverse impacts of climate change. Combining our econometric estimates with updated CMIP6 scenarios, we compute policy-relevant projections of future child health. Our results show that future warming is projected to significantly increase child mortality, and share of underweight and stunted children, in all but the Paris Agreement scenario. Given the links between health, a key element of human capital, and economic growth, our findings and projections provide yet more evidence of the importance of a rapid reduction in global emissions combined with adaptation funding, if lower-income countries are to achieve poverty reduction and increasing prosperity.

KEYWORDS

Burkina Faso, child health, climate change, extreme weather events, socio-economic modifiers, stunting, wasting

JEL CLASSIFICATION

I14, O55, Q51, Q54

1 | INTRODUCTION

There is increasing evidence that anthropogenic climate change is already having both direct and indirect effects on the health and well-being of children (Helldén et al., 2021; Romanello et al., 2021, 2022; Watts et al., 2020). UNICEF estimates that approximately one billion children live in extremely high-climate-risk countries, with 820 million children (over one-third of children globally) highly exposed to heatwaves (UNICEF, 2021). Gradual warming, heatwaves, changes in precipitation levels and droughts have all been linked to childhood morbidity and mortality, and increased risks due to undernutrition and malnutrition such as stunting (low height for age) and wasting (low weight for height) (Davenport et al., 2017; Grace et al., 2015; Kuehn & McCormick, 2017; Rylander et al., 2013).

The links between health, a key element of human capital, and economic growth are well-recognised (Bloom et al., 2019; Well, 2007). Economic growth tends to lead to improved human health, and improved human health tends to benefit economic growth, suggesting a possible virtuous cycle linking the two (Ranis et al., 2000). Conversely, if climate change is harming human health, there could be a vicious cycle, whereby efforts to reduce poverty and increase prosperity, particularly in lower-income countries, are partially negated by the impacts of a warming planet.

Yet, there is still insufficient detailed evidence for policymakers to make informed decisions over where best to invest scarce resources, for development banks to most effectively provide support and for increasingly needed adaptation funding to be allocated, so as to enable lower-income countries to grow along resilient well-adapted low-carbon pathways. Moreover, any policy actions are likely to be context-specific, requiring detailed country analyses in addition to broader global studies.

To address some of the gaps in knowledge, we undertake a rigorous empirical analysis to investigate the impact of population-weighted climate and weather shocks on several indicators of child health and nutrition, specifically mortality, wasting and stunting. We focus our analysis on Burkina Faso because it is an example of a low-income country that has long been facing development challenges from existing stressors including climate change (Brown & Crawford, 2008), in part manifested in increasing temperatures, a downward trend in overall rainfall but an increase in heavy precipitation days. Despite food security worsening across the Sahel region, Burkina Faso has improved its human development indicators, including reducing child mortality, in part through investing in women's access to universal health care (Samb & Ridde, 2018), and a focus on improved nutrition (Turowska et al., 2022). Yet, climate change may well negate these improvements. Droughts, heatwaves, changing pattern of rainfall and other extreme weather events, combined with high levels of poverty and malnutrition, low access to electricity, low quality of housing and sanitation and weak healthcare systems, make the country particularly vulnerable to health impacts of climate change (Fonta et al., 2019; Lucero-Prisno et al., 2020), and the negative impact this is likely to have on economic growth.

We use data from multiple waves of the Demographic and Health Survey (DHS) from Burkina Faso, which allows us to control for household and individual-level covariates that we would expect to influence child health and nutrition, combined with high-resolution meteorological data. We use a standard fixed-effects regression framework to examine the impacts of climate and weather shocks. In a second step, we combine these empirical estimates with future climate data under various warming scenarios, and incorporate spatial heterogeneity in future population distribution, to compute policy-relevant projections of climate impacts on child health and nutrition.

Across various specifications, our results are consistent with respect to several key findings. First, over the longer term, the higher a child's lifetime exposure to high temperatures, the greater the probability of mortality, wasting and stunting. In the short term, extreme heat in the previous month increases the probability of mortality by 0.07% for neonatal mortality, 0.081% for infant mortality and 0.09% for child mortality. Similar impacts are found for stunting and wasting. Increases in temperature anomaly from the long-term mean during major crop growing seasons also increase these probabilities, suggesting a link between domestic food production and child health outcomes, which is consistent with the literature.

Our results also provide evidence of the importance of economic growth for lower-income countries to build resilience to the changing climate. For example, our results suggest that wealthier households are more able to mitigate some of the negative health impacts of climate and weather shocks, similarly those with access to electricity and where the mother has a higher level of education. Children born in a health facility, rather than at home, have a lower probability of mortality. We also explore plausible impacts of future climate change on child health. Our results demonstrate clearly the health co-benefits of achieving the Paris Agreement of holding mean global temperatures below 1.5°C above pre-industrial levels.

Our paper makes an important contribution to the literature by providing the first comprehensive quantitative assessment of how climate change is already affecting child health and will continue to do so in the future, controlling for an extensive set of socio-economic and sociodemographic drivers of child health and nutrition. More broadly, quantifying the links between climate change and health can provide further evidence of the benefits of climate change mitigation for economic growth, poverty reduction and increased prosperity, particularly for lower-income countries (Romanello et al., 2021, 2022). Specific to Burkina Faso, our findings complement those of Yeboah et al. (2022), which uses satellite and population-based data to show that poorer child nutritional outcomes are associated with lower average rainfall; and those of Amondo et al. (2023), which finds significant and negative impacts of extreme weather events on child health, specifically stunting, through reduced consumption of calories, protein and important vitamins and minerals. Although we focus on just one country, our findings are broader than many others, in part because we include both urban and rural households, whereas most related literature looks only at rural households (Helldén et al., 2021; Phalkey et al., 2015); in part because we address three important indicators of child health, mortality, stunting, and wasting; and in part because we compute projections under future climate change scenarios, enabling us to explicitly show the health co-benefits of achieving more stringent climate targets.

In the next section, we contextualise our research within the literature. We then in Section 3 provide a detailed description of our econometric framework and the data sets used in the analysis. In Section 4, we present our results. Section 5 combines our econometric estimates with warming scenarios under the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Eyring et al., 2016), to project the impacts of future climate change on child health and nutrition in Burkina Faso, and Section 6 concludes.

2 | LITERATURE

The pathways linking climate and weather to child health are complex, and there remains insufficient understanding of the extent to which climate change is already affecting child health. However, there is a considerable literature that identifies specific risk factors associated with stunting and wasting. The interaction of risk factors for stunting and wasting tends to be complex, and boys appear more at risk than girls (Muñoz Sabater, 2018). Historically, much of the research addressing stunting focussed on inadequate food intake, but there is increasing evidence that stunting is also affected by a child's natural and physical environment, including poor sanitation, food-borne mycotoxins, inadequate health care and infection with parasites (GNR, 2021; Vilcins et al., 2018). Similarly, specific associations for wasting include insufficient quality and quantity of food, but also infectious diseases, diarrhoea, mother's education, household wealth (Muñoz Sabater, 2018) and prolonged illness (World Health Organization, 2022).

Increasing extremes of precipitation due to climate change, and in particular drought, can affect child malnutrition as manifested in stunting and wasting through multiple pathways, as mapped by Cooper et al. (2019). For example, access to food may be reduced where drought increases insect and disease infestation and lowers yields, or harms livestock (Centers for Disease Control and Prevention, 2022). Insufficient water for sanitation can lead to the spread of disease and the pollution of ground and surface water, each of which can negatively affect food utilisation (Centers for Disease Control and Prevention, 2022). Grace et al. (2012) is one of the first (and few) papers to combine climate and household level data to explore the drivers of childhood stunting. Focussing on Kenya, this paper finds socio-economic indicators of wealth (proxied by home floor material), mother's education and vulnerability to drought (proxied by water source) to be linked to child malnutrition.

There is even less literature addressing how child health is likely to be affected by climate change in the future, depending on the emissions and socio-economic pathway the planet finds itself on. This remains one of the most important weaknesses in the climate and health literature. For example, papers such as Baker and Anttila (2020) use a large data set to estimate the impact of climatic stressors on child health, and they do so at the subnational level, but do not control for socio-economic drivers such as income, access to electricity and toilet facilities, nor do they project the impacts of future climate change on child health.

Particularly in lower-income countries, there is likely to be a link between domestic food production, access to food and undernutrition. Phalkey et al. (2015) show schematically the many and complex pathways from climate and weather variability to undernutrition for subsistence farming households, which include food crop yields, infectious diseases and access to health care. Their systematic review of the literature suggests that there is evidence of a significant link between weather variables and household-level childhood stunting, but it also highlights the additional importance of childcare practices, sanitation and annual infectious disease episodes.

Food security and therefore nutrition-related poor health in lower-income countries tends to be seasonal, particularly where a large proportion of the working population is employed in agriculture, agriculture is predominantly rain-fed and domestically produced cereals are an important element of food security. This is the case for Burkina Faso, where 80% of the population works in agriculture, and where there is a high prevalence of infectious diseases during the lean season (Ouedraogo et al., 2020; Sié et al., 2018). In Ethiopia, a study using longitudinal panel data finds both rainfall during the growing season and temperature to be linked to an increased risk of child stunting and wasting (Hagos et al., 2014. Data from Chad, South Sudan and Sudan show evidence of clear seasonal peaks in the prevalence of acute malnutrition, as proxied by wasting, both at the end of the hot dry season, and at the end of the rains and beginning of the harvest season (Young & Marshak, 2017, 2019).

In Burkina Faso, despite improvements over the past decade, just over a quarter of children under five years old were found to be stunted in 2019, and 8.1% wasted (Ouedraogo et al., 2020). Children's diets in Burkina Faso tend to be low in dietary diversity and important micronutrients (Ouedraogo et al., 2020). Various interventions have been undertaken to reduce child malnutrition, including programmes of fortified and nutritious supplemental food aid (Cliffer et al., 2020).

A number of papers focus specifically on climate, weather and health outcomes in Burkina Faso. An increase in rainfall variability in Burkina Faso has been shown to be associated with an increase in chronic undernutrition in children, which is likely to negatively affect their educational attainment and adversely affect future economic growth (Mank et al., 2021). Rainfall has also been shown to affect child health through its impact on yields, income and the spread of infectious diseases (Bonjean et al., 2012). Socio-economic conditions also matter. For example, higher rates of stunting have been found in communities in Burkina Faso with lower rates of improved sanitation, and communities with higher rates of professionally-assisted births tend to have lower wasting rates (Chuang et al., 2019).

3 | ECONOMETRIC FRAMEWORK AND DATA

Following the recent literature using econometric techniques combining household and subnational-level data with high-resolution weather and climatic data (Antonelli et al., 2021; Blom et al., 2022; Cooper et al., 2019; Dasgupta & Robinson, 2021a, 2021b; Pezzulo et al., 2016; Shayegh et al., 2020; Shayegh & Dasgupta, 2022), we employ a fixed-effects regression using a pseudopanel framework to study the relationship between climate, weather, socio-economic drivers and child health in Burkina Faso. In the case of child mortality incidences, we use a linear probability model (LPM), while for stunting and wasting, our specification is a standard fixed-effects regression. Our choice of variables is based on our review of the literature and availability of data. Importantly, we take into account extremes of precipitation, access to health care and access to sanitation, and temperature during key growing seasons.

$$h_{ipht} = \delta L_{ipt} + \phi W_{ipt} + \theta C_{ipt} + \pi S_{ht} + \rho_m + \alpha_h + \gamma_t + \in_{ht} \tag{1}$$

where h_{ipht} is a measure of child mortality (incidence), weight-for-age (wasting) Z-score or height-for-age (stunting) Z-score of child i in household h in province p in wave t. We account for both recent and cumulative temperature anomalies and precipitation extremes affecting mortality and undernutrition by examining the impact of lifetime exposure to temperature, and monthly temperature and precipitation variability. To do this, we control for both long- and short-term exposure to climatic shocks and attempt to disentangle their effects on child health and nutrition. δL_{it} includes long-term or lifetime exposure of climatic stressors for child i in the form of cumulative number of months with average temperature above 26°C and the cumulative number of months where the Standardised Precipitation Evapotranspiration Index (SPEI) was below −1.5 (standard measure of a drought month) in province p. Short-term exposure to weather shocks (φW_i) such as the mean temperature of the previous month a child died, number of heat-wave days (defined as a period of at least 2 days where both the daily minimum and maximum temperatures are above the 95th percentile of the respective trend) in the previous 3 months and whether that month was a drought month are also likely to affect health and well-being of children (in the case of weight-for-age Z-score and height-for-age Z-score, φW_i includes temperature and drought in the month before the month of interview). Given the importance of agricultural production for food security and health in Burkina Faso, climatic conditions (θC_{ipt}) in the crop-growing season are also likely to affect a child's health through impacts on food production. We therefore include temperature anomaly from a 30-year (1981–2010) mean of the crop-growing season in the year before a child died or the previous year of interview in the case of stunting (height-for-age Z-score) and wasting (weight-for-age Z-score). This also allows us to control for seasonality effects. We extract information from Monfreda et al. (2008), which provides gridded data on growth area and length of growing season for major crops at 10 × 10 km resolution. We use information on the four major crops grown in Burkina Faso: sorghum, millet, cowpea and maize.

Socio-economic drivers such as household income and wealth, household size, educational attainment of the mother, access to electricity and quality of housing and sanitation are expected to negate some of the negative impacts of climate and weather shocks on child health (Phalkey et al., 2015; Vilcins et al., 2018). We use the International Wealth Index (IWI) as a measure of household wealth. The IWI is a comparable asset-based wealth index that can be used to measure the level of material well-being or standard of living of households in low- and middle-income countries. The International Wealth Index ranges from 0 to 100, with 0 representing households having no assets and the lowest quality housing and 100 representing households having all assets and the highest quality housing. Asset-based wealth indices such as the IWI are considered effective indicators of a household's economic situation or standard of living. They are highly correlated with income or expenditure measures. As the included durable goods are typically bought for use over a longer time period and their availability is not as influenced by shocks, they best indicate the household's long-term economic situation.[1] πS_{ht} also includes household size, mother's education in the form of number of years of schooling and whether the household has access to a toilet facility and electricity access. We include interaction terms between the IWI and both lifetime exposure and short-term exposure to temperature above 26°C to examine whether improvements in household-level income and wealth reduce potential negative impacts of climate change on child health. Child health has been demonstrated to be influenced by whether a child had a professionally assisted birth, and the time/distance to a healthcare facility (Chuang et al., 2019). Although the survey data we are using do not provide this level of detail, we are able to control for whether a child was born in a health facility (government hospital, government clinic/health provider, private hospital and private clinic/health provider).

Our specification includes region (α_h), a geographically integrated variable that provides spatially consistent units over time, and wave (γ_t) fixed effects to control for unobserved heterogeneity affecting child health such as changes in child health policy. We also include a calendar month fixed effect (ρ_m) to control for any seasonality in the month a child died or the month of interview in the case of stunting and wasting. Our standard errors are clustered at the province-wave level. We use survey weights from the survey.

3.1 | Data

We use four waves of the DHS from Burkina Faso, conducted between 1993 and 2010. Demographic and Health Survey data sets are nationally representative household surveys providing data for a wide range of indicators in the areas of population, health and nutrition. Furthermore, they provide household and respondent characteristics to serve as key background indicators for comparing data and viewing trends across countries and over time. Demographic and Health Survey data for Burkina Faso contain both a geographic identifier at the survey cluster level (coordinates of the cluster) and temporal information (date of survey). These surveys collect data on household characteristics including household composition, educational attainment and school attendance ratios. Data on housing characteristics such as availability of electricity, water and sanitation facilities, type of flooring material and cooking fuel are also collected. Respondent characteristics provide basic demographic information including age, marital status, region of residence and level of education.

We use reanalysed climate data from ERA5-Land, the fifth-generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate. Reanalysed climate data combine global climate model (numerical representation of the recent climate) with observational and satellite observations. Reanalysed data have the advantage of producing long time series and spanning the entire planet (Hersbach et al., 2020). Data from ERA5-Land are available at a spatial resolution of $0.1° \times 0.1°$and hourly temporal resolution (Muñoz Sabater, 2019). First, we extracted the climatic data at the original resolution, then used gridded population data (spatial resolution of 1×1 km) from the LandScan population data set (Bright et al., 2011) to compute population-weighted climatic and weather variables aggregated at the provincial level in Burkina Faso. Finally, we matched the climate data by each respondent's date of interview.

[1]The IWI includes 12 components: water source, floor type, toilet type, television, refrigerator, phone, electricity, car/truck, bicycle, cheap utensils (such as a watch or radio), expensive utensils (such as a computer or a car/truck) and number of sleeping rooms.

4 | RESULTS

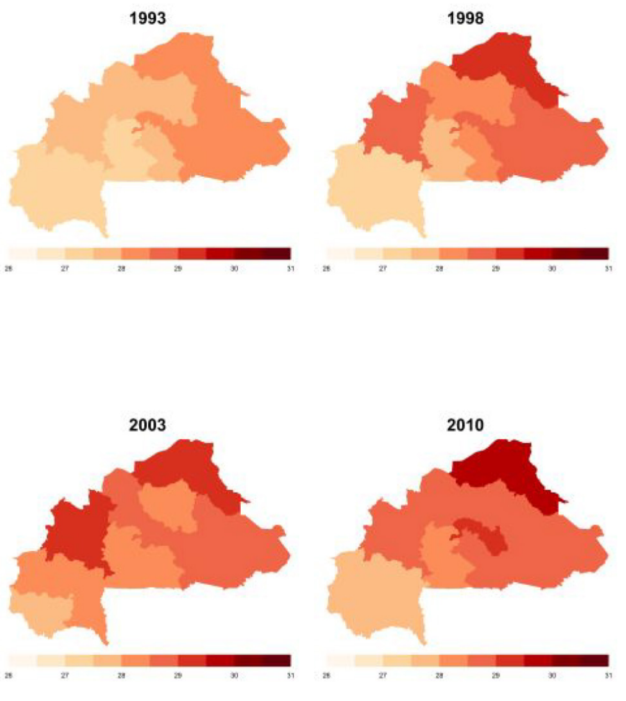
4.1 | Descriptive statistics

That Burkina Faso has been warming over the past three decades is made clear from the climate data presented in a series of maps in Figure 1. This warming has been highest in the provinces of Sahel, Boucle du Mouhoun and Centre-Est. Figure 2 clearly shows that, over the same time period, child health in Burkina Faso has been improving steadily. However, a close look at the subnational data shows signs of some of these gains being reversed in the south east of the country. We provide descriptive statistics of the key climatic and health indicators used in this paper in Table 1.

In the following subsection, we provide empirical evidence of the impact of lifetime and short-term exposure to climatic stressors on child health and nutrition in Burkina Faso, and the extent to which socio-economic drivers may have negated some of the negative climatic effects.

4.2 | Empirical results

Our findings suggest that increased exposure to higher temperatures, higher crop season temperature anomaly and extremes of precipitation all adversely affect child health outcomes. As



(a) Mean annual temperature (°C)

FIGURE 1 Annual mean temperature in Burkina Faso.

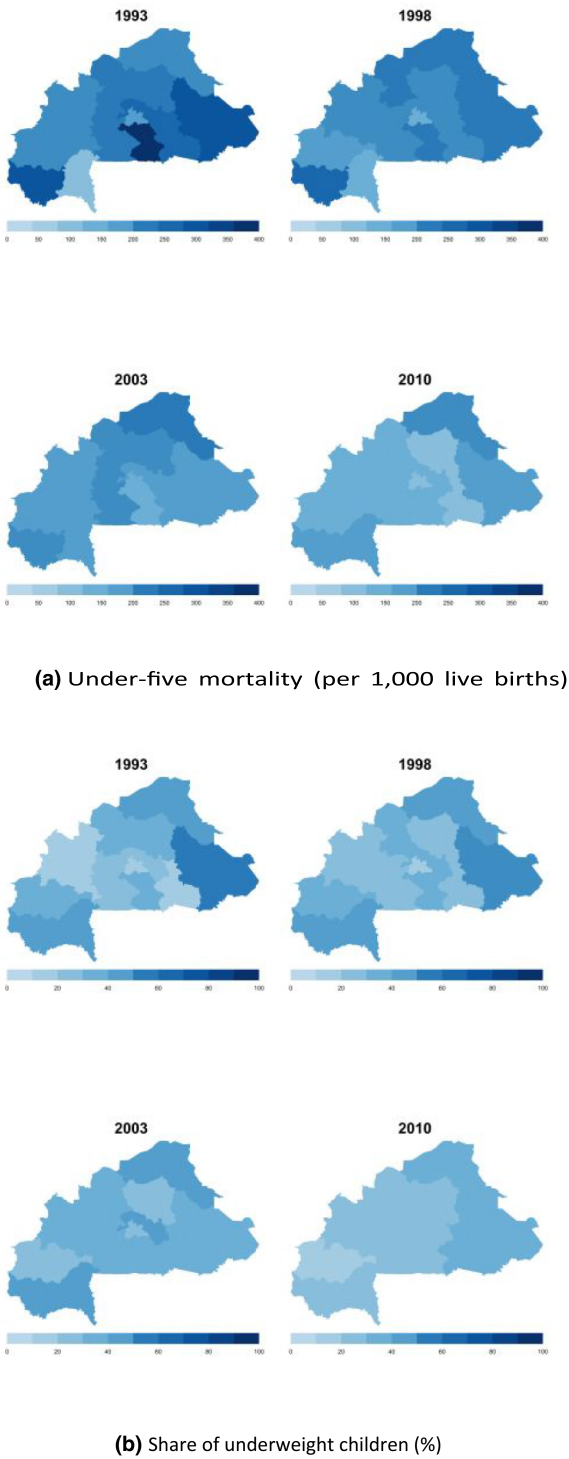


FIGURE 2 Child mortality and share of underweight children in Burkina Faso.

TABLE 1 Descriptive variables of the key variables from our analysis.

Variables	Mean	Min	Max
Mean temperature (°C)	28.85	26.70	29.69
Precipitation (mm)	760.84	341.41	1196.16
Wet days	6.48	3.59	9.74
International Wealth Index	21.6	8.96	98.6
Neonatal mortality (per 1000)	38.94	0.01	117.00
Infant mortality (per 1000)	90.84	21.40	263.00
Child mortality (per 1000)	92.29	0.01	258.00
Underweight share (%)	28.37	0.01	65.40
Stunted share (%)	38.69	2.56	77.30

such our data reveal and quantify important links between climate change and health. The higher a child's lifetime exposure to high temperatures, proxied by the cumulative number of months with average temperatures above 26°C, the greater the probability of mortality (an additional month above 26°C during a child's lifetime increases probabilities of neonatal mortality by 0.096%, infant mortality by 0.095% and child mortality by 0.076%), and incidences of wasting (0.099% decrease in weight-for-age Z-score) and stunting (0.093% decrease in height-for-age Z-score) (Table 2). Exposure to one additional month with average temperature higher than 26°C increases the risk of under-five mortality by 0.076%. Furthermore, an increase in cumulative precipitation in the previous year reduces the incidence of both wasting and stunting.

Short-term exposure to weather shocks also affects child health outcomes. Specifically, mean temperature higher than 26°C in the previous month increases the probability of child mortality (0.070% for neonatal mortality, 0.081% for infant mortality and 0.090% for child mortality) and a child wasted (0.083% decrease in weight-forage Z-score) and/or stunted (0.089% decrease in height-for-age Z-score). However, we find that precipitation in the previous month has no impact on child health and nutrition. Higher number of heatwave days in the previous 3 months also worsens child health, increasing the probability of mortality and reducing wasting; however, we find no impact of heatwave days on stunting. Our results further show that increases in temperature anomaly from a long-term mean during the major crop (sorghum, millet, cowpea and maize) seasons increase the probability of child mortality, wasting and stunting, suggesting a possible link between climate, food production and child health outcomes.

In terms of socio-economic drivers, our findings suggest that in Burkina Faso, higher income and wealth directly improve child health outcomes (specifically, a 1-unit increase in the IWI reduces the probability of under-five mortality by 0.447%), supporting the literature that finds a link between economic growth and health. Furthermore, the coefficients of interaction terms between the IWI and both lifetime and contemporaneous exposure to temperature above 26°C suggest that higher income and wealth also indirectly improve child health outcomes by mitigating some of the negative health impacts of climate and weather shocks. That is, wealthier families in Burkina Faso are better equipped to reduce these adverse effects. Our findings also suggest that a child being born in a health facility reduces the probability of mortality (specifically, the probability of under-five mortality is reduced by 0.101%) and improves weight-for-age Z-score but has no effect on height-for-age Z-score, inline with the findings by Pezzulo et al. (2016). Our results therefore provide empirical evidence that poverty not only worsens child health but also exacerbates the impacts of climate change on child health. In terms of the other socio-economic drivers, the results show that higher levels of mother's education and electricity access in the dwelling improve child health across all the indicators, while larger households and a lack of toilet facilities are linked to worse child health.

We also run our main specification by age group (<1 year, <2 years and <5 years) for each of the child health indicators (Table 3). These results are consistent with those from the regression

TABLE 2 Regression with degree month temperature.

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z*-score
Delivery in a health facility	−0.140**	−0.117**	−0.101**	0.090*	0.040
	(0.037)	(0.015)	(0.016)	(0.062)	(0.168)
Household size	0.092***	0.050**	0.041*	−0.056***	−0.098***
	(0.004)	(0.029)	(0.062)	(0.009)	(0.001)
Mother's education	−0.085**	−0.077***	−0.089***	0.716***	0.067
	(0.013)	(0.002)	(0.001)	(0.003)	(0.251)
No toilet facility	0.028**	0.052**	0.031***	−0.040**	−0.036*
	(0.027)	(0.012)	(0.005)	(0.048)	(0.056)
Electricity access	−0.051**	−0.042	−0.045**	0.054***	0.069***
	(0.041)	(0.138)	(0.012)	(0.000)	(0.002)
International Wealth Index	−0.310**	−0.601***	−0.447***	0.566***	0.545***
	(0.021)	(0.001)	(0.007)	(0.004)	(0.000)
Precipitation in the previous month	−0.001	−0.004	−0.001	−0.009	−0.007
	(0.214)	(0.522)	(0.136)	(0.244)	(0.189)
Cumulative precipitation in the previous year	−0.008**	−0.003**	−0.049**	0.005***	0.007**
	(0.032)	(0.021)	(0.023)	(0.001)	(0.025)
Heatwave days in the previous 3 months	0.006**	0.005***	0.004**	−0.004**	−0.005
	(0.024)	(0.009)	(0.039)	(0.041)	(0.191)
Sorghum season temperature anomaly	0.047***	0.034***	0.050***	−0.063***	−0.074***
	(0.005)	(0.000)	(0.008)	(0.001)	(0.005)
Millet season temperature anomaly	0.039***	0.052**	0.058***	−0.083***	−0.069***
	(0.004)	(0.039)	(0.007)	(0.008)	(0.001)
Cowpea season temperature anomaly	0.007	0.042**	0.062**	−0.050**	−0.077**
	(0.211)	(0.028)	(0.041)	(0.034)	(0.029)

TABLE 2 (Continued)

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z*-score
Maize season temperature anomaly	0.053***	0.015*	0.082**	−0.070**	−0.050*
	(0.007)	(0.064)	(0.029)	(0.045)	(0.081)
Degree month >26°C (mean monthly temperature)	0.070**	0.081***	0.090***	−0.083**	0.089***
	(0.019)	(0.004)	(0.001)	(0.040)	(0.005)
Cumulative number of degree month >26°C (lifetime exposure temperature)	0.096***	0.095***	0.076***	−0.099***	0.093***
	(0.002)	(0.000)	(0.009)	(0.007)	(0.001)
International Wealth Index #Degree month >26°C (mean monthly temperature)	−0.018**	−0.013***	−0.012**	0.017**	0.009**
	(0.021)	(0.009)	(0.039)	(0.044)	(0.032)
International Wealth Index #Degree months >26°C (lifetime exposure temperature)	−0.012*	−0.017**	−0.018***	0.012	0.013*
	(0.061)	(0.037)	(0.008)	(0.107)	(0.058)

Note: Robust *p*-values in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

TABLE 3 Regression by age group.

	(1) <1 mortality	(2) <2 mortality	(3) <5 mortality	(4) <1 Weight-for- age Z-score	(5) <2 Weight-for-age Z-score	(6) <5 Weight-for-age Z-score	(7) <1 Height-for-age Z-score	(8) <2 Height-for-age Z-score	(9) <5 Height-for-age Z-score
Delivery in a health facility	−0.191**	−0.142**	−0.106***	0.104**	0.078*	0.092	0.084**	0.710**	0.508
	(0.022)	(0.029)	(0.008)	(0.014)	(0.057)	(0.211)	(0.014)	(0.019)	(0.227)
Household size	0.046**	0.040**	0.034*	−0.095***	−0.062***	−0.051***	−0.091***	−0.087***	−0.083***
	(0.033)	(0.041)	(0.056)	(0.008)	(0.005)	(0.004)	(0.002)	(0.002)	(0.000)
Mother's education	−0.078***	−0.081***	−0.076***	0.088***	0.084***	0.072***	0.068**	0.076*	0.075
	(0.006)	(0.000)	(0.004)	(0.000)	(0.000)	(0.001)	(0.020)	(0.062)	(0.266)
No toilet facility	0.052**	0.046***	0.031***	−0.049**	−0.046***	−0.040**	−0.039**	−0.033***	−0.028*
	(0.012)	(0.001)	(0.005)	(0.041)	(0.004)	(0.048)	(0.042)	(0.000)	(0.056)
Electricity access	−0.009	−0.016**	−0.021**	0.038***	0.031***	0.029***	0.029***	0.025***	0.022***
	(0.155)	(0.022)	(0.010)	(0.000)	(0.007)	(0.001)	(0.000)	(0.000)	(0.006)
International Wealth Index	−0.45***	−0.49***	−0.400***	0.469***	0.462***	0.560***	0.552***	0.544***	0.441***
	(0.003)	(0.000)	(0.002)	(0.009)	(0.008)	(0.001)	(0.009)	(0.006)	(0.001)
Precipitation in the previous month	0.004	0.009	0.007	−0.007	−0.008	−0.008	−0.005	−0.004	−0.0061
	(0.222)	(0.158)	(0.103)	(0.263)	(0.259)	(0.200)	(0.187)	(0.109)	(0.177)
Cumulative precipitation in the previous year	−0.006**	−0.009**	−0.006**	0.007***	0.007***	0.006***	0.006**	0.005**	0.005**
	(0.012)	(0.021)	(0.014)	(0.000)	(0.000)	(0.009)	(0.025)	(0.017)	(0.020)
Heatwave days in the previous 3 months	0.007***	0.006**	0.004**	−0.004**	−0.003**	−0.003**	−0.003	−0.003	−0.002
	(0.002)	(0.029)	(0.015)	(0.022)	(0.014)	(0.030)	(0.117)	(0.205)	(0.147)
Sorghum season temperature anomaly	0.037***	0.045***	0.059***	−0.058***	−0.053***	−0.052***	−0.082***	−0.074***	−0.079***
	(0.002)	(0.008)	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.001)
Millet season temperature anomaly	0.059**	0.055***	0.051***	−0.080***	−0.070***	−0.072***	−0.059***	−0.056**	−0.055***
	(0.031)	(0.006)	(0.001)	(0.006)	(0.007)	(0.002)	(0.001)	(0.014)	(0.005)
Cowpea season temperature anomaly	0.046**	0.055**	0.069**	−0.059**	−0.056***	−0.054**	−0.092***	−0.088***	−0.083**
	(0.022)	(0.028)	(0.033)	(0.042)	(0.000)	(0.039)	(0.004)	(0.000)	(0.022)

TABLE 3 (Continued)

	(1) <1 mortality	(2) <2 mortality	(3) <5 mortality	(4) <1 Weight-for- age *Z*-score	(5) <2 Weight-for-age *Z*-score	(6) <5 Weight-for-age *Z*-score	(7) <1 Height-for-age *Z*-score	(8) <2 Height-for-age *Z*-score	(9) <5 Height-for-age *Z*-score
Maize season temperature anomaly	0.018*	0.035**	0.078**	−0.085***	−0.070**	−0.076**	−0.066**	−0.060**	−0.056*
	(0.060)	(0.038)	(0.031)	(0.002)	(0.038)	(0.022)	(0.039)	(0.041)	(0.072)
Degree month >26°C (mean monthly temperature)	0.089***	0.084***	0.081***	−0.088**	−0.086**	−0.082**	0.090***	0.085***	0.080***
	(0.001)	(0.004)	(0.000)	(0.024)	(0.030)	(0.033)	(0.004)	(0.009)	(0.001)
Cumulative number of degree month >26°C (lifetime exposure temperature)	0.095***	0.080***	0.077***	−0.087**	−0.081***	−0.083***	0.105***	0.094***	0.098***
	(0.001)	(0.001)	(0.001)	(0.028)	(0.000)	(0.001)	(0.000)	(0.007)	(0.009)
International Wealth Index #Degree month >26°C (mean monthly temperature)	−0.019***	−0.015**	−0.010**	0.019**	0.018**	0.011*	0.012**	0.010***	0.009**
	(0.001)	(0.027)	(0.033)	(0.022)	(0.014)	(0.064)	(0.011)	(0.004)	(0.022)
International Wealth Index #Degree months >26°C (lifetime exposure temperature)	−0.011**	−0.013***	−0.015***	0.017	0.012	0.014	0.016**	0.014**	0.012*
	(0.018)	(0.008)	(0.005)	(0.109)	(0.247)	(0.166)	(0.040)	(0.006)	(0.055)

Note: Robust p-values in parentheses.
$^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$.

using the full data set (Table 2). We find that both lifetime and short-term exposures to high temperatures are associated with worse child health outcomes in Burkina Faso. The socio-economic drivers show similar results to those of the overall data set. The most critical finding from this set of results is that climatic and weather shocks have a higher impact on child health in the lower age groups, suggesting that younger children are relatively more vulnerable to increased warming and increased frequency of extreme events. The interaction terms between the IWI and both long-term and short-term exposure to high-temperature months suggest that increased wealth reduces the negative impacts of warming on child health across all age groups to some extent.

4.3 | Robustness tests

We replace the cumulative precipitation variables with SPEI-6 (Table 4). The results show that both cumulative number of months (SPEI < -1.5) that can be considered drought months, and whether the month before a child's death or before the interview, worsen child health (for example, exposure to one additional month of drought during a child's lifetime increases the probability of under-five mortality by 0.006%). The other coefficients are similar in terms of both magnitude and statistical significance. As an additional robustness test, we control for quadratic temperature instead of degree-month temperature (Table 5). These findings show that child mortality is convex in mean temperature while the probabilities of a child being wasted or stunted are concave in mean temperature. The optimal monthly temperatures minimising neonatal, infant and child mortality in Burkina Faso are between 26.6°C and 27.2°C, while incidences of underweight and stunting are minimised at 26.2°C and 26.4°C, respectively. Our results further show that the optimal lifetime exposure temperatures are lower than the short-term exposure optimal temperatures. The optimal lifetime temperature minimising child mortality in Burkina Faso is between 23.1°C and 25.7°C, while probability of underweight and stunting is minimised at 24°C and 24.9°C, respectively.

5 | CHILD HEALTH IN BURKINA FASO UNDER FUTURE CLIMATE SCENARIOS

We compute plausible impacts of future climate change by combining our econometric estimates from the main specification (Table 2) with various warming scenarios (SSP1-RCP1.9, SSP4-3.4, SSP2-RCP4.5 and SSP3-RCP7.0) simulated using a multimodel mean of 12 Global Circulation Models (GCMs) from CMIP6 climate scenarios. To ensure that our child health projections reflect changing pattern of future population distribution in Burkina Faso, we merge data from Jones and O'Neill (2016) with the future climate scenarios by Shared Socioeconomic Pathways (SSPs). The same methodology as Section 3.1 is used to compute population-weighted future climate data at the provincial level. We use the following scenarios for our projections:

- SSP1-RCP1.9 (Paris target): informing the Paris Agreement target of 1.5°C above pre-industrial levels, CO_2 emissions are cut to net zero around 2050. Global temperature increases by 1.5°C by 2100.
- SSP4-RCP3.4 (closest to Glasgow commitments): a gap-filling mitigation scenario that fills in the range of low forcing pathways. Global temperature increases by 2.7°C by 2100.
- SSP2-RCP4.5 (middle of the road): CO_2 emissions follow the current trajectory before starting to fall mid-century but do not reach net zero by 2100. Socio-economic factors follow their historic trends with slow progress towards sustainability and development and income growing unevenly. Global temperature increases by 2.95°C by 2100.

TABLE 4 Regression with degree month temperature and Standardised Precipitation Evapotranspiration Index (SPEI).

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z* score
Delivery in a health facility	−0.129***	−0.115**	−0.123**	0.089*	0.087
	(0.005)	(0.016)	(0.017)	(0.061)	(0.104)
Household size	0.089***	0.046**	0.034*	−0.051***	−0.083***
	(0.002)	(0.033)	(0.056)	(0.004)	(0.000)
Mother's education	−0.009**	−0.008***	−0.006***	0.012***	0.005
	(0.010)	(0.006)	(0.004)	(0.001)	(0.266)
No toilet facility	0.031**	0.052**	0.031***	−0.040**	−0.028*
	(0.027)	(0.012)	(0.005)	(0.048)	(0.056)
Electricity access	−0.015**	−0.009	−0.021**	0.029***	0.022***
	(0.020)	(0.155)	(0.010)	(0.001)	(0.006)
International Wealth Index	−0.334**	−0.355***	−0.441***	0.360***	0.241***
	(0.027)	(0.003)	(0.002)	(0.001)	(0.001)
Drought month (SPEI < −1.5)	0.007	0.003	0.007	−0.008	−0.006
	(0.201)	(0.222)	(0.103)	(0.200)	(0.177)
Cumulative number of drought months (SPEI < −1.5)	0.007***	0.006**	0.006**	−0.006***	−0.009**
	(0.002)	(0.012)	(0.014)	(0.009)	(0.020)
Heatwave days in the previous 3 months	0.006**	0.004***	0.004**	−0.003**	−0.004
	(0.018)	(0.004)	(0.031)	(0.022)	(0.227)
Sorghum season temperature anomaly	0.040***	0.037***	0.059***	−0.052***	−0.079***
	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)
Millet season temperature anomaly	0.030***	0.059**	0.051***	−0.072***	−0.055***
	(0.001)	(0.031)	(0.001)	(0.002)	(0.005)
Cowpea season temperature anomaly	0.011	0.046**	0.069**	−0.054**	−0.083**
	(0.200)	(0.022)	(0.033)	(0.039)	(0.022)

(Continues)

TABLE 4 (Continued)

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z* score
Maize season temperature anomaly	0.058***	0.018*	0.078**	−0.076**	−0.056*
	(0.000)	(0.060)	(0.031)	(0.022)	(0.072)
Degree month >26°C (mean monthly temperature)	0.066**	0.089***	0.081***	−0.082**	0.080***
	(0.011)	(0.001)	(0.000)	(0.033)	(0.001)
Cumulative number of degree month >26°C (lifetime exposure temperature)	0.099***	0.089***	0.077***	−0.083***	0.098***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.009)
International Wealth Index #Degree month >26°C (mean monthly temperature)	−0.016**	−0.019***	−0.012**	0.011*	0.009**
	(0.027)	(0.001)	(0.033)	(0.064)	(0.022)
International Wealth Index #Degree months >26°C (lifetime exposure temperature)	−0.012*	−0.011**	−0.015***	0.014	0.012*
	(0.066)	(0.018)	(0.005)	(0.166)	(0.055)

Note: Robust *p*-values in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

TABLE 5 Regression with continuous temperature.

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z*-score
Delivery in a health facility	−0.171**	−0.144**	−0.115**	−0.098*	−0.085
	(0.016)	(0.010)	(0.021)	(0.055)	(0.125)
Household size	0.081***	0.062**	0.054*	−0.095***	−0.037***
	(0.001)	(0.022)	(0.079)	(0.000)	(0.006)
Mother's education	−0.008**	−0.007***	−0.009***	0.016***	−0.007
	(0.013)	(0.002)	(0.001)	(0.003)	(0.251)
No toilet facility	0.066**	0.060**	0.041**	−0.081*	−0.004
	(0.019)	(0.022)	(0.044)	(0.053)	(0.111)
Electricity access	−0.013*	−0.008	−0.011***	0.017***	0.006**
	(0.087)	(0.120)	(0.006)	(0.001)	(0.022)
International Wealth Index	−0.342**	−0.387***	−0.455***	0.399***	0.427***
	(0.015)	(0.004)	(0.001)	(0.008)	(0.002)
Precipitation in the previous month	−0.009	−0.005	−0.007	−0.005	−0.002
	(0.187)	(0.115)	(0.125)	(0.418)	(0.144)
Cumulative precipitation in the previous year	−0.009**	−0.004**	−0.007*	0.007**	0.009**
	(0.017)	(0.036)	(0.082)	(0.022)	(0.044)
Heatwave days in the previous 3 months	0.007**	0.005***	0.004**	−0.005**	−0.003
	(0.022)	(0.008)	(0.024)	(0.017)	(0.314)
Sorghum season temperature anomaly	0.038**	0.012***	0.028***	−0.030***	−0.047***
	(0.012)	(0.007)	(0.000)	(0.004)	(0.001)
Millet season temperature anomaly	0.022***	0.041**	0.037***	−0.063**	−0.052***
	(0.001)	(0.029)	(0.004)	(0.036)	(0.009)
Cowpea season temperature anomaly	0.014	0.028*	0.053*	−0.077**	−0.088**
	(0.147)	(0.071)	(0.055)	(0.041)	(0.013)

(Continues)

TABLE 5 (Continued)

	(1) Neonatal mortality	(2) Infant mortality	(3) <5 mortality	(4) Weight-for-age *Z*-score	(5) Height-for-age *Z*-score
Maize season temperature anomaly	0.037**	0.007	0.051**	−0.061*	−0.041
	(0.011)	(0.142)	(0.021)	(0.071)	(0.211)
Mean monthly temperature	−0.852***	−0.971***	−0.762***	0.997***	0.897***
	(0.009)	(0.001)	(0.003)	(0.000)	(0.002)
Mean monthly temperature-squared	0.016**	0.018***	0.014***	−0.019**	−0.017***
	(0.010)	(0.001)	(0.007)	(0.017)	(0.005)
Mean lifetime exposure temperature	−0.397***	−0.308***	−0.416***	0.529***	0.499***
	(0.000)	(0.007)	(0.000)	(0.003)	(0.009)
Mean lifetime exposure temperature-squared	0.008***	0.006***	0.009***	−0.011***	−0.010***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Optimal monthly temperature (°C)	26.6	27.0	27.2	26.2	26.4
Optimal lifetime exposure temperature (°C)	24.8	25.7	23.1	24.0	24.9

Note: Robust p-values in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

- SSP3-RCP7.0 (near catastrophic): emissions and temperatures rise steadily and CO_2 emissions roughly double from current levels by 2100. Countries become more competitive with one another, shifting towards national security, and ensuring their own food supplies. Temperatures increase by 3.6°C by 2100.

Using a multimodel mean from a large number of models allows us to reduce bias and model uncertainty associated with individual climatic models. Following the existing literature (Dasgupta, 2018; Hajdu & Hajdu, 2021; Schleypen et al., 2022), first, we estimate child health under a no-climate change scenario (1995–2014) using the historical data from the GCMs and then compare the health outcomes from this scenario against projections for two time epochs, medium term (2030–2050) and long term (2050–2070), to obtain the ratio of future child health outcomes to synthetic historical child health in Burkina Faso. The output is percentage change in child health indicators due to future climate change compared with a reference period of 1995–2014. We recognise that GCMs are not able to correctly simulate weather over historical periods at high frequency. However, they can be used to estimate average historical climatic conditions over a longer time interval. As such, our projections are not based on direct comparisons between simulated future climate and observed historical data but, rather, based on comparisons between simulated future climate and current climate conditions.

5.1 | Future burden of climate change on child health

Our projections show that climate change impacts on child health in Burkina Faso will increase as temperature increases over time (Table 6). We find that the highest increase due to future warming will be in the case of child mortality. Under SSP2-RCP4.5—the middle-of-the-road scenario—child mortality in Burkina Faso is projected to increase by 8.6% by 2050 and by 10.8% by 2070. While under the near catastrophic SSP3-RCP7.0 warming scenario, child mortality is projected to increase by 11.6% and 14.6% by 2050 and 2070, respectively.

Our projections clearly show the health benefits of mitigation and achieving low emission scenarios, with child health situations in Burkina Faso being significantly worse under the higher warming scenarios. This difference is particularly striking under SSP1-RCP1.9, which reflects the Paris Agreement of achieving the net zero target by 2050 to keep the increase in mean global temperature within 1.5°C above pre-industrial levels. Under this scenario, climate change-induced child health outcomes do worsen by 2050 but as temperatures start to stabilise beyond this period, the increases in child mortality and shares of wasting and stunting are projected to be lower by 2070 than 2050.

There is considerable spatial heterogeneity according to our projections of child health outcomes in Burkina Faso due to climate change (Figures 3 and 4). The regions of Boucle du Mouhoun, Nord, Sahel, Est and Centre-Ouest are expected to suffer the highest increases

TABLE 6 Child health impacts under climate and socio-economic scenarios in Burkina Faso (% change compared with the 1995–2014 reference period).

	SSP1-RCP1.9		SSP4-RCP3.4		SSP2-RCP4.5		SSP3-RCP7.0	
Scenario	**2050**	**2070**	**2050**	**2070**	**2050**	**2070**	**2050**	**2070**
Neonatal mortality	3.0	2.6	4.9	5.7	7.6	8.1	9.2	11.0
Child mortality	2.5	2.2	3.8	5.0	8.6	10.8	11.6	14.6
Under-five mortality	2.9	2.5	5.3	5.9	7.7	9.6	9.3	11.7
Wasting	3.0	2.7	5.9	6.1	8.5	10.7	10.1	13.0
Stunting	3.2	2.8	5.6	6.1	8.4	10.9	10.3	13.0

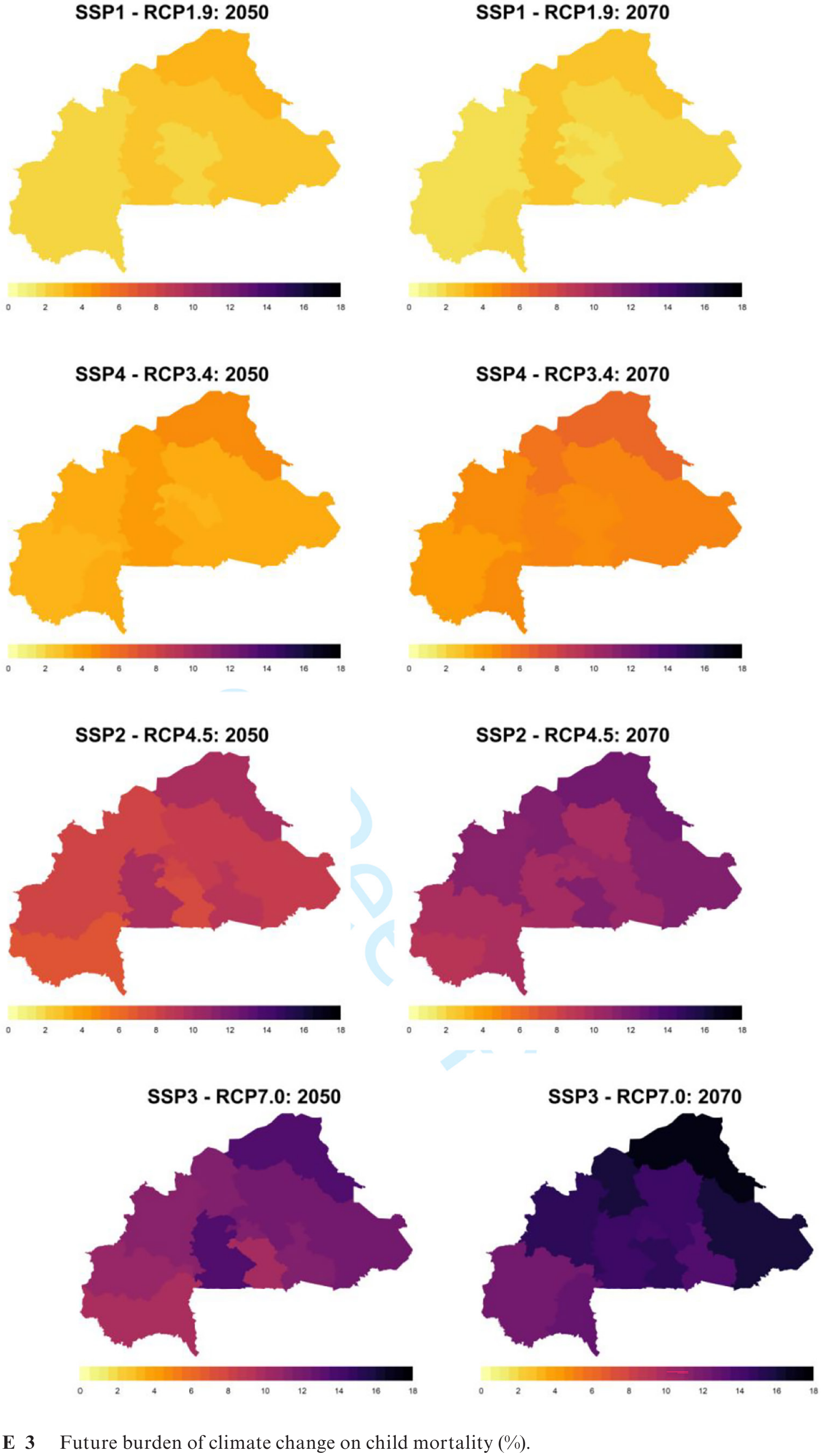


FIGURE 3 Future burden of climate change on child mortality (%).

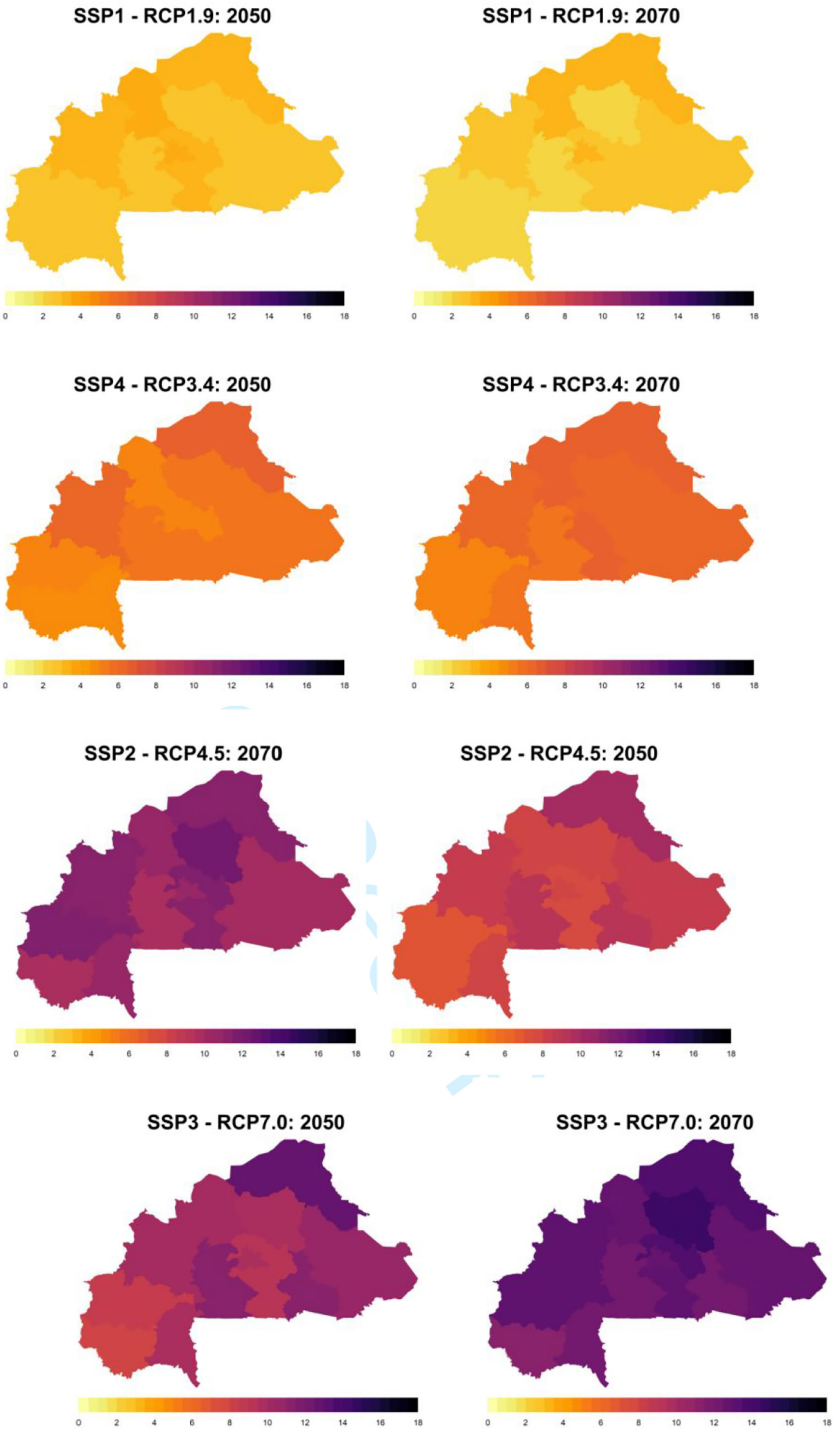


FIGURE 4 Future burden of climate change on underweight (%).

in child mortality, and shares of underweight and stunted children in future due to climate change. These subnational-level projections can be used by public health authorities to identify climate–child health *hotspots* in Burkina Faso that will be at most risk due to climate change, and implement tailored policies taking into account local contexts.

6 | DISCUSSION

Climate change is increasingly recognised as a health problem, and indeed it has been suggested that the life of every child born today is likely to be profoundly affected by climate change (Romanello et al., 2021, 2022; Thiery et al., 2021; Watts et al., 2020). This is particularly so in lower-income countries, where climate change is already having a negative impact on crop production, where increasing precipitation extremes harm efforts to improve access to clean water and sanitation, and where the burden of disease is already high. Poor child health perpetuates intergenerational inequalities, making it harder for households and indeed countries to escape from poverty traps (Bhargava et al., 2001), and harming economic growth (Well, 2007). Climate change, by worsening child health outcomes, also puts yet more pressure on what, in lower-income countries, tend to be already under-funded and under-pressure health systems.

Although the complex links between climate, weather and child health are increasingly well-documented, there are few quantitative assessments of the scale of these impacts, making our analysis in this paper particularly timely. Our empirical findings are in line with this limited literature. In the case of stunting, estimates from the related literature are in the range of 4.0% to 18% historical increase due to temperature increases since pre-industrial times, while we estimate the average increase to be 4.6% (Baker & Anttila, 2020; Blom et al., 2022; Mank et al., 2021). For wasting, the range from the literature is 3.1% to 16% increase, whereas we find an increase of 4.2% (Baker & Anttila, 2020; Blom et al., 2022; Mank et al., 2021).

Comparing estimates for the impact of extremes of precipitation on health outcomes is more challenging because there is little consistency across the literature with respect to the choice of variables and indicators used to measure precipitation variability and droughts. However, there is broad agreement across the literature that increased frequency of drought conditions results in higher incidences of stunting and wasting (Baker & Anttila, 2020; Cooper et al., 2019; Diboulo et al., 2012; Mank et al., 2021).

Our estimates are generally on the lower end of the range found in the literature. This is most likely because we control for both weather and climatic shocks in the same specification to ensure that both short- and long-term effects on child health and nutrition are being captured and because we include a richer set of socio-economic and sociodemographic variables, including interaction terms between socio-economic conditions and temperature. These covariates partially mitigate the negative effects of climate and weather shocks on child health and nutrition in Burkina Faso. Our findings therefore suggest that economic growth and development help to build resilience in the context of a changing climate.

Whether countries such as Burkina Faso can indeed reduce poverty and increase prosperity fast enough to counter the negative impacts of climate change on health depends on both the future pathway the planet finds itself on and the choices made by local policymakers. Our empirical analyses provide some guidance on how governments in lower-income countries, and Burkina Faso in particular, can improve health outcomes while climatic shocks worsen. Our analysis suggests that heat and drought worsen child health, and the mechanisms through which this occurs are most likely a combination of the negative impact on crop yields, maternal health and sanitary conditions. Adaptation policies relevant to agricultural production include a shift toward irrigation, given that Burkina Faso's agriculture sector is highly dependent on rainfed crops, and drought-resistant crops. With respect to access to food and nutrition, safety nets have been proven to be a policy that can successfully reduce food insecurity and undernutrition caused by climate and weather shocks (Dasgupta & Robinson, 2021b). Our data also confirm that household characteristics matter, particularly wealth and mother's education; and access to key services including electricity, toilet facilities and a health facility for delivery, confirming the continuing importance of general development policies; and access to health care and clean water and sanitation more broadly. As is the case for many lower-income countries, Burkina Faso struggles to provide health care for pregnant women and children, and climate change will make these services more important, but possibly harder to provide. Lessons from Bangladesh, however, suggest targeted policies can have a significant impact. Bangladesh has been successful in reducing under-five child mortality from 239 per thousand in 1970 to 27 in 2021 (World Health Assembly, 2021). Policies demonstrated to work include introducing and expanding community-based health care, particularly clinics in rural areas where women typically do not have the option to birth their children in healthcare facilities (World Health Assembly, 2021).

Early warning systems, combined with access to cooling, are an adaptation strategy that can improve child health, but this requires access to electricity (Blom et al., 2022). Burkina Faso has one of the lowest electrification rates in the world, 19% overall, and just three per cent in rural areas as of 2020 (World Bank, 2023), but has high potential for renewable energy, particularly solar. Relevant policies to increase investment in low-carbon electrification that is compatible with net zero will likely need to address the high cost of capital in lower-income countries. More broadly, many policies that address poverty reduction and economic growth have adaptation co-benefits, which increase resilience, at least to some extent, to climate and weather shocks that are worsening due to climate change.

Finally, our empirical results and policy-relevant projections can be further used to identify hotspots where children's health and nutrition are likely to be most affected in future and to predict these hotspot locations where the impacts of future climate change are likely to be most extreme. The empirical estimates can be used by policymakers, local public health authorities and child health practitioners, to contribute to the design of tailored locally relevant policies, and improve the existing efficacy of policies to improve child health in Burkina Faso.

7 | CONCLUSION

Many lower-income countries already struggle with underfunded health systems and poor health outcomes, which are likely to reduce the potential for these countries to reduce poverty and increase prosperity, given the recognised links between health and economic growth. Although many papers identify and explore the link between climate and weather shocks and child health, our paper is one of the few to quantify the extent to which climate change, as proxied by increasing heat and drought, is already worsening child health outcomes and is likely to do so in future, making the achievement of key sustainable development goals ever more difficult.

Somewhat worryingly, our analysis suggests that only if global temperature increases are kept at 1.5°C or below from 2050 onwards will child health outcomes in Burkina Faso improve between 2050 and 2070. Low-income countries including Burkina Faso have made a negligible contribution to global greenhouse gas emissions, will likely make a relatively small contribution in future, yet are likely to be particularly harmed unless global emissions are halved by 2030 and global net zero emissions are achieved by 2050. Our findings, by identifying the extent to which negative child health and nutrition outcomes are worsened by climate change, highlight the importance of adaptation for individual countries, but are also be of particular relevance to the Loss and Damage debate that was at the heart of the 'Africa COP27' negotiations.

Despite evidence such as ours, and despite evidence across the globe that the costs of inaction on climate change mitigation outweigh the costs of action (Shukla et al., 2022), the world is on track for temperature rises of 2.7°C or more by 2100. Of course, if climate change tipping points are breached, which is quite possible at 2.7°C (Lenton, 2012; Lenton et al., 2019), then calculations such as ours will have woefully underestimated the negative impact on people's health and economic growth in lower and higher income countries alike.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from *The DHS Program*. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available from https://dhsprogram.com/data with the permission of *The DHS Program*.

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