TECHNICAL PAPER

GENDER-DIFFERENTIATED AND AGE-SPECIFIC RISKS OF HEAT STRESS IN A WARMING WORLD

IMPLICATIONS FOR EQUALITY AND RESILIENCE

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UN WOMEN

FOR ALL WOMEN AND GIRLS

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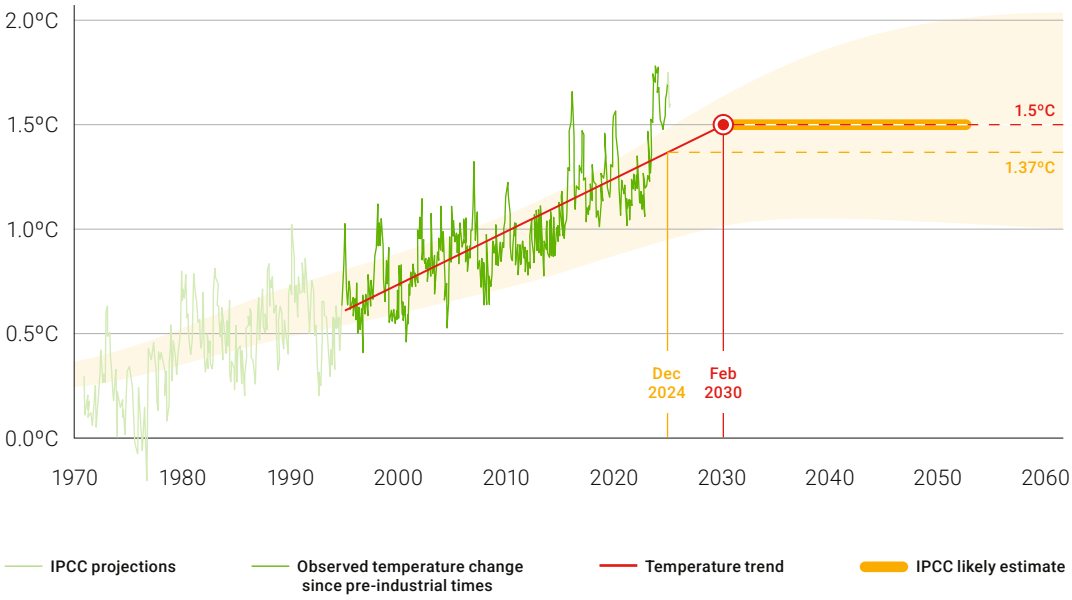
INTRODUCTION

1. INTRODUCTION

On 10 January 2025, the World Meteorological Organization published a report confirming 2024 as the warmest year on record, with average global temperatures reaching 1.55°C above pre-industrial levels and breaching the long-term climate goal of not exceeding 1.5°C above pre-industrial levels agreed under the Paris Agreement. While other measures varied on the exact averages, they were all unanimous in the year being the warmest on record.

FIGURE 1
Heat trends since 1970



Source: C3S Climate Data Score.

In its 2018 Special Report on "Global Warming of 1.5° Celsius", the Intergovernmental Panel on Climate Change (IPCC) estimated that approximately 1°C of global temperature rise was attributable to human activities and warned that the impacts of anthropogenic emissions would linger for centuries, if not millennia. These impacts are now more strikingly experienced in frequent and more intense events ranging from severe storms and wildfires to oceanic rise, which are upending lives, livelihoods and societies across regions and timeframes.

The steep rise of average global temperatures observed from the 1960s to date and its associated losses and damages to the socio-ecological system —with consequent economic dislocation—can no longer be considered exclusively as a slow onset event. Rather, the direct impacts of heat will need what the IPCC terms "incremental and transformational adaptation".[1] As according to the Sixth Assessment Report of the IPCC, every additional 0.5°C of global warming causes clearly discernible

increases in the intensity and frequency of temperature extremes, including the intensity, frequency and duration of heatwaves.[2] Moreover, the bulk of analysis on loss and damage has focused on losses and damages that can easily be identified, quantified and, therefore, monetized.[3]

It is in light of these phenomena that this paper considers the record-breaking streaks of global mean temperature rises through the lens of a usually invisible, yet insidious impact of global warming, i.e. heat stress, which is the body's inability to cool down efficiently under high temperatures and can lead to dehydration, heat exhaustion, heat stroke and exacerbation of other health issues. It is undeniable that as climate change is driving more frequent and intense heatwaves, heat stress is becoming a growing public health concern and socioeconomic challenge.[4] Crucially, the impacts of extreme heat are not uniform across populations: they vary by gender and age, as well as by level of economic development and resources.[5] Women, men, children and the elderly experience heat stress differently due to biological differences and gendered social roles. Those who have contributed least to climate change (often in developing countries) tend to be the most vulnerable to its effects,[6] underscoring neglected equity issues.

More specifically, the paper examines the gender-differentiated biological impacts of heat (including effects on fertility), how gender roles and responsibilities modify heat vulnerability in developed versus developing contexts, the intersection of age and gender in heat risk, and why addressing these issues is urgent for climate resilience, public health, labour productivity and gender equality.

1.1. CLIMATE CHANGE AND ESCALATING HEAT RISKS

The planet has already warmed by approximately 1.3°C above pre-industrial levels though short-term observations (see Figure 1) seem to surpass this figure significantly, and with every additional increment of warming, heat extremes are becoming more intense and frequent. This means that populations around the world will face unprecedented heat stress in the coming decades, even if aggressive climate action is taken. UNICEF observes that, by 2050, virtually every child on earth is forecast to face more frequent heatwaves.[7] Developing countries in Africa, Asia and Latin America, which have contributed the least to greenhouse gas emissions, are projected to endure some of the most life-threatening heat because of geography and limited adaptive capacity.[8] In these regions, existing gender inequalities can worsen outcomes; for example, if more intense droughts force women to travel longer distances to collect water or fuelwood and undertake manual irrigation for household plots and smallholder farming, lifting, carrying and distributing water over longer distances and for longer durations under high radiant heat. If heatwaves strike in areas where women have little access to healthcare, the loss of life and livelihoods could be immense. Climate change is basically multiplying the risks to vulnerable groups and people in marginalized situations,[9] largely children and youth, pregnant women, outdoor workers and the elderly, who will bear a disproportionate share of heat-related illnesses and death. The IPCC's latest assessments emphasize that without adaptation, heat-related mortality will increase, with strong differences across age and gender and heavier impacts on those with the least resources. This is a climate justice issue, and failing to address gender- and age-specific vulnerabilities—by not integrating gender-responsive considerations into solutions—means allowing the climate crisis to deepen existing social injustices.

2

BIOLOGICAL IMPACTS OF HEAT STRESS: DIFFERENCES BETWEEN MEN AND WOMEN

2. BIOLOGICAL IMPACTS OF HEAT STRESS: DIFFERENCES BETWEEN MEN AND WOMEN

2.1. THERMOREGULATORY DIFFERENCES

People[10] have physiological differences that influence their responses to heat. In a study using stratified data on mortality after heatwaves, researchers find men generally have a higher sweat rate and greater sweat gland output, which can enhance heat dissipation compared to women who tend to sweat less for a given heat load.[11] This gap is especially pronounced in older age as elderly women have about half the sweating capacity of elderly men, which translates into a reduced ability to cool via sweat.[12] Furthermore, women often have a slightly higher body fat percentage and lower lean muscle mass, which can affect heat storage and blood flow to the skin. At the same time, as noted by the Children's Environmental Health Collaborative, hosted by UNICEF, women's smaller body size and higher surface-area-to-mass ratio can in some cases aid heat loss, but overall, under extreme conditions, females may be more physiologically prone to heat strain. In 2022, when Folkerts and their co-researchers examined data over a 23-year period for the Netherlands, they noted that, on average, during heatwaves, after controlling for age, female mortality rates were higher than male. This is reinforced by reports from the 2003 French heatwave, during which women's heat-related death rates were 15 per cent higher than that of men of the same age. Scientists suggest reduced sweat production and greater cardiovascular strain in females (especially post-menopausal women) as possible reasons.[13]

At the same time, men tend to experience higher rates of acute heat illnesses like heat stroke. A systematic review found that the incidence and mortality of heat stroke are significantly higher in men than women even after adjusting for age.[14] Similarly, men show a higher risk of heat-related cardiac events, such as heart attacks, during heatwaves.[15] These patterns likely reflect both biology and social behaviour. Men often perform more strenuous physical activity or labour in the heat, which raises internal body temperatures, mainly reflecting their greater presence in industrial sectors.[16]

In summary, male physiology may allow slightly better cooling through sweat, but male behaviour and exposure put them at greater risk of certain heat injuries, whereas female physiology, especially in older age, can lead to higher vulnerability even during passive heat exposure.

2.2. IMPACTS ON FERTILITY AND REPRODUCTIVE HEALTH

Heat stress can adversely affect the reproductive systems of both men and women, with implications for fertility. In males, it is well established that sperm production is temperature sensitive. Even small increases in testicular temperature can reduce sperm count and quality.[17] Occupational heat exposure, for example, applying to men working in high-heat environments like steel plants or farms, has been documented as a risk factor for male infertility, associated with abnormal sperm morphology and delayed conception. Medical reviews conclude that chronic heat exposure can significantly impair spermatogenesis, or sperm formation.[18]

In females, extreme heat can disrupt pregnancy and fetal development. Pregnant women have a harder time regulating body temperature due to increased metabolic heat and fluid needs, making them more prone to heat stress than non-pregnant women.[19] High ambient temperatures, especially heatwaves, are strongly associated with adverse pregnancy outcomes. A comprehensive meta-analysis of 70 studies, with data collected across 27 countries, found that for each 1°C rise in temperature, the risk of stillbirth and premature birth increases by some 5 per cent.[20] Ilango and colleagues[21] found that the impacts on premature deliveries in the US state of California were highest if exposure occurred the week before birth.

Heat exposure in pregnancy has been linked to higher rates of miscarriage, stillbirth, low birth weight and preterm delivery. For example, days of extreme heat can trigger preterm labour as suggested by an analysis that noted a significant increase in preterm birth during heatwave days compared to average temperature days.[22] The Children's Environmental Health Collaborative similarly found that early gestation appears to be a particularly sensitive window, with heat exposure in the first trimester raising the risk of congenital birth defects such as heart defects and neural tube defects. Mechanistically, heat stress in expecting mothers may reduce uteroplacental blood flow and induce inflammatory responses, contributing to these outcomes.[23]

Beyond pregnancy, it is possible that severe heat stress could affect female fertility by disrupting ovulatory cycles or implantation. Although direct human evidence is limited, studies on mammals show heat can impair oocyte quality and ovarian function.[24] Thus, extreme heat threatens fertility in both sexes by lowering sperm counts and male fertility potential, and by jeopardizing healthy pregnancies and birth outcomes in women. These biological impacts have long-term societal implications, potentially affecting population health and demographics in chronically hot regions.

To summarize some key biological differences in heat response and reproductive impacts:

Aspect	Men (on average)	Women (on average)
Sweating and cooling	Higher sweat output and heat dissipation capacity.	Lower sweat output (especially post-menopause), making cooling less efficient. Specific to younger women, higher core temperatures after ovulation mean they heat up more quickly.
Heat stroke incidence	More prone to exertional heat stroke and heat-related cardiac events, often due to occupational or sports exposure.	Lower incidence of heat stroke; however, under extreme passive heat, e.g. staying at home during heatwaves, mortality can be high.
Cardiovascular strain	Heat can still strain the heart, but men often have higher aerobic capacity which may offer slight resilience.	Heat imposes greater cardiovascular strain on women; older women have the lowest ability to dissipate heat, contributing to higher mortality in heatwaves.
Reproductive health	Elevated scrotal/testicular temperature reduces sperm count and motility; chronic heat exposure can cause subfertility in men.	Extreme heat during pregnancy increases risk of miscarriage, stillbirth and preterm birth; heat stress may shorten duration of breastfeeding and contribute to child undernutrition.

3

GENDERED ROLES, OCCUPATIONS AND SOCIAL FACTORS IN HEAT EXPOSURE

3. GENDERED ROLES, OCCUPATIONS AND SOCIAL FACTORS IN HEAT EXPOSURE

Biology alone does not dictate heat risk, and may not be the most substantial factor leading to loss and damage. Gender roles and societal norms strongly influence who is exposed to heat and how they cope. Men and women often have different jobs and responsibilities, which can lead to unequal heat stress burdens in both developed and developing countries.

3.1. OCCUPATIONAL EXPOSURE

Around the world, industries with intense heat exposure are frequently gender segregated. Men are overrepresented in many outdoor and manual labour jobs such as construction, mining, firefighting, road maintenance and certain military roles, which put them at direct risk of heat exhaustion and heat stroke. For instance, construction workers labour under the sun or in hot enclosed spaces and the sector is globally male-dominated. In developing countries, a large proportion of men work in agriculture and fisheries, often performing heavy labour under high heat and humidity. These factors contribute to men's higher incidence of work-related heat injury and even death.[25] By contrast, women make up a significant share of subsistence and small-scale agriculture workers in many regions.

In rain-stressed seasons, a sizeable share of women's agricultural labour shifts to manual irrigation, including lifting and transporting water to fields, operating treadle pumps and hand watering seedlings. These tasks are typically performed at times of peak heat to reduce evaporative loss, paradoxically maximizing women's exposure to heat stress while increasing metabolic workload and dehydration risk. Evidence emerging from smallholder systems indicates that irrigation duties expand in both frequency and duration as droughts intensify, compounding the gendered time poverty and health risks already documented for women producers. Where mechanization and shade infrastructure are limited, manual irrigation functions as an uncounted 'hidden heat burden' within agricultural value chains and should be recognized in occupational heat standards and adaptation finance targeting smallholders.[26]

Heat stress poses a major threat to subsistence farmers, many of whom are women, particularly in regions such as sub-Saharan Africa and South Asia and may worsen working conditions for women in farming even more than for men in other sectors.[27] Women farmers often have fewer resources such as access to irrigation, mechanization or cooling and, thus, must toil longer in extreme heat to secure

livelihoods. In manufacturing, women are heavily employed in industries such as textiles and garments, working in factories without adequate cooling or ventilation (a common issue in some developing economies), which exposes them to heat stress indoors. Both men and women in informal urban jobs, e.g. street vending, waste picking and domestic work, also suffer in hot weather. Their experiences again differ: men street vendors might endure direct sun on asphalt, while women market vendors might be in crowded, poorly ventilated bazaars.

Crucially, heat on the job can reduce productivity and income, forcing difficult choices. It is estimated that by 2030, heat stress will reduce total working hours worldwide by about 2.2 per cent (equivalent to 80 million full-time jobs lost), with productivity losses greatest in lower-income countries.[28] In agriculture, part of this loss is absorbed off-the-books through women's unpaid manual irrigation during drought periods, which lengthens working days, crowds out rest and care, and magnifies heat exposure for women producers, a pattern largely invisible in conventional labour statistics but significant for adaptation planning.[29] This economic toll can then exacerbate gender wage gaps, as sectors losing the most work hours (e.g. farming, low-skill labour) often employ large numbers of women or marginalized men. The ILO (2019) notes that, without [transformational] adaptation, heat stress "could widen existing gender gaps in the world of work", for example, women in agriculture struggling to work in hotter conditions and men on construction sites facing more frequent heat stoppages. Moreover, pregnant women working through hot conditions face compounded risks, i.e. heat exposure on the job adds to health and productivity risks during pregnancy.

In both developed and developing countries, workplace heat protections often fail to account for gender-specific needs. For instance, women's work clothes, like nurses' uniforms or factory attire, may not be designed for optimal cooling, or pregnant workers may lack special accommodations such as extra breaks or hydration during heatwaves. Gender-responsive labour policies such as mandated shade and rest breaks in agriculture or construction, and flexible hours for pregnant or nursing employees during hot periods, are still being developed in most parts of the world.

3.2. DOMESTIC AND CAREGIVING RESPONSIBILITIES

Outside the formal workplace, gender roles heavily influence heat exposure, and here women often carry a greater burden. In many cultures, women and girls are primarily responsible for unpaid care, domestic and community work, which can turn deadly during heat extremes. Their main roles in collecting fuelwood (mostly in sub-Saharan Africa but also in South Asia) put stress on women and girls, but a particularly striking example is household water collection: in 8 out of 10 households without running water, women are the ones who fetch water.[30] During heatwaves or droughts, both household water collection and women's manual irrigation for kitchen gardens and small plots may require longer routes or waiting times, with overall water needs surging (for drinking, cooling and hygiene). This dual responsibility—domestic supply and field irrigation—extends the time they are exposed to heat to the hottest parts of the day and should be accounted for in local heat action plans. Such exertion raises their risk of heat exhaustion and dehydration. It also consumes time and energy that could have been used for education or paid work, effectively widening gender gaps in opportunities. Girls between ages 5 and 14 already spend up to 50 per cent more time than boys on household chores globally, and climate stressors like heat only increase this disparity.

Beyond water, women and girls are often tasked with cleaning, caring for younger children and the elderly, and cooking—frequently over open fires or

stoves that add heat to the home—all of them activities that become harder and more draining in hot weather. Caregiving during extreme heat can be a life-or-death responsibility. For example, tending to infants, who are highly sensitive to heat, or to elderly relatives with heat vulnerability, usually falls to the women in the family. This expectation can mean that women put others' comfort first. For instance, when underpinned by "emotional engagement",[31] a mother might forego using the only fan so that her baby can sleep, or a female caregiver might prioritize hydrating an elder, even as she herself grows dehydrated. During the 2003 European heatwave, it was observed that many elderly women who died were living alone without adequate care;[32] conversely, in cultures where extended families live together, it is the women in the household who try to keep grandparents and children cool.

The emotional stress and physical toll on women as caregivers intensify with each heatwave, which contributes to what some researchers call an "invisible" impact of climate change on women's health. In developing regions, pregnant and post-partum women caring for families face double risks: their own bodies are less heat-tolerant or increasingly susceptible to dehydration,[33] while they are expected to continue daily chores and childcare.

3.3. SOCIETAL EXPECTATIONS AND NORMS

Cultural norms can also modulate heat risk. In certain societies, dress codes require women to cover most of their body, for instance, long sleeves, headscarves or veils, even in extreme heat. This limits the body's ability to dissipate heat and can lead to higher core temperatures for women adhering to these norms, commonly observed in regions like the Middle East or South Asia. Men, in contrast, often have more freedom to go shirtless or wear light clothing in hot weather, aiding cooling. Mobility restrictions on women in some areas mean they may not access public cooling centres or swimming areas as freely as men. However, there are also gender differences in health-seeking behaviour: men might be culturally conditioned to "tough out" heat discomfort and avoid seeking help until collapse, which could explain why men outdoor workers sometimes die at higher rates than women outdoor workers. For example, men farmers or day labourers may delay stopping work or refuse to admit weakness, increasing heat stroke risk.

Decision-making power in households can play a role too. Where men control finances, they might decide whether to hire extra labour to reduce time exposure to heat for family members. They might also purchase fans, airconditioners or cool drinks. In some cases, men may prioritize other expenses or not recognize the severity of a woman's heat discomfort, leaving women with fewer adaptive resources. At the same time, women with less autonomy might not be able to leave a hot home for a cooler shelter without a male family member's permission or company in very conservative contexts. In disasters and emergencies related to heat, including wildfire evacuations, traditional gender roles can hamper effective disaster response, i.e. women might be waiting for a husband's decision to move to safety, or men might take risks to protect property. Studies have noted that existing disparities in gender roles, power and resources significantly shape climate vulnerability.[34] For instance, women's limited decision-making authority can undermine timely evacuation from an area during a heat crisis. Moreover, societal norms often expect women to endure discomfort without complaint, which is dangerous in a heatwave if women delay seeking medical care for heat-related illness. For men, masculinity norms might prevent them from acknowledging heat stress or using cooling aids, leading to, for example, construction or farm workers not taking breaks. Both genders can be constrained in different ways by societal expectations, calling for gender-sensitive public health messaging, e.g. encouraging everyone, men included, to rest and hydrate, and empowering women to take protective measures for themselves.

3.4. ACCESS TO RESOURCES AND COOLING

A final social factor is access to adaptive resources such as cooling systems, green space and healthcare. Gender-differentiated access to economic resources such as land and physical property, a bank account or information, and the associated decision-making power mean women, especially single mothers and widows, may have less ability to afford air conditioning or improved housing. In low-income urban neighbourhoods, often with more female-headed households, there is typically less tree cover and more heat-trapping concrete, resulting in urban heat islands that disproportionately affect women and children who spend time at home. Data from cities such as Los Angeles, California, show that neighbourhoods lacking greenery and air conditioning saw not only worse heat outcomes but also rises in domestic and intimate partner violence during heatwaves,[35] highlighting how compound stressors hit disadvantaged groups. Burke et al. observed similar rises in violence in South Africa.[36]

Women's comparatively limited access to quality healthcare can result in untreated chronic conditions that make heat more dangerous. Meanwhile, in some situations, men might be more likely to be homeless or living in poorly cooled prisons, which is another facet of vulnerability. Encouragingly, research finds that social support networks can mitigate heat risks. Women often have stronger social networks (friends, community groups) that check on each other during heatwaves, which can reduce fatalities. One study noted that women's physiological vulnerability was partly offset in areas where community cohesion is higher than in places lacking social support.[37] Men, who may lack such support or be reluctant to ask for help, might not have anyone ensuring they are coping, which could be one reason why isolated older men suffer in silence.

All these factors illustrate how heat stress is not just a climate or biological issue, but a social one. Gender roles in both developing and developed societies also shape who is more exposed and who is more protected. Any effective heat adaptation strategies, from workplace regulations to community cooling centres, must account for these gendered realities, for example, ensuring women have equal access to cooling resources and that men in high-risk jobs receive training to recognize and act on heat illness symptoms. Without addressing gendered roles, policies could inadvertently leave one gender more vulnerable to rising temperatures.

4

AGE-BASED VULNERABILITY AND THE INTERSECTION OF GENDER AND AGE

4. AGE-BASED VULNERABILITY AND THE INTERSECTION OF GENDER AND AGE

Heat affects all age groups, but children, adolescents, adults and the elderly each face distinct vulnerabilities. Moreover, gender can amplify or alter risks within each age category. The following sections outline how different age groups are exposed and affected by heat stress, and how these impacts intersect with gender equality in both developed and developing contexts.

4.1. CHILDREN (INFANTS AND YOUNG CHILDREN)

Young children, especially infants and toddlers, are among the most vulnerable to heat stress. Biologically, children's bodies are not as efficient at thermoregulation as adults'. Infants have a high body surface area relative to their mass, which means they absorb heat from the environment quickly, i.e. a baby can heat up faster than an adult under the same conditions.[38] At the same time, children have immature sweating mechanisms; they produce less sweat (and start sweating at a higher core temperature) than adults.[39] This combination —more heat absorption and less cooling—can cause children's body temperature to spike rapidly in hot environments. Infants also have underdeveloped circulatory systems and still-maturing kidneys, so they are less able to cope with dehydration and heat's strain on the body.[40] Heat-related illnesses in children can manifest as high fevers, heat rash, dehydration and, in severe cases, heat stroke. There is evidence linking extreme heat to higher incidence of Sudden Infant Death Syndrome (SIDS).[41] The health impacts begin even before birth: if pregnant women are exposed to extreme heat, it increases the odds of preterm birth and can affect fetal development, leading to more babies born with congenital defects.[42] For example, maternal heat stress in the first trimester has been associated with certain heart defects and neural tube defects in newborns.[43]

From a gender perspective, boy and girl children are physiologically quite similar in early childhood; both sexes face the heat-related risks described previously. However, social factors can introduce differences in exposure. For example, in many developing societies, young girls are kept at home more, helping with chores or caring for siblings, while boys are allowed to play outside or attend school. In extremely hot conditions, staying inside could be protective if the home is cooler—but if the home lacks cooling and ventilation (common in poor settings), indoor heat can be just as deadly, and girls might spend long hours in sweltering kitchens or huts. Conversely, boys who roam outside might find shade under trees or near water, or they might also engage in labour (e.g. herding animals, working in fields) that exposes them to the sun.

Child labour can start at a young age in some developing regions: boys sometimes begin working in agriculture or trades in their pre-teens, putting them in hot environments, while girls often start fetching water or firewood very early. For instance, girls as young as 5 in parts of Africa and Asia are tasked with water collection during dry seasons and droughts,[44] meaning even at that tender age, they bear heat stress for their households. Boys, even into adolescence, may spend long days tending livestock under the harsh sun. These differences suggest that even among children, gender roles (as defined by culture and social norms) shape heat exposure. In a purely biological sense, an 8-year-old boy and girl have similar heat tolerance, but if one is climbing a hill with a water jar in 40°C weather while the other is not, their risk diverges.

In developed countries, severe heat risks for young children often arise from situations like being left in overheated cars or playing outside on extremely hot days. Such tragedies are not gender-specific with respect to children, but awareness raising must be designed to reach parents of both genders. One notable gendered aspect in developed contexts is caregiving: who monitors the child's environment? Often mothers are expected to ensure children are cool and hydrated. If, for example, single mothers are working and a heatwave hits, their children left in substandard childcare or alone may suffer. On the other hand, fathers or male caregivers might be less educated on warning signs of heat illness in children if caregiving has been seen as the mother's role. Ensuring that all caregivers, regardless of gender, are informed and vigilant is critical to protect children in heat events. Finally, when climate shocks such as heatwaves strike, children are dependent on adult action. If gender norms impede those actions (for example, if a mother cannot leave the house without the father's permission to take a sick child to a cooler location), then the child's well-being is indirectly tied to gender dynamics.

4.2. ADOLESCENTS (APPROXIMATELY 10 TO 19 YEARS)

Adolescents occupy a transitional stage with unique vulnerabilities. Physiologically, by adolescence, boys and girls begin to diverge due to puberty—boys typically develop greater muscle mass and sweat capacity, while girls may have hormonal fluctuations (menstrual cycles) that can affect hydration and thermal comfort. Generally, healthy teenagers can tolerate heat similarly to adults, but high activity levels make them prone to heat stress. Physical exertion in heat is a big risk for this age group: teen boys and girls involved in sports (from football to sprinting to marching bands) have suffered heat exhaustion or heat stroke during training camps in hot weather. Notably, in sports and military cadet settings, adolescent males have a higher incidence of exertional heat illness, reflecting both higher participation in intense activities and possibly a tendency to push past their limits. For example, studies in the United States have found the vast majority of high school football players who died of heat stroke were male, as the sport is male-only and very demanding. While female athletes, e.g. in soccer or cross-country running, also face risks, coaches may be slightly more cautious with girls, or girls may be more likely to report feeling unwell, potentially lowering the incidence of heat strokes—though data are limited. Another health consideration is that adolescent girls begin menstruation, and there is some evidence that heat can exacerbate symptoms like dehydration or faintness during their periods.[45] Culturally, in hot climates, girls might skip school if they feel unwell or if schools lack water and sanitation, i.e. a girl dealing with menstruation in a school without fans may be pushed into absenteeism due to discomfort. This points to an interaction between heat, gender, and education in adolescence.

Late adolescence is when gender roles solidify. In many developing countries, adolescent boys may start full-time work or strenuous apprenticeships, for instance, as a construction helper or agricultural labourer, directly exposing them to extreme heat

daily. Adolescent girls, on the other hand, might take on increased domestic duties or enter jobs like garment factory work or market vending—which can also be hot, though perhaps with some shade. A concerning issue is child marriage and early pregnancy: millions of girls 15 to 19 years of age become pregnant each year. A pregnant teenager faces all the heat-related risks of pregnancy (higher chance of complications under heat stress) on top of still developing herself. For instance, a 17-year-old pregnant girl working in fields or doing manual labour (common in parts of South Asia and sub-Saharan Africa) is extremely vulnerable to heat—she could suffer heat exhaustion more quickly, with dangerous consequences for her and the fetus.[46] It is in these scenarios that gender (being female and in early motherhood) and age (still an adolescent) combine to create high risk. In contrast, adolescent males are not at risk of pregnancy but might engage in risk-taking behaviour during heat, e.g. a teen boy might challenge himself to work longer in the sun or may be compelled by elders to carry out heavy tasks.

In developed societies, adolescents may seem relatively protected—many have access to air-conditioned schools or homes. But marginalized youth, e.g. homeless teenagers, or those in poorly insulated housing, can be at risk. Moreover, teenagers often partake in outdoor activities (sports, hiking, summer jobs like lifeguarding or landscaping) that coincide with the hottest months. Education on heat safety is therefore key for this group. It is also worth noting psychological aspects: heat can increase irritability and aggressive behaviour, which in a teenage population might lead to conflicts or accidents. Some studies even suggest that high temperatures can affect cognitive performance and concentration, which could impact learning for adolescents in non-cooled education settings.[47] In summary, while adolescents have strength and resilience on their side, they are not invincible to heat; gender roles (e.g. the expectation for boys to do manual work or for girls to shoulder domestic chores or early childbearing) strongly influence their heat exposure and outcomes.

4.3. ADULTS (WORKING-AGE ADULTS)

Working-age adults, those aged approximately 20 to 64 years, are the core of the labour force and caregiving in society, and they face heat stress both at work and at home. At a purely biological level, young and mid-life adults are generally the most heat-tolerant age group as they have fully developed physiological systems, and many are healthy. However, occupational heat exposure peaks in adulthood, and so do related health impacts. As discussed earlier, men in this age range often work in the hottest jobs (e.g. in construction, heavy industry, outdoor agriculture and the military), leading to higher rates of heat-related injuries and deaths on the job.[48] Women in this age group also work in heat-exposed roles, especially in developing countries where, for example, women take on roles as farmers, market vendors, seamstresses and brickmakers.[49] The difference is that men's heat exposure is often formal and visible (e.g. a men construction crew working through midday heat), whereas women's may be informal or overlooked (e.g. a woman farming a family plot or cooking in a sweltering kitchen).

This age group also includes pregnant and post-partum women, who warrant special attention. Pregnancy reduces a woman's ability to dissipate heat given her core temperature is already slightly elevated and her cardiovascular system is under strain. As described earlier in this paper, extreme heat significantly raises risks of adverse pregnancy outcomes. For working pregnant women, even mild heat stress at work, e.g. standing for hours in a hot factory, can lead to dizziness or preterm contractions. Pregnant women often continue working late into pregnancy, especially in low-resource settings, due to economic necessity. The ILO identifies heat protections for pregnant workers, like shade, rest, hydration and adjusted hours, as a critical need.[50] After childbirth, nursing mothers also need cool conditions as dehydration from heat can reduce

breast milk production, and, indeed, studies show infants tend to be breastfed for shorter durations on very hot days, possibly because both mother and baby are heat-fatigued.[51]

Gender relations in adulthood are largely about roles and power. In developing societies, adult women may have less say in community planning, for instance, men leaders might allocate electricity and water in ways that do not prioritize women's comfort, like powering irrigation pumps but not investing in cooling centres for pregnant women. Adult women also often lack land rights or equal access to other productive resources, which could allow them to adopt adaptive measures like planting shade trees on a farm or purchasing a water tank. Adult men, conversely, might migrate for work if local farming becomes untenable due to heat, leaving women behind to manage households under harsher conditions.[52] This "heat-driven migration" is on the rise. As farming men seek cooler highlands or urban jobs, the women staying behind face both increased work and extreme climate.

In developed societies, many working-age adults can access climate control (e.g. offices and cars with air conditioning) but disparities remain. Outdoor workers (often men, or immigrant labourers of either gender) in wealthy countries still face high heat. Farmworkers in the United States, for example, suffer heat illness and even death every summer, with Latino men farmworkers being particularly affected due to the combination of hard labour and sometimes inadequate enforcement of labour laws.[53] At the same time, it is low-income women in developed countries who often work in sectors like home healthcare, cleaning and food services, where they work in hot kitchens or clients' homes that are not cooled. If an urban heatwave causes power outages, those in sub- standard housing, often single mothers with children, or the working poor, face heightened vulnerability.

Another aspect for adults is health conditions. By mid-adulthood, some individuals have developed chronic illnesses such as diabetes and hypertension that make heat more dangerous. There are gender patterns in these conditions, e.g. men might have higher rates of cardiovascular disease by their 50s while women might have thyroid issues affecting heat tolerance. Medications for conditions such as blood pressure or mental health can impair heat regulation as well. If women have less access to healthcare, their conditions may be unmanaged and thus pose greater risk in extreme heat.

Mental health and interpersonal violence intersect here too: heat can increase aggression levels, and studies as in South Africa and the United States have linked extreme heat to higher rates of domestic violence.[54] Adult women who are trapped in abusive relationships are at heightened risk during heatwaves as, not only do they face physical violence, which may be exacerbated by partners' heat-aggravated aggression, but escaping the home to a cooler or safer location may not be easy for them. Men, on the other hand, might be more likely to perpetrate violence under heat stress if societal pressures and heat-provoked frustration combine. Thus, heat stress in adulthood has a cascading effect: it directly endangers health and productivity and indirectly strains family dynamics and safety, with gender influencing both the direct and indirect outcomes.

4.4. THE ELDERLY (OLDER ADULTS)

Older adults, generally 65 years and above, are well recognized as the most vulnerable age group to heat stress. Ageing brings about a decline in physiological resilience as sweat glands become less effective, skin blood flow response diminishes, and the sense of thirst is blunted. By approximately age 50, the body's thermoregulatory efficiency starts dropping for both men and women.[55] Elderly individuals often have multiple chronic diseases such as heart disease, lung conditions and kidney problems that are exacerbated by heat. For instance, heat can stress the cardiovascular system, potentially triggering heart attacks or strokes in those with underlying conditions.[56] The ability to maintain a

stable core temperature is much lower in seniors, making prolonged heat quickly lead to heat exhaustion or heat stroke if cooling interventions (like fans and hydration) are not readily available. This is why deadly heatwaves disproportionately kill the elderly.

When considering gender equality among the elderly, a striking pattern emerges: elderly women have been found in many instances to suffer higher mortality in heatwaves compared to elderly men.[57] This research also found that, during Europe's 2003 heatwave, for example, women over 75 died at higher rates than men over 75. Researchers have analysed this in detail and found that even when controlling for age (since women often live longer, skewing the demographics), on average, older women still had some 15 per cent higher heat-related mortality than men in the same age group.[58] Significantly, this pattern is not confined to lower income settings. Studies from Europe and North America also report disproportionate heat-related mortality among older women, even where general access to cooling is higher.[59]

There are several reasons for this gender gap: physiologically, post-menopausal women have lost the vasodilatory benefits of estrogen and typically have lower sweat gland output. As one physiologist explains, "the ability of older females to lose heat from the body is the lowest" of any adult group.[60] In fact, an elderly person sweats only about half as much as a young person, and an elderly woman sweats roughly half as much as an elderly man under the same heat stimulus. This means an 80-year-old woman accumulates heat faster and cools down slower than an 80-year-old man, all else being equal. Moreover, cardiovascular strain tends to be higher in older women under heat stress as their hearts may work harder to pump blood for cooling, which can precipitate heart failure or fainting.[61]

Social factors play a huge part too. Many elderly women live alone (often widowed, as women outlive men on average). Living alone is a known risk factor in heatwaves,[62] particularly as there, more often than not, may be no one to help when the house becomes unbearably hot or to call for assistance if a woman becomes ill. An older man is also at risk if alone, but historically this is more a phenomenon associated with older women. Conversely, elderly men are more likely to have a spouse caregiver (since they tend to marry younger women or their wives survive till the man dies). This means an elderly man might have a wife reminding him to drink water or turn on a fan, whereas an elderly widow has no such support unless community or family intervenes.

Moreover, studies note that even when both are living alone, older women might be more vulnerable because of lifestyle, and social, cultural and legal expectations: they may be less inclined to go to an air-conditioned public space (due to mobility issues or safety concerns), and some evidence suggests older women persist in doing household tasks during heatwaves more than older men.[63] For example, an 80-year-old woman might still cook or tidy up out of habit, whereas an 80-year-old man living alone might be more likely to just stay still or do less, although this can vary. Continuing physical activity in a hot home (a more likely reality in poorer settings), even light housework, could tip an already heat-stressed body into collapse.[64]

Recent work further indicates that the intersection with poverty is critical, in that even where some analyses find larger heat effects for older men, the higher prevalence of poverty among older women in many high-income countries can translate into systematically lower access to effective cooling and social support, sustaining a net disadvantage for older women during heatwaves.[65] Older women generally have lower incomes and higher rates of poverty, especially in developing countries, meaning they may not afford cooling appliances or proper housing. In rural developing countries, an elderly woman might still labour outside, e.g. weeding a garden or tending animals, because there may be no pension to rely on, exposing her to heat, whereas an elderly man might be deemed too frail and is allowed to rest (or he might receive more familial support).

That said, elderly men are also vulnerable. They often have higher rates of certain chronic illnesses, like cardiovascular disease, that heat aggravates.[66] There have been cases in developed countries such as the United States where older men, especially those

who are socially isolated or homeless, have higher heat death rates. For instance, men over 65 who live in poor urban areas without air conditioning and who may have a stoic attitude towards heat, thus not inclined to seeking help, are frequent victims. The net global trend, however, leans towards older women bearing the brunt of heatwave mortality,[67] making it a pressing gender issue. It is important to implement targeted interventions: community "buddy" systems to check on older women living alone, distribution of cooling fans or cool packs especially to elderly female residents, and ensuring that both elderly men and women can easily access cooling centres while accounting for any mobility or cultural barriers.

In summary, across all age groups, heat vulnerability is a product of both age-specific physiology and gendered life circumstances. The following table provides an overview of age-based heat impacts and how gender disparities can influence each:

Age group	Key heat vulnerabilities (all genders)	Gender interactions and differences
Children (0–9 years)	**Physiology:** High surface-to-mass ratio, low sweat production, rapid dehydration. Fully depend on others for thermal regulation (cannot remove clothing, get water by themselves). Heat can impair development (e.g. heat exposure in utero linked to birth defects).	**Gender roles:** In many cultures, young girls do more household tasks (like water fetching) from early ages, increasing their heat exposure. Boys may be allowed more outdoor play or herding work, which can also be risky in heat. **Care:** Girls might be kept indoors (potentially safer if the home is cool, but dangerous if not); boys might be out in the sun. Both rely on caregivers (often mothers) to monitor heat safety.
Adolescents (1–19 years)	**Physiology:** Near adult-level thermo-regulation, but high physical activity (sports, outdoor work) can lead to exertional heat illness. Puberty brings changes: boys gain muscle (can generate more heat during work), girls begin menstrual cycles (heat may worsen discomfort). They are generally healthy, but heat can affect their concentration and mental well-being.	**Gender roles:** Adolescent boys often start manual labour or strenuous sports, raising heat stroke risk. Adolescent girls may have heavy domestic chores or even early pregnancy, heightening heat vulnerability In school, if facilities are hot, girls might skip classes (especially if managing menstruation in heat), while boys might be expected to be tough. Socially, boys might be pressured to work through heat; girls might lack freedom to seek cooler spaces if it is not considered socially acceptable for them to go out.
Adults (20–64 years)	**Physiology:** Prime age for work; generally good heat tolerance if healthy. Heat risk comes from cumulative exposure (long working hours in heat) and health conditions (hypertension, diabetes, etc. can worsen outcomes). Heat stress can reduce labour capacity and cause chronic kidney injury in manual workers (seen in sugarcane workers in hot climates).	**Gender roles:** Men dominate many high-heat occupations (construction, heavy industry, outdoor agriculture), leading to more on-the-job heat injuries. Women often juggle employment with unpaid domestic labour—so a woman may work in the field under the sun then cook in a hot kitchen at home, effectively a double shift of heat exposure. Pregnancy is a major factor: only women face the intense heat strain of pregnancy, which significantly raises health risks during heatwaves. Culturally, men might resist slowing work in heat (to meet job expectations), whereas women may lack authority to demand better conditions. Men have higher rates of heat-related workplace fatalities; women have more heat-related reproductive and household health burdens.
Elderly (65+ years)	**Physiology:** Greatly reduced ability to sweat and regulate body temperature. Often have chronic illnesses (heart, lungs, kidneys) that heat exacerbates. Less mobility and may be bedridden or home-bound. Diminished thirst can lead to severe dehydration. Very high risk of heat exhaustion, heat stroke, and organ failure in heat.	**Gender roles:** Older women often live longer but with less financial stability. Many live alone and cannot afford cooling. They also sweat less and experience more cardiovascular strain in heat, contributing to higher heatwave mortality. Older men, if alone, are also at risk (and may be reluctant to seek help). Women may continue caregiving roles into old age (e.g. grandmothers watching grandchildren) even when heat is dangerous, whereas men are somewhat more likely to cease physical tasks in advanced age. Community support networks often focus on checking in on "elderly ladies"—which indicates acknowledgment that older women are a particularly vulnerable group.

5

WHY HEAT DEMANDS URGENT ATTENTION FOR GENDER EQUALITY

5. WHY HEAT DEMANDS URGENT ATTENTION FOR GENDER EQUALITY

The differentiated impacts of heat stress by gender and age represent a pressing challenge at the nexus of climate change, public health, labour productivity and gender equality. As global temperatures steadily rise, heat stress will increasingly become a major impediment to the achievement of gender equality and women's and girls' empowerment. Therefore, urgent action is needed; the following outlines some of the reasons why.

5.1. PUBLIC HEALTH IMPERATIVES

Heatwaves are now recognized as a significant global public health hazard. In an average year, extreme heat kills more people than hurricanes, floods or earthquakes in many countries. The public health community is sounding the alarm that women, children and the elderly often lack adequate protection in heat events.[68] Health systems must adapt. For instance, hospitals and clinics need reliable power for cooling and refrigeration of medicines. It is estimated that 1 billion people in low-income countries are served by health facilities without reliable electricity,[69] meaning even basic cooling or fan support is absent, a situation that disproportionately affects women and infants, as maternal health services and paediatric care are hampered. Heat-related health issues range from dehydration and kidney stones to heat stroke and heart failure and to mental health issues, as heat can worsen anxiety, dementia symptoms and more. Women's health can be uniquely impacted, e.g. higher rates of stillbirth during heatwaves represent not just personal tragedies but also a stress on healthcare systems and communities. From a public health planning perspective, early warning systems and heat action plans need to incorporate gender and age lenses. That means ensuring warning messages reach women (who may have lower literacy or access to media in some areas) and advising caretakers on protecting children and seniors. It also means tailoring interventions, e.g. cooling centres should be made accessible and welcoming to women, children and the elderly. They must be safe spaces, with provisions like privacy areas for women if needed, and are accessible within available financial means. If these nuances are not considered, certain groups may not use life-saving services.

The urgency is also because heatwaves often come with little notice and societies that are unprepared can suffer catastrophic losses such as seen in the European heatwaves of 2003, 2010 and 2022, and recent events in South Asia. Every heatwave now is essentially a test of our ability to protect the most vulnerable and marginalized. With climate change, these tests will become more frequent and severe. We need to learn and implement protective measures quickly.

5.2. LABOUR AND ECONOMIC IMPACTS

Heat stress is not only a health issue but an economic one. As noted, by 2030 an estimated 80 million full-time-equivalent jobs could be lost due to heat stress globally,[70] with global economic losses projected in the trillions of US dollars over the decade in question. These losses will be concentrated in hotter, poorer regions, threatening both development and efforts to reduce poverty. There is an urgent need to protect workers, both for their own safety and to safeguard livelihoods. Gender equality considerations come into play in that the sectors expected to be hardest hit, e.g. agriculture, informal street work and small-scale manufacturing, have large female workforces in many countries.[71] Without intervention, families that rely on women's subsistence farming or market trading could see incomes collapse as midday hours become too hot to work. Men in heavy manual labour may suffer wage losses or unemployment if they physically cannot meet labour demands in peak heat.

There is also concern that as certain jobs, like construction, become more arduous, women might be pushed out if they are perceived as less able to handle heat, thus reinforcing occupational gender gaps. The ILO warns that heat stress could exacerbate gender inequality in work by the degradation of conditions in sectors where women are over-represented and men underrepresented.[72] This calls for urgent action in the world of work, which means that implementing occupational heat safety standards like shade, rest and hydration mandates must be done well ahead of the hottest years. It is imperative to invest in mechanization and technology, so that, for example, women farmers do not have to do as much manual drudgery in heat and ensure both men and women workers have the training and rights to protect themselves. Moreover, as heat drives rural-to-urban migration or international migration (sometimes called "climate migration"), the gendered consequences must be anticipated and managed. Often, young men migrate and women are left behind to cope with the farm, or entire families migrate, putting women and children in precarious situations in unfamiliar urban slums. Labour policies and climate adaptation plans, therefore, need to be gender-responsive to truly cushion society against heat stress. The cost of inaction is high not just in economic terms but in human development. For instance, if girls are pulled out of school to cover for a heat-stricken working mother, the cycle of inequality continues.

5.3. GENDER EQUALITY AND SOCIAL JUSTICE

Fundamentally, addressing the gendered impacts of heat stress is a matter of human rights and equity and must be central to the fulfilment of the right to a safe, clean, healthy and sustainable environment.[73] Women and girls often have the least voice in decision-making yet bear a heavy burden of climate-related heat stress.[74] Climate justice frameworks highlight that those who are socially and economically marginalized, which includes many women, particularly women of colour, Indigenous women and single mothers, face a double injustice given their higher exposure to climate hazards while being equipped with fewer resources to adapt. In heatwaves, this can be seen clearly: wealthier men and women can stay in air-conditioned environments, while the poor, often female-headed households or minorities, cannot. Ensuring equitable access to cooling is a new frontier of climate justice. This could mean subsidizing electricity or cooling devices for low-income families, designing affordable housing that is passively cooled, and planting urban trees in slums and low-income neighbourhoods where women spend their days. It also means collecting data as, currently, there is an alarmingly scarce amount of disaggregated data and gender statistics on heat impacts. More research and monitoring is needed of how heat affects women differently from men, and girls from boys, to craft effective policies.

Gender-responsive approaches to heat stress will yield multiple benefits. They can improve overall community resilience, for example, by setting up networks of groups in local communities to check on vulnerable people during heatwaves, not only saving lives in heat events but strengthening social ties for other emergencies. Zavala et al. showed that empowering women through education, resources and rights, for example, is proven to improve outcomes in disaster situations.[75] Heat adaptation is no different. When women have greater agency, they can make household changes like improving ventilation and managing finances to invest in cooling that protect everyone. Moreover, focusing on the young and the old, who cannot protect themselves, could be an economic imperative, but is certainly a moral imperative.

6. CONCLUSION

In conclusion, the gendered impacts of heat stress across all ages demand urgent attention. They sit at the intersection of the climate emergency and social inequality. With climate change accelerating, extreme heat is no longer an occasional inconvenience but a defining challenge of our era, one that will test our commitment to protecting the most vulnerable.

While physiological differences between men and women do shape how heat is experienced, they are not the primary drivers of vulnerability. What truly determines who suffers most are compounding social and economic factors: unequal access to cooling, gendered labour roles, expectations of care-giving, as well as cultural norms and disparities in decision-making power. These structural conditions amplify biological risks and often leave women, children and the elderly with fewer options to adapt or protect themselves.

By understanding how heat affects women and men differently at each life stage, and how these differences are shaped by social context, targeted interventions can be designed: everything from cooling classrooms and maternity wards to enforcing heat safety in workplaces and building community networks that ensure no one is left alone in the heat. Such actions will save lives, protect livelihoods and advance gender equality in the face of a warming planet.

The time to act is now, before rising temperatures write an even more unequal and tragic story for future generations.

ENDNOTES

1. IPCC 2018
2. IPCC 2022a
3. UNFCCC 2024
4. IPCC 2022a
5. Ibid.
6. Ibid.
7. UNICEF 2021
8. WMO 2023
9. Including persons with disabilities, displaced and migrant people, Indigenous and ethnic minorities, people living in extreme poverty, and others.
10. In this section, where the analysis focuses on biological differences, the terms "women" and "men" are used as broad references to individuals with female and male sex characteristics, respectively. This is strictly for analytical clarity regarding sex linked physiological differences. As recognized in UN Women's terminology guidance, gender is socially constructed and distinct from sex, and people's gender identities and expressions are diverse. This paper therefore acknowledges that not all individuals with particular sex characteristics identify as women or men, and that gender identities exist along a spectrum. The terminology used here is a pragmatic shorthand for sex-based biological discussion and does not negate the broader diversity of gender identities.
11. van Steen et al. 2019
12. Ibid.
13. Folkerts et al. 2022
14. Zavala et al. 2024
15. Ibid.
16. Spector et al. 2019
17. Thonneau et al. 1998
18. Ibid.
19. Ha 2022
20. Chersich et al. 2020
21. Ilango et al. 2020
22. Ha 2022
23. Ibid.
24. Takahashi 2012
25. Zavala et al. 2024
26. FAO 2024; ILO 2019; Lee et al. 2025
27. ILO 2019
28. Ibid.; Spector et al. 2019
29. FAO 2024; ILO 2019; Lee et al. 2025
30. WHO , UNICEF and World Bank 2022
31. Folbre 2006
32. Folkerts et al. 2022
33. Samuels et al. 2022
34. Zavala et al. 2024
35. IPCC 2022b
36. Burke et al. 2021
37. Bell et al. 2008
38. UNICEF 2023
39. Ibid.
40. Ibid.
41. Ibid.
42. Ibid.
43. Ibid.
44. WHO, UNICEF and World Bank 2022
45. Greenfield et al. 2023
46. Samuels et al. 2022
47. Anjum and Aziz 2025
48. Zavala et al. 2024
49. ILO 2019
50. Ibid.
51. UNICEF 2023
52. ILO 2019
53. Ibid.
54. IPCC 2022a; Burke et al. 2021
55. ILO 2019

56. Ibid.
57. Folkerts et al. 2022
58. Ballester et al. 2023
59. van Steen et al. 2019; Ballester et al. 2023
60. Ibid.
61. Ballester et al. 2023
62. Ibid.
63. Ibid.
64. Ibid.
65. Päivärinne et al. 2025
66. ILO 2019
67. Ibid.
68. WMO 2023; Zavala et al. 2024
69. WHO et al. 2023
70. ILO 2019
71. Ibid.
72. Ibid.
73. See United Nations General Assembly. 2021. Resolution adopted by the Human Rights Council. The human right to a clean, healthy and sustainable environment. 18 October. A/HRC/RES/48/13 and United Nations General Assembly. 2022. Resolution adopted by the General Assembly. The human right to a clean, healthy and sustainable environment. 1 August. A/RES/76/300.
74. Zavala et al. 2024
75. Ibid.

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