Energy Transition's Impact on Populations: An Empirical Study on Arab Children's Lives

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Abstract

Climate change and energy poverty pose significant barriers to inclusive growth in the Arab region, particularly affecting the most vulnerable populations, including children. This paper explores the complex relationship between climate change, energy poverty, the low-carbon energy transition, and child health across ten Arab countries. Using a modified Multidimensional Energy Poverty Index and high-resolution temperature data, key health outcomes are assessed such as child stunting, wasting, infant mortality, and neonatal mortality. The findings reveal that energy poverty, exacerbated by climate change, is strongly linked to increased stunting rates in Morocco, Palestine, and Tunisia, hindering equitable development in these countries. Wealth inequality further amplifies disparities, with wealthier households generally showing better child health outcomes, except in Jordan and Mauritania. While female children have lower probabilities of stunting in most countries, these findings need careful interpretation due to possible regional anthropometric differences. Additionally, energy poverty is significantly associated with higher infant mortality in Tunisia, while extreme temperatures, a manifestation of climate change, contribute to rising mortality rates in countries like Comoros. This study highlights the urgent need for policies that address both energy poverty and climate resilience to improve child health outcomes and promote inclusive growth across the Arab region.

Keywords: Energy Poverty, Stunting, Wasting, Neonatal mortality, Child mortality, Climate change, Low-carbon energy transition, Arab region

JEL Classification: Q٥٤, I١٤, O١٣, O٥٣

١. Introduction

The problem of energy poverty and systematic energy inequalities has long plagued the socioeconomic development across the Arab region. Out of the ٢١٤,٨ million people residing in the Arab countries, approximately ٦٥ million lack access to electricity, and an additional ٦٠ million endure extended power outages and inadequate supply (Olawuyi, ٢٠٢٠). Problems with energy affordability, reliability, and cleanliness are widespread. In general, numerous researchers have assessed energy poverty through diverse approaches, but as of now, a unanimous agreement has not been achieved. According to the available surveys, energy poverty primarily manifests itself through the lack of access to clean cooking fuel facilities, and inadequate electrification in households, which lead to the incidence of respiratory and cardiovascular diseases, ailments associated with improperly stored and prepared foods, and an increase in premature deaths caused by indoor air pollution exposure (González-Eguino ٢٠١٥; Pondie et al., ٢٠٢٤).

Many children in Arab countries live in hazardous living conditions at their home and their community, receive inadequate access to qualified prenatal and early-life care, or fail to receive an adequate supply of nutrients. In part due to these shortfalls, disproportionately many children suffer chronic ailments leading to some children becoming stunted or wasted or dying before reaching their first birthday. Beside the immediate human tragedy of these health outcomes, the effects may have long-term consequences on a larger cohort of children who survive but are permanently scarred by their early-childhood deprivations. For one, stunting is related to a sizable decrease in income during adulthood (Grantham-McGregor et al. ٢٠٠٧; Molina, ٢٠١٢). "Improvements in basic human development can alter the shape of the human life course, creating entirely new patterns of human capital formation, savings, and time use" (Kuhn ٢٠١٢:٦٥٣). It is worth noting that energy poverty disproportionately affects women and young girls, who often bear the burden of collecting traditional energy sources, leading to adverse health outcomes and limited access to developmental opportunities.

More broadly, energy poverty brings numerous disadvantages to families, most acutely affecting the physical and mental health and cognitive development of children. Despite childhood being deemed highly susceptible to energy poverty, there has been a dearth of empirical research examining the impact of energy poverty on childhood development in energy-poor countries (Karmaker, et al. ٢٠٢٢). In Sub-Saharan Africa and South Asian regions, electricity access is limited, and there is also inadequate access to clean energy sources and cooking facilities (IEA, ٢٠١٩; ESMAP, ٢٠٢٠; Seforall, ٢٠٢٠). Research has demonstrated the adverse impact of energy poverty on the subjective well-being of children in China and India, with adverse health and academic performance being identified as crucial mediating factors, leading to lower subjective well-being due to energy poverty (Rafi, Naseef, & Prasad, ٢٠٢١; Zhang, Appau, and Kodom, ٢٠٢١). In the Northern Mediterranean, studies have linked energy poverty to poor mental health, higher rates of asthma, and childhood overweight rates in Barcelona (Oliveras, et al., ٢٠٢١).

There have been limited investigations into the effects of transitioning to low-carbon energy sources (like electrification, and natural gas) and renewable energy on energy poverty (Dong, et al. ٢٠٢١; Don, Ren, & Zhao, ٢٠٢١; Karpinska & Śmiech, ٢٠٢١). Energy poverty in the Arab region exhibits a strong relationship with income poverty, particularly evident in North Africa, Yemen, and parts of the Levant (Hamed and Peric, ٢٠٢٠; Belaïd, ٢٠٢٢). Additionally, geography significantly influences energy poverty in the region, as urban areas tend to have better access to modern fuels and electricity compared to undersupplied rural areas (El-Katiri, ٢٠١٤).

Climate change and global warming significantly impact both energy poverty and health. The interconnection between these three issues can exacerbate vulnerabilities in already at-risk populations, such as children. Climate change exacerbates energy poverty in several ways. More extreme summers and winters and localized extreme temperature waves place a greater burden on energy producers and distributors for meeting the cooling and heating needs. Extreme weather events, such as storms and floods, also damage energy infrastructure, disrupting energy supply and access. In some cases, entire communities are cut off from the main energy grid for extended periods, making them even more vulnerable to energy poverty.

Given the inherent difficulty of measuring the impact of energy poverty at the micro-level, especially in developing countries (Rafi, Naseef, & Prasad, ٢٠٢١), this paper aims to make a unique contribution to the economic literature on energy. This paper proposes a modified Arab-region Multidimensional Energy Poverty Index (Arab-MEPI) based on the work of Nussbaumer et al. (٢٠١٢, ٢٠١٣) and Multidimensional Energy Poverty Principal Component Analysis score (MEP PCA) to measure energy poverty. The effect of energy poverty on health of children has been previously empirically studied in different world regions. In the Arab region, no empirical studies have been conducted to explore this relationship. Within the Arab region, there is a notable absence of empirical studies that have delved into the association of energy poverty and low-energy transition on children's health in the presence of global warming. Furthermore, this study stands as the inaugural effort to explore this connection. A comprehensive assessment of how this relationship can be a valuable resource for policymakers in crafting effective strategies to foster the growth of the green energy transition sector and alleviate energy poverty.

This study evaluates the impact of the Energy Poverty-Low Carbon Energy Transition Nexus on children's health outcomes in the context of climate change across ten Arab countries: Algeria, Comoros, Egypt, Iraq, Jordan, Mauritania, Morocco, Palestine, Tunisia, and Yemen. For all these countries, information is available for two recent years, allowing us to evaluate the trends in the levels of health outcomes and the impacts of pollution, and climate change over time. We use multivariate regressions for limited dependent variables to estimate the effects of dirty energy, energy poverty index, climate change and various other child and household circumstances on children’s health outcomes. This offers policy recommendations addressing energy poverty, climate change and its health consequences for children in the selected Arab countries. Children’s health outcomes are gauged using four common health indicators – the incidence of stunting among children younger than ٥ years, the incidence of wasting among children younger than ٥ years, neo-natal mortality within the first ٢٨ days of newborn life and infant mortality before the first birthday. Air pollution is measured using three alternative indicators: Arab-MEPI, MEP PCA, and access to adequate clean energy sources within households, which helps assess indoor air quality. Climate-events information is also considered by using average maximum temperature anomalies as a proxy for temperature extremes, as they heighten the potential threats to nutrition by exacerbating food insecurity (Baker and Anttila-Hughes, ٢٠٢١; McMahon and Gray, ٢٠٢١; Thiede and Gray, ٢٠٢٠; van der Merwe et al. ٢٠٢٢).

The impacts of air pollution and temperature extremes are evaluated across Arab countries. The analysis accounts for child demographics (age, gender), family characteristics (wealth index, mother’s and father’s education, urban/rural nature and governorate of residence). The evaluation of a large, updated set of surveys and the derivation of detailed child-outcome and energy-poverty indicators represent the original contributions of our study. Finally, by combining country-level results across multiple survey waves, this study identifies additional patterns regarding the evolution of children's health outcomes across the region. Highlighting the unique characteristics and challenges of the Arab region given its climate, energy resources, political dynamics, and cultural factors that may have significant influence. As resource-rich and resource-poor countries alike pursue their decarbonization and energy diversification agendas, the fate of children, as the emerging generation of stakeholders, should be central to the agenda/policy-setting process.

The remainder of this study offers a literature review in Section ٢ providing an overview of energy poverty measures along with the effects of climate change on child malnutrition. Section ٣ motivates and explains the applied data and method to estimate the effects of dirty energy, climate change and various other child and household circumstances on children's health outcomes. Followed by the empirical results of the estimated models in Section ٤. Finally, Section ٥ concludes the main findings and policy implications.

٢. Literature review

Energy poverty gained significant attention from many recent studies as it has crucial impact on various aspects of households such as health index, expenditure level, and general wellbeing of households. Alongside this focus on energy poverty, recent research has also examined the effects of energy transition. Table (١) provides a concise overview of the evolving definition of energy poverty and its empirical associations with economic development, children's health, and the energy transition. Drawing attention to gender inequality, energy poverty may adversely affect women and young girls. Conventionally, they bear the burden of collecting traditional energy sources and utilizing them for cooking purposes, and these burdens may interact with their preexisting less privileged access to developmental opportunities (Hamed and Peric, ٢٠٢٠). On the other hand, male toddlers have a more fragile health, so they may have higher energy-poverty related mortality, and so the question of gender gaps is an empirical question. Boardman (١٩٩١) introduced a single index method based on household energy expenditure relative to income to determine energy poverty. Subsequent efforts by the IEA (٢٠١١) emphasized the transition to modern fuels as a measure of energy poverty. Nussbaumer et al. (٢٠١٢) developed the Multidimensional Energy Poverty Index (MEPI) to assess deprivation in accessing modern energy services. According to Kose (٢٠١٩), energy poverty, measured by heating inadequacy, negatively impacts health index in Turkey, with an average health index of ٢,٠٥٪ lower. He urged policymakers to focus on individuals and households t-level interventions, rather than regional actions. Addressing housing conditions and improving insulation can help reduce energy poverty in Turkey and other developing regions. Elimination of energy poverty has economic repercussions, directly impacting health outcomes and household budget allocation decisions. Better housing conditions also have long-term societal impacts, particularly for children.

In Vietnam, Nguyen et al. (٢٠١٩) found that despite economic growth, energy poverty persists, particularly among poor and ethnic minority households reliant on traditional energy sources. Similarly, Abbas et al. (٢٠٢١) noted high energy poverty levels in South Asia, with Bangladesh facing significant challenges due to the shortage of modern cooking fuels. In another South Asian study on energy poverty, Bangladesh emerged as the most affected, scoring ٠,٣٧ due to geographical and infrastructural challenges. Afghanistan followed closely with a score of ٠,٣٥, attributed to economic and political instability. In contrast, the Maldives, an archipelago nation, stood out as the least deprived state in South Asia, with less than ١٪ of households lacking access to electricity. Pakistan also fared relatively well, ranking among the least poor states in the region.

Bangladesh faces a severe shortage of modern cooking fuels, with over ٨٠٪ of households relying on contaminated traditional sources like firewood and animal dung, particularly in rural areas. This reliance poses significant health risks due to inadequate ventilation (Abbas et al., ٢٠٢١). This study sheds light on the significant relationship between multidimensional energy poverty, educational level, marital status, occupation, water sources, mosquito bed net affordability, sterilization, and women's obesity levels in South Asia. These factors significantly impact the well-being of households emphasizing the need for targeted interventions. The findings underscore the urgent need for interventions to address energy poverty in South Asia, particularly in countries like Bangladesh and Afghanistan, where significant proportions of the population lack access to clean energy sources. Such efforts could significantly improve health outcomes and overall well-being, particularly in rural and marginalized communities heavily reliant on traditional fuels.

Authors like Amin et al. (٢٠٢٠), Zhang, Appau & Kodom (٢٠٢١), and Rafi, Naseef & Prasad (٢٠٢١) expanded on multidimensional measures of energy poverty, considering factors such as electricity access, household energy consumption patterns, and its impact on children's well-being and educational achievements. Dong, Ren & Zhao (٢٠٢١) focused on energy structure and its impact on reducing energy poverty through low-carbon energy transitions. Their study highlighted the importance of government policies in promoting renewable energy technologies and reducing dependence on solid fuels to address air pollution and health issues. Xie et al. (٢٠٢٢) introduced the concept of energy poverty line, considering dimensions such as energy poverty gap, breadth, and depth, while also identifying socioeconomic factors influencing energy poverty.

Overall, these studies underscore the complexity of defining and measuring energy poverty and its multifaceted relationship with economic development, children's health, and the transition to cleaner energy sources. They provide valuable insights for policymakers aiming to formulate targeted interventions to alleviate energy poverty and promote sustainable development.

On the other hand, climate change presents a global challenge, particularly in its impact on food security. The continuous rise in surface temperatures, coupled with more frequent and intense heatwaves and precipitation events is projected to have profound implications worldwide. These effects include reduced water availability, compromised food security, infrastructural damage, and decreased agricultural incomes. Notably, low and middle-income countries are expected to bear a disproportionate burden due to their heightened vulnerability to economic slowdowns and food shortages, exacerbating poverty and potentially escalating conflicts (Louis and Hess, ٢٠٠٨).

The repercussions of climate change on agriculture manifest in a loss of aggregate crop production, with tropical and temperate regions relying on rainfed agriculture facing the strongest impact (Challinor et al., ٢٠١٤). Among these regions, developing countries in Africa stand out as particularly vulnerable, experiencing adverse effects on agricultural production due to erratic rainfall patterns and soaring temperatures (Davenport et al., ٢٠١٧). Frequent flooding, droughts, and extreme heat further challenge families which are dependent on subsistence farming to meet their nutritional needs. Given that children in developing regions, especially impoverished communities, are already susceptible to food and nutritional insecurity, understanding the potential impact of climate change on their nutritional status becomes paramount.

Table ١. The evolution of the energy poverty definition.

Author	Energy Poverty Index (EPI)	Relationship with		
		Economic development	**Children's health**	**Energy transition**
Boardman (١٩٩١)	a single index method is proposed, which indicated that if energy expenditure exceeded ١٠٪ of household income, household was said to be energy poor.			
IEA (٢٠١١)	a single index measurement was proposed to assess the process of a region's transition to modern fuels.			
Nussbaumer et al. (٢٠١٢)	a new index – the Multidimensional Energy Poverty Index (MEPI) – was developed to test the deprivation of access to modern energy services.			
Amin et al. (٢٠٢٠)	they measured EPI by the % of the population who have access to electricity.	energy poverty has a negative impact on economic development in both the short-run and long-run in the sampled South Asian countries.		
Zhang, Appau & Kodom (٢٠٢١)	multidimensional EPI that considers the economic condition as well as clean energy adoption practices at the household level using China Family panel studies dataset. To construct MEPI, they followed Nussbaumer et al. (٢٠١٢) and assign relative weights on five indicators, including cooking, lighting, household appliance ownership, entertainment/education, and communication.		energy poverty has a negative impact on children's subjective wellbeing, and that academic performance is an important channel through which energy poverty lowers children's subjective wellbeing.	
Rafi, Naseef & Prasad (٢٠٢١)	multidimensional measure of energy poverty, which focuses on quantifying energy deprivation, covering both accessibility to and affordability of a broad range of energy forms.		energy poverty has significant negative effects on children's health and educational achievements.	
Dong, Ren & Zhao (٢٠٢١)	energy structure (denoted as ES) by employing the proportion of the sum of coal and oil consumption converted into standard coal by the conversion coefficient in total energy consumption.			low-carbon energy transition can affect the reduction of energy poverty by having an impact on the energy services availability, the energy consumption cleanness, as well as

				affordability and efficiency of energy.
Xie et al. (٢٠٢٢)	by setting an energy poverty line, given its wide acceptance in literature and its objectivity in measurement. Following Boardman (٢٠١٠), twice the median proportion of energy expenditure in household income is taken as the energy poverty line. energy poverty measured in the following three dimensions: (١) energy poverty gap, which is defined as the gap between actual energy expenditure and someone energy expenditure threshold; (٢) the breadth of energy poverty, which is defined as the proportion of households whose energy expenditure ratio is below the energy poverty line; and (٣) the depth of the energy gap, which is defined as the distance between threshold energy expenditure and the average energy expenditure of households in energy poverty.	it observed that the low-income, and less educated households are the ones who have high probability in experiencing energy poverty.		energy poverty increased significantly when coal was replaced with electricity and gas. However, energy poverty decreased when it was replaced with clean coal.
Okushinma (٢٠١٦)	change in domestic energy prices (as measured by the energy consumer price index, the energy CPI) in Japan after the ٢٠٠٠s. ‘Energy price’ is a composite index of electricity, gas, and other fuels (kerosene) prices using the ٢٠١٠ official weights.	the findings show that throughout the previous ten years, energy poverty among lower-income and vulnerable households has gotten worse due to a combination of rising energy prices and declining income.		
Papada and Kaliampakos (٢٠١٨)	$\mathit{Energy\ poverty\ index} = \dfrac{\text{Modelled fuel costs (i.e. modelled consumption x price)}}{\mathit{Income}}$ the basic household energy uses in Greece were taken into consideration: • Space heating • Space cooling • Domestic hot water • Cooking, lighting and electrical devices	The results showed that Greece has a rate of energy poverty of ٧٠,٤٪. Income is the key factor influencing energy poverty, accounting for ٦٣٪ of the total, while other variables (Htot, etc.) follow at much smaller percentages.		

Malnutrition, both in the short and long term, carries significant adverse effects. Preconception and early pregnancy malnutrition adversely affect maternal, neonatal, and child health outcomes, while in-utero malnutrition increases the risk of disability and reduced years of schooling (Almond and Mazumder, ٢٠٠١; Meng and Qian, ٢٠٠٩). Furthermore, childhood stunting correlates with diminished adult stature and educational attainment, along with increased mortality rates (Alderman et al., ٢٠٠٦; Hoddinot and Kinsey, ٢٠٠١; Currie and Vogl, ٢٠١٣; Van den Berg et al., ٢٠٠٩). Given the higher prevalence of stunting in low and middle-income populations, particularly in developing countries, prioritizing these regions becomes imperative (Black et al., ٢٠٢٠).

Previous research has endeavored to capture the relationship between climate change exposure during pregnancy and early childhood and subsequent health outcomes, such as stunting. Studies have shown that climate variability during pregnancy affects child health outcomes, with pregnancies conceived during periods of low precipitation associated with shorter gestation periods and increased risk of preterm birth (Rayco-Solon et al., ٢٠٠٥). Extreme temperatures and reduced agricultural production have been linked to lower birth weights in Mali, while precipitation extremes in South Asia during a child's first year of life have been associated with stunting, particularly in underprivileged households (Grace et al., ٢٠٢١; McMahon and Gray, ٢٠٢١).

Similarly, studies across Sub-Saharan Africa have highlighted the adverse effects of temperature and precipitation anomalies on child weight and wasting, with high temperatures associated with lower weights and increased risk of wasting, and low precipitation linked to weight reductions (Thiede and Strube, ٢٠٢٠). Rainfall shocks have also been found to impact children's growth, with droughts resulting in decreased growth rates, particularly among children aged ١٢ to ٢٤ months (Hoddinott and Kinsey, ٢٠٠١). Moreover, drying conditions in Kenya have been associated with increased stunting levels in children aged ١ to ٥ (Grace et al., ٢٠١٢). Elayouty et al. (٢٠٢٢) provides valuable insight into the link between climate change and child nutrition in the Nile Basin countries.

The relationship between climate and child health outcomes, varying across regions, underscores the need for further research. To address this gap, we aim to explore the impact of climate change, specifically in the form of temperature extremes, on four common health indicators.

٣. Methodology and data

The main objective of this study is to investigate how changing **the energy mix from fossil fuel dependence towards the adoption of green energy** affects the prevalence and incidence of four common health indicators –stunting among children younger than ٥ years, wasting among children younger than ٥ years, neonatal mortality within the first ٢٨ days of newborn life and infant mortality before the first birthday in the Arab region. In this context, we endeavor to provide robust evidence on the following research questions:

١) What are the estimated effects of energy poverty on children’s health outcomes in Arab?
٢) What are the estimated effects of energy poverty on infant mortality?
٣) What are the gender differentials in children’s health and infant mortality?
٤) How have energy poverty and the associated child stunting and infant mortality evolved across survey waves?
٥) Which demographic and economic groups in Arab are the most vulnerable to severe energy poverty?

Assessing changes in low-carbon energy transition, energy poverty and in children's outcomes across survey rounds will let us comment on the pattern and the trend of development, and the value but presumably also pitfalls of the Arab countries' decarbonization drive.

٣,١ Data

This study relies on a set of twenty-four standardized population and health surveys from ten Arab countries, namely: Algeria (٢٠١٢–١٣, ٢٠١٨–١٩), Comoros (٢٠١٢, ٢٠٢٢), Egypt (٢٠١٤, ٢٠٢١), Iraq (٢٠١١, ٢٠١٨), Jordan (٢٠١٢, ٢٠١٧–١٨), Mauritania (٢٠١٥, ٢٠١٩–٢١), Morocco (٢٠١١, ٢٠١٨), Palestine (٢٠١٤, ٢٠١٨–١٩), Tunisia (٢٠١١–١٢, ٢٠١٨) and Yemen (٢٠١٢, ٢٠٢٢). These surveys are taken from the UNICEF-coordinated Multiple Indicator Cluster Surveys (MICS) program, the USAID-coordinated Demographic and Health Surveys (DHS) and the Pan-Arab Project for Family Health (PAPFAM) Surveys (a brief summary is provided in Table A١). It is important to note that sample sizes and data completeness may vary across surveys, and standardization efforts account for differences in format, variable coverage, and missing observations.

These surveys are partially harmonized among themselves. The surveys encompass a broad spectrum of indicators related to living conditions, education, health, nutrition, and time-use of the national population, with a particular emphasis on the living conditions of children and their mothers. This comprehensive dataset provides an ideal foundation for studying the health and physical development of young children.

Children's health, the dependent variable, is measured by four indicators. Neo-natal mortality which refers to the death of a newborn within the first ٢٨ days after birth. Infant mortality measured as the death rate within the first year of life. Children's stunting means extremely low height for age as measured using the World Health Organization's (WHO) ٢٠٠٦ global child growth standards (de Onis *et al.* ٢٠٠٦; Leroy ٢٠١١).[١] Children's wasting refers to a condition described by rapid weight loss, typically due to acute food shortage and/or disease. It is typically assessed using the weight-for-height index, comparing a child's weight to their height, and is indicative of acute malnutrition. These four children's health outcomes can be analyzed across cohorts of children, at different ages, to flag instability or poor safety of food supply, chronic or repeated experience of illnesses, and overall child well-being.

The explanatory variables accounted for in the analysis include households' wealth, achievement of various levels of education by mothers, by their partners (or children's fathers, or household heads, depending on availability), household's residence in rural versus urban areas, residence in individual administrative regions (typically governorates), and gender of the child and of the household head.[٢] Household wealth is defined by quintiles based on the asset index of durable

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[١] Children's measurements are converted into standard deviations from the reference population with a healthy median and variance, and values two or more standard deviations below the median are flagged as stunting. The conversion is done using the *zscore06* automatic do-file program in Stata. *zscore06* takes children's height and weight, age in months, sex, and an indicator for whether the children were recumbent or standing while measurement was taken.

[٢] The small group of women who head their own households is made up of women who are widowed, self-employed, reliant on remittances from relatives abroad, or divorced. As a result of this heterogeneity of goods (McKenzie, ٢٠٠٥). This paper proposes a modified Arab-region Multidimensional Energy Poverty Index (Arab-MEPI) based on the work of Nussbaumer et al. (٢٠١٢, ٢٠١٣) and Multidimensional Energy Poverty Principal Component Analysis score (MEP PCA) to measure energy poverty. The DHS is also a rich dataset with variables related to air pollution, access to electricity, and low-carbon energy transition. The key variables used in constructing these indexes are available in Table A٢.

Geographically gridded daily meteorological and anthropogenic variables are matched to the twenty-four standardized population and health surveys from ten Arab countries. This matching process aligns data based on provinces and child's month of birth at the time of the survey interview. The provinces referred to as administrative regions, vary in names and count across Arab countries, including ٧ Espace de programmation territoriale in Algeria, ٢٥ governorates in Egypt, three islands in Comoros, ١٨ governorates in Iraq, ١٢ governorates in Jordon, ١٢ Wilaya in Mauritania, ١٤ région in Morocco, ١٦ governorates in Palestine, ٩ région in Tunisia, and ٢٢ governorates in Yemen. These spatial units are roughly equivalent to provinces, and we refer to them as such thereafter. Some provinces are excluded from the Egypt '١٤ survey as North and South Sinai due to their border status. The study focuses on children's exposure to climate extremes during the prenatal period and first two years of life, as these are the primary years during which children experience growth faltering. The anticipation is that exposures during the first year of life significantly influence height-for-age among this population (McMahon and Gray, ٢٠٢١).

Temperature extremes are constructed from daily maximum temperature data extracted from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC). The data is global GTS data and is gridded using the Shepard Algorithm. CPC Global Unified Temperature are a ٠,٥°x٠,٥° degrees resolution that span from ١٩٧٩-٠١-٠١ to Present. These data were obtained from the public domain in NetCDF format, which was subsequently extracted and analysed using geographic information system software (ArcGIS) and R statistical software. Time-standardized shapefiles from GADM and the extracted data are employed to compute spatial mean of maximum temperature values in each month from January ٢٠٠٥ until April ٢٠٢٤. GADM.org provides maps and spatial data for all countries and at all levels of sub-division. It provides data at high spatial resolutions that includes an extensive set of attributes. Maximum temperature is reported in degrees Celsius (°C).

In each province, running ٩-month and ١٢-month means are created and standardized into temperature anomalies using historical mean. Relative to raw climate values, standardized climate anomalies have multiple advantages for analyses of climatic impacts on health, serving as locally meaningful deviations from familiar conditions, interpretable as exogenous shocks, stronger predictors of social outcomes, and significantly associated with population health outcomes (Gray & Wise, ٢٠١٦; Nordkvelle, Rustad, & Salmivalli, ٢٠١٧; Mueller et al. ٢٠٢٠; Thiede & Strube ٢٠٢٠; Nicholas et al. ٢٠٢١). The study combines high-resolution maximum temperature data with household and health survey data, integrating two key developmental periods. Constructed monthly climate measures are linked to prenatal, and first year of each child based on their month of birth and province of residence.

circumstances of female household heads, estimates of the effects of household-head gender should be viewed with caution (Belhaj Hassine ٢٠١٤).

٣,٢ *Methodology*

First, we propose a modified Arab-region multidimensional energy poverty index (Arab-MEPI) relevant to middle-income Arab countries, using the aggregation approach of the Oxford Poverty and Human Development Initiative (Nussbaumer et al. ٢٠١٢, ٢٠١٣), and building on up-to-date evidence in academic and international-organization studies (e.g., Mendoza et al. ٢٠١٩; Zhang et al. ٢٠١٩; Siksnelyte-Butkiene et al. ٢٠٢١) and Multidimensional Energy Poverty Principal Component Analysis score (MEP PCA).[٣] The decisions regarding the choice of energy-poverty indicators, their standardization and weighted aggregation are assessed. The inputs and results of the Arab-MEPI framework are checked for their normative and statistical properties.

Second, we use multivariate regressions for limited dependent variables to estimate the effects of factors such as dirty energy, Arab-MEPI, MEP PCA, temperature extremes and various child and household circumstances on children's health outcomes namely stunting, wasting, infant mortality, and neonatal mortality. This entails assuming that child i's true (latent) health outcome y_i is a linear function $E(y_i|x_i) = f(x_i\ , \beta) = x_i\beta+\varepsilon_i$. This unobserved variable y_i is related to the observed dependent variable $\dot{y}_i$ as follows: $\dot{y}_i$ = ١[y_i > ٠] = ١[$\varepsilon_i > -x_i\beta$]. Here ε_i accounts for other uncontrolled factors including the child caretakers' efforts and luck. Under the assumption that ε_i follows a normal distribution, the well-established maximum-likelihood probit model is appropriate for estimating $\dot{y}_i$ and Pr($\dot{y}_i$=١| x_i). Thereby, $\dot{y}_i$ will be denoted by ECD_{ijt} where each child i at age t in province j is estimated by the following model using probit:

$$ECD_{ijt}= \alpha+ \beta\ EPov_i+\gamma\ X_i+ \varphi\ Z_{jt} + \varepsilon_{ijt} \qquad (١)$$

ECD_{ijt} denotes one of several early childhood health (ECD) outcomes for child i at province j at age t. $EPov_i$ is the scores for one of the three pollution measures. X_i is a vector of other socio-economic determinants of each child's health outcomes. Z_{jt} is temperature extremes province j at child's age t.

The regressions account for population sampling weights, and coefficient standard errors are corrected for arbitrary heteroskedasticity and correlation at the household level. The results are compared across survey waves, to comment on the prevalence and depth of energy poverty and their effects on children's outcomes across demographic groups and countries, and over time. stimated probit coefficients are used to predict the standardly reported average marginal effects (AMEs) at variable means (refer to the appendix for different models estimated).

٤. Estimation procedures and empirical results

٤,١ *Descriptive statistics*

The prevalence of child stunting and infant mortality in each country is observed in Table ٢. It shows that Mauritania has the highest stunting rate counts for ٢٥,٢١٪ in ٢٠٢١; the lowest stunting rate witnessed in Palestine with ٧,٣٩٪ in ٢٠١٤ followed by Algeria ٧,٩٧٪ in ٢٠١٩. The remaining countries range between this range. The infant mortality was the highest in Mauritania as it reached out more that %٧ in ٢٠١١. However, it decreased during the following years till it became ٣,٨٥٪ in ٢٠٢١. The lowest infant mortality rate has been witnessed in Jordan in ٢٠٢٣ that is ١,٤٪.

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[٣] Another alternative index has been advanced using principal component analysis (PCA) of the candidate indicators (Robertson et al. ٢٠١٩; Gupta et al. ٢٠٢٠; Jayasinghe et al. ٢٠٢١).

Generally, the infant mortality witnessed a decline in all countries over years except of Egypt; as the infant mortality increased from ١,٤٨٪ in ٢٠١٤ to ٣,٠٦٪ in ٢٠٢١.In addition, the multidimensional energy poverty index has been observed as shown in Table ٣. Also, Mauritania reached out the highest energy poverty index of ٠,٥٠٢ in ٢٠١١ relative to the rest of the countries. The lowest has been observed equally in both Egypt and Jordan that counts for ٠,٠٠١ in ٢٠١٤ and ٢٠١٢, respectively. Additional summary statistics of explanatory variables in regression samples are added to Table A٣.

According to Table ٣, the highest multidimensional energy poverty index (MEPI) is observed in Mauritania where generally the majority of the surveyed African countries witnessed a typical increase over years. The opposite is witnessed in the surveyed Asian countries. The data shows that there are many contributors to the energy poverty such as the dirty fuels, open stove x dirty fuels, number of available fridges and/or freezers, number of available radios and or TVs, and number of phones used withing the households. Dirty fuels are considered the most contributor of energy poverty among all other sources in most of the countries.

Table ٢. Summary statistics of children's health outcomes in regression samples and alternative climate-conditions indicators (%/١٠٠)

	Stunting (%)	Infant mortality (%)	MEP principal components: ١st component score [٠–١]	Dirty fuels (٠ / ١)	Temperature extremes up to ٩ months pre birth (units)	Temperature extremes up to ١٢ months post birth (units)
ALG '١٣	٩,٣٤	٣,٥٦	.٠١١	.٠٠٥	-.٣٣٧	-.٢٢١
ALG '١٩	٧,٩٧	٢,٢٥	.٠٣٨	.١٢٨	.٢١١	.٢٢٢
COM '١٢	٢٩,٦١	٣,٢٦	.٦٣٦	.٨٥٩	-.٢٢٦	-.١١٦
COM '٢٢	١٤,١٠	٢,٩٨	.٣٣٤	.٦٠٢	.٣١٢	--
EGY '١٤	١٧,٧٤	١,٤٨	--	--	.١٠٤	-.٠٠٤
EGY '٢١	١٣,٠٩	٣,٠٦	--	--	.٠٠٩	-.٢١٣
IRQ '١١	٢١,٨٢	٣,٦٣	.٠١٤	.٠١٢	-.٠٦٩	-.٢٩٣
IRQ '١٨	٩,٨٩	٢,٥٩	.٠٠٧	--	.٢٢٥	.٤٩٥
JOR '١٢	٨,٦٧	٢,٤٤	.٠٨٥	.٠٦١	-.٠٥٤	-.٠١٧
JOR '١٨	*	١,٥٧	.٠٣٥	.٠٣٠	-.١١٦	-.٠٢٥
JOR '٢٣[a]	٨,٠	١,٤	--	--	--	--
MRT '١١	٢٤,٩٦	٧,٧١	.٥٣٢	.٦٠١	-.٠٩٦	.٠٠٢
MRT '١٥	٢٣,٤٠	٤,٩٦	.٤٤٦	.٣٨٥	-.٢١٩	-.١٠٦
MRT '٢١	٢٥,٢١	٣,٨٥	.٥٢١	.٦٤٠	.٣٠٤	.٣٥٧
MAR '١١	١٥,٦٢	٢,٧٠	.٠٩٢	.١٠٢	-.٢١٥	-.٣١٢
MAR '١٨	١٥,٨٨	١,٧٤	.٠٣٩	.٠٣٩	.٣٤٥	.٢٧٩
PAL '١٤	٧,٣٩	٢,٢٢	.٠٣٧	.٠١٩	.٢٩١	.٢٥٨
PAL '٢٠	٨,٧٢	١,٩٣	.٠١٤	.٠١١	.٢٧٦	.٢٨١
TUN '١٢	١٠,١٣	٢,٣٣	.٠١١	.٠٠٤	-.٢١٠	-.٢٤١
TUN '١٨	٨,٢٧	١,٤٥	.٠٠٥	.٠٠٢	.١٩٩	.٢٤٠
TUN '٢٣	١٣,٥٠	١,٤٣	.٠١٠	.٠٠٥	-.١٦٤	-.٠٠٧

Notes: Child samples are nationally weighted. * Child anthropometrics unavailable. [a] Initial figures as per Key Indicators report. "--" indicates missing data for a particular indicator. Evaluated on sampling-weighted children's sample.

Table ٣. Summary statistics of multidimensional energy poverty (%/١٠٠)

	Multidimensional energy poverty index (MEPI)	Deprivation intensity, constrained among poor (A)	MEP headcount ratio (H)	Contrib. of dirty fuels to MEP	Contrib. of open stove × dirty fuels to MEP	Contrib. of no electricity to MEP	Contrib. of no fridge/ freezer to MEP	Contrib. of no radio/TV to MEP	Contrib. of no phone to MEP	Pearson's correlation of MEPI with wealth quintile
ALG '١٣	.٠٠٥	.٤٩٢	.٠١١	.٠٨٥	.٠٨٣	.١٣٩	.٠٩٤	.٠٦٥	.٠٢٦	-٠,٢٤٧
ALG '١٩	.٠٥١	.٤٢٦	.١٢٠	.١٩٦	.١٩٥	.٠٠٨	.٠١١	.٠٠٨	.٠٠٨	-٠,٣٦٣
COM '١٢	.٥٩٢	.٦٤٩	.٩١١	.١٨٢	.١٠١	.٠٨١	.١٠٨	.٠٥٠	.١٢٧	-٠,٧٢٢
COM '٢٢	.٣١٣	.٥٤٢	.٥٧٨	.١٩١	.١٣٣	.٠٤٥	.١٠٣	.٠٥٣	.٠١٧	-٠,٦٨١
EGY '١٤	.٠٠١	.٤١٧	.٠٠٢	--	--	.٠٦٥	.١٢٢	.١٢٣	.١٠٧	-٠,٢١١
EGY '٢١	.٠٠١	.٤١٠	.٠٠٢	.٠٧٠	--	.٠٤٢	.١١٩	.١٠٩	.٠٧١	٠,٠٩٨
IRQ '١١	.٠٠٨	.٥٠١	.٠١٧	.١٤٤	.١٣٦	.٠٨٧	.٠٧٨	.٠٣٦	.٠٢٠	-٠,٢٧٦
IRQ '١٨	.٠٠١	.٤٥٠	.٠٠٢	--	--	.١٤١	.١٣٣	.١٢٨	.٠٤٨	-٠,١٧٩
JOR '١٢	.٠٦٥	.٩١٠	.٠٧١	.١٧١	.١٧١	.١٨٩	.١٢٥	.١٢١	.١٣٣	-٠,١١٧
JOR '١٨	.٠٢٠	.٦٦٥	.٠٣٠	.١٩٧	.١٩٧	--	.١٣١	.١٣١	.٠٠٩	--
MRT '١١	.٥٠٢	.٧٠٠	.٧١٧	.١٦٧	.١٥٥	.١٦٩	.١٢٧	.٠٥٥	.٠٢٧	-٠,٨٤٦
MRT '١٥	.٦٢٠	.٦٤٨	.٤٠٢	.١٢٤	.١١٧	.١٩٣	.١٣٢	.٠٦٧	.٠١٦	-٠,٨٣٨
MRT '٢١	.٤٨٦	.٦٩٨	.٦٩٧	.١٧٨	.١٥٥	.١٥٩	.١٢٤	.٠٦٨	.٠١٣	-٠,٨٦٩
MAR '١١	.٠٧٧	.٤٨٢	.١٦١	.١٢٥	.١١١	.١٠٦	.٠٩٥	.٠٢٢	.٠٢٤	-٠,٦٣٦
MAR '١٨	.٠٢٧	.٥٠٠	.٠٥٤	.١٤٣	.١٤١	.٠٨١	.٠٧٠	.٠٣٩	.٠٢٦	-٠,٣٨٤
PAL '١٤	.٠١١	.٥١٨	.٠٢٢	.١٦٨	.١٥٦	.٠٠٩	.٠٤٠	.٠٢٤	.١٢٢	-٠,٣٦٩
PAL '٢٠	.٠٠٥	.٤٥٦	.٠١٢	.١٧٤	.١٧٢	.٠١٦	.٠٣٩	.٠٤٥	.٠١١	-٠,٣٦٤
TUN '١٢	.٠٠٦	.٤٩٠	.٠١٣	.٠٦٧	.٠٦٦	.٠٨٣	.١١١	.٠٨٨	.٠٧٥	-٠,٣١٤
TUN '١٨	.٠٠٣	.٤٧٢	.٠٠٦	.٠٤٦	.٠٤٤	.٠٧٧	.١٢١	.١٠٥	.٠٧٧	-٠,١٩٤
TUN '٢٣	.٠٠٦	.٦٥٠	.٠١٠	.١٠١	.١٠١	.٠٩٤	.١٢٥	.١١٧	.١١١	-٠,٢٧٢

"--" indicates missing data for a particular dimension of MEPI. The rest of statistics are computed as if the missing contributions are zero.

٤,٢ *Preliminary results across Arab countries*

The following subsections report on the average marginal effects (AMEs) of all covariates on children's propensity for the four children's health outcomes, across the evaluated surveys. Table ٤ provides a summary of key variables' marginal effects from probit regressions on the four child health outcomes. This summary focuses on the association of MEPI instrumented, MEPI, MEP, temperature extremes on the likelihood of stunting, wasting, infant mortality, and neonatal mortality among children in Arab countries, accounting for a full set of controls. The probit regression models in Table ٤ include multiple specifications (Models ١ to ١٥). Model ١ addresses endogeneity concerns by focusing on the effect of the instrumented MEPI score. The potential issue of endogeneity, which can arise from omitted variable bias or reverse causality, is a significant concern in our analysis. Previous studies have shown a possible connection where health status influences income levels, thus contributing to energy poverty (Awaworyi Churchill et al., ٢٠٢٠; Zhang et al., ٢٠١٩, Zhang et al., ٢٠٢١). To address this issue, we adopt an instrumental variable (IV) approach, following recommendations from existing literature (Awaworyi Churchill et al., ٢٠٢٠; Zhang et al., ٢٠١٩). Model ٢ uses the MEPI score directly without instrumentation, providing a straightforward assessment of its effect on stunting. Model ٣ incorporates the effect of using dirty cooking fuels. Model ٤ includes the MEP PCA ١st-component score as an additional measure for air pollution. Model ٥ examines the impact of temperature extremes ٩ months before birth and ١٢ months post-birth, reflecting the effects of climate change. Model ٦ includes the MEPI score, temperature extremes ١٢ months post-birth, and their interaction term, offering a more comprehensive model for the energy poverty-climate change nexus. Model ٧ mirrors Model ٢ but analyzes child's wasting. Models ٨ to ١٣ follow the same structure as Models ١ to ٦, respectively, but analyze infant mortality. Finally, Model ١٤ focuses on the effect of the MEPI score on neonatal mortality, and Model ١٥ examines the effect of temperature extremes ١٢ months post-birth on neonatal mortality.

Stunting Models

Stunting, a key indicator of chronic malnutrition, reflects both immediate and long-term impacts on children's health, cognitive development, educational attainment, and overall well-being. The results of each model reveal several interesting findings for children's health outcomes. The large number of observations and clusters ensures the reliability and robustness of the estimated marginal effects, enhancing the statistical validity of the findings. Model statistics confirm a high degree of model fit and show that the selected covariates significantly explain children's predisposition for stunting.

MEPI score could be endogenous in regressions of children's health, so we have instrumented for it using MEPI score of other households in the same governorate-urban/rural area, same wealth quintile, during the same season. Essentially, we view households' membership in these clusters as relatively exogenous. These clusters are associated with different supplies of fuels by government and by nature, and so they affect MEPI. Households' average MEPI in these clusters may not directly affect any specific child's health. In each survey, there are ~١٠٠-٤٠٠ of such clusters. Linear transformation has been used to the models, so that the instrumented variable would have the same minimum and maximum as MEPI. Model ١ estimated the effect of the instrumented MEPI on the likelihood of stunting and the results showed positive significance in ALG '١٢, IRQ '١٨, MAR'١١, and TUN '١١. Model ٢, MEPI score serves as a proxy for the energy poverty experienced by households. We confirm that countries such as MAR’١٨, MRT’١٥, PAL’١٤, and TUN ’١١ have higher MEPI scores correspond to an increased likelihood of stunting among children. This suggests that energy poverty, characterized by limited access to modern energy sources, may exacerbate the risk of malnutrition, particularly in resource-constrained settings. The significance of MEPI score, instrumented and MEPI score and in several countries reinforces the importance of addressing energy poverty as part of broader efforts to combat health and nutrition deprivations.

In Model ٤, MEP PCA score did not demonstrate superior performance compared to the MEPI score or the instrumented MEPI score in predicting the likelihood of stunting. Similarly, the impact of using dirty fuels was assessed on stunting, revealing a positive but insignificant association in most cases. However, in MRT'٢١, the use of dirty fuels was found to be significantly associated with a lower likelihood of stunting. Potential biases in data collection and reporting may contribute to this result.

In addition, the effect of temperature extremes ٩ months prior birth and ١٢ months post birth on stunting have been measured in Model ٥. The results showed a significant negative association of the extreme temperatures ٩ months prior birth on stunting in most of the surveyed countries such as EGP '١٤, IRQ '١٨ and others except for some positive effects. On the other hand, the extreme temperatures ١٢ months post birth showed a positive association in most of the countries and the only negative significantly is in MRT’٢١.

Adding an interaction term of *MEPI score × Tempr. extremes 12months* in model ٦ showed more positive significant effect of MEPI on the likelihood of stunting in more countries relative to the first tested model. The significance of MEPI was in several countries (MAR ’١٨, MRT ’١٥, PAL ‘١٤, PAL ‘٢٠, TUN ‘١١, and TUN ‘١٨). The same applies to the effect of the extreme temperatures ١٢ months post birth on stunting as more countries showed a positive significant association between temperature extremes and likelihood of stunting such as MAR ’١٨, TUN ’١١, and TUN ’١٨.

The demographic and socioeconomic factors included in the estimation exhibit some significant effects on the probability of stunting. For example, in JOR‘١٢, and MRT’٢١, households led by females exhibit a higher prevalence of stunting among children. This observation underscores the need for gender-sensitive interventions to address nutritional disparities within households. Female children in ALG‘١٩, EGP‘١٤, IRQ‘١١, and PAL‘١٤ are less susceptible to stunting compared to their male counterparts. The negative marginal effect for female children in relation to stunting may seem counterintuitive, but it underscores the complexity of factors influencing the evolution of child growth. It is possible that biological differences between genders play a role in susceptibility to stunting. For instance, hormonal differences may influence nutrient absorption and metabolism differently in males and females (Headey et al., ٢٠١٦; Pande, ٢٠٠٣). Further research is needed to explore the underlying mechanisms and contextual factors contributing to this phenomenon, ensuring that interventions effectively address the nutritional needs of all children, regardless of gender.

Advancing age is associated with an increased likelihood of stunting in several countries, indicating that older children may face prolonged exposure to nutritional deficiencies, exacerbating the risk of stunted growth at a decreasing rate. The education attainment of both fathers and mothers significantly influences stunting outcomes in some countries. Higher levels of parental education are generally associated with reduced probabilities of stunting among children, emphasizing the importance of education in improving child nutrition outcomes.

Household characteristics also play a role in child stunting. Children residing in rural areas are more likely to experience stunting compared to their urban counterparts. This rural-urban disparity underscores the need for targeted interventions addressing the challenges faced by rural citizens. Household wealth status plays a pivotal role in determining children's nutritional status. Wealthier households, as observed in ALG‘١٣, EGY‘٢١, MRT’٢١, PAL’١٤ and PAL’٢٠, demonstrate lower probabilities of stunting, indicating the protective effect of socioeconomic prosperity against health and nutrition deprivation.

Wasting Model

The effect of MEPI has also been measured on additional health indicators represented in the likelihood of wasting. The results showed that there is no significant association of MEPI on wasting.

Infant Mortality Models

Infant mortality models are controlled only for factors that are available for both living and deceased children. Infant deaths are relatively rare (refer to Table ٢), we are technically restricted to be using only covariates whose values vary in both outcome groups.[٤] The results are similar to those for stunting rates. Energy poverty is typically associated positively with infant mortality, and showed significance in MAR '١٨, TUN '١١, and TUN '٢٣. Also, the effect of the extreme temperatures ١٢ months post birth on infant mortality has been measured after adding the interaction term and the results showed additional positive significance in COM ’٢٢ in addition to TUN '٢٣. Obviously, the African countries of the surveyed Arab countries are the most ones proved to have a significant positive association between the high temperatures and children’s mortality rates given the effect of malnutrition on health outcomes. Based on Challinor et al., (٢٠١٤), crop production declines because of climate change, with tropical and temperate regions that depend on rainfed agriculture being most affected. Developing nations in Africa are particularly vulnerable among these locations, with unpredictable rainfall patterns and extreme temperatures having a negative impact on agricultural output (Davenport et al., ٢٠١٧).

Infant girls have a lower mortality rate than boys, a common finding. Fathers' education has a mixed record of association with infant mortality, while mothers' higher education is typically associated with lower mortality rates, especially the excluded highest level of education. Similarly, household wealth is associated negatively with mortality, especially the excluded highest level of wealth.

Dirty-Fuels effect has been also measured on infant mortality. The rate of infant mortality also has an association with dirty-fuels where the majority of the countries have witnessed a mix of positive and negative insignificant association of dirty-fuels on infant mortality rate except of MAR’١٨ has positive significant effect on infant mortality rate. Apparently, the Arab region in the represented surveyed countries is not facing severe shortage of modern cooking fuels relative to other south

[٤] For instance, in Tunisia ٢٠١٢, there are incidentally no infant deaths in female headed households, so this variable cannot be used.

Asian countries like Bangladesh that is facing a severe shortage with over ٨٠٪ of households relying on contaminated traditional sources (Abbas et al., ٢٠٢١). The reason could be the difference between Bangladesh and Afghanistan in their significant proportions of the population lack access to clean energy sources relative to the countries of the Arab region.

Neonatal Mortality Models

The effect of MEPI has also been measured on additional health indicators represented in the likelihood of neonatal mortality. The results showed that the likelihood of neonatal mortality where the positive significance has been proved only in TUN '١١. An additional model has been added to measure the effect of temperatures extremes ٩ months pre-birth on neonatal mortality, but the results showed consistent negative association where mainly significantly negative in IRQ '١١ & ١٨, and PAL '١٤.

The substantial number of observations and clusters ensures the reliability and robustness of the estimated marginal effects, enhancing the statistical validity of the findings. Indeed, model statistics confirm a high degree of model fit and show that the selected set of covariates explain a non-trivial share of children's predisposition for stunting. The estimated models showed that the variation in the likelihood of stunting, wasting, infant mortality, and neonatal mortality is explained by the models by less than ١٠٪ almost in all countries given the observed R٢ (reported for some regression models, available from the authors on request for other models).

Comparing the results of all models, MEPI is considered as significant as PCA on the likelihood of both stunting and infant mortality, but other measures of indoor/outdoor environmental conditions represented in dirty-fuels and temperature's extremes are less significant relatively. The most significant model that showed how energy poverty is positively associated with the likelihood of both stunting and infant mortality is the model where the interaction term "MEPI x Temp. Extreme" has been added to the model. In addition, the AME has been compared over years individually for each country and the results showed a typical increase (not necessarily significant) in the likelihood of both stunting and mostly infant mortality in most of the surveyed countries. ٢

Pooled Regression Results

In this section we report the results of pooled regressions by country. This controls for unobserved country-specific factors that are time-invariant, such as cultural norms, institutions, or geographic characteristics, which could potentially influence childcare and feeding habits and other practices that affect overall health and mortality. Second, pooling the data across countries and years increases the overall sample size and variation, thereby improving the precision of the estimates and enhancing the statistical power of the analysis. Furthermore, this allows us to examine both cross-sectional variations across countries and longitudinal variations over time, providing valuable insights into how the relationship between child health outcomes and energy poverty or extreme temperatures vary across different national contexts as well as how they evolve dynamically within countries over the observed time periods.

Tables ٦b-٧ and Figure ٢ report results of the pooled regressions of energy poverty on stunting. We again control for a full set of household characteristics and the region of residence. Results show that energy poverty (MEPI) has a positive effect in the vast majority of countries, and significant for Morocco, Palestine and Tunisia. This implies that once we control for unobserved country specific factors higher energy poverty is associated with higher stunting probability. Interestingly, being a female child is associated with lower probability of stunting in the majority of countries. This result needs to be interpreted with caution however since international anthropometric standards on height may need to be adapted to region specific trends before we can safely conclude that female children are less likely to be stunted. Wealth is associated with lower stunting, except in Jordan and Mauritania.

Turning now to the examination of extreme temperatures on stunting using the pooled regressions, the results are in Table ٦. The results suggest that extreme temperature in the ٩ months before birth are significantly associated with lower stunting in Iraq and Mauritania, while the association is positive and significant in Jordan and Palestine. Extreme temperatures in the ١٢ months after birth are associated with higher stunting in Egypt and Tunisia. Checking the joint significance of these two variables, we see they are significant in Egypt, Jordan and Palestine (positive) and also in Iraq and Mauritania (but with negative association).

The last two tables provide similar analysis on pooled data for infant mortality. Table ٧ provides results for the energy poverty and reveal that there is no significant relationship except for Tunisia. Results show that energy poverty (MEPI) has a positive and significant effect for these two countries. This implies that once we control for unobserved country specific factors higher energy poverty is associated with higher child mortality probability. The regressions on extreme temperatures in Table ٨ reveal few significant associations with the impact of extreme temperatures both before and after birth insignificant in most countries. The main exceptions are Iraq, Palestine and Tunisia (١٨-٢٣) where there is a negative association between extreme temperature before birth and infant mortality. The results on infant mortality in general are more problematic since in almost all countries infant mortality has been declining due to other factors such as rising income, access to healthcare, lifesaving vaccines and clean water and sanitation. While Comoros' results show that Extreme temperatures for both the ٩ months before birth and in the ١٢ months after birth are associated with higher child mortality. We are essentially trying to explain how extreme temperature would slow down an already very strong positive trend worldwide which is hard to capture given available data. Ideally, we would be able to estimate a "counterfactual" infant mortality rate absent this extreme temperature and compare the current levels to it but there are no standard methods to readily do that.

٥. Conclusions and policy implications

The connections between energy poverty, the transition to low-carbon energy, and socioeconomic disadvantage among households in the context of current climate change are under-researched, particularly in the Arab region (Jessel, Sawyer, & Hernández, ٢٠١٩; Nawaz, ٢٠٢١; Sen et al., ٢٠٢٣). The complexities surrounding the clean energy transition, energy reliability and affordability, are pressing concerns that intersect with health outcomes, particularly in the context of climate change. Within the Arab region, energy poverty and health disparities intertwine, exacerbating vulnerabilities, especially among children. Many children in the Arab countries lack access to adequate prenatal and early-life care, reside in precarious living conditions, and suffer from malnutrition, leading to chronic illnesses, stunting, and tragically, infant mortality.

Given the inherent challenges of estimating the impacts of energy poverty, particularly at the micro level in developing countries (Rafi, Naseef, & Prasad, ٢٠٢١), this paper represents a significant contribution to the energy poverty literature. Notably, empirical studies exploring the association between energy poverty and low-energy transition are scarce within the Arab region. Moreover, this study pioneers the investigation into the nexus between low-carbon energy transition, energy poverty, and children's health. Our research aims to illuminate the health consequences of energy poverty among children in Arab countries, with a particular emphasis on indoor air pollution, stunting, and infant mortality, prevalent in households utilizing outdated, polluting cooking methods.

This proposed study attempts to fill this knowledge gap by offering a novel viewpoint on typical deterrent mechanisms associated with the energy poverty faced by countries especially in the face of disrupters such as the COVID-١٩ pandemic and the Ukrainian war. The transition to low-carbon energy is advantageous for conserving energy and lowering emissions, making it a subject deserving of significant scrutiny when it comes to its influence on energy poverty. Our research seeks to shed light on the specific insights into health outcomes and risks associated with energy poverty among children in the Arab region. It seeks to highlight how energy poverty can lead to indoor air pollution, stunting and infant mortality, especially in households relying on traditional and polluting cooking methods. Additionally, it identifies the socioeconomic factors, geographical location, and housing conditions that make certain groups of children more vulnerable to the health impacts of energy poverty.

Our findings underscore the intricate interplay of socioeconomic, demographic, and environmental factors in shaping children's health status in Arab countries. The use of the Multidimensional Energy Poverty Index (MEPI) as a proxy for household energy poverty confirms a significant association between higher MEPI scores and increased risk of childhood health problems across most countries. Notably, socioeconomic disparities, gender dynamics, education levels, and household characteristics significantly influence stunting outcomes. In some countries, stunting is significantly more prevalent among children in female headed households, in others, lower education and lower wealth are also associated with higher prevalence of children's health problem. These findings highlight the importance of gender-sensitive and socio-economic specific interventions to address nutritional disparities within and across households.

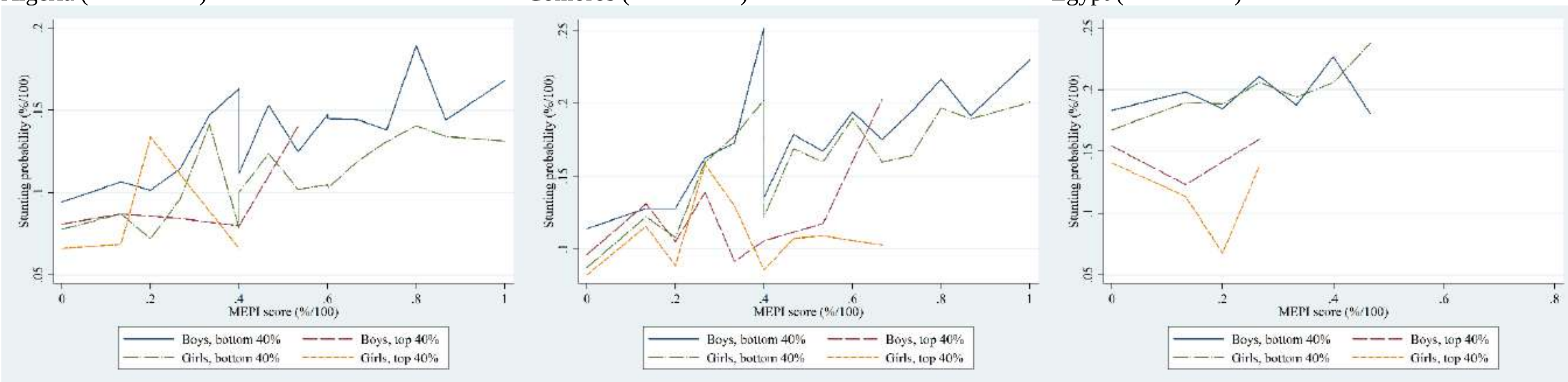
This implies that energy poverty, characterized by restricted access to contemporary energy sources, may heighten the risk of malnutrition, particularly in resource-constrained settings. Addressing the underlying causes of children's health problems requires a multifaceted approach, including women's empowerment, education interventions, poverty reduction, and focused healthcare activities tailored to vulnerable populations. Further research is necessary to ensure gender-inclusive interventions and to explore contextual factors contributing to potential biases in data collection and reporting due to gender discrimination.

Given the findings of the study, which highlight the adverse effects of energy poverty and extreme temperatures on child health outcomes in the Arab region, especially in countries like Comoros, Jordan, Mauritania, Morocco, Palestine, and Tunisia. Several targeted policy implications can be proposed: i) enhanced access to clean energy for households, ii) expand the infrastructure investment in modern and clean energy sources, particularly in rural and underserved areas, iii) develop renewable energy projects such as solar and wind power, iv) provide subsidies and financial incentives for households to transition from traditional fuels to cleaner energy sources, v) develop and expand integrated health services that address both energy poverty and child malnutrition, vi) provide nutritional support and healthcare services in regions with high energy poverty rates, vii) strengthen disaster preparedness and response systems to better handle the impacts of extreme weather events. This includes early warning systems and emergency healthcare services, viii) introduce or expand cash transfer programs aimed at the poorest households to alleviate energy poverty, vix) foster regional cooperation among Arab countries to share best practices and resources in combating energy poverty and improving child health, xv) seek international funding and technical assistance from organizations such as the World Bank, UN agencies, and other development partners to support the implementation of these policies.

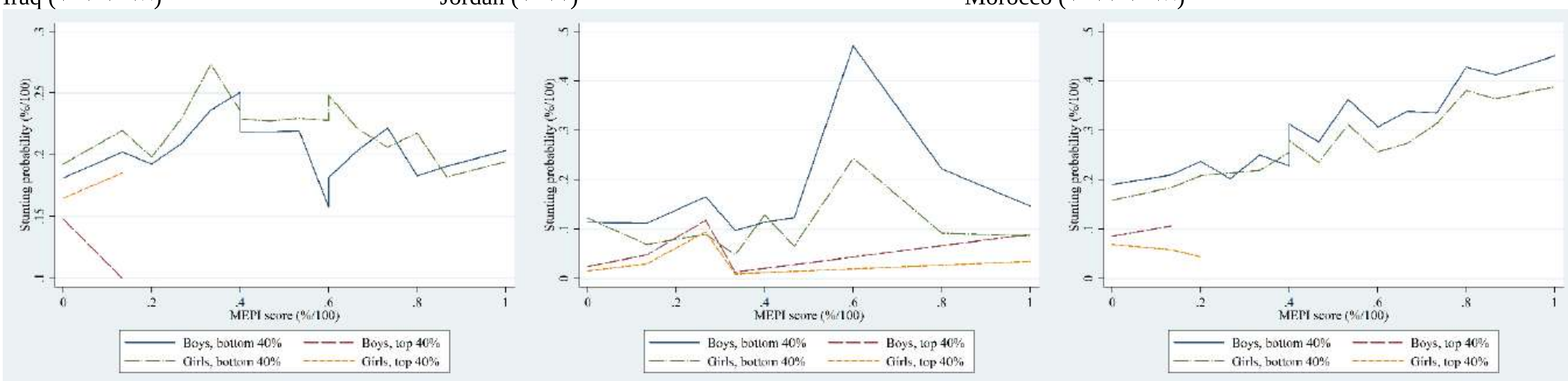
By addressing energy poverty and its health impacts through these targeted policies, Arab countries can improve child health outcomes and foster sustainable development in the region.

Figure ٢. Estimated probabilities of stunting by MEPI score, by children's sex and household wealth, regressions on pooled survey rounds (model ١٦)

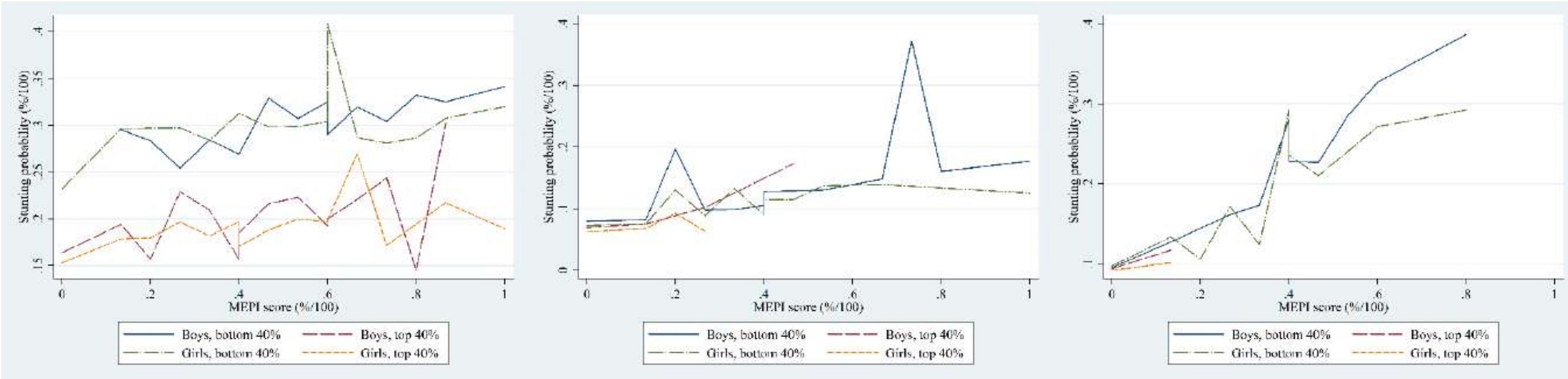
Algeria (٢٠١٢-٢٠١٨) Comoros (٢٠١٢-٢٠٢٢) Egypt (٢٠١٤-٢٠٢١)



Iraq (٢٠١-٢٠١٨) Jordan (٢٠١٢) Morocco (٢٠١١-٢٠١٨)



Mauritania (٢٠١١-٢٠٢١) Palestine (٢٠١٤-٢٠٢٠) Tunisia (٢٠١١-٢٠١٨)



Notes: These estimates come from Model ١٦ in Table ٤b. Full regression results are presented in Table ٥.

Table ٤. Summary of Key Variables' Marginal Effects from Probit Regressions on Child Health Outcomes.

Model	Variable	ALG12	ALG18	COM12	COM22	EGY14	EGY21	IRQ11	IRQ18	JOR12	JOR18	MAR11	MAR18	MRT11	MRT15	MRT21	PAL14	PAL20	TUN11	TUN18	TUN23
STUNTING																					
Model 1	MEPI score, instrumented	0.083***	-0.033	0.250	-0.089	-0.400***	-0.053	-0.035	0.439***	0.048		0.180*	0.002	0.047	0.108	-0.110	0.059	0.129	0.334**	-0.173	-0.793**
		(0.021)	(0.030)	(0.355)	(0.072)	(0.131)	(0.065)	(0.031)	(0.138)	(0.079)		(0.097)	(0.046)	(0.099)	(0.105)	(0.124)	(0.075)	(0.103)	(0.134)	(0.130)	(0.402)
2	MEPI score	0.052	0.017	0.037	0.001	0.008	0.033	-0.036	-0.011	0.014		0.073	0.126***	-0.022	0.054*	-0.022	0.077**	0.080	0.190**	0.136	-0.197
		(0.038)	(0.023)	(0.071)	(0.034)	(0.108)	(0.071)	(0.037)	(0.098)	(0.041)		(0.045)	(0.040)	(0.034)	(0.030)	(0.038)	(0.033)	(0.056)	(0.076)	(0.092)	(0.196)
3	Dirty cooking fuels	0.028	0.004	-0.042	-0.025		0.054	0.021		0.014		-0.006	0.027	-0.029	0.010	-0.039**	0.021	0.038	0.127		
		(0.027)	(0.010)	(0.048)	(0.015)		(0.108)	(0.025)		(0.037)		(0.022)	(0.025)	(0.018)	(0.016)	(0.017)	(0.024)	(0.030)	(0.102)		
4	MEP PCA 1st-component score	0.056*	0.036	0.074	0.021	0.024	0.105	-0.007	-0.017	0.013		0.082*	0.116***	-0.014	0.053*	-0.015	0.035	0.047	0.221*	0.029	-0.460
		(0.034)	(0.027)	(0.075)	(0.037)	(0.072)	(0.101)	(0.036)	(0.068)	(0.037)		(0.046)	(0.038)	(0.036)	(0.031)	(0.039)	(0.031)	(0.034)	(0.116)	(0.131)	(0.396)
5	Tempr. Extremes 9months pre birth	0.008	0.004	0.186	-0.626***	-0.048*	-0.034	-0.007	-0.038***	0.052**		-0.023	0.016	0.021	-0.131***	-0.392***	0.032*	0.021	0.030	-0.026	-0.097
		(0.012)	(0.012)	(0.159)	(0.153)	(0.025)	(0.027)	(0.009)	(0.012)	(0.021)		(0.031)	(0.029)	(0.043)	(0.045)	(0.055)	(0.017)	(0.026)	(0.032)	(0.027)	(0.174)
	Tempr. Extremes 12months post birth	0.000	-0.059	-0.174	0.864***	0.087	0.171	-0.074	-0.100	0.049		-0.068	0.162	0.068	-0.037	-0.627***	0.022	0.033	0.327*	0.277	1.381
		(0.062)	(0.083)	(0.290)	(0.191)	(0.090)	(0.113)	(0.053)	(0.080)	(0.058)		(0.136)	(0.128)	(0.090)	(0.101)	(0.208)	(0.062)	(0.117)	(0.178)	(0.200)	(1.355)
6	MEPI score	0.032	0.018	0.037	0.004	0.013	0.081	-0.146	-0.067	0.400		0.076	0.153***	-0.020	0.060**	0.025	0.088***	0.155**	0.185**	0.218*	0.031
		(0.040)	(0.023)	(0.071)	(0.034)	(0.108)	(0.082)	(0.162)	(0.103)	(0.508)		(0.049)	(0.044)	(0.034)	(0.030)	(0.048)	(0.034)	(0.076)	(0.087)	(0.117)	(0.415)
	Tempr. extremes 12months post birth	0.003	-0.052	-0.341	0.807***	0.107	0.134	-0.071	-0.090	0.038		-0.065	0.225*	0.114	-0.248	-0.386	0.085	0.072	0.320*	0.330*	0.848
		(0.062)	(0.087)	(0.438)	(0.217)	(0.093)	(0.125)	(0.052)	(0.085)	(0.095)		(0.148)	(0.136)	(0.174)	(0.201)	(0.412)	(0.071)	(0.121)	(0.186)	(0.200)	(0.898)
	MEPI score × Tempr. extremes 12months	-0.348	-0.117	0.086	0.124	-0.654	1.344	0.038	0.010	-0.136		0.136	-1.113*	-0.062	0.405	-0.638	-0.670*	-1.865	0.268	-2.998	-0.618
		(0.552)	(0.483)	(0.542)	(0.236)	(1.191)	(1.455)	(0.053)	(0.038)	(0.200)		(0.495)	(0.620)	(0.233)	(0.310)	(0.606)	(0.398)	(1.368)	(1.452)	(2.160)	(8.247)
WASTING																					
7	MEPI score	0.030	-0.022**	-0.058	0.020	0.011	-0.046	0.016	0.029	-0.014		-0.007	0.014	0.004	0.013	0.024	-0.001	-0.013	-0.016	-0.045	-0.114
		(0.023)	(0.011)	(0.045)	(0.020)	(0.069)	(0.030)	(0.018)	(0.042)	(0.021)		(0.018)	(0.017)	(0.028)	(0.024)	(0.022)	(0.013)	(0.028)	(0.068)	(0.047)	(0.111)
INFANT MORTALITY																					
8	MEPI score, instrumented	-0.001	0.000	0.003	0.015	-0.049	0.002	-0.011	0.033	-0.003	-0.020	0.018	0.023*	-0.011	-0.043	-0.011	0.006	-0.005	-0.027	-0.001	-0.065
		(0.012)	(0.015)	(0.089)	(0.038)	(0.041)	(0.035)	(0.012)	(0.051)	(0.033)	(0.078)	(0.035)	(0.014)	(0.050)	(0.057)	(0.044)	(0.029)	(0.056)	(0.040)	(0.055)	(0.091)
9	MEPI score	-0.026	0.006	-0.006	-0.018	0.004	0.010	0.011	0.039	-0.011	-0.011	0.008	0.020*	0.003	0.001	0.005	-0.013	-0.003	0.051**	0.004	0.071*
		(0.019)	(0.011)	(0.023)	(0.018)	(0.029)	(0.027)	(0.015)	(0.031)	(0.015)	(0.018)	(0.023)	(0.011)	(0.018)	(0.017)	(0.015)	(0.015)	(0.024)	(0.021)	(0.030)	(0.038)
10	Dirty cooking fuels	-0.019	0.004	-0.023	0.002			0.004		-0.002	-0.004	0.005	0.015*	-0.003	-0.002	0.007	-0.011		0.023		
		(0.015)	(0.004)	(0.019)	(0.008)			(0.008)		(0.010)	(0.000)	(0.011)	(0.008)	(0.009)	(0.008)	(0.007)	(0.013)		(0.020)		
11	MEP PCA 1st-component score	-0.024	0.008	-0.008	-0.012	0.011	0.001	0.007	0.038*	-0.004	-0.006	0.009	0.020*	0.005	0.001	0.002	-0.015	-0.028*	0.039*	0.002	-0.136
		(0.020)	(0.013)	(0.022)	(0.021)	(0.017)	(0.026)	(0.013)	(0.019)	(0.010)	(0.012)	(0.023)	(0.011)	(0.018)	(0.017)	(0.016)	(0.015)	(0.017)	(0.020)	(0.067)	(0.183)
12	Tempr. Extremes 9months pre birth	-0.009	-0.005	0.033	0.293***	0.000	0.003	-0.014***	-0.017***	0.006	-0.002	-0.003	-0.008	-0.008	-0.012	-0.030*	-0.019**	-0.009	-0.018	0.010	-0.027
		(0.007)	(0.006)	(0.040)	(0.108)	(0.007)	(0.007)	(0.005)	(0.006)	(0.011)	(0.009)	(0.014)	(0.010)	(0.022)	(0.026)	(0.017)	(0.010)	(0.009)	(0.011)	(0.009)	(0.017)
	Tempr. Extremes 12months post birth	0.012	0.007	0.082	0.077	0.022	0.029	-0.009	0.024	-0.015	-0.003	-0.046	0.019	-0.038	0.046	-0.060	-0.030	0.046	-0.110	-0.086	0.017
		(0.032)	(0.034)	(0.051)	(0.110)	(0.022)	(0.031)	(0.023)	(0.024)	(0.032)	(0.056)	(0.053)	(0.040)	(0.040)	(0.050)	(0.066)	(0.025)	(0.038)	(0.068)	(0.055)	(0.052)
13	MEPI score	-0.025	-0.003	-0.007	-0.050**	0.004	0.015	0.027	0.050	-0.003	-0.064	0.001	0.022**	-0.014	0.000	-0.003	-0.005	0.017	0.033*	0.020	-0.045
		(0.015)	(0.006)	(0.023)	(0.025)	(0.023)	(0.017)	(0.032)	(0.033)	(0.023)	(0.050)	(0.020)	(0.011)	(0.013)	(0.011)	(0.011)	(0.011)	(0.019)	(0.018)	(0.025)	(0.030)
	Tempr. extremes 12months post birth	-0.006	0.020	0.270**	-0.125	0.031	-0.033*	-0.003*	0.009*	0.001	-0.006**	-0.012	0.013	-0.041	0.098**	-0.046	-0.005	0.011	-0.094	-0.009	0.027
		(0.026)	(0.017)	(0.134)	(0.144)	(0.022)	(0.018)	(0.002)	(0.005)	(0.003)	(0.002)	(0.057)	(0.037)	(0.068)	(0.049)	(0.045)	(0.019)	(0.024)	(0.062)	(0.025)	(0.025)
	MEPI score × Tempr. extremes 12months	0.039	0.118	-0.303	0.728**	-0.534	0.237	-0.004	-0.020*	0.004	0.020	-0.304	-0.042	0.005	-0.145*	0.060	0.051	-0.312	0.115	-0.649	0.812***
		(0.251)	(0.115)	(0.210)	(0.337)	(0.473)	(0.365)	(0.011)	(0.012)	(0.010)	(0.019)	(0.204)	(0.165)	(0.100)	(0.086)	(0.066)	(0.123)	(0.202)	(0.256)	(0.617)	(0.315)
NEO-NATAL MORTALITY																					
14	MEPI score	-0.040*	-0.009	-0.026	-0.013	-0.004	0.003	0.011	-0.015	-0.021	0.001	-0.034	0.006	-0.003	0.009	0.004	-0.015	-0.030	0.040**	0.019	
		(0.023)	(0.011)	(0.019)	(0.013)	(0.019)	(0.023)	(0.012)	(0.032)	(0.017)	(0.013)	(0.021)	(0.010)	(0.014)	(0.015)	(0.012)	(0.013)	(0.033)	(0.016)	(0.019)	
15	Tempr. Extremes 9months pre birth	-0.001	-0.000	-0.002	0.012*	-0.000	0.000	-0.001**	-0.002***	0.000	-0.000	0.000	-0.000	-0.002	0.001	-0.002	-0.002***	-0.001	-0.001	0.000	-0.001
		(0.001)	(0.001)	(0.003)	(0.007)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Notes: Variable AMEs are reported. Statistical significance is given by * at ١٠ percent, ** at ٥ percent, and *** at ١ percent level. Standard errors in parentheses are heteroskedasticity robust and clustered at the household level. The baseline group is newborn boys in male-headed urban wealthy households with highly educated mothers, and fathers of unknown educational attainment. Child samples are nationally weighted. Mortality regressions evaluated among children ١٢-٥٩ months old.

Table ٤b (cont.) Summary of Key Variables' Marginal Effects – Regressions on Pooled Survey Waves

		ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR12	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
STUNTING (Pooled survey rounds)										
Model 16	MEPI score	0.018	0.018	0.051	-0.044	0.014	0.131***	0.014	0.077***	0.139**
		(0.020)	(0.032)	(0.057)	(0.032)	(0.041)	(0.030)	(0.019)	(0.030)	(0.058)
17	Tempr. Extremes 9months pre birth	0.005	-0.014	0.011	-0.014*	0.052**	0.000	-0.137***	0.047***	0.003
		(0.008)	(0.009)	(0.015)	(0.009)	(0.021)	(0.021)	(0.025)	(0.014)	(0.019)
	Tempr. Extremes 12months post birth	0.005	-0.008	0.176***	-0.086**	0.049	0.034	-0.006	0.035	0.145*
		(0.046)	(0.009)	(0.056)	(0.040)	(0.058)	(0.088)	(0.055)	(0.054)	(0.082)
	(Joint significance test, Chi-squared statistic)	0.35	4.76*	10.17***	6.78**	6.15**	0.15	30.02***	12.04***	3.15
INFANT MORTALITY (Pooled survey rounds)		ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR12-18	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
18	MEPI score	-0.002	-0.018	-0.008	0.013	-0.011	0.011	0.002	-0.013	0.022**
		(0.009)	(0.015)	(0.021)	(0.012)	(0.011)	(0.013)	(0.010)	(0.013)	(0.010)
19	Tempr. Extremes 9months pre birth	-0.007	0.008**	-0.002	-0.014***	0.003	-0.004	-0.014	-0.016**	-0.008*
		(0.005)	(0.004)	(0.005)	(0.004)	(0.007)	(0.009)	(0.012)	(0.007)	(0.005)
	Tempr. Extremes 12months post birth	0.011	0.008*	0.013	0.001	-0.008	-0.032	-0.013	-0.008	-0.039
		(0.023)	(0.005)	(0.018)	(0.017)	(0.029)	(0.033)	(0.025)	(0.021)	(0.025)
	(Joint significance test, Chi-squared statistic)	2.63	7.23**	0.71	13.85***	0.25	1.03	1.96	5.39*	6.72**

Notes: Mortality regressions evaluated among children ١٢-٥٩ months old.

Table ٥. Marginal effects from probit regressions of stunting on MEPI scores (pooled surveys by country)

	ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR12	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
MEPI score	0.018	0.018	0.051	-0.044	0.014	0.131***	0.014	0.077***	0.139**
	(0.020)	(0.032)	(0.057)	(0.032)	(0.041)	(0.030)	(0.019)	(0.030)	(0.058)
Female household	0.003	-0.033***	-0.010	0.018	0.065**	-0.027	0.014*	0.013	-0.004
	(0.011)	(0.013)	(0.014)	(0.013)	(0.029)	(0.017)	(0.007)	(0.016)	(0.021)
Female child	-0.016***	-0.011	-0.013**	0.009*	-0.030***	-0.028***	-0.018***	-0.007	0.001
	(0.004)	(0.011)	(0.006)	(0.005)	(0.010)	(0.009)	(0.006)	(0.005)	(0.008)
Child age (yrs)	0.008	0.062***	0.026***	0.049***	0.024*	0.098***	0.170***	0.009	-0.014
	(0.006)	(0.015)	(0.008)	(0.007)	(0.013)	(0.012)	(0.008)	(0.007)	(0.011)
Child age squared	-0.001	-0.014***	-0.006***	-0.011***	-0.007**	-0.019***	-0.027***	-0.003**	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)
Father: Primary education	-0.012	-0.035**	0.010	-0.009	-0.038	-0.016	-0.016*	-0.099**	-0.017
	(0.008)	(0.017)	(0.013)	(0.010)	(0.031)	(0.011)	(0.008)	(0.041)	(0.022)
Father: Secondary education	-0.002	-0.023	-0.012	-0.031***	-0.027	-0.006	-0.031**	-0.086**	-0.031
	(0.008)	(0.017)	(0.012)	(0.010)	(0.030)	(0.016)	(0.013)	(0.040)	(0.023)
Father: Higher education	0.007	0.003	-0.014		-0.031	0.016		-0.097**	-0.027
	(0.011)	(0.020)	(0.015)		(0.034)	(0.021)		(0.040)	(0.026)
Father: Not present	0.004			-0.052**			0.004	-0.068	0.034
	(0.014)			(0.020)			(0.014)	(0.046)	(0.032)
Mother: Primary education	-0.011	0.027	0.001	-0.026***	0.028	-0.013	0.003	-0.059	-0.029**
	(0.008)	(0.016)	(0.012)	(0.008)	(0.026)	(0.012)	(0.008)	(0.048)	(0.014)
Mother: Secondary education	-0.022***	-0.016	-0.017*	-0.046***	0.028	0.006	-0.041***	-0.079*	-0.029*
	(0.007)	(0.016)	(0.009)	(0.010)	(0.024)	(0.016)	(0.012)	(0.047)	(0.015)
Mother: Higher education	-0.035***	-0.136**	-0.022*		0.003	-0.064**		-0.094**	-0.045**
	(0.010)	(0.054)	(0.013)		(0.027)	(0.030)		(0.047)	(0.018)
Rural residence	-0.005	0.001	-0.009	-0.001	0.010	0.034***	-0.015	0.002	0.017
	(0.005)	(0.014)	(0.008)	(0.007)	(0.011)	(0.012)	(0.010)	(0.006)	(0.011)
Wealth: poorest	0.015*	0.084***	0.017	0.036***	0.123***	0.078***	0.137***	0.033**	-0.019
	(0.009)	(0.027)	(0.013)	(0.012)	(0.029)	(0.020)	(0.021)	(0.014)	(0.019)
Wealth: poorer	0.006	0.061**	0.015	0.020*	0.077***	0.068***	0.111***	0.037***	-0.033*
	(0.008)	(0.024)	(0.012)	(0.011)	(0.027)	(0.017)	(0.020)	(0.011)	(0.017)
Wealth: middle	-0.002	0.024	-0.002	-0.005	0.071**	0.037**	0.083***	0.013	-0.038**
	(0.008)	(0.023)	(0.011)	(0.011)	(0.028)	(0.016)	(0.017)	(0.009)	(0.016)
Wealth: richer	0.002	0.039*	-0.002	0.001	0.079***	-0.002	0.046***	0.004	-0.020
	(0.008)	(0.022)	(0.010)	(0.012)	(0.027)	(0.016)	(0.014)	(0.009)	(0.015)
Wave 2	-0.012***	-0.124***	-0.045***	-0.124***		0.034***	-0.015*	0.013*	-0.007
	(0.005)	(0.014)	(0.006)	(0.007)		(0.011)	(0.009)	(0.007)	(0.010)
Wave 3							0.001		0.051***
							(0.009)		(0.014)
Observations	27,714	6,641	23,774	51,402	6267	12,585	27,957	12,634	7,659
Chi-squared	190.6***	288.19***	532.7***	1036***	146.29***	391.4***	1026***	158.70***	118.2***
Pseudo R-squared	0.0177	0.0733	0.0361	0.0568	0.0784	0.0724	0.0526	0.0255	0.0282

Table ٦. Marginal effects from probit regressions of stunting on temperature extremes (pooled surveys by country)

	ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR12	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
Tempr. Extremes 9months pre birth	0.005	-0.014	0.011	-0.014*	0.052**	0.000	-0.137***	0.047***	0.003
	(0.008)	(0.009)	(0.015)	(0.009)	(0.021)	(0.021)	(0.025)	(0.014)	(0.019)
Tempr. Extremes 12months post birth	0.005	-0.008	0.176***	-0.086**	0.049	0.034	-0.006	0.035	0.145*
	(0.046)	(0.009)	(0.056)	(0.040)	(0.058)	(0.088)	(0.055)	(0.054)	(0.082)
(Joint significance test, Chi-squared statistic)	0.35	4.76*	10.17***	6.78**	6.15**	0.15	30.02***	12.04***	3.15
Female household	0.001	-0.036***	-0.009	0.016	0.071**	-0.024	0.013*	0.013	-0.004
	(0.012)	(0.013)	(0.014)	(0.013)	(0.033)	(0.017)	(0.007)	(0.017)	(0.021)
Female child	-0.016***	-0.015	-0.013**	0.009*	-0.030***	-0.030***	-0.018***	-0.008	0.000
	(0.004)	(0.012)	(0.006)	(0.005)	(0.010)	(0.009)	(0.006)	(0.005)	(0.008)
Child age (yrs)	0.006	0.080***	0.034***	0.052***	0.018	0.100***	0.166***	0.008	-0.018
	(0.006)	(0.020)	(0.009)	(0.007)	(0.013)	(0.013)	(0.008)	(0.008)	(0.012)
Child age squared	-0.000	-0.018***	-0.008***	-0.012***	-0.006**	-0.019***	-0.027***	-0.003**	0.002
	(0.001)	(0.004)	(0.002)	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Father: Primary education	-0.012	-0.040**	0.010	-0.008	-0.036	-0.017	-0.016*	-0.101**	-0.022
	(0.008)	(0.017)	(0.013)	(0.010)	(0.031)	(0.012)	(0.008)	(0.041)	(0.023)
Father: Secondary education	-0.003	-0.023	-0.013	-0.030***	-0.024	-0.006	-0.031**	-0.089**	-0.035
	(0.008)	(0.017)	(0.012)	(0.010)	(0.029)	(0.017)	(0.013)	(0.041)	(0.023)
Father: Higher education	0.007	0.012	-0.015		-0.029	0.019		-0.099**	-0.031
	(0.011)	(0.022)	(0.015)		(0.034)	(0.022)		(0.041)	(0.026)
Father: Not present	0.004			-0.061***			0.006	-0.066	0.033
	(0.016)			(0.021)			(0.013)	(0.048)	(0.033)
Mother: Primary education	-0.010	0.029*	0.000	-0.025***	0.029	-0.012	0.003	-0.061	-0.039***
	(0.008)	(0.017)	(0.012)	(0.008)	(0.026)	(0.012)	(0.008)	(0.054)	(0.014)
Mother: Secondary education	-0.022***	-0.022	-0.018*	-0.045***	0.029	0.008	-0.041***	-0.081	-0.037**
	(0.007)	(0.017)	(0.009)	(0.010)	(0.024)	(0.016)	(0.012)	(0.054)	(0.015)
Mother: Higher education	-0.034***	-0.149***	-0.022*		0.004	-0.061**		-0.096*	-0.057***
	(0.010)	(0.053)	(0.013)		(0.027)	(0.031)		(0.054)	(0.018)
Rural residence	-0.008	0.001	-0.009	-0.001	0.009	0.032**	-0.013	0.003	0.020*
	(0.005)	(0.014)	(0.008)	(0.007)	(0.011)	(0.012)	(0.010)	(0.006)	(0.011)
Wealth: poorest	0.020**	0.091***	0.017	0.035***	0.124***	0.123***	0.143***	0.043***	-0.017
	(0.009)	(0.023)	(0.013)	(0.012)	(0.030)	(0.019)	(0.018)	(0.013)	(0.019)
Wealth: poorer	0.008	0.063***	0.015	0.021*	0.078***	0.078***	0.116***	0.039***	-0.033*
	(0.008)	(0.022)	(0.012)	(0.012)	(0.027)	(0.018)	(0.017)	(0.011)	(0.017)
Wealth: middle	0.001	0.022	-0.002	-0.004	0.071**	0.039**	0.087***	0.014	-0.040**
	(0.008)	(0.022)	(0.011)	(0.011)	(0.028)	(0.017)	(0.015)	(0.009)	(0.016)
Wealth: richer	0.004	0.035	-0.002	0.002	0.078***	-0.002	0.048***	0.003	-0.020
	(0.008)	(0.022)	(0.010)	(0.012)	(0.027)	(0.017)	(0.014)	(0.009)	(0.015)
Wave 2	-0.012**	-0.119***	-0.044***	-0.116***		0.020	-0.017**	0.008	-0.013
	(0.005)	(0.014)	(0.006)	(0.008)		(0.012)	(0.009)	(0.006)	(0.011)
Wave 3							0.008		0.033*
							(0.010)		(0.019)
Observations	27,102	6,271	23,774	50,901	6267	11,828	27,882	12,536	7,471
Chi-squared	180.3***	281.74***	536.6***	1053***	156.16***	370.4***	1053***	159.52***	119.2***
Pseudo R-squared	0.0175	0.0743	0.0367	0.0574	0.0823	0.0694	0.054	0.0257	0.0283

Table ٧. Marginal effects from probit regressions of infant mortality on MEPI scores (pooled surveys by country)

	ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR12-18	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
MEPI score	-0.002	-0.018	-0.008	0.013	-0.011	0.011	0.002	-0.013	0.022**
	(0.009)	(0.015)	(0.021)	(0.012)	(0.011)	(0.013)	(0.010)	(0.013)	(0.010)
Female household	-0.007	-0.011*	0.006	-0.001	-0.005	-0.012	-0.053***	-0.005	-0.008
	(0.007)	(0.006)	(0.005)	(0.005)	(0.010)	(0.008)	(0.004)	(0.008)	(0.009)
Female child	-0.003	-0.005	-0.004*	-0.006***	-0.001	-0.006	-0.009***	-0.002	-0.007***
	(0.002)	(0.005)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Father: Primary education	-0.015***	-0.004	-0.005	-0.016***	0.003	-0.002	0.002	0.004	-0.007
	(0.004)	(0.007)	(0.006)	(0.005)	(0.010)	(0.005)	(0.004)	(0.005)	(0.004)
Father: Secondary education	-0.021***	0.001	-0.009*	-0.014**	0.002	0.004	0.000	0.001	-0.002
	(0.004)	(0.007)	(0.005)	(0.005)	(0.009)	(0.005)	(0.006)	(0.005)	(0.004)
Father: Higher education	-0.029***		-0.007	-0.013**	-0.003	-0.003		0.005	-0.001
	(0.007)		(0.007)	(0.006)	(0.010)	(0.010)		(0.005)	(0.006)
Father: Not present									0.003
									(0.007)
Mother: Primary education	0.007**	-0.010	0.006	-0.003	0.027**	-0.003	0.001	0.039***	-0.010***
	(0.004)	(0.008)	(0.005)	(0.003)	(0.011)	(0.005)	(0.004)	(0.009)	(0.004)
Mother: Secondary education	0.003	-0.012	0.001	-0.003	0.023**	0.002	-0.007	0.026***	-0.017***
	(0.004)	(0.008)	(0.005)	(0.004)	(0.010)	(0.006)	(0.007)	(0.009)	(0.005)
Mother: Higher education	0.007		-0.010	-0.011*	0.014	-0.017		0.002	-0.017***
	(0.006)		(0.007)	(0.006)	(0.010)	(0.013)		(0.010)	(0.006)
Mother: Not present									0.128***
									(0.016)
Rural residence	0.003	0.017**	0.002	-0.002	0.003	-0.000	-0.005	-0.002	0.005
	(0.003)	(0.007)	(0.004)	(0.003)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)
Wealth: poorest	0.003	-0.004	0.011**	-0.002	0.001	0.017*	0.015	0.004	-0.009*
	(0.005)	(0.012)	(0.005)	(0.005)	(0.008)	(0.009)	(0.010)	(0.007)	(0.006)
Wealth: poorer	-0.003	0.003	0.007	-0.005	-0.004	0.017**	0.018**	0.003	-0.006
	(0.005)	(0.011)	(0.005)	(0.005)	(0.007)	(0.008)	(0.009)	(0.006)	(0.005)
Wealth: middle	-0.002	-0.004	0.007	-0.008	-0.005	0.012	0.016**	0.004	0.001
	(0.004)	(0.011)	(0.005)	(0.005)	(0.008)	(0.008)	(0.008)	(0.004)	(0.004)
Wealth: richer	0.001	-0.009	-0.000	-0.005	-0.002	0.007	0.011*	-0.002	-0.014***
	(0.004)	(0.010)	(0.005)	(0.005)	(0.007)	(0.008)	(0.006)	(0.005)	(0.005)
Wave 2	-0.004*	-0.003	0.004	-0.011***	-0.001	-0.013***	-0.001	-0.021***	-0.009***
	(0.002)	(0.007)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)
Wave 3							-0.011***		-0.015***
							(0.004)		(0.003)
Observations	24,652	6,089	26,244	44,417	17,130	10,672	27,651	11,798	7,072
Chi-squared	117.7***	18.97	110.3***	79***	32.4	60.80***	233.7***	148.2***	1386***
Pseudo R-squared	0.0308	0.0156	0.0226	0.0128	0.0157	0.0395	0.0391	0.0671	0.3450

Notes: Regressions evaluated among children ١٢-٥٩ months old.

Table ٨. Marginal effects from probit regressions of infant mortality on temperature extremes (pooled surveys by country)

	ALG12-18	COM12-22	EGY14-21	IRQ11-18	JOR18	MAR11-18	MRT11-15-21	PAL14-20	TUN11-18-23
Tempr. extremes 9months pre birth	-0.007	0.008**	-0.002	-0.014***	0.003	-0.004	-0.014	-0.016**	-0.008*
	(0.005)	(0.004)	(0.005)	(0.004)	(0.007)	(0.009)	(0.012)	(0.007)	(0.005)
Tempr. extremes 12months post birth	0.011	0.008*	0.013	0.001	-0.008	-0.032	-0.013	-0.008	-0.039
	(0.023)	(0.005)	(0.018)	(0.017)	(0.029)	(0.033)	(0.025)	(0.021)	(0.025)
(Joint significance test, Chi-squared statistic)	2.63	7.23**	0.71	13.85***	0.25	1.03	1.96	5.39*	6.72**
Female household	-0.006	-0.011*	0.004	-0.002	-0.007	-0.012	-0.042***	-0.003	-0.005
	(0.006)	(0.006)	(0.004)	(0.005)	(0.010)	(0.008)	(0.004)	(0.008)	(0.006)
Female child	-0.002	-0.005	-0.004**	-0.006***	-0.001	-0.006	-0.008***	-0.002	-0.004*
	(0.002)	(0.005)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)
Father: Primary education	-0.016***	-0.004	-0.007	-0.015***	0.003	-0.002	-0.003	0.007	-0.006*
	(0.004)	(0.007)	(0.005)	(0.005)	(0.010)	(0.005)	(0.005)	(0.005)	(0.003)
Father: Secondary education	-0.020***	0.002	-0.008	-0.013**	0.002	0.004	-0.003	0.004	-0.004
	(0.004)	(0.007)	(0.005)	(0.005)	(0.009)	(0.005)	(0.006)	(0.005)	(0.004)
Father: Higher education	-0.028***		-0.006	-0.013**	-0.002	-0.001		0.008	-0.002
	(0.006)		(0.006)	(0.006)	(0.010)	(0.010)		(0.005)	(0.005)
Father: Not present									0.004
									(0.005)
Mother: Primary education	0.008**	-0.010	0.004	-0.002	0.027**	-0.003	-0.004	0.044***	-0.007**
	(0.004)	(0.008)	(0.005)	(0.003)	(0.011)	(0.005)	(0.004)	(0.011)	(0.003)
Mother: Secondary education	0.004	-0.012	0.001	-0.001	0.023**	0.003	-0.011*	0.032***	-0.009**
	(0.004)	(0.008)	(0.004)	(0.004)	(0.010)	(0.006)	(0.007)	(0.011)	(0.004)
Mother: Higher education	0.008		-0.008	-0.008	0.014	-0.016		0.011	-0.009*
	(0.005)		(0.006)	(0.006)	(0.010)	(0.013)		(0.011)	(0.005)
Mother: Not present									0.097***
									(0.015)
Rural residence	0.003	0.015**	0.003	-0.002	0.003	-0.000	-0.003	-0.003	0.000
	(0.003)	(0.007)	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)
Wealth: poorest	0.003	-0.011	0.011**	-0.002	0.001	0.022**	0.015**	0.001	0.000
	(0.005)	(0.010)	(0.005)	(0.005)	(0.008)	(0.009)	(0.008)	(0.006)	(0.004)
Wealth: poorer	-0.002	-0.003	0.006	-0.005	-0.004	0.020**	0.019***	0.002	-0.001
	(0.004)	(0.010)	(0.005)	(0.005)	(0.007)	(0.009)	(0.007)	(0.005)	(0.004)
Wealth: middle	-0.002	-0.006	0.006	-0.009*	-0.005	0.015*	0.017***	0.003	0.003
	(0.004)	(0.010)	(0.005)	(0.005)	(0.008)	(0.009)	(0.007)	(0.004)	(0.003)
Wealth: richer	0.002	-0.009	-0.000	-0.006	-0.002	0.009	0.010*	-0.001	-0.006*
	(0.004)	(0.010)	(0.004)	(0.005)	(0.007)	(0.009)	(0.006)	(0.004)	(0.003)
Wave 2	-0.004	-0.009	0.000	-0.010***	0.000	-0.011**	0.005	-0.017***	-0.003
	(0.003)	(0.007)	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.003)
Wave 3							-0.000		-0.008***
							(0.004)		(0.002)
Observations	24,341	6,055	26,025	44,201	17,130	10,256	24,298	11,768	6,883
Chi-squared	102***	26.03*	92.52***	91.23***	33.03***	62.08***	182.1***	128.7***	992.8***
Pseudo R-squared	0.0288	0.0212	0.0198	0.0164	0.0153	0.0400	0.0342	0.0703	0.3540

Notes: Regressions evaluated among children ١٢-٥٩ months old.

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Documentation for the Included Surveys

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Appendix

Table A١. Description of survey samples

	Survey instrument	Households (complete interviews)	Ever-married women ١٥–٤٩ in women's module (complete int.)	Children younger than ٥ covered by responding women (complete int.)	Live births covered by responding women
Algeria '١٢-١٣	MICS	٢٧,١٩٨	٣٨,٥٤٧	١٤,٧٠١	٥٣٦٦٨
Algeria '١٨-١٩	MICS	٢٩,٩١٩	٣٧,٢٢٧	١٤,٨٨٩	٥٠٦٧٩
Comoros '١٢	DHS	٤,٤٨٢	٣,١٤٩	٢,٨٨٦	١١,٤٩٧
Comoros '٢٢	MICS	٦,١٥٨	٦,٩٤٥	٤,٤٩٧	١٦,٥٣٣
Egypt '١٤	DHS	٢٨,١٧٥	٥٩,٢٦٦	٥٦,٥٦٨	١٥,٨٤٨
Egypt '٢١	FHS	٣٠,٦٦٧	٢١,٢٦٧	١٥,٧٨٥	٥٩,٤٩٠
Iraq '١١	MICS	٣٥,٧٠١	٥٥,١٩٤	٣٣,٩٠٨	١٣,٩٩٤
Iraq '١٨	MICS	٢٠,٢١٤	٣٠,٦٦٠	١٦,٦٨٩	٧٠,٩٨٦
Jordan '١٢	DHS	١٥,١٩٠	١٠,٣٠٤	٦,٣٥٠	٨,٤٦٢
Jordan '١٧-١٨	DHS	٧,١٧٦	١٠,٥٢٩	١٠,٢١٠	٤٧,٠٤٠
Jordan '٢٣	DHS*	--	--	--	--
Mauritania '١١	MICS	١٠,٣٢٠	١٣,٦٥٧	٩,٥٤٣	٣٠,٣٣٥
Mauritania '١٥	MICS	١١,٧٦٥	١٤,٣٤٢	١٠,٦٦٣	٣٧,٥٠٦
Mauritania '١٩-٢١	DHS	٦,٣٩١	١٩,٩٤١	١١,١٧٦	٣٩,٧٩٣
Morocco '١١	PAPFAM	١٥,٣٤٣	١١,٠٦٩	٦,١١٧	٨,١٣٦
Morocco '١٨	ENPSF	١٥,٠٢٢	٩,٩٦٩	٦,٦٦٢	٦,٣٣٢
Palestine '١٤	MICS	١٠,١٨٢	١٣,٣٦٧	٧,٨١٦	٧,٩٤٨
Palestine '١٩-٢٠	MICS	٩,٣٢٦	١١,١٣٥	٦,٣٢٨	٢٥,٤٨٢
Tunisia '١١-١٢	MICS	٩,١٧١	١٠,٢١٥	٢,٨٩٩	٢,٩٧٧
Tunisia '١٨	MICS	١١,٢٢٥	١٠,٥٥٩	٣,٤٢٠	١٤,٠٥٨
Tunisia '٢٢-٢٣	MICS	٨,٩٣٧	٧,١٤٠	١,٩٢٦	٩,٤١٥
Turkey '١٣	DHS	١١,٧٩٤	٩,٧٤٦	٣,٤٨٧	٣,٣٢٦
Turkey '١٨-١٩	DHS	١١,٠٥٦	٧,٣٤٦	٢,٩٧٩	٢,٥٦٨

Notes: Sample sizes are only partially standardized due to differences in format, variable coverage, and missing observations in individual surveys. Samples sizes used in regression models may be lower than these numbers due to missing data for dependent or explanatory variables, or perfect prediction of outcomes among some explanatory variables for some observations. "--" indicates missing data for a particular survey module. * Currently unavailable.

Table A٢. Exploring Energy Dynamics: Key Variables in DHS Surveys

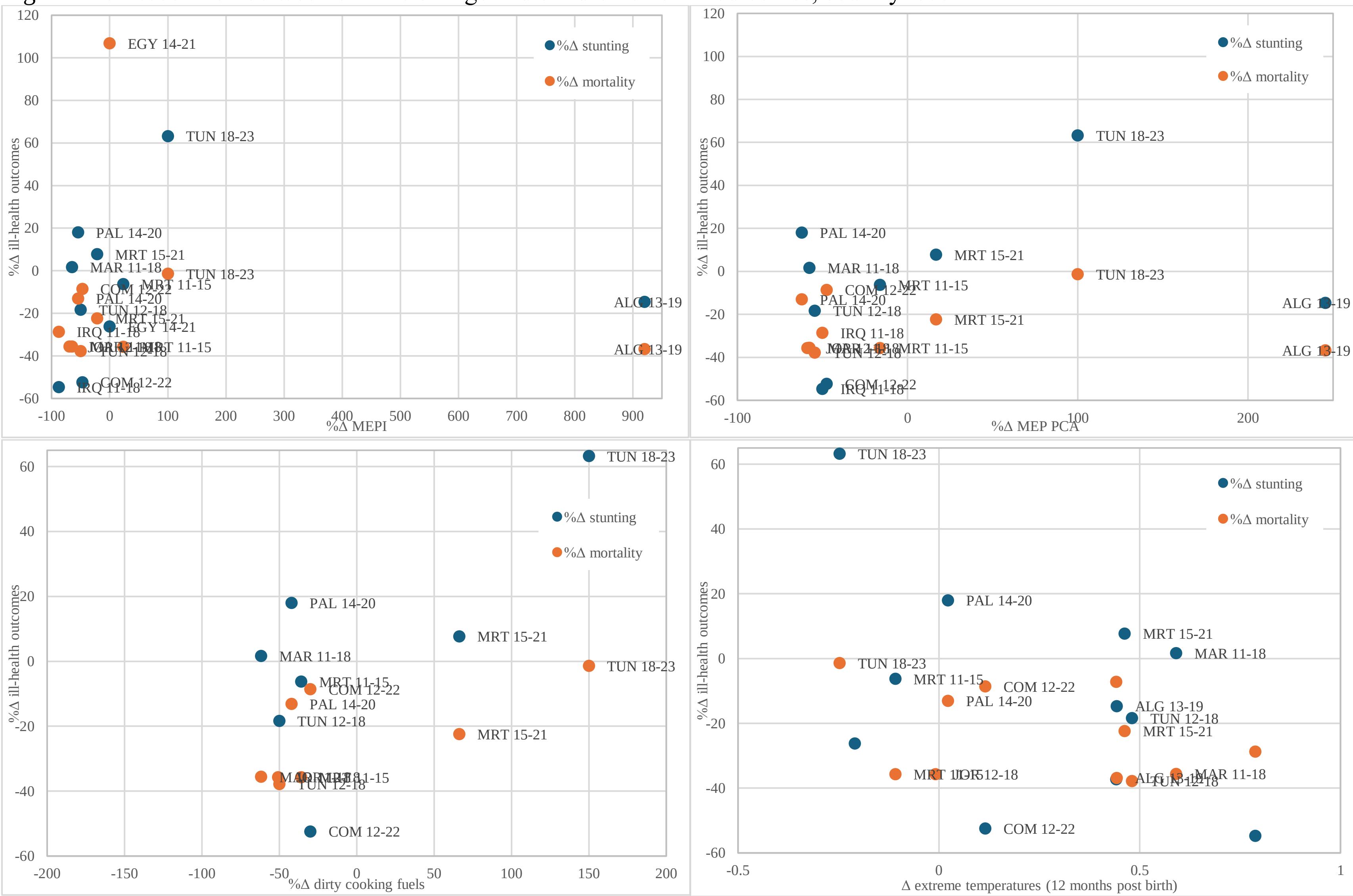
Exposure to non-clean fuels	Access to electricity	Low-carbon energy transition
- solid fuel used for cooking (charcoal, wood, straw/shrubs, dung, crop residue, garbage, other). - solid fuel used for space heating (charcoal, wood, straw/shrubs, dung, crop residue, garbage/plastic). - fuel used for lighting (gasoline, kerosene, oil, candle, fire). - cooking done in a separate room from living quarters - household that cook have a chimney, hood or neither. - in child labor, child is exposed to (dust, fumes, gas, extreme cold, heat, humidity).	- no electricity. - access to household appliances whose acquisition depends critically on reliable energy (refrigerator/freezer, radio, television, telephone/mobile) - no lighting at home	- clean fuels used which include electricity, liquefied petroleum gas (LPG), natural gas, and biogas.

Table A۳. Summary statistics of explanatory variables in regression samples

	ALG ‘۱۳	ALG '۱۹	EGY ‘۱٤	IRQ ‘۱۱	JOR ‘۱۲	MRT ‘۱۱	PAL ‘۱٤	TUN ‘۱۲
MEPI score	۰,۰۱۷	۰,۰٦۱	۰,۰۱۲	۰,۰۱۹	۰,۰۰٦	۰,٥٥٥	۰,۰۹۳	۰,۰۱۹
	(۰,۰٦۸)	(۰,۱٤٤)	(۰,۰٤٦)	(۰,۰۸۲)	(۰,۰۳۳)	(۰,۳۲٥)	(۰,۱۰۸)	(۰,۰۷۲)
Female HH	۰,۰۳٦	۰,۰۲۸	۰,۰۳۲	۰,۰٥۸	۰,۰٤٤	۰,۱۹٤	۰,۰۲٥	۰,۰۱٦
	(۰,۱۸۷)	(۰,۱٦٤)	(۰,۱۷٥)	(۰,۲۳۳)	(۰,۲۰٥)	(۰,۳۹٥)	(۰,۱٥٥)	(۰,۱۲٥)
Female child	۰,٤۸۹	۰,٤۸٦	۰,٤۸۲	۰,٤۸۹	۰,٥۰۰	۰,٤۹٤	۰,٤۸٥	۰,٤۷۳
	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٥۰۰)	(۰,٤۹۹)
Age	۲,۳۲۰	۲,٤۸٥	۲,٤٤۹	۲,۳۷۳	۳,٥۰۸	۲,۳۱۷	۲,٤۹۷	۲,٤۲۱
	(۱,٤۳۳)	(۱,٤۳۷)	(۱,٤۱۳)	(۱,٤۲۳)	(۰,۸٦۱)	(۱,٤۳٦)	(۱,٤٤۱)	(۱,٤۱٦)
Age-squared	۷,٤۳۷	۸,۲۳۷	۷,۹۹٥	۷,٦٥۸	۱۳,۰٤٦	۷,٤۳۰	۸,۳۱۲	۷,۸٦٦
	(۷,۱۳۳)	(۷,۳٤۲)	(۷,۱۸۳)	(۷,۱۳٤)	(٦,۰۲٦)	(۷,۰٦۷)	(۷,٤۰۳)	(۷,۰۷٦)
Father: no education	۰,۱۰٦	۰,۰۸۲	۰,۱۳۲	۰,۰۸۳	۰,۰۱۳	۰,۱٦۳	۰,۰۰٤	۰,۰٤٥
	(۰,۳۰۸)	(۰,۲۷٤)	(۰,۳۳۸)	(۰,۲۷٦)	(۰,۱۱۲)	(۰,۳٦۹)	(۰,۰٦۰)	(۰,۲۰۷)
Father: incomplete	۰,۰۰۲	۰,۱۷۹	۰,۰۸٤	۰,۳۹۹	۰,۰٥۳	۰,۳٦۲	۰,۰۲۹	۰,٤۰۲
primary	(۰,۰۳۹)	(۰,۳۸٤)	(۰,۲۷۷)	(۰,٤۹۰)	(۰,۲۲٥)	(۰,٤۸۱)	(۰,۱٦۸)	(۰,٤۹۰)
Father: complete	۰,۱۹۹	۰,٤۰۱	۰,۰٥۹	۰,٥۱۷	۰,۰٤۳	۰,۱۷۲	۰,۳٥٤	۰,۳۷٥
primary	(۰,۳۹۹)	(۰,٤۹۰)	(۰,۲۳٥)	(۰,٥۰۰)	(۰,۲۰۳)	(۰,۳۷۷)	(۰,٤۷۸)	(۰,٤۸٤)
Father: incomplete	۰,۳٦۷	۰,۲۳۰	۰,۱۲٥	۰,۰۰۱	۰,٥۲۸	۰,۰۲۰	۰,٥۹٦	۰,۱۳٤
secondary	(۰,٤۸۲)	(۰,٤۲۱)	(۰,۳۳۰)	(۰,۰۲۹)	(۰,٤۹۹)	(۰,۱۳۹)	(۰,٤۹۱)	(۰,۳٤۱)
Mother: no education	۰,۱۸۱	۰,۱۲٤	۰,۱۹۲	۰,۱۷۸	۰,۰۱۸	۰,۲٤٤	۰,۰۰٤	۰,۱۳۰
	(۰,۳۸٥)	(۰,۳۲۹)	(۰,۳۹٤)	(۰,۳۸۲)	(۰,۱۳٤)	(۰,٤۳۰)	(۰,۰٦٦)	(۰,۳۳٦)
Mother: incomplete	۰,۰۰۱	۰,۱٤۹	۰,۰٥۱	۰,٥۰۳	۰,۰۳۱	۰,۳۳۱	۰,۰۱۱	۰,۳۳۳
primary	(۰,۰۳٦)	(۰,۳٥٦)	(۰,۲۲۰)	(۰,٥۰۰)	(۰,۱۷٥)	(۰,٤۷۱)	(۰,۱۰٤)	(۰,٤۷۱)
Mother: complete	۰,۱۷۳	۰,۳۲۱	۰,۰٤۰	۰,۳۱۸	۰,۰٥۱	۰,۱٥۸	۰,۲۸۳	۰,۳٦۱
primary	(۰,۳۷۹)	(۰,٤٦۷)	(۰,۱۹٦)	(۰,٤٦٦)	(۰,۲۲۱)	(۰,۳٦٥)	(۰,٤٥۰)	(۰,٤۸۰)
Mother: incomplete	۰,۳۱۰	۰,۲۲٦	۰,۱٤۳	۰,۰۰۱	۰,٤٦۱	۰,۰۰۰	۰,۷۰۲	۰,۱۷٦
secondary	(۰,٤٦۳)	(۰,٤۱۸)	(۰,۳٥۰)	(۰,۰۳۹)	(۰,٤۹۹)	(۰,۰۱٦)	(۰,٤٥۷)	(۰,۳۸۱)
Rural residence	۰,۳۸٥	۰,٤۳٦	۰,۷۱٥	۰,۳۳۸	۰,۱٦٦	۰,٦۰۰	۰,۲۳٦	۰,۳۷۳
	(۰,٤۸۷)	(۰,٤۹٦)	(۰,٤٥۱)	(۰,٤۷۳)	(۰,۳۷۲)	(۰,٤۹۰)	(۰,٤۲٥)	(۰,٤۸٤)
Wealth: poorest	۰,۲۱۹	۰,۲٤۱	۰,۲۰٥	۰,۲٤٤	۰,۲٦۷	۰,۲۲۷	۰,۲٦٥	۰,۲۰۳
	(۰,٤۱۳)	(۰,٤۲۸)	(۰,٤۰٤)	(۰,٤۳۰)	(۰,٤٤۳)	(۰,٤۱۹)	(۰,٤٤۲)	(۰,٤۰۲)
Wealth: poorer	۰,۲۲۱	۰,۲۳۲	۰,۱۹۹	۰,۲۲۳	۰,۲۲۰	۰,۲۰٦	۰,۲۱۸	۰,۲۲۲
	(۰,٤۱٥)	(۰,٤۲۲)	(۰,٤۰۰)	(۰,٤۱٦)	(۰,٤۱٤)	(۰,٤۰٤)	(۰,٤۱۳)	(۰,٤۱٥)
Wealth: middle	۰,۱۹۸	۰,۲۰۰	۰,۲٤۹	۰,۲۰٦	۰,۲۰۱	۰,۱۹۰	۰,۱۸۹	۰,۱۸۸
	(۰,۳۹۹)	(۰,٤۰۰)	(۰,٤۳۲)	(۰,٤۰٥)	(۰,٤۰۱)	(۰,۳۹۲)	(۰,۳۹۲)	(۰,۳۹۱)
Wealth: richer	۰,۱۹۱	۰,۱۸۱	۰,۱۹۹	۰,۱۸۰	۰,۱۸۳	۰,۲۰۳	۰,۱۸۲	۰,۲۲۲
	(۰,۳۹۳)	(۰,۳۸٥)	(۰,۳۹۹)	(۰,۳۸٤)	(۰,۳۸۷)	(۰,٤۰۲)	(۰,۳۸٥)	(۰,٤۱٥)

Notes: Standard deviations in parentheses. Child samples are nationally weighted.

Figure A١. Association between climate change and children's health outcomes, country level



Note: Algeria ١٣-١٩ omitted from panel (c) for its outlying value.