Journal of Midwifery & Women's Health
www.jmwh.org
Review
Continuing Education

The Impact of Extreme Heat Exposure on Pregnant People and Neonates: A State of the Science Review

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The relationship between heat exposure and perinatal morbidity and mortality is of increasing concern as global temperatures rise and extreme heat events become more frequent and intense. Heat exposure can lead to a multitude of harmful outcomes for pregnant individuals and neonates, including hospitalization and death. This state of the science review explored the evidence on the associations between heat exposure and negative health outcomes during pregnancy and the neonatal period. Findings suggest that improving health care provider and patient awareness of heat-related risks and implementing specific interventions could mitigate adverse outcomes. Furthermore, public health and other policy interventions are needed to increase thermal comfort and reduce societal exposure to extreme heat and related risks. Early warning systems, medical alerts, provider and patient education, and increased access to health care and thermal comfort may improve pregnancy and early life health outcomes. J Midwifery Womens Health 2023;68:324–332 © 2023 Adrienne Arsht – Rockefeller Foundation Resilience Center. *Journal of Midwifery & Women's Health* published by Wiley Periodicals LLC on behalf of American College of Nurse Midwives (ACNM).

Keywords: climate/environmental health, global health/international, health policy, newborn care, patient education, patient safety and risk management, pregnancy complications, public health

INTRODUCTION

Exposure to extreme heat is a growing global health concern. By 2070, it is estimated that, without migration, one-third of Earth's population will reside in areas with annual average temperatures greater than 84.2°F (29°C), currently only experienced in less than 1% of Earth.[1] Heat waves were the deadliest meteorological hazard over the past 30 years in the United States[2] and globally from 2015 to 2019.[3] Thus, researchers are increasingly studying the effects of heat exposure among vulnerable groups such as the elderly, pregnant people, infants and children, outdoor workers, heat-exposed indoor workers, and low-income and marginalized communities.[4,5] Heat exposure interacts with underlying health conditions including chronic obstructive pulmonary disease, asthma, cardiovascular events, and mental health disorders, particularly suicide risk.[6–8]

Identifying and categorizing the impacts of heat exposure is challenging, as there are no universally accepted definitions for *excessive heat*, *extreme heat*, *heat waves*, *extreme heat events* (EHEs), *heat exposure*, and *high ambient temperatures*.[9–11] The World Meteorological Organization (WMO) and World Health Organization (WHO) acknowledge that there is "no universally accepted definition" of heat waves, and that heat waves are "understood to be periods of unusually hot and dry or hot and humid weather that have a subtle onset and cessation, a duration of at least 2 to 3 days, usually with a discernible impact on human and natural systems."[9(p xi)] Heat exposure was defined by the literature in this review in a variety of ways, including multiday periods of elevated temperatures, experiencing temperatures over a certain threshold, incremental/quartile increases in average temperatures, and seasonal averages or abnormalities in temperature.

Extreme heat warnings are most frequently issued using temperature or apparent temperature thresholds.[9] However, thresholds vary greatly by region and within countries. Furthermore, specific heat thresholds are not always well correlated with adverse health effects.[12] In the United States, for example, the National Weather Service generally issues heat advisories based on the heat index, which combines heat and relative humidity.[12] Yet, the heat index currently accounts for only 2 meteorological variables, excluding the impact of other variables, such as several consecutive days of oppressive weather, which further contribute to poor health outcomes.[12]

Factors Influencing the Effects of Heat Exposure

Climatological and environmental factors such as humidity,[13] urban heat islands,[14] access to cooling, minimum nighttime temperatures, and access to shade mediate apparent temperature and the body's cooling ability.[9] Gender differences can

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1526-9523/09/$36.00 doi:10.1111/jmwh.13502

Quick Points

- Heat exposure is associated with many adverse health outcomes for pregnant people and newborns.
- Consistent global definitions and criteria for various heat conditions, such as excessive heat, extreme heat, heat waves, "high" ambient temperatures, and extreme heat events, are lacking.
- Policy, public health, and health care provider advocacy and action can increase access to interventions that improve patients' resilience to heat.

also influence vulnerability to extreme heat.[15] Lower socioeconomic status (SES) and historically marginalized communities are frequently exposed to higher temperatures,[16] with negative consequences for health and well-being. Additionally, factors such as acclimatization,[11] thermoregulation,[7] access to health care,[15] medications, and ability to self-care influence heat-related health outcomes.[14,17,18]

During pregnancy, normal physiologic changes, such as increased hormonal sensitivity and changes in circulation and blood volume, can reduce a pregnant individual's ability to regulate body temperature, increasing susceptibility to adverse heat-related health effects.[15,19] Heat exposure can cause elevations in maternal core body temperature and maternal pulse, which can lead to fetal heart rate tachycardia and trigger uterine contractions.[15] Pregnancy increases blood volume and hydration needs, increasing risks for dehydration.[19] The combination of dehydration and heat exposure further contributes to the incidence of preterm contractions[19] and can alter blood flow to the placenta, leading to more serious complications such as placental abruption[20] and fetal growth restriction.[4] Heat can cause the secretion of antidiuretic hormones and oxytocin, which can also trigger uterine activity.[15] Hyperthermia has well-documented teratogenic effects in clinical and animal studies, which may have implications for congenital birth defects, although the connection with ambient heat is less comprehensively understood.[21] More research is needed to identify critical windows of pregnancy and examine heat's relationship with pathophysiology. This state of the science review was therefore conducted to examine associations between heat exposure and negative health outcomes for pregnant people and neonates and synthesize recommendations for reducing heat-related mortality and morbidity.

HEAT-RELATED MORTALITY AND MORBIDITY

A literature search was conducted in Web of Science, Google Scholar, PubMed, and MEDLINE and supplemented by reference tracking, ancestry approach, and author tracking. To be included, articles had to address heat exposure and neonatal or maternal morbidity or mortality. English language systematic reviews with or without meta-analyses, cohort studies, case studies, ecological studies, time series studies, and case-control studies were included. Evidence for heat-related mortality and morbidity is presented through all-cause mortality, obstetric complications, and neonatal complications.

Negative heat-health outcomes for pregnant people included obstetric complications such as placental abruption,[20] gestational hypertension,[15,22] gestational diabetes mellitus (GDM),[23] cardiovascular events,[24] preterm birth (PTB),[5,11,13,17,24–34] miscarriage,[22,35–37] stillbirth,[5,10,13,18,25–27,37–40] and potential impacts on maternal mental health.[41] Neonatal complications included fetal distress,[42] neonatal intensive care unit (NICU) admissions,[43] fetal growth restriction or low birth weight,[4,13,25,26,29,44] congenital birth defects,[26,45–47] diarrheal disease,[48–50] vector-borne diseases (VBDs),[51–55] and sudden infant death syndrome (SIDS).[56]

All-Cause Mortality

Extreme heat increases mortality primarily by interacting with existing health conditions, such as cardiovascular, cerebrovascular, and respiratory diseases.[12] Few studies, however, have examined broad associations, instead exploring mortality by specific etiologies.[15] In a case-crossover analysis in the Catalonia region of Spain, researchers identified an association between extreme heat days (defined as days with maximum temperature above the 95th percentile) and an increased risk of neonatal mortality in the perinatal period (relative risk [RR], 1.53; 95% CI, 1.16-2.02).[57] The neonatal mortality causes most sensitive to extreme heat days included hemorrhagic and hematologic disorders and respiratory, cardiovascular, and digestive complications.[57] In the United States, where maternal mortality is the highest among industrialized countries, traditionally marginalized and low-income communities suffer greater heat-related morbidity and mortality.[15] Researchers have found that Black women were 3 to 4 times more likely than White women to experience maternal mortality linked to disproportionate exposure to heat and less access to thermally safe spaces.[15]

Obstetric Complications

Placental Abruption

Placental abruption is a medical emergency with high risk of mortality and morbidity for both the pregnant person and infant.[20] A case-crossover analysis in Canada found that a maximum weekly temperature of 86°F (30°C), compared with a maximum weekly temperature of 59°F (15°C), was associated with an increased risk of abruption in pregnancies at or close to term (odds ratio [OR], 1.12; 95% CI, 1.02-1.24).[20] This association was more pronounced in women who were nulliparous, under 35, or had low SES.[20] Kim et al also identified increased risk of hospitalization due to antepartum hemorrhage, the third leading cause of maternal mortality, with exposure to extreme heat.[15]

Gestational Hypertension and Preeclampsia

Several studies suggested exposure to EHEs and elevated ambient heat during pregnancy may increase the risk of developing gestational hypertension, including preeclampsia and eclampsia.[15,22,58–60] In a case-crossover analysis of pregnancy complications and EHEs in New York State, EHEs were associated with a 13% increase in emergency department visits for hypertensive pregnancy complications (OR, 1.13; 95% CI, 1.02-1.25).[22] Other researchers compared hospital discharge records and temperature variations for 2.24 million mothers in Arizona, New York, and Washington, finding that an additional day with an average temperature 3 SDs or more above the county's monthly mean temperature during pregnancy increased odds of hospitalization by 0.1 percentage points.[15] The authors noted that multiple pregnancy complications contributed to this increase, but gestational hypertension was one of the most frequent.[15]

A national cohort study in China identified that exposure to high weekly average ambient temperatures (above 95th percentile) during the first half of pregnancy increased the likelihood of gestational hypertension (OR, 1.16; 95% CI, 1.10-1.22).[58] Likewise, a cohort study conducted in Be'er Sheva, Israel found that an elevation of one interquartile range of the mean daily temperature averaged over each trimester, in the second or third trimester, was associated with an increased risk of developing preeclampsia (RR, 2.91; 95% CI, 1.98-4.28).[59] A meta-analysis across multiple climate and development contexts also noted an increased risk of developing preeclampsia in pregnancies with a warm season conception date (June, Northern hemisphere/December, Southern hemisphere pooled RR, 1.3; 95% CI, 0.78-2.27).[60] Although all reviewed studies found that seasonality and exposure to extreme temperatures was associated with gestational hypertension or preeclampsia, additional research is needed to clarify temperature ranges with adverse effects and gestational windows of greatest vulnerability.

Acclimatization, adaptation, and cooling access influenced the magnitude of heat's effects on hypertensive disorders in pregnancy. Hospitalizations in counties that were adapted to higher temperatures were not affected by an additional hot day.[15] In unadapted counties, however, an additional day of temperatures greater than 90°F (32.2°C) increased the likelihood of hospitalization by 5.1% ($P = .04$).[15] Shashar et al suggested that adaptation mitigated preeclampsia risk, positing that the higher risk of preeclampsia observed in local nomadic Bedouin populations compared with Jewish ethnicity patients may have been largely due to differences in heat stress coping mechanisms, housing, and cooling access.[59]

Gestational Diabetes

A systematic review of heat impacts on gestational diabetes, covering studies from Australia, Brazil, Canada, Greece, Italy, Israel, Spain, Sweden, Taiwan, and the United Kingdom, identified a consistent association between summer seasons, higher prevalence of GDM, and increased blood glucose levels.[23] GDM is associated with increased incidence of cesarean birth, PTB, preeclampsia, macrosomia, neonatal hypoglycemia, type 2 diabetes, and cardiovascular disease.[23] Studies focused on ambient temperature were also included in Preston et al's review, with several suggesting an association between high ambient temperature and increased blood glucose levels in pregnancy.[23] This finding has potential implications for the development and treatment of GDM.[23] Future research is needed to better understand the sensitivity windows and magnitude of this effect.

Cardiovascular Events

Cardiovascular events during pregnancy and birth, including heart attacks and strokes, account for 15% of pregnancy-related deaths.[24] Ha et al found in a US-based case-crossover study that a 1.8°F (1°C) increase during the warm season the week before birth was associated with a 7% (OR, 1.07; 95% CI, 3%-12%) increase in the risk of a cardiovascular event during labor.[24] Increased risks of cardiovascular events were more pronounced the closer the temperature increase was to the onset of labor.[24] This study also found that Black women were more susceptible to cardiovascular events than non-Hispanic White women at the same temperature increase.[24]

Preterm Birth

Heat exposure may elevate the risk of PTB, a leading cause of morbidity and mortality in neonates.[11,13,26,29–31] Researchers have suggested that heat exposure increases the likelihood of dehydration and the secretion of antidiuretic hormones and oxytocin, contributing to PTB.[19,27,28]

Ha et al examined heat exposure (temperatures >90th percentile) across 12 US states by gestational weeks of pregnancy, finding that heat exposure was correlated with a 6% to 21% increase in PTB risk at week 34 and weeks 36 to 38.[61] Additionally, a 5°F (2.8°C) increase in temperature the week before birth was associated with 12% to 16% higher risk of early PTB (<34 weeks) (OR, 1.16; CI, 1.12-1.19) and late PTB (34−36 weeks) (OR, 1.12; CI, 1.10-1.15).[61] In a systematic review, with studies mostly conducted in the United States, the European Union, and New Zealand, Chersich et al found that the likelihood of PTB rose 1.05 times with every 1.8°F (1°C) increase in temperature (OR, 1.05; 95% CI, 1.03-1.07).[5] Moreover, heat wave conditions increased the odds of PTB more substantially, by 1.16 times (OR, 1.16; 95% CI, 1.10-1.23).[5]

Likewise, evidence from multiple studies conducted in rural China, Korea, Taiwan, the United States, and across 14 low- and middle-income countries in Africa and Central and Southeast Asia supported this finding, suggesting that exposure to multiday periods of extreme heat had a stronger effect on PTB rates than exposure to mild or moderate elevations in temperature.[17,25,27,28,32–34]

Several researchers have examined the impact of heat exposure on PTB during specific gestational windows. Ha et al's study and Wang et al's time series study in Guangzhou, China both found that exposure to hot and cold temperature extremes in the first trimester of pregnancy increased risk of PTB.[10,61] Wang et al defined heat waves as greater than or equal to 2 days of temperatures higher than 91.4°F (33°C) or when temperatures exceeded the 75th, 90th, 95th, or 98th percentile.[10,61] Significant associations with PTB and heat exposure around conception were described by authors

conducting studies in China.[31,33] In a prospective cohort study, authors noted a significant association between PTB, ambient temperature, and extreme heat and cold days in the month of conception (OR, 1.17; 95% CI, 1.06-1.28).[31] Likewise, Zhou et al's survey in Henan, China found that exposure to extreme heat (>90th percentile) in the 2 to 3 weeks before conception increased the risks of PTB.[33]

Several studies identified population subgroups that were more susceptible to heat-related PTB. A cohort study in Seoul, South Korea found that the most significant and strongest effect of heat on PTB was in mothers who had low education levels and lived in low SES communities.[30] Other risk factors identified were higher pre-pregnancy BMI, extremes of maternal age, late or no prenatal care, and chronic diseases.[5,17] In a study of Korean birth data, researchers found that in the second trimester heat waves combined with high particulate matter (PM) 2.5 exposure (a metric for air pollution levels) had a stronger effect than either exposure alone.[32] The authors concluded that communities with poor air quality may be more susceptible to heat-related PTB.[32]

Miscarriage

Miscarriages affect approximately 20% of all pregnancies globally.[36] Several studies suggest a positive relationship between increasing temperature and increased risk of miscarriage.[22,35–37] For example, a case-control study in Nanjing, China found that increases in ambient temperatures higher than the median temperature of 62.6°F (17°C) gradually increased the risk of miscarriage.[36] The effect of extreme heat (91.4°F [33°C]) on the probability of miscarriage (2%-5% increase) was especially pronounced during summer and transitional months (OR, 2.07; 95% CI, 1.36-3.16).[36] A cross-sectional study of the Ghana Maternal Health Survey found that with each 1.8°F (1°C) increase in wet bulb globe temperature (WBGT) the risk of miscarriage rose by 12% to 15%.[37] However, these findings were not statistically significant.[37] A case-control study of miscarriage and heat effects in Guangdong, China found that the risk of miscarriage decreased in the high heat exposure group compared with the moderate heat exposure group.[35] Authors theorized that the decrease may be associated with increased adaptation, such as air conditioning use or reduced outdoor activity during high heat.[35]

Stillbirth

Asamoah et al suggested that each degree increase in maternal heat exposure (measured in WBGT) in warm regions was correlated with a 27% to 42% increase in likelihood of miscarriage or stillbirth (crude OR, 1.42; 95% CI, 1.00-2.03).[37] Other researchers in the United States found that incremental increases in temperature were associated with an increase in the risk and incidence of stillbirth.[39,40] Additionally, an average increase of 2.8°F (1°C) over the county 97.5th percentile temperature threshold was associated with a 10% increase in risk of stillbirth (OR, 1.1; CI, 1.04-1.17).[40]

Some studies suggest that the timing of exposure to temperature extremes affects risk of stillbirth. A cohort study in Brisbane, Australia found an increased risk of stillbirth with exposure to high ambient temperatures (measured in percentiles) during the second and third trimesters.[38] A second cohort study conducted in the same area found associations between heat wave exposure and increased risk of stillbirth in every month of pregnancy.[10] However, authors reported a stronger association during early pregnancy compared to late pregnancy.[10]

Multiple studies found that pregnancies of historically marginalized groups may be at greater risk of stillbirth.[18,27] For instance, a case-crossover study in Texas found that there was an elevated stillbirth risk in the summertime among Hispanic and non-Hispanic Black women but no elevated risk in non-Hispanic White women (Hispanic women: OR, 1.60; 95% CI, 1.19-2.15; non-Hispanic Black women: OR, 1.61; 95% CI, 1.12-2.30; non-Hispanic White women: OR, 0.90; 95% CI, 0.54-1.50).[18]

Maternal Mental Health

Some research has suggested that heat waves may contribute to increased risk of suicide and mental health-related admissions in the general population.[8] Although studies on the relationship between temperature and maternal mental health are limited, a cohort study in Shanghai, China found that extreme heat conditions may exacerbate emotional stress and life-event stress on the day of, and up to 2 days after, heat exposure (OR, 2.9; 95% CI, 2.1-4.2; $P < .001$).[41] Considering evidence of heat-related adverse effects on mental health in the general population, more research is needed on heat-related mental health impacts in pregnancy and postpartum.

Neonatal Complications

Fetal Distress and NICU Admissions

A time series analysis indicated a potential association between heat wave exposure (when the heat index exceeded locally or regionally defined thresholds for a heat advisory) during pregnancy and increased rates of perinatal fetal distress, meconium aspiration, and neonatal ventilator use.[42] Cil and Cameron noted that a heat wave during the third trimester was associated with a 3.5% increase in the fraction of births (1/1000) in which at least one of fetal distress, meconium aspiration, or neonatal ventilator use occurred.[42] Fetal distress increased by 2.1 cases per 1000 births ($P < .05$) with heat wave occurrence in the third trimester.[42]

Kakkad et al conducted a retrospective review of birth records and NICU admissions at Shardaben Chimanlal Lalbhai (SCL) Municipal General Hospital in Ahmedabad, India, identifying an association between heat and neonatal morbidity.[43] SCL Hospital primarily serves low-income patients and did not have air conditioning during the study period.[43] A strong relationship between heat and NICU admissions was observed after temperatures exceeded 107.6°F (42°C), above which every 1.8°F (1°C) increase was associated with a 43% increase in heat-related NICU admissions (95% CI, 9.2%-88%).[43] SCL Hospital moved the maternity ward to

a lower floor and saw a protective effect, with heat-related NICU admissions reduced by 64% (95% CI, 3%-89%).[43]

Fetal Growth Restriction and Low Birth Weight

Multiple studies suggested a strong association between heat exposure and fetal growth restriction or low birth weight.[4,13,25,26,29,44,62] An empirical cohort study in Bolivia, Colombia, and Peru found that a one SD increase relative to the municipality's long-term temperature mean was correlated with an average reduction in birth weight of 20 g and raised the probability of low birth weight by 0.7 percentage points.[44] Sun et al found that fetal growth restriction was associated with exposure to above-average temperatures during pregnancy.[4] However, an association between small for gestational age (SGA) and heat was less established. In a retrospective observational study of 29,597,735 births in 402 US counties, researchers found that high temperatures (>90th percentile) throughout the pregnancy were associated with a higher risk of SGA in term births (OR, 1.041; 95% CI, 1.029-1.054).[4] The risk was especially pronounced when temperatures were high during the second and third trimesters and in areas with historically cooler climates.[4] However, a study in southern Israel found that higher temperatures were associated with a lower risk of SGA.[63] Although ambient temperatures may affect SGA, more research is needed to understand the magnitude and direction of this association.

Congenital Birth Defects

Of congenital birth defects, research on congenital heart disease (CHD) was most frequently identified. A cohort study of live and stillbirths in the Tel Aviv region of Israel found that the risk for multiple CHDs increased with a 1-day increase in EHEs (OR, 1.13; 95% CI, 1.06-1.21).[46]

The US National Birth Defects Prevention Study (1999-2007) found that increased odds of ventricular septal defect were present only in offspring exposed to both high PM 2.5 levels and an EHE in utero (OR, 0.82; 95% CI, −0.39 to 2.17).[47] A follow-up study noted that regional differences in CHDs may be associated with ambient temperature variations, with the Southern United States experiencing more conotruncal CHD and the Northeast more atrial septal defects.[64] With projected increased heat exposure due to climate change, researchers suggest that CHD burden may increase.[64]

Teratogenic effects of increased maternal core body temperature, including neural tube defects (NTDs) (eg, spina bifida, anencephalus/encephalocoele), are well documented with concentrated heat exposures (hot tubs, saunas, etc.).[21] However, less research has investigated connections with high ambient heat.[21] A retrospective cohort study in Canada identified that exposure to 86°F (30°C) (relative to 68°F [20°C]) was associated with increased risk of NTDs when the exposure occurred during the neural tube closure window of gestation (prevalence ratio, 1.56; 95% CI, 1.04-2.35).[21] More research is needed on heat exposure associations with birth defects, especially for noncardiac congenital abnormalities including NTDs, orofacial clefts, hypospadias, and ocular defects.

Diarrheal Disease

Diarrheal diseases are the second highest cause of death in children under 5.[49] Diarrheal diseases contribute to growth reductions, delayed cognitive development, and greater susceptibility to chronic disease and infection, with the most severe impacts concentrated in low-resource settings.[48,49] In a global meta-analysis covering multiple development contexts, Levy et al found that 65% of studies reviewed saw a positive relationship between temperature and all-cause diarrheal diseases.[48] Likewise, Carlton et al conducted a similar review of studies concentrated in Bangladesh, Australia, and the United Kingdom, also noting that elevations in temperature were strongly associated with higher rates of diarrheal disease.[48,49] Few studies examining relationships between diarrheal diseases and pregnancy were identified in this review; however, research in Nepal identified a potential association between diarrheal disease during pregnancy and increased risk of SGA births.[50]

Vector-Borne Diseases

The effects of heat on vector populations and VBDs is dependent on existing VBD burden and baseline average temperatures.[51,52] Regions historically on the upper end of a vector's ideal temperature range may experience decreases in vector prevalence and VBDs as heat waves or unusually high average temperatures exceed the vector's temperature range and limit proliferation.[51,52] However, when heat waves or unusually high temperatures occur in regions historically beneath a vector's ideal temperature range, increases in vector proliferation, the introduction of new vectors, and outbreaks of VBDs in previously unexposed or low prevalence regions may occur.[51–53] Outbreaks in historically low exposure regions are of significant concern, as low population immunity may influence higher mortality.[51–53] In a case study conducted in Rwanda, Loevinsohn identified that after a year of record high temperatures, malaria incidence increased by 337%.[53] Increased incidence was most pronounced among low acquired immunity groups ($P < .001$) and those in high altitude regions ($P < .005$), which may have contributed to the rapid increase in fatality rate (RR, 4.85; $P < .001$).[53]

VBDs are a major driver of poor perinatal health outcomes. Malaria alone is a primary cause of mortality in low-resource countries, disproportionately affecting young children and pregnant women.[50] VBDs can also influence adverse pregnancy and birth outcomes. A systematic review across 14 countries found that dengue infection was associated with increased risk of preeclampsia and cesarean birth.[65] Contracting dengue during pregnancy also increased the risk of miscarriage, PTB, and low birth weight.[54] A meta-analysis spanning studies in 10 sub-Saharan African countries, Colombia, Indonesia, and Thailand suggested that pregnancy-associated malaria increased the risk of low birth weight by 63% (95% CI, 1.48-1.80) and PTB by 23% (95% CI, 1.07-1.41).[55]

Sudden Infant Death Syndrome

Temperature extremes and incremental temperature changes are correlated with increased incidence of SIDS.[56] Auger et al

Table 1. Recommendations for Patients

Recommendations
1. Check your local news, weather, and health services for heat wave alerts and safety tips. Learn the signs and symptoms of overheating in adults and children, and consult your health care provider on how to keep yourself and dependents safe from heat. Check in with friends, neighbors, and family members during heat waves and high heat and humidity conditions.
2. Drink extra water, even when not thirsty. Avoid sugary drinks, alcohol, and caffeine. Eat small, frequent meals. Use cooking techniques that do not release as much heat or steam and avoid using the oven.
3. Speak with your health care provider about managing heat-related risks in extreme-age pregnancies,[5] if you have a disability impairing your ability to access cooling, or if you have underlying health conditions such as asthma, cardiovascular disease, or chronic obstructive pulmonary disease.[6]
4. Speak with your provider about how your medicine might affect you during heat waves. Individuals taking medications that alter the ability to thermoregulate may be at greater risk of heat-related illness. These medications include, but are not limited to, anticholinergics,[70] antihistamines,[71] blood pressure medications (including antihypertensives, ACE inhibitors, beta blockers, and calcium channel blockers),[70] decongestants,[70] diuretics,[71] opioids,[72] and psychotropic or psychiatric medicines[73] (including antipsychotics,[71] lithium,[73] SSRIs,[72] stimulants such as Adderall and Ritalin,[70] and tricyclic antidepressants[70]).
5. Speak with your provider about how to minimize heat risk at work and at home. Low-income status,[5] historical social or racial marginalization,[27] minimal or no access to cooling, and outdoor work (such as construction or agriculture) or heat-exposed indoor work (such as in industrial and light-industrial facilities or warehouses) are all associated with greater risk of heat-related illness.
6. Install thermometers. The WHO and WMO recommend that electric fans (such as ceiling fans) not be used when dry-bulb temperatures are above 95°F (35°C), as moving hot air around an individual can worsen heat stress.[9] Above 95°F (35°C), electric fans should be turned off and air conditioning should be used.[9]
7. If you work outdoors or in hot indoor workplaces, take regular breaks, use a buddy system, and rehydrate in shaded or air conditioned areas.
8. If you cannot access cooling at work or at home, seek alternative cooling locations, such as official cooling centers, public libraries, or other air conditioned public spaces and shaded outdoor areas.
9. Avoid heavy exercise during peak heat hours of the day.
10. Wear loose-fitting, lightweight, and light-colored clothing. Wear a hat and put on sunscreen of at least SPF 15 at least 30 min prior to going outside.
11. Cool as much of the body's surface as possible with cold baths or showers and cold towels, with a priority for face, hands/wrist, groin, underarms, and feet. Moisten skin with water and use a fan or wind to increase evaporation under 95°F (35°C). Use air conditioning above 95°F (35°C).
12. Sleep as cool as possible with cotton, bamboo, or linen sheets. Sleep low to the ground if possible.
13. Open windows during cool times of day. Close windows during warm times of day. Install shades, reflective windows, light-colored curtains, air conditioning, and/or shading structures. Use external shade to reduce heat into homes and buildings, and keep blinds closed if no external shading is possible.

Abbreviations: ACE, angiotensin-converting enzyme; SSRI, selective serotonin reuptake inhibitor; WHO, World Health Organization; WMO, World Meteorological Organization.

found that maximum daily temperatures greater than or equal to 84.2°F (29°C) were associated with 2.78 times higher odds of SIDS (OR, 2.78; 95% CI, 1.64-4.70) and that this relationship increased proportionally with higher temperatures.[56] A potential explanatory mechanism is that heat stress interactions with brainstem abnormalities overwhelm the autonomic nervous system, leading to SIDS.[56] One study noted that cold temperatures were strongly correlated with an increase in SIDS.[66] However, Auger et al hypothesize that an increase in SIDS is more likely to result from high room temperatures and over swaddling, rather than cold outdoor temperatures.[56] Auger et al recommend that monitoring high ambient temperatures in infant bedrooms be included in the safe sleep recommendations of the American Academy of Pediatrics.[56]

IMPLICATIONS FOR PRACTICE

Midwives and other health care providers are critical in modifying patient response to elevated heat and can advise on reducing and mediating heat risks to pregnant individuals and neonates. Health care providers who care for pregnant people and infants should be aware of heat risks and recommend protective actions during high heat (See Table 1).[40,62,67] In their practice, perinatal care providers can optimize ventilation in clinics and labor suites, monitor hydration, and make cold, potable water available.[5] The WHO and WMO recommend that electric fans (such as ceiling fans) not be used when dry-bulb temperatures exceed 95°F (35°C), as circulating hot air can worsen heat stress.[9] Above 95°F (35°C), electric fans should be turned off and air conditioning should be used, if

available.[9] Fan use may worsen heat stress more in exceptionally hot and arid regions, such as the Middle East or southwest United States, and in hot and humid regions, such as northern India and parts of Pakistan.[68] No research on conditions when fan use may be detrimental specifically for pregnancy or labor was identified, and future research should examine precise thresholds. In conditions in which space cooling is not possible, moving labor and neonatal intensive care units to lower floors and away from roofs can help reduce ambient indoor temperatures.[5,43] In settings where air conditioning is not accessible, efforts to cool the laboring patient, such as keeping them well-hydrated, applying wet cloths to the skin, and hand fanning, may help mitigate hyperthermia, but more research is needed to define conditions when these interventions are effective or when more substantial interventions may be needed. In home birth settings without air conditioning, laboring individuals should be monitored for signs of hyperthermia and transferred to a facility with air conditioning if heat-related risks or symptoms are identified.

Patients should be counseled on the links between high heat, dehydration, and health risks, especially to themselves and their infants. Access to adequate hydration during hot days can mitigate risks. Clinician advocacy for safer working conditions could advance protections and improve outcomes for heat-exposed pregnant workers.

Given the variability of extreme heat definitions in both the literature and from official weather and health services, it can be difficult for clinicians to know when heat may be dangerous and how to advise patients. When local, critical WBGT are met or exceeded, all persons, and especially those who are pregnant, should be advised to immediately cool off. Clinicians' ability to authorize days off work may vary by location, but when WBGTs exceed local thresholds for health impacts, it is advisable to recommend that pregnant patients avoid overexertion during peak heat hours.

Policy maker, public health, and health care provider interventions that increase access to health care and prenatal care are needed to support resilience to heat.[69] Interventions that improve the thermal comfort of homes, workplaces, and communities would benefit the health of pregnant people and infants. These interventions can include increased access to cool, potable water, passive cooling (eg, shade, green and blue spaces, cool roofs, thermally and energy efficient buildings), active cooling (eg, air conditioning), public health interventions, including better indicators of when heat impacts health, and early warning systems. Heat-health early warning systems and medical alerts for pregnant people and infants during heat waves are theorized to decrease heat-related disease burdens.[28,56,67] Integrating interventions with global and local public health strategies, local stakeholder interventions, and the insurance industry could increase the longevity and efficacy of interventions.[69] Table 2 provides additional resources for providers.

Table 2. Resources for Providers

Resources
The Climate Resilience for Frontline Clinics Toolkit (https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/)
Global Heat Health Information Network (ghhin.org)
National Integrated Heat Health Information System (heat.gov)
American Red Cross (redcross.org)
World Health Organization (who.int)
The Climate Psychiatry Alliance (climatepsychiatry.org)
Local heat exposure guidance (eg Understanding Heat Exposure in Miami-Dade County: https://storymaps.arcgis.com/stories/6f1e91cf8a8e4d5d9bd67525575c042e)
Local Health Department guidance on heat (eg Extreme heat information for clinicians, Victoria Department of Health: https://www.health.vic.gov.au/environmental-health/extreme-heat-information-for-clinicians)
Pharmaceutical and drug reference guides

CONCLUSION

Heat exposure is associated with increased risk of maternal and neonatal mortality and morbidity through numerous obstetric and neonatal complications. A lack of globally consistent definitions and criteria for heat exposure limits researcher and practitioner ability to provide guidance on which heat conditions are dangerous for pregnant individuals and neonates. This review examines heat-related health impacts in pregnant people and neonates and recommends actions that practitioners and patients can take to improve health outcomes and patient care in conditions of heat.

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

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