START CENTER | STRATEGIC ANALYSIS, RESEARCH & TRAINING CENTER
Department of Global Health | University of Washington

Health Impacts of Heat Exposure on Mothers and Babies

KEY TAKEAWAYS

Maternal and neonatal vulnerabilities: Extreme heat exposures can overwhelm pregnant individuals' thermoregulatory capacities, resulting in dehydration, placental abnormalities, and dangerous temperature exposures to the fetus. After birth, neonates remain vulnerable to extreme heat due to their small body mass to surface area ratio. Addressing the risks associated with extreme heat exposure requires interventions that may strain resources for vulnerable populations given disparities in wealth, access to health care, and gender power dynamics.

Adverse MNCH outcomes: Extreme heat exposure has been associated with a variety of adverse health outcomes in the literature, including preterm birth (PTB), low birth weight (LBW), stillbirth (SB), congenital anomalies, and maternal hypertension and diabetes.

Data challenges: Studies examining effects of extreme heat exposure come primarily from the global North and utilize a wide array of study designs and exposure definitions. There is a need to strengthen and harmonize data systems in key geographies to enable comparisons between studies.

Increasing exposure to extreme heat: Climate change is increasing extreme heat exposures globally, and particularly across the global South. It is challenging for individuals to adapt to rapid increases in extreme heat exposure, leaving vulnerable communities at increased risk of heat-related complications

Work Overview

PROJECT GOALS

Completed

1. Increase awareness and understanding of climate change, including projections of extreme heat exposure and how MNCH communities are more vulnerable to weather shocks
2. Prioritize the immediate need for research and implementation to address climate change effects in Sub-Saharan Africa (Ethiopia, Kenya, Nigeria and Burkina Faso)
3. Highlight priority research questions and identify evidence-based risk reduction strategies

Future Work

4. Create partner landscape in key geographies and make a call for adaptation

RESEARCH METHODS

5 Experts Interviewed from University of Washington and Climate, Heat, and Maternal and Neonatal Health in Africa (CHAMNHA), and physicians from Ethiopia.

97 Manuscripts reviewed (2020-2022) investigating high ambient temperature exposure and maternal and neonatal health outcomes

66 Manuscripts included as update to Dalugoda et. al. scoping review (2022)

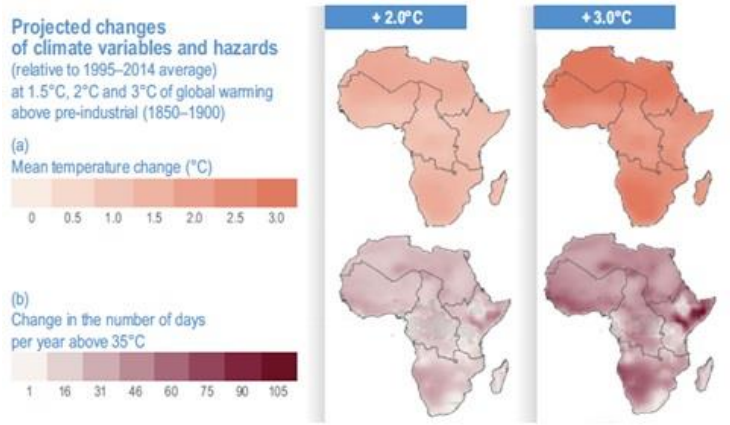
Key Terminology

Term	Definition
Pre-term birth (PTB)	Babies born alive before 37 weeks of pregnancy are completed[1]
Low birthweight (LBW)	Weight at birth of <2500 grams (<5.5 pounds)[2]
Stillbirth (SB)	Babies who die after 28 weeks of pregnancy, but before or during birth[3]
Minimum Mortality Temperature (MMT)	The temperature at which the risk of heat-related mortality is lowest for a given individual[4,5]

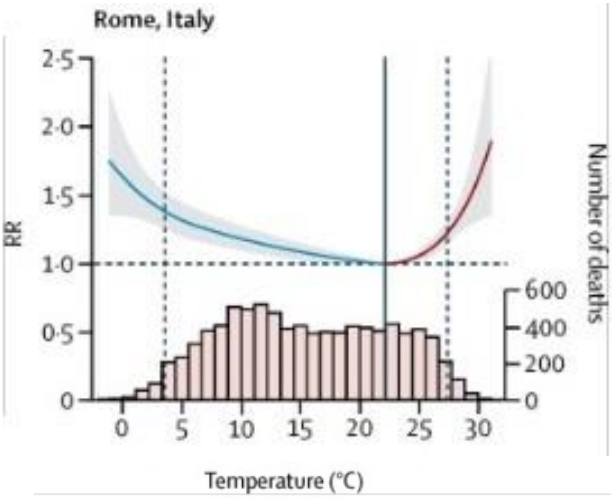
Climate Projection Maps[6]

Children born in Nigeria, Burkina Faso, Kenya, and Ethiopia in 2020 will be exposed to up to 9 times more heatwaves in their lifetimes compared to people born in 1960 under global warming levels (GWL) of 2 degrees C.

The number of potentially lethal heat days per year in East Africa is projected to increase from less than 50 (1995-2005) to between 50 and 120 days per year at GWL 2.5 degrees C.



Minimum Mortality Temperatures



Minimum mortality temperatures (MMTs) vary by climate zone, and studies of urban centers in high income countries (HICs) found that risk of death increases most dramatically at high temperature extremes (>97.5th temperature percentile).[5,7]

The level of individual acclimatization to temperature changes is thought to be significantly determined by regular exposure to a given temperature range.[8] Studies in HICs have shown a decreased risk of death as MMTs increase.[9] However, high heat warning systems, adequate infrastructure and air conditioning, and increased awareness of heat effects may play a role in adaptability in these settings.[9] As extreme heat exposure continues to rapidly increase due to climate change, individuals in low resource settings may remain at increased risk of heat-related mortality due to insufficient adaptation measures.

Vulnerabilities to Heat[10]

Heat exposure has (1) direct effects on maternal and neonatal health; (2) indirect effects on health systems. Both direct and indirect effects will be amplified when considering additional shocks, such as: extreme cold temperatures, air pollution, flooding, etc.

Box 1) Direct impacts on pregnant women
Raised maternal core temperatures with "energy failure" in the fetus
Endocrine system dysfunction
Dehydration
Compromised placental development and function

Box 2) Indirect impacts on infections
Increased reproductive tract infections
Increased food-borne infections
Increased water-borne infections
Increased vector-borne infections

Box 3) Heat impacts on health systems
Poor work performance of health workers, patient disrespect
Compromised cold chains
Compromised safe storage of drugs and diagnostics
Undermine healthcare seeking behaviors

Box 4) Adverse maternal and newborn health outcomes
Hypertensive disorders
Antepartum and postpartum hemorrhage
Prolonged labor
Obstetric emergencies and cesarean sections
Mental health conditions
Other maternal morbidities
Preterm birth, low birth weight, neonatal sepsis
Fetal distress
Stillbirth
Neonatal mortality
Adverse child and adult health and behavioral outcomes

Physiological Vulnerabilities to Heat[10]

Pregnancy

High ambient air temperatures may overwhelm the capacity of maternal thermoregulatory processes that would otherwise allow for homeostatic temperature regulation under normal temperature conditions; endogenous heat production from metabolic and physical activity adds to the overall heat load and is exacerbated by periods of high ambient temperatures.[10] This is exacerbated for pregnant women who are employed in demanding physical labor during hot periods.

Maternal dehydration reduces the amount of amniotic fluid surrounding the fetus, potentially leading to congenital deformities, preterm birth, and stillbirth.[11]

High ambient temperatures increase maternal output of heat-shock proteins, affecting placental adaptation to hypoxia and cell regulation.[12, 13]

Long-term exposure to high ambient temperatures has been linked to placental shrinkage, limiting efficiency of oxygen and nutrient transportation to the fetus.[14]

Labor & Delivery

Exposure to high ambient air temperatures increases the risk of dehydration. This may lead to electrolyte imbalances as well as endothelial, oxidative, and inflammatory effects that overburden cardiovascular and renal functions already strained by pregnancy.[15]

Maternal body temperature increases leading up to and during labor;[10] these temperature increases occur more rapidly for individuals delivering their first baby,[16] have prolonged labor,[17] or who are obese.[18]

Since fetal temperature is consistently 0.3-0.5°C higher than maternal temperatures,[19] changes in maternal regulatory capacities during birth due to high ambient temperatures increases neonates' risk of neurological damage due to lack of oxygen and other substrates delivered to the brain.[20, 21]

Neonatal Period

Neonates are particularly vulnerable to effects of high and low ambient air temperatures due to their small body mass to surface area ratio and an inability to appropriately thermoregulate.[10] Historically, mothers were encouraged to keep neonates warm because of their thermoregulatory difficulties, but this can lead to overheating during warm periods if caretakers are not educated about potential heat stress effects.

Maternal Effects | Neonatal Effects

Dalugoda 2022 Summary[22]

A scoping review by Daloguda, et al., included 75 studies published from 2015-2020. Due to the heterogeneity in exposure definitions and outcome measures in the included studies, no overall estimate of effect sizes are possible. However, the strongest evidence is found for association between elevated temperature and preterm birth. Heat exposure in the last few weeks of pregnancy was associated with increased preterm birth and stillbirth risks. The susceptible window seen most often in studies of preterm birth was acute exposure in the last week and the last month of pregnancy and the most observed susceptible window for stillbirths was the last week of pregnancy. Most studies of low birth weight reported that risk was higher for ambient heat exposure during the second and third trimester of pregnancy. For congenital anomalies, there is limited evidence, but a suggestion that exposure to elevated temperature during the first few weeks of pregnancy is most strongly associated with congenital heart defects. There was consistent evidence of an association between elevated ambient temperatures and risk of gestational diabetes mellitus, particularly in the summer. Mixed results or too few studies were found for neonatal mortality, small for gestational age, hypertensive disorders in pregnancy, miscarriages, placental abruption, premature rupture of membranes, placenta weight/volume, cardiovascular events at labor, bacteriuria, maternal stress, newborn telomere length, and newborn international normalized ratio (INR).

UPDATED LITERATURE REVIEW

Preterm Births (N = 19)

- Heatwave days are estimated to increase risk of preterm birth by 16% compared to non-heatwave days, with a linear 5% increased risk for each additional 1° F.[23]
- Extreme heat exposure during pregnancy is associated with increased risk of preterm birth, medically indicated preterm birth, and spontaneous preterm birth (HRs of 1.63, 1.84 and 1.50, respectively).[24]

Low Birth Weight (N = 12)

- Exposure to extreme heat was associated with a 25.3% increased LBW risk;[25] a second study revealed that college-educated mothers had a 44% dampening of the adverse association with extreme heat and birthweight.[26]
- Higher temperatures during gestation were associated with lower birthweight after accounting for newborn and maternal characteristics, seasonality, and climate zone. The associations between higher temperatures and lower birthweight were of greater magnitude during months 7–9 of gestation.[27]

Maternal Hypertension (N = 4)

- High temperature in early pregnancy is associated with an increased risk of pre-eclampsia/ eclampsia/ HELLP. Exposure in the third and fourth weeks of pregnancy posed the greatest risk, with hazard ratios of 1.76 (95% CI 1.12-2.78) and 1.79 (95% CI 1.19-2.71), respectively.[28]

Congenital Anomalies (N = 7)

- Temperature variability during weeks 3-8 post-conception was significantly related to cardiac defects.[29]
- Associations between heat exposure and congenital cardiac anomalies were found in three of six studies of a systematic review, with point estimates highest for atrial septal defects.[30]

Gestational Diabetes (N = 4)

- There is consistent evidence of a seasonal effect on GDM risk, with higher prevalence of GDM and higher pregnancy glucose levels in summer months.[31]
- There is suggestive evidence of an association between higher ambient temperature and elevated glucose levels from GDM screening tests.[32]

Stillbirth (N = 7)

- The estimated risk of stillbirth in those exposed to moderate heat (25–29 °C) and extreme heat (> 29 °C) during the third trimester increased by 15% and 18%, respectively, compared to those exposed to the optimal temperature of 21 °C.[33]
- There is evidence of an increased risk of stillbirth among pregnant women who experienced hot temperatures (20–30 °C) within the seven days prior to giving birth.[34]

KEY GAPS IN THE LITERATURE

- There are few published studies from the global South and sub-Saharan Africa specifically.
- Studies assessing effects of heat on maternal and neonatal populations have widely variable study designs and exposure periods, making comparisons between studies and meta-analyses difficult.[35] Datasets on both temperatures and MNCH outcomes in sub-Saharan Africa lack sufficient granularity to conduct studies on extreme heat exposure and MNCH health outcomes similar to those conducted in high income countries.
- Few published studies focus on maternal outcomes related to extreme heat exposures; studies assessing relationships between extreme heat exposure and rates of hospitalization and both maternal and neonatal deaths are also scarce.
- There is limited information on associations between heat and prenatal care access, compound hazards (e.g., heat and drought), and violence against pregnant women, which is otherwise known to increase during hot periods.
- Few published studies account for seasonality in their analysis which is of particular importance in countries with distinct hot and cold seasons. Seasonal weather patterns can influence MNCH outcomes, particularly through disruptions to care access for vulnerable populations. Studies that did account for seasonality did so by restricting the analysis to either the hot or cold season, limiting our understanding of how extreme heat exposure impacts MNCH outcomes throughout the year.

Key Informant Interviews

Dr. Sari Kovats (Consortium co-lead for CHAMNHA)

CHAMNHA is working on projecting adverse pregnancy, fetal and neonatal health impacts through 2050; these results are expected within the next year

Context matters: complexity of heat epidemiology necessitates context-specific behavior change interventions

Difference between adaptation and intervention strategies requires a two-pronged approach with multiple strategies that are linked (i.e. support integrating climate into maternal health strategies and getting maternal health policies into climate adaptation strategies)

Low quality of systematic reviews: Many reviews tend to overestimate effects and omit both heat and cold effects

Dr. Nancy Krebs & Dr. Kartik Shankar (Professors, University of Colorado Paediatrics - Nutrition)

Data gaps: Investing in strengthening health systems to collect consistent and accurate routine datasets such as large birth cohort and birth registrars will make a significant difference in understanding geography-specific heat outcomes for MNCH populations

Level of data: Local is more informative than population data and should be considered often during studies on heat exposure because knowing the exact time of conception can help link exposure to the actual time of outcome

Dr. Sileshi Ayele (MD, Gondar Hospital Ethiopia)

Different regions require different intervention strategies. For instance, NW regions of Ethiopia typically experience the hottest weather during March-May and drought exacerbates exposure risk

In order to decrease the normalcy around heat and raise awareness of its effects, effective heat communication messaging should be introduced from top-to-bottom

Meconium aspiration syndrome and preterm outcomes are common neonatal outcomes noticed in hottest seasons while maternal anemia and increased c-sections due to fetal distress are highest during peak seasons

Conclusions & Next Steps

The literature contains studies with widely heterogenous methods to investigate associations between extreme heat exposure and health outcomes among pregnant and neonatal populations. Experts agree that there is a need for more granular data and consistent definitions of exposure in order to accurately assess these relationships, particularly in LMICs where adequate data is limited.

However, despite these data gaps, there is consistent evidence from multiple settings that high heat threatens maternal health, fetal development, pregnancy outcomes, and neonatal health: increased risk of PTB, LBW, SB, and congenital anomalies have been observed, as well as suggestive evidence of increased risk of gestational diabetes and maternal hypertension. These outcomes are being experienced currently and will become more prevalent as the climate changes further and extreme heat becomes much more commonplace. The adverse impacts of heat exposure will interact with other climate-related stressors such as drought, food insecurity, water insecurity, violence, and increased infectious disease risks.

While additional research is needed to understand the full scope of expected health impacts (including maternal outcomes, mortality, and prenatal care access), there is sufficient evidence to warrant investment in adaptations to reduce risks and to identify opportunities for scaling up effective interventions. The next phase of this project will involve identifying such evidence-based strategies and highlighting priority research questions in this space to prompt a call to action for teams at the Bill & Melinda Gates Foundation.

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