REVIEW ARTICLE

Occupational heat perception and susceptibility in outdoor workers: A mini review

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ABSTRACT

The impacts of climate change are worsening occupational heat exposure worldwide, putting outdoor workers at the forefront of thermal risk. While the physiological impacts of heat stress are well documented, little attention has been paid to how workers themselves perceive heat exposure and the associated health threats. This mini-review synthesizes objective evidence on occupational heat perception among outdoor workers, focusing on perceived heat burden, symptom experience, vulnerability, and adaptive responses. A structured search of major scientific databases identified 16 original studies across different geographical settings, covering agriculture, construction, brick kilns, forestry, and informal labor. Across regions and occupations, workers commonly perceived heat as a leading occupational hazard associated with heat-related symptoms (HRIs): exhaustion, dehydration, dizziness, headaches, and reduced productivity. Heat was more often characterized as a daily bodily burden than a general environmental condition. Physiological perception of heat consistently emerged as an embodied indicator of underlying thermal strain, linking subjective experience with cardiovascular and hydration stress. Perceived vulnerability was not homogeneous: women, pregnant workers, older workers, workers with chronic disease, and those in the informal sector repetitively reported heightened perceived vulnerability and lower coping capacity. Importantly, workers' accounts strongly mirrored objective indicators of physiological strain, confirming perceived heat stress as a valid occupational health indicator. Yet despite broad awareness of heat-related risks, effective protective practices were often limited by economic constraints and weak organizational support. Heat perception is an important yet often overlooked factor in occupational heat risk. Incorporating lived thermal experience into surveillance, research, and prevention may enhance early identification of heat strain and enable more worker- centered, equitable climate adaptation approaches.

Keywords: Climate change, occupational heat risk, HRIs, vulnerability, adaptive responses

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INTRODUCTION

One of the defining occupational health challenges of this century, increasingly recognized, is climate change. Along with rising global temperatures, the approach of the United Nations Framework Convention on Climate Change (UNFCCC) 1.5°C target and the escalating frequency and severity of heatwaves, the working population is facing increasingly extreme thermal conditions.[1,2] Occupational heat exposure is an emerging international public-health issue owing to its daily exposure, exposing workers to a high risk of heat strain, dehydration, cardiovascular stress, injury, and loss of productivity.[3-5]

Research over the past twenty years has been almost entirely concerned with quantifying environmental heat loads and documenting physiological effects. Solid evidence links occupational heat exposure to heat-related illnesses, renal and cardiovascular stress, impaired cognitive performance, and reduced work capacity in agriculture, construction, and other outdoor industries.[6-8] However, occupational risk is not solely a function of exposure. Perceptions of heat and bodily strain, symptoms, and personal vulnerability help workers make daily choices about pacing, rest, hydration, and protection.[5]

Heat perception is the integrated psychophysiological response that fuses thermal sensation with fatigue, discomfort, emotional reactions, and perceived threat.[8] Occupational and environmental health studies have established that perceived risk is a key driver of preparedness and adaptive behavior in extreme heat conditions.[9-11] Perceptions among workers vary greatly, even in objectively dangerous circumstances, because they are shaped by a combination of experience, work organization, education, and organizational support.[12-14] This may lead to a dulled or distorted perception, delaying protective responses and increasing vulnerability to preventable heat-related illnesses. [15,16]

The influence of heat is rarely documented as a neutral background condition in studies of outdoor workers. In lieu of this, workers tend to attribute heat exposure to well-being and/or productivity. Awareness based on symptoms also more frequently precedes clinical awareness. Some of the first warning systems of accumulating physiological strain in resource-constrained work environments can be perceptual signals.[18]

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The perception of heat is also socially embedded. The community associations, collective cultures within occupations, and shared narratives form the basis of knowledge about heat risk and the measures taken based on that knowledge, both affecting individual coping behaviors and shaping adaptation at the communal level. These influences leave no doubt that the perception of heat is not merely sensory but is created through lived experience in particular occupational and socioeconomic contexts.[19-21]

Although research on occupational heat has expanded, it is largely based on environmental measurements and physiological outcomes, with little consideration of workers' experiences and how they interpret heat exposure. There is still limited evidence synthesizing the perception of heat among outdoor workers. This mini-review presents a focused, narrative synthesis of a limited number of empirical studies that describe key findings, aiming to show how outdoor workers perceive occupational heat, highlight a population that reports greater perceived vulnerability, and describe patterns related to perceptions relevant to occupational heat risk and climate acclimatization. Unlike systematic or scoping reviews, which aim to provide complete coverage of the literature, the current mini-review is focused and interpretive, synthesizing a small volume of empirical evidence. It is not intended to be a comprehensive mapping of all potential studies, but rather to identify and synthesize the key patterns in the conceptualization of occupational heat perception, perceived vulnerability, and adaptive mechanisms among outdoor workers.

MATERIALS AND METHODS

Study Design and Literature Search Strategy

The purpose of the mini-review is to synthesize original evidence on heat perception, perceived health effects, and perceived occupational risk factors among workers exposed to heat. A literature search has been performed through major scientific databases such as PubMed, Semantic Scholar, and Google Scholar to identify peer-reviewed original articles published in the English language up to 12th January, 2026. PubMed was chosen because it is an extensive collection of literature on biomedical and occupational health; Semantic Scholar because it is an interdisciplinary index of scientific research; and Google Scholar because it is a larger collection of literature on biomedical and occupational health. The advanced search was carried out by using a combination of controlled vocabulary and keywords in free-text form as follows: ("occupational heat exposure" OR "heat stress") AND ("heat perception" OR "risk perception") AND ("outdoor workers" OR "outdoor laborers" OR "outdoor occupational groups"). Therefore, only primary studies in full text were included in the results and were manually retrieved for consideration.

Eligibility Criteria

We included studies that: (i) examined the population characteristics and important findings; (ii) were original studies of a cross-sectional, qualitative, mixed-methods, or field-based design; (iii) explicitly investigated the perceived exposure to heat, perceived symptoms, risk awareness, vulnerability, or adaptation behavior.

The studies were excluded if they were reviews, editorials, laboratory experiments without worker populations, or if the full text was not available.

Study Selection and Data Extraction

Titles and abstracts were screened for relevance, followed by full-text evaluation. For each included study, data were extracted on authorship (year of publication, country, and occupational sector), study design, participant characteristics, and principal findings related to heat perception and perceived health or work impacts. Finally, a narrative synthesis approach was adopted.

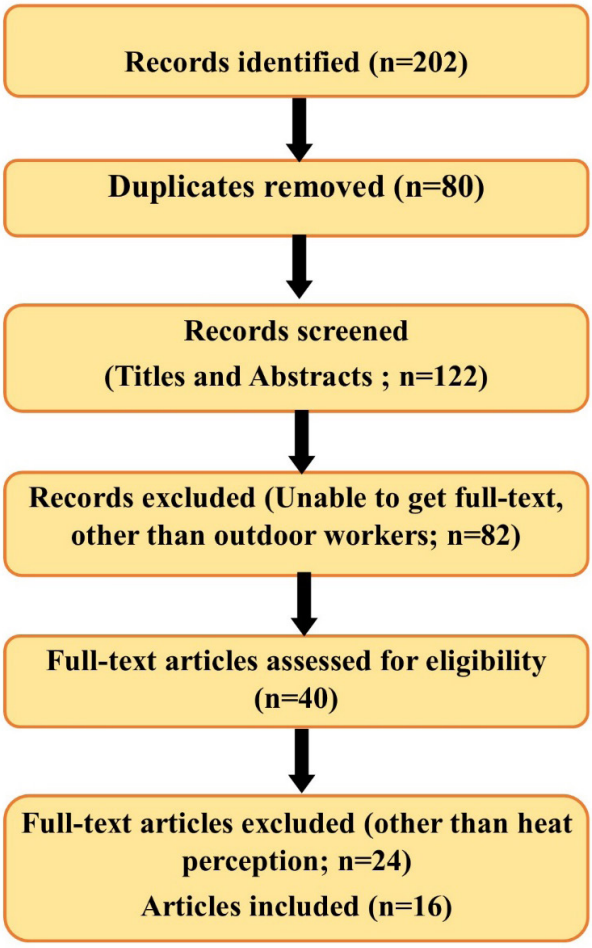

Figure 1: Illustration of study selection procedure.

RESULTS

The initial database search returned 202 records. After eliminating the duplicated articles, 122 records remained. The screening of these records was based on titles and abstracts, and the 82 articles that failed to meet the eligibility criteria (could not be obtained in full or were irrelevant to outdoor occupational groups) were excluded. The remaining 40 articles were then evaluated as suitable. After evaluating the full text, 24 articles were eliminated as irrelevant to the perception of heat at work or as lacking perception-related results. Lastly, 16 main studies were identified and m*et a*l inclusion criteria for inclusion in the synthesis of results (illustrated in Figure 1).

The studies included covered both South Asia and Southeast Asia, as well as Africa, Australia, and North America. They represented a wide range of occupations exposed to heat, including agriculture, brick kilns, construction, forestry, and informal urban labor (highlighted in Table 1). All included studies were original empirical studies (cross-sectional, qualitative, mixed-methods, or field studies) and explicitly examined perceived exposure to heat, perceived symptoms, perceived risk, or adaptive behavior among workers. Sample sizes were small qualitative cohorts and large workforce surveys that, collectively, represented both male- and female-dominated occupational groups and both older workers and pregnant women.

Beyond the general patterns summarized in Table 1, the included studies consistently identified distinct vulnerable subgroups. Heat perception was not evenly distributed but clustered around specific biological and socio-occupational categories. In particular, women workers, pregnant women, elderly workers with chronic disease, and informal or brick-kiln workers repeatedly reported higher perceived heat burden, greater symptom awareness, and lower adaptive capacity. To synthesize these recurring vulnerability patterns, the key at-risk groups and their perception-related findings are summarized in Table 2.

DISCUSSION

Heat Perception as an Occupational Health Signal

Heat is a key occupational problem among workers across climatic zones and work sectors, and is tightly linked to physical discomfort, fatigue, dehydration, decreased work capacity, and anxiety about becoming ill. Specifically, outdoor and informal-sector workers frequently characterized heat as more than an environmental exposure but as a daily body stressor that influences work pace, coping behavior, and health awareness.[9,11,12,15]

These perceptions were founded on experienced symptoms. Notably, agriculture, construction, and brick field workers perceived susceptibility due to heat-related symptoms, including excessive sweating, headaches, cramps, dizziness, and exhaustion, while working in a hot environment. [22,27] Critically, perceived vulnerability had to extend beyond temporary suffering. Harmful heat effects to pregnant women and women agricultural workers contextualized thermal stress with other forms of economic insecurity and occupational insufficiency.[16,24]

Perception, Vulnerability, and Adaptive Behavior

Heat perception was not uniform across worker populations, but it was patterned by social and biological vulnerability. Older workers, people with chronic disease, workers in the informal sector, and women more often reported increased susceptibility and decreased capacity to adapt to heat exposure. Differences in education, income, and occupational experience also variedly influenced awareness and responses, suggesting that perceptions of heat reflect both physiological strain and structural working conditions.[14,25]

A consistent tension between awareness and action arose. While workers widely recognized heat as dangerous, truly protective practices were often limited. Evidence from South and Southeast Asia revealed great disparities between risk perception and the actual practice of mitigating heat, largely driven by productivity demands, financial pressure, and weak organizational support.[10,11,13,14] This perception-practice gap indicates that in institutional settings, risk awareness may raise psychological burdens without substantially protecting them.

Physiological Meaning of Perceived Heat Stress

The accounts made by workers of unbearable heat are in line with the accepted principles of human thermoregulation. When exposed to heat during occupational tasks, heat transfer is carried on by the persistence of both metabolic heat production and heat loss to the environment. Excessive heat gain beyond the capacity of the body to dissipate heat causes body core temperature to increase and heat strain to develop, which is manifested as cardiovascular strain, dehydration, and functional decline.[29,30]

Occupational heat strain is the combination of the environmental heat load, metabolic demand, and insulation of clothing. Increased ambient temperatures, sunlight, and humidity enhance the net heat gain and decrease evaporative cooling, exacerbating perceived fatigue and discomfort. Part of the compensation may be due to the air movement, which may enhance convective and evaporative heat loss and the stagnant conditions will increase strain.[8,31,32]

The second important driver is the physical workload. In heavy manual work, a majority of metabolic energy is lost in the form of heat; this will have a strong effect of increasing the internal heat load. The combined heat loads of the environment and metabolism are felt in workers in the agricultural sector, construction and production of bricks, which explains the sharp increase in the perception of heat during long or physically demanding work.

Clothing further adjusts thermal load. Non-permeable and protective clothing prevents heat loss and retains physiological and perceptual heat near the skin, thereby increasing physiological and perceptual loads. Even

Table 1: Characteristics and key findings of included studies examining occupational heat perception.

Serial no.	Author(s) Study type	Places of Study Number of participants (Male/ Female)	Key findings
1	Hale *et al*. (2024)[9] Cross-sectional survey	USA 44 male and 28 female agricultural workers	The occupational heat was found as a serious health and productivity burden with fatigue, dehydration, and decreased working capacity. There were differences in perception, with females reporting higher levels of discomfort, symptom awareness, and concern, which are seen as reflecting biological vulnerability and socially constructed patterns of occupational exposure.
2	Han *et al*. (2021)[10] Cross-sectional survey	China 318 construction workers, including 79 females	The construction workers recognized heat as an occupational hazard that could lead to fatigue, dizziness, and reduced productivity. However, the level of general injury risk perception was low. Gender differences were also evident: male respondents reported greater productivity loss, while female respondents showed greater physiological sensitivity.
3	Lohrey *et al*. (2021)[11] Cross-sectional Knowledge-Attitudes-Practices (KAP) survey	Vietnam 524 male and 504 female outdoor workers, including construction and street vendors	Intense heat was generally recognized as harmful, and there were frequent complaints of exhaustion, thirst, dizziness, and pain. Women and older employees were more symptomatic and used health care. Although risk awareness increased, the prevalence of symptoms remained high, suggesting greater vulnerability among subpopulations.
4	Mathee *et al*. (2010)[12] Pilot study	South Africa 151 workers, including 22 females	Heat in the workplace was generally seen as a significant health and productivity problem, linked to fatigue, dehydration, and headaches. Different perceptions were also based on individual vulnerability, as women participants reported more intense symptoms and increased concern, in particular, regarding reproductive and general health risks.
5	Sharma *et al*. (2025)[13] Mixed-Method cross-sectional KAP study	Nepal 204 male and 152 female outdoor workers	Heatwaves are perceived as a major occupational threat, including fatigue, dizziness, headaches, and reduced capacity. Limited formal awareness despite experience. Men showed poorer protective practices; women showed higher concern and vulnerability.
6	Shahrujjaman *et al*. (2025)[14] Cross-sectional survey	Bangladesh 361 male and 59 female outdoor workers	One occupational hazard is heat, which is often coupled with fatigue and reduced work capacity. The level of preparedness was low, given moderate awareness. The difference in sex can be observed as men were more prepared, and women had lower adaptive capacity and were more susceptible.
7	Xiang *et al*. (2016)[15] Cross-sectional questionnaire-based survey	Australia 719 males and 30 females from different work sectors such as agriculture, construction, electricity, gas, and water, etc.	It has been generally agreed that heat perception is influenced by prior heat illness, physical workload, and the use of personal protective equipment. Although the workforce was predominantly male, female employees also said they were as concerned, or even more dissatisfied, with preventive actions. Heat exposure was also linked to awareness and support of adaptive practices, suggesting that risk perception depends mainly on exposure rather than sex, though female representation remains low.
8	Flocks *et al*. (2017)[16] Qualitative research	USA 35 female farmworkers	Female agricultural workers considered occupational heat to be a serious health threat, and they complained of dizziness, dehydration, exhaustion, and faintness. They were also concerned about pregnancy and the health of the fetus, the lack of control at their workplace, and insufficient training also added to their vulnerability.
9	Sen and Nag (2019)[18] Analytical cross-sectional study	India 632 male and 512 female agriculture workers	Agricultural workers also found the heavy heat an occupational burden, reporting fatigue, dizziness, and headaches. The pattern of symptoms was found to be cumulative physiological strain, and, in this way, the women had a higher frequency and severity of symptoms, and thus a sex difference in vulnerability, as well as a strong correspondence between perceived and actual heat strain.
10	Dutta *et al*. (2015)[22] Cross-sectional field study	India 186 male and 33 female construction workers	Heat was recognized as one of the significant occupational hazards by construction workers, and more frequently reported symptoms in the summer. Workplace protectants were curtailed even as awareness of this risk increased. Women were also more vulnerable because of the hard labor, limited access to cooling systems, and lack of sanitation, hence gender-specific occupational disadvantages.

Cont...

11	Rother *et al*. (2020)[23] Qualitative interviews	South Africa 14 male and 16 female forestry workers	Forestry workers were identified to have heat exposure, which was said to be inevitable and physically demanding, linked with fatigue, dizziness, and fainting. The situation worsened due to a lack of protective equipment and poor ventilation. Women indicated their vulnerability more, and the lack of institutional support strengthened the workers to use informal coping measures.
12	Spencer *et al*. (2022)[24] Qualitative study	Ghana 12 pregnant women farmers	Pregnant agricultural workers considered the exposure to heat to be a significant threat to maternal and fetal health, reporting fatigue, dizziness, and nausea. Pregnancy increases susceptibility and decreases work ability, leading to financial and social limitations to the effectiveness of coping mechanisms in extreme heat.
13	Siriswasd *et al*. (2022)[25] Cross-sectional study	Thailand 230 male and 122 female agriculture workers	Older agricultural workers who had chronic pathological conditions mentioned that they had a significant thermal burden, with most of them being subjected to high ambient temperatures. The strain among female workers was marginally high. The predisposition to perceptions was affected by age, health, income, and tenure of employment, thereby indicating a collective biological and socioeconomic vulnerability.
14	Sett and Sahu (2014)[26] Cross-sectional study	India 120 female brick kiln workers	Female brickfield workers were subjected to heat stress, which they described as exhaustive and economically burdensome, and also reported high levels of discomfort and low productivity. Increased cardiac load was supported by this heavy workload, and the use of self-determined work to respond resulted in decreased production and, in turn, a loss of income.
15	Nath *et al*. (2025)[27] Field-based cross-sectional study	India 15 male and 10 female brick-kiln workers	In Eastern India, brick-kiln workers experienced significant heat exposure, characterized by fatigue, cephalalgia, and exhaustion. An increase in Wet-Bulb Globe Temperature (WBGT) heightened cardiovascular load and reduced productivity, and female workers exhibited higher physiological load and greater productivity loss, highlighting their vulnerability.
16	Nath and Sahu (2026)[28] Analytical cross-sectional study	India 200 male agricultural workers	Occupational heat was a long-term experience of male agricultural workers, manifested by frequent fatigue, sweating, and exhaustion. The rising WBGT levels were associated with increased physiological strain and dehydration, indicating a clear exposure-response relationship and the need for sex-based comparative studies.

Table 2: Vulnerable groups highlighted across included studies

Vulnerable group	*Supporting studies*	*Perception-related findings*
Women workers	Flocks *et al*. (2017)[16]; Mathee *et al*. (2010)[12]; Nath *et al*. (2025)[27]	Higher perceived heat burden, frequent symptoms, and greater concern about health impacts.
Pregnant women	Spencer *et al*. (2022)[24]; Flocks *et al*. (2017)[16]	Pregnancy-related heat risk; limited control over exposure conditions.
Elderly workers and/or chronic disease	Siriswasd *et al*. (2022)[25]	Significantly higher perceived vulnerability, discomfort, and functional limitation.
Informal & brick-kiln workers	Mathee *et al*. (2010)[12]; Shahrujjaman *et al*. (2025)[14]	Elevated heat risk perception; limited coping capacity; economically constrained exposure.

traditional work clothes produce quantifiable levels of heat resistance in hot, wet conditions.[8,29]

Individual Modifiers of Heat Perception

Individual characteristics also importantly influence the response to occupational heat. Advancing age is associated with reduced cardiovascular and sweating efficiency and may increase heat sensitivity among older workers, as reported for elevated heat perception in elderly farming populations.[25] Sex-related physiological differences, including generally lower average sweating capacity and variation in body composition, may partially explain higher symptom reporting and perceived vulnerability among women working in hot environments.[16,24] Lower sweating capacity can limit heat dissipation and increase susceptibility to heat strain, contributing to a greater overall heat burden among women.[33-35] Accordingly, a conceptual framework was developed to depict how climate change-driven occupational heat exposure leads to physiological strain, heat perception, and differential vulnerability among outdoor workers (highlighted in Figure 2).

Taking these together, environmental conditions, work demands, clothing constraints, and individual susceptibility provide a mechanistic foundation for the subjective experiences reported across studies. Workers' heat perceptions, therefore, appear to reflect physiological strain, shaped and often intensified by socioeconomic limitations that restrict adaptive capacity.

Physiological Perception of Heat

Heat physiological perception is the subjective estimate of thermal pain and cardiovascular work, although the accumulating evidence shows that such perception is not necessarily the predictor of the actual physiological strain. Experimental data support this inconsistency, as there is only a small correlation and large inter-subject differences between self-reported heat stress as a risk factor and perceptual and physiological strain indices, which reduces the reliability of self-reported heat stress as a single risk factor.[38] Climate change may normalize warning signals and make individuals more susceptible to heat-related morbidity by normalizing environmental heat loads and chronic exposure.[39,40]

As such, the perception of heat must not be interpreted as an unreliable indicator but a context-specific complement, a marker of occupational heat strain. A combination of subjective perception and objective physiological indicators can help to have a more comprehensive picture of the risks of heat on outdoor workers.

Implications for Occupational Heat Policy

Evidence synthesis shows that subjective thermal experience can serve as an early indicator of occupational heat risk, often before clinically identifiable illness. Experimental, epidemiological, and occupational studies consistently show that excessive heat exposure leads to dehydration, cardiovascular strain, reduced productivity, and increased injury risk, underscoring the need for preventive controls in hot work environments.[3,6,31,41] These findings stress the need for occupational heat-risk systems that take into consideration reported workers' experiences within surveillance and preparedness efforts. Strengthening Heat-Health Warning Systems and embedding occupational priorities into public-health responses may improve early protection and coordinated action.[42-44]

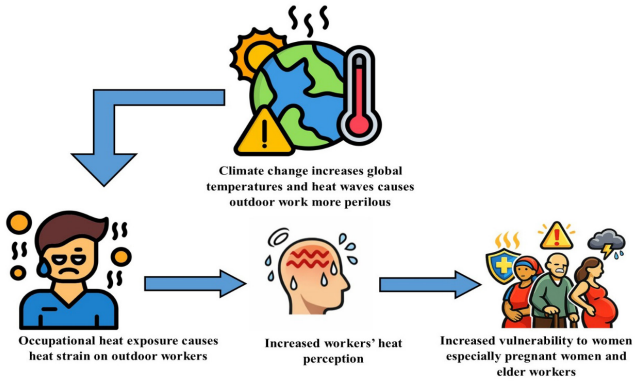

Figure 2: Conceptual framework illustrating how climate change-driven occupational heat exposure leads to increased environmental heat load, resulting in physiological strain (e.g., dehydration, cardiovascular stress), which is perceived as thermal discomfort and fatigue. These perceptions interact with socioeconomic and individual factors (e.g., sex, age, occupation, income) to shape vulnerability and adaptive capacity among outdoor workers.

LIMITATIONS

This review has several limitations. Most of the included studies were observational, cross-sectional, or qualitative, limiting causal attribution and insight into how heat perception evolves. Heat perception was mainly evaluated by self-report, raising the possibility of recall, reporting, and cultural interpretation biases. A substantial heterogeneity is attributable to occupations, climates, and measurement approaches, which restrict comparison and quantitative synthesis. Although there was representation of vulnerable populations, longitudinal and sex-disaggregated evidence remains limited. Publication bias may also be present, as studies reporting more pronounced or observable heat perceptions and health impacts are more likely to be published than those with non-significant or less evident findings. Lastly, the restriction to English-language peer-reviewed original studies may have excluded suitable grey literature.

Future Research Directions

The next steps for future research should take into account that longitudinal and repeated measures approaches will provide a better understanding of how heat stress and perceptions related to it change through time and correlate with health outcomes. Subjective and objective measures for the assessment of heat may help to increase the validity of perceived heat as an index of heat strain. Further research should explore gender-specific effects and focus on pregnant women and older workers. Finally, researchers need to identify the social and organizational reasons behind the practice-perception gap and investigate effective heat risk management practices and warning systems.

CONCLUSION

In conclusion, this review demonstrates that occupational heat is perceived across diverse climatic regions and labor sectors as a dominant, manifested health burden rather than a transient environmental discomfort.

Workers' accounts of fatigue, dehydration, dizziness, and reduced work capacity align with established physiological mechanisms of heat strain, confirming that perceptions reflect physiological strain. Importantly, this perception is not uniformly distributed but patterned by vulnerability, with women, pregnant workers, elderly laborers, and informal-sector workers showing heightened susceptibility and constrained adaptive capacity.

In sum, there is evidence that workers' thermal experiences represent significant, early signals of occupational risk and provide a crucial perspective on the human dimensions

of heat exposure linked to climate change. Incorporating perceptions of heat into occupational surveillance, prevention strategies, and heat-health warning systems may improve the early detection of heat strain and facilitate fairer, worker-centered heat adaptation. To protect heat-exposed workers as global temperatures rise, alignment among physiological evidence, lived experience, and institutional responses is needed to maintain sustainable labor conditions and avoid unnecessary heat-related morbidity.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR (S) CONTRIBUTION (S)

SS designed the study and supervised the project. SS and AN conducted a literature search and curated the data. AN drafted the manuscript, and SS revised it.

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.